RISK ASSESSMENT AND MANAGEMENT

Stodola Jiří *)

ABSTRAKT
Príspevok sa zaoberá skúsenosti v praktickej implementácii vyhodnotenia rizika a jeho mapovania a predovšetkým s využitím existujúcich dobrých praktických skúsenosti s hodnotením rizík hlavných prirodzených a technických katastrof. Zahrnuje vybrané hodnotenie z EU legislatívy, smerníc rizík napr. povodní, ochrany kritickej infraštruktúry, možnosti riadenia rizík nehôd, a iných. Krom toho sa zaoberá kodifikáciou Európskej únie. Kodifikácia obsahuje zhrnutie výsledkov nových výskumov v oblasti vyhodnotenia a mapovania rizík.

Kľúčové slová:
Riziko, hazard, vyhodnocovaní, riadení, mapovaní.

ABSTRACT
The article deals with experience in the practical implementations of risk assessments and mapping, in particular existing good practice risk assessments of major natural and man-made disasters. It takes full account of existing EU legislation including the directives on flood risks, protection of critical infrastructures, and on the control of major accident hazards, etc. Moreover, there are considering a number of Eurocodes of the European Union. It consists of also gather results from most recent research in the area of risk assessment and mapping.

Key words:
Risk, hazard, assessment, management, mapping.

INTRUDUCTION

Czech Republic has generated a wealth of efficient disaster management practices which effectively limit the negative consequences of hazards. Some regions have developed valuable specialised expertise for particular types of risks. Sharing this

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experience it is possible to help to further reduce the impacts of hazards in the most efficient and acceptable ways and allows the joining of forces for the challenges ahead. Framework on disaster prevention, developing our perspective may create significant opportunities of successfully combining resources for the common objective of preventing and mitigating shared risks. Risk assessments include risks which are of sufficient severity to entail involvement by national government in the response, in particular via civil protection services. Several regions have already produced their own risk assessments or carried out substantive work in the area. These article is build on experience in the practical implementations of risk assessments and mapping, in particular existing good practice risk assessments of major natural and man-made disasters. The article take full account of existing EU legislation (details in [1]) including the directives on flood risks, protection of Critical Infrastructures, and on the control of major accident hazards, etc. Moreover, the article consider a number of Eurocodes, such as Eurocode 8 on building design standards for seismic risks, and also the conclusions on prevention of forest fires. The article also deals with gather results from most recent research in the area of risk assessment and mapping.

1 ROLE OF RISK ASSESSMENT

Risk assessment and mapping are the central components of a more general process which furthermore identifies the capacities and resources available to reduce the identified levels of risk, or the possible effects of a disaster, and considers the planning of appropriate risk mitigation measures, the monitoring and review of hazards, risks, and vulnerabilities, as well as consultation and communication of findings and results. Capacity analysis, capability planning, monitoring and review, consultation and communication of findings and results are not the subject of this article. However, risk assessments and mapping deliver the essential input for informed capacity building and the enhancement of both disaster prevention and preparedness activities. When carried out at national level, disaster risk assessments and risk management can become essential inputs for planning and policies in a number of areas of public and private activity. By improving the awareness and understanding of the risks, decision makers, stakeholders and interested parties are in a better position to agree on the preventative measures to take and to prepare in ways to avoid the most severe consequences of natural and man-made hazards and of other adverse events. Furthermore, the process of producing a risk assessment will enable both public authorities, and the general public to reach a common understanding of the risks faced as a community and help fostering an inclusive debate about the relative priority of possible prevention and mitigation measures. Wide dissemination and awareness-raising are important steps to further develop and fully integrate a risk prevention culture into sectoral policies. Once risks are analysed in some detail it will become possible to plot risk maps as one of the outputs of risk assessments. Risk maps generate a level of transparency which can help engage all interested actors in society. Risk assessments and risk mapping contribute to ensuring that policy decisions are prioritised in ways to address the most severe risks with the most appropriate prevention and preparedness measures. Risk assessments deal with uncertainty and

probabilities. These are the necessary subjects of a rational debate about the level of risk, may find acceptable when considering the costs of associated prevention and mitigation measures.

