THE CONCEPT OF THREAT MODEL IN THE ASPECT OF SAFETY IN LOGISTIC SYSTEMS

KONCEPCJA MODELU ZAGROŻENIA W ASPEKCIE BEZPIECZEŃSTWA SYSTEMÓW LOGISTYCZNYCH

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Abstract:The overall aim of the study is to improve the processes of threat monitoring in military logistic systems, while the specific objective is to uniquely define the concept of a threat in the process of perceiving warning signals. This work uses the following scientific methods: analysis and criticism of literature, analysis and logical construction, as well as the heuristic methods: "new look" method and the analogue transfer method. These concepts incorporate the method of inference, including deductive inference combined with enumerative induction. The work resulted in the concept of threat model providing division into causal and consequential hazards. It was supplemented with partial models: threat development and threat perception model.

Key words: threat, hazard, risk, threat development, threat perception.

INTRODUCTION

Contemporary logistic systems, including military logistic systems (Bartosiewicz, 2015), need to monitor threats arising from negative impacts of the internal or external environment to ensure efficient and effective implementation of the tasks. At the same time, the problem of limited effectiveness of these systems is stated, most often expressed in underestimation or failure in perception of recorded warning signals. Conducted studies and analyzes indicate the need to undertake research aimed at finding improvements in this area (Ćwik, 2017). The starting point is to arrange the interpretation of basic concepts, where the basic term "threat" seems to be one of the most commonly used terms in the field of system security. It is claimed that although the term is intuitively intelligible and widely used, it seems that the lack of clear definitions and apparent differences in its interpretation may affect the monitoring of warning signals.

Dealing with this problem is related to research and studies conducted by the author for exploring the causes of the limited effectiveness of warning systems, monitoring systems, threat management systems and other hazard recognition systems, as well as repeated situations where combination of unexpected negative events causes unexpected emergencies, and when after a time many say that the signs of the coming events had been visible earlier.

1. GENERAL DEFINITION OF THREAT

Most definitions in the literature and in the comments describe the concept of threat as follows: "a phenomenon triggered by human or forces of nature, which causes the sense of security to diminish or totally disappear." This is the most common interpretation provided in the literature and it refers basically to the awareness of a given entity (man, social group, nation), identifying in general a specific state of mind of a single man or a group of people, caused by the perception of phenomena assessed as unfavorable or dangerous. However, this way of interpretation is imprecise, inaccurate and creates problems with its interpretation, and if automatically applied, may create colloquial knowledge (Lachowicz-Tabaczek, 2004). Subsequent problem is the conviction in collective consciousness that one feature of reality, surrounding modern economic systems as well as social systems, is functioning in constant presence of threats. As a result, the term "threat" is overused in scientific and professional arguments, as well as in number of oral statements, where expressions like "threat", "hazard", "risk", "state of emergency", "warn against threats" are commonly used. The basic problem (question) that arises here is how to warn against something common or how to understand the phase "state of emergency" in the situation of widespread dangers. Another issue is what to measure or monitor, what criteria to accept to issue warnings in the event of threats such as an outbreak of armed conflict, a railway or aviation disaster. In specific issues such as the threat of methane explosion in a mine, the problem to measure and, as a result, to warn is, in principle, clear-cut.

When taking up the concept of a threat model, the general assumption will be that the threat to a given system may be considered as a dynamic state of the system, related to the existence (with threat or danger) of adverse effects on the relationships that form its structure or on its function. Its further change and exceeding limit values of these effects may lead to the development of negative phenomena or events (in structure or performed functions) to such extent that the system will collapse or irreversible qualitative changes will occur. In short, one can say that threat is a real possibility of something unfavorable, including the loss of functional capacity, disintegration or alteration of the system's structure, the loss of certain characteristics, or creation of other negative and irreversible changes, both quantitative and qualitative.

