November 5, 2017

Risk Analysis: Fundamental Principles

The Society for Risk Analysis (SRA) Specialty Group on foundational issues in risk analysis has established a group of risk analysis experts with the mandate to develop a list of key principles that expresses high quality and trustworthy risk analysis.

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The term Risk Analysis is here used in line with the established tradition of SRA to include: risk assessment, risk characterization, risk perception, risk communication, risk management, risk governance, and policy relating to risk, in the context of risks of concern to individuals, to public- and private-sector organizations, and to society at a local, regional, national, or global level. Risk analysis addresses both negative (undesirable) and positive (desirable) consequences, but the main focus of the present work is on the negative part.

Objectives

The objectives behind the preparation of this document, including the list of key principles, are:

1. To initiate and foster a discussion on what high quality and trustworthy risk analysis and key principles of risk analysis are
2. To provide an authoritative guidance on the fundamental principles to be adopted when conducting risk analysis.

Scope, rationale and process

Approaches and methods for risk analysis are now applied all over the world and in most societal sectors, and many advances have been made on different topics of risk analysis over the years. However, risk analysis is not broadly recognised as a separate/distinct science. An illustrating example is categorisations of scientific areas, as used for instance in research funding schemes, where risk analysis is not included. Globally we also find rather few educational programmes (such as Masters programmes) and professorships in risk analysis.

To solve risk problems, the risk analysis approaches and methods are combined with knowledge from statistics, psychology, social sciences, engineering, medicine, and many other disciplines and fields. The problems require multidisciplinary and interdisciplinary activities. The focus is on climate change, business, medicine, etc., with risk analysis supporting the work. However, research is also conducted on risk analysis concepts, principles and methods as such, for example related to how to best conceptualise and describe risk, and how to understand and use the precautionary principle. Thus risk analysis is not only a science supporting the knowledge generation of risk related to various activities (e.g. operation of engineering systems, natural phenomena, medical treatments), but also a science producing knowledge related to concepts, theories, principles, models and methods regarding how to understand, assess, characterise, communicate, manage and govern risk.

In a recent document from the Society for Risk Analysis (www.sra.org/resources) a list of core subjects of risk analysis has been developed. It captures five main categories of subjects: Fundamentals (I) (science, knowledge, uncertainties, risk - and other basic concepts); Risk assessment (II); Risk perception and communication (III); Risk management and governance (IV), and Solving real risk problems and issues (V).

This document defines some core subjects/topics of risk analysis, but it does not take a stand on which are the key ones and how to interpret them. It just lists them. The present document goes one step forward and provides guidance on what fundamental principles to adopt in order to ensure high quality and trustworthy risk analysis. This is considered important as the risk field still suffers from a lack of clarity and consensus on what are the key scientific pillars of the field. The situation is chaotic and leads to poor communication. It also hampers effective risk management and the development of the risk field, as many of the definitions and perspectives adopted lack proper scientific support and justification.

The history shows that it is difficult to obtain consensus on this type of issues. However, the development of the SRA Glossary and the Core Subjects document (www.sra.org/resources) has shown that broad consensus can be achieved if the work is properly structured and some level of flexibility is allowed for, within given frames.

The fundamental principles are necessary to ensure that risk analysis applications and training can progress from a scientifically solid platform. It is always a challenge to balance the need for authoritative guidance and solutions on the one hand, and the need for continuous debate, research and improvement on the other. The present document acknowledges the importance of this balance, and is focused on rather high level principles. The document is built on the risk analysis literature providing analytic arguments on how to conduct risk analysis, also reflecting the authors' insights on these issues obtained from both practical experience and theoretical work.

The target audience for the document is all individuals who have an interest in risk analysis, SRA members or not, ranging from risk analysis professionals and practitioners, to researchers, to students, to decision makers, to bureaucrats, to regulators, to journalists and to curious lay people who would like to get an overview of what the fundamental principles are to ensure prudent risk analysis.

If you have any comments on the document, please email terje.aven@uis.no.