2 THE RISK ASSESSMENT PROCESS

At the beginning of the risk assessment process one authority must be designated for the task of coordinating the work. The process will normally require the setting up of a number of working groups for different types of natural and manmade hazards and representatives of different interested groups (e.g. transport operators), and in some instances also different levels of authorities (regional, etc.). Successful planning will require coordination between the varied government departments or agencies responsible for managing the consequences of different types of emergencies. A risk assessment provides an agreed basis for priorities in emergency planning which will facilitate this coordination. It can also be used to ensure an appropriate balance of investment in measures to prevent and mitigate risks. The process of producing a risk assessment involves public authorities, research, non-governmental organisations and the wider general public. Risk assessments should aim at making these actors reach a common understanding of the risks faced and of their relative priority. This shared understanding should cover both the range of risks considered relevant and the levels of severity for which preparedness planning would be judged appropriate. An approach which is objective, comprehensive and based on the most robust available evidence helps to avoid planning under pressure from recent events including public and media perceptions of the greatest risks. All parties involved in the risk assessment process should:

1. Agree on the scoring criteria at the start of the assessment process,
2. Record the methods used and their level of uncertainty,
3. Record the scores allocated to each risk and their justification,
4. Note the justification for including or excluding specific risks,
5. Devise a protocol for the use of expert opinion.

Public Consultation and Communication

Draft risk assessments should be widely consulted with stakeholders and interested parties, including central and regional levels of management and specialised departments. Risk assessments which are seen to be objective and impartial can help to build and sustain public trust and credibility. As a result, it may also help to ensure that policy-makers accept and use the assessment even where they are not directly involved in producing it. Moreover, extensive public information on the process and outcomes of risk assessments will be necessary to lead to a better understanding of the risks and to enable all stakeholders and the general public to become more engaged in emergency planning, preparedness and response. For example some the EU directive [2] (e.g. Floods Directive) require consultation of interested parties on flood risk management plans at the catchment scale, and also requires to make flood maps and plans publicly available. The following actions should accompany risk assessments:

- Publication of potential risk scenarios to inform the population about preparatory measures for emergencies and to provide advice on how the general public could be better prepared;
- Information to stakeholders and the general public on the particular risks they face, through for instance the dissemination of hazard maps;
- Cooperation with the private sector where their risk assessments complement the efforts of public authorities.

Risk assessments will have to draw on data from many different sources posing challenges in terms of data traceability, reliability, proper documentation, interoperability and other. It is therefore important that data sources are made explicit, including as concerns the use of expert know-how. Agreed models for the measurement of likelihood and impacts are still rather scarce for many types of hazards and risks. This means that a number of assumptions and estimations will need to be used in risk assessments. It is important that the types of assumptions, proxies and estimates be made explicit and that the merit of the applied models is clearly stated. The EU bodies such as the European Environment Agency (EEA) is developing actions assessing data and information gaps, as well as comparability issues. An EEA technical report that provides an overview on the impact of natural hazards and technological accidents in Europe 1998-2009 is due at the end of the year 2010. This report additionally points out the data gaps and information needs related to several hazard types. The main challenges for the future include:

- Further geographical information (vector data, spatial resolution, GIS-data);
- Inclusion of more events and impacts (e.g. including impacts on ecosystems or smaller events, levels of global disaster databases etc.);
- Improved and standardized definitions and terminology for economic losses and/or damage costs , affected people, etc.;
- Validation of specific data and Quality Assessment/Quality Control in general;
- Harmonization of methodologies, data and models.

