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Organizational Interface In Reactor Emergency Planning and Response

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ABSTRACT

The purpose of this research was to determine if existing regulations have led to effective interfaces between utilities and offsite organizations in emergency planning and response. Findings suggest that regulations have provided the necessary framework for achieving adequate interfaces. That interface has been achieved is demonstrated by comprehensive response plans and good cohesiveness among organizations involved in emergency response. Interface problems identified in the research can be reduced by better implementation of existing regulations rather than by revision of existing ones.

EXECUTIVE SUMMARY

The purpose of this research was to determine if existing regulations resulted in adequate interface between utilities and offsite organizations in emergency planning and response. To address this question, we attempted to assess two elements of emergency management which could be used to measure the level of interface: the comprehensiveness and cohesiveness of planning and response. Comprehensiveness of planning was determined by a detailed review of emergency plans. Comprehensiveness of response was determined by the evaluation of a test exercise. To assess cohesiveness, we identified, from a review of relevant literature, a set of factors associated with cohesive response. Two case studies were used to measure the presence of these factors in planning. Second, a test exercise was observed to measure the presence of these factors in response.

FINDINGS FROM THE PLAN REVIEWS

The two purposes of the review of the emergency plans were to determine whether these plans would constrain a comprehensive response to an emergency and to determine if planning activities were reasonably coordinated. In general, the review suggested that there is adequate interface between utilities and offsite organizations in the planning process and that this interaction has led to well-coordinated planning documents. Although this conclusion applies in general, we also noted several areas in which interface during the planning process can be improved.

FINDINGS FROM THE CASE STUDIES

The case studies attempted to measure and assess the presence of factors that help promote cohesive response efforts both within and between organizations. We found that, internally, organizations are quite cohesive. Cohesion tends to break down, however, in relationships across organizational response networks. Organizations demonstrated flexibility in their response systems, which increases the effectiveness of response.

FINDINGS FROM THE TEST EXERCISE

The test exercise was used to determine if comprehensive planning led to a coordinated response and to assess how cohesiveness may change during a simulated response. Overall, the actual response that we observed was not as well coordinated as the planned response. This discrepancy was mainly due to problems in implementing procedures and not from inadequate plans and procedures. In addition, we found that internal cohesiveness within an organization increased during the exercise but that interorganizational cohesiveness decreased.

CONCLUSIONS

Findings suggest that implementation of existing regulations have led to comprehensive planning efforts. Minor improvements to plans can be made, but they fall within the scope of existing rules, regulations, and implementation guides. On these grounds, no regulatory changes are warranted.

Findings suggest that regulations will lead to fairly comprehensive responses to an emergency. Evidence from the case studies and the test exercise suggests that problems are due to poor execution of emergency plans and to lack of resources. Existing regulations explicitly deal with these problems, which can be reduced by better enforcement of the regulations.

More difficult and abstract to assess is the level of cohesiveness in and between emergency organizations. Our work revealed that cohesiveness as measured in the planning process is strong within the organizations but weaker between organizations. The difference was even more pronounced for cohesiveness in emergency response. The major reason for lack of cohesiveness was poor communication and a lack of knowledge about whom to communicate with. This is made more problematic by a lack of legitimacy among organizations; that is, some organizations do not have confidence in others or do not believe they play an important role.

Overall, our research suggests that the problems experienced at the Three Mile Island Nuclear Plant with respect to planning and coordination will not occur in another emergency unless existing regulations are not followed or existing plans are not properly implemented. However, mechanisms for ensuring that plans are properly implemented are part of the existing regulations.

1. INTERFACE IN EMERGENCY PLANNING FOR NUCLEAR POWER PLANTS

1.1 RESEARCH ISSUE

One of the many "human factors" issues in nuclear power plants (NPPs) emphasized by the accident at the Three Mile Island (TMI) Plant was the problem associated with organizational conflict, communication breakdown, lack of planning, and lack of coordination.* While the uncertainty and the characteristics of the accident helped in creating these problems, so did the nature of the organizational interfaces both prior to and during the emergency.

As a result, the U.S. Nuclear Regulatory Commission (NRC) and the Federal Emergency Management Agency (FEMA) issued revised rules and implementation guidelines on emergency planning which set forth requirements that intend to assure adequate interfaces between the utility and offsite organizations.**,† The purpose of the research reported here was to evaluate whether existing regulations result in adequate interfaces among organizations involved with emergency response. Where appropriate, recommendations for improved interface are offered.

1.2 RESEARCH OBJECTIVES

In addressing the general topic of evaluating interfaces among response organizations, three general research objectives were advanced:

- (1) to assess how utilities and power plant organizations interact with offsite organizations,
- (2) to determine if utility plans are consistent with local, state, and federal plans, and
- (3) to determine if emergency planning efforts will result in a comprehensive and cohesive response should an accident occur.

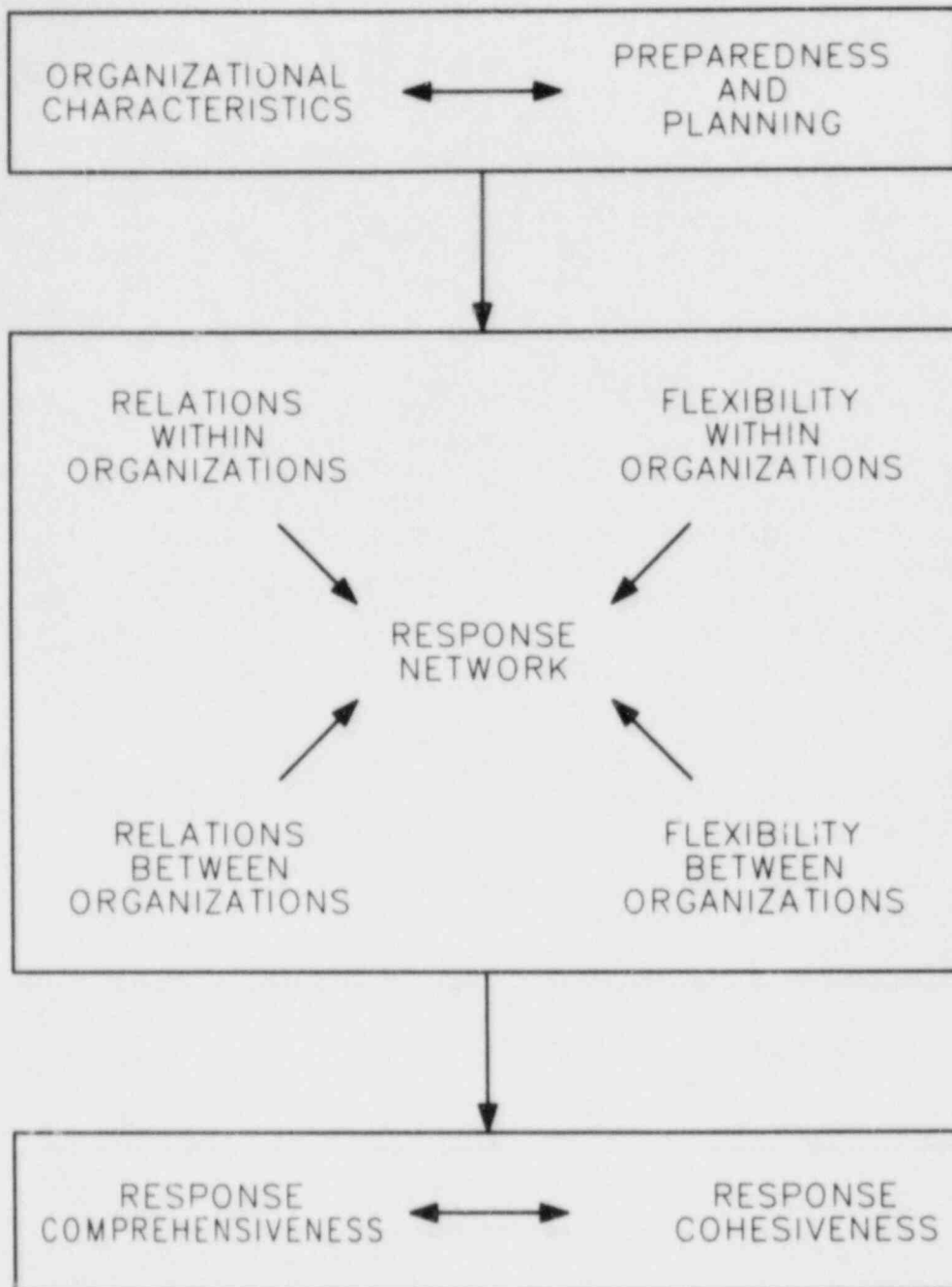
1.3 RESEARCH FRAMEWORK

Figure 1 illustrates a general model of interactions in emergency preparedness and response which guided this research. The key element

*President's Commission on the Accident at Three Mile Island. The Need for Change: The Legacy of TMI. U.S. Government Printing Office, Washington, D.C., 1979.

**U.S. Nuclear Regulatory Commission/Federal Emergency Management Agency, Criteria for Preparation and Evaluation of Radiological Response Plans and Preparedness in Support of Nuclear Power Plants, NUREG-0654/FEMAREP-1, Rev. 1, 1980.

†U.S. Nuclear Regulatory Commission, "Emergency Planning; Final Regulations," Federal Register, Vol. 45, No. 162, 1980, 55402-55418.