Fundamental principles

We have structured the principles according to the five themes of the Core subjects of Risk Analysis document, mentioned above.

1 Fundamentals

1. Terminology in line with the SRA Glossary (www.sra.org/resources)

2. Risk analysis covers two main types of knowledge generation:
   A. Risk knowledge related to specific activities (interpreted in a broad sense covering also natural phenomena) in the real world, for example the use of a medical drug, the design of a process plant, or the climate.
   B. Generic knowledge on concepts, theories, frameworks, approaches, principles, methods and models to understand, assess, characterise, communicate and (in a broad sense) manage risk.

   Concrete activities to collect data and establish data bases are to be considered of type A, whereas methods for how to do these activities are covered by B.

   Contributions to risk analysis mean adding knowledge to A or B, or both. For each of the coming four themes, we can relate the knowledge generation to A and B as indicated in the Core Subject document.

3. In risk analysis we make clear distinctions between variation/variability, uncertainty and imprecision, and different methods are used to represent and/or express these, like frequentist probabilities (and related probability models), probability and imprecise probability, respectively. Clear and meaningful interpretations are required for these concepts, such as:

   Frequentist probability of an event A: the limiting fraction of times A occurs if the situation considered were repeated (hypothetically) an infinite number of times.

   Probability of an event A: the number such that the uncertainty about (degree of belief in) the occurrence of A is considered equivalent by the person assigning the probability, to the uncertainty about (degree of belief in) some standard event, for example drawing at random a red ball from an urn that contains P(A) x 100% red balls. Hence a probability of 0.1 means that the assigner considers the uncertainty (degree of belief) for the event to occur to be the same as randomly drawing one particular ball out of an urn comprising 10 balls. The probability is conditional on the knowledge K of the assessor. We write P(A|K).

   Imprecise probability of an event A: A probability interval [a,b] expressing that the assigner is not willing to be more precise than the interval specified given his/her knowledge K. If for example an interval [0.1, 0.2] is specified, it means that the assigner's degree of belief for A to occur is higher than or equal to the degree of belief of randomly drawing one particular ball out of an urn comprising

10 balls and less than or equal to the degree of belief of randomly drawing one particular ball out of an urn comprising five balls. Given the knowledge K, he/she is not willing or able to be more precise.

2 Risk assessment

- Risk assessment is the systematic process to identify risk sources, threats, hazards and opportunities; understanding how these can materialize/occur, trigger events/event sequences, and what their consequences can be; representing and expressing uncertainties and risk; and determining the significance of the risk using relevant criteria.
- Risk assessment uses the best available data, information and knowledge, within the constraints and frames of the assessment.
- Probability theory and other frameworks for representing, modelling and treating variation and uncertainties, as well as traditional statistical and Bayesian analysis, provide basic tools of risk assessment.
- Quantitative measures of uncertainty (typically, probability and imprecise probabilities) should be supplemented with characterisations of the knowledge that these measures are based on. Such characterisations may cover lists of assumptions and judgments of the strength of the knowledge.
- A high quality scientific risk assessment meets the following criteria:
    - i) It meets some basic scientific requirements
        - It is solid (complying with all rules, assumptions, constraints, etc; the basis for all choices, judgments etc. are clear; principles, methods, etc are subjected to order and system so that critique can be raised; etc.
        - It is relevant and useful (contributing to solving a problem, meeting stakeholders' expectations, etc)
        - It is reliable and valid. While reliability is concerned with the consistency of the 'measuring instrument' (analysts, experts, methods, procedures), validity is concerned with the success at "measuring" what one sets out to "measure" in the analysis. A key aspect to be considered in relation to validity is the degree to which the knowledge and lack of knowledge have been properly addressed.
    - ii) The decision maker (and other stakeholders) has confidence in the assessment with its results and findings. This confidence will depend on many factors, including the analysts' and scientists' own evaluations of the quality of their assessments, and how the decision maker judges the competence of the analysts and scientists.
- Peer review is a useful tool for checking and improving the quality of scientific risk assessments

3 Risk perception and communication

- Risk perception refers to a person's subjective judgement or appraisal of risk, which can involve social, cultural, and psychological factors.
- Risk perceptions need to be carefully considered and incorporated into risk management, as they will influence how people respond to the risks and subsequent management efforts.

