

The Definition of Risk and Associated Terminology for Risk Analysis^a

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INTRODUCTION

The broad field encompassing risk analysis through risk management involves a large number of different disciplines. The terminology used within the field has not been consistent. An attempt to create a set of definitions for use by the SRA was initiated by the formation of a committee on definitions. Initially, it was assumed that it would be easy to reach a consensus on the more commonly used terms. This assumption proved false. After about two years it was realized that a consensus was not being reached for the key definitions of risk, hazard, risk analysis and risk assessment. The Committee decided that rather than trying to establish "official" SRA definitions of these terms, it would recognize that different definitions are in use and prepare a discussion paper of different definitions. This process was started with emphasis on the single term "risk."

BACKGROUND

It is the hope of the Committee that this effort will produce a broader understanding and appreciation of the differences in the way risk terminology is used and encourage broader-based discussions among a more uniform usage. In the meanwhile, authors should clearly define how they use risk terms so as to avoid confusion.

The problem of consistent terminology for use by risk analysts has become a greater issue as more practitioners with different areas of expertise contribute their results to this expanding field. The National Research Council,¹ in its report on *Risk assessment in the Federal Government: Managing the Process*, addressed the problem of terminology. The report indicated that "despite the fact that risk assessment has become a subject that has been extensively discussed in recent years, no standard definitions have evolved, and the same concepts are encountered under different names." The authors of this NRC report spent a considerable initial effort on definitions and consequently adopted their own terminology for the reported study.

a. This paper was prepared as a discussion document for use in a special session at the 1987 Annual Meeting of The Society for Risk Analysis.

Gratt's 1985 review of terminology indicated that the terms "risk assessment" and "risk analysis" had been used in various ways and the need for a consistent set of definitions for use by practitioners in the field.² This resulted in a Committee for Definitions for the Society of Risk Analysis to address this problem. This paper will present some proposed definitions of risk for further consideration.

DEFINITIONS

The problem of defining the terminology used by risk analysts was indicated by the National Research Council which sought to clarify the differences between "risk assessment" and "risk management."¹ "Risk assessment" was defined as the qualitative or quantitative characterization of the potential health effects of particular substances on individuals or populations, and "risk management" as the process of evaluating alternative regulatory options and selecting among them. The NRC report made no attempt to define exactly what is "risk" or "risk analysis." As a result, the NRC was able to avoid the terminology controversy and provide widely accepted definitions.

Gratt,² attempted to synthesize definitions of all three terms. Gratt's proposed definitions were as follows:

- *Risk* is the potential for realization of unwanted, adverse consequences to human life, health, property, or the environment; estimation of risk is usually based on the expected value of the conditional probability of the event occurring times the expected consequence of the event given that has occurred.
- *Risk analysis* is defined as a detailed examination performed to understand the nature of unwanted, negative consequences to human life, health, property, or the environment; an analytical process to provide information regarding undesirable events; the process of quantification of the probabilities and expected consequences for identified risks.
- *Risk assessment* is the process, including both risk analysis and risk management alternatives, of establishing information regarding acceptable levels of that risk for an individual, group, society, or the environment.

These definitions view analysis as more restrictive than assessment: assessment includes analysis and judgment. Also, analysis is the scientific objective process of risk estimation; assessment is the combination of the objective analysis with subjective considerations. These definitions were based on common usage where analysis refers to the separation of a whole into its component parts (also an examination of a complex, its elements and their relationships) and where assessment is the act of determining a value. Opposing points of view state that analysis is the all-encompassing process that includes assessment.

SUMMARY OF POSITIONS

Gratt received numerous responses to his proposed definitions. Most of the replies stressed the fact that creating widely accepted definitions is a difficult problem. Many of these responses disagreed with Gratt's definitions of risk, risk analysis and risk assessment. The majority disagreed with his position that assessment is a much broader term than analysis.

