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SYSTEMS ANALYSIS OF SECURITY MANAGEMENT AND ANALYSIS OF RISK IN CRISIS SITUATIONS

A general model of threats, systems' safety and safety management has been presented. The model of safety management is considered in terms of a duplex control over the allocation of means and security measures. The article presents also the general crisis situation model of the system caused due to the external threats' accumulation. The risk analysis has been adopted as a condition to rationalise anti-crisis situations as risk makes up an attribute of systems' activities in a dynamic uncertain environment.

Keywords: *threats; risk; modeling; systems approach.*

Introduction

A system analysis of security of any objects is sensible when danger exists, that is to say when there are threats that can cause either an interruption of functioning (existence, progress) of those objects, or a loss of certain properties thereof. Security is a ambiguous notion, regarding to: (1) lack of danger; (2) a system of institutional and non-institutional guarantees of threats' elimination or minimization; (3) one of the existing existential values, related to sense of stability, an enduring favorable state of affairs, a sense of lack of threats, confidence. In terms of political science and national (international) security related studies, both the coverage criterion (e.g. regional security, global security) and the subject criterion (military, economic, ecological, technical, cultural security) are applied. On the other hand, on the basis of system analysis, two dominant approaches exist, namely:

Security understood as an object's property, qualifying its resistance to the emergence of dangerous situations (threats), the major accent being put on the object's security failure, that is its susceptibility to real or potential threats;

Security of a system understood as its capability to protect its intrinsic values against outside threats.

We need to notice two aspects of security: the objective one, when conditions exist to create real threats, and the subjective one, which expresses the feeling of security or insecurity. In systemic studies, the relation is highlighted, between the security of systems and other system characteristics, such as e.g. stability, balance, reliability, resilience, readiness, etc, especially their effectiveness (in terms of efficiency and/or economy).

Risk, connected with uncertainty, belongs to the most common and irremovable social life dimensions (Kozielecki, 2004). Humanity from its beginnings has been dealing with crisis situations provoked by unexpected tragic events, lack of success and life failures (Konieczny, 2001). Certainly it would be difficult to prove that "crisis development" is a systemic characteristic feature of modern organisations. However, one must agree with the opinion that the crisis management ability, i.e. decision making in crisis situations, should make up an attribute of modern strategic management systems. The connection of risk and crisis management problems can be easily expressed assuming that decision making in crisis situations means the necessity to make choices of action strategies in high risk conditions.

Model of threats

A threat to the system's security is any occurrence (process, event) that is undesirable in terms of uninterrupted functioning of the system. Such occurrences or their accumulation in the given time and place, by affecting it destructively, create a threatening situation for the system's existence (development). It should also be noted that there is a possibility of creating situations dangerous to the system, caused internal threats resulting from e.g. system's failure.

System's **situation** is taken into consideration $\Sigma=\langle S,E,R\rangle$

Where: S – the system, which is the **object** of threats: $S<M,R^w>$, M – a set of elements, R^w – a set of relations between elements;

E – the environment, consisting of elements, which are the **sources** of threats; $Rz \subset SxE$ – a set of relations.

The system as an object of threats is characterized by its defensive potential (system security): $P(S)\geq 0$. The source of threats is characterized by its destructive potential: $P(e)\geq 0$, $e\in E$. Set R^z describes the **threat relation** $Rz=Rz(e.S)$, such that $eR^zS \Leftrightarrow P(e)\geq P(S)$, which means that the object is threatened by $e\in E$. The function $R^z(t)$ can be a threat relation in real time $t\in T$. The **state of threat** may be interpreted as a point on a complex Gaussian plane, described with the coordinates P(e), P(S), which means that $z=z(e.S) = (P(e),P(S))$; suppose that to every $t \in T$ we can assign a complex number $Z(t)=P(e.t)+iP(S.t)$ and then the collection of points described with the equation $z=z(t)$ may be interpreted as a trajectory of the states of threat situation.