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Figure 1

A Descriptive Model of the Relationships Between Emergency Planning
Response Network and Response Effectiveness

in the model is the process by which interaction takes place. As depicted in the middle box, planning and response are characterized by

- (1) intraorganizational relationships, that is, the set of interactions that take place among members of an organization,
- (2) interorganizational relationships, that is, the set of interactions between organizations and their members,
- (3) intraorganizational flexibility, or the ability of individual organizations to change in response to new environments or circumstances,
- (4) interorganizational flexibility, or the ability of organizations to change relationships with other organizations and
- (5) response networks, or the pattern of interactions among all organizations in the response effort.

The nature of the relationships, flexibility, and network is determined to a large extent by the characteristics of each organization and by the planning efforts that take place before or between emergencies. In turn the organizational process has a direct effect on response comprehensiveness and cohesiveness. In this research, comprehensiveness and cohesiveness were used as indicators of effective interface. This model also helps to depict the relationship between planning and response. As such, it is possible to have comprehensive planning but not a comprehensive response or vice versa. Thus, in order to determine the adequacy of regulations, it is necessary to systematically assess organizational relationships, flexibility, and networks for emergency response and planning.

1.4 RESEARCH METHODS

Studying interactions during NPP accidents is limited by the lack of serious accidents for which empirical studies can be conducted. Given this problem, a research design was formulated to study interactions as they are thought to occur in an emergency and to attempt to understand how the interactions may differ during an actual emergency. The first task of the research team was to document interaction by reviewing sets of emergency plans for a sample of reactor sites. The second task was to review literature on organizational interaction during disasters and other emergencies. Based on this review, a set of conditions or factors that help explain cohesive response was developed. The third task was to conduct interviews with representatives of all emergency response organizations at a given site. The purpose of the interviews was to measure the presence of factors that are associated with cohesive response. Finally, a test exercise at an NPP was used to examine interactions under a simulated emergency. Pre-exercise interviews were held with organizations to ascertain the perceived nature of interactions. Overt behavior during the exercise was then observed. Exercise participants were subsequently interviewed about their experiences during the exercise to again determine the presence and absence of factors associated with a cohesive response network.

2. PLAN REVIEWS

2.1 Sample Selection

Resource limits prevented studying all NPP sites in the U.S. A non-random sample of sites was chosen to meet the following criteria:

- (1) Geographic Coverage
 - one site in each state with an operable reactor
 - one site in each NRC region
 - one site in each FEMA region
- (2) Multiple Jurisdictions
 - range in number of local political jurisdictions
 - sites with multiple states in emergency planning zone
- (3) Nuclear technology
 - reactor types covered
 - different vendors covered
- (4) Population in EPZ
 - rural and urban sites
 - population range

Our chosen sample consisted of 23 sites that met the above goals. We were successful in collecting data on 17 of those sites, and sets of emergency plans were analyzed for each. The mix of reactor sites represents a full range of variation in factors important to consider when evaluating probable emergency responses by organizations. As a result, the purposive sample selected provides a strong, albeit nonstatistical, basis for generalizing findings.

2.2 Data Collection

As the first step in evaluating linkages among organizations, it was necessary to determine, on the basis of information in the plans, which organizations performed specified tasks and their assumptions about which tasks other organizations were to perform. Functional emergency response tasks for a radiological emergency have been summarized in Table 1; both key decision points and routine tasks are identified. This functional description was used to index how each organizational emergency response plan (utility, state government, local government) assigned responsibility for each task. The purpose of this procedure was to verify that all plans written for a particular plant were consistent in organizational assignments—not to evaluate the adequacy of the plans.

To the extent possible, the three principles specified in the literature review as necessary to help ensure effectiveness of emergency response will also be addressed: (1) work and role definition, (2) interorganizational network integration, and (3) maintenance of organizational and interorganizational flexibility. Work and role definition

TABLE 1 Functional emergency response tasks for a radiological emergency

- | | |
|---|--|
| <p>A. Detection/Warning</p> <ol style="list-style-type: none"> 1. Key Decisions <ol style="list-style-type: none"> a. Event Classification b. Public Alert/Warning 2. Routine Tasks <ol style="list-style-type: none"> a. Offsite Notification b. Accident Monitoring <p>B. Communications/Control</p> <ol style="list-style-type: none"> 1. Key Decisions <ol style="list-style-type: none"> a. Activate EOF-EOCs* b. Establish Command 2. Routine Tasks <ol style="list-style-type: none"> a. Communications b. Exercise Authority <p>C. Accident Assessment</p> <ol style="list-style-type: none"> 1. Key Decisions <ol style="list-style-type: none"> a. Locate Radiation Monitoring Equipment b. Diagnose Plant Conditions c. Estimate Population Exposure 2. Routine Tasks <ol style="list-style-type: none"> a. Collect/Analyze Data on Radioactive Emissions b. Estimate Source Terms c. Monitor Meteorological Conditions d. Estimate/Project Exposure/Doses e. Track Plume <p>D. Protective Action</p> <ol style="list-style-type: none"> 1. Key Decisions <ol style="list-style-type: none"> a. Site Evacuation b. General Evacuation c. Radioprotective Drug Utilization 2. Routine Tasks <ol style="list-style-type: none"> a. On Site Protection b. Monitor On Site Exposure c. Account for On Site Population d. Recommend Protective Actions e. Direct Evacuation f. Issue Radioprotective Drugs g. Control Access to Plant h. Monitor Off Site Exposure i. Measure Contamination | <p>E. Emergency Relief</p> <ol style="list-style-type: none"> 1. Key Decisions <ol style="list-style-type: none"> a. Activate Emergency Facilities 2. Routine Tasks <ol style="list-style-type: none"> a. Operate Medical Facilities b. Transport Victims c. Decontaminate d. Isolate Contamination e. Provide Emergency Supplies f. Establish Evacuation Centers g. Military Support Activities h. Welfare Services i. Public Health and Sanitation j. Emergency Food k. Firefighting l. Law Enforcement m. Rescue <p>F. Recovery</p> <ol style="list-style-type: none"> 1. Key Decisions <ol style="list-style-type: none"> a. Reentry 2. Routine Tasks <ol style="list-style-type: none"> a. Radiation Detection/Monitoring b. Decontamination c. Food and Agriculture Control <p>G. Maintaining Emergency Preparedness</p> <ol style="list-style-type: none"> 1. Key Decisions <ol style="list-style-type: none"> a. Training Needed b. Equipment Needed 2. Routine Tasks <ol style="list-style-type: none"> a. Train Emergency Staff b. Conduct Test Exercise c. Evaluate Emergency Preparedness d. Maintain and Test Equipment |
|---|--|

*EOF = emergency operations facility; EOC = emergency operations center.

includes identifying the emergency response tasks to be done and who is to do them. Interorganizational network integration occurs when the plans of more than one organization are melded and when decision criteria are present regarding shift of responsibility/authority and level of participation in each emergency response task. Maintenance of organizational and interorganizational flexibility reflects the ability to change decision making processes and operational procedures in order to respond quickly to new circumstances; this need for flexibility is sometimes contradictory to the earlier requirements for well-defined roles and authority. Analysis of the indexes prepared for each of the plans from the 17 NPPs allows us to draw generalizations about interface in relation to each general category of functional response and about emergency planning in general.

2.3 Findings By Functional Response Tasks

Each of the major functional response tasks (see Table 1) is reviewed below.

Detection and Warning

1. Key Decisions - There is uniform agreement that the utilities must make the initial event classification to start the emergency response process both onsite and offsite. In each of the 17 plans, the responsibility for the sounding of a public warning is clearly specified.

2. Routine Tasks - Likewise, there is uniform agreement that the utility must give notification to state or local officials to activate off-site emergency plans. Initial accident monitoring is a utility responsibility until the offsite emergency plans are activated; therefore, no conflicts were noted in this area.

Communications and Control

1. Key Decisions - There seems to be little problem in the activation of utility and state emergency operation centers, but establishing shifts between state and local governments in command and authority remains the thorniest issue to define in written emergency plans. Most of the uncertainty may come from the authority to make decisions versus the authority to implement decisions once they are made; for example, often a decision is made at the state level but carried out at the local level. It is sometimes not clear if only the state can initiate action or if the local government can set some plans in action before decisions are made at the state level. There appears to be a need for more integration of activities in state and local plans and more specification of authority for segments of the integrated activities. For example, the organization charts appearing in each plan showing who has primary and secondary responsibilities for tasks in that organization's plan (not overall responsibility) sometimes appear to conflict with the texts of plans that do try to address interorganization responsibilities. The

plans could also be more specific as to how interactions with voluntary organizations (such as the Red Cross) will be handled. However, more specification of authority between organizations may be an inhibiting factor in maintenance of organizational and interorganizational flexibility.

2. Routine Tasks - Communications appear to be well defined with regard to communication networks and the equipment available for transmittal. What is less clear is exactly what information is to be communicated and what is necessary except for the state, local, and public warning procedures interactions are necessary in addition to the state, local, and public warning procedures, which appear clear-cut and apportioned to more than one organizational level.

