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Risk as one of the properties of decisions taken under uncertainty

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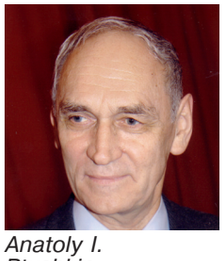

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Abstract. Aim. *The variety of activity types and the corresponding unfavorable outcomes has led to a dramatic diversity in terminology interpretations of the concepts related to risk, including ones in regulatory documents. This circumstance contradicts the primary purpose of the scientific and technical terminology standardization, which is the establishment of unambiguous and non-contradictory terminology in all types of documentation involved in the standardization activities or using the results of such activities. Given the above, this paper aims to estimate the conformity of the definitions of the concept of "risk" in the set of risk management standards with the requirements of the regulatory documents of the Russian standardization system and development of proposals regarding a new interpretation of this concept.* **Methods.** *The need for updating the existing definitions of risk and developing a definition complying with all the requirements of the regulatory documents of the Russian standardization system was based on the methods of terminological, logical-semantic and system analysis.* **Results.** *An analysis of compliance of the existing definitions of the term "risk" with the requirements of the Russian standardization system has been conducted and revealed that none of them fully meets such requirements, therefore the interpretation of the concept of "risk" requires a revision. The paper substantiates the interpretation of risk as one of the properties of the quality of a decision made in situations of uncertainty. This property characterizes the possibility and consequences of not achieving the goal of human activities in the situation of decision-making regarding the selection of further actions under uncertainty. Hence is given the following new definition of the term risk, i.e. one of the properties of the quality of a decision made in a situation of uncertainty that characterizes the possibility and consequences of not achieving the stated goals. The advantages of the proposed interpretation of risk over the existing definitions have been considered.* **Conclusions.** *The paper proposes and substantiates a new definition of the term "risk" that can be considered preferable over the existing versions. The proposed definition is based on most important concepts in terms of the theory and practice of management, i.e. "property", "quality", "decision", "situation", "goals" that are among the basic categories of human knowledge. This enables the use of both the existing quantitative characteristics of risk and the extension of the system of substantiated characteristics of risk, including those borrowed from the toolboxes of assessment of the manifestation rate of various objects' properties adopted in other domains of science. The authors show such special features of the proposed interpretation of risk as complexity, situation awareness and goal orientation. The complex and goal-oriented nature of risk prompts to consider actual capabilities to achieve the target characteristics of safety, performance, resource intensity and timeliness of reaching the specified goals of activities. The situational nature of risk as a property of a decision in a specific situation prompts the examination of the entirety of the associated contributing properties of the situation, i.e. the composition of the objects and subjects of human activity, as well as the conditions and circumstances that create specific relations between them. This approach significantly improves the precision of identification of the inventory and nature of the risk factors and therefore expands choices of risk management means and methods.*

Keywords: *term, risk, property, quality, situation, uncertainty of outcome, administrative decision, failure to achieve goal, characteristics, indicators.*

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Introduction

For a long time, the concept of risk has been associated with the possibility of some unfavorable (undesirable) outcome of a certain activity in the context of incomplete information about its further course. Such outcome could be damage or conflict of some kind (material or economic damage, damage to life or health of people and animals, environmental damage, political conflict, etc.). Risk assessment is mandatory for justifying nearly all important decisions.

When it comes to risk, the variety of activity types and the corresponding unfavorable outcomes has led to a dramatic diversity in terminology interpretations, including ones in regulatory documents (RD). This contradicts the primary purpose of the scientific and technical terminology standardization [1], i.e. the establishment of unambiguous and non-contradictory terminology in all types of documentation involved in the standardization activities or using the results of such activities.

Hence, one of the main tasks of scientific and technical terminology standardization is the analysis, identification and correction of the terminology shortcomings, most notably in national standards. The importance of this research area has long been emphasized in the works of prominent specialists in such knowledge-intensive, energy-intensive and risk-sensitive branches as nuclear and radiation safety [2], dependability and safety of structurally complex systems [3, 4], dependability and safety of pneumohydraulic components of space rocket systems [5], etc. The significance of this problem is most evidently expressed in [2]: "… our whole life largely depends on the clarity of regulatory documents… The clarity of terminology is the basis of both the scientific problems formulation and the regulatory laws adoption". The relevance of this task in terms of the research od substantial interpretation of such important concepts as dependability, safety and risk is being confirmed by a number of recent publications of a terminological nature, for example [6, 7, 8].

