Protocols for Communication and Governance of Risks

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ABSTRACT: The aim of this paper is to explain the need to organize the development of standard protocols for communication about major public risks. Tragic events, such as inadequate earthquake preparedness or great unnecessary losses of life due to public misunderstandings underline the importance of such protocols to protect the public and support confidence in government and experts. The required contents of such protocols are suggested in outline. It is concluded that the need is urgent internationally to organize the development of standard protocol paradigms, one for scientific-professional analysts and another for authorities' communications to the public.

1. INTRODUCTION

We deal with the numerous hazards in a modern developed society in three different ways: By unthinking reflex (touching a hot stove), by emotion (the dreadful and unknown), by reason (e.g., flood) or in a combination of the last two (e.g., when the mayor recommends earthquake preparedness, but we feel it isn't worth the trouble). Yet all three serve to preserve life, health and property.

When gut feeling overrides reason in decisions about risk it can be costly. For example, in the year after 9/11 many Americans chose to travel by car instead of flying. That cost about 1600 lives (Gigerenzer 2006). Worse, annual influenza vaccination in the USA is far below national goals; full coverage could save in the order of 25,000 lives annually (Lind 2014). "It should be possible to change this behaviour [emotional risk management], so long as we are primed to recognise it" (Bond 2008). A protocol for risk communication from authorities to the public would prescribe minimum standards to serve this aim.

There is also a need for a standard protocol for communication about risks from experts to decision-making authority. The need is illustrated by events following the 2009 Abruzzo earthquake that killed over 300 persons in L'Aquila, Italy (Grandori and Guagenti 2009). The Italian Civil Protection Agency was severely criticized for ignoring the foreshock activity. But, following a particularly large foreshock, a meeting of scientists did not recommend evacuation. This was criticized in hindsight by mass media and the public (van Stiphout et al. 2010). Six experts who took part in that meeting, accused of giving inexact, incomplete and contradictory advice, were convicted of manslaughter in a local court but later acquitted. Expressing a scientific and professional opinion can thus be considered a crime. If a suitable protocol were followed such peril should be avoidable. More importantly, authorities would have a clearer basis to justify interventions taken and recommended.

The hazards in modern society are widely different, natural and man-made hazards: hurricanes, flood, earthquake, dangerous goods, toxic releases, viruses, contamination of food, etc. It is a duty of the various professionals involved in risk assessment to strive for a balance of protective effort between the various hazards. A primary duty of local, national or even supra-national authorities is to offer adequate and acceptable levels of protection. This includes by appropriate communication to ensure that citizens respond appropriately to hazards (e.g. vaccination or fire alarms). High risks should be avoided but, on the other hand, available resourses are limited.

Ensuring that the public have an unbiased feeling of the risks is not simple. Fast worldwide communication brings sensational events immediately to market in the press. Although journalists, too, have a professional duty to communicate reliably and truthfully, they are at liberty to strive to select and present the news in a captivating manner. The by-product is much public misjudgment of risks, and consequent losses (Gigerenzer 2006).

In order to gain insight into the nature and severity of the hazards as well as into the effect of possible safety measures, authorities have to seek advice from experts in the relevant domains. Experts generally claim that no firm predictions can be made because of the many uncertainties and unknowns. Nevertheless decisions must be made.

Risk management in society involves four kinds of stakeholders: Experts, authorities (policy makers), companies, and the public. The various stakeholders may have different or even conflicting interests, but all are often involved and may play a role in the decision making process. The 'rules of the game' (or protocols) should be transparent and fully clear to all parties. Misunderstanding about key words, such as uncertainty or risk, as well as confusion about ability, responsibility and liability, should be avoided by effective communication. Basic principles of accountability in risk governance and a valuation based on the economics of human welfare should be understood by all parties. This is important during the decision making process, but also afterwards when things may turn out different from expected.

There is nowadays an unacceptable variability in legal, organizational, strategic and operational approaches to risk management, between and within nation states and industries. This problem should be addressed by a broad international authority to establish a common dispassionate rationale for societal risk management. The next sections of this paper give some first ideas for standard information protocols, one for communication between risk analyst and government, and another for communication to the public.

2. PROTOCOLS FOR RISK MANAGEMENT AND COMMUNICATION

A standard or protocol for formal risk management should serve several purposes. It could serve as a roadmap to identify the various steps in the procedure from observation to action. It should indicate who is the main responsible party for which activities. In particular it is important to distinguish between the assessment of risks (how large is it?) and the risk management (what do we accept and do?). Assessment is mainly of a technical/scientific nature; Regulation is in essence political, while industrial and personal actions are individual. However, uncertainty is present for all; good collaboration and trust are important.

