TOPICS IN SAFETY, RISK, RELIABILITY AND QUALITY

Integrated Risk and Vulnerability Management Assisted by Decision Support Systems

Relevance and Impact on Governance

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TOPICS IN SAFETY, RISK, RELIABILITY AND QUALITY

VOLUME 8

Aims and Scope. Fundamental questions which are being asked these days of all products, processes and services with ever increasing frequency are:

What is the risk?
How safe is it?
How reliable is it?
How good is the quality?
How much does it cost?

This is particularly true as the government, industry, public, customers and society become increasingly informed and articulate.

In practice none of the three topics can be considered in isolation as they all interact and interrelate in very complex and subtle ways and require a range of disciplines for their description and application; they encompass the social, engineering and physical sciences and quantitative disciplines including mathematics, probability theory and statistics.

The major objective of the series is to provide a series of authoritative texts suitable for academic taught courses, reference purposes, post graduate and other research and practitioners generally working or strongly associated with areas such as:

Safety Assessment and Management
Emergency Planning
Risk Management
Reliability Analysis and Assessment
Vulnerability Assessment and Management
Quality Assurance and Management

Special emphasis is placed on texts with regard to readability, relevance, clarity, applicability, rigour and generally sound quantitative content.

The titles published in this series are listed at the end of this volume.

Motto: "In companies today, only 10% to 20% of users access DSS tools. To reach the remaining 90% to 80%, companies are going to need to *embed analytics into core solutions*."

- *PricewaterhouseCoopers Consulting* -

PREFACE

Introduction

This book includes terms of reference and offers an augmented volume of relevant work initiated within the comprehensive concept of *"Knowledge Management and Risk Governance"*. The latter stood for the initial title of an *ad-hoc* meeting held in Ascona, Switzerland, organized by the Technological Risk Management Unit of the Joint Research Centre of the European Commission (JRC) and the KOVERS Centre of Excellence in Risk and Safety Sciences of the Swiss Federal Institute of Technology, ETH Zurich.

Background

Risk governance, in addition to the continuous interest of researchers, has recently attracted the attention of policy-makers and the media and the concern of the public. New and emerging risks in various fields and a number of risk-related issues increased the public interest and prompted for a new framework in dealing with risks. The Conference on Science and Governance organized by the European Commission in October 2000 is one of the international forums addressing this issue. Other recent events such as the establishment of the *International Risk Governance Council* outline the importance of the governance concept in relation to that of risk management (see www.irgc.org).

At the same time noticeable progress has been made in Information Technologies and Decision Support, passing from the process of information

to the process of knowledge. In this context new tools and methods became available, whose application in risk management may be beneficial. Moreover, it has been observed that tools and techniques in dealing with certain risk-related issues are more advanced in certain, specific fields, in some direct proportion to the technical, environmental and societal challenges involved. Therefore, there is an added value in understanding what tools are available for dealing with risks in various disciplines and explore their cross-applicability to other fields.

Objectives

The purpose of the present volume is to bridge the gap between risk sciences and decision support tools, in view of a better performance in governance. In particular, the main objectives are:

- To define the knowledge management methods and tools applicable in risk governance;
- To bring experience from the application of methods and tools available in various disciplines to other fields of risk governance;
- To determine the present and future needs for knowledge management tools in risk governance; and
- To promote the development and dissemination of such tools in a problem-solving context and for educational purposes.

The work here assemblied addresses questions, and provides tentative answers to issues such as:

- Do adequate tools for risk governance exist?
- Are they available to decision-makers?
- What are the needs of the various stakeholders (i.e. planners, regulators, industry, public) for an effective risk management?
- What new tools have to be developed in order to cover these needs? What features should they have?

The range of applications and associated decision support tools to address aspects of integrated risk and vulnerability management by use of decision support systems cover numerous disciplines and fields of application including process industry, transportation, natural disasters, emerging risks, critical infrastructures, insurance, national security related aspects.