This paper aims to estimate the conformity of the definitions of the concept of "risk" in the set of risk management standards with the requirements of the regulatory documents of the Russian standardization system and to develop proposals regarding a new interpretation of this concept.

1. Subject and aim of the requirements of the Russian standardization system analysis

To make the following provisions more constructive and specific we shall narrow down the considered subject matter by restricting it to the following two conditions:

- instead of individual GOST standards the analysis will cover the set of existing "risk management" standards with practically identical subjects of standardization and application areas. This set currently includes over 25 standards! However, not all the standards in this set contain definitions of risk, so only those document where such definitions are given [10-24] are analyzed;

- the analysis is carried out in order to estimate the conformity of the terminological provisions in the considered set of standards with the requirements of the regulatory documents of the Russian standardization system. To achieve this goal, the following three questions should be answered.

Firstly, how justified is the above diversity of views on the concept of "risk"? The most logical explanation could be a significant dependence of the definitions on the characteristics of the activity types. Therefore, the first thing that needs to be clarified is whether the existing definitions of risk depend on the specifics of a particular activity.

Secondly, if the analysis of the first question reveals that the existing definitions of risk are activity invariant, then the next question arises: is there, among many existing definitions, one that best meets the requirements of the standardization system RD and therefore can be used (recommended) as a universal, generally accepted definition of risk?

And thirdly, if the answer to both previous questions is negative, the last question arises: what definition of risk can be proposed as acceptable in terms of conformity with the requirements of the standardization system RD?

The following subsections of the article are devoted to finding answers to these questions and developing the corresponding proposals.

2. Review of existing definitions of the term "risk" in the current standards

The analysis of the above set of documents [10-24] showed that there are mainly three definitions of risk:

- risk is the probability of causing harm to the life or health of citizens, property, the environment, etc. subject to the severity of this harm [10]. In [11], the definition is almost identical with the difference being that it proposes a qualitative measure of the possible severity of harm in addition to the quantitative measure;

- risk is the combination of the probability of hazardous event and its harm [12-21];

- risk is the effect of uncertainty on objectives [22-24].

The definitions from the science and technical publications where the risk is understood as a hazardous (undesirable) event, measure of danger, taking pot luck, loss of opportunity etc. can be added to these definitions of risk in RD. These and other definitions are followed by lengthy risk classifications by a variety of different attributes, for example, by hazard type (technology-related, natural, etc.), by field (financial, economic, ecological risks, etc.), by consequence scale (high, moderate, low, critical, catastrophic, etc.). Unfortunately, neither these definitions and classifications nor the names, functions and properties of risks listed in them clarify the essence of the concept itself leaving the question open.

The answer to the first of the questions follows from the above definitions of risk, namely *the existing definitions of risks in RD and scientific and technical literature are*

rather general and are not related to the characteristics of a particular activity. Therefore the existing diversity of these definitions in RD can hardly be considered useful for theory and practice.

3. Analysis of compliance of the existing definitions of the terms "risk" with the requirements of the Russian standardization system

The primary, guiding principle of the Russian standardization system RD [25-29] is the unambiguousness of the requirements included in the standardization documents [26]. To implement this principle, a set of basic requirements of this system should be met. Table 1 shows a summary of those requirements.

Table 1. Requirements of the standardization system regulatory documents for the generation of terms and their definitions

№	Requirement content
1	One designation (i.e. term, symbol or name) shall correspond to one concept, and only one concept shall correspond to one designation
2	One term shall not be used for many concepts and many terms shall not be used for one concept
3	Terminological entries in closely related standards shall not be contradictive
4	A term shall show the limiting characteristics of the concept expressed
5	A term shall maintain the usual form of expression established in the speech community
6	A term shall correspond to the morphological, morphosyntactic and phonological norms of the language
7	Native language shall be prioritized
8	A term definition shall be a single phrase defining the concept and, if possible, reflecting its position in the system of concepts

Note that the requirements 4 to 6 in Table 1 apply not only to terms, but also to their definitions. The first thing to observe when analyzing the listed requirements is that the aforementioned definitions of risk have different concepts for the same term, which contradicts requirements 1 and 2. Moreover, there is a contradiction between the first two and the third interpretation of risk. Indeed, in the former case the risk appears as a measure, and in the latter as a certain effect of uncertainty, which can be interpreted as you please: numerically, qualitatively, with verbal constructs, etc., which does not comply with requirement 3.