3 RISK ASSESSMENT METHODS

According to ISO 31010, risks are the combination of the consequences of an event or hazard and the associated likelihood of its occurrence. Consequences are the negative effects of a disaster expressed in terms of human impacts, economic and environmental impacts, and political/social impacts. In situations where the likelihood of occurrence of a hazard of certain intensity can be quantified we refer to the term probability of occurrence. When the extent of the impacts is independent of the probability of occurrence of the hazard, which is often the case for purely natural hazards, such as earthquakes or storms, risk can be expressed algebraically as:

$$R = I.p\,, \tag{1}$$

where R … effective risk, I … hazard impact or consequences and p … probability of occurrence

In particular in the analysis of natural hazards, impacts are often expressed in terms of vulnerability and exposure. Vulnerability is defined as the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. Exposure is the totality of people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses.

$$R = f(V.E.p), \tag{2}$$

where V … vulnerability, E … exposure and p … probability of occurrence.
Using the concept of vulnerability makes it more explicit that the impacts of a hazard are also a function of the preventive and preparatory measures that are employed to reduce the risk. For example, for a heat wave hazard it may be the case that behavioural preparedness measures, such as information and advice, can critically reduce the vulnerability of a population to the risk of excess death. Effective prevention and preparedness measures thus decrease the vulnerability and therefore the risk. Depending on the particular risk analysed, the measurement of risk can be carried out with a greater number of different variables and factors, depending i.a. on the complexity of the chain of impacts, the number of impact factors considered, and the requisite level of precision. Generally, the complexity of the modelling and the quantification of factors can be increased as long as this also improves certainty. Hence, when quantitative models and additional variables and factors increase complexity without at the same time improving certainty (in terms of reliability, prediction and robustness) the use of more qualitative assessments and expert opinions will in principle be the better choice, also from the point of view of resource efficiency and level of transparency. For the purpose of these needs we can define three types of impacts:

- Human impacts are the number of deaths, the number of severely injured or ill people, and the number of permanently displaced people.
- Economic and environmental impacts are the sum of the costs of healthcare, cost of emergency measures, costs of restoration of buildings, public transport systems and infrastructure, property, cultural heritage, etc.
- Political/social impacts are usually rated on a semi-quantitative scale and may include categories such as public outrage and anxiety, encroachment of the territory, infringement of the international position, violation of the democratic system, and social psychological impact, impact on public order and safety, psychological implications, and damage to cultural assets, etc.

Human impacts can be estimated in terms of number of affected people, economic/environmental impacts in terms of costs/damage and political/social impacts can be generally refer to a semi-quantitative scale comprising a number of classes, e.g.:

1. limited/ insignificant,
2. minor/ substantial,
3. moderate/ serious,
4. significant/ very serious,
5. catastrophic/ disastrous.

To make the classification of such latter impacts measurable the classes must be based on objective sets of criteria. In risk identification and risk analysis, always all three categories of impacts should be considered when assessing the impact of any analysed event, hazard, or risk, including for risk scenarios and multi-risk assessments. Impact assessments need to define a reference space-time diagram of events. Impacts should be presented separately for the different impact categories, even though they may be combined or aggregated for certain purposes. Risk matrices [1] (see Figure 1 and 2) should also be available in disaggregated format, i.e. separate matrices for each category of impact. The availability of such a disaggregated format is important for making comparisons between the risk assessments of different region and to make it possible for produce an overview of risk for region or country. When impact categories are aggregated, special attention must be paid to avoid double counting of impacts, as there are frequent overlaps. Impact analysis should rely as much as possible on empirical evidence and experience from past disaster data or established quantitative models of impact. It is clear that for quantification purposes a number of assumptions and estimates will have to be used, some of which may be rather uncertain. These assumptions and estimates should always be clearly identified and substantiated. There are a number of available techniques, standards, and models that can be used for impact quantification, many of which are hazard specific, such as e.g. the resilience of buildings to earthquakes, storms, or floods, the death rate from heat waves etc. This first version of the guidelines recommends the use of good-practice risk assessment methods unless impossible. The three categories of impacts can often be assessed one by one but there may be circumstances with strong interdependencies, such as the number of dead and injured people from collapsed buildings due to earthquakes. In particular the assessment of economic impacts will need to assess interdependencies, such as the effect of supply disruptions of essential inputs, such as energy, transport, networking, water etc. Ideally, the assessment of economic impacts can make extensive use of asset registers or databases of exposed elements, which should exist at least for all critical infrastructures, networks and transport, hazardous installations, transport of dangerous substances on roads, essential ecosystems, and others. Impacts should be considered in the short term and the medium term. A risk matrix relating the two dimension likelihood and impact is a graphical representation of different risks in a comparative way. The matrix is used as a visualisation tool when multiple risks have been identified to facilitate comparing the different risks.