The trajectory can go as follows:

a) If the relation Rz(t) is true for every t∈T, which means that Imz(t)≤Rez(t), then the trajectory z=z(t) is a **threat trajectory**.

b) If the relation Rz(t) is not true for every t∈T, then the trajectory z=z(t)≡b(t) is a **security trajectory**.

Between trajectory z(t) and t axis, a threat plane ∏(z(t)) can be spread, whereas between trajectory b(t) and t axis, a safety plane ∏(b(t)) can be spread. Both these planes create a whole. An analysis of this model allows us to consider threat situations in terms of R. Thom's catastrophe theory.

A system analysis of threat situations can be "scaled" according to two **criteria**:

a) Probability criterion (*security*) of emerging of a state of threat (or other measure of the possibility of threat occurrence, e.g. fuzzy measurement);

b) Importance criterion (*severity*) of the state of threat (e.g. the risk and the value of the system in question or the value of resources it disposes).

If the system S has a function of security threats z(t) assigned to it and the function of reliability is Rel(t), then the function of the systems effectiveness is:

E(t)=f(u(t),K(t)≡ϕ(z(t), Rel(t)), where U(t) – utility function, K(t) – cost (expenditure) function.

System's security model

If the threats have been recognized, then the system's security depends on equipping it with a specified resistance potential (security). In particular, it can be a particular, usually layered security system, protecting against threats.

Let us consider, as before, a given system situation Σ and assume that the data is as follows:

Outside threats A(t) coming from the system's (S) environment (E), to which a function of threat potential corresponds;

System's (S) resistance to outside threats B(t), which corresponds to the function of the defense (security) potential.

Above situation characteristics are random functions with known probability distribution:

$F(a,t)=Pr\{A(t)<a,\ a\geq 0\}$, $G(b,t)=Pr\{B(t)<b,\ b\geq 0\}$, $t\in T$

A generalized indicator of the system's security can be expressed by the probability that the threats will not exceed a given critical (permissible) point $a_0\geq 0$ and the system's resistance will be greater than a specified limit bo, which is $\beta(t)\equiv\beta(a_0,b_0)=Pr\{A(t)\leq a_0, B(t)>b_0\}$ which, in terms of statistical independence of the values in question, gives us an indicator of the system's security: $\beta(t) = F(a_0, t)\,[1 - G(b_0, t)]$.

Accepting the desirable level of system's security as $\beta_0>0$, we may say that the system is safe within time T, provided that in every moment t∈T the condition $\beta(t)\geq\beta_0$ is met.

In the case of technical objects, analyses of the object's security utilize certain simplified procedures, which boil down to determining the probability of "destruction"

$P=p(P_S\leq P_e)$, $P_e\equiv A(t)$, $P_S\equiv B(t)$,

Which means that there is a possibility of generalized resistance (bearing capacity) P_s is no larger than a generalized threat (encumbrance) P_e.

Apart from crisis situations, where national or business security is at stake, special attention is paid to crisis situations caused by extensive threats (e.g. chemical and energy disasters, weather anomalies, viral epidemics, etc.) and local threats (e.g. road accidents, building disasters, explosions, etc.). Procedures and standards are made for various types of crisis situations, setting out e.g. threat classes and threat objects' classes, severity of the threats' results, etc.

Security management

In the system analysis of security it has been assumed that the following have im-pact on the system's effectiveness:

a) System's reliability, its capability to operate smoothly (with no failure, damage, errors, etc) in the given time;

b) System's security, its capability to protect itself efficiently against the effects of outside threats.

System security management is an integral part of system management and is associated with rationalizing the choice of measures (methods, technologies) providing secure (consistent with its purpose) functioning of the system in a dangerous environment.

If there are no outside threats, then system security management can be reduced to managing over the system's reliability: we must chose such a reliability strategy, whose criterion value (function of system's reliability) is at maximum, assuming that the cost of the reliability increase (or keeping reliability on the desirable level) does not exceed the permissible limit.

