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weaknesses were present', they were only of 'peripheral significance for the course of events' (Royal Commission of Inquiry, 1977, p. 4).

Almost two years later on March 28, 1979, a series of events culminating in a nuclear plant accident with a partial core melt-down occurred in the United States. From this time until the initial danger subsided on 2 April, an unspecified but probably low amount of radiation was released into the environment. This nuclear accident was the first major accident in the United States, and it too captured world-wide attention and signalled to the nuclear industry and governments that nuclear accidents were a reality and something to be reckoned with, even though prevention in-depth and safety requirements exist. Prior to this time such accidents were also viewed as 'impossible'. The Presidential Commission set up to investigate this accident concluded that 'fundamental changes will be necessary in the organization, procedures, and practices – and above all – in the attitudes of the Nuclear Regulatory Commission and, to the extent that the institutions we investigated are typical, of the nuclear industry' (Presidential Commission, 1979, p. 7).

Given two similar conclusions stemming from two dissimilar but major accidents, it would seem reasonable to compare some of the organizational and administrative issues surrounding these accidents, particularly since both of these energy-related accidents have resulted in slowing down the production of new energy in an energy-short world. It may be surprising that each of these accidents has resulted in public controversy and temporary moratoria on further development since in neither accident did significant off-site damage occur. The resulting oil slick at Bravo which escaped being contained did very little damage to marine life and no oil reached the Norwegian or Danish shores. The radiation releases at Three Mile Island (TMI) were largely contained and the overall health effects have been found to be minimal. There was also no loss of human life in either accident. Regardless of the minimal physical damages incurred, both accidents have spawned political moratoria for a variety of reasons: increased safety consciousness by the public, increased awareness of invisible and environmental damages, existing government emphasis on safety regulations, existing industrial 'propaganda' on the impossibility of major accidents, lack of familiarity with such accidents, increasing spread of large-scale energy production facilities, etc. While an investigation of these phenomena would be of interest, this paper does not attempt to do so. Neither does it attempt an analysis of the accident prevention systems surrounding these energy technologies.

Rather, its purpose is to look at possible lessons to be gained from a

comparison of the organizational responses for the managing of these two accidents after they occurred. No attempt will be made here to outline the sequence of events in these accidents or to discuss the significance of such events.[1] Certain human and technical features are comparable in these two accidents and interested readers are urged to compare them, but a total comparison is beyond the scope of this paper. Table 1 displays a comparison of certain technical features of these two accidents as background for this paper, but no description is included to elaborate on any of the listed items. Out of this organizational comparison it is hoped that certain lessons may be drawn that would be useful for further research into the organizational aspects of major accidents involving large-scale energy technologies. Certainly, the experiences of these two accidents highlight a need to focus on the organizational systems created to manage accidents, particularly in countries where national policies for public safety are emphasized.

1. The Actor Types Involved at Accidents

Given an inherent awareness of accident probability, why were these two accidents seemingly unexpected and the organization and administrative practices surrounding their management created ad hoc? Such a question can be partially studied by looking at the actors who are expected to respond to accidents. An actor's ideological foundation for safety and accident management as well as its communication and linkage to other social actors appear as important determinants of the adequacy of organized responses to large-scale accidents.

Any technology has a protective core of organizations or actors linked together by a common ideology or set of oversimplifications of shared knowledge and interests that supports that technology. An energy technology is no different since the technological expertise and resulting ideology required gives power to organized technical experts in private and public bureaucracies. Such influence is communicated to other actors, whether rival, beneficiary or sufferer, via information used to foster public opinion to achieve the ends desired by the technocrats and others sharing the same values (Meynaud 1969). For example, while the setting of a safety standard directly involves the industry designing, manufacturing, supplying, using and servicing the technology as well as the regulator, other actors include unions, politicians, local governments, residents, consumers, rival technologists, other government agencies, research ex-

Table 1. Comparison of Bravo and TMI Accidents.

Items	Bravo	TMI
1. location	Norwegian sector of North Sea	Middletown, Pennsylvania, U.S.A.
2. technology	offshore oil production platform	nuclear power plant
3. accident	oil blowout, first in North Sea	core overheat, first in U.S.A.
4. timing & extent	late evening, 8 days	early morning, 6 days
5. indirect cause	maintenance program	maintenance program
6. early warning	mud leaking from valve	water leaking from polisher valve
7. initiating event	stuck open downhole safety valve	stuck open pilot operated relief valve
8. contributing events	not ready to install backup valve plus installed it upside down	not see to close backup valve plus shut down cooling pump
9. on-duty crew	• not act on warnings • not share info between shifts • no formal engineering education • lacked experience offshore, events	• same • same • same • lacked experience with events
10. supervisors	• lack of theoretical knowledge • on-site but absent • lacked experience with events	• same • off site • same

perts, etc. Such a broad array of actors drawn into the setting of, say, a safety standard can generate conflict because of differing perspectives and hence ideologies (Fischer 1979).

