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Decision Support Systems for Emergency Management

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Publication date:
1988

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit]

Citation (APA):
Andersen, V., & Rasmussen, J. (1988). *Decision Support Systems for Emergency Management*. Risø-M No. 2724

Risø National Laboratory **Risø – M – 2724**

Title and author(s)	Date June 1988
Decision Support Systems for Emergency Management V. Andersen and J. Rasmussen Risø National Laboratory, DK-4000 Roskilde	Department or group Information Technology Groups own registration number(s) R-7-88 Project/contract no.

Pages 34	Tables	Illustrations 7	References 13	ISBN 87-550-1437-2

Abstract (Max. 2000 char.)

During recent years large industrial accidents have revealed the necessity of efficient decision support systems for accident fighting and emergency management. At the same time there is rapid development within electronic information technology resulting in widespread efforts to exploit this technology in the design of such systems.
A short review of the state of the art of decision support systems in general has been given revealing common problems, and specific problems concerning decision support in emergency management have been stressed.
A framework for analysis and design of decision support systems based on the new technology and utilising a cognitive point of view has been presented. For design it is necessary to structure the great variety of real life work conditions into domains which correspond to design decisions. An appropriate representation of the problem space should reflect the varying span of attention in the part/whole dimension, and the varying level of abstraction in the means/end dimension. A joint Nordic project concerning decision support in emergency management has been taken as an example of the use of this technique.

Descriptors

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EUROPEAN CONFERENCE ON EMERGENCY PLANNING FOR INDUSTRIAL HAZARDS

Varese November 4-6th, 1987

Decision support Systems for Emergency Management.

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1. INTRODUCTION

The current trend in the industrial development is towards large, centralized production units and there is, consequently, an increasing potential for severe accidents. This in turn creates an increasing demand on methods for systematic risk analysis and in case of release of the accident potential - means for effective emergency management. At the same time, there is a dramatic development within electronic information technology and, quite naturally, widespread efforts to exploit this technology in the design of systems for support of systematic risk analysis, decision support systems for operating crews during plant disturbances and accident control, and for support of the general emergency management organization.

2. REVIEW OF THE STATE OF THE ART OF DECISION SUPPORT SYSTEMS

As a. basis for discussing the use of information technology in support of emergency management, we will briefly view the general development of decision support systems.

2.1management information and Decision Support systems

Development of managerial decision support systems has been pursued separately in two schools, one based on a management science perspective, focusing on the 'formulation of rational, normative decision making strategies based on objective economic analysis of the problem domain, another based on a social science perspective and focusing on the social system and considering the roles and needs of the people in the system. The two approaches considering what are generally labelled "management information systems" and "decision support systems", respectively, have been considered alternative paths to a solution, an attitude which has caused considerable controversy. However, due to increasing understanding of the cognitive aspects of decision making, a more integrated view of the system has recently been evolving. These lines of development will be briefly reviewed.

Management science approach. A major class of proposals for decision support systems has been based on decision making research rooted in economic theories, in particular the expected utility theory developed by economists and mathematicians. The approach focuses on decision-making from a prescriptive point of view only. It is & logical structure for decisions and makes no claim that it represents or describes the information processing of human decision makers. The emphasis is not on what they do, but on what they should do.

A general criticism of this approach has been that the formal models based on economic or decision theories fail to appreciate the complexity of the challenges under which real-world decision makers must operate. Critics of decision theory also argue that it is not useful as a. guide because human beings do not behave in accordance with the fundamental assumptions of the theory.

Social science approach. Whereas the management science-approach is focused on the problem characteristics, the perspective of the social science is primarily concerned with the characteristics of the decision makers and their social roles. This means that there will be no formal basis for evaluating the performance of such a system; the only basis for judgement will be user-acceptance, and there- will be no structured way to plan a functional system design, which, therefore, will be based on bottom-up integration of the requirements of the individual activities.

System science approach. Recently, a more integrated, top-down approach to the design of management decision support systems has been taken by system scientists. An illustrative example is the discussion presented by Sutherland (1983). He compares the approaches taken by the two schools based upon management science and social science, respectively. His conclusion is that both approaches are too schematic and drawn to unacceptable extremes, and that a-more balanced view should be taken.

His discussions relate to business decision making, but the conclusions are well related in the present context.

In doing so it is necessary to take into consideration that decision making in the different levels of organization cannot be covered by one theoretical model, and will require different tools for effective support.

Four levels of decision types are identified and correlated with decision processes and support models:

Goal programming and long range planning at the highest level are related to sequential state model for heuristic problem solving procedures or structured decision making procedures. Support in this function is essential for executives who are responsible for development of the policy over the long run.

Strategic analysis at the next lower level includes contingency planning related to stochastic-state techniques to provide for deductive techniques for problems the "state" outcomes of which are variable, such as game-theoretic models or logical analysisprograms. This technique underlies most classic military contingency planning.

The tactical programming, one level further down includes "equilibrium maintenance" mainly based on statistics-based decision and control instruments for dealing with probabilistic problems, such as econometric methods,, parametric decision theory, etc..

The lowest level is.concerned with operations management, based on discrete-state instruments which are primarily algorithmic and analytical methods that allow optimal solutions of deterministic problems. This is the domain of methods of industrial engineering and operations research.

The basic idea of this system theoretic approach is that any properly conceived management support system should include tools for all of these levels. And, this is so, whether or not it is requested by the exis management authorities.