If, however, threat to the system's security exists, then security management can be reduced to choosing such security strategy (means for protection against threats) from a set of permissible strategies, whose anticipated value of the effects of threats (losses) is minimal, assuming that the cost of applying this strategy (implementing security measures) does not exceed the permissible limit.

Crisis Situation

"Crisis" belongs to basic notions that cannot be replaced in the Greek language. Deriving from *krino* – meaning to divide, choose, decide, judge and also to face, argue and fight with something, crisis was to mean an inevitable solution or development. This notion showed a severe alternative, not allowing for any revision: success or failure, life or death, and ultimately salvation or condemnation. Crisis is always an evolutionary state as it is transitional. The state of crisis appears after a state that is understood as (relatively) normal. Crisis either leads to a disaster or is "dissolved" causing consequences of different nature or weight. In crisis there often arises a loss or imbalance of the loss of values necessary for "normal" system functioning, i.e. the one that favours its development.

A crisis situation is defined as such a systemic situation whose characteristic feature is the appearing

of negative (destructive) phenomena (processes, events) or their accumulation that lead to threatening the abilities of the system autonomous development (effective conducting of their basic functions).

Generally, the reasons for the crisis to appear may be divided into the following:

external, i.e. accumulated negative phenomena, the source of which is the system environment:

internal, i.e. accumulated negative phenomena, the sources of which are placed outside the system.

Taking into consideration the crisis situation from the system management point of view, the situation can be assumed to be:

the situation in which system functioning has been permanently disturbed;

the situation in which the system really or apparently lost the control (management) function;

the situation that threatens accomplishing the system strategic tasks;

the situation that breaches the dynamic functional balance of the system;

the situation that may threaten the existence of the system (disaster) or its sub-systems.

Nonetheless, analysing the crisis situation as a particular decision making situation, the following features can be attributed to it:

time of decision making – very short:

degree of predictability – very low (surprise);

level of risk – very high;

fears resulting from uncertainty – very high (fright).

Depending on the phase of crisis situation development, there may be distinguished the following anti crisis strategies:

active: anticipatory and preventive;

reactive: repulsive and eradicating.

Due to its ability to control the crisis and the degree of its intensity, there can be differentiated four basic types of crisis situations (often following each other as the subsequent stages of threat development for the system):

(1) **potential crisis** – the crisis symptoms are relatively weak, there appear signals of decreased functionality effectiveness in various areas (subsystems) of the system;

(2) **hidden crisis** – difficulties appear in effective accomplishment of the system tasks and functions, but their causes cannot be identified or their effects revealed.

(3) **acute crisis, but possible to resolve**- the effects of persisting and growing difficulties that disturb the functioning of the system can be felt;

(4) **acute crisis, impossible to resolve** – accumulation of threats and unrestrained (chaotic) development of destructive phenomena lead to losing the system stability and control, the consequence of which may be the depletion of reserves (defence potential), losing control of the environment, drastic limitation of decision making freedom.

Chart 1

Taxonomy of Crisis Situations.

Sources of Crisis	Kind of Crisis Situation	Type of Crisis
Life threatening states of the: heart, breathing, gastrology, kidney, and neurogenic background – trauma – diabetes – injuries – drowning – electrocution – hypothermia – intoxication – burns – heat stroke - frostbite	acute life threatening state	physiological
Leaving home. Getting married, Starting a job. Graduating from school. Retirement.	life, normative and development transformations	psychological
Death of a close person. Accident. Disaster. Sudden disability. Losing a job. Sudden threat in family relationships. Sudden illness.	traumatic	
Lack of resolving the transformation crisis. Lack of abilities to cope with problems. Lack of motivation to change. Resigning from responsibility. Deterioration of social relations	chronic	
Disaster. Natural calamity. Company liquidation and bankruptcy, massive lay-offs.	destabilisation of the social system function	social
Toxic leak. Disaster. Natural calamity. Equipment breakdown. Smuggling of dangerous wastes	extraordinary environmental threat, destabilisation of the ecosystem function	ecological
External sources: - changes in the conditions of the company/firm functioning – market changes in demand and sale – bad legal regulations Internal – lack of keeping balance between prices and company assets – erroneous perception of the environment and one's position in it – the lack of vision and mission for the company – not knowing the tasks by both the employees and executives. **Internal sources**: Lack of the staff identification	destabilisation of economic system function	economic