It should also be stressed that threat has also a psychic dimension expressed in, so-called, a sense of danger, which is a mental state of mind, characterized by the state of stimulation to certain structures in the nervous system and of human mind with its readiness to launch certain defensive scenarios (Świerszcz, 2012, pp. 69-86).

In addition, it may also be noted that threat is the antinomy of security, where security in Latin is *securitas* that consists of two words: *sine* means without, lack, absence and *cure* – care, custody, concern, supervision, surveillance, attendance, attention, diligence, guardianship. In this reasoning, security means something that does not require custody, worry or supervision. Most references in the literature define security as a state of calm, certainty and lack of danger. The theoretical side of this issue is described in, inter alia, Remigiusz Rosicki's work (Rosicki, 2010).

2. CONCEPT OF THREAT MODEL

Introducing the concept of threat model, the basis will be to assume that the concept of threat must be considered in two categories, namely in the category of cause and consequence. The first category includes characteristics associated with the cause of something negative to happen. These characteristics can be termed interactions (or impacts), where the interaction is to be understood as any physical, chemical, mechanical, biological, psychological, economic, social or other forces which have a negative impact on investigated system. These forces can be measured and expressed in terms of their value on a certain scale, and therefore they are quantitative. While the second category includes the characteristics related to effects of negative influences expressed either in terms of the ability of the system to perform certain activities or the realization of negative events or phenomena (outbreak of war, communication catastrophe, mine gas explosion, breakdown of the flood embankment, collapse of a company, breaking contact by customer, etc.). They are rather unmeasurable and can be expressed on a nominal scale.

Thus, when monitoring logistic warning signals systems, it is suggested to divide threats into causal and consequential. At the same time, the causal threat will relate to certain impacts and will be defined as (possibility, threat or probability of) exceeding limit values of those impacts beyond which significant qualitative changes may occur in the structure of the system or its functions.

While the consequential threat will mean (possibility, threat or probability of) an occurrence of a particular negative effect – a company collapse, a sudden stock market decline, a fire in a warehouse, a methane explosion in a mine, a chemical leak, a communications or industrial disaster, a conflict breakout and other as a result of the impact of a specific (real) causal threat.

At this point it should be noted that in the literature of the field there are number of classifications of such interactions and related effects, commonly called hazards (Wojciechowska-Filipek and Mazurek-Kucharska, 2014), and the simplest is the division into: natural hazards, that is, caused by nature and civilizational – means man made.

The basis for monitoring threat signals is to identify significant impacts, both on side of causes (including their origin mechanisms or the mechanisms of their transmission, as well as their development mechanisms), and the effects they may have. In other words, knowledge of causal hazards and resulting consequential dangers is required. As Małgorzata Kuć states "threats have to be named as they are" (Kuć, 2004). In the case of early warning systems, including normal warning systems, the basic problem is what and how to observe and what and how to measure to provide effective warning of threats. This problem should explain the model of threat development.

3. MODEL OF THREAT DEVELOPMENT

This model illustrates the course of a certain negative impact (of causal hazard) which, when exceeded, will lead to negative and irreversible qualitative changes. This is shown in Figure 1, where the vertical axis "Z" represents the value of the observed impact (causal hazard) on the given system and the horizontal axis – its duration. Under normal conditions, the system almost always functions at a certain level of negative impact, which can be considered as a permissible level within applicable standards. After exceeding the permissible level of Z_{dp} (acceptable Z), the level of the observed impact becomes so significant that first changes in the ability to perform tasks begin to appear in the system (system characteristics deteriorate). In the first phase these are mostly quantitative changes and the system may correct them. At this stage, the changes are identified as interruptions as they occur at the presence of conditions, forces, and capability to stop or change the unfavorable course of events. However, when the level of this impact exceeds the limit Z_{gr}, then permanent quantitative and qualitative changes in the system start and the resulting effects become irreversible, i.e. there appear permanent quality changes. This moment is marked as SG (limit state) in Figure 1. It is a consequence of the limit value of this impact (GWO), after which the process of system destruction begins; it changes the properties irreversibly and results in permanent qualitative changes. As Fig. 1 shows, two breakthrough points encounter here; on the side of causal hazards, the limit value of the GWO influence appears and on the consequence side we may observe the limit state of the SG system. After excessing the SG point a specific consequential threat is reached – the company starts firing or sells the property, the water begins to overflow through the flood embankment. Initially the implementation of the consequential threat is partially reversible as it is possible to re-hire fired workers or stop selling the property, or increase the flood embankment with sandbags, but after some time the consequential threat of irreversible qualitative changes is fully completed – the collapse of the company, the flooding of the land.

