METHODOLOGY OF RISK ANALYSIS

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Abstract
Modern society, yet a human being existence on the Earth are connected with the nature and environment which we are trying to adapt to our needs. Such activity is associated with many risks threatening not only the environment but the existence of human being on the Earth itself. Starting from the beginning of the 21st century mankind is being affected by many crises resulting in casualties, material losses and natural damage. The society responds to crises origin by predicting consequences, planning, creating human and material resources and also by creating system theory development and crisis management experience. The paper presents general resources, principles and comments on risk problems and its system analysis.

Key words:
Definition, analysis, probability and risk management possibilities, risk system approach

1. INTRODUCTION

Present modern society connects the life quality with technologies, from which it expects by a right a risk minimization. However based on routine experience, concerns of the future emerge and the future is sometimes perceived not as a progress, but often it is referred to in terms of risks. Even some authors do not refer to the Information society or as to Knowledge society, but as to Risk society. The society lawfully expects from a state executive authority and its structures a development of mechanisms regulating risks, mitigating potential catastrophic consequences of disasters and accidents, especially in situations, when a society is jeopardized with artifacts having been produced by the society itself. A modern society cannot choose but to learn how to live with risks, therefore it wants to understand them, to predict and to analyze them, to prepare itself to them deliberately and to find its acceptable solution. In practice the risk has become a highly frequent term, as well as an object of a research and even in undertaking, in practice it is has been treated in a very authoritative, non-competent, dogmatic and self-willed way. For these reasons some information is mentioned underneath that should be respected in risk analyses.

2. A RISK IN MACRO AND MICRO FIELDS

We speak often about risk in area of macrostructure (macro environs), which can be recognized; we can define its mechanism, a rate of its occurrence and to find a symmetry as well among its results. A risk probability in a macro area relates to a mathematical expectation expressed through the Poisson distribution function

$$P(X \leq n) = \exp\{-a\}.\frac{a^n}{n}\ , \qquad (1)$$

where a …mathematical expectation (a > 1) after arrangements and simplifications, it applies a = P. n,
n …number of occurrences (events, accidents, fatal cases, injuries, individuals etc.),
P …probability of an occurrence.

A distribution function is the most important term for a description of random quantities and its properties are known: $0 \leq F(t) \leq 1$, is non-decreasing, or continuous, or it has a definite amount of points of discontinuities, a. o. Number of positive results amount n trials should range around size a. Such presumption speaks nothing about any particular implementation; it speaks only about a long-term trend. A risk in such expression represents an average value, which can be assigned to a particular entity, however, it is charged with a significant uncertainty, valid for a large amount of implementations (theoretically infinite). In an individual case then a risk is conditioned, or influenced in a subjective way. If a calculated probability is in conflict with a reality, it does not relate to a wrong calculation, but to wrong data, assumptions etc.

In addition to a risk in a macro area, there is a risk in a micro area as well, where a mechanism of occurrence generation is not known and mathematical expectation is low ($a < 1$). E.g. a probability of a null occurrence $P(0) = 0{,}9$, $P(1) = 0{,}09$ etc. The troubles then start with a reaction to consequences perceived. The reason why we use a term of a risk in a micro area is not its low probability, but a length of a time period, which can be understood as an inverse rate of a probability. As an example, a mathematical expectation of a number of injured persons from a view of a society is reasonable, in case when a time period is longer than $1/10^{-5}$ i.e. more than 100.000 years. This extremely rare case has to be taken into consideration in a micro area, e.g. during a mean active human life. A risk in a micro area is usually related to a unique event (e.g. a potential collision of the Earth with a space body a. o.), to which no practical experience (fortunately) is related to or occurrences.

3. OBJECTIVE AND SUBJECTIVE PROBABILTY

An objective probability is called a probability in accordance with its occurrence resulting from historical data and is an estimate of a real probability approaching to a truth. Law of averages is valid for a rate of occurrence, which can be simplified and interpreted so that with an increasing number of occurrences (risks, floods, tempests, fires, and earthquakes a. o.) a value of a probability is asymptotically approaching to a true value of probability. To be mathematically expressed: if any sequence of random values respects a law of averages (more accurately a teak law of averages), it means that their arithmetical average is approaching to their mean value, if a number of random values increases in arithmetical average ad infinitum. However, beware of a paradox related with a law of averages. An example: probability, that an event with an occurrence rate 10^{-6}/a year occurs 1x in 30 years (one generation) is equal to 3.10^{-5}/a year. A total probability of an event with a high frequency is calculated by a relation

$$P = 1 - (1 - 1/T)^N, \qquad (2)$$

where N … period of an object (system) lifetime,

T … repeated occurrence of a particular event in years,

1/T …an annual probability of an occurrence.