with the company. Style of managing not adapted to outer conditions. Errors in financial management. Loss of control of expenditures, stores and dues. Lack of marketing strategy. High level of individual costs. Old fashioned material and technical base. Old fashioned technologies.		
Unfavourable government activities. Civil servants' corruption. Co-operation of high state officials with foreign intelligence agencies.	destabilisation of political system	political
Terrorism. Tensions between countries that threaten a military conflict outbreak	destabilisation of political and defensive system	political and military

According to J. Konieczny (2001)

Apart from crisis situations in business (Zelek, 2003), a particular attention is paid to crisis situations caused by extensive threats (e.g. chemical and energy disasters, weather anomaly, viral epidemics etc.) and local threats (e.g. road accidents, construction accidents, explosions etc.)

Risk Analysis

Each human activity is accompanied by connected with it risk, generally understood as a possibility of appearing undesired events that threaten human life, health and environment, and also threatening a "normal" functioning of social systems (organisations) and technical systems.

The risk understood in this way makes up an immanent feature of real decision making situations when there exists a possibility to choose between alternative variants of activities, whereas for their possible consequences (both positive and negative ones) the probability values of their appearance are known. In such situations we often talk about deliberate risk. They are the subject of the decision theory.

The methods of analysing risk in crisis situations, when undeliberate risk is involved will be discussed below. It may be caused by the following sources:

constant emission of toxic substances by industrial works, air, soil and water pollution:

work environment: the state of technical equipment and devices, increased concentration of harmful substances etc.

industrial breakdowns: fires, explosions and toxic substances releases as a result of transformation, transportation and storage of dangerous materials;

urbanisation and consequently the infrastructure development as sources of threat for the environment through the contamination of ground water and air pollution by transport means etc.;

agriculture activities on a large scale (fertilisers, insect repellents and herbicides as a source of ground water, rivers and ground contamination) etc.

The most often used risk methodology include Probabilistic Safety Assessment and Quantitative Risk Assessment. In these analyses risk is described as an orderly three:

$R = (S, P, C)$

Where: S – situation scenario, usually as a sequence of events in succession; P – probability of S occurrence; C – appropriate measurement of consequences (losses) caused by S.

Chart 2

Assessment of Risk Level

Probability of Risk – Pr Category of Losses – Cl	- Little Probable – LP PZ < 0,3	Probable – P 0,3 < PZ < 0,7	Highly Probable – HP PZ > 0,7
	Degree of Risk		
Ma – Marginal	L	L	M
Cr – Critical	L	M	H
Ka – katastrofalne	M	H	H

L – Low, M – Medium, H – High

A general methodology of risk analysis in crisis situations is presented in Drawings 1, 2, and 3.