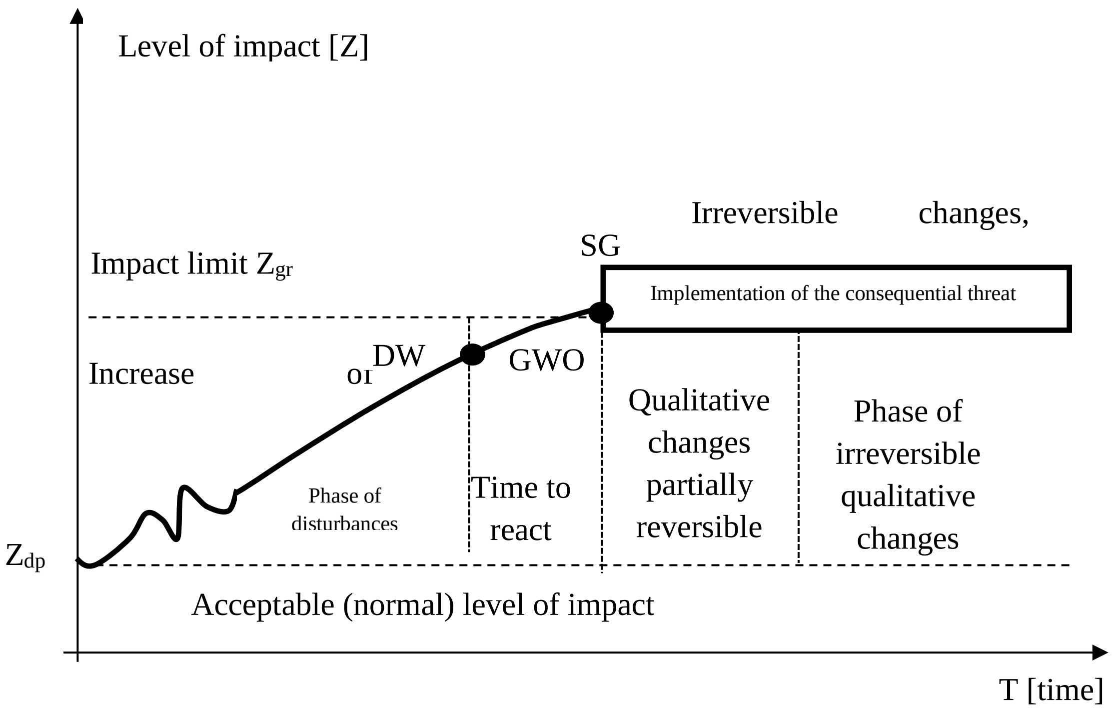

Fig. 1. Model of threat development in the system

Source: own work

Returning to the subject of early warning, it is important to generate resources or structures that are responsible and capable of determining in sufficient advance when to take preventive action. This moment has been marked in Figure 1 as perceiving DWG – the impact (causal threat) limit value.

Time to react, that is the time to generate a warning signal and take defensive actions, is equal to GWO – DWG. The problem, however, is that in many logistics systems it is not always possible to place the equals sign between cause and effect (consequence), i.e. between GWO and SG. This is possible in technical sciences, e.g., in the stretching test of a metal sample where exceeding the elasticity limit F_s, or the yield point F_p, or the F_{gr} moment of sample rupture is visible and the limits (causal and consequential) are easily visible and measurable. Exceeding the limit value of the tensile force F_{gr} means breaking the sample, i.e. exceeding the limit state SG (Figure 2).