Sutherland emphasizises the need for a structured design methodology:

1. The first step is to identify "a population of decision requirements that is derived by examining organizations in aggregate in terms of universalistic (e.g., ideal-type or categorial) as well as context specific properties-"
2. The next step is an attempt to reduce a population of functionally abstracted decision requirements to their most fundamental constituents, i.e., to decompose into elementary operations or primitives.
3. Then, the set of all primitives is reduced into prime set., in order to remove redundancies.
4. Given this prime set, attention shifts to the instrumental capabilities they imply in terms of a collection of decision aids. All integral.decision aids or model base components are now decomposed. into their lowest order transformational components - the microfunctions which are the basic elements of "any structured model-base"
5. Now a prime set of system facilities is generated, to have- a mutually exclusive set which in aggregate should be able to perform all the functions associated with the set of decision aids from which they were derived.
6. Any of the higher-order decision requirements should thus be able to be met by synthesizing in effective real-time the functions pertinent to the integral decision aid.

The prerequisite for this concept will be that the analytical procedures or techniques underlying a support system are cc)ngruent with the nature of the problem at hand. Therefore, the tools for the different levels in an Organisation will be different. This congruence is discussed with reference to generic problem/instrument domain. Four levels of problems are considered: Deterministic, probabilistic, equifinal, and indeterminate problems. Also four instrument categories are used: Discrete state (operations research, industrial engineering, or AT algorithms), finite state (statistical decision theory, correlation, regression), stochastic state (contingency planning), and sequential state. Optimal tools are then to be found in the diagonal of the representation, while choice outside the diagonal will be either ineffective (insufficient) or inefficient (too sophisticated) for the purpose.

The rationale for this solution will be to ensure that-organisational decision problems get all the precision and discipline they deserve, but no more.

2.2. Expert-Systems, Artificial Intelligence A

While the approaches to decision support systems mentioned above are predominantly problem driven, the solutions based on artificial intelligence approaches are by nature tool driven.

Expert Systems. In the present context the term "expert system" is used in the "classical" sense to characterize a decision support system based on heuristic rules derived from experts and intended to support a well defined decision maker- having a uniform set of decision tasks within a bounded information context. Recent reviews of the historical development of expert systems (Hayes-Roth et al., 1983) focus on expert systems for application in domains of very uniform characteristics, such as

'Dendrall, for analysing mass spectroscopic, nuclear magnetic resonance, and other such data to infer molecular structures,

Mycin', for medical diagnosis of infectious blood desease,

'Expert', 'Caduceus', for other domains of medical diagnosis.,

'Prospector' for geologic survey support, etc..

The present expert systems are laboratory "demonstration" Systems,, of which only few are in actual, serious use. In order to be accepted by a user, advice from an expert system in a risky decision context will require a more elaborate explanation capability than is presently available (see, for instance, Rasmussen and Goodstein, 1985). Likewise, Hayes-Roth et al.,, (1983), has formulated that todays's expert systems typically show up badly when measuring along a number of dimensions:

They are unable to recognize or deal with problems for which their own knowledge is inappli@cable.or insufficient.

They have no independent means of checking whether their conclusions are reasonable.

Explication of their reasoning process is frequently silent on fundamental issues.

From this review, use of "expert-systems" for support of the decision making process "on-line-" seems to be premature. However, AT tools for organization of the distributed data base available to emergency management may be feasible.

Other Artificial intelligence Approaches. More differentiated approaches have been taken to the design of decision support systems, when AT techniques have been considered tools in a design effort based on analysis of the problem requirements.

A system oriented approach to design of a system for support of distributed decision making, based on the tools made available by artificial intelligence research has been proposed by Thorndyke et al. (1982). This proposal will be reviewed in some detail because distributed problem solving appears to be an important feature of emergency management:

Thorndyke et al. describe a system for model-based situation assessment and planning based, on expert system architecture. Applications are described for military strategic planning, air traffic control, as well as location and identification of hazardous chemical spills. To model the organization of time stressed situation analysis and planning, the "cooperating experts paradigm" is used.

For the Organisation of these activities the Hearsay-11 paradigm is used (Erman et al., 1980). A number of experts are organised around a common data base, the "world model": a sensor, a plan generator, an evaluator, a communicator, and a controller.

The conclusion of this review is that the structure offered by the HEARSAY system concept for communication and coordination in a distributed group of decision makers appears to match the needs for data base support in emergency management, and should be considered in more detail for future developments.

2.3. Decision support in Emercrency Manaqement

The-present problem of information systems for emergency management appears to be characteristic in the following respects:

The problem domain is poorly defined. The system should support decision making related to a large variety of emergencies, caused by very different physical processes. The resources to consider in emergency control may belong to different technical service fields.

The decision maker(s) are difficult to identify in advance, being dependent on the size and nature of the actual case.

Several organisations and technical services may be involved, and decision making will have the nature of a- cooperative effort in a. distributed system.

Support from the system may be- relevant during dynamic emergency situations, as well As for planning purposes.

The information needed for decisions may stem from a large variety of sources, such as engineering textbooks/ laws and regulations, risk analysis, analysis of Prior accidents procedures, and instructions.

Key problems for system development will, therefore, be to consider:

Organisation of large, inhomogenous data bases, information retrieval, requirements for analysis supplying data in order to have proper data attributes and formats compatible with user needs.

Analysis of the Organisation of the cooperative decision making, and the structure of the communication network involved.

The nature, in general terms (covering typical situation scenarios), of the control and decision task, and the related information needs.

At present it appears very plausible that a coordinated- data base and a consistent specification of the information needs of the various decision makers, as well as of the requirement to the information formats used by the information sources, will be an important area of development for advanced information technology.

3. A FRAMEWORK FOR ANALYSIS AND DESIGN OF DECISION SUPPORT SYSTEMS

In consequence of the discussion in the previous section, the approach to the design of a decision support system based on new technology should be taken from a cognitive point of view, and should include an analysis of the decision task and the information processing requirements in terms referring to human cognitive functions. In general, when designing systems for support of decision making, the problem is to design systems which are also effective during situations which have not been foreseen during design, and which are not familiar to the user.