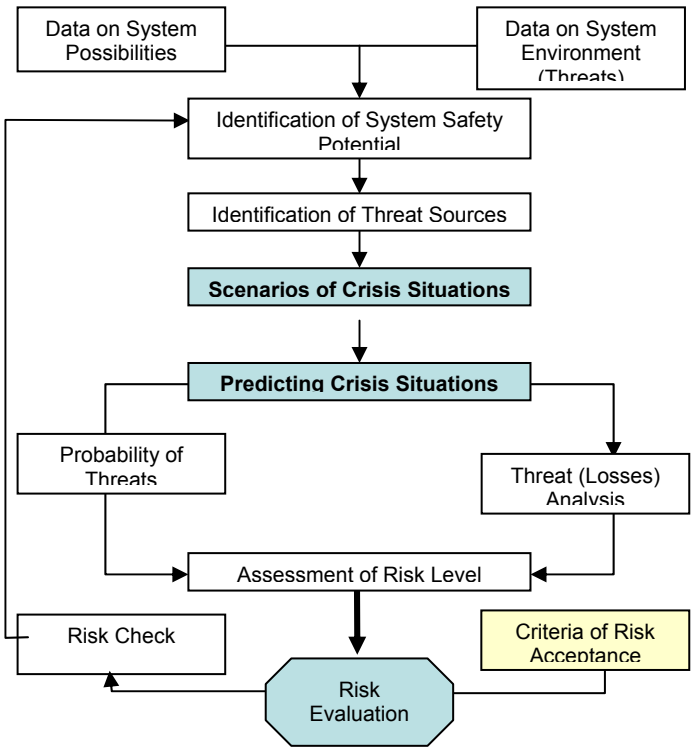

Figure 1. Model of Risk Evaluation in Crisis Situations
Source: the authors own development

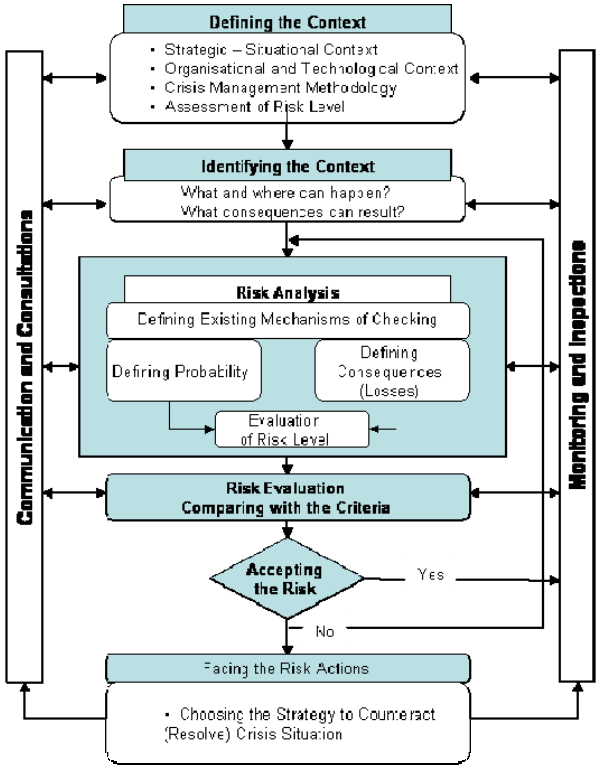

Figure 2. Model of Crisis Management.
Source: the author's own development.