Ambiguities in exercising authority may stem from some decisions being made at the state level but carried out at the local level. Where and how the local organizations can make decisions normally reserved for state organizations and how state disaster and emergency service organizations coordinate overlapping responsibilities with state departments of health are examples of this type of problem. Some emergency plans are clearer than others on lines of responsibilities and when they shift from one organizational unit to another. Some plans also address what happens if utility and state governments disagree but do not resolve the differences. The issue, once again, may be how specifically interorganizational authority can be spelled out without precluding flexibility.

Accident Assessment

1. Key Decisions - The placement of radiation monitoring equipment is straightforward and not likely to cause conflict. Decisions about plant conditions and estimating population exposure are less clearly defined; this can cause confusion. One possible conflict identified in one set of emergency plans examined concerned possible disagreement between the state organization and the utility regarding classification of the accident. The utility plan states that the plant management will maintain the classification it believes correct and will act accordingly even if the state organization classifies the situation as more severe.

2. Routine Tasks - There seems to be fairly uniform agreement about which organization exercises authority and implements most of the accident assessment tasks themselves. When more than one organization is involved in accident assessment, it is sometimes unclear how they will coordinate activities with each other.

Protective Action

1. Key Decisions - The authority and responsibility for key decisions about sheltering, site evacuation, general evacuations, and radio-protective drug utilization appear to be well defined. The general

evacuation decision is an example of one that can be made by the local organization if the need is deemed immediate and the necessary state organization is not available, thus retaining some interorganizational flexibility.

2. Routine Tasks - There is reasonable agreement about organizational responsibilities in carrying out the protective action tasks, and no major conflicts are anticipated in this area.

Emergency Relief

1. Key Decisions - It appears that the local organizations make more decisions in the area of emergency relief than in any other segment of our breakdown of functional emergency response tasks. Once the state has made the decision to recommend evacuation (under Protective Action), there is agreement in about 16 of 17 sets of plans on who is to make decisions about maintaining emergency facilities. One ambiguity was found where the state could take over this function from local government if they so chose.

2. Routine Tasks - In most cases, it is clear that the local organizations retain primary responsibility for most of these tasks, with the states offering assistance where needed. Specification of tasks and interorganizational integration appear to be well defined in the written plans.

Recovery

1. Key Decisions - The decisions on reentry to contaminated zones is always the state's decision offsite and the utility's onsite. Little ambiguity exists in this area.

2. Routine Tasks - Again, the state plays the primary role in the recovery tasks offsite, and most of these tasks are carried out by the state organizations, often assisted by local organizations. The primary reason for ambiguity lies in the minimal overlap of functions between organizational levels.

Maintaining Emergency Preparedness

1. Key Decisions - No major conflicts exist in the plans regarding the training and equipment needed. What is less clear is how the equipment will be acquired.

2. Routine Tasks - All organizational levels accept that they have significant responsibility in training and testing personnel, in maintaining and testing equipment, and in evaluating the effectiveness of their efforts.

2.4 GENERAL FINDINGS

From this analysis, we were able to assess five potential problem areas:

1. We could identify functional emergency response tasks not covered by any organization.
2. We could determine if overlapping authority existed for response tasks.
3. We could identify faulty assumptions about the responsibilities of other organizations.
4. We could reveal conflicts in authority and responsibilities.
5. We could assess the level of awareness possessed by one organizational level of the entire response system.

In the first problem area, major gaps concerning coverage of each of the functional response tasks were not found. If organizations carry out what they acknowledge in the plans, a comprehensive response will be achieved. In the second problem area, we found a great amount of overlapping responsibilities for certain emergency tasks. Plans in general, however, do not specify the boundaries of shared responsibilities nor present a mechanism for coordination of efforts. This could be problematic if communications during an emergency are not effective. In the third area, we found that occasionally one organizational level assumes that some other organization is going to perform a task while that other organization does not present information in its plan about doing that task. Although this was not common, it could create problems in an emergency. In the fourth area, conflicts in authority and decision making were not evident except in one case where two different organizations claimed to be in charge of the same task. Thus, on paper, clearly defined lines of authority exist. In the fifth area, we found that most plans attempted to reflect the functioning of other organizations and the structure of the entire response effort. In many cases, organizations could go further to improve this type of information in their plans.

Overall, the review of emergency plans suggested that utilities are becoming reasonably well coordinated with offsite organizations in their planning efforts. The review also suggests that the weakest area of coordination is between the Federal government (NRC, FEMA, others) and all other organizational levels. This, we suspect, can be attributed to the fact that Federal agencies have not developed response plans commensurate in scope and finality with others. Consequently, utilities do not have a good picture of the details of Federal involvement, and this is reflected in the plans.

In addition, the reviews solidly demonstrate that planning has led to comprehensive response mechanisms. These findings demonstrate adequate interactions in the planning process. However, it was demonstrated that actual response may differ from that outlined in the plan

for numerous reasons. Potential problems that might cause this difference in behavior have been listed in Appendix B. Accordingly, the next two sections describe activities that were undertaken to assess the adequacy of interaction in emergency response settings and the cohesiveness of both planning and response.

3. CASE STUDIES

Two case studies (one at a relatively new plant and one at a well-established one) were undertaken to gain greater insight into interface. The studies sought to identify (1) the degree to which emergency response organizations possessed characteristics of a cohesive system and (2) site-specific factors which may influence interface but which would not be identified in reviews of emergency plans. Information was collected for the case studies through discussions with representatives of major organizations involved with emergency response. These included the utility and agencies of state and local governments. A checklist of topics was developed to measure the existence of factors related to effective response (see Table A-1). Two groups of factors—those measuring organizational relationships and interorganizational networks—were selected on the basis of the literature review (Appendix A). Several measures of flexibility were developed. Table 2 provides examples of values for each factor associated with a cohesive response. The checklist used for the interviews is given in Appendix C.

3.1 CASE STUDY ONE

3.1.1 Evaluation of Cohesiveness

Discussions were held with utility personnel, state organizations, affected local organizations, and federal regional offices. Five state organizations were represented, including those responsible for emergency management, radiological health, human resources, and transportation. Local organizations included were county emergency management, police departments, the Red Cross, and another volunteer organization connected with communications and radiological health services. From these discussions, we could code each organization's level of effective and cohesive emergency abilities according to the factors presented in Table 2. This provided us with a measure of cohesiveness for each separate organization and for each organizational level. In addition, it allowed us to make judgments about how well the entire system rated on each of the factors. Appendix E provides a summary of data on which the following conclusions are based.

3.1.1.1 System Cohesiveness

(1) Intraorganizational Relationships. Overall, the emergency response system demonstrated a high degree of internal cohesiveness. This means that organizations, by themselves, possess characteristics that will make them effective in an emergency. Most had clearly defined roles in an emergency that were clearly understood. Second, in all but one case, it was clear who was in command. Third, division of responsibilities among personnel within the organizations was well understood. Fourth, organizations had mechanisms for setting priorities (or already knew the priorities) in emergency response. Fifth, eight organizations

Table 2. Organizational factors used to evaluate cohesiveness

Factors	Values Associated with Cohesiveness
<u>Organizational Relationships</u>	
Role definition Authority	Clearly defined responsibilities Clearly defined powers and authority hierarchy
Territory Priority setting Normativeness	Clearly limited boundaries of authority Understood mechanism for setting priorities Similarity between normal and emergency responsibilities
Legitimacy Communications ability Knowledge	Responsibilities are viewed as significant Ease and clarity of access and information Level of understanding about responsibilities
<u>Intra- and Inter- organizational Flexibility</u>	
Formalization Adaptability Control	Ability to deviate from written procedures Ability to respond to new situations Ability to exercise and retain authority
<u>Interorganizational Network</u>	
Domain Dispute resolution Legitimacy of roles Resource adequacy Autonomy Communications ability Authority Interaction clarity Knowledge	Clearly defined division of responsibility Mechanism for negotiating differences Acceptance by other organizations Sufficient resources to perform role Ability to relinquish for good of system High level of linkages between organizations Network hierarchies are clearly established Organizations know whom to interact with Functioning of the system is understood

have emergency responsibilities that are similar to the normal duties. Sixth, all demonstrated a sense of importance in their emergency response roles. Seventh, in all but one case, communications within the organizations were at least adequate. Finally, most organizations exhibited a good sense of knowledge about their emergency roles.

(2) Flexibility. The systems demonstrated a high level of flexibility, that is, the ability to respond to contingencies and unanticipated situations. Only one organization had somewhat formalized procedures that would constrain flexibility. Most showed some degree of adaptability. Finally, the organizations exhibited the type of control over their functioning in an emergency which allows for changing internal priorities.

(3) Interorganizational Network. The cohesiveness of the system as a whole was adequate but was not as well integrated as for individual organizations. The domain of various responsibilities or the way in which responsibilities of organizations are specified were fairly well established. Few, however, had mechanisms established for resolving any disputes or conflicts that might occur. Most organizations felt accepted as an important part of the network. Resources to carry out emergency functions were identified as a potential problem area for some. One of the weaker areas concerned communications ability, where a lack of adequate linkages and hardware emerged as the dominant problem. Another problem area concerned clarity of interaction. Many organizations did not demonstrate a good sense of knowing with whom they would be working in an emergency, as was also the case regarding their knowledge of the functions of other organizations. The response network showed fairly clear lines of authority, and organizations displayed signs of willingness to cooperate with all involved in the response effort.