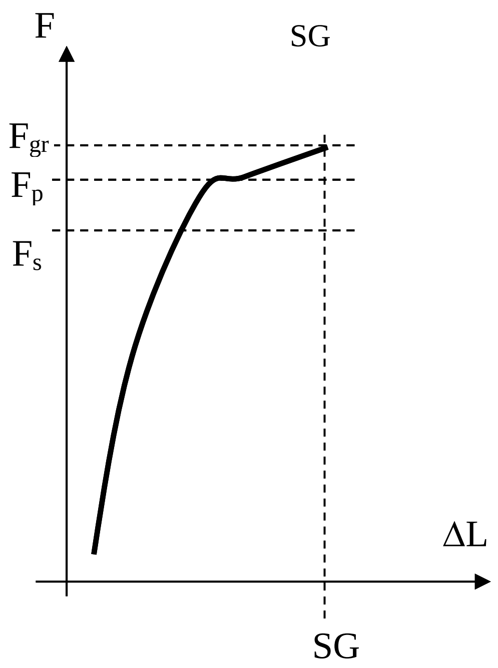

Fig. 2. Limit values for tensile test

Source: own work

The results of our own observations and analyzes indicate that there are almost 100% correlation between WGO and SG (Pearson correlation coefficient greater than 0.99) in the area of technical, physical, chemical as well as natural sciences. High correlation can also be indicated in medical diagnostics. On the other hand, in many logistic systems, where generated impacts are the result of human decisions and choices, correlations between GWO and SG are significantly smaller (Pearson's correlation coefficient is less than 0.9).

Another model for exceeding the limit state by the system may be a flood wave in the river. The water level in the river H is the parameter to be observed (Figure 3). The value of the water level equal to H_{gr} means GWO on the side of the causal hazard (cause) and on the side of the consequential threat (effect), the limit state SG, so in this case GWO = SG. Further increase and exceeding H_{gr} is the overflow of water through the dike and consequently significant qualitative changes. DWG should take place some time ahead at the H_d level. Both of these values are known, and the way they are determined is carried out according to clearly defined methodologies (Boris, 2007).

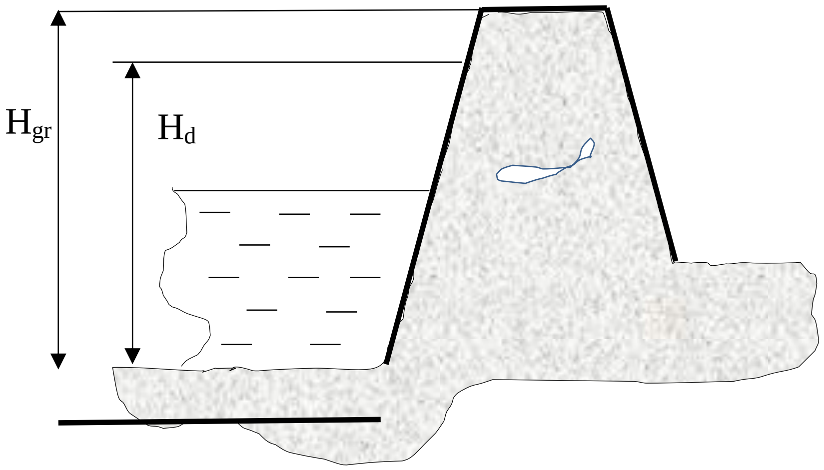

Fig. 3. Limit state during a flood wave in a river.
Source: own work

In practice, however, the limit state can be reached earlier than at the H_{gr} water level, e.g., when the dike internal structure is damaged (softening or deterioration of the strength properties), which are not directly observed.

