

**DEVELOPING AN INTEGRATED RISK MANAGEMENT SYSTEM
IN
EMERGENCY MANAGEMENT PROCESS**

by

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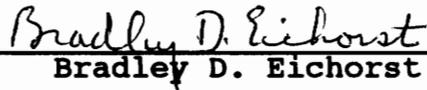
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(ABSTRACT)

This paper focuses on the basis for the development of an Integrated Risk Management System (IRMS) for use by federal government emergency management offices in fulfilling their responsibilities to maintain public health and safety. It identifies that a risk-based approach, which integrates the scientific and technical analyses of risk with the public perception of risk, be adopted to develop an IRMS. An integrated approach to risk management can serve as an "umbrella" of safety over operational and management decision-making. Four major underlying premises in developing an Integrated Risk Management System are proposed. One major premise is interpreting scientific/technical analyses, public perceptions, and acceptability of risks. A second major premise is that a risk-based approach will help to identify problems in risk, rank them, establish priorities, and allocate resources based on risk. A third

major premise is that risk-based standards will help in developing management strategies for acceptability and allocation of different kinds of risks. A fourth major premise is that risk management tools operationalize risk management strategies, leading to implementation of the Integrated Risk Management System in a given target domain.

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1. INTRODUCTION

Management of environmental risks is an important element in the emergency management process for emergency operations organizations (EOOs). An emergency operations organization is an organization with specific emergency functions and responsibilities that are separate from those of the normal operational organization. The management of environmental risks, often referred to as 'environmental risk management,' evaluates alternative risk control and risk reduction actions, then selects and implements these actions (National Research Council, 1983). An effective risk management program can help emergency operations in the long run, when it can effectively support emergency operations organizations and associated organizations who are responsible for coordination and implementation of various functions in an emergency management process.

The emergency management process consists of four phases of activity - mitigation, preparedness, response and recovery - in all types of disasters, and coordinates the

efforts and resources of many different organizations. Mitigation and preparedness activities are generally seen as taking place before the impact of any given disaster, while response and recovery activities are seen as post-impact measures (Figure 1). These four phases are concerned with:

Mitigation - Deciding what to do where a risk to the health, safety, and welfare of society has been determined to exist; and implementing a risk reduction program;

Preparedness - Developing a response plan and training first responders to save lives and reduce disaster damage, including the identification of critical resources and the development of necessary agreements among responding agencies.

Response - Undertaking to comprehend and control the emergency, providing emergency aid and assistance, reducing the probability of secondary damage, and minimizing problems for recovery operations; and

Recovery - Providing immediate support during the early recovery period necessary to return vital life support systems to minimum operation levels, and continuing to provide support until the community returns to normal.

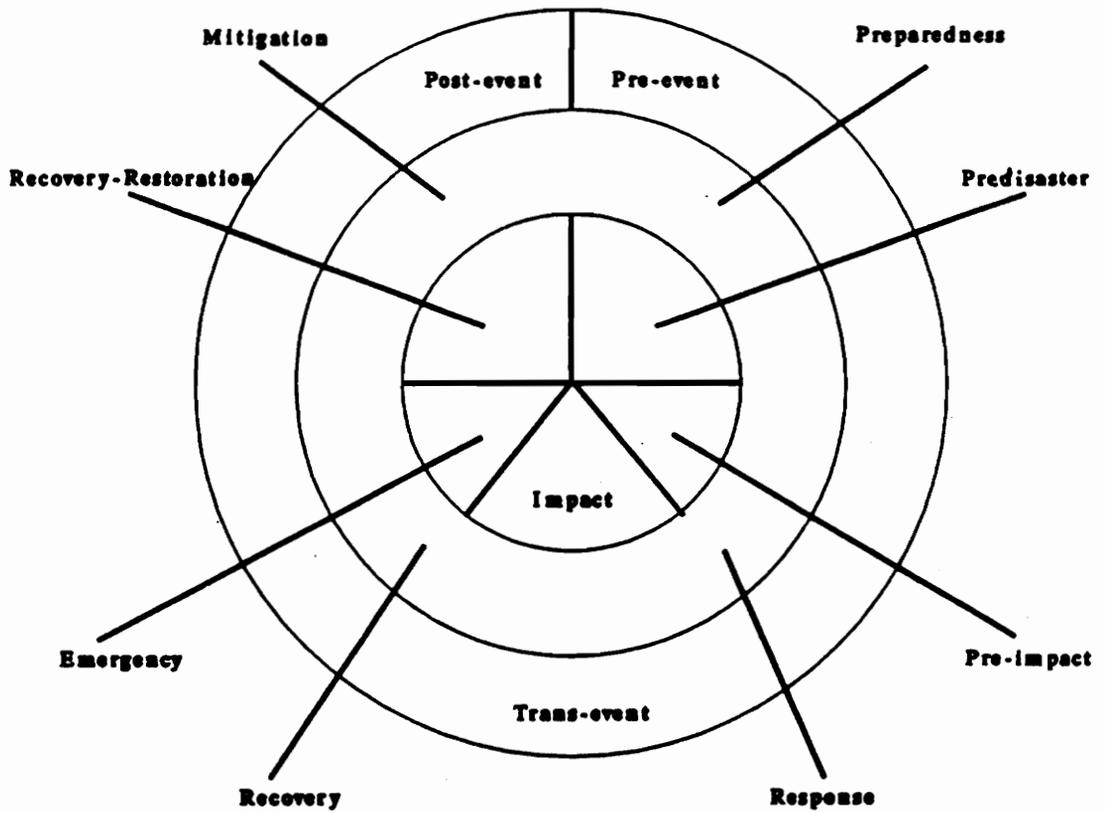


Figure 1. Four Phases of Emergency Management

Source: Adapted from L. K. Comfort (1988).

Mitigation activities are directed towards eliminating the causes of emergencies or significantly reducing the chance that a disaster will occur. The focus here is upon prevention. Mitigation activities have in common the characteristics of being long-range measures. They are taken well in advance, either in response to a specific disaster or after a risk has been identified, and tend to be aimed at hazard reduction or, more simply, at minimizing the chance that an incident will occur that could become a disaster. Interestingly, in the history of emergency management in the United States, the smallest proportion of resources has been traditionally devoted to mitigation activities.

Preparedness activities are those which are undertaken to protect human lives and property in conjunction with threats that cannot be manipulated via mitigation measures, or for which only partial prevention may be achieved. These activities mainly fall into two general categories: actions related to providing an alert that impact is imminent, and actions designed to enhance the effectiveness of emergency operations. Preparedness measures related to providing an alert include the development and improvement of detection and prediction technologies that allow authorities to monitor the environment to insure that they will have

forewarning of environmental threats. Preparedness measures aimed at enhancing emergency operations encompass a variety of activities, including developing routing plans for evacuations, stockpiling medical and survival material for public shelters, assembling lists of community resources and their location for possible use in responding to a given emergency, and training cadre and conducting drills and rehearsals of emergency response plans. Therefore, like mitigation measures, preparedness activities are conducted or undertaken in advance of any particular disaster event. They represent ways of protecting life and property when disasters do strike.

It has been documented that preparedness activities historically have also received comparatively few resources relative to response and recovery. Disaster researchers have for some time documented a general cycle in which there is a great deal of interest in preparedness issues immediately following a major disaster, which declines significantly as time passes. Furthermore, because considerable time is often required to translate such concern into budget allocations and implementable programs, many preparedness strategies have simply failed to get off the ground. Disaster researchers have argued that it is far more

desirable to prevent damage in the first place than it is to try and deal with it after the fact.

Emergency response activities are conducted during and just after the period of impact and focus upon assisting the affected public, as well as minimizing damage from secondary or repeated impact. During the response stage, emergency managers must assess damages, care for victims, coordinate and deploy converging material, and anticipate any additional short range threats. Such activities are usually accomplished through the coordinated efforts of diverse groups - some formally constituted, some volunteer - and managed via an Emergency Operations Center (EOC). An EOC is a central facility from which management and support personnel carry out coordinated emergency response activities. These activities are marked by time pressures and a sense of urgency which are less prevalent in mitigation, preparedness and recovery.

Recovery activities begin shortly after disaster impact and may extend for long periods of time. The objective of recovery measures is to restore the physical part of the community, as well as the quality of life to at least the same levels as before the disaster, and possibly to introduce improvements.

In summary, two points should be reiterated here. First, although the distinction among the four phases of emergency management is largely analytic, the four activities are somewhat time-phased. Mitigation and preparedness measures take place and should be planned for in advance of any specific disaster impact, while response and recovery occur during and following disaster impact. Therefore, practical problems accompany the development of mitigation and preparedness strategies because they must usually be accomplished during so-called normal times, when an environmental threat is not imminent. Historically it has been difficult to mount efforts to engage in these sorts of activities. Response and recovery take place within the context of a disaster impact - clearly non-normal times - and benefit from the operations of an emergency social system as well as from the community's cohesiveness usually promoted in the short-range aftermath.