A clear common language is essential to enable discussion about risks between experts, authorities and the other stakeholders. Presently government decision makers and the public are often confused when they receive statements by experts about risk to the public; statements are often vague, incomplete and doubtful. Even experts in different fields may use different notions or different definitions. This indicates that next to a description of steps and a setting of responsibilities clear definitions of risk-related terminology and methodology is necessary.

The protocol should be based on three main steps: Risk analysis, Risk management and Communication.

The *risk analysis*, assessment or evaluation is primarily a scientific and technical activity. It always starts with a description of the relevant systems and processes. An inventory of normal and deviating situations is made and social economic implications, environmental impacts and health and safety consequences are quantified using a proper risk metric. Possible mitigating measures are developed and their effects evaluated. The protocol should harmonize the possible present differences between various technical disciplines.

Governance. In the *risk management* step, the various alternatives have to be compared and an optimal choice has to be made. The fundamental problem is always the tradeoff between cost of mitigating intervention on the one hand and risk reduction on the other. The protocol should indicate the tools available in formal decision theory and the way these tools should be used. In the end the choice is a political one, in particular the choice between accepting a theoretical outcome or to overrule it for whatever political reason.

Finally there is the *risk communication*, both before, during and after the decision making process. All notions of existing and acceptable risks and necessary safety measures need to be discussed between people who usually have no education in risk management, nor in the domain of the hazard. The protocol should assist in this process by offering a uniform and understandable way of presentation in almost everyday language.

All issues mentioned will be discussed in more detail in the following sections. The aim is to keep the methods as general as possible and applicable in a wide domain of hazards.

3. RISK ANALYSIS

3.1. Uniformity in terminology

It can be observed that experts in various fields of application or even within one field do not always mean the same when using the same words. This may already be a problem when performing their own work, but surely it is so in the cooperation and communication with semi-professionals or laymen such as public servants, politicians, press and the public. It is essential to have clear definitions of the subject at hand. This holds for the typical jargon in the various domain fields (nourishment, earthquakes, floods, health, industry) as well as for the key notions in risk analysis. This paper concentrates on the latter one. To some extent most stakeholders are in foreign territory, as also many scientists and practical experts have only limited knowledge of the risk domain. Also, in different technical domains different notions of risk may be used. In some cases this may be justified by the nature of the subject; in other cases it is simply a situation that grew out of, and/or lack of knowledge of the theoretical probability and decision theory.

We will discuss here three main notions: uncertainty, probability and risk.

The notion of *uncertainty*, of course, is known for a long time to mankind, but a systematic treatment is relatively new. It had to wait till the 17th century before Pascal and Fermat formulated probability in sound mathematical terms. The first applications were actually only in the field of games (cards, dice). Serious applications had to wait till the start of the industrial revolution in the 19th century. These developments already indicate that the idea of talking of uncertainty in mathematical terms is not easy, not because the mathematics is difficult (it can be, but certainly not more so than in other fields of science) but because of the correct reasoning and interpretation: in short their relation to the real world. In particular, when it comes to low-probability events, understanding becomes difficult.

Another major question is the type of uncertainty we want to address. A distinction can be made between aleatory and epistemic uncertainties. *Aleatory* uncertainties are the fundamental uncertainties in nature. The thing we cannot predict, like the long term wind speed or the outcome of the toss of a die. We can only discuss them in statistical terms, for instance the probability of having a 6 on top when throwing a fair die is 1/6. *Epistemic* uncertainties refer to lack of knowledge (e.g., is the die really fair?), either in the scientific models or as a result of limited statistical data. In principle we could eliminate these uncertainties by investigation. In many cases, however, the difference between the two is vague. Some experts (the frequentist school) like to treat both types of uncertainty in different ways, while other experts (the Bayesian school) treat both alike (Faber, 2005). The point is that epistemic uncertainties often require a subjective estimation, which may be considered as a step outside the objective scientific world. A counter-argument is that the decision process is not improved by giving the objective and subjective uncertainties different and separate treatments. Anyhow, in communication this may be an extremely confusing factor.

The next confusion is the word *risk*. Strictly, in risk analysis it means the product of probability and consequences, summed over all possible (exclusive) scenarios. In many texts - even some scientific ones - the word risk however is used according to the meaning in everyday language, perhaps indicating only the chance of some adverse event. The protocol may make a choice or indicate that always the definition should be specified.