3.1.1.2 Organizational Cohesiveness

(1) Utility. The NPP organization for emergency response demonstrated a reasonably effective structure. It was very cohesive internally and demonstrated flexibility. Some minor problems were evident in the way the utility interfaced with other organizations. Potential problem areas include communications, clarity of interactions, and ability to resolve disputes.

(2) State. Organizations within the state showed varying levels of effectiveness in their structure for response. Several rated well on almost every factor; one was notably poor. Problem areas were reflective of those for the system in general.

(3) Local. Organizations at the local level showed good, although not outstanding, response structures. They were internally cohesive but were less adept at interacting with other organizational levels. Communications appeared to be a major problem area.

3.1.2 Observational Notes

Overall, mixed appraisals of state-utility interfaces were received, although the stronger response was that of good working relationships. The major link between the state and utility is through interactions between the emergency organization and utility corporate emergency planners (often not located at actual plant site). This precludes much interaction between the state and onsite personnel. The state radiological health organization felt a lack of qualified personnel for radiological emergencies. This lack can lead to a questioning of technical ability; such a problem can affect working relationships between the state government and the utility. Most felt one great value of the exercise was the opportunity to meet and work with the people who would be responding to an emergency.

Local government has a minimal amount of interaction with the utility regarding planning and response other than through the annual test exercises. In the past, some of the agencies have had difficulty with initial notification procedures and feel the procedures are too complex. Another major area of concern for local government is the lack of understanding the public has concerning sirens and emergency response. More utility cooperation concerning public education is needed, particularly in reaching seasonal populations and in improving a utility-disseminated brochure on emergency preparedness and evacuation plans. A general overall feeling conveyed by local organizations is that the utility is not highly concerned about working with them except to meet regulatory requirements.

We had difficulty in assessing utility/Federal interactions because they were not readily observable. This difficulty suggests that greater attention should be placed on planning Federal involvement in emergency response.

3.2 CASE STUDY TWO

3.2.1 Evaluation of Cohesiveness

The same techniques for assessing cohesiveness were used in case study two. In this study a smaller number of organizations played key roles in emergency response. The state emergency management organization has overall responsibility for response and is assisted by a separate health department, which is responsible for radiological assessment. Although the primary responsibility for implementing response lies with local government, the state activates and maintains control over local organizations because of multiple jurisdictional involvement. All contacts between the utility and local government, whether for planning or response, are channeled through the state. The state emergency planning organization assumes responsibility for coordinating all state and local planning with the utility. In this context, the cohesiveness of the system and of organizations is reviewed in Sects. 3.2.1.1 and 3.2.1.2 with respect to the factors in Table 2.

3.2.1.1 System Cohesiveness

(1) Intraorganizational Relationships. The internal cohesiveness of emergency response organizations is extremely high. Almost uniformly, we coded organizations high on each dimension measured. In only one instance did an organization display a problem, and this was a lack of response priorities.

(2) Flexibility. As with internal relationships, the organizations rated well on flexibility. In every case, organizations showed evidence of being able to deviate from formal procedures, adapt to new situations, and maintain internal control.

(3) Interorganizational Response Network. The cohesiveness of the entire network displayed greater variability, with problems in three particular areas. First, the drive for autonomy, or the desire to maintain control over responsibilities, could be detrimental to response. Second, communication abilities are not well demonstrated in some cases. Third, lines of authority for offsite response have not been well defined. Other factors that were problems in case one did not emerge as problems in this system. These include interaction clarity, knowledge of the functioning of the entire response system, and resource availability.

3.2.1.2 Organizational Cohesiveness

Unlike case one, no great variations between organizations were observed. The utility demonstrated cohesiveness in nearly every factor assessed. At the state and local level, some organizations rated marginally better than others, but no single organization consistently measured poorly. Overall, the system reflected effective response planning.

3.2.2 Observational Notes

The organizations interviewed saw no problems in getting adequate resources for an emergency response and clearly understood with which other organizations they would be working. In many cases, there was frequent contact among the agencies.

The state emergency response organization has a somewhat military-oriented structure, and some of its staff, as well as the local emergency response directors are former military officers. The emphasis of some of these persons on the control aspects may be a reflection of both the plan and their own backgrounds. Other agencies tended to stress coordination. Turf battles were considered by those interviewed as more likely to occur because of personality conflicts than because of plan deficiencies.

The state and local staff persons believed they had a clear understanding of what their own and other agencies' responsibilities are and

thought that their work was well accepted. Several stated that commitment to emergency planning by their upper management prompts acceptance and support throughout the rest of the organization.

The personnel interviewed anticipated that during an emergency there might be some communications problems. These included mechanical problems, too few telephones, lack of direct contact between the local government and the utility, problems with interpreting technical language, a somewhat cumbersome formal message system in the state emergency operations center (EOC), and possible personality conflicts. Difference in time zones within the state was identified as a point of possible confusion. The state EOC located at the state capital as well as the state EOC located close to the plant operate on the time zone of the capital. The local government response organization would operate on local time.

Actual interfaces between different levels of an organization had not been tested through exercises, although the set of plans described the assignment for key decisions and routine response tasks. Some examples of potential problems were discussed. Although information on control is given in the plans, a city or local government might not accept direction from the county or state in actual practice. Enforcing control authority was expected to be difficult. Another expressed concern was that the state radiological health department is dependent on the utility for atmospheric-release projections, and there are no independent checks on the utility's projections.

In summary, weak points agreed upon by all included data communications (the utility hopes to install an automatic system), control of field teams from different agencies, recovery and reentry operations, notification of the public in rural areas, sheltering arrangements (since a nongovernmental agency is providing them), depth of technical ability and training for monitoring teams, adequacy of staffing for monitoring teams, ability for timely response in a quickly developing incident since monitoring teams have several hours of travel time to the site, and inadequate allowance for human nature and unanticipated response in the plan.

4. TEST EXERCISE

In conjunction with one case study, observation of a test exercise was used as a means of collecting further data about interface. This simulated situation provided a useful surrogate for examining interaction in an actual emergency. It is assumed that the interface problems revealed by the exercise would reflect general deficiencies in existing regulations as well as illustrate the problems corrected by those same regulations.

Findings were derived from observations of activities and interactions in the utility technical support center (TSC) and emergency operations facility (EOF) and in the state/county EOCs. No Federal agencies participated in the exercise except as reviewers. Participants in the exercise representing the major emergency organizations were debriefed, utilizing a checklist of topics designed to complement that developed for the case studies (see Appendix D for the test exercise check-list). A comparison of the exercise results with those of the case study offers insight on how organizational interactions may change in an actual emergency. Appendix F provides information on the nature and scope of the exercise.

4.1 INTERFACES DURING THE EXERCISE

By comparing data from the case study with those from the exercise, we can systematically observe potential differences between interface as reflected by planning activity and planned response and interface in actual response in an exercise. Again, we distinguish between cohesiveness of the system and that of organizations.

4.1.1 System Cohesiveness

Differences in cohesiveness between planning and exercise response reflected the general patterns emphasized in the case study. Organizations, in general, displayed greater internal cohesion and similar levels of flexibility, but there was poorer cohesion between organizations.

(1) Intraorganizational Relationships. Organizations demonstrated improved cohesiveness in the exercise from what was observed in the case study. Responsibilities were better defined, and people within organizations had a clearer delineation of roles and an improved sense of legitimacy. Communications, identified as a potential problem in the case study, were an even greater problem in the exercise.

(2) Flexibility. As in the case study, organizations demonstrated adequate flexibility. Overall, ability to respond to new situations proved higher, although ability to deviate from written procedures decreased slightly.

(3) Intraorganizational Response Network. Problems identified in the case study were exacerbated in the exercise. Factors that did not pose problems in case studies either remained adequate or were rated more effective in the exercise.

Across organizations, three factors proved extremely problematic. First, interorganizational communications constrained effective interaction. This was heightened by a lack of interaction clarity and any observable means of solving differences. In addition, the exercise revealed some problems of legitimacy among organizations that were not evident in the case study.

On the other hand, the exercise revealed that there was an increased level of knowledge about what other organizations do than was measured in the case study. Furthermore, division of responsibilities remained adequately defined. This suggests that organizations are adequately prepared, and know what to do but have some difficulties in coordinating those efforts with others in the emergency response system.

4.1.2 Organizational Cohesiveness

When the cohesiveness of a specific organization in the test exercise is compared with that of the same organization in the case study, several patterns emerge. First, the utility displayed less cohesiveness in the exercise. This is mainly attributed to less cohesive ratings on interorganizational factors. Second, the same trend and cause are observed for all state organizations. Third, an opposite trend is found for local government. Organizations at this level demonstrated increased cohesiveness during the exercise. One possible explanation is that organizations with little experience actually performing emergency tasks show lower cohesiveness in response than in planning. On the other hand, those with more practical experience demonstrate more cohesiveness in behavior in comparison to planning. This underscores the necessity of simulated response to develop cohesive organizational interaction.

4.2 THE VIEW FROM THE UTILITY EOF/TSC

The major problem observed onsite was communications with offsite organizations. Difficulties with the offsite notification procedures started immediately with technical problems with phone lines. This was made more severe when the person designated as the state warning point, reached by using automated dialing to a predetermined list of persons to be notified, gave instructions to call someone else. This caused delays in notification and also undermined the utility's confidence in offsite organizations. The personnel communicating the information on the standard notification form had difficulties in delivering messages and could not provide explanations or more detailed information. Information updates were quite untimely. Once the EOF was activated, better communications ensued because of more direct and continuous lines of contact.