The second point is that in the past, far more resources and emphasis have been given to response and recovery activities than mitigation and preparedness. It has sometimes seemed both expedient and logical to devote resources to response and recovery. In the future, if emergency management is successfully implemented, the approach should be to acknowledge existing limits but at the

same time to develop creative mitigation measures within these limits.

The mitigation phase, being a long-term process, involves activities during both emergency and non-emergency times. It is in this phase that a risk management program can be very useful.

A structured risk management program can help the risk managers in the EOOs respond to information needs during non-emergency or "normal" operations. It will also help other agencies associated with the mitigation phase in emergency management to have a better understanding of the various risk issues and find ways to manage them effectively. The emergency management system will be strengthened not only by controlling risks during emergencies, but also by reducing risks in the long run. As a long-term program, risk management has the potential to identify and evaluate more comprehensively all available alternatives to reach a risk management decision. Past studies in emergency management have recognized the need for additional attention to an integration of risk management in the mitigation phase of an emergency management system. This paper will attempt to describe the basis for the development of an integrated risk management system for use

by federal emergency management offices in fulfilling their responsibilities to protect public health and maintain safety.

Problem

The risk management approach to be proposed here will be different from more traditional approaches. Traditionally, risk management has been dominated by a three-stage process. It starts with an inventory of operational activities, then attempts to discover discrepancies between public perceptions and expert assessments of the probabilities and extent of hazards, and finally aims to educate the public either to avoid the danger or to accept that the mechanisms that the experts have devised are adequate to reduce risk to an acceptable level.

The above approach has limited the efficiency and effectiveness of environmental protection efforts because it looks at environmental problems separately, relies solely on scientific and technical analysis of identified risk, and ignores the social, economic, and political concerns required to reach risk management decisions. The problem with this approach to risk management, of closing the gap

between public perceptions and the "actual" risk as it is assessed by the experts, is that it is based on the highly questionable assumption that expert perceptions properly represent reality unmediated by sociocultural conditions (Rayner, 1984). Instead, it is proposed in this paper that we need to take a broader, integrated approach geared towards community involvement, public education and information, in addition to scientific and technical assessment of risk. An attempt will be made to address questions such as: Why is there a need to take an integrated approach to risk management? Can we separate risk assessment from risk management? Why do we need an integrated risk management system in emergency management? How is the proposed approach different from other approaches which incorporate both scientific and public assessment of various risks?

Outline of the Paper

The problem set out in this paper will be discussed by using a conceptual framework developed from the literature review on risk management and emergency management. Chapter 2 will provide a comprehensive review of the academic and practitioners' bodies of literature supporting this paper's claim that there is a need for an integrated approach to

risk management. In this regard, the separability issue -- whether risk assessment be separated from risk management -- will also be discussed. **Chapter 3** will provide a conceptual framework for an Integrated Risk Management System (IRMS). It will begin by defining some of the key terms and explaining how these terms are used in this conceptual framework. It will be followed by a discussion to show where risk management lies in a range of management pursuits and why an integrated risk management is appropriate in an emergency management system. Finally, the various components of the IRMS will be described and an attempt will be made to integrate these components and demonstrate how IRMS can be implemented. **Chapter 4** will conclude with a discussion of the implications of this conceptual framework and directions for further research to test IRMS at federal, state, and local emergency operations organizations.

2. LITERATURE REVIEW

Academic body of knowledge

Research on risk originally evolved from the study of natural hazards and from technical safety analysis (Mitchell, 1990). The notion of "risk analysis" was thrust into the public consciousness due to several unfortunate catastrophes, federal legislation, and media attention and interest (Fiksel, 1990). Over the past 30 years, risk analysis has become influential in shaping risk management decisions in both public and private sector organizations. However, risk management has been a natural aspect of human evolution and reaction since the Garden of Eden (Kloman, 1990).

Due to multiple definitions and practices, there is no unique set of steps or guidelines to manage risks. The academic body of knowledge recognizes that there is a need to respond to multiple definitions, complexities, interdisciplinary nature, and practices of risk management.

Ikeda (1986) suggests that risk management should have four major components: science, technology, society, and politics. A new definition of risk management is necessary to integrate these major components. The National Research Council (1983) defined risk management as "the process of weighing policy alternatives and selecting the most appropriate regulatory action, integrating the results of risk assessment with engineering data and with social, economic, and political concerns to reach a decision." This definition conveys that there is a need to focus on the interface between policy decisions and regulatory measures. The interface involves not only science and technology but also politics, social values, and perceptions. There is a need to develop a general framework within which to view the interplay among social and technical factors in risk management (Lave and Menkes, 1985).

Scientists and experts in decision-making tend to recommend that, for complex or important problems, formal (scientific) decision-making methods be used (Fischhoff, et al., 1981). However, attempts to apply formalized decision-making methods, such as Cost-Benefit Analysis, to health and safety decisions have drawn serious criticisms from the public (MacGregor and Slovic, 1986).

An integrated risk management system (IRMS) will take a holistic approach, and therefore, be able to respond to the complexity and interdisciplinary nature of risk management. To arrive at a fair and appropriate risk management strategy one must look at many different social contents - various continua of action, thought, and feeling (Tiemann, 1987). A global philosophy concerning the importance of risks and their management should be incorporated in the approach towards developing an integrated risk management system. Currently, an ever-increasing number of risk professionals and risk managers in industry, government, and academia are devoting a larger portion of their time and resources to the task of improving their holistic approach to, and understanding of, risk management.

An approach to risk management which has generated a lot of attention since the report of the Science Advisory Board to William K. Reilly, Administrator of the U.S. EPA (Sept, 1990), is the risk-based approach. Typically, a risk-based approach is guided by a few principles. It is first necessary to identify hazards. It is then necessary to attempt to quantify the risks associated with these hazards. Finally, priorities must be assigned to risk reduction because of limited resources, and therefore, some technique for establishing priorities must be developed (Stern, 1985).

This risk-based approach makes risk management more effective because it helps to avoid frivolous concerns with trivially low risks and helps focus attention on more dangerous threats.

Even though sound science can help us to establish priorities and allocate resources based on risk, to the extent statutory mandates allow, there are a number of other important factors that go into shaping our priorities: public values, public perceptions, and economic constraints (Reilly, 1990). Unless a risk analysis comprehends the social structure within which decisions are made, it may fall short of understanding either the process or the consequences of those decisions (White, 1988). Social science has a significant role in risk management. But there is too much emphasis on technical and methodological issues, especially concerning the quantification of risks, and a comparative neglect of important perspectives from sociology, economics, political science, anthropology, and psychology (Kraft & Freeman, 1989). Risk management cannot in its entirety be performed as expert assessments, divorced from the political decision-making process and from social values in general. The severity of risk depends on many factors. The task of professional risk managers should be to shed light on these different factors, and certainly not

to hide them through reduction to a unidimensional concept that ignores them (Hansson, 1989). Rayner and Cantor (1987) identified three notions that have dominated discussions on societal risk management:

1. Risk is a definable (i.e., measurable) phenomenon.
2. Societal risk management is concerned with minimizing the probability and/or magnitude of undesired consequences without incurring excessive costs.
3. The assumption that the critical question facing risk managers charged with this delicate balancing act is "How safe is safe enough?"

However, Rayner and Cantor assert that risk management and assessment are improved when societal preferences are given priority over estimates of probabilities and magnitudes of undesired events. Public acceptance of any risk and public involvement are important considerations in risk management decision-making. Public acceptability of risk is more dependent on public confidence in risk management than on the quantitative estimates of risk consequences, probabilities, and magnitudes (Starr, 1985).

Public involvement in the risk management decision-making process is seen as the best way to deal with both the

technical aspects of a problem and the value-centric concerns that will ultimately need to be a part of the risk management decision (Hance, Chess, & Sandman, 1989). Hance et al., (1989) provide several reasons for involving the public:

1. People are entitled to be involved in issues that directly affect them.
2. Involvement in the process leads to a greater understanding of, and more appropriate reactions to, the particular risk.
3. The input of those who live with the risk every day and are familiar with their own needs can lead to better policy decisions and solutions.
4. Cooperation between the agency and the community can increase agency credibility.

Members of the scientific community have been searching for understanding of the differences that exist between the public and the experts in their perception of risk (Sagan, 1987). Covello and Mumpower (1985) noted nine changes between mid-1970s and early 1980s that they considered most important for risk analysis and risk management. Among these changes two are concerned with the public. There has been an increase in participation of special interest groups

in societal risk management, and an increase in public interest, concern, and demands for protection. As a result, public policy directions for energy policy and industrial policy, as well as government regulations, require the public's (electorate's) view towards risks (Burger, 1988).