There is a similar disagreement in the literature. Lawless, *et al.*, agrees with the choice of assessment as the broader term.³ On the other hand, other authors have made the

opposite choice. These include the authors of a DOD handbook called *Risk Assessment Techniques*.⁴

At this point, the Committee for Definitions met in conjunction with the 1985 Annual meeting and decided to focus efforts on a consensus definition of "risk." An attempt has been made to summarize some of the responses to the definition of risk. Fritz Seiler expressed his dissatisfaction with Gratt's proposed definition of "risk." He felt that this definition was neither concise nor disjunctive enough to be effective. He also disagrees with the "non-mathematical" approach Gratt had taken, saying that it possibly "obscured things more than it ought to." He continues to say that the main problem of the current definition is that it fails to admit that a risk is a probability. Seiler then states that since the "probability of occurrence is the product of the probability of the occurrence of the cause...multiplied by the conditional probability of the event...Both of these factors are really risks, so that the product is a composite quantity...[allowing] us to use a simpler definition of risk...The definition of the basic quantity 'risk,' however, has now been shifted to the lower level of a conditional probability for the occurrence of one single 'untoward' event, given that a series of other events has occurred. In my opinion, this is the simplest and most basic definition you can give."

Paul Slovic heartily agreed with the old definition of "risk," but not with the risk analysis/assessment definitions. He believes that risk analysis is the broader of the two ideas, and that assessment is just a part of analysis.

The suggestion of Edmund Crouch includes simple, curt definitions. He dislikes all of the (negative) qualifiers and adjectives, and he stresses the idea that "risk" must be defined quantitatively. For "risk," he suggests the following definition: An quantitative measure of the realization of a hazard. The related definition of "hazard" is: A condition with the potential of causing a consequence. For the risk analysis definition, Crouch again omits the negative qualifications as well as the "human life, health and property" phrase, saying "we might be interested in the effects of something on the duck population." He comments that the key work of the definition should be "hazards" instead of "risks." He then introduces a new idea---that "hazard analysis" should be introduced as the identification of hazards, and that "risk analysis" be replaced by "hazard assessment." Crouch states that risk assessment should not "contain judgments on what is or is not acceptable." He sums up "risk analysis" as "the process of breaking down and looking at all the pieces (the analysis), in order to find out how your risk measure depends on all the bits." He defines "risk assessment" as a "synthesis, taking account of how the bits are all related, and the uncertainty, etc., to predict the risk measure for the whole." He also states that risk management should not be considered a part of risk assessment, "except insofar as it is desirable to perform the synthesis in such a way as to be compatible with what it is going to be used for---possibly risk management."

Chris Whipple from EPRI commented that he prefers "risk analysis" as the broader field, "and 'risk assessment' as the more technical part." He then adds, however, that he has seen the terms used interchangeably, and that "based on the actual meaning of analysis and assessment, I agree that your definitions make a bit more sense."

Jeffery Roseman commented that he felt "the possibility of loss..." does not necessarily suggest something of "a probabilistic nature... Whether reality is basically probabilistic or deterministic is still a metaphysical question," he says. "The statement that an outcome is 'possible' may merely reflect human 'ignorance' of an essentially determined outcome rather than a probabilistic one."

Commenting on the definition, Lee Abramson stresses the importance of the specific severity of risk. He also states that the best way to represent a risk is in the form of a distribution which reflects the cause and accounts for the effect and the severity. He states

his definition of risk as "a probability distribution over all possible consequences of specific cause which can have an adverse effect on human health, property, or the environment."

Later, the Committee arrived at a proposed definition for risk:

Risk is the probability of an adverse effect to human health, property and the environment and the severity thereof.

After the committee meeting, the definition was mailed to meeting participants and widespread rejection was received. Summarizing some of the comments on this definition it is useful to quote Ed Lawless, who found this definition inappropriate for several reasons. "First, the probability of adverse effects may not be the same for all items as implied." He states that "the probability of the severity is unclear, but is unlikely to be the same as the 'probability of an effect' in the first part of the definition." Lawless believes that the measure of interval must be included to make a quantitative statement of risk meaningful. His proposed definition is as follows: "Risk is a statement of the probability (or a qualitative expression of the uncertain potential) of incurring a specified adverse consequence during some stated measure of interval (e.g., time, distance, number of events, etc.)."

The Committee for Definitions met again in conjunction with the 1986 SRA Annual meeting. The problem of "seeming to get a consensus which falls apart upon reflection" was discussed. At that time, the Committee decided to assemble the favored definitions of risk and submit them to the SRA membership through the newsletter for comments, discussion and possible consensus by the whole Society.

The process of standardization of general use terminology may not be possible. Rayner and Cantor give the equation: $\text{Risk} = (\text{Probability} \times \text{Magnitude})/\text{Time}$. They state that "however and wherever it is discussed, it seems that there is a consensus that the essence of risk consists of the probability of an adverse event and the magnitude of its consequences."⁵ The problem with this definition is that the formula defines risk as a probability rate, whereas the statement defines it as a probability.