Communications seemed to break down, however, during the transition of communications and other functions from the TSC to the EOF.

Some difficulties existed regarding the coordination of protective actions between the utility and state. Although the site emergency coordinator made a recommendation at 9:45 a.m., following the 9:00 a.m. General Emergency, to activate the warning system, disagreement over evacuation led to a delay in that recommendation until 11:08 a.m. Consequently, evacuation was not ordered by the state until 11:55 a.m. This points to a need for more timely coordination between the state and utility on protective action decisionmaking.

4.3 THE VIEW FROM THE STATE EOC

The state's most difficult situation was with gathering enough information to make an informed decision regarding evacuations. A State of General Emergency was declared at 9:00 a.m., and the evacuation decision did not become effective until 11:55 a.m. Part of the decision-making confusion stemmed from the utility declaration of a general emergency with a recommendation for no protective action. The state radiological emergency team was unable to get more than a minimum of information transmitted from the utility for up to 1 h before and after the utility declared a general emergency and needed more data regarding plant status, projected doses, and other problems. Though the state and the utility had standardized dose conversion factors, isopleths, etc., some confusion remained regarding population doses versus individual doses and in some field measurements. Smoother flow of information from the utility to the state EOC would have been expedient, as would have been quicker assessments and recommendations from the state radiological team to the state EOC director.

Once the evacuation decision was declared, the simulation of evacuation was accomplished quickly, though both the emergency medical services and the Red Cross stated they would prefer more lead time for evacuation.

The major events as posted at the state EOC log board are summarized in Appendix F, Table F-1.

4.4 THE VIEW FROM LOCAL EOCs

The local county EOCs experienced their greatest difficulties in communications as well, particularly those with the utility. The infrequency of incoming information and their inability to open better communication links with the utility were frustrating. The local EOCs would like to have a utility representative at the local EOCs or at least one person per county in the utility EOF designated to provide information directly to the local EOCs during emergency test exercises.

Since the county units maintain ongoing relationships with the local and state units dealing with different types of emergencies, it is only the utility which does not have frequent contact and therefore has fewer information channels through which to communicate. For example, the local EOCs were not advised of the first radiation release for 2 h. Because communications were slow, there were times when contradictory information was received and it was hard to verify what was happening. Particularly when the utility EOC had to be evacuated, communications were lost for a significant time period at a vital point in the test exercise.

All local organizations would have welcomed more frequent updates of information; and better radio communication links/equipment are needed, although all thought the amateur radio network instituted for the first time was helpful. The shelter program worked well, but the Red Cross could have used earlier notification that evacuation was imminent.

Lack of communication between state and local units about a decision to distribute protective drugs (KI) to emergency workers created some problems on the county level. The county EOC was unsure what situation prompted this action and felt that the local health personnel should at least be informed of the decision, if not allowed to participate in making such decisions.

Better radio communications are still needed, even though the amateur radio network which was used in this exercise for the first time was extremely beneficial. However, the state radio van and even the phone line to the utility did not work part of the time during the test exercise.

Some concern was expressed about the initial message on the Emergency Broadcast System which stated that the governor had taken over emergency operations before the public had been told that there was any problem at the power plant. This, however, may have been a function of the brevity of the overall test exercise; everything had to be done in a highly compressed time frame.

5. FINDINGS AND THEIR IMPLICATIONS

In this section, we present the conclusions from each of the three research tasks and discuss the implication of the findings for regulatory change. Each task is discussed and a final set of implications is presented.

5.1 FINDINGS FROM THE PLAN REVIEWS

The two purposes of the plan reviews were to determine whether plans would constrain a comprehensive response to an emergency and to determine if planning activities were reasonably coordinated.

In general, the review of emergency plans suggested that there is adequate interface between utilities and offsite organizations in the planning process and that this interaction has led to well-coordinated planning documents. Although this conclusion is generally true, we also noted several areas in which interface during the planning process can be improved. Specifically, we found that

- (1) All major response functions are covered by the plans.
- (2) Few conflicts about responsibilities exist. Those that do can be alleviated through further communication between the utility and the appropriate offsite organization in the planning process.
- (3) Plans do a good job of describing the responsibilities of other organizations in the emergency response system. Several plans reviewed could be improved by providing more details about the roles of other organizations.
- (4) One area that could be improved concerns situations where organizations share responsibilities on the same response task. Mechanisms for dividing or coordinating the shared responsibilities are lacking in the plans.
- (5) A second area requiring improvement concerns the level of detail in plans about the responsibilities of Federal agencies. Although the utility plan clearly specifies the role of, and coordination with, NRC, the level of information about other Federal agency involvement does not provide an adequate picture of Federal responsibilities.

5.2 FINDINGS FROM THE CASE STUDIES

The case studies attempted to measure and assess the presence of factors that help promote cohesive response efforts both within and between organizations. We found that, internally (intraorganizationally), organizations are quite cohesive. Cohesion tends to break down, however, in relationships across organizational response networks. Organizations demonstrated flexibility in their response systems, which will help increase the effectiveness of response. Specific findings include the following:

- (1) The major barrier to effective interface among organizations is communication ability and hardware.
- (2) Response cohesiveness is constrained, in addition, by uncertainty over who should be communicating with whom and by a lack of knowledge within an organization about the roles of other organizations.
- (3) Response organizations showed some variability in their overall levels of cohesion as measured by the research. Key organizations such as the utility, however, rated high on an index of cohesiveness.
- (4) Local organizations have the weakest interfaces with the utility and must rely on the state for information and guidance.
- (5) Individual personalities within organizations play a strong role in facilitating or preventing interaction in the planning process. This will vary from site to site and with changes in personnel within organizations.
- (6) Offsite organizations are constrained in their interfaces with utilities by a lack of equipment and trained personnel. This is particularly evident in radiological monitoring and assessment.

5.3 FINDINGS FROM THE TEST EXERCISE

The test exercise was used to determine if comprehensive planning led to a coordinated response and to assess how cohesiveness may change during a simulated response. Overall, we found that the observed response was not as well coordinated as the planned response. This was mainly due to problems in implementing procedures and not from having inadequate plans and procedures. In addition, we found that internal organization cohesiveness increased during the exercise but that interorganizational cohesiveness decreased. Specific findings include the following:

- (1) Communications difficulties created the major problems in achieving effective interfaces. This was exacerbated by confusion over the proper lines and contents of communications.
- (2) Legitimacy posed an interface problem for some organizations. Attitudes of the utility toward offsite organizations with respect to their technical ability and resources was a constraint to interaction. Furthermore, offsite organizations did not fully trust utility personnel regarding communications about plant status and protective action recommendations.
- (3) Poor implementation of the offsite notification procedure created problems but is sound in principle.

5.4 IMPLICATIONS FOR EMERGENCY PLANNING REGULATIONS

The purpose of this research was to determine if existing regulations resulted in adequate interface between utilities and offsite organizations in emergency planning and response. To address this question, we attempted to assess two elements of emergency management that could be used to measure the level of interface: the comprehensiveness and

cohesiveness of planning and response. Comprehensiveness of planning was determined by a detailed review of emergency plans. Comprehensiveness of response was determined by the evaluation of a test exercise and case studies of two response networks. To assess cohesiveness, we identified, from reviewing relevant literature, a set of factors associated with cohesive response. The two case studies were used to measure the presence of these factors in planning, and a test exercise was observed to measure the presence of these factors in response.

Findings suggest that implementation of existing regulations has led to comprehensive planning efforts. Minor improvements to plans can be made, but they fall within the scope of existing rules, regulations and implementation guides. On these grounds, no regulatory changes are warranted.

Findings suggest that regulations will lead to fairly comprehensive responses to an emergency. Evidence from the case studies and the test exercise suggest that problems are due to poor execution of emergency plans and lack of resources. Existing regulations explicitly deal with these problems, which can be reduced by better enforcement of regulations.

More difficult and abstract to assess is the level of cohesiveness in and between emergency organizations. Our work revealed that cohesiveness as measured in the planning process is strong within the organizations but somewhat weaker between organizations. The difference was even more pronounced for cohesiveness in emergency response. The major reason for lack of cohesiveness was poor communications and a lack of knowledge about whom to communicate with. This is made more problematic by a lack of legitimacy among organizations; that is, some organizations do not have confidence in others or do not believe they play an important role. In a related fashion, personalities of individuals within organizations constrain effective interaction and heighten the legitimacy problem.

We feel that the communication problem can be solved within the existing regulatory framework. It is chiefly a matter of better equipment, better training, and greater interaction in the planning process. The problems and potential resolutions are acknowledged and understood by the organizations involved. The legitimacy and personality issues are not addressed by current regulations. Although they contribute to interface problems, it is our belief that they cannot be effectively or even inefficiently solved by regulatory change. Whether they can be reduced by enforcement of existing regulations is also doubtful. Any effective solution to the legitimacy problem must come from within the organizational system itself and not through regulatory change, which could create more problems than it could solve.