For design it is necessary to structure the great variety of real life work conditions into domains which correspond to design decisions. By use of a multi-facetted description system it is possible to represent a great variety of conditions by a rather low number of categories in each domain, related to general features. From this point of view, the following dimensions of a conceptual framework for description of a cognitive task have proved useful for the analysis of cognitive tasks, and, hence, for design of decision support systems:

The problem domain. The first domain of an analysis which will serve to bridge the gap between the purely technical description of the work content and the psychological analysis of user resources should represent the functional properties of the system in a way which makes it possible to identify the control requirements of the system underlying the supervisory task. This is an analysis in technical systems terms and will result in a systematic and consistent representation of the problem space. since decision making in emergency management, as in many other contexts, is a. resource management problem, an appropriate representation of the problem space should reflect the varying span of attention in the part/whole dimension, and the varying level. of abstraction in the means/end dimension. Change in representation along both dimensions is normally used by decision makers in order to cope with the complexity of a decision task (Rasmussen,, 1985).

The decision sequence. The next domain of analysis to consider is related to the decision process which has to be applied for operation upon the problem space. It is generally accepted that the decision process can be structured into a fairly small number of typical decision processes representing the various phases of problem analysis and diagnosis, evaluation and choice of goal priority, planning of resources, and, finally, execution and monitoring.

Mental strategies anq heuristics. An analysis in this problem domain can serve to identify the information processing strategies which are effective for the different phases of the decision sequence in order to identify the required data, control structures, and processing capacities. It is generally found that a given cognitive task can be solved by several different strategies varying widely in their requirements as to the kind of mental model and the type or amount of observations required.

Cognitive control domain. While the information content should be included in the messages from a decision support system from an analysis of problem space and mental strategies the form of the displays should be selected from consideration of human cognitive control mechanisms.

4. IMPLEXENTATION FOR EMERGENCY MANAGEMENT SUPPORT

It follows from the preceeding section that the most important domain of analysis for emergency management will be the problem domain and the decision task, including the role and cooperation of several decision makers.

4.1. Problem Domain

The first aspect to consider will be the problem doraain, i.e., the representation of the relationships controlling the state of affairs in the-emergency management context.

Emergency management can be considered a resource management problem in a- means-end hierarchy representing the functional properties of the environment. In this hierarchy, these properties are represented by concepts which belong to several levels of abstraction.

The lowest level of abstraction represents only the physical form of the system, its material configuration. The next higher level represents the physical processes or functions of the varic us components and systems in a language related to their specif ic electrical, chemical, or mechanical properties. Above this, the functional properties are represented in more general concepts without ref erence to the physical process or equipment by which the functions are implemented, and so forth.

At the lower levels,, elements in the process description match the component configuration of the physical implementation. When moving from one level of abstraction to the next higher level ' the change in system properties represented is not merely removal of details of information on the physical or material properties, More fundamentally, information is added on higher level principles governing the cofunction of the various functions or elements at the lower level. In man-made syst'tms these higher level principles are naturally derived from the purpose of the system, i.e., from the reasons for the configurations at the level considered. Change of level of abstraction involves a shift in concepts and structure for representation, as well as a change in the information suitable to characterize the state of the function or operation at the various levels of abstraction. Thus an observer asks different questions to the environment depending on the nature- of the currently active internal representation.

In other words, models at low levels of abstraction are related to a specific physical world which can serve several purposes or violate different goals. Models at higher levels of abstraction are closely related to a specific-purpose which can be met by several physical arrangements. Therefore, shifts in the level of abstraction can be used to change the direction of paths, suitable for transfer- of knowledge from previous cases and problems. For the emergency management systems, the information related to the decision space will be discussed for two separate categories, the domain of. the potential risk, and the domain of mitigation resources.

4.2. Domain of Potential Risk

This part of the representation includes information identifying the potential risk sources, their functional physical properties making it possible to predict the accidental propagation of effects of accident releasing mechanisms, and the possible higher level consequences in relation to social norms and legal rules. This part of the data base will supply the basis for the analytical part of the representation, and the information will be available from risk analysis, technical manuals, and analysis of the technical features of prior cases. Examples of the information at the various levels may be seen in Figure 1.

4.3. The Mitigation Resource Domain

This domain includes the information about functions, processes, and equipment/personnel which is available to form the counteracting and mitigating forc e. It represents the problem space for the- planning part of the representation. The information included at the various levels can, for-instance, be as shown in Figure 2.

4.4. The Use of Problem Renresentation

This representation of the problem space will be a multi-level representation in terms available/required equipment-processfunction-purpose elements, and decision making in a specific situation will be a resource management task aiming at a. proper relationship in the potential many-to-many mapping between the levels. A property of the total emergency management system considered at an individual level can be characterised in three different ways, (1) "what" it is, i.e. its causal properties in interactions at that particular level, (2) "why" it may be chosen, i.e., its role at the next higher level, and (3) "how" it may be implemented by resources at the next lower level. This means that the data element in a data base should be characterised from at least three different points of view. Decision making in a particular situation will be an iterative consideration of the resources at the various levels until a satisfactory relationship through the levels has been identified, connecting the various, possibly conflicting, goals and constraints with the available physical resources. This will involve the task of keeping track of a many-to-many mapping in a complex net, and the use of inf ormation technology should be considered not only for advice giving a la expert system, but also f or support of the decision process itself (f or instance by alerting the user to consider other relevant means-end mappings than the one behind an actual information request).

The nature and the related sources of information to be included in & data base should be specified for each of the cells in the domain abstraction/decomposition matrix (Figures 3 and 4).