Sam Morris says that "risk is the product of the probability of an adverse event times the consequence of that event were it to occur (dimensions units of consequence \times time...)." These definitions go along with Seiler in that they are mathematical in nature. They are, however, more direct than Seiler's definition, and thus possibly simplified past the point of usefulness.

According to Cauncey Starr, "Risk is a measure of the exposure to a loss arising from an activity, with the usual descriptives of what, when, who and how much. The ambiguities associated with this simple definition arise from the variety of the losses that may be incurred,...the time period used for the probability statement,...the population exposed...and the uncertainty of the probability estimate." Starr states that risk calculation must consider the probability of an event, the magnitude of this event, and the resulting magnitude of the loss. Starr emphasizes the fact that a risk is neither only a probability nor only an end result, but a synthesis of the two in a certain time period and for a certain population. Starr also stated that assessment is a subset of analysis, and suggests a reversal in "the terminology...This would be consistent with the title of our Society of Risk Analysis and our journal."

Seiler states: "The problems that we encounter seem to root in the ambitious attempt to define the unqualified term 'risk.' In view of the wide diversity of phenomena considered, 'risk' can just mean to many things. However, these problems disappear as soon as we put this quantity in the proper context, something we almost always do or should do. As an example, the lifetime risk of lung cancer as a consequence of an

exposure, or the risk of a loss within the next 5 years of 100 million dollars due to environmental damages are quantities which are clearly and unambiguously defined. The dependence on the time interval, the severity of the event or on any other parameters is thus relegated to the definition of the adverse event and the risk can quite generally be defined as a simple conditional probability."

Roseman has offered a categorization of risk definitions: non-probabilistic, probability of specified outcome with/without time specified, probability of specified outcome and a function of the consequences of the outcome with/without time specified, and "as a function of uncertainty." He believes this categorization indicates how many fundamentally different definitions of risk are of concern. Since the different fields which make up the Society use different definitions, Roseman feels "no single definition will satisfy all." He suggests the best approach is not to decide on one single definition for "risk," but to make it clear how many different definitions exist and, stressing the multidisciplinary nature of risk assessment, the use of "risk" along with its explicit definition.

Clearly there is a considerable disagreement on the most basic terms. Apparently, risk analysts know what they do, but can't agree on what to call it!

DEFINITIONS

Selected definitions of risk are listed below for consideration by the Society.

1. *Risk* is possibility of loss, injury, disadvantage or destruction; to expose to hazard or danger; to incur risk or danger.
2. *Risk* is an expression of possible loss over a specified period of time or number of operational cycles.
3. *Risk* (consequence/unit time) = Frequency (events/unit time) \times Magnitude (consequence/event).
4. *Risk* is a measure of the probability and severity of adverse effects.
5. *Risk* is the conditional probability of an adverse event (given that the causative events necessary have occurred).
6. *Risk* is the potential for unwanted negative consequences of an event or activity.
7. *Risk* is the probability that a substance will produce harm under specified conditions.
8. *Risk* is the probability of loss or injury to people and property.
9. *Risk* is the potential for realization of unwanted, negative consequences to human life, health, or the environment.
10. *Risk* is the product for a probability of an adverse event time the consequences of that event were it to occur (dimensions of consequence \times time).
11. *Risk* is a function of two major factors: (a) the probability that an event, or series of events of various magnitudes, will occur, and (b) the consequences of the event(s).

12. *Risk* is a probability distribution over all possible consequences of a specific cause which can have an adverse effect on human health, property or the environment.
13. *Risk* is a measure of the occurrence and severity of an adverse effect to health, property or the environment.
14. *Risk* .. [write in your own favorite]..

RECOMMENDATIONS

The next step in an attempt to arrive at a consensus is to have an open discussion of the above definitions and a vote. At this time, the consensus may be to have a set of fundamentally different definitions. Gratt will chair at a special session during the annual meeting to address this topic. Committee members will present short arguments in favor of their favorite definition or contrary opinions. Comments on the definitions and alternate definitions will be solicited from the floor. If appropriate, a vote can be taken so that opinions can be recorded. Recommendations for work on further terminology on behalf of the SRA membership will be solicited.

REFERENCES

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