Problematique

In the face of a turbulent and sometimes perplexing behavior of a world in transition, the *Disaster Risk and Vulnerability Management (DRVM)* tends to become a key buzzword in the business of governance. It naturally starts as an exasperated perception of an urgent need, gradually turning into an

articulated intellectual challenge awaiting sound solutions in terms of strategies, guidelines, implementation procedures, and practical tools to assist the 'live' management. ***Gheorghe and Vamanu*** in their paper *"Disaster Risk and Vulnerability Management – from Awareness to Practice"* introduce in detail theoretical and application-oriented work done to support assessment of risks and vulnerability in the context of modern governance oriented needs, including education and training. Starting from the existing reality, outstanding in the quest for a substantive and systematic commitment to responding the issue was the establishment, by the World Bank, of a *Disaster Risk Management Institute* (DRMI), based in Washington, D.C. The institute undertakes to, quote, *'enable people anticipate disasters and take action to protect life and property, and to ensure sustainable social and economic development'*. Its activities include '*supporting the pursuit of an optimal balance between disaster prevention, risk-sharing mechanisms and acceptance of residual risks in the face of limited resources*'. It is believed that such an aim can be achieved *'by filling knowledge gaps, providing a clearing-house for information, building know-how, mobilizing resources and forging partnerships with governments, private enterprises, international agencies and NGO's'*. DRMI aims at offering a comprehensive and effective implementation to the concept of integral risk assessment, treating the vulnerability of the infrastructures, the probabilistic analysis of hazards and the risk evaluations in one smooth flow. Throughout the process, public perception considerations and stakeholders postures are believed to play an important part. Also, a satisfactory coverage of both natural disasters and technical hazards would involve in a balanced fashion the natural sciences and technical engineering offering the basic language to quantify risk, and the political and socio-economic science bringing in the geo-economic and geopolitical considerations, as well as the human dimension, that are indispensable in talking risk, carrying its messages, and properly responding to it. DRMI is geared towards *'developing tools for fast and efficient implementation; contracting of expertise; identifying expertise and know-how on defined risk issues; providing adequate quality control in project management, and for risk evaluation of large investments'*, etc. To manage risk, one has first to comprehend it. In turn, this means to mentally grasp, qualitatively perceive and define and, hopefully, objectively quantify the targeted systems' vulnerabilities; the system control variables which, when monitored, may indicate the imminence of a disaster about to strike; the foreseeable proportion of the disruptions; the likelihood of the latter; and, necessarily, the people's perception of the potential disaster's severity. Sizing the mitigating response in fair proportion to the disaster, and ensuring a proper preparedness to face mishaps is also a part of the risk management equation.

The number of variables involved may soar high - in the order of hundreds, or even thousands. And it is more to that: whenever *risk* management turns into *emergency* management, the time factor, and the manager's stress factor start to rank high in the overall performance. Doing disaster assessment near-real-time *and* reliably is an irreducible must. The natural manner to comply is - computer assistance. To this effect, ever since its inception DRMI has contemplated the development of capabilities to identify, evaluate, acquire, develop, custom-tailor, and dispatch *computer-based tools*. This line of action is evidently consistent with the ubiquity that the decision support systems (DSS) have gradually, gained ever since the advent of the 'true' mainframes, back in the 60s. Starting from the dictionary definition, *'decision support systems are interactive computer-based systems and subsystems intended to help decision makers use communication technologies, data, documents, knowledge, and/or models to complete decision process tasks'*, the approach taken by the authors include: Communication-driven DSS; Data-driven DSS; Document-driven DSS; Knowledge-driven DSS; Model-driven DSS. While a review of the currently expanding market of risk assessment–oriented DSS software is not on this book's agenda, a fair recognition and illustrative description of its typological profile may however be in order. The said profile can be discerned in terms of needs, and the means to have these served.