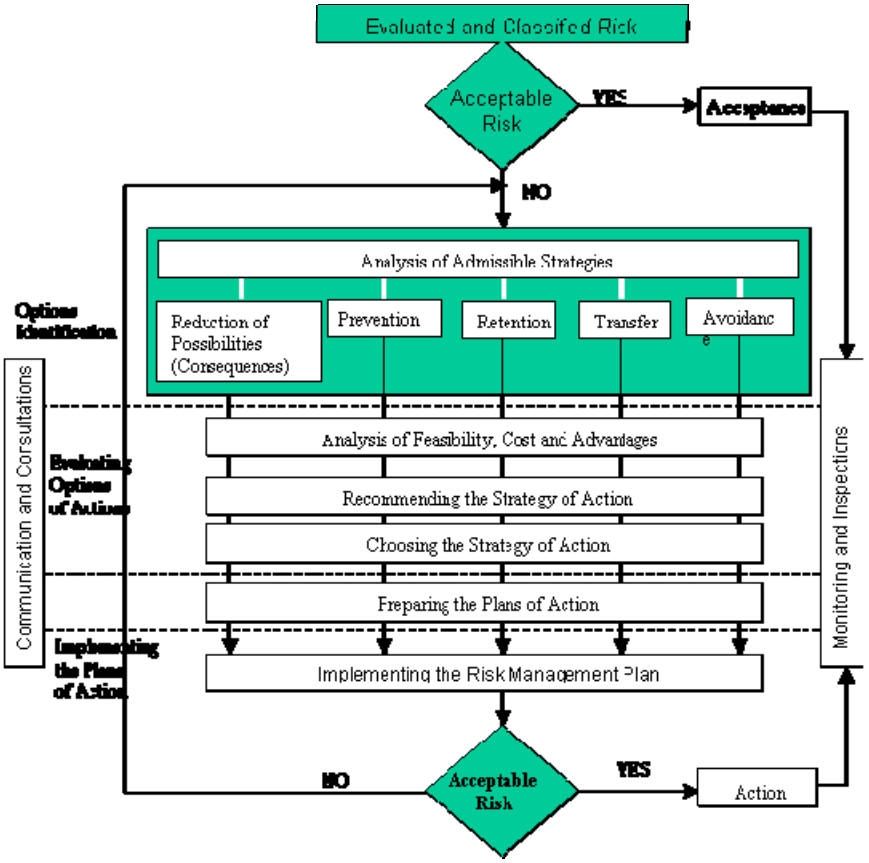

Figure 3. Process of Taking Actions towards Risk
Source: the author's own development.

The identification of threats and evaluation of risk in the process of crisis situations' prediction serves to develop the prediction of the threats' territorial arrangement, especially the risk territorial arrangement. These arrangements carried out for a particular area (e.g. commune, county or a larger area) are presented in a graphic form - **maps** of risk level and selective threats levels. They may make up useful means in the crisis management system of an appropriate state or local administration body on a given area. The risk defines the possibility of losses as a result of undesired events that may appear in a given time. The basic kinds of losses that the local or state administrations suffer, and therefore they are analysed in creating the maps of risk, are human and financial losses.

Conclusion

It should be pointed out, that both the problem of reliability management and the problem of system security management, can be reduced to the following: (1) minimizing the risk function, provided the value of effects (utility) obtained due to the functioning of the system are greater than the desirable limit or (2) maximizing the function of the system's effectiveness, provided the function of risk is no greater than the permissible ("safe") limit.

Undoubtedly the characteristic feature of modern social life is the awareness of risk that accompanies both individual decisions in a "dense" social environment and various actions organised in the world, in which largely "everything depends on everything". "The differentiation between a calculated risk and uncalculated uncertainties, between risk and its awareness have become blurred" (Beck, 2002). Crisis situations resulting from accumulation in politics and business become somehow inevitably connected with local and global expression of human activity. Controlling the risk is an imperative of all systems' rational functioning.

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СИСТЕМНИЙ АНАЛІЗ УПРАВЛІННЯ БЕЗПЕКИ І АНАЛІЗ РИЗИКУ В КРИЗОВИХ СИТУАЦІЯХ

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Була представлена загальна модель загроз, систем безпеки та управління безпекою. Модель безпеки управління розглядається з точки зору дуплексного контролю за розподілом коштів і заходів безпеки. У статті також представлена модель загальної системи ситуації кризи, викликана накопиченням зовнішніх загроз. Аналіз ризиків було прийнято як умова для раціоналізації антикризових ситуацій, так як ризик становить атрибут діяльності системи в невизначеному динамічному середовищі.

***Ключові слова:** загрози; ризик; моделювання; системний підхід.*

СИСТЕМНЫЙ АНАЛИЗ УПРАВЛЕНИЯ БЕЗОПАСНОСТИ И АНАЛИЗ РИСКА В КРИЗИСНЫХ СИТУАЦИЯХ

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Была представлена общая модель угроз, систем безопасности и управления безопасностью. Модель безопасности управления рассматривается с точки зрения дуплексного контроля за распределением средств и мер безопасности. В статье также представлена модель общей системы ситуации кризиса, вызванная накоплением внешних угроз. Анализ рисков был принят как условие для рационализации антикризисных ситуаций, так как риск составляет атрибут деятельности системы в неопределенной динамичной среде.

***Ключевые слова:** угрозы; риск; моделирование; системный подход.*

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