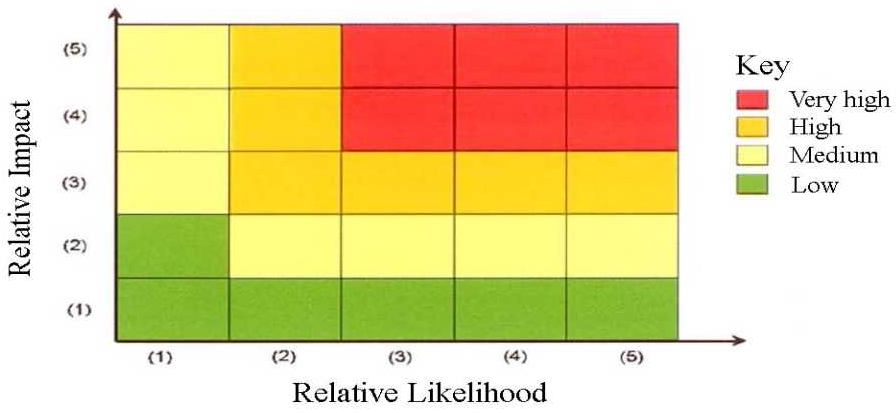

Figure 1 Example of risk matrix

The scale used may have 5 or more points. The matrix may be set up to give extra weight to the impact or to the likelihood, or it may be symmetrical. Within each category of impact (human, economic/environmental, political/social) the relative importance should be graded using a single set of criteria to score the relative likelihood and the relative impact applicable to the different hazards or risk scenarios. In particular, the human impact should be measured in number of affected people and the economic and environmental impact should be measured in Kč/Euro. The political/social impact can be measured in a qualitative scale comprising five classes, (see above). It should be considered to produce distinct risk matrices for human impact, economic and environmental impact and political/social impact see Figure 2 [3], as these categories are measured with distinct scales and would be otherwise very difficult to compare.

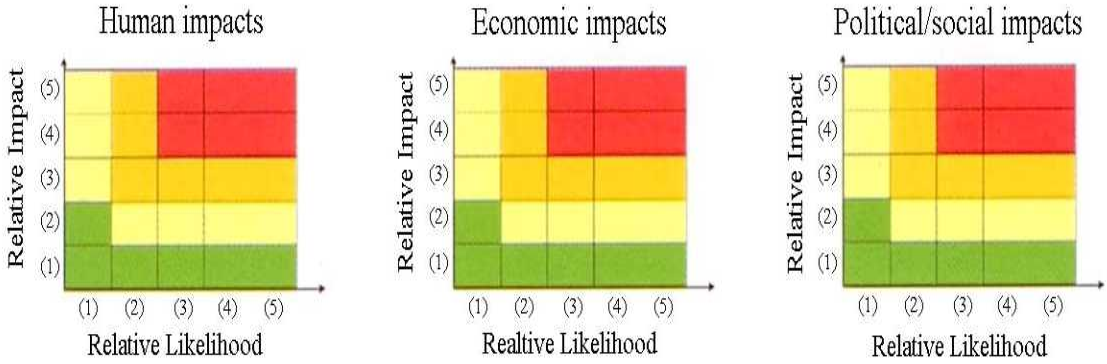

Figure 2 Example of risk matrix with disaggregated presentation of impacts

Risk matrices can be used in all stages of risk assessment. While there are various ways of dividing up the risk assessment process into a number of logical steps depending mainly on the roles of different actors involved, for the purpose of these guidelines, and taking into account work at level on methods of hazard and risk mapping, the overall risk assessment process of risk assessments should be composed of at least the following three stages: risk identification, risk analysis and risk evaluation see Figure 3 [4]. Examples of relevant Eurocodes [1] for different types of natural and industrial disasters is in Table.