APPENDIX A

DYNAMICS OF INTERFACE: ORGANIZATIONS DURING EMERGENCIES

BACKGROUND

An elaborate body of literature exists on organizational behavior and interorganizational relationships. A subset of this literature concerns the response of organizations to a variety of disasters. Several attempts to summarize this literature already exist (Mileti, 1980; Quarantelli and Dynes, 1977; Mileti et al., 1975; Barton, 1969; Dynes, 1970; Fritz, 1961, 1968). Organizational response to disaster is not unique. On both theoretical and applied grounds, organizational behavior relationships in disaster reflect the more general findings of organizations research. In this section, we review what is known about why organizations are effective or not in response to disaster, as well as what is known about why organizational coordination does or does not occur. To do so, we have organized the findings into four categories based on the intra- and interorganizational dichotomy and the pre-disaster preparedness and warning versus the disaster response period. From this review, we are able to specify the factors that lead to cohesive planning and response.

ORGANIZATIONAL EFFECTIVENESS IN DISASTER WARNING RESPONSE

Studies that have explicitly focused on the behavior of organizations during disaster warnings have been scant compared to other types of organizational studies of disasters. Some dozen or so studies, however, have revealed that several factors do seem to affect the effectiveness of organizations during disaster warnings. A general conclusion of these studies is that disaster experience enhances the ability of an organization to participate in the warning process, as well as respond to warnings (Mileti et al., 1975; Barton, 1970; Dynes, 1970; McLuckie, 1970; Anderson, 1969; Moore, 1956; Eliot, 1932). The capacity of an organization for communication (Leik, Carter, and Clark, 1981; Mileti et al., 1975; Kennedy, 1970) has also been pointed out as central to organizational effectiveness. A third factor that has been documented as important for organizational warning effectiveness is the perceived probability of the disaster (Anderson, 1969; Fritz, 1961; Fritz and Williams, 1957; Spiegel, 1957; Instituut Sociaal Onderzoek Van Het Nederlandse Volk Amsterdam, 1955). Organizations are quite reluctant to participate in warning dissemination if organizational officials are not reasonably confident that the hazard will materialize. Fear of negative public reactions for issuing a false alarm is a main reason. The fourth factor research has shown to be linked with the effectiveness of organizations during warnings is the structure of the organization itself. Factors of structure shown to have an influence on the ability of an organization to mobilize in the preimpact situation are varied.

Mobilization is typically quicker and less problematic for organizations that dispersed rather than centralized and formalized decision-making structure (McLuckie, 1970; Instituut Voor Sociaal Onderzoek Van Het Nederlandse Volk Amsterdam, 1955); and little role conflict for organizational members (Thompson and Hawkes, 1962).

ORGANIZATIONAL EFFECTIVENESS IN DISASTER IMPACT RESPONSE

A large number of studies have been performed which provide a sound basis for concluding what determines the effectiveness of organizations, as individual entities, in their disaster response. The findings of these studies, when brought together, point out that seven key ingredients are necessary for an effective response. The first of these is labeled normativeness. That is, it has been found (Adams, 1970; Anderson, 1969; Dynes, Haas, and Quarantelli, 1967) that the less an organization has to change its predisaster functions and role to perform in a disaster, the more effective is its disaster response. In essence, organizations whose daily operations can be switched to the topic of the emergency at hand do better than organizations who must adopt new operations that are unique to the emergency.

Second, and closely linked to the notion of normativeness, is the ability of an organization to be flexible. Organizations that are better able to vary from standard operating procedures during the disaster are typically more effective than those that cannot be flexible (Drabek et al., 1981; Kreps, 1978; Stallings, 1978; Weller, 1972; Brouillette and Quarantelli, 1971; Haas and Drabek, 1970; Drabek and Haas, 1969a, 1969b; Dynes and Warheit, 1969; Warheit, 1968; Dynes, 1966; Moore, 1964; Barton, 1962; Form and Nosow, 1958). An organization that is rigid in structure, in general, has a difficult time dealing with the uncertainty of disaster (Dynes, 1969) and adapting to its needs. The result is that effectiveness suffers.

A third major factor affecting the ability of an organization to be effective in disaster emergencies is work definition. Extensive evidence exists on which to conclude that organizations who know what to do, how to prioritize work, and how to administer the activities are more effective. The issue of work definition is particularly important in organizations for which emergency work is not a daily routine. In this case, definition of disaster or emergency roles as part of emergency operations is essential (Haas and Drabek, 1973; Adams, 1970; Kennedy, 1970; Dynes, 1969; Thompson, 1967; Barton, 1962; Form and Nosow, 1958). Organizations must be able to see emergency response as their job and have clearly defined roles to play. In addition, the clear definition of the internal authority structure of an organization must be spelled out (Dynes, 1969; Form and Nosow, 1958). This need is particularly acute since authority in organizations during emergencies typically shifts from what it is during routine operations.

To complement authority, the work domains or territory of each organization, as distinct from other organizations, should be clearly defined (Dynes, Quarantelli, and Kreps, 1972). Fourth, adequate resources are necessary for effective response (Kreps, 1978; Dynes, Quarantelli, and Kreps, 1972). It has also been suggested (Form and Nosow, 1958) that interorganizational resource dependence helps ensure an adequate supply of resources. A fifth important ingredient for effectiveness is information and communication ability (Quarantelli, 1970). Organizations that are able to effectively get and share information with others typically enhance effectiveness (Dynes, 1969). Sixth, organizational legitimation, or the claim to be able to do their emergency-tied work with approval and recognition from other organizations, is related to effective response.

Finally, internal organization cohesion between members is an impetus for organizational effectiveness. Commitment (Dynes, 1970; Quarantelli and Dynes, 1977), group cohesion (Form and Nosow, 1958), and a lack of role conflict (Dynes, 1969; Barton, 1962; Thompson and Hawkes, 1962; Form and Nosow, 1958) typically all signify that organizational workers are ready to get the job done.

INTERORGANIZATIONAL COORDINATION AND EFFECTIVENESS IN DISASTER WARNING RESPONSE

Little systematic research has been performed on this topic beyond a few studies (cf. Leik Carter, and Clark, 1981; Mileti, et al., 1975; McLuckie, 1970; Anderson, 1969). The results of these efforts indicate that the interorganizational elements essential for effective interorganizational warning-tied interaction and communication are definition of an organizational role in warning (cf. Mileti, et al., 1975; Kennedy, 1970) and preemergency patterns of interorganizational communication on which to build during the emergency (cf. Barton, 1969; Dynes, 1970). Put simply, for warnings and information flow between organizations to be effective, organizations must define dissemination as part of their job, and then communication will still favor familiar lines. In addition, effectiveness is enhanced if information is clear, unambiguous, and communicated in a speedy fashion (Anderson, 1969).

INTERORGANIZATIONAL COORDINATION AND EFFECTIVENESS IN DISASTER IMPACT RESPONSE

A rich research history has explored the nature and character of interorganizational relationships in emergencies in an effort to trace through their impact on emergency response effectiveness. An overriding conclusion of this research is that interorganizational coordination enhances the effectiveness of the overall response to the emergency. This research has shown that many concepts form a basis for the effectiveness of overall response. When the different approaches of

researchers to the topic are taken into consideration, the array of concepts, however, fits well into four general categories: (1) domain consensus and role specification, (2) network definition and integration, (3) communication, and (4) autonomy maintenance.

Domain consensus and role specification refer to the degree to which each organization knows what it and other organizations are to do during the emergency (Dynes, 1978; Kreps, 1978; Dynes, Quarantelli, and Kreps, 1972). Put simply, the effectiveness of overall response to an emergency escalates if all responding organizations know who is to do what and if those boundaries are well understood. Knowing, however, is not enough to ensure effective response; it is also necessary that organizations view each other's jobs as being important or legitimate (Dynes, 1978; 1969; Stallings, 1978; Warheit, 1970). This facilitates clear lines of authority between organizations (Drabek et al., 1981; Thompson and Hawkes, 1962; Rosow, 1955). Clear lines of authority between organizations help avoid conflict and enable conflicts to be resolved when they do occur, although not as well as does a predetermined mechanism for settling disputes.

Integration across organizations is a second important factor and is easier to achieve if participating organizations interact normatively during nonemergency periods (Drabek et al., 1981; Dynes, 1978; Brouillette, 1971; Form and Nosow, 1958; Clifford, 1956). Organizations that are used to interacting with each other are easier to coordinate for interaction in an emergency. Coordination and integration across organizations in emergencies also escalates as a function of organizations having overlapping members or the same people being on boards, panels, committees, and the like across organizations (Dynes, 1969). The notion of interlocking membership suggests that interaction, communication, and coordination are facilitated if people have overlapping organizational roles. In this same vein, the existence of boundary personnel, people who are charged with interorganizational communications, usually guarantees that interaction occurs (Dynes, 1969, 1978). Interaction escalates coordination, and coordination enhances effectiveness (Drabek et al., 1981; Dynes, Quarantelli, and Kreps, 1972; Dynes, 1970; Warheit, 1970; Barton, 1969; Parr, 1969; Drabek, 1968; Fritz and Marks, 1954; Kutak, 1928). An additional factor that has been shown to facilitate network integration and coordination is knowledge about other organizations (Dynes, 1978). If organizations understand about the internal operations and structure of other organizations, it is easier for them to coordinate and communicate with those other organizations. The general idea of network definition and integration for interorganizational coordination, although comprised of several concepts, is straightforward. Interorganizational coordination increases as a result of work to integrate the organizations participating in the interorganizational emergency response. A key device for enhancing integration is the construction of resource linkages across organizations (Drabek et al., 1981; Dynes, 1978, 1970b; Kreps, 1978; Stalling, 1978; Quarantelli and Dynes, 1977; Warheit, 1968; Demerath and Wallace, 1957). Resource

sharing and interdependence across organizations sometimes foster other avenues for interorganizational linkages. The major conclusion of this research suggests that coordination and effectiveness of interorganizational emergency response increase as a result of prior efforts to cast participating organizations into an integrated response network.