The f orm in which the inf ormation should be stored in the. data base depends entirely upon the users' formulation of their problem and needs (cf. Pejtersen's work on information retrieval in libraries). This, in turn, depends on the identity of the actual decision maker, and the boundaries of his information needs in terms of location in the problem space chart (see Figure 5), as well as upon the hierarchical structure of the operating organisation.

The data base representing the problem domain in terms of risk potential and emergency management resources will include structural information about functional properties and causal relationships which must be transformed into procedural information in order to be operational in the actual accident situation. This transformation can be based on heuristics derived from prior experience or deductions based. on state information from the case actually present. If procedural transformations are incorporated in the data base, it will have to be rather general rules, unless very specific information can be supplied. If the procedural information have to be generated on-site, it will either have to be done by the decision maker-himself, or information on the actual state of affairs will have to be transmitted to the advisor in possession of the necessary general background knowledge or- the intermediary working on the available data bases(see Figure 6) . This advisor can be a human domain expert or an "expert system inference machine" attached to the data base.

The conclusion of this preliminary analysis is that the means-end hierarchy is well suited. to structure the information content of the data base which is underlying emergency management decisions, during preplanning as well as during the actual situations. Thus structured, it will be possible in & consistent way to identify the proper search terms to use for retrieval design,, and to specify the format in which information should be supplied by the numerous data sources, such as risk analysis, incident analysis, plant design, operations planning, and inspections.

5. EMERGENCY MANAGEMENT IN NUCLEAR AND NON-NUCLEAR INDUSTRIES

The problems involved in industrial emergency management appear to fall into two rather distinct groups. one group includes the rather frequent, smaller scale accidents related to fires, toxic spills, etc.. The emergency management organization is established ad hoc, and must be able to cope with a wide variety of accidents. The other group includes emergency management related to accidents in hazarduous industrial installations for which emergency organizations have been carefully planned and. for which risk analysis typically have been made. Nuclear power installations are typical for this category. Figure 7 shows a. schematical representation of different types of emergency situations, where the foci of optimal support for-a given situation is found in the diagonal of the representation. Outside the diagonal the task will be either insufficient of ineffective. Most non-nuclear emergency situations will be located in the upper left of the diagram, while most nuclear power-plant emergency situations will be located in the lower right of the diagram. A decision support system for@ the latter is being developed as a. joint Nordic programme NKA/INF, where a top-down approach has been taken by analysing the requirements needed to satisfy the specified goals for an emergency management system.

A short description of the content and status of this programme will be given:

5.1. NKA/INF Prolect content

The basis for the study of the potential use of advanced information technology for accident and emergency management was established in a pilot project undertaken in -1985. The subjects addressed in this project led to a preliminary description of accident and emergency scenarios (Johansson et al., 1986), a state-of-the-art review of models and methods available for construction of a conceptual system (Rasmussen, 1986), and a review of available tools from Artificial Intelligence, e.g. expert systems (Berg et al., 1985).

The programme, at present, has two lines of development. one is to analyze the present emergency management organizations and procedures, to evaluate the problems perceived and the possibility of remedy by means of modern information technology. Another, concurrent line of approach has been to establish models of the distributed decision making involved in operations like emergency management, in order to evaluate whether advanced information technology will influence the effective way of organizing. The approach taken to such a model.may be to consider decision making a control task involving a. number of decision . makers each controlling only part of a loosely coupled problem space. For conserted activity communication between the decision makers is necessary.

The programme consists of five main activities:

1) The study and. detailed analysis of accident and emergency scenarios based on records from incidents and drills in nuclea@ installations.

2) Development of a. conceptual understanding of accident and emergency management with emphasis on distributed decision making, information flow, and control structures that are involved.

3) Development of a general experimental methodology for evaluating the effects of different kinds of decision aids and forms of Organisation for emergency management systems with distributed decision making.

4) Development and- test of a prototype system for a limited part of an accident and emergency Organisation to demonstrate the potential use of computer and communication systems,' data-base and knowledge base technology, and applications of expert systems and methods from artificial intelligence.

5) Production of guidelines for the introduction of advanced inf ormation technology in the organizations based on evaluation and validation of the prototype system.

In an early stage of the project a. limited target area must be defined. Based on the scenario descriptions, a "vertical slice" is identified dependent primarily on two criteria: it must be able to display the major features of the conceptual system, and it must be limited to the extent where the prototype development is possible using the available resources. in the later phases of the project the scenario descriptions will gradually change to data and knowledge acquisition, and. the conceptual work will be followed by development of a general experimental methodology and by experimental work using the prototype as test bed. The prototype system. will experience a dynamical development throughout the major part of the project. The keyword for the project is system studies with emphasis on system integration. This will be reflected in the recommendations and guidelines developed in the final phase of the project.

5.2. Status of the NKA/TNF-,orocrramme.

The programme has developed conceptually, in data acquisition and specification of data and knowledge base, and in prototype implementation, but in the present context only the status of the conceptual work will be described.

Conceptual work. The general point of departure for the conceptual work has been to design a framework for analyzing different kinds of emergencies.

In the first stage, we have been concerned With the problems of hierarchical organizations in emergency management. Such organizations were found to present problems under- certain conditions because (Brehmer, 1986)

-all kinds of emergencies cannot be foreseen, and this may create a need for a more flexible structure with the capacity to reconfigure itself;

- information delays would make it hard to exercise control by means of a hierarchical system that would be too slow;

- some aspects of emergency management cannot be modelled hierarchically but require a different control structure; and

- hierarchical command and control systems are not needed for all kind of emergencies.

In the second stage, we have tried to create a general framework for analyzing emergency management based on the view of emergency management as a control system. This (Brehmer, 1987)

- provides a clear specif ication of the goals of an emergency management system;

- provides a specification of what the components of such a system should be;

- specifies the information needs; and

- specifies what can, and what cannot, be controlled in emergency management.