Cozzani and Zanelli, outlining the Directive 96/82/EC (i.e. "Seveso-II" Directive) on the control of major hazards caused by dangerous substances report on relevant innovations in the safety requirements of process plants that have an impact on risk management. Among these are: the inclusion of substances likely to be formed in the loss of control of chemical processes in site inventory, the evaluation of domino accident hazard, and the requirement of land-use planning criteria. The development of land-use planning (LUP) criteria for the minimization of the industrial risk to which the population is exposed calls for the application of quantitative area risk analysis (QARA) techniques. QARA techniques currently available are mainly based on the modification of risk analysis techniques originally developed for the major accident risk assessment of single risk sources. Thus, these techniques show important limitations, mainly in the assessment of the effects on the global industrial risk due to the contemporary presence of different risk sources in a narrow area. The application of QARA techniques to land use planning - "Seveso-II" Directive requires the further development of procedures to assess specific problems as the presence of linear risk sources due to the transport of hazardous substances, the release of substances formed in the loss of control of chemical processes, domino accident hazards. This contribution addresses two of the open technological problems that arise in the application of QARA techniques to LUP. The

methodologies available and the research needs in the quantitative assessment of domino hazards and of the hazards deriving from the release of dangerous substances formed in the loss of control of chemical processes are discussed. The potential impact on LUP of these hazards is also evidenced, discussing the results of two Italian case studies.

Spadoni and Bonvicini discuss specialized decision support systems relating to a shared concern in all industrialized countries: the risks due to major accidents in the storage, production and transportation of dangerous chemicals. In Italy, it is argued, relevant work has been performed in the field of risk analysis. The chief aim of the research done over the past years has been the development of detailed techniques for the quantization of specific risks, implemented in user-friendly software codes. The main features of those tools are presented, particularly highlighting the application field for each of them and the support they can give to decision-makers in risk management.

The paper by ***Abrahamsson, Johansson, Nilsson, and Magnusson*** discusses three ongoing, or recently finalised, projects carried out at the Lund University Centre for Risk Analysis and Management. The first section introduces decision making situations involving extreme or catastrophic events and the application of a newly developed decision analysis method. The second chapter discusses the framework and the methodological aspects of a computer based decision analysis tool for assessing and managing local or municipal vulnerability. The third part presents a comparative uncertainty analysis of risks from an ammonia storage facility employing a number of methods: Monte Carlo analysis, interval analysis, fuzzy arithmetic and probability bounds theory.

In their paper, ***Amendola, Ermoliev, Ermolieva***, address the issue of natural catastrophe risk management. The catastrophe risk management process has all the characteristics of a complex systems problem: multiple conflicting objectives and strategies, a diverse range of views on fairness, multiple stakeholders and interests, and many different policy variables. The purpose of research at the International Institute for Applied Systems Analysis in Laxenburg, Austria, is to develop and test an integrated systems approach that can potentially provide insights on the complex issues and trade-offs involved. The approach also includes development of tools. These are designed to take into account the complexities and spatial – temporal dependencies of catastrophic risks, and to investigate multiple policy options (i.e. interplay between investment in mitigation and risk-sharing measures). Case studies have been demonstrating how these tools can aid a decision process that involves the public and stakeholders from the very beginning.

The apparent lack of transparency inherent to complex risk networks due to the increasing globalization and dynamics of risks calls for close co-

operation among risk players in terms of the exchange of risk information, assessment procedures and methodologies as well as risk handling strategies.

Building on this finding, the paper by ***Capaul*** argues that such a task requires another approach in risk management, called *interactive risk management* that takes into account not only the interdependency of risks but also the *risk life cycle* of risk-bearing systems, entities and situations as well as their interplay with the human element. Interactive risk management will help to lift the veil from hidden risk networks, thus facilitating an early warning system and a risk handling strategy to protect the public, the corporations involved and the environment from devastating incidents.

Following the dramatic cyanide spill of Baia Mare (Romania) in January 2000, a project jointly supported by the Italian Ministry of the Environment and the World Health Organization, has been launched with the endorsement of the European Environment and Health Committee. The methodology presented by ***Frattini and Manning*** is grounded on the definition of an integrated environment and health risk assessment, directed to the development of homogeneous comparison between several countries. The tool is directed to national and local authorities in order to help making first-recourse decisions in terms of emergency planning and risk reduction policies. The methodology was carried out with the involvement of international institutions (e.g. EC Joint Research Centre, the Hungarian National Institute for Environment and Health, the Florida State University, the Danish Toxicological Centre). For the sake of rapidity, the information necessary to run the model was reduced to the minimum set, capable to represent a complete (even if simplified) picture of the site risk. Suitable check lists have been printed for data gathering and a software tool has been developed for data management and results. A first test application was carried out in Bulgaria, with the help of the local Ministry of the Environment and Water. The application required training courses, site visits to selected industries and a final discussion on the results.