Third, communication between organizations is another essential ingredient for an interorganizational emergency response system to be coordinated and for heightened effectiveness (Drabek et al., 1981; Dynes, 1978; Brouillette, 1971; Quarantelli, 1970; Dacy and Kunreuther, 1969). Efficient interorganizational communication is essential for the provision of information between organizations regarding their specialized roles and tasks and for the quick dissemination of news about the changing context of the emergency.

Finally, autonomy maintenance (Mileti et al., 1975; Dynes, 1970; Dynes and Warheit, 1969; Parr, 1969; Warheit, 1968; Quarantelli and Dynes, 1967; Thompson and Hawkes, 1961), or the struggle on the part of individual organizations to resist giving up autonomy, is a major constraint to effectiveness. A requisite for an effective response to an emergency is that participating organizations be convinced that inconsequential losses of autonomy are in the overall interest of an effective response.

SUMMARY AND CONCLUSIONS

The behavior of organizations is a critical component of emergency planning and response. Moreover, factors important to casting the effectiveness of that response are not only limited to organizational ones, but also extend to those which profile the type and intensity of interorganizational relationships that go on between organizational actors. Table A-1 presents a summary of factors important for emergency response coordination and organizational and interorganizational system effectiveness which were derived from the literature review. Three key principles critical to effective response emerge from this table. First, organizations must know what they are supposed to do and who is to do it. Second, organizations must be integrated with other organizations. Third, they must maintain flexibility. Each specific factor is related to one or more of these general principles. The specific factors and the three overriding principles will be used to develop evaluation criteria and to guide the analyses used in this research.

Table A-1 Summary of organizational factors related to effective response

Organizational Relations	Interorganizational Network
<u>Planning and Warning Period</u>	
<ul style="list-style-type: none"> ● Disaster experience ● Communications ● Perceived probability of disaster ● Organizational structure <ul style="list-style-type: none"> - Flexible decision making - Role conflict (territory) 	<ul style="list-style-type: none"> ● Role definition ● Communication
<u>Disaster Response Period</u>	
<ul style="list-style-type: none"> ● Normativeness ● Flexibility ● Work definition <ul style="list-style-type: none"> - Role definition - Priority setting - Authority - Knowledge ● Resources ● Information and communications ● Legitimacy ● Cohesion 	<ul style="list-style-type: none"> ● Domain consensus (boundaries) ● Legitimacy ● Dispute resolution ● Authority ● Interaction ● Flexibility ● Knowledge ● Resource linkages ● Communication ● Autonomy

Appendix B

SOME POTENTIAL PROBLEMS IN EMERGENCY RESPONSE

Functional Tasks	Potential Problems
A. Detection/warning	
Event classification	<ul style="list-style-type: none"> • Incorrectly classified • Event not recognized • Resistance to declare emergency • Resistance to change classification • Disagreement over interpretation/classification
Offsite notification	<ul style="list-style-type: none"> • Contact (offsite) cannot be reached • Wrong person is contacted • Equipment failure • Correct message not given • Message not understood • Message not believed • Notification is overlooked
Public alert/warning	<ul style="list-style-type: none"> • Equipment fails • People not reached by warning • Correct message not given • Message not understood • Message not believed • Decision to warn not made • Rumors precede "official" notice • Warning responsibilities not carried out
Initial accident monitoring	<ul style="list-style-type: none"> • Equipment failure • Data not believed • Data misinterpreted • Information not communicated • Information miscommunicated
B. Communications/control	
Activate EOC/EOF	<ul style="list-style-type: none"> • Personnel not reached • Facilities not useable
Establish communications network (hardware)	<ul style="list-style-type: none"> • Equipment not available • Equipment failure • Links overlooked • Decision to activate not made • Personnel unavailable to operate
Establish command/authority hierarchy	<ul style="list-style-type: none"> • Message not communicated • Personnel not available • Decisions not made • Competition for control • Misinterpretation of responsibility • Emergent responsibilities needed
C. Accident assessment	
Locate radiation monitoring sampling equipment	<ul style="list-style-type: none"> • Placed in wrong location • Equipment failure missing • Not used • Responsibility overlooked
Collect/analyze data	<ul style="list-style-type: none"> • Personnel unavailable • Equipment not used correctly • Sampling not carried out • Data not used correctly • Data not believed • Results not communicated
Estimate source terms	<ul style="list-style-type: none"> • Procedure followed incorrectly • Data interpreted incorrectly
Monitor meteorological conditions	<ul style="list-style-type: none"> • Equipment failure • Micro-climatic variability not detected • Data not collected • Information not communicated
Estimate dose/exposure	<ul style="list-style-type: none"> • Miscalculation • Erroneous assumptions about transport • Not done • Not communicated
Track plume	<ul style="list-style-type: none"> • Insufficient data • Miscalculation • Not communicated

Appendix B (continued)

Functional Tasks	Potential Problems
D. Protective action	
Site evacuation	<ul style="list-style-type: none"> • personnel not reached • warning not understood • warning not believed • people do not know what to do • people resist leaving • transportation not available
General evacuation	<ul style="list-style-type: none"> • risks not correctly estimated • recommendation not given • decision not made • same as public warning (Section A)
Onsite protection	<ul style="list-style-type: none"> • equipment missing/fails • decision/notification not made • incorrectly used • not used
Monitor human exposure (onsite)	<ul style="list-style-type: none"> • equipment missing/fails • not done
Account for population onsite	<ul style="list-style-type: none"> • people not located • inadequate personnel • overlooked
Recommend protective actions (for public)	<ul style="list-style-type: none"> • cannot reach proper person • cannot decide if needed • insufficient information/data • communicated to wrong person
Direct general evacuation	<ul style="list-style-type: none"> • public does not behave as anticipated • transportation routes blocked • emergency personnel unavailable or missing • can not communicate with public • directions not given/or/insufficient • vehicles unavailable
Issue radioprotective drugs	<ul style="list-style-type: none"> • not available • decision on use not made • cannot be distributed • incorrectly used
Control access to power plant	<ul style="list-style-type: none"> • inadequate personnel • responsibility overlooked
Monitor human exposure offsite	<ul style="list-style-type: none"> • equipment not available/malfunction • inadequate personnel • responsibility overlooked
Measure environmental contamination	<ul style="list-style-type: none"> • cannot locate • inadequate/malfunctioning equipment • responsibility overlooked
E. Emergency relief	
Activate/operate emergency medical facilities	<ul style="list-style-type: none"> • decision not made • staffing unavailable • communications fail • facilities not available
Transport "victims"	<ul style="list-style-type: none"> • transportation not available • routes not useable • personnel unavailable
Decontaminate/isolate contamination	<ul style="list-style-type: none"> • inadequate personnel/equipment • cannot locate • inadequate means of distribution
Establish Evacuation Centers	<ul style="list-style-type: none"> • Evacuation routes blocked • People not informed • Not set up
Provide Various Emergency Services/Supplies	<ul style="list-style-type: none"> • needs not communicated • personnel inadequate • responsibilities not carried out • inadequate supply/resource • access to is blocked • inadequate means of distribution
F. Recovery	
Reentry	<ul style="list-style-type: none"> • inadequate data/information • decision not made/conflict over decision • responsibility not clear
Food/agriculture control	<ul style="list-style-type: none"> • inadequate personnel to monitor • not implemented

APPENDIX C

DISCUSSION TOPICS ON ORGANIZATIONAL INTERFACE

INTRAORGANIZATIONAL RELATIONSHIPS

- 1a. How does your organization fit into the broader scope of emergency response activities in the event of a nuclear power plant accident?
- b. Is it clear what your responsibilities are?
2. What things do you anticipate having to do in an emergency that are not covered in the emergency plan and implementing procedures?
- 3a. In an emergency does the structure of authority within your organization change from normal situations?
- b. If yes, how?
If no, describe.
4. Is it clearly understood by all who are in charge?
- 5a. Does anyone's emergency responsibilities overlap with others in your organization?
- b. If yes, how?
6. How clear are the priorities for your organization's emergency response activities?
7. In what ways do your emergency response activities differ from what you do on a daily routine?
- 8a. Are there people within your organization that you feel don't understand what you do in an emergency?
- b. Are there people who don't agree about their own emergency jobs?
9. Are there any problems in communicating with others in your organization about emergency response activities? Why or why not?
- 10a. How closely are you required to follow procedures in the emergency plan and implementation procedures?
- b. What are the consequences of not following them?
- 11a. Does your organization have adequate resources to carry out its emergency responsibilities?
- b. If not, what is lacking?