Probability, that a one hundred year flood occurs in one year is $P(1) = 0.01$ $(1/T) = 10^{-4}$ and a probability that a one-hundred year flood occurs during one hundred year is not 1, as it could seem from the first view (100 . 0,01), but it is equal only to 0,63. So $P(100) = 0{,}63$ because it applies $P = 1 - (1 - 1/100)^{100}$.

A subjective probability is a rate of conviction that an event occurs and it depends on level of knowledge and availability of information. There is a subjective probability depending on problem solutionists, whose changes are functions of changes in functions of contents of information about emergencies, risks, terms of particular occurrences and others. Scaling (scoring) of a risk relates with a subjective probability. However a scaling is only a marking of priorities and therefore it does not relate with an above mentioned objective probability, or it is closer to a subjective probability. Generally we can note, that scaling must be comparable (homogenous). Different ranges of scales within the same analysis are not correct; even though they exist in practice very often. However we can use a system of weight factors (a value analysis, e.g. a method of a sequence, points system, PATTERN, a. o) which express in a more objective way an importance of one standpoint towards the other one.

Risk analysis, computations, a. o. are surely important, however we must not overestimate them, as they are only one of tools in a future decision-making. Equally important, maybe much more important, is a physical nature of a risk, a technical analysis, impacts on lives, health, environment, costs, benefits etc. Generally a risk analyses is composed of three basic components:

- an empirical (historical data) i.e. information about issues, that had already happened in the past,
- logical (conceptual), that informs about what should be done,
- practical (operational) informs about what could be done.

4. PRINCIPLES OF AN ANALYSIS AND RISK MANAGEMENT

General principles of an analysis and risk management include:

- clear and logic distinction, identification, location, quantification and other analyses from methods and procedures of risk management, not related to separation, but clarification of links, relations, structures, etc.,
- depth of analyses, objectives, benefits, costs etc. when the decisions must be proportional to an importance of a respective solution.
- Risk assessment includes:

- Obtaining and use of all available information, data, knowledge, a. o. for assessment of risks jeopardizing lives, health, safety, material values, environment etc.,
- Qualitative and quantitative assessment using available consistent data with a predicative capability aiming to define, if and in which way a risk can be reduced,
- All risks, having a direct or in-direct effect on a menace to a human being, his/her health, property, environment are to be systematically included into an analysis etc.,
- To state explicitly all assumptions, uncertainties, starting points etc. and their effect on risk assessment,
- Analysis of risks should be subject to a professional (expert) supervision so a high standard is guaranteed a. o.

Principles of risk management:

- The decisions taken must result from a thorough analysis of a risk distribution, analysis of benefits and costs related to measures taken, when measures should include regulation mechanisms (offers, limits a. o.),
- Measures aiming to reduce risks should include analysis of a life quality, preferences, elements of justice, distribution of benefits and costs,
- Criteria of assessment must be known in advance and routinely managed aiming to assess the decisions, measures, management (risk management strategy).

Priorities in risk analysis:

- Classification of risks in categories e.g. non-significant, significant, catastrophic a. o. all in context of menace to population, environment, property or defined uncertainties,
- Respecting the impacts on lives, health, environment, property, benefits and costs a. o.

Practical conclusions, recommendations and generalization of an experience:

- A term of a risk is only a certain indicator, which cannot completely reflect a whole real system and therefore it is needed to assess it from different points of view. For example from a view of an addressee, effect and impact of a risk, i.e. social groups (a population as a whole, the citizens of a town, district, a house, passengers a.o.), professional groups (employees, businessmen, housewives, teachers, workers a.o.), environs (company, town, river basin, a.o.), property (of bank, insurance agency clients, a.o.). From a point of view of a risk source, it relates e.g. a risk of an organization (a shop, a plant, a factory, a company, a corporate etc.), management (with economic, psychological, organizational, legal, social, political, mathematical aspects etc.), transportation (a road, railway, vessel, aviation, combined etc.), technology (chemistry, nuclear power, mechanical engineering, textile industry, agriculture a.o.) etc. In practice there are physical, social, financial, operational risks etc.
- A risk as a probability is expressed with a figure fascinates people and at the same time it can fully distort a perception of relations. We can hardly reach at a routine experience with a low probability of a risk from a social point. For example an entry $1/10^6$ on a time axis means only 30 seconds/year. Therefore it is recommended to use a certain rate of analogy, to express such date graphically etc.
- Occurrence probability and consequences of emergencies are to be evaluated completely separately. Occurrence and significance of such consequences are often uncertain and doubtful, therefore we should separately define a risk of occurrence and a risk of relevance globally, and not through a single summary, giving a basic perception about a total risk of a particular event. At the same time we need to be aware of difficulties resulting from two utmost options, namely from an event with a high rate and a low importance and on contrary with a low rate of occurrence and high level of consequences.
- Qualitative approach to a risk should result from an analysis, what can be measured, regardless importance of an analyzed value. If we are successful in measuring the importance and at the same time through a measurable value we can obtain important complex information enabling us a real practical application.
- Qualitative approach to a risk, based on descriptive (linguistic) values with relative importance could relate only with a possibility of occurrence, description how high the high risk is, it can compare various high risks, which are differences between high, medium and low risks etc.
- A qualitative approach in defining a risk in complicated situations, then there is no mutual explicit display between areas of elements (values) and areas of classes of elements (risks) and their corresponding areas of states can be used with an advantage with existing methods, enabling to work with uncertain data, linguistic variables a. o. It relates with methods of artificial intelligence: in particular e.g. application of expert systems with neuron network and a multiple value so called „fuzzy" logics. Such logic is featured by more than two probability values in interval $<0, 1>$, where a statement in fuzzy logic can be partially true, or false and a value is given by a so called level of reference. The fuzzy logic relates to a term of a linguistic logic, or a linguistic (language) variable, whose values are words, so called terms. Whereby a level of reference cannot be replaced by a value of a probability. A risk probability is calculated based on statistical data, a level of reference is estimated based on

experience of expert(s) using a linguistic expression capability in describing an uncertainty of a risk event.

- If there is no experience with a risk occurrence, the risk probability and its consequences can be assessed through a sequence of events – an event tree. In doing so we must remember a difference between an occurrence (number of events/a time unit) and a probability (number of positive events /total number of cases).
- It is important to strictly differentiate an issue expressed through data of 10^{-5} type that is no actual risk but a statistical upper limit of possibilities that a risk could occur. Power of a ten leads to a trust, that the risks reduced by an order or two orders is only a multiple of ten. For example a risk reduced from 10^{-3} to 10^{-4} means, that a risk reduces by 90 %. A subsequent reduction from 10^{-4} to 10^{-5} is 10 x smaller it means 9 %. Therefore it is recommended to express a risk graphically as well.

5. CONCLUSION

Instead of conclusion, I would mention some recommendations (a decalogue) for a risk management, or to mitigate the risk consequence, which is an analogue of an admirable risky sport, namely mountaineering, where I immodestly suppose, that the mentioned recommendations are universal ones and they can be applied in practice:

1. Let´s try to reduce a height of a possible fall (let´s create a life-net in advance, let´s find some clues, safety zones etc.),
2. Let´s extend the option of a free movement (maximum room for decision-taking etc.),
3. Let´s choose successive risks (preferably smaller actions with a risk distribution),
4. Let´s have our evasive maneuvers ready (crisis planning, emergency scenarios, emergency plans etc.),
5. Let´s minimize risk windows (a minimum period of a risk action),
6. Let ´s test a risk on a model (testing of procedures, methodologies, actions etc.),
7. Let´s avoid extrapolations (it misguides the heuristic supporters to conviction, that the last procedure was safe, because nothing happened but the contrary may be true),
8. Let´s minimize risk factors (each change means a risk, therefore do not combine several risks at the same time),
9. Let´s carefully study the history (last procedures and faults, let ´s take lessons from the past),
10. Let´s assess the risks in relation to the possible decision adjustment (decisions must be adjusted if a risk is present, even strategic decisions, decisions made by superiors etc.).

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