This proposition has as its core the concept of actors or social groupings representing various organizations involved or wanting to be involved in the responses to safety and accident management. As responses to the accidents at Bravo and TMI showed, new organizations can be instantly created (as at Bravo) and new roles can be created by and for existing organizations (as at TMI). Major actor groupings that would appear useful in examining and comparing accident management roles and linkages at Bravo and TMI include the following:

1. The company(s) owning, operating, and servicing the technology;
2. The government agency(s) regulating the technology;
3. The response agency(s) which has responsibilities for managing emergency situations/accidents (this agency can also be part of a regulatory agency);
4. The inside experts from government agencies, research institutes, companies and universities;
5. Those heterogeneous social groups impacted upon or potentially benefitting or suffering from the technology and an associated accident;
6. The exogenous and unorganized influential groups that an accident affects, such as politicians, outside experts, and media representatives.

These actor groupings are seen as a minimal actor configuration required for a comparison of the accident responses generated at Bravo and TMI. While each of these different actor groupings have different ideologies that affect goals, incentives, information, perceptions, and alternatives, the accident is the basis for their being bound together in some form of combined and linked management response. Their inconsistencies can be used, set aside, ignored or cancelled in order to meet the commonly perceived threat to their livelihood. No direct a priori organizational forms normally exist to integrate all of these actor groups; rather it has been the accident itself that was the integrating factor. Choices of organizational form and function have tended to evolve during the course of such accidents as occurred at Bravo and TMI. As such, the actual responses have been ad hoc, based upon experiences during the accident rather than being based upon normatively derived organizations and administrative prac-

tices from a priori analyses. This ad hoc approach had the advantage of allowing access by certain impactees and exogenous actors into the accident management system, but it can lead to interference and wrong interpretations within the management system itself and outside for the public at large. Thus a planned accident management system should account for the inclusion of seemingly external, but influential and involved actor groups.

Given that a large-scale, politically important accident can involve such actor groups as those listed above, the questions are: who are involved, and in what ways are they involved? In addition, the linkages between these actor groups for the purposes of on-site accident control, mitigation of its off-site consequences, and the giving and acting on information about the accident would be of concern.

In order to shed light on these questions, the actor involvement and interrelationships that evolved at the Bravo and TMI accidents will be presented. From these brief descriptions a schematic organizational form for each of these accident responses will be presented. Through a comparison of these two evolved organizational responses, suggestions can be made about the outline of a more adequate organizational form for responding to major accidents. However, this paper does not attempt to describe the individual actors responding to these two accidents. An earlier paper described the Bravo accident, the responding actors, their organizational form, and their key decisions (Fischer 1978).

2. Comparison of the Bravo and TMI Actor and Organizational Responses

This section of the paper provides the comparison of the actors involved in the Braco and TMI accidents. In addition, the organizational linkages between these actors are discussed. Each of the six actor types are used as the basis for this effort. Table 2 is the keystone in this comparison and has been designed to be self-explanatory so that only amplification of selected issues will be discussed in the text.

For the *Accident Response Actor* the significant differences between Bravo and TMI lie in its manner of creation and the degree of authority and centralization of this actor type. At Bravo an immediate ad hoc decision was made by the Minister for Environment to place all major regulatory and supportive actors within one Action Command under a single leader. While this response existed earlier in outline form, it had never been

Table 2. Comparison of Actor Types for the Bravo and TMI Accident Responses

Actor type	Bravo	TMI
Accident Response Organization(s)	• organized at beginning of accident • direct authority to take over accident if necessary • one centralized body for on/off-site responses including normal regulators as part • worked through normal regulators who implemented decisions. • centralized source for information • political role in background	• organized during the accident • indirect authority to take over accident • actors merged into three groups with split responses between on/off-site • finally based on normal regulator • separate sources for information • political role required
Normal Regulator(s)	• contingency planning had begun • reliance on operator self-interest • pre-accident regulatory functions split by speciality • local authority of regulator recognized • no a priori accident roles, alternatives developed • adopted passive role in accident • contained political and public anxieties • good internal communications • no on-site regulator	• contingency planning had not foreseen acc. • same • pre-accident regulatory functions centralized • regulator has no local off-site authority • same • adopted ad hoc active role in accident • created political and public anxieties • poor internal communications • moved to on-site regulator
Operator	• unlimited liability plus obligation to reimburse off-site costs • small petroleum company • reason to expect accident • primary responsibility for accident responses	• limits to liability • small utility company • unexpected accident • same

implemented and was done so by oral authority within hours after notification of the accident. All on- and off-site public responses were placed under this single technocratic actor, and the Action Command was a direct representative of the central government so that no politicians had to participate directly in its decisions. The Action Command carried out its functions through the normal regulators and left the primary responsibility for management of the on and off-site consequences with the operator. In addition, all official statements released to the media were done through this one body which eliminated the possibilities for conflicting and speculative information from elsewhere within the government or the operator. Finally, the Action Command had a priori authority to take over the management of the accident from the operator if it was deemed necessary in the public interest.