Speaking of each definition of risk separately, the third interpretation is the most arguable, since although it is present in harmonized terminological standards [22, 23], it does not meet the requirements 4 to 6.

The last requirement in the table can be best met by using intensional definitions [29]. The basic part of the intensional definition defines the superordinate concept that includes the concept in question, and the second part specifies the limiting characteristics that differentiate this concept from its peer concepts. At this point the shortcomings of the most common definitions of the concept of "risk" that are the first two interpretations should be mentioned. Unfortunately, they don't use intensional definition with the corresponding basic part and limiting characteristics, but simply identify risk with its measure (as already mentioned above), i.e. with one of the possible numerical characteristics, which is a confusion of different semantic categories and contradicts requirement 8. In addition, replacing the semantic interpretation with a numerical characteristic (indicator) contradicts other standards of the "risk management" set (see, for example, [20, 21]), that mention such indicators as risk index and risk severity index that are similar in meaning to the mentioned risk interpretations, but describe the level of risk, not the risk itself.

Thus, *the analysis of existing risk definitions has shown that they are far from fully complying with the basic principles and requirements of the Russian standardization system. Hence the conclusion that the concept of "risk" requires revising*, and that is what the next subsection of this article is devoted to.

3. Proposed interpretation of the concept of "risk" that complies with the requirements of the Russian standardization system

First of all, it should be noted that in the existing scientific and technical publications, much less in the RD, no substantiation of the above risk definitions could be found. In almost all cases, they are simply postulated, often with numerous notes supplementing the proposed definition with its possible interpretations (see, for example, [22-24]). The undesirability of this approach is illustrated above.

The substantiation of the interpretation of the term "risk" can be based on terminological, logical-semantic and system analysis methods and is as follows.

Human experience shows that the concept of "risk", whatever the understanding, is nearly always associated with the situation of decision-making under uncertainty. This situation is about making a choice among a set of alternatives when the information on the possibility and nature of the decision consequences is insufficient. This situation is most typical for management decisions that are made with lacking initial information. Such close relation between risk and management decisions allows us using some findings of the management theory widely covered in management-related literature.

One of the central concepts in this theory is the quality of managerial decisions, that by analogy with the widely

accepted interpretation of product quality in [32], means (see, for example, [30, 31]) a set of decision properties (characteristics, parameters) that fulfil a certain function in the management process and satisfy a specific consumer. The indispensable attributes of decision-making under uncertainty are the possibility and consequences of not achieving this decision's goals.

What remains to say is that management decision quality should be measured, it is therefore impractical to conceptually deviate from the recommendations of qualimetry, a scientific discipline that concerns the methods and problems of quantification of the quality of any object, according to which quality is a combination of properties of an object that a person deals with in practical activities.

As a result, it seems logical and reasonable to include the decision riskiness (risk) into the set of such properties. It is the property that characterizes the possibility and consequences of not achieving the goals of a human activity when making a decision under uncertainty. Then the following final definition of the term "risk" can be proposed:

Risk (riskiness) is one of the properties of the quality of a decision made in a situation of uncertainty that characterizes the possibility and consequences of not achieving the stated goals.

At the same time, when conducting a scenario analysis of a situation, the entire potential semantics of the possible outcomes (positive, negative, neutral, etc.) should be taken into consideration.

Briefly summarizing, the main system features of the proposed definition are as follows. Firstly, it interprets risk not as a measure, but as a certain attribute of a decision being made, namely, its property. Secondly, risk as a property is a component of the quality of this decision being a kind of management act. Thirdly, risk as a decision property in goal-oriented processes is complex. Indeed, any human activity is associated with the need to achieve at least four goals: ensuring the required safety, performance, resource-intensiveness and timeliness characteristics. The multi-objective nature of this activity requires risk to be considered as a complex property, which includes properties that characterize the possibility and consequences of actual goal achievement values not meeting the required values. Table 2 shows examples of not achieving these goals in technical areas.