There is also a cultural aspect of risk perception. Studies, such as Douglas and Wildavsky (1982), Gross and Rayner (1983), and Michael Thompson (1981), indicate that the social organization of the institutions and communities concerned, rather than the risks themselves, determine the policy process. People experiencing different forms of social organization maintain different principles for recognizing a risk, for obtaining social consent to it, and for the distribution of liabilities and benefits arising from it. Thus, effective risk management requires an optimal combination of risk assessment, technical feasibility, human intervention, and political support (Starr, 1985).

The above academic findings will provide a basis for the conceptual framework of IRMS. In addition, the practitioner's body of knowledge developed in the following section describe the more applied aspects of risk management.

Practitioner body of knowledge

There are two major practical problems which arise in the risk management decision-making process. First, it is difficult to define a quantitative measure of risk which can generally be understood, and which permits a comparison of absolute risk levels. The second major problem is the difficulty in arriving at a consensus as to either what risk levels are acceptable, or the costs which should be borne to achieve risk reduction (Stern, 1985; Gori, 1980; Okrent, 1980; Cole & Merletti, 1980). As long as there are large gaps in key data sets, efforts to quantify or evaluate risk on a consistent, rigorous basis or to define optimum risk management strategies necessarily will be incomplete, and the results will be uncertain. In addition, there is uncertainty associated with the existing data. More and better data is needed to develop effective risk management tools, and overcome methodological inadequacies. An additional difficulty in integrating scientific and public values to a risk-based approach is the inevitable value judgements that must be made (U.S. Environmental Protection Agency, 1990).

In spite of all these difficulties, there are a number of factors that must be considered in ranking risk and

setting priorities based on risk. The Science Advisory Board (U.S. Environmental Protection Agency, 1990) identified three major factors. Those factors include the number of people and other organisms exposed to the risk, the likelihood of the environmental problem actually occurring among those exposed, and the severity of the effects, including the economic losses and other damages involved. Public perception plays an important role in determining how these factors are incorporated into the decision-making process. Risk perception experts (especially psychologists Fischhoff, Slovic, and Lichtenstein, 1982) have found in their surveys that public perceptions of environmental risk tend to incorporate deeply-held subjective values, like justice and equity, that although difficult to quantify, reflect important elements of the quality of life that government is bound to protect. Therefore, scientific understanding alone should not be the sole determinant to be used in environmental risk management.

Another aspect emphasized in the applied literature is the risk infrastructure. It includes the spectrum of risks and their inter-relationships. Effective risk management can only be accomplished by an understanding of the risk infrastructure in a given situation. A specific risk

management organization can determine the spectrum of risks and their interrelationships by means of a department-by-department inventory of activities and associated risks, by following the flow of material or products through the facility, or by following a number of representative individuals through their daily work routine. Each of these surveys will provide a different cross section of the risk infrastructure (Stern, 1985). With this understanding of the risk infrastructure, an approach to risk management should be to reduce the largest risks first (Doll, 1981). But such a strategy requires that a wide variety of risks be expressed in comparable terms (Cairns, 1975; Albert & Altshuler, 1976; Kelsey, 1978; Cohen & Lee, 1979; Reissland & Harries, 1979; Solomon & Abraham, 1980).

It may be perceived that ranking various types of potential risks is not an easy task. However, this task can be made easier by trying to identify certain situations, individuals, or combinations of circumstances which lead to excessive health risk. A carefully-conducted survey of each facility, the elimination of unnecessary risk, and investigations that focus on less tractable, delayed effects will provide a better picture of the risk infrastructure. In particular, efforts may be directed toward developing strategies for the management of risks with (a) low

probabilities but high consequences; (b) delayed effects; and (c) large variations in individual susceptibilities to a given risk (Stern, 1985).

Integration of risk assessment and risk management

In 1983 the National Research Council completed a study on managing risk, leading to a report *Risk Assessment in the Federal Government: Managing the Process*. The report focused on improving risk assessment and risk management within the government. The Council recommended that risk assessment be distinguished from risk management:

We recommend that regulatory agencies take steps to establish and maintain a clear conceptual distinction between assessment of risks and considerations of risk management alternatives; that is, the scientific findings and policy judgements embodied in risk assessments should be explicitly distinguished from the political, economic, and technical considerations that influence the design and choice of regulatory strategies. (NRC, 1983, p7)

The above conceptual distinction or the divorce between risk assessment and risk management is the formulation of risk assessment as specific decisions and authorities separated from other parts of environmental policy making. Proponents of the separation argued that risk assessment is the characterization of potential adverse effects of exposures

to hazards, and include estimates of risk and of uncertainties in measurements through the use of plausible assumptions. Risk management, in contrast, is the public process of deciding what to do in the face of such estimates. The reason for separating these two processes, according to these proponents, is that removal of risk assessment from the regulatory agencies will result in a clear demarcation of the science and policy aspects of regulatory decision-making. Therefore, regulatory decision-making will not be affected by the values of the risk assessors.

This separation of certain aspects of risk assessment from risk management has generated some controversies in the risk assessment literature. The major question in this separability issue is whether the empirical, scientific, and technical concerns in estimating the risks either can or should be separated from the social, economic, political, and ethical concerns of how the risks should be managed.

The NRC report noted that much of the controversy that surrounds the use of risk as a guide to making regulations may arise from the confusion between risk assessment, a largely scientific enterprise that may involve science policy decisions, and risk management, which is the process

by which a regulatory agency decides what to do about the results of a risk assessment. Russell and Gruber (1987), supporting the NRC report, said that the two processes are to be separated. They argued that risk assessment be separated from risk management because they differ methodologically.

While risk assessment consists of only three steps: hazard identification, dose response evaluation, and exposure analysis, risk management takes into consideration various judgements, including acceptability, feasibility, equity, and economics. Another reason for separation is typological difference. The risk assessment process involves "hard" science and does not incorporate political and economic values. Risk management is considered as social science and incorporates socio-economic and political values. The third reason given by Russell and Gruber for separation is ownership. They believed that risk assessment process should be administered by scientists and technicians, who are to be insulated from policymakers and the public. The risk managers, consisting of policymakers and the public, will evaluate alternative risk control actions, select an acceptable range of alternative decisions and implement them within the technical constraints identified by the risk assessors.

There are at least two implicit assumptions behind Russell and Gruber's arguments for separating risk management from risk assessment. First, risk managers will not misinterpret uncertainties in the analytical results produced by the risk assessors. Second, the risk assessors will be able to produce risk assessment reports which are value free. These assumptions raise several fundamental philosophical and methodological questions. Will the risk managers be able to recognize and overcome the limitations of scientific risk assessment without interacting with the risk assessors? Is risk assessment objective and value-neutral? Since there is no one best method affecting a policy, can risk assessors choose the best method without knowing for whom risk assessment is done and for what purpose? The obvious answer to all these questions is "no" and therefore there is a need to integrate risk assessment and risk management.

William Ruckelshaus, who served as EPA's administrator (1970-73, 1983-85) also stressed the importance of separating risk assessment and risk management. He said that "risk assessment at EPA must be based only on scientific and scientific consensus. Nothing will erode public confidence faster than the suspicion that policy considerations have been allowed to influence the assessment

of risk" (Ruckelshaus, 1983). According to him, "although there is an objective way to assess risk, there is, of course, no purely objective way to manage it" (Ruckelshaus, 1983). His view, portraying the old image of scientific objectivity and rationality, is challenged by philosophers, historians, and sociologists (Mayo, 1991). Ruckelshaus, however, acknowledged that separating the assessment of risk from its management is difficult to accomplish. In this regard, he mentioned that "...values, which are supposed to be safely sequestered in risk management, also appear as important influences on the outcomes of risk assessments" (Ruckelshaus, 1984).

Psychometric studies of risk perception, like the work of Paul Slovic, B. Fischhoff, S. Lichtenstein, and others, (for example, Fischhoff et al. 1981, 1982; Slovic et al. 1980), have found that there is no assurance that experts' judgements are immune to biases. Even if there is a greater understanding of scientific uncertainties and better estimates of risk, giving experts an exclusive franchise for risk assessment and concluding that the public should be removed from the risk assessment process would mean substituting short-term efficiency for the long-term effort needed to create an informed citizenry. This leads to the question whether only resolving uncertainties and

recognizing limits of risk assessment methods will improve risk assessment process. In this regard, Silbergeld's work needs to carefully examined.