To summarize this stage of analysis, it is concluded that in the description of the situations in which some consequential threats took place, in different structures and environments (both in corporates and in societies) we may find several common phenomena:

- event participants (including „decision makers") are usually surprised by the fact that the threat has already been realized,
- both corporate executives and community leaders (managers, also those in organizations) have fundamental difficulties in predicting the course of further events,
- situation control is often hampered by lack (especially fast enough) of understanding the core of implementing the given consequential threat and the mechanisms of its development,
- decision making process, organizing and implementation of defense activities is too slow for the needs of the moment, which greatly delays (and sometimes even precludes) the achievement of a breakthrough point to overcome current situation (Bujak and Śliwa, 2007).

In the hazard monitoring systems, the subjective factors, resulting from the psychic and emotional state of the observer, are important (Ćwik, 2017), as they affect significantly on the correlation between perception of GWO and perception of SG, which is related to the actual realization of a particular threat. Figure 4 shows the situation where, at low value of causal threats, the consequential threat may be ignored by systems of observers' perception and, as a result, it will not be recorded by their perceptual systems. However, with the increase in the level of causal threat, the perceived consequential threat increases and, at some point, the perceived and actual values equate, and with further increase of the causal threat, the perception of consequential threat is increasingly greater than the real threat. The, so called, curve of consequential threat perception is presented in the Figure 4. Visible continuous lines (thin and bold) represent the weights (subjective values) assigned by the observer to the perceived threats. If there were no cognitive distortions in the mind of the observer, the weights of the consequential dangers would overlap the weights of causal threats (continuous thin line), but in reality those both types of threats are perceived differently (continuous line in bold for causal threats). The course of this curve depends to a great extent on the individual attitude of the observer towards the threats resulting mainly from, so-called, individual differences, including personality, temperament, intelligence, emotion, motivation, mood, abilities and cognitive style (Strelau, 2015).

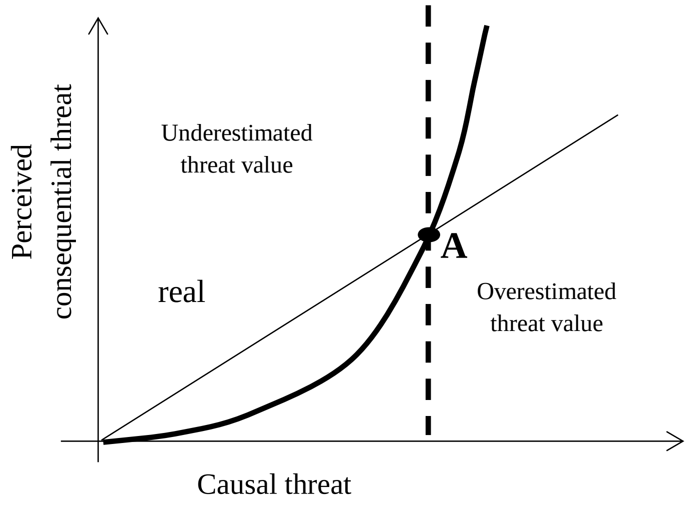

Fig. 4. Perception of causal and consequential threats
Source: own work

The course of causal threats perception is most often clear – it follows standard methodology where observation processes or the processes of measurement are carried out. The weight (value) of the perceived consequential threat realized in mind raises a problem

(Ćwik, 2017). This perception can be subject to various interferences and distortions. While consequential threat is most often perceived subjectively and is realized in several dimensions.

4. Threat perception model

Taking into account the dimensions of perceived consequential threats may be useful in terms of improving the effectiveness of threat monitoring in logistics systems. The concept of this model is presented below. It considers perception of consequential threat Wz in 8 basic dimensions. It is illustrated by Wz vector in eight-dimension space:

$$\mathbf{W}_z = \langle \mathbf{S}, \mathbf{O}, \mathbf{N}, \mathbf{C}, \mathbf{K}, \mathbf{D}, \mathbf{W}, \mathbf{P} \rangle$$

where:

S – size of losses;

O – distance;

N – catastropheness (seriousness);

C – frequency;

K – controllability;

D – voluntariness;

W – imaginability;

P – probability.