INTERORGANIZATION RESPONSE

12. Do you have the means of obtaining adequate resources?
13. Is it clear which other organizations you will interact with in an emergency? Please explain.
- 14a. Do you interact with these organizations as part of your normal activities?
 - b. How frequently?
15. Is someone specifically responsible for communicating with each of these other organizations during an emergency?
16. Is it clear which other organizations your organization can tell what to do in an emergency? Which can tell yours what to do? Please explain.
- 17a. Do any other organizations have the same responsibilities in an emergency?
 - b. If so, where do yours end and theirs begin?
- 18a. Are there any other organizations that are difficult to work with?
 - b. In what ways?
19. Do you feel that regulations about what to do in an emergency are a burden?
- 20a. Are there any other organizations who do not understand what you do in an emergency?
 - b. Who feel what you do is not important?

FLEXIBILITY

21. What problems do you anticipate in communicating with other organizations in an emergency?
22. Do you anticipate that the control your organization has over what it does would be lost or changed in an emergency?
- 23a. Do you feel the entire plan and strategy for emergency response will successfully work if an emergency occurred?
 - b. What are the weakest links?

APPENDIX D

TEST EXERCISE EVALUATION TOPICS

1. What was your role in the exercise?
2. Is that the role you would actually perform in an emergency?
3. Was it clear what your responsibilities were in the exercise?
4. Was everything you did in the exercise described in the emergency plan and Emergency Operating Procedures?
5. Was it clearly understood who was in charge? Explain.
6. Did anyone's emergency responsibilities overlap with yours? How did you coordinate your efforts? What problems did this cause?
7. Was your role in the emergency exercise similar to your normal work responsibility?
8. Was it clear how you were to set priorities among things to do?
9. Did anyone disagree with you over your responsibilities or tasks?
10. Were there others who did not understand your responsibilities? Who did not feel they were important?
11. Did you have adequate resources to carry out your responsibilities?
12. Did you have adequate means of obtaining more resources?
13. Was it clear with whom else you were to communicate with? To work with (if different)?
14. Have you ever interacted with these people before? Describe. Was the nature of your interaction different in the exercise?
15. Did you have any communications problems? Explain.
16. Was there anyone difficult to interact with?
17. How closely did you follow written procedures? Why?
18. Did you ever feel things were not under control? Describe.
19. What were the weakest aspects of the emergency response organization?

APPENDIX E

DATA FROM THE CASE STUDIES AND EXERCISE

Table E-1. Case study one matrix*

Organizational Cohesiveness Factors	Utility	Organization										
		State					Local					
		A	B	C	D	E	A	B	C	D	E	F
INTRAOrganizational RELATIONSHIPS												
Role definition	C	C	U	C	C	C	C	C	U	C	C	U
Authority	C	C	U	C	C	C	C	C	C	C	C	U
Territory	C	C	U	C	C	C	C	C	C	C	C	U
Priority setting	C	C	U	C	C	C	C	C	C	C	C	U
Normativeness	N	C	U	C	C	C	C	C	C	C	C	U
Legitimacy	C	C	U	C	C	C	C	C	C	C	C	U
Communications ability	C	C	U	C	C	C	C	C	C	C	C	U
Knowledge	C	C	U	C	C	C	C	C	C	C	C	U
FLEXIBILITY												
Formalization	N	C	C	C	C	C	C	C	C	C	C	C
Adaptability	C	C	C	C	C	C	C	C	C	C	C	C
Control	C	C	N	C	C	C	C	C	C	C	C	C
INTERORGANIZATIONAL RESPONSE NETWORK												
Domain	C	N	U	C	C	C	C	C	C	C	C	N
Dispute resolution	C	C	U	C	C	C	C	C	C	C	C	N
Legitimacy of roles	C	C	U	C	C	C	C	C	C	C	C	N
Resource adequacy	C	C	U	C	C	C	C	C	C	C	C	N
Autonomy	C	C	U	C	C	C	C	C	C	C	C	N
Communications ability	C	C	U	C	C	C	C	C	C	C	C	N
Authority	C	C	U	C	C	C	C	C	C	C	C	N
Interaction clarity	C	C	U	C	C	C	C	C	C	C	C	N
Knowledge	C	C	U	C	C	C	C	C	C	C	C	N

*In this table, C=cohesive value, U=uncohesive value, N=neutral value, and ?=inadequate data.

Table E-2. Case study two matrix*

Factors	Organizations					
	Utility	State Govt.		Local Govt.		
		A	B	A	B	C
INTRAORGANIZATIONAL RELATIONSHIPS						
Role definition	C	C	C	C	C	C
Authority	C	C	C	C	C	C
Territory	C	C	?	C	C	C
Priority setting	C	C	U	C	C	C
Normativeness	C	C	C	C	C	C
Legitimacy	C	C	C	C	C	C
Communications ability	C	C	C	C	C	C
Knowledge	C	C	C	C	C	C
FLEXIBILITY						
Formalization	C	C	C	C	C	C
Adaptability	C	C	C	C	C	C
Control	C	C	C	C	C	C
INTERORGANIZATIONAL RESPONSE NETWORK						
Domain	C	C	N	C	C	C
Dispute resolution	?	?	?	?	?	?
Legitimacy of roles	C	C	C	C	C	C
Resource adequacy	C	C	C	C	C	C
Autonomy	C	U	?	C	C	?
Communications ability	N	C	N	C	N	C
Authority	C	C	U	C	N	C
Interaction clarity	C	C	C	C	C	C
Knowledge	C	C	C	C	C	N

*In this table, C=cohesive value, U=uncohesive value, N=neutral value, and ?=inadequate data.

Table E-3. Test exercise matrix*

	Utility	State			Local				
		A	B	C	A	B	C	D	E
INTRAOORGANIZATIONAL RELATIONSHIPS									
Role definition	C	C	N	C	C	C	C	C	C
Authority	C	C	U	C	C	C	C	C	C
Territory	C	C	C	C	C	C	C	C	C
Priority setting	C	C	C	C	C	C	C	C	C
Normativeness	C	C	C	C	C	C	C	C	C
Legitimacy	C	C	C	C	C	C	C	C	C
Communications ability	C	U	U	N	U	C	C	C	C
Knowledge	C	C	N	C	C	C	C	C	C
FLEXIBILITY									
Formalization	U	C	C	C	C	C	C	C	C
Adaptability	C	C	C	C	C	C	C	C	C
Control	C	C	C	N	N	C	C	C	C
INTERORGANIZATIONAL RESPONSE NETWORK									
Domain	C	N	N	C	C	C	C	C	C
Dispute resolution	U	?	U	N	?	?	?	N	U
Legitimacy of roles	C	C	U	C	C	C	C	C	U
Resource adequacy	N	N	C	N	N	U	C	C	N
Autonomy	N	C	C	C	C	N	C	C	N
Communications ability	U	U	U	N	U	N	U	U	U
Authority	C	C	U	C	C	N	C	C	C
Interaction clarity	U	U	U	C	U	U	U	U	U
Knowledge	C	C	N	C	N	C	C	C	N

*In this table, C=cohesive value, U=uncohesive value, N=neutral value, and ?=inadequate data.

APPENDIX F

DESCRIPTION OF THE EXERCISE

Table F-1. Major Exercise Events

Abbreviated controller scenario from exercise plan

2000: Unusual Event reported by personnel at Plant

0410: Radiation material detected in release piping

0606: Analysis of discharge canal indicates radioactive material

0730: Jet pump problems

0800: Reactor scram

0801: Rods stuck out, reactor critical

0805: Inject stand-by liquid control

0940: Diesel generator #3 on fire

0950: Reactor subcritical

1018: Temperature increase and increase of airborne radioactive gases; gases in reactor building

1020: Heavy steam in minipipe tunnel

1025: Radiation alarm sounded in reactor building

1031: Auxiliary operator missing in reactor building

1040: Auxiliary operator found, seriously injured and contaminated

1040: Radiation levels in reactor building at 4 at 40 R/h

1045: Fire extinguished in diesel generator

1100: Reactor building radiation levels at 68 R/h

1200: Reactor building radiation levels at 136 R/h

1200: (Based on above events, it is expected that the state radiation protection section, the Nuclear Regulatory Commission (NRC) the Utility Technical Support Center, and General Electric will jointly decide to do an orderly blowdown and depressurization. Expected reaction: state activated sirens and EBS message.)

Table F-1. Major Exercise Events (continued)

Major Events at the Utility

0519:	Unusual Event declared
0622:	Release into canal reported
0625:	Alert status declared
0738:	Manual scram
0743:	16 rods fail to scram
0800:	Site Emergency
0900:	General Emergency declared because of leak in dry well
0905:	Site evacuation sounded
0920:	Decision made to tell state that evacuation may be necessary
0945:	Recommend state activate warning system to notify public as an advisory but no evacuation notification
0945:	EOF Activated
1108:	Evacuation recommendation issued
1220:	EOF begins relocation

Table F-1. Major Exercise Events (continued)

State EOC Posted Log Board

0820: Scrammed reactor. 16 fuel rods failed. Damage to core.
0912: General Emergency with no Protective Action recommended
0945: Plant did site evacuation
1015: Plant EOF at site evacuated
1030: County 1 reported 306 in shelter*
1155: Decision at SERT to evacuate 4 sectors
(within 2 miles of plant)
1200: County 1 opening 2 shelters
1245: KI being administered to emergency workforce
1245: Evacuation of 3 sectors complete
1300: Evacuation of 4th sector complete

*Some county tests, etc. were conducted out of sequence.

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