According to Silbergeld (1991), there are severe consequences of the separation of risk assessment from risk management. However, she focused only on the consequences of misinterpretations of uncertainty due to the divorce and gave two reasons for highlighting uncertainty: "It is critical part of the decision to act, and it crosses the line between the technical assessment and the policymaking management dichotomy" (p.112). She discussed five scientific issues of uncertainty: the distinctions between initiators and promoters of carcinogenesis; statistical handling of data and the graphical presentation of risk assessment; the appropriate interpretation given to weight of evidence; the definition of potency; and the use of safety factors. There is no doubt that these issues have major implications for policymaking. She stressed that these issues are neglected and the problems arising from these issues are concealed to a large extent by the current trend to distinguish risk assessment from risk management:

This intellectual separation tends to exacerbate the problems associated with these issues because the discussion of these problems, insofar as they involve issues of scientific uncertainty

usually occurs within the context of a so-called scientific risk assessment exercise. (Silbergeld 1987, p.148)

Silbergeld concluded that if the scientists were excluded from the policymaking process based on the implications of scientific choices, they can only guess how their choices may affect policy. She did not think that the social value of separating risk assessment and risk management has been positive:

It has not resolved the basic problems with risk assessment as a mode of analysis or decision making in environmental issues. Stratifying the process and emphasizing risk communication as a method of resolving disputes over the content of risk-related decision making has not improved the public's acceptance of the EPA's actions over the past few years, despite the best hopes of Ruckelshaus and his colleagues. (Silbergeld, 1991, p.112)

It is true that the failure to understand how the scientific uncertainties are resolved in specific risk assessment exercise limits the policymaker's understanding of the role of uncertainty in policymaking and the different perspectives on the issue of uncertainty. However, she puts too much emphasis on the scientific methodologies and practically neglects the societal argument for integrating risk assessment with risk management:

Indeed, both science and policy could be better served by recognizing the scientific limits of risk-assessment methods and

allowing scientific and policy judgement to interact to resolve unavoidable uncertainties in the decision-making process. (Silbergeld 1991, p.99)

She exaggerated the public's affinity towards scientific methodologies and their trust on science. It seems that she believes that the public will automatically trust policymakers and scientists if these two groups interact with each other and recognize the scientific limits of risk assessment methods. She emphasized only the role of uncertainty in policymaking and did not even recognize public input, their perception and values, in improving risk assessment. In this regard, Slovic (1991) rightly points out:

Lay people sometimes lack certain basic information about hazards. Their basic conceptualization of risk, however, is much richer than that of the experts and reflects legitimate concerns that are typically omitted from expert risk assessments. (Slovic 1991, p. 63)

Based on these arguments this paper supports the integration of risk assessment and risk management. If the purpose of risk assessment is to aid decision-making, then, risk assessors should know for whom and for what purpose risk assessment is being done. Solving complex decision problems requires a comprehensive approach which carefully defines the available alternatives and assesses the direct and

indirect costs, risks, and benefits of these alternatives in light of the objectives of the decision making institution. Thus, if risk assessment is to serve specific decision aiding purposes, it must be seen as a part of a more comprehensive analysis, rather than as a separate tool.

The other point is that most people will agree that there is a need for greater scientific and methodological understanding in the risk assessment process, even those who view that risk assessment should also incorporate social and political values. However, if there is too much emphasis on technical and methodological issues, especially concerning the quantification of risks, and a comparative neglect of important perspectives from sociology, economics, political science, anthropology, and psychology, risk assessment may fall short of understanding either for whom or for what purposes it is being done. Risk management cannot in its entirety be performed as expert assessments, divorced from the political decision-making process and from social values in general.

To have an effective risk policy it is necessary that the policy be acceptable to the public. Public acceptability is more dependent on public confidence in risk

management than on the quantitative estimates of risk consequences, probabilities, and magnitudes.

3. CONCEPTUAL FRAMEWORK OF AN INTEGRATED RISK MANAGEMENT SYSTEM

Definition of key terms

Researchers in risk management have defined 'risk', 'risk management', and other associated terms in different ways. Therefore, it is necessary to define some key terms used in this paper. The focus of this paper is on managing environmental risks. The word 'risk' in this sense is used as the probability that an environmental hazard will occur and the characteristics of that hazard, while 'risk perception' helps illuminate the values attached in evaluating different qualities of environmental hazards. Certain attributes of hazards, such as the catastrophic potential, voluntariness, familiarity, controllability, dread, understanding and trust, etc., make a hazard appear 'more risky' or 'less risky' than the "actual" risk estimate of an environmental hazard. Public perceptions of risks play a vital role in evaluating different alternative risk reduction and risk control actions.

'Risk management' comprises the evaluation of alternative risk reduction and risk control actions by qualitative and quantitative characterization of risks and understanding public perceptions of risks, and the selection of acceptable alternatives. An 'acceptable risk' for an emergency management office is defined as the environmental risk associated with the most acceptable risk reduction or risk control action from a range of options evaluated through integration of scientific and technical assessment with social, economic, and political concerns to reach a decision.

To reach an acceptable risk management decision a risk-based approach is used. A 'risk-based approach' first identifies possible hazards. It then integrates the scientific and technical analyses of risk with the public perceptions of risk associated with each hazard for identification, characterization and evaluation of alternative risk reduction or risk control actions.

Risk-based standards are then developed from the risk-based approach. A 'risk-based standard' is defined as a standard which restricts the probability of a hazard to a predetermined acceptable level of risk. The management strategies which are used to implement the standards are

referred to as 'risk management strategies' and the tools used to implement the strategies are the 'risk management tools'.

Risk Management on an uncertainty spectrum of management pursuits

According to Kurstedt (1986), there are five major types of management pursuits, each with a degree of uncertainty. Figure 2 illustrates the range of management pursuits arranged according to an uncertainty scale. Process management deals with normal or "business-as-usual" management activities, where the objective is achieving the same known end of a routine operation or task. As managers, we know where we are (WWA), where we want to be (WWWTB), and how to get there (HTGT).

The next management pursuit is project management, where we know the start and have specifications for the end. A program is next along the scale and is a management pursuit with a definite starting point, yet with only a qualitative fix on the outcome. Further along the scale, and further away from business-as-usual, a management problem is a pursuit with a definite starting point but a completely unspecified end. When a problem occurs, and we

find out about it, we know where we are (WWA) and must determine WWWTB and then HTGT. Finally, at the highest level of uncertainty, a perplexity is a pursuit for which neither the start nor the end and nothing in between can be specified.

Management of perplexities is at the top of the uncertainty scale, while process management falls at the bottom (Kurstedt, 1986). Risk management, in this range of management pursuits, falls under the management pursuit called a program. Risk management lies in the middle of the entire spectrum of management pursuits, and is lower in the uncertainty scale than preparing for the management of emergencies, which is an example of perplexity management. Consequently, risk management decision-making occurs at a lower level of uncertainty than that confronted by emergency preparedness (a perplexity) or emergency response (a problem).

Managing risk is more certain because, unlike managing emergencies, we know (1) where we are (WWA), (2) we have a fix on where we want to be (WWWTB), and (3) we can design a program for how to get there (HTGT). However, emergency management may be made more effective with the inclusion of a risk management program, early in the range of management

pursuits and closer to "business as usual." Emergency management may become more effective because inclusion of a risk management program in the emergency management process will help to reduce some uncertainties during emergencies.

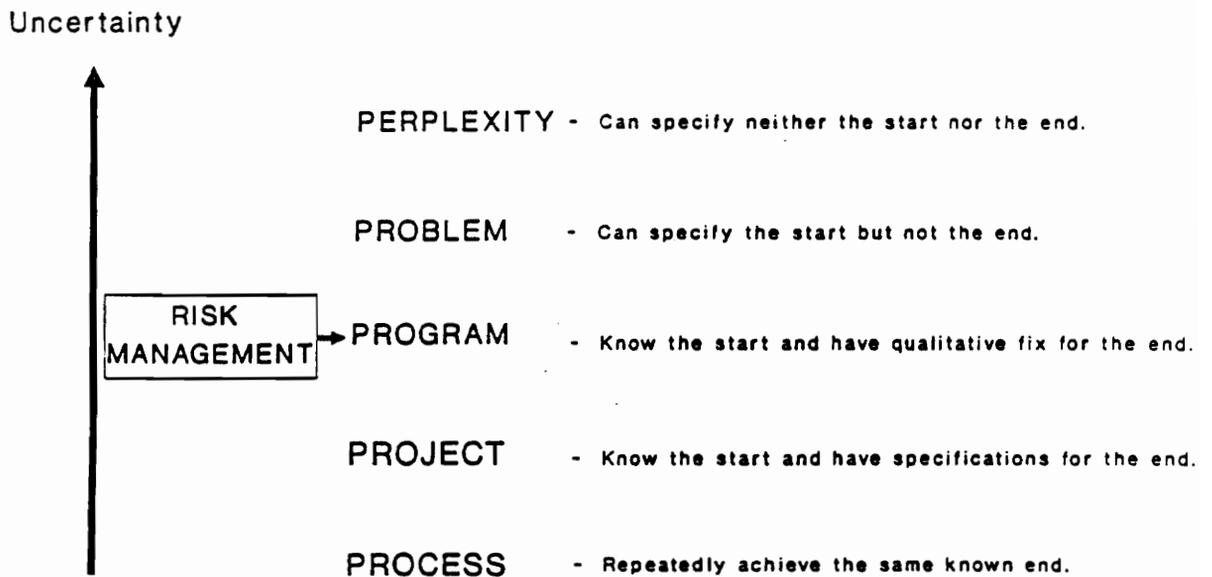


Figure 2. Risk Management depicted on Kurstedt's (1986) uncertainty-based spectrum of management pursuits

Integrated Risk Management System (IRMS)

There is a need to integrate both scientific and societal knowledge into the risk management decision-making process. An integrated risk management system can provide for recognition and reconciliation of the different values various groups have towards managing risks, and therefore can deal legitimately and effectively with environmental risk problems. The proposed IRMS integrates both objective and subjective judgements for determining the acceptability and allocation of risks. It weighs policy alternatives and selects the most appropriate one for a given risk management problem.