Further work is now directed towards solving two problems:

1. To develop a conceptual framework for those aspects of emergency management that cannot be controlled hierarchically. The problems here are those of coordination in a system characterized by distributed decision making.

2. Using the time-area diagrams developed as part of the analysis of emergency management as a control system to analyze a variety of emergencies. This is done in an attempt. to test the general usefulness of these diagrams as an analytical tool for analyzing information needs in emergency management.

In addition, some f irst thoughts on how the decision support system should be evaluated have been looked into. Here a distinction between two forms of evaluation has been discussed: analytical evaluation and empire cal evaluation. It is recommended that an analytical evaluation be performed f irst. This comprises two steps:

mapping the decision support system onto a set of general decision tasks, and

assessing the extent to which these tasks are supported by analyzing (a) the nature of the situation, (b) the kind of displays that are provided, and (c) the knowledge required f or understanding these displays.

It is also recommended that the empirical evaluation be directed towards limited and well-defined functions of the decision support system. DESSY-D, a general interactive program for simulating dynamic systems, is being developed for this purpose- in Uppsala.

The methodological problems in using this system for the evaluation of a decision-support system-are now being analyzed.

6. CONCLUSIONS AND RECOMMENDATIONS

The conclusion of the present fe asibility study will be that the recent development of advanced information technology, together with the trend towards more cognitively oriented approaches to studies of decision making, offer promising lines of development of improved tools for emergency management. Such improvements will be necessary in order to cope with the increasing potential for unacceptable consequences of accidents which is the result of industrial centralization together with the widespread use of hazardous substances. In addition, a reconsideration of the information basis of emergency management- will be relevant now because much information of great importance for emergency management will be generated or collected from activities such as. systematic risk analysis, safety inspections, quality assurance programs, etc..

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DOMAIN OF POTENTIAL RISK

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<tr><td rowspan="2">FUNCTION OF SPECIFIC INSTALLATIONS, GROUPS AND EQUIPMENT</td><td rowspan="2">National and geographical patterns, meteorological data, water streams, other propagation characteristics</td><td colspan="3">Physical processes and mechanisms behind accidents, causation, propagation, potential for interaction with accident control measures</td><td rowspan="2">Properties of substances and materials</td></tr>
<tr><td>General data on industrial practices, processes and accidental mechanisms. Safety measures</td><td>Functional information on specific plants, accident potential and mechanisms, safety measures</td><td>Relation to specific manufacturing processes</td></tr>
<tr><td rowspan="2">MATERIAL LOCATIONS CONFIGURATIONS APPEARANCE</td><td rowspan="2">National pattern of potential sources and population, propagation routes, road and barrier topography</td><td colspan="3">Locations, topography, physical design and appearance</td><td rowspan="2">Information for identification and location of material, substances, and components. Personal data</td></tr>
<tr><td>Distribution according to branches and risk categories</td><td>Location of specific plants and installations. Drawings of buildings and access routes, maps of likely propagation paths</td><td>Location of specific process equipment, identification data, transport and access information</td></tr>
</table>

Figure 1

DOMAIN OF EMERGENCY MANAGEMENT RESOURCES

	NATIONAL OVERVIEW & PATTERNS	ACTIVITY CATEGORIES EMERGENCY CLASSES	ORGANIZATIONS AND INSTITUTIONS	EMERGENCY TASK FORCES	INDIVIDUAL PEOPLE AND MAJOR TOOLS
GOALS AND CONSTRAINTS	National laws and government agency regulations	Goals and constraints for measures against: fires, floods, traffic accidents, etc.	Goals and targets for services and institutions: hospitals, fire-brigades, "Falck".	Goals and targets for groups and task forces	Exposure limits for individuals, regulation data
PRIORITY CRITERIA ECONOMY, RISK, MAN POWER FLOW		Criteria and measures for priority setting Flow, accumulation, and turn-over of funding, man power, and material according to: - Risk categories	- Services	- Task forces	- Individuals and equipment
GENERAL FUNCTIONS AND OPERATIONS		Available resources for general emergency control functions: Fire fighting, medical care, transportation and evacuation, etc. General overview of resources. General rules and heuristics for counter measures	Resources specified with reference to organisations, institutions. General institutional rules and practices	Resources of identified task forces, groups, and operational units and institutions	Capabilities of equipped individuals and major tools
FUNCTION OF SPECIFIC INSTALLATIONS, GROUPS AND EQUIPMENT		Physical functioning, capabilities, and limitations of emergency control mechanisms;		Physical functions and capabilities of tools as available to task forces and groups. Instructions and procedures, standing orders	Physical Characteristics and limitations of tools. Information on possible, unacceptable interaction with media and installations (chemical, electrical, etc.). Procedures and practices
MATERIAL LOCATIONS CONFIGURATIONS APPEARANCE	Road system with data on traffic and load capacity.	Locations, descriptions, identification of items, forces, groups. Geographical location of services and institutions, access routes.	Drawings of premises of individual institutions. Drawings of buildings. Inventory lists of service stations	Inventory, locations, identifying characteristics of equipment, tools, and members of task forces	Drawings of equipment, with size and weight data