3.2. Uniformity in methodology

A risk analysis combines models of physical processes and (statistical) data to assign the probabilities to certain unfavorable events. In general the following steps can be distinguished:

I. A description of the system or process under consideration

II. An inventory of possible anomalies from external as well as internal sources.

III. A qualitative definition of scenarios, models and consequences

IV. A quantitative estimate of probabilities and consequences

V. Evaluation of the results and search for mitigating measures

When setting up a risk analysis a close cooperation between various domain experts and risk experts is usually necessary. In particular this holds for the quantification stage. Most of the essential information is in the hands of the domain experts, but the knowledge of how to interpret the often scarce data in probabilistic terms is the domain of the risk expert. This cooperation is extremely difficult but also crucial for having meaningful results. In particular when data indeed is almost absent we need opinions to get at least indications of the levels of likelihood. Such expert elicitation is by itself a field of expertise (Cooke, 1991).

Models used in risk analysis may be based on physical principles but can be also be of a purely statistical nature. Examples of the first category are the response of structures to hurricanes or earthquakes. In the cases of the development of a fire, on the other hand, we may use an event-tree approach indicating discrete steps in the development of the fire (e.g., the sprinkler starts or does not), neglecting the underlying failure mechanisms. The protocol should propagate the use of physically-based models where appropriate.

The actual evaluation of the risk will usually be performed using computers and established algorithms such as Monte Carlo, FORM, Fault/Event tree calculations, or Bayesian networks. This step may be quite time-consuming. For practical applications to a large population of structures or processes it is often recommendable to set up a semi-probabilistic approach that has been calibrated to accepted targets.

More information can be found in documents like JCSS (2008) and relevant ISO codes (e.g., ISO2394 and ISO 13824:2009…). It is proposed that the Protocol makes formal and explicit references to these documents.

4. RISK MANAGEMENT / DECISION MAKING

Given the results of the risk analysis, it should be judged whether or not the existing situation, the projects envisaged, or the current legal setup are acceptable. Mitigating measures may be necessary which may take any form like (immediate) evacuation of people, closing roads or bridges for traffic, taking food out of shops, preparing vaccination, strengthening of buildings, etc. Where possible, measures for risk reduction shall be sought from best practice, such as expressed in codes and standards, unless it can be justified that such are inappropriate in a given situation.

The choice out of a set of possible alternative measures is essentially a political matter. One reason is that it has to be decided how much of the (national) available resources will be used for realizing certain safety levels. Another reason is that the measures also have to be manageable; perhaps an evacuation of people or a strengthening of residential buildings is not achievable or too cumbersome for the local population.

Although the final responsibility for decisions is in the hands of government, formal decisions theory may be of a help. Common but fuzzy phrases in such approaches is ALARP (ALARA, ALARF, ALARD): As low as reasonably practicable (achievable, feasible, doable).

The simplest case is a small-scale system where only economic issues are at stake. The theory then requires a balance between money spent on safety measures on the one hand and the resulting risk reduction on the other. As measures and risks are payments spent on different points in time a proper discounting procedure is needed. Still the choice of the discount rate (constant? random?) is a difficult one. Another problem might be that the risks may be present for one group of people and the profits for another. Here we are back in legal and political matters.

When also human life is at stake (injuries, sickness, health) things become more complex. Various options are available. Relatively easy is the situation where only the options “no harm” or “death” of anonymous persons are at stake, the probability of death is low and the potential number of victims is small. In that case the economic optimization has to be extended using a marginal life-saving-cost type of reasoning as for instance by the Life Quality Index (LQI) proposed by Nathwani et al. (1997). The idea behind the LQI is that the preference of a society with regard to investments into health and life safety improvements can be described at the societal level characterized by just a few statistical indicators, i.e., the life expectancy at birth, the Gross Domestic Product (GDP) per capita and the ratio between working time and leisure time. Thus the LQI bears some significant similarities with the Human Development Index (HDI) (UNDP 1990-2015), but offers some significant advantages (Nathwani et al. 2009). Whereas the LQI was originally proposed on the basis of socio-economic theoretical considerations, its validity has subsequently been justified empirically (Rackwitz, 2005; Kübler, 2005). The LQI facilitates the assessment of decisions with regard to their conformity with societal socioeconomic.

Finally, when deeper values - historical, cultural, ethical, etc. - are at stake, decisions in the hands of government and/or individuals may rest upon moral or emotional judgment of what is right or good, but proper risk analysis is still of paramount importance.

Furthermore, in addition to the LQI, the notion of an acceptable maximum *individual risk* level may play a role, since it is hardly ethical to expose a relatively small group of people to a large risk, even if averaged on a larger area or time scale the risk may be judged as okay. At the other end of the scale we have the situation of a large number of people dying in one event. This is always very shocking to the community, even when the risk averaged over time and place seems to be acceptable. It brings in the notion of *group risk* or *societal risk*. In practice it has turned out to be difficult to find rational and acceptable limits.

In case people may get injured (for a longer or shorter time) or when exposure to toxic material may give rise to extended health problems, the above types of reasoning have to be adjusted. How do we judge the shorting or a life by one month on average, in particular if there is also large scatter around the average?. In the food safety and medical world the notions of DALY and QUALY (Disability- and Quality-Adjusted Life Years) have been introduced (NICE 2012).