Two sets of operational functions exist in the IRMS. One set of operational functions is designed to support the management of risks during emergencies. However, on a long-term basis, another set of operational functions of IRMS is designed to operate during 'normal' or non-emergency times, in support of long-term emergency management. In this long-term operational mode IRMS has a significant role in the mitigation phase of emergency management. As a long-term program, risk management in the IRMS has the potential to identify and evaluate more comprehensively all available alternatives to reach a risk management decision. A global

philosophy concerning the importance of risks and their management should, therefore, be incorporated in the approach towards developing an integrated risk management system.

Four major underlying premises in developing an IRMS are discussed: (1) interpreting scientific and technical analyses, public perceptions, and acceptability of risks; (2) utilizing a risk-based approach, which integrates the scientific and technical analyses with the public perceptions of risk, will identify the different information needs for setting standards; (3) developing management strategies for acceptability and allocation of different kinds of risks from risk-based standards; (4) operationalizing risk management strategies with risk management tools.

a) Interpreting scientific and technical analyses, public perceptions, and acceptability of risks

In recent years risk analyses, scientific and technical analyses, risk acceptance, and the development of risk management strategies have gained increasing weight. A large number of publications, articles and conferences on risk analysis have dealt with the problems of risk

management due to misinterpretation of scientific and technical risk assessment and misinterpretation of public perceptions and acceptability of risks. It is recognized that there is a fundamental problem of linking scientific risk assessment and public perceptions to arrive at a consensus for acceptable risk management decisions. The problem of finding a linkage to integrate both experts' and public views is a difficult one.

To make better risk management decisions, the risk managers should recognize the limits of both scientific assessment and public understanding of risks. In order to improve scientific understanding the scientists can become more involved in integrating diverse types of complex information and have peer review. Also, ways must be found to help risk managers incorporate complex outcomes and more explicit depictions of uncertainties into their decision-making process. In order to improve the public's understanding of risks, there is a need for better communication of risk information. This can be done through greater awareness of the nature of risk perceptions, and the fundamental values and concerns that underlie those perceptions. Research scientists and physicians, industrial spokesmen, governments, media, and a number of important intermediaries should engage in more creative efforts to

communicate risk information to the public. These various parties can have a hand in shaping the public's reception of risks.

There are, however, communication problems due to different ways in which scientists and the public interpret risk information. In this regard, it is necessary to take into account the different backgrounds and standpoints of the parties involved. Risk managers and their expert advisers sometimes characterize the public perception of risk as inaccurate or distorted. These characterizations only reflect the risk managers' own inability to deal with different interpretations and viewpoints. Therefore, a closer scrutiny and proper interpretations of differing perspectives are needed, where the different needs and standpoints of the parties involved are taken into account.

b) Utilizing a risk-based approach for setting standards

There may be different approaches to developing a basis for an integrated risk management system. An approach which has generated a lot of attention since the September, 1990, report of the Science Advisory Board to William K. Reilly, Administrator of the U.S. EPA, is the risk-based approach.

In this paper, a risk-based approach is proposed but with some modifications.

The risk-based approach to be followed in IRMS will incorporate both scientific and public assessment of various risks in order to set standards for environmental protection and safety. We differ from those who view that standards should be set based only on scientific and technical analyses. They argue that setting up standards requires actual quantification and estimation of risks; thus public perceptions of risks have no role in setting these standards. According to them, public involvement in risk-based decision-making process should take place after the standards are established, when understanding public perceptions of risks is necessary to implement those standards and to develop risk management strategies and tools.

However, this approach to gaining public trust and acceptance in implementing the standards has not been effective and has been under severe criticism from the public. Risk managers have faced more frustration than success in implementing standards established without public understanding of risk. Again, the issue is not only achieving public understanding of risk, but also achieving

an understanding of public attitudes toward dealing with risk-based decisions. Therefore, utilizing a risk-based approach, which integrates the scientific and technical analyses with the public perceptions of risk, will identify the different information needs for setting standards.

c) Developing management strategies for acceptability and allocation of different kinds of risks from risk-based standards

Implementation of risk-based standards can be accomplished through risk management strategies developed as a component of the Integrated Risk Management System. These risk management strategies would lead to greater acceptability of risk management decisions because the standards were set through integration of scientific assessment and public perceptions. However, lack of information is always a problem in developing risk management strategies and making risk management decisions. Also, risk management decisions are often made under conditions of uncertainty. Many competing strategies have been developed for decisions under conditions of uncertainty. Under the constraints of lack of information and conditions of uncertainty we still need to develop

management strategies to implement risk-based standards and make acceptable risk management decisions.

There is no generic set of risk management strategies which risk managers may use to implement an IRMS. Effective strategies may have to vary from one federal agency's emergency management office to another. The purpose here is not to identify a specific set of strategies because unless the risk-based standards are known specific strategies cannot be developed. But, it is realized that an overall risk management strategy can be developed which will help risk managers to understand the role of specific risk management strategies in the IRMS and to identify some important elements for developing effective strategies.

Risk managers, consciously or subconsciously, have to deal with an overall strategy to implement the risk-based standards in the IRMS. This overall strategy is referred to here as a 'grand strategy.' The 'grand strategy' will lay out how the risk managers intend to implement the risk-based standards, and therefore, to accomplish an IRMS in their emergency management system.

A 'grand strategy' includes and integrates all the information used in establishing risk-based standards. It

is holistic in nature because it incorporates not only scientific and technical information necessary to develop specific strategic options to implement the standards but also includes different perspectives suggesting different types of strategic solutions. Each perspective should be evaluated to determine the degree of feasibility in implementing the standards. Constraints such as financial resources, cost of information, time, degree of uncertainty, public acceptability of the strategy, etc. should be carefully examined.

A grand strategy should proactively respond to changes in the internal forces operating in the IRMS as well as external forces influencing the IRMS. It should relate execution to formulation for each strategy. It should be able to administer, implement, and verify the status of each strategy. Balancing cost, schedule, quality, and public involvement are essential components of a grand strategy. It must span interdependent units of analysis, such as a federal agency's emergency management office, its project sites, and its various staff echelons and/or contractors. Finally, a grand strategy should promote linkages among different levels of an emergency management office, between groups and individuals involved in the IRMS.

There can be competing risk management strategies for making decisions under conditions of uncertainty. However, a grand strategy will enable all of these specific strategies to reflect both expert and public concerns towards risk. These strategies will not be developed in a vacuum if they evolve from this grand strategy. Even though policy makers will finally lay down the specific risk management strategies, the information and the method used in developing the strategies from the grand strategy would ensure implementation of risk-based standards efficiently.

d) Operationalizing risk management strategies with risk management tools

The primary concern of the proposed Integrated Risk Management System in the emergency management system is to make emergency management more effective through reduction, control, and allocation of environmental risks in the four phases of emergency management. It was discussed earlier that this concern should be addressed by integrating scientific and technical assessments with public perceptions of risks. It was also discussed how a risk-based approach could be utilized to accomplish this objective and to develop risk-based standards and risk management strategies. Following this, a secondary concern is to implement IRMS by

operationalizing risk management strategies with appropriate risk management tools. The specific risk management tools should be developed after the risk-based standards and the strategies to implement those standards are formulated. However, five generic management tools constrained to risk management are proposed below to address the primary concern of an IRMS.

i) Methods

Improved scientific and technical methods can eliminate biases and limitations of risk assessment. Research and development can improve understanding of the scientific and technical measures. Risk managers would be able to understand the problems in scientific methods and be able to compare different quantitative measures and their appropriateness to decision-making. For example, it is important to know which statistical test will give a better risk estimate -- a maximum likelihood estimation or a Neyman-Pearson test.