Figure 2

INFORMATION SOURCES

DOMAIN OF POTENTIAL RISK

	NATIONAL OVERVIEW & PATTERNS	EMERGENCY CLASSES	COMPANIES AND INSTALLATIONS	SPECIFIC PRODUCTION PLANTS AND EQUIPMENT	PROCESSES, SUBSTANCES & COMPONENTS
GOALS AND CONSTRAINTS		Generalizations in terms of policies and goals			
PRIORITY CRITERIA ECONOMY, RISK, MAN POWER FLOW		Generalizations from accident and risk analysis and overviews; in terms of economic and risk level terms for setting priorities			
GENERAL FUNCTIONS AND OPERATIONS	Statistical reports and overviews	Overviews from branch organizations, safety authorities, journals, etc.	Company overviews and safety records. Risk analyses and consequence prognoses.	Risk analysis, consequence prediction. Incident and accident reports. Textbooks and journals	Chemical, technical textbooks and journals. Risk and work safety handbooks
FUNCTION OF SPECIFIC INSTALLATIONS, GROUPS AND EQUIPMENT	National summaries and overviews	Summaries over branches and emergency classes	Technical manuals, emergency and safety plans and procedures. Overall production, transport, and management manuals and reports.	Technical equipment manuals, process specific accident research and event reports. Inspection reports; maintenance logs.	Toxicologic and pharmacologic handbooks. Incident analysis reports and data banks. Hospital rules and data
MATERIAL LOCATIONS CONFIGURATIONS APPEARANCE	National summaries and overviews	Geographical overviews for emergency classes from branch organizations and authorities	Drawings, maps, manuals on sites, buildings, and configuration of installations and supply / waste piping	Drawings, manuals, descriptions of plants and equipment. Installation and handling manuals. Inspection reports. Inventory lists.	Reports from companies, suppliers, inspection reports. Inventory lists

Figure 3

INFORMATION SOURCES

DOMAIN OF EMERGENCY MANAGEMENT RESOURCES

	NATIONAL OVERVIEW & PATTERNS	ACTIVITY CATEGORIES EMERGENCY CLASSES	ORGANIZATIONS AND INSTITUTIONS	EMERGENCY TASK FORCES	INDIVIDUAL PEOPLE AND MAJOR TOOLS
GOALS AND CONSTRAINTS	National laws and regulations		Statutory instruments. Authority regulations. Institutional constitutions	Institutional derivation of laws and regulations	Worker protection regulations. Union agreements
PRIORITY CRITERIA ECONOMY, RISK, MAN POWER FLOW					
GENERAL FUNCTIONS AND OPERATIONS		Resources and capabilities; reports from institutions and services General strategies: textbooks, generalizations from incident, accident, and risk analysis. Generalizations from drills, exercises, and experiments			
FUNCTION OF SPECIFIC INSTALLATIONS, GROUPS AND EQUIPMENT		Functional information from accident and risk analysis, exercises and manuals for equipment. Derived procedural information and empirical know-how			Equipment manuals, data from research, textbooks, accident and risk analysis
MATERIAL LOCATIONS CONFIGURATIONS APPEARANCE	Road authorities, statistical institutions	Descriptions, architectural drawings and maps, equipment inventories, and staffing information			Equipment manuals and specifications