Mock is addressing new challenges in the field of risk analysis in the context of advancements in the information technology. Risk analysts are currently faced with far-reaching changes in their professional field. The growing importance of complex systems, e.g. in telecommunication and transport pinpoints the limitations of established risk analysis techniques in the non-nuclear industries. These techniques are identified and rated according to their major goals, modernity, level of system sophistication, manageability, and user satisfaction. The challenging situation in risk analysis is characterized by updating the "lessons learned" from an early ETH Zurich Polyproject on what to do when dealing with integrated regional risk assessment and safety management.

In his paper, ***Lucia*** introduces the mission of the EC - Joint Research Centre, aiming at the protection of the citizen and the environment, and some activities planned in the Framework Program 6 (2003 – 2006), particularly related to the assessment and management of technological and natural risks. The focus of these activities is on:

- Development and maintenance of harmonized European monitoring and reporting systems;
- Accident and disaster analysis and elaboration of lessons learnt, recommendations and guidelines;
- Methodological development in the field of risk analysis, civil protection and emergency management, land use planning and strategic decision-making.

Concluding remarks

The advent of computers, decision support systems, Internet and new methods of calculation and assessment of risk and vulnerability of complex technical systems, up to integrated critical infrastructures, bring new dimensions to the overall governance issues of potentially hazardous technologies in their interaction with people and the environment. The *risk governance* concept has been recently established as an instrument of management, at the societal level, of new emerging risks, or in relation to critical infrastructure complexities. As recent realities show, the unexpected risks and vulnerabilities tend to exceed 'design bases', and even 'plausibility'.

A sad *failure of imagination* in relation to new potential attacks and manners of viewing infrastructures as a weapon has eventually left societies wide-open to events such as the U.S. 9-11 strike. And a sloppy *emergency preparedness* blatantly contradicting the standard red tape rhetoric has contributed to outrageous losses of lives and property, like with the December-2004 post-earthquake tsunami in South-East Asia.

All of a sudden mankind found itself in a new era where, understanding how to protect infrastructures on the one hand, and the quality of life on the other hand, requires new instruments of assessing potential consequences of a large variety of situations from the explosion of a chemical plant, to the decommissioning of a nuclear facility, to loosing control on a satellite re-entry, to the impact of a major near-Earth object, to an ill-advised regulation or political/military move.

The present work is addressing characteristic risks and vulnerability situations in view of assisting governance related initiatives. It endeavors to stimulate the establishment of fresh platforms for *risk dialogue and exchanges with stakeholders* who rightfully demand to be better informed,

and look for some documented indications that the ongoing developments in science and technology would not negatively affect their business; their environment; their *life*. After all people has to have access to satisfactorily reliable and handy tools and computational instruments that would enable at least rough estimations on the risks and vulnerabilities they are currently facing. The advances in the IT & C and the ubiquity of their ways and means revive and bring to the forefront of scientist's attention a plethora of on-the-shelf concepts and methods in applied mathematics, physics, computer sciences, and systems engineering, from analytical models of phase transitions to correlation approaches such as the neural nets, the search for order in chaos, for predictiveness in time series, for complex behavior in simply-minded cellular automata. These, and others, are likely to be increasingly engaged into shaping new governance policies that would hopefully enjoy the participation of a new breed of *informed* stakeholders in complex, if sometimes controversial, decision making situations.

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For the record, let it be said that the manuscript had a complicated history, due not only to the timing and style of the different authors, but also to the essentially emerging nature of the subject and to a shifting emphasis on a variety of issues in the field of decision support systems assisting the integrated risk and vulnerability assessment of complex technical and environmental systems.

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