ii) Guides and Rules

The policies, plans, procedures, standards, instructions, directives, constraints, specifications,

conditions, and laws are some formulation tools or guidance that can be used to implement risk management strategies and accomplish the goals and objectives of an IRMS. For example, regulatory emission and performance standards are used for guidance to risk management decisions. The guides and rules for managing risks can be developed by understanding key public issues. Public outreach programs provide a starting point along with the technical elements. Hearing from people is the key element that often wins their trust. Creative ways of reaching a middle ground through negotiation and compromise can often mean a solution to establishing guides and rules. Mechanisms such as public reviews, monitoring groups and stations, public hearings and local control mechanisms can help in formulating plans and policies to operationalize the risk management strategies.

iii) Database and Information

Acquiring, storing, retrieving, and manipulating data to generate information are important in providing information for risk reduction to the public. Generation and portraying of information from the data-to-information chain may include communicating risk in a plain language. Risk communicators engaged in this process will require sufficient time, personal commitment, and background

information to explain alternatives to risk reduction. This will empower the citizens to participate in risk management and in setting acceptable risk-based standards. Also long-term investment should be made in solving environmental problems. For example, we can create educational programs for both youth and adults, using school systems, the media, and other resources to build a knowledge base of comparable risks, to identify new risk management tools, and technical solutions to environmental problems.

iv) Relationships and Structures

Strong relationships and structures within the management domain provide stable management decisions. They tie together "what is managed" and "who manages." Strong organizational structure, work breakdown, communication, cooperation, and coordination are the basis for successful management. Under the constraints of risk management these tools can be modified to have an effective risk management program in the emergency management process.

v) Incentives

Risk managers must provide incentives to different groups to ensure that risk management strategies are

implemented. Examples include marketable permits for new innovation in reducing risks, tax credits and compensation.

These five generic management tools constrained to IRMS are not mutually exclusive, exhaustive, and independent of each other. Detailed investigation of the existing standards for any federal, state, or local agency, identification of discrepancies and problems in those standards, identification of options for developing risk-based standards, and modification and effective implementation of risk-based standards would finally generate specific risk management strategies and tools in the IRMS.

Implementation of IRMS

The conceptual model illustrated in Figure 3 will help to understand how IRMS can be implemented in a federal agency's emergency management office. The figure shows the integration of various concepts leading to the IRMS concept.

The risk analysis theory evolves from two concepts: scientific and technical analyses, and public perceptions of risk. Each concept describes a different approach to defining, assessing, and making decisions about risks.

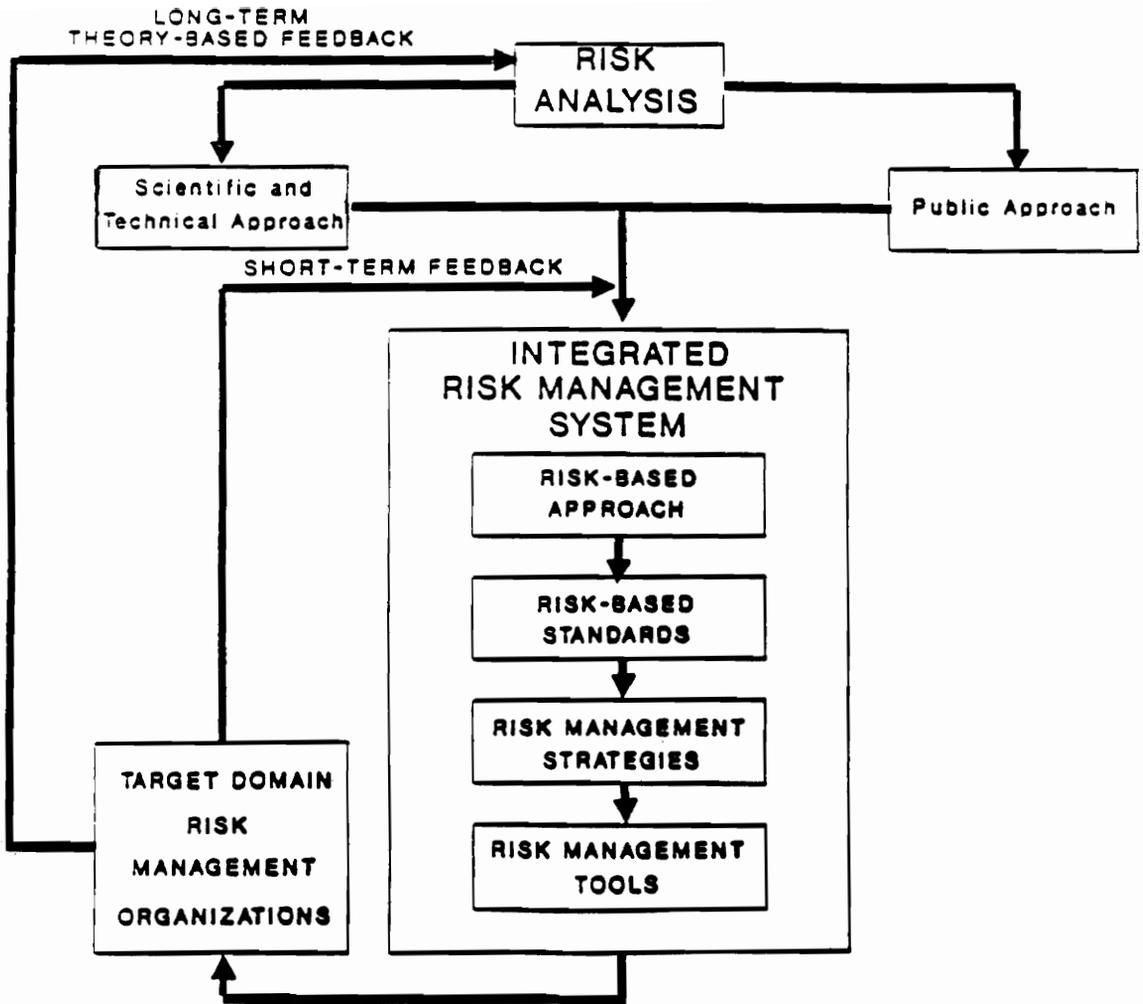


Figure 3. Conceptual Model of an Integrated Risk Management System

The scientific and technical analyses emphasize values of rationality, efficiency, and expertise, while public perceptions stress subjective, experiential, and sociocultural values. Although each concept incorporates public values into decisions, one does so indirectly and the other directly.

An Illustration

The Emergency Management System (EMS) is utilized by the U.S. Department of Energy (DOE) as an integrated mechanism for the development, coordination, direction, and maintenance of activities in the four phases of emergency management: preparedness, response, recovery, and mitigation. The EMS consists of emergency operations organizations (EOOs) responsible for implementing requirements and standards established by DOE for emergency management at various facilities owned by DOE and throughout the DOE organizational complex.

A key objective of the DOE-EMS is to ensure that DOE facilities develop and maintain emergency planning, preparedness, and response capabilities, as well as effective public and interagency communications, to minimize the consequences to workers and the general public from

events and accidents involving the release of hazardous materials (U.S. DOE, 1989). To effectively plan for such emergencies, a comprehensive hazards assessment specific to each facility is performed. The objective of the hazards assessment is to provide a measure with which to determine the extent and scope of emergency planning and preparedness activities required for a particular facility (U.S. DOE, 1991).

The hazards assessment methodology (U.S. DOE, 1991) involves the following steps:

1. Develop a complete description of the facility being analyzed.
2. Identify hazards within the facility. Screen out those hazardous materials which exist in such small quantities in the facility that they pose no appreciable potential hazard consequences (i.e., they do not exceed threshold criteria). This is determined by comparison of material quantities with predefined threshold criteria.
3. Characterize the remaining hazards in terms of their physical and chemical properties, as well as their specific location within the facility.
4. Identify initiating events and accident scenarios that could lead to a potential release of hazardous materials,

and specify the release characteristics (i.e., source terms).

5. Calculate and analyze the potential consequences resulting from the release of hazardous materials.

The facility-specific hazards assessment is followed by emergency response plans developed for each DOE facility through the establishment of an Emergency Planning Zone (EPZ) for each facility. An EPZ is defined as an area around a facility within which detailed response planning would provide flexibility in both preparation and capabilities. It is established to identify geographical, administrative, and jurisdictional areas for which specific planning and training must be provided, predetermined standards must be implemented, and emergency response officials should be prepared to make judgements related to the initiation of protective actions.

There are several deficiencies in the DOE-EMS. First, it gives very little emphasis to the mitigation phase of emergency management and focuses attention mainly on emergency preparedness and response phases.