Finally, the fourth feature of the given risk definition is its situational nature, dependency on the decision-making situation, i.e. the composition of objects and subjects of human activity, the conditions and circumstances that create a certain relationship between them.

It should be noted that decision-making should be preceded by a set of preparatory procedures, including, for example, forecasting the possible consequences of catastrophic climatic and natural phenomena. Based on the results of such procedures, a decision should be made on the nature and sequence of further actions to achieve the goal.

Table 2. Examples of not achieving activity goals

Goals	Examples
Provision of safety	Death of personnel or citizen, harm to health of personnel or citizens, equipment or property of citizens, the environment
Performance	Failure to achieve the required values of product quality indicator, failure to perform the task
Achievement of the required result with the allocated resources	Excessive consumption of allocated resources (material, financial etc.)
Timely achievement of the required result	Delays in completion of works at various stages of achieving the result

Conclusions

The above substantiation and features of the proposed interpretation of risk suggest the following advantages over the existing definitions.

1. First of all, this definition is free from the shortcomings of the existing definitions and meets all the requirements of the Russian standardization system. Therefore, the proposed definition of risk can be considered preferable over the existing ones, that, as the article shows, do not meet the requirements of this system.

2. The proposed definition is based on the most important concepts in terms of the theory and practice of management, i.e. "decision", "property", "quality", "goal", "situation" that are among the basic categories of human knowledge and largely define the differentiation of sciences. Risk as a property, as an aspect of quality has a certain intensity, i.e. it can be "major" or "minor", "high" or "low", "acceptable" or "unacceptable", etc. This enables the extension of the system of substantiated characteristics of risk, both qualitative and quantitative. For example, interpreting risk as of one the properties of quality enables the use of methodology for assessing the manifestation rate of various objects' properties adopted in other domains of science, including qualimetry, dependability theory, game theory, operations research, etc. For instance, following a well-developed conceptual framework of such important technical property as dependability [33], the most well-established and proven terms and concepts can be borrowed from this domain. In particular, risk as a complex property can be differentiated into a number of its particular properties. At the same time, risk as a property of a human decision is objective in nature, although its estimation may also have signs of subjectivity, and rightly so.

3. The proposed interpretation of risk does not cancel, but allows the use of the existing risk characteristics that can be found in literature, such as probability of a risk realization scenario, extent of damage (harm), their combination, risk level, risk index [20, 21], etc. Numerous classifications of risk by type of activity and other characteristics, consider-

ing the stages and phases of risk requirements development, risk analysis and risk management, etc., i.e. the whole set of tools of research of risk as a full-fledged scientific category, remain in force.

4. The "decision situation" featured in the risk definition prompts the examination of the entirety of the associated contributing properties of the situation when choosing and considering risk characteristics. Therefore, the analysis of all undesirable event scenarios (scenario analysis) of this and other potential situations that may arise from implementing the decision should be an essential component of risk assessment. This approach significantly increases the precision of identifying the inventory and nature of the risk factors and therefore extends the options of risk management means and methods:

5. This goal-oriented interpretation of risk directly implies a number of important requirements to the management activities organization including:

- any management decision should be goal-oriented, i.e. it should include the estimation of the characteristics of the possibility and consequences of not achieving the decision goals;
- generation of decision requires combined consideration of mutual influence of risk components related to all the decision goals;
- to improve the quality of coordination of the interests of the parties involved in the decision implementation and the use of allocated resources, the whole range of institutional relationships among them should be taken into account;
- to improve the precision of identification of the inventory and nature of the risk factors and to extend the options of risk management means and methods, the whole set of situational characteristics should be considered when developing alternative solutions.

In conclusion, it should be mentioned that the term "risk" is widely used in various domains and therefore requires close attention of all stakeholders. The authors are convinced that the proposed interpretation of risk as a property of the quality of a decision made in situation of uncertainty is productive in terms of the risk management theory development. However, they are well aware that the proposed definition and its justification are not flawless, and therefore their constructive criticism as part of the corresponding discussion could be useful.

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