- Risk perception studies are important for (i) identifying concerns but not necessarily for measuring their potential impacts and (ii) for providing value judgement with respect to unavoidable trade-offs in the case of conflicting values or objectives.

- Risk communication can be broadly understood as an iterative exchange or sharing of information related to the characterization, assessment, and management of risk between and among different groups, including regulators, stakeholders, consumers, media, and general public. It is multi-directional and includes both formal and informal messages and purposeful and unintentional ones. In today's super-mediated environment, risk professionals must also recognize that any risk message they seek to communicate is likely competing with multiple, conflicting messages from unofficial sources.
- Successful risk communication requires an understanding of the target audience, including the best means for reaching the audience: a credible or trusted source; and a message that has ideally been pre-tested to ensure its effectiveness. Those seeking to develop and test risk messages employ host of methods, including surveys, focus groups, interviews, and experiments. There is also a vast theoretical literature to inform the practice of risk communication.
- A prerequisite for successful risk communication in many situations is clarity on fundamental risk analysis concepts and principles, for example what uncertainty means in a risk assessment context.
- With few exceptions, such as proprietary information or that which may damage public security, risk professionals should seek an open, transparent, and timely risk communication policy. Such a policy not only demonstrates respect for the target audiences and ensures they have the information they need to take risk mitigation actions, if necessary, but it also can help ensure the perceived trustworthiness and legitimacy of the sources.

4 Risk management and governance

- Risk management covers all measures and activities carried out to manage and govern risk, balancing developments and exploring opportunities on the one hand, and avoiding losses, accidents and disasters on the other. In general, the proper risk level is a result of a value and evidence/knowledge-informed process, balancing different concerns. To generate value, risk taking is needed. How much risk to accept in pursuit of value is context-dependent and depends on how values are weighted.
- Risk governance is the application of governance principles to the identification, assessment, management and communication of risk. Governance refers to the actions, processes, traditions and institutions by which authority is exercised and decisions are taken and implemented. Risk governance includes the totality of actors, rules, conventions, processes, and mechanisms concerned with how relevant risk information is collected, analysed and communicated and management/regulatory decisions are taken.
- Three major strategies are needed for managing or governing risk: risk-informed strategies (I), cautionary/precautionary/robustness/resilience strategies (meeting uncertainties and potential surprises) (II), and discursive (III) strategies. In most cases

the appropriate strategy would be a mixture of these three types of strategies. The higher stakes involved and larger uncertainties, the more weight on the second category and the more of interpretative ambiguity and normative ambiguity (different views related to the relevant values) the more weight on category III.

- This process of balancing different concerns can be supported by cost-benefit methods, but this type of formal analyses needs to be supplemented with broader judgements of risk and uncertainties, as well as stakeholder involvement processes.
- To protect values like human lives and health, and the environment, the associated risk must be judged to be sufficiently low.

5 Solving risk problems and issues

- There are many challenges and issues related to solving real risk problems in practice (which are usually multidisciplinary and interdisciplinary in their form), by integrating theories and methods from risk assessment, risk perception, risk communication and risk management, as well as from other fields/disciplines.

Successful risk analysis in practice, means inter alia that

- The risk assessment is engaged effectively in the risk management decision process
- The risk characterization has a format suitable for the decision-making situation
- The disclosure of the actual role of the analysis, e.g. advise vs. defend, is practiced
- Assumptions and caveats, and the implications of these for the decision-making has been stated
- Potential surprises are addressed and relevant management strategies implemented.
- Legal requirements are met

Peer review is commonly used in relation to risk assessment (2) but is useful also for other types of risk analysis activities, including the design of risk management strategies and policies.