Secondly, the threshold criteria for assessing hazards are predetermined. DOE-EMS develops standards and

requirements at the federal level through adoption of the "regulatory standards" and standards developed from "good industry practices." The "regulatory standards" are developed based on the recommendations of the Nuclear Regulatory Commission (NRC) and the U.S. Environmental Protection Agency (U.S. EPA). The standards developed from "good industry practices" are informal as they are developed by various industrial organizations, for example, American Industrial Hygiene Association, to promote industrial safety for the workers and the public. The problem with these standards is that they are developed largely by scientific experts and do not properly reflect socio-economic and political considerations.

Public involvement takes place in the standard-setting process but the mechanisms used (for example, public hearings, public notices, mediated negotiation, etc.) may not reflect the values of all public interest groups. At least when DOE adopts standards other than the regulatory ones it is much easier for the DOE to evaluate those standards, modify and adopt them. DOE has greater flexibility in modifying the standards developed from "good industry practices" before adopting them. The proposed risk-based approach may help DOE to modify and adopt

standards, and manage risks in the emergency management system.

Thirdly, each facility owned by the DOE adopts the "regulatory standards" and standards from "good industry practices." A facility conducts hazards assessment based on predetermined threshold criteria, standards and requirements established by the DOE at the federal level. Even though the hazards assessment is facility-specific and some of the DOE standards and requirements are modified, the problem of integrating scientific and public values in modifying the standards and requirements still exist at the facility level.

Finally, the DOE-EMS does not have any long-term risk management program to control and reduce risks not only during emergencies but also during "normal" times.

Therefore, as discussed earlier, there is an overall need for the development of an integrated risk management system within the DOE Emergency Management System. It is DOE's responsibility to make EMS more effective by maintaining public health and safety. It is both desirable and possible to protect the environment and public health in a consistent manner through the establishment of a risk-

based framework for the standards setting and implementation process.

The logical starting point is the identification of existing standards for controlling hazards. Once identified, the risk basis (or lack thereof) needs to be determined and potential discrepancies or omissions need to be noted. This could be achieved by including both scientific experts plus representatives from various public interest groups in the standard setting process. Their job will first be to interpret the scientific analyses and public perceptions of risks associated with the hazards, and then to come to a consensus in developing new standards or modifying the existing standards.

A risk-based standard set up by this process should restrict the probability of occurrence of an event to some predetermined "acceptable" level (or range of levels). However, there may be a need to modify these standards in EOs at different sites due to different environmental settings and different public values of estimated risk at those sites. So even though there will be a uniform set of risk-based standards at the federal level, the EOs at the sites will still be able to modify the uniform standards

with local options for greater stingency using the same risk-based framework.

It is recognized that the setting of standards is a difficult task because it is difficult to get experts and representatives of the public to agree on what constitutes an acceptable risk. One potential method is to establish a range of risk values that encompasses a generally agreed-upon range.

Implementation of risk-based standards derived in this fashion can then be accomplished through developing risk management strategies and tools. Two major issues are to be addressed in this regard - resolution of inter/intra agency issues and the development of DOE guidance. Inter/intra agency issues include compatibility with other regulations, development of compliance schedules, and reaching agreements on appropriate regulatory actions. The DOE guidance should establish the risk-management framework, i.e., IRMS, that accounts for the process of integrating scientific analyses and public perceptions of risks.

4. CONCLUSION

Summary

This paper attempts to provide a conceptual understanding of an integrated risk management system that can be used in the federal emergency operations organizations. Most of the federal emergency management offices have established emergency management systems but very few (if any) have developed any systematic and structured risk management programs for the four phases of an emergency management system: preparedness, response, recovery, and mitigation.

The emergency plans that are developed to prepare federal agencies for emergencies require that emergency managers be able to respond promptly, efficiently, and effectively to any emergencies. To determine the extent and scope required for emergency planning and preparedness activities, an emergency plan must be based on a hazard assessment, developed from vulnerability and target

analyses, probabilistic risk assessments, environmental assessments, environmental impact statements, and other inventory documents. However, there is no clear evidence that hazard assessment is followed by any organized risk management program in the four phases of emergency management. Most emergency management offices at the federal level do not require risk management in their emergency management system. There is no provision in the emergency management system to reduce, control, and allocate risks through a risk management program either during the preparedness and response phases or during recovery and mitigation phases. This paper, therefore, proposes that an IRMS be developed for the four phases of emergency management.

The emergency management process is not likely to be effective if it is treated as a purely technical exercise. To reduce uncertainties and cope better with emergencies a risk management program should be conducted also. An IRMS should be developed not only by "experts" but also through public involvement. Due respect must be given to the public's views even if the perceptions of the public differ from those of the so-called "experts." Somehow the technical analysis has to be integrated with public input if the emergency management process is to be effective.

The base of the IRMS concept is the risk-based approach which integrates the scientific and technical and the public approaches. The risk-based approach helps in formulating the risk-based standards. To implement the standards a set of risk management strategies will be developed. This would require identification of the constraints unique to risk management and constraints that the federal agency's emergency management office face to implement an IRMS. Finally, appropriate risk-management tools will be developed to ensure that the IRMS is accomplished in the emergency management system.

How to test the IRMS concept?

The IRMS model can be tested by applying it in a federal emergency management system. Case studies of emergency operations organizations (EEOs) can be conducted to identify constraints unique to managing risks in those organizations in the four phases of emergency management. Through careful investigation several issues may be examined. In the first phase research may document how standards, management strategies and tools have been developed by these EEOs. Has there been any attempt to evaluate the effectiveness of these standards, risk management strategies, and tools, and, if so, how was

evaluation conducted? In the second phase the IRMS model may be used to modify existing standards, risk management strategies and tools. Then, using criteria for effectiveness of IRMS, data may be collected on perceptions of risk managers about the effectiveness of IRMS. It may be recognized that the second phase of the research will be a long-term process.

Usefulness of IRMS

The test for effectiveness of the IRMS concept may produce results of general usefulness:

1. The concept of using an IRMS to help manage risk and uncertainty;
2. An understanding of how to develop strategies and use tools to provide acceptability of risk by different interest groups and to allocate different kinds of risks.
3. An increased understanding that experts and public play equal roles in the risk management decision-making process.
4. Experts will develop an appreciation and an understanding of public perceptions of the risks of technology and realize and accept the fact that these perceptions must

play an important role in the risk management decision-making process.

5. Early and real involvement of all affected parties in the risk management decision-making process.

Concluding Remarks

It is the responsibility of any federal agency to maintain public health and safety for all of its operations. Because of this responsibility, it is agency's goal to manage risks in their emergency management operations. An Integrated Risk Management System can serve as an 'umbrella' of safety over operational and management decision-making. The IRMS will permit the use of risk-based standards in a consistent manner and generate strategies and tools for risk management decision-making process to enable emergency management organizations to strengthen the emergency management system by not only controlling risks during emergencies, but also by reducing risks in the long run. We conclude that an IRMS in emergency management at the federal level should serve as a starting point, while recognizing that the final regulatory risk management decisions may well be both community-driven and found through inter-agency discussions.

BIBLIOGRAPHY

- Albert, R. E., & Altshuler, B. (1976). "Assessment of Environmental Carcinogen Risks in Terms of Life Shortening," Environmental Health Perspectives, 13, 91-94.
- Burger, E. J. Jr. (1988). "How Citizens Think About Risks to Health," Risk Analysis, 8(3), 309-313.
- Cairns, J. (1975). "The Cancer Problem," Scientific American, 233, 64-78.
- Cohen, B. L., & Lee, I-S. (1979). "A Catalog of Life Risks," Health Physics, 36, 707-722.
- Cole, P., & Merletti, F. (1980). "Chemical Agents and Occupational Cancer," Journal of Environ. Pathol. Toxicol, 3, 399-418.
- Comfort, L. K. (1988). Managing Disaster: Strategies and Policy Perspectives. Durham and London: Duke University Press.
- Conn, W. David, & Feimer, N. R. (1985). "Communicating with the Public on Environmental Risk: Integrating Research and Policy," The Environmental Professional, 7, 39-47.
- Covello, V. T. (1984). "Social and Behavioral Research on Risk: Uses in Risk Management Decisionmaking," Environmental International, 4.
- Covello, V. T. (1987). "Decision Analysis and Risk Management Decision Making: Issues and Methods," Risk Analysis, 7(2), 131-139.
- Covello, V. T., & Mumpower, J. (1985). "Risk Analysis and Risk Management: An Historical Perspective," Risk Analysis, 5(2), 103-120.