The protocol should try to harmonize the different approaches and make suggestions on how to use each of the methods depending on the type of risk management situation.

5. COMMUNICATIONS

In the previous sections the risk analysis and decision making principles have been described. In order to draw rational conclusions, input is necessary from at least three parties: the experts in the domain of the hazard, experts in decision making under uncertainty and policy makers or their civil servants. It is essential that these three groups understand each other well, although they may all be laymen in eachothers' fields. This requires a well-organized process. In particular, experts should very carefully explain their methods and finding in understandable language. Visualization using pictures, movies or animations may prove to be a good help, but should be chosen with care.

It is also important that the process and outcome of the risk management be acceptable for all stakeholders involved. These may be citizens, companies, financial and legal people and of course the press and media. The communication here may be even more difficult as the outcomes may directly affect their economic, social or human interests. Strong debates, sometimes emotional, may be the result. Outcomes of the process may be quite unfavorable for some parties and they may feel treated in an unjustified way. Difficult legal questions may pop up between various parties about liability.

It is essential that the outcomes of the Risk Analysis at least are clear to all parties. It may require extensive explanations. For instance, the probability of 1 percent in 100 years may better understandable than a probability of 10^{-4} per annum or a return period of 10 000 years. Also the presence of subjective probability estimates may be a difficult topic and at least an easy target for parties that do not like the outcome. One should make absolutely sure that the experts responsible for the subjective probability estimates were not associated, one way or another, with any of the involved parties. The outcomes of a partly subjective Quantitative Risk Analysis (QRA) should beyond all doubt be as far as numbers and procedures are concerned. This brings forward the responsibility for the objectivity and neutral attitude of all experts in this process.

An important issue in the communication may be the perception of risk in the heads of the various stakeholders. A hazard that according to the risk analysis is important may be completely underestimated by the public or vice versa. In the first case it will be doubted whether all (costly, disturbing) safety measures are really necessary. In the second case a feeling of unsafety may exists which is not confirmed by the analysis. On should keep in mind here that a feeling of safety is also a kind of reality and that satisfied stakeholders only can be achieved by taking these feelings seriously.

Two protocol paradigms are required to initiate the process of broad international development of risk communication protocols, because of the profound difference between the rational approach expected of authorities and the intuitive feelings expected of the public.

5.1. Communication to authorities

Faber and Lind (2012) briefly provided an overview and an example (an earthquake advisory) of what ought to be covered. For the authorities, the scientists and professionals should specify: the intended recipient(s); the hazard including its geographic extent; the expected and extremes of consequences envisaged and the time frame; quantitative probability estimates with estimated uncertainty bounds; the author with contacting information; and the documentary support for the risk assessment.

5.2. Communication to the public

Although this sort of communication requires input from the social psychology specialty, Faber and Lind (2012) have also drafted some questions and given an example (seasonal influenza). Thus, before an event occurs, the general public should be informed about:

1. Why risk management is essential,
2. What their risks are,
3. Who is responsible for public risk management before, during and after events,
4. Responsibilities and liabilities of government officials,
5. Responsibilities the public has, and how individuals and industry actively can contribute to mitigation,
6. How decisions about risk management are made in society, the basis for deciding on what and how much to commit,
7. What is being done to reduce risks before and during disasters,
8. Precursors and their significance,
9. What to expect if disaster strikes - likely and possible scenarios and their expected consequences,
10. What to do if disaster strikes, and
11. What help to expect in the case of a disaster, during and after the event.

The during-disaster situation covers the time from the possible first observation of a precursor until the end of rescue, evacuation and other loss-reduction activities. Based on actual knowledge about the event, the public should be informed about:

1. (If observed,) the disaster precursors, their interpretation, likely reasons and possible further scenarios,
2. The estimated intensity and duration of the anticipated events,
3. The likely consequences, ranges, and their extent in time and space,
4. Which societal functions are likely to be lost and for how long,
5. How best to protect themselves, other persons, the environment and property,
6. How and where to evacuate,
7. Where and how to get help, and
8. What to do when the event is over.

Finally, after the disaster, it is important to give an official account of what happened, why it could happen, and what lessons to draw. The public should be informed about the extent of the consequences, why the disaster and the losses could happen, and what can be learned. Will it lead to a change in priorities and, if not, why?

6. CONCLUSIONS

The need to organize the development of two standard protocols for the communication about major risks to the public is urgent. One should serve and guide scientific-professional analysts in their communication with authorities, the other to guide authorities in risk communication with the public. It is suggested that a broad international effort, with contributions from scientists, public health officials, engineers and social psychologists, be established under the auspices of international academies.

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