It is also proposed to take into account only three value levels of each dimension that correspond to three levels of its significance:

1- level not significant (not important);

2- level partially significant (important);

3 - level strongly significant.

This division is related to the fact that in a similar way our minds automatically categorize the significance and associated readiness to activate cognitive and energy resources (Ćwik, 2017).

The dimension of "size of losses" will be determined by the magnitude of possible losses, expressed either by costs or in other amounts, such as: social position (workplace, society, organization), family situation, health status (possible health or life loss), the ability to perform certain functions or maintain specific structures. The "size of the losses" dimension will be a three-element set:

$$\mathbf{S}\ \{ s_1, s_2, s_3 \}$$

- s_1 - no or insignificant loss level, not constituting a threat to the existence or functioning of the system (organization, object or entity),
- s_2 - partially significant loss level, constituting a threat to the existence or functioning of the system (organization, object or entity),
- s_3 - strongly significant level of loss constituting a threat to the existence or functioning of a given system (organization, object or entity); there is a danger of exceeding the limit beyond which permanent quality changes or downfall will take place.

Next dimension is "distance", which is defined by the range (distance) in time or space of the resulting threat. The practical presence of this dimension results from the awareness of whether the consequences of the consequential threat are immediate or may be postponed in time, as well as whether the execution of the threat will take place very close to the perceiver or rather further. It was observed that people underestimate negative consequences (losses) if they are postponed temporarily or located in a large distance. The observation also provides that over time, the negative utility of negative results decreases. An example of this may be that warnings about the harmfulness of smoking (increased likelihood of lung cancer) or drinking alcohol often do not have a clear effect because the anticipated "punishment" is often quite distant in time.

The dimension "distance" can be considered as a set of the following elements:

$$\mathbf{O}\ \{ o_1, o_2, o_3 \}$$

- o_1 - close in time or space distance at which a significant (strong) sense of security loss is triggered related to the existence or functioning of a given system (organization, object or entity); but there is a danger of exceeding the limit beyond which permanent quality changes or downfall will take place.
- o_2 - time or space distance at which partially significant sense of security loss is triggered related to the existence of a given consequential threat;

- o_3 - time or space distance is so large that the feeling of security loss is not induced or the security loss level is insignificant, related to the existence of a consequential threat.

Another dimension describes "catastrophic" effect of the consequential threat. This dimension is related to the possibility of experiencing sudden and severe damage simultaneously by many people (e.g. due to some serious accident or disaster). The opposite is the, so-called, chronic consequential threat that is extended over time and entails single victims. Mine gas explosions, air disaster or collapsing buildings are examples of catastrophic consequential dangers. While dangers such as car accidents and accidents at work are chronic consequential hazards. It turns out that people tend to attribute greater value to the perceived threat of the catastrophic danger, although chronic hazards over a longer period of time, e.g. throughout the year, entail a greater number of victims.

The "catastrophic"dimension can be considered as a set of the following elements:

$$\mathbf{N}\ \{\ n_1, n_2, n_3\ \}$$

- n_1 – low level of "catastropheness" (chronic consequential threats);
- n_2 - significant level of "catastropheness"where the execution of consequential threat may involve more victims, affect more people;
- n_3 - highly significant level of "catastropheness" where the execution of consequential threat may occur suddenly, on a mass scale, and may involve a very large number of victims.

Next dimension is the frequency of consequential threats fulfillment. This dimension is related to the fact that where the frequency of negative events, such as accidents, is high, people attribute greater value to threats, they also feel less safe. The "perceived relative frequency of accidents" is a significant problem in this dimension. Psychologists point out that the judgments on magnitude of the threat are more influenced by frequency of threat fulfillment subjectively perceived by people than actual statistics. For example, accidents with which people meet every day or which are commonly commented on in the media appear to be more frequent, more likely, and therefore more dangerous.