- Doll, R. (1981). "Relevance of Epidemiology to Policies for the Prevention of Cancer," Journal of Occupational Medicine, 23, 601-609.
- Douglas, M., & Wildavsky, A. (1982). Risk and Culture. Berkeley: University of California Press.
- Fiksel, J. (1990). "Risk Analysis in the 1990s," Risk Analysis, 10(2), 195-196.
- Fischhoff, B., Lichtenstein, S., Slovic, P., Derby, S. L., & Keeney, R. L. (1981). Acceptable Risk. Cambridge University Press, Cambridge, England.
- Fischhoff, B., Slovic, P., & Lichtenstein, S. (1982). "Lay Fables and Expert Foibles in Judgements about Risk," The American Statistician, 36, 240-255.
- Florino, D. J. (1989). "Technical and Democratic Values in Risk Analysis," Risk Analysis, 9(3), 293-299.
- Glaser, B. G., & Strauss, A. L. (1967). The discovery of grounded theory: Strategies for qualitative research. Hawthorne, New York: Aldine Publishing Company.
- Gori, G. B. (1980). "The Regulation of Carcinogenic Hazards," Science, 208, 256-261.
- Gross, J. L., & Rayner, S. (1983). Measuring Culture: A Paradigm for the Analysis of Social Organization. Columbia University Press, New York.
- Hadden, S. G. (1984). Risk Analysis, Institutions, and Public Policy. Associated Faculty Press, Port Washington, New York.
- Haines, Y. Y. (1989). "Toward a Holistic Approach to Risk Assessment and Management," Risk Analysis, 9(2), 147-149.
- Haines, Y. Y., & Stakhiv, E. Z. (1989). Risk Analysis and Management of Natural and Man-Made Hazards. American Society of Civil Engineers. New York.
- Hance, B. J., Chess, C., & Sandman, P. M. (1989). "Setting a Context for Explaining Risk," Risk Analysis, 9(1), 113-118.
- Hansson, S. V. (1989). "Dimensions of Risk," Risk Analysis, 9(1), 107-112.

- Hoerger, F. D. (1990). "Presentation of Risk Assessments," Risk Analysis, 10(3), 359-361.
- Hohenemser, C., & Kasperson, J. (1982). Risk in the Technological Society. Westview Press, Boulder, Colorado.
- Ikeda, S. (1986). "Managing Technological and Environmental Risks in Japan," Risk Analysis, 6(4), 389-401.
- Johnson, B. B., & Covello, V. T. (1987). The Social and Cultural Construction of Risk. Reidel Publishing Company, Holland.
- Kahneman, D., Slovic, P., & Tversky, A. (1982). Judgement Under Uncertainty: Heuristics and Biases. Cambridge University Press, Cambridge, England.
- Kelsey, C. A. (1978). Comparison of Relative Risk from Radiation Exposure and Other Common Hazards. Health Physics, 35, 428-430.
- Kloman, H. F. (1990). "Risk Management Agonistes," Risk Analysis, 10(2), 201-205.
- Kraft, M. E., & Freeman III, A. M. (1989). "Introduction: Economic and Political Issues in Risk Analysis," Risk Analysis, 9(3), 279-281.
- Kurstedt, H. A. Jr. (1986). The management system model helps your tools work for you. Unpublished manuscript, Virginia Polytechnic Institute & State University, Management Systems Laboratories, Blacksburg, Virginia.
- Lave, L. B., & Menkes, J. (1985). "Managing Risk: A Joint U.S.-German Perspective," Risk Analysis, 5(1), 17-23.
- MacGregor, D., & Slovic, P. (1986). "Perceived Acceptability of Risk Analysis as a Decision-Making Approach," Risk Analysis, 6(2), 245-256.
- Mayo, D. G. & R. D. Hollander (1991). Acceptable Evidence: Science and Values in Risk Management. Oxford University Press, NY.
- Mitchell, J. (1990). "The Evolution of Acceptable Risk," The Environmental Professional, 12, 114-121.
- Mumpower, J. (1986). "An Analysis of the de minimus Strategy for Risk Management," Risk Analysis, 6(4), 437-445

- National Research Council (1982). Risk and Decision Making: Perspectives and Research. National Academy Press, Washington, D.C.
- National Research Council. (1983). Risk Assessment in the Federal Government: Managing the Process. National Academy Press, Washington, D.C.
- National Research Council. (1989). Improving Risk Communication. The National Academy Press, Washington, D.C.
- North, D. W. (1990). "Risk Analysis: Where Have We Been? Where Are We Going?" Risk Analysis, 10(2), 197-198.
- Okrent, D. (1980). "Comment on Societal Risk," Science, 208, 372-375.
- Rayner, S. (1984). "Disagreeing About Risk: The Institutional Cultures of Risk Management and Planning for Future Generations," in S. Hadden (ed.) Risk Analysis, Institutions, and Public Policy. Port Washington, New York: Associated Faculty Press.
- Rayner, S., & Cantor, R. (1987). "How Fair Is Safe Enough? The Cultural Approach to Societal Technology Choice," Risk Analysis, 7(1), 3-9.
- Reilly, W. K. (1990). "Aiming Before We Shoot: The Quiet Revolution In Environmental Policy," U.S. EPA, Communications And Public Affairs (A-107).
- Reissland, J., & Harries, V. (1979). "A scale for measuring risks," New Scientist, 3, 809-811.
- Rowe, W. D. (1977). An Anatomy of Risk. Wiley, New York.
- Ruckelshaus, W. (1983). "Risk, Science and Public Policy." Science 221:1026-28.
- Ruckelshaus, W. (1984). "Risk in a Free Society." Risk Analysis, 4 (3), pp 157- 162.
- Ruckelshaus, W. (1985). "Risk, Science, and Democracy." Issues in Science and Technology, 1, pp 19-38.
- Russell, M. & M. Gruber (1987). "Risk Assessment in Environmental Policymaking." Science, 236, pp 286-90.
- Sagan, L. A. (1987). "Beyond Risk Assessment," Risk Analysis, 7(1), 1-2.

- Schwing, R., & Albers, W. (1980). Societal Risk Assessment. How Safe is Safe Enough? Plenum Press, New York.
- Shrader-Frechette, K. S. (1985). Risk Analysis and Scientific Method: Methodological and Ethical Problems with Evaluating Societal Hazards. D. Riedel Publishing Company, Boston.
- Silbergeld, E. K. (1987). "Five Types of Ambiguity: Scientific Uncertainty in Risk Assessment." Hazardous Waste and Hazardous Materials, 4, pp 139-50.
- Silbergeld, E. K. (1991). "Risk Assessment and Risk Management: An Uneasy Divorce," in Mayo & Hollander (eds), Acceptable Evidence: Science and Values in Risk Management. Oxford University Press, New York.
- Slovic, P., B. Fischhoff, & S. Lichtenstein (1980). "Facts and Fears: Understanding Perceived Risk," in Schwing & Albers (eds), Societal Risk Assessment: How Safe is Safe Enough? Plenum Press, NY.
- _____ (1985). "Characterizing Perceived Risk," in Kates, et al. (eds), Perilous Progress: Managing the Hazards of Technology. Westview Press, Boulder, CO.
- Slovic, P. (1986). "Informing and Educating the Public About Risk," Risk Analysis, 6(4).
- Slovic, P. (1987). "Perception of Risk," Science, 236.
- Slovic, Paul (1991). "Beyond Numbers: A Broader Perspective on Risk Perception and Risk Communication," in Mayo & Hollander (eds), Acceptable Evidence: Science and Values in Risk Management. Oxford University Press, NY.
- Solomon, K. A., & Abraham, S. C. (1980). "The Index of Harm: A Useful Measure for Comparing Occupational Risk Across Industries," Health Physics, 38, 375-391.
- Starr, C. (1985). "Risk Management, Assessment, and Acceptability," Risk Analysis, 5(2), 97-102.
- Stern, R. M. (1985). "The Management of Risk: Application to the Welding Industry," Risk Analysis, 5(1), 63-72.
- Thompson, M. (1981). "Beyond Self-Interest: A Cultural Analysis of a Risk Debate," Working Paper, International Institute for Applied Systems Analysis, Laxenburg, Austria.

- Tiemann, A. R. (1987). "Risk, Technology, and Society," Risk Analysis, 7(1), 11-13.
- U.S. Environmental Protection Agency (1990). Reducing Risk: Setting Priorities And Strategies For Environmental Protection. The Report of The Science Advisory Board: Relative Risk Reduction Strategies Committee. Washington, DC.
- U.S. Department of Energy (1989). "A Study of Emergency Management in the Department of Energy." Co-Sponsored by The Office Of Security Evaluations (DP-4) and The Office Of Emergency Operations (DP-6), August 1989.
- U.S. Department of Energy (1991). "Guidance for A Hazards Assessment Methodology," Emergency Management Guide.
- White, G. F. (1988). "Paths to Risk Analysis," Risk Analysis, 8(2), 171-175.