Figure 4

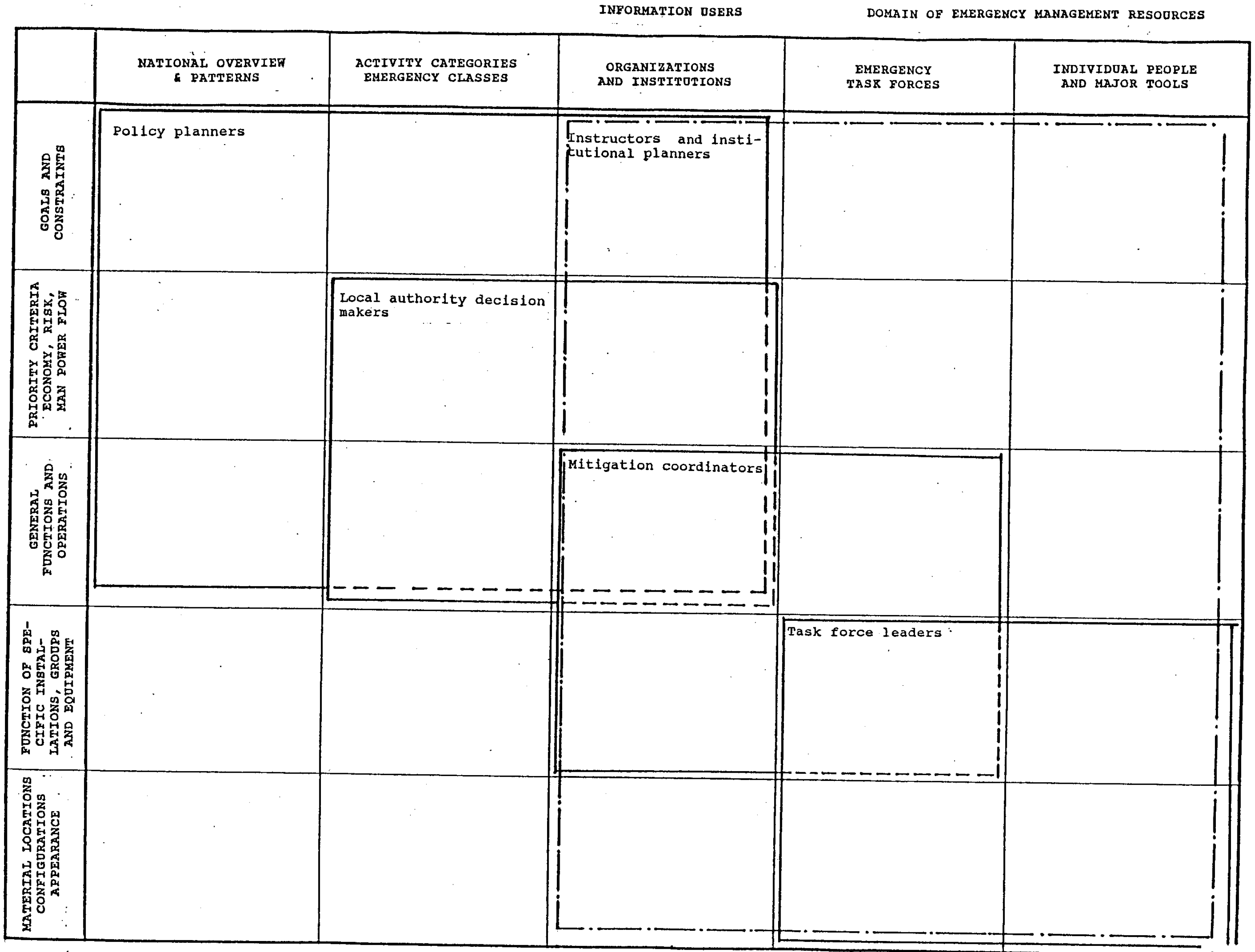

INFORMATION USERS
DOMAIN OF EMERGENCY MANAGEMENT RESOURCES
NATIONAL OVERVIEW & PATTERNS
ACTIVITY CATEGORIES EMERGENCY CLASSES
ORGANIZATIONS AND INSTITUTIONS
EMERGENCY TASK FORCES
INDIVIDUAL PEOPLE AND MAJOR TOOLS
GOALS AND CONSTRAINTS
PRIORITY CRITERIA ECONOMY, RISK, MAN POWER FLOW
GENERAL FUNCTIONS AND OPERATIONS
FUNCTION OF SPE-CIFIC INSTAL-LATIONS, GROUPS AND EQUIPMENT
MATERIAL LOCATIONS CONFIGURATIONS APPEARANCE
Policy planners
Local authority decision makers
Instructors and insti-tutional planners
Mitigation coordinators
Task force leaders

Figure 5

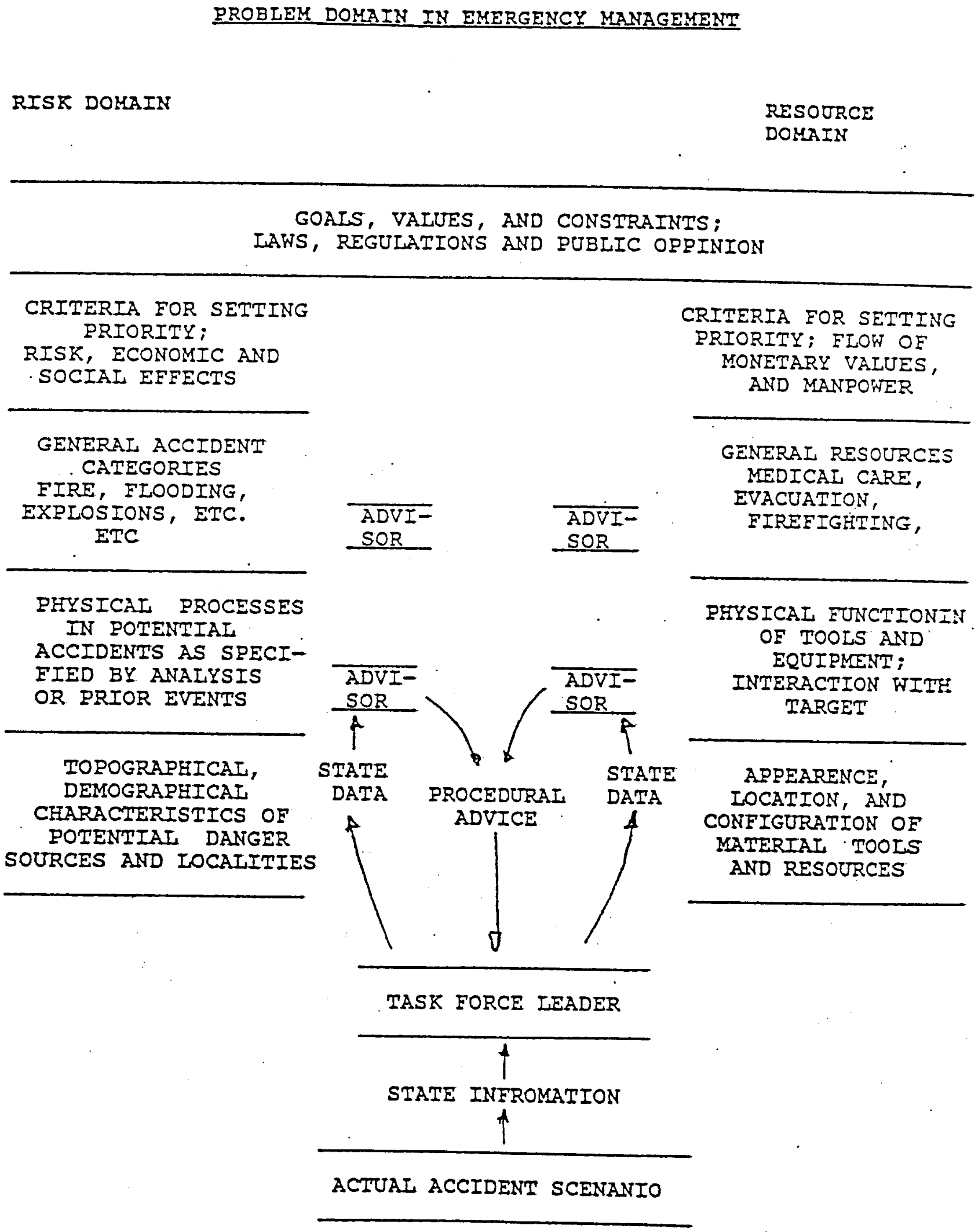
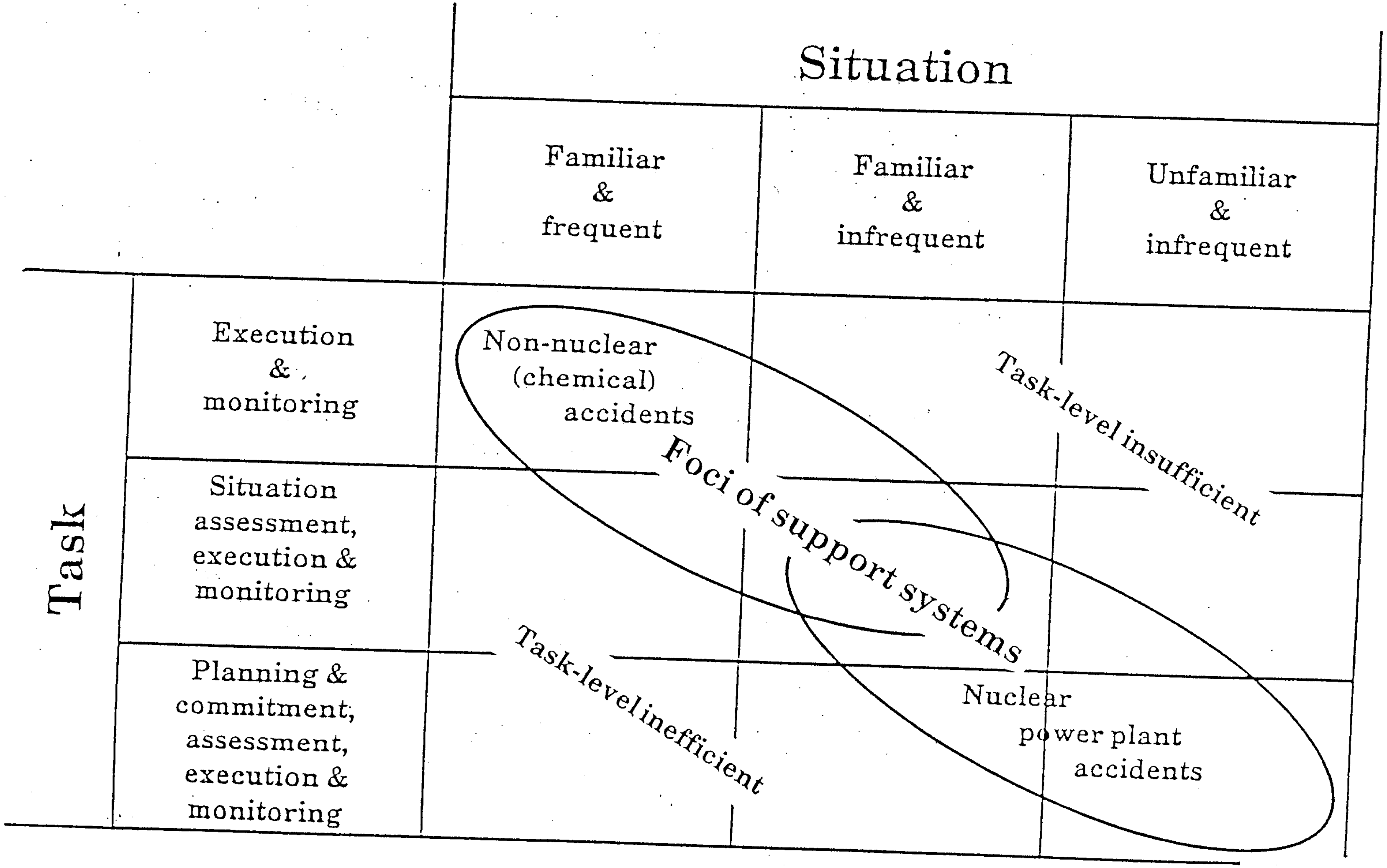