Considering the above, the "frequency"dimension can be considered as a set of the following elements:

$$\mathbf{C}\ \{\ c_1, c_2, c_3\ \}$$

- c_1 – low frequency of consequential threats implementation;

- c_2 - significant frequency of consequential threats implementation;
- c_3 - strong level of frequency of consequential threats implementation;

Subsequent dimension of risk perception is the ability to control negative consequences of possible events (consequential threats). This dimension may be understood as the ability to control events by performing actions protecting against negative effects, e.g. against accident, or reducing the likelihood or size of these effects when an accident has already occurred. The awareness that the course of a situation may be controlled, reduces the level of perceived consequential threat. In this area, there is also a phenomenon of so-called illusion of control, which is apparent quite commonly among drivers or athletes, where some of them overestimate their skills or their fitness.

Considering the above, the “controllability” can be considered as a set of the following elements:

$$\mathbf{K}\ \{\ \boldsymbol{k_1}, \boldsymbol{k_2}, \boldsymbol{k_3}\ \}$$

- k_1 – no or slight impact on the course of consequential threat;
- k_2 – significant impact on the course of consequential threat;
- k_3 – strong impact on the course of consequential threat;

The next dimension defined as „voluntariness“, expresses the level of freedom for voluntary exposure. It was distinguished since human actions can be of two kinds: either necessary, it means „forced“, or voluntary. While the former are often necessary for the survival of individuals or larger populations (food production, energy, means of transport), the latter type of activity does not play such a strategically important role and a person can refrain from exercising it (e.g. smoking, drinking alcohol, practicing sports). People overestimate the magnitude of the dangers resulting from necessary actions, and underestimate the magnitude of the dangers stemming from voluntary activities. They are willing to accept even more dangerous voluntary actions than those imposed on them. For instance, racers who take part in dangerous car races at the same time do not accept much lower risks they encounter in certain everyday situations, such as periodic radiological examinations or fear of Lyme disease and associated avoiding trips to the forests.

Considering the above, the “voluntariness” can be considered as a set of the following elements:

$$\mathbf{D}\ \{\ \boldsymbol{d_1}, \boldsymbol{d_2}, \boldsymbol{d_3}\ \}$$

- d_1 – full voluntariness to expose to consequential threats;

- d_2 – partial voluntariness to expose to consequential threats;
- d_3 – no voluntariness to expose (forced participation in) to consequential threats;

Another dimension of the perceived threat is the conception of causes and negative effects of events (imaginability). Identification of this dimension results from the fact that dangerous activities may differ with one feature, which can be defined as the simplicity or difficulty of imagining and constructing „in the mind“ the scenario of unfavorable course of events. As a result, activities that are easily associated with certain dramatic scenarios are assessed as more dangerous (Ślachcińska, 2013). For example, people generally underestimate these dangers when reporting on them with dry, statistical information that does not speak too much to the imagination (e.g. the number of victims in a rail disaster). On the contrary, in the event when information are transmitted with a colorful and sensational image of an event (e.g. filmed disaster), people are exposed to feel an increased consequential threat. In this dimension Maryla Łukasik-Goszczyńska points out the novelty of the threat (Łukasik-Goszczyńska, 1997, p. 60-71).

Considering the above, the "imaginability" can be considered as a set of the following elements:

$$\mathbf{W}\ \{\, w_1, w_2, w_3 \,\}$$

- w_1 – no or low imaginability of the probability of consequential threat realization;
- w_2 – partial imaginability of the probability of consequential threat realization;
- w_3 – strong imaginability of the probability of consequential threat realization;

An important dimension of perceiving the magnitude of a threat is the probability of its realization. The greater the likelihood of a given consequential threat, the greater the perceived magnitude of risk. An important factor is the magnitude of perceived probability of a given threat realization. The greater the likelihood of a given consequential threat, the greater the risk seems to be to the perceiver.