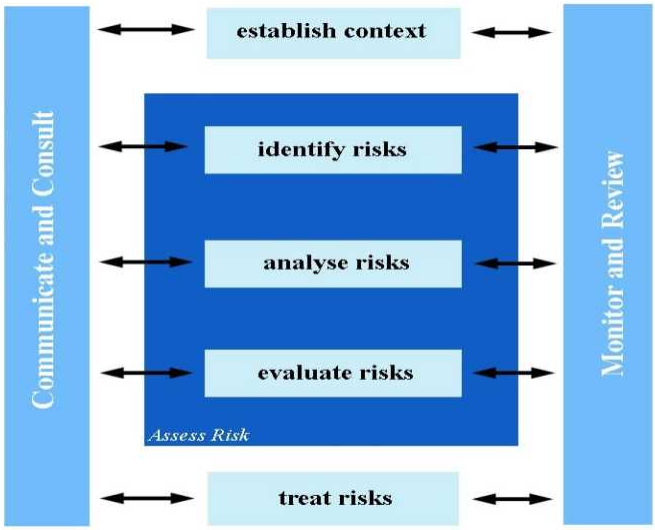

Figure 3 Stages of risk assessment in the overall risk management process

Table 1 Eurocodes relevant for different types of natural and industrial disasters

Type of disaster	Technical / normative framework
Forest fires	Eurocode 1 (actions on structures) defines protective design measures against fire for buildings made of Various materials (steel, concrete, wood, etc.)
Ground movements	Eurocode 7 defines calculation and design rules for stability of buildings according to Geotechnical conditions of construction site (XP ENV 1997, PR EN 1997-2, ENV 1997-3)
Earthquakes	Eurocode 8: EN 1998-1 (general rules, seismic actions), EN 1998-3 (assessment and strengthening of buildings), ENV 1998-4 (reservoir, pipes), EN 1998-5 (foundations, structures), EN 1998-6 (masts, towers…)
Storms, Hurricanes	Wind resistant design of buildings is covered by Eurocode 1 - EN 1991-1-4
Cold waves	Eurocodes cover protection against cold and snow
Heat waves and drought	Eurocode EN 1991-1-5 includes design to resist heat Waves. Partly covered by Eurocode EN 1997-1-1
Industrial and technological hazards	Eurocode 1 (EN 1991-2-7) also defines building design rules against explosions

4 ACKNOWLEDGEMENT

This paper was elaborated being supported by the European Commission team and has been sponsored by the Ministry of Defence of the Czech Republic in work on the Project of Research Establishment Development.

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Článok recenzoval:
prof. Ing. Ladislav Šimák, PhD.

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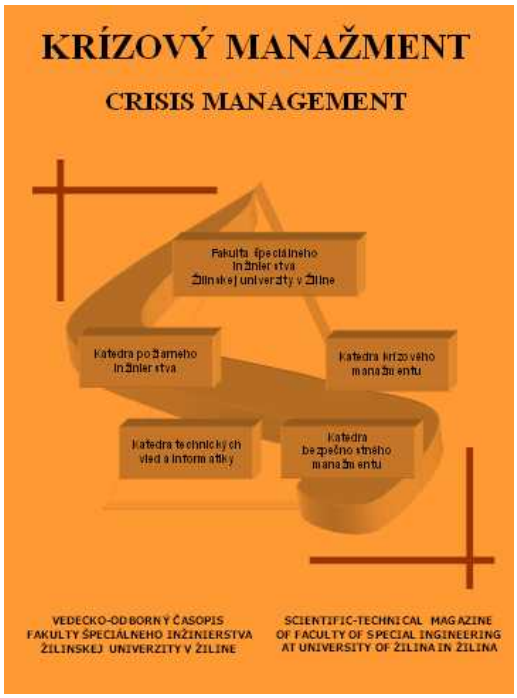

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