PROBLEM DOMAIN IN EMERGENCY MANAGEMENT
RISK DOMAIN
RESOURCE DOMAIN
GOALS, VALUES, AND CONSTRAINTS; LAWS, REGULATIONS AND PUBLIC OPPINION
CRITERIA FOR SETTING PRIORITY; RISK, ECONOMIC AND SOCIAL EFFECTS
CRITERIA FOR SETTING PRIORITY; FLOW OF MONETARY VALUES, AND MANPOWER
GENERAL ACCIDENT CATEGORIES FIRE, FLOODING, EXPLOSIONS, ETC. ETC
ADVI-SOR
ADVI-SOR
GENERAL RESOURCES MEDICAL CARE, EVACUATION, FIREFIGHTING,
PHYSICAL PROCESSES IN POTENTIAL ACCIDENTS AS SPECI-FIED BY ANALYSIS OR PRIOR EVENTS
ADVI-SOR
ADVI-SOR
PHYSICAL FUNCTIONIN OF TOOLS AND EQUIPMENT; INTERACTION WITH TARGET
TOPOGRAPHICAL, DEMOGRAPHICAL CHARACTERISTICS OF POTENTIAL DANGER SOURCES AND LOCALITIES
STATE DATA
PROCEDURAL ADVICE
STATE DATA
APPEARENCE, LOCATION, AND CONFIGURATION OF MATERIAL TOOLS AND RESOURCES
TASK FORCE LEADER
STATE INFROMATION
ACTUAL ACCIDENT SCENANIO

Figure 6



Situation
Familiar & frequent
Familiar & infrequent
Unfamiliar & infrequent
Task
Execution & monitoring
Situation assessment, execution & monitoring
Planning & commitment, assessment, execution & monitoring
Non-nuclear (chemical) accidents
Foci of support systems
Task-level insufficient
Task-level inefficient
Nuclear power plant accidents

Figure 7