Considering the above, the "probability" can be considered as a set of the following elements:

$$\mathbf{P}\ \{\, p_1, p_2, wp_3 \,\}$$

- p_1 – no or low probability of the consequential threat realization;
- p_2 - significant probability of consequential threat implementation;
- p_3 - strong probability of consequential threat implementation;

The presented dimensions in which the consequential threat is perceived, each of them individually influenced the effectiveness of perception. These dimensions place the vector of the perceived threat in three basic areas of possible levels of consequential threats: insignificant threat, significant threat, strong threat. These areas should be as closely as possible correlated with actual levels of causal threats.

Summary

The presented concept of the threat model is a preliminary approach to a problem that can be further developed. It seems that sorting out the problem allows to address the problem from the perspective of the system, allows to generalize the approach to understand the notion of the threat, creates the conditions for the development of methodology, measurement and risk assessment. It tries to explain the causes of disruptions and distortions in threats perception.

The presented concept of the threat model can be treated as the nucleus of a new research area that might be called „theory of risk". The division into causal, measurable and expressible in the measurement scale, and consequential, expressed on a nominal scale, threats provides the basis for more effective alignment of risk monitoring methodologies, the organization of early warning systems or risk management systems.

References

[1] BARTOSIEWICZ S. (2015) *Centra logistyczne w aspekcie zrównoważonego rozwoju*, WAT, Warsaw.

[2] BORYS M., *Przepisy i wymogi oraz aktualny stan obwałowań przeciwpowodziowych w Polsce*, Institute for Land Reclamation and Grassland Farming, Falenty 2007.

[3] BUJAK A., ŚLIWA Z. (2007) *Zarządzanie procesami logistycznymi*, development of the Military Academy of the Army in Wroclaw, Wroclaw.

[4] Ćwik B. (2017) *Postrzeganie sygnałów ostrzegających organizację w sytuacjach niedeterministycznych*, WAT, Warsaw.

[5] KUĆ M. (2004) *Zagrożenia nazwać po imieniu - świadomość zagrożeń sposobem przeciwdziałania wiktymizacji* in: Kowalski D., Kwiatkowski M., Zduniak A. (ed.) *Edukacja dla bezpieczeństwa. Wybrane perspektywy*, Wydawnictwo O'Chikara, Lublin, p. 34-40.

[6] LACHOWICZ-TABACZEK K. (2004) *Potoczne koncepcje świata i natury ludzkiej: ich wpływ na poznanie i zachowania*, Gdańskie Towarzystwo Psychologiczne, Gdańsk.

[7] ŁUKASIK-GOSZCZYŃSKA M. (1997) *Człowiek wobec zagrożeń: uwarunkowania oceny i akceptacji ryzyka*, Wydawnictwo Żak, Warsaw.

[8] ROSICKI R. (2010) *O pojęciu i istocie bezpieczeństwa*, "Przegląd Politologiczny", No. 3.

[9] STRELAU J. (2015) *Różnice indywidualne: historia, determinanty, zastosowania*, Wydawnictwo Naukowe Scholar: Warsaw School of Social Psychology, Warsaw.

[10] Ślachcińska E., Kopczewski M. (2013) *Ochrona i odporność kluczowych zasobów infrastruktury krytycznej*, in: M. Kopczewski, I. Grzelczak-Miłoś, M. Walachowska (ed.), *Paradygmaty badań nad bezpieczeństwem*, Zarządzanie krytyczne w teorii i praktyce, Poznań.

[11] ŚWIERSZCZ K. (2012) *Poznanie naukowe wobec problemów rozwoju gospodarczo-cywilizacyjnego*, Przedsiębiorczość i Zarządzanie, vol. XIII, issue 3, SAN, Warsaw.

[12] WOJCIECHOWSKA-FILIPEK S., MAZUREK-KUCHARSKA B. (2014) *Zarządzanie w kryzysie. Aspekty organizacyjne i psychologiczne*, CeDeWu, Warsaw.