At TMI this actor type was created ad hoc in the midst of the management of the accident by the two top affected politicians, one of whom personally directed the key off-site responses. The organizational form was decentralized into three separate headquarters using political and technocratic actors with responsibilities matching their normal jurisdictional boundaries. An understanding of the accident and communications between these sets of actors thus became crucial, especially with increasing distance from the site of the accident. Oral authority was also used by these politicians in the creation of this form of response. Information given to the media was jointly done by the Governor of Pennsylvania and a designated representative of the NRC, the Nuclear Regulatory Commission, both of whom were directing the key on and off-site accident management activities. PEMA, the Pennsylvania Emergency Management Agency, which was given greater authority during the accident, became separated from the information flow from the Governor's Office during the latter stage of the accident.

Accident management was split among different actors because of the unfamiliarity with nuclear accidents, the slow recognition of the nature of the accident, conflicting information and recommendations from the NRC, the rising interests and conflicting information being presented in the media, the potential for public misinformation and panic, and the potential political impacts on governance and the future use of nuclear power. Three separate accident management and media information centers were established ad hoc during the course of the accident. This arrangement was only possible because of the action by the State Governor and the U.S. President who acted to limit the sources of information and to consolidate the supporting agencies. These centers included:

1. The on-site accident center at the TMI plant was supplemented by headquarters NRC staff where one man became the source of all technical and on-site information;
2. The off-site accident management center in the State Governor's Office which coordinated all state and federal responses, and was the source of information on evacuation and other protective measures;
3. The President's Office coordinated the federal agency responses for emergency relief and gave out information on this effort.

The direct responsibility for on-site management of the nuclear accident became mooted during its course because of the increasing involvement of the NRC, the Nuclear Regulatory Commission, in the cooling down of the reactor. No a priori authority existed for the NRC to take over the management of the plant from the NRC licensee-operator. In addition, the operator was requested not to release information to the media and it was not present at the press briefings.

The *Normal Regulators* at Bravo and TMI played different roles in the management of these accidents. The crucial differences are that the NRC headquarters initially took an ad hoc active role in the accident at a distance, and later at TMI when designated to do so by the U.S. President. Accident information gained in Washington from the site generated considerable concern and hasty recommendations which, in turn, created misinformed advice to off-site managers and speculative statements to the media. The NRC role at the site contributed to its on-site management while the NRC in Washington created needless anxieties among off-site managers and the general public. Information flow between the NRC Regional and Washington Offices is not clear from accident accounts. No a priori scientific knowledge seemed to surface within the NRC for responding to this multi-faceted accident or to understanding the nature of the hydrogen bubble. This combined lack of scientific knowledge and appropriate responses was a shortcoming and should have acted as a brake on hasty and speculative statements both to accident managers and the media (Presidential Commission, 1979, p. 39–40).

During the Bravo accident the on-site regulator, the Oil Directorate, played only a passive role with the operator by checking and assessing their prospective plans for controlling the accident. This regulator then advised the Action Command on the quality of the plans as presented. The off-site regulator, the Pollution Control Authority, played a supplementary role in that it specified the operator to use mechanical pollution

control devices and aided Phillips in finding and using them.

The *Operators* at Bravo and TMI each had primary responsibility in preventing and responding to accidents. Each operator responded similarly by protecting their employees and physical plant, by calling in industrial experts to supplement their efforts and by notifying and cooperating with government regulators and accident managers. Also, both operators cooperated with the wishes of the governments' accident response actor with regard to the media. Neither operator relied on previously developed assessments of alternatives in responding to the particular set of events confronting them, including preventing escalation to the accident level as well as responding to it. Accident management was not a priority for these two operators.

The possibility of both of these accidents should have been expected. However, in both cases the supervisory and operational staff did not respond correctly while the accident was still preventable. Once the accident had occurred, experts from elsewhere in the industry occupied key roles in bringing the accident under control.

Phillips Petroleum had the primary responsibility of preventing and responding to the Bravo accident. This responsibility existed even though the accident occurred during a time of transition from few preparations to moving toward adequate preparation for mobilizing this responsibility. Thus it would seem that the government regulators would have had some a priori role or means of supplementing the operator's existing responses before the operator was fully capable of responding to an accident in the required manner. The reasons given for not having such supplementary postures a priori was the hope that no accident would occur during the interim, the requirements having already been levied on the operators, and the concern for diluting the operators' responsibility.

Other oil companies operating in the Norwegian sector of the North Sea did not come to the aid of Phillips in this accident. Although a cooperative plan existed among the oil companies, it was not followed. On the other hand, at least one offer from the British sector was received and accepted. Apparently, a fear of future government responses toward oil development inhibited the oil companies responding to Phillips' plight as well as the government's decision to ignore the use of chemicals, which was the only alternative the oil companies could immediately use in a joint response. Requirements now exist for inter-company responses to accidents based on the use of mechanical means for pollution control.

At TMI the company itself had the primary responsibility of responding to the accident as long as the status of the accident and its consequences

were contained within the perimeter of the plant site. The plant staff summoned technical engineers from its parent company for operation efforts in containing the accident. In addition, the plant supervisor brought in representatives from Babcock and Wilcox, the designers and constructors of the reactor cooling systems, their control, and their instrumentation. Finally, at a later stage in the accident, aid was requested from the nuclear industry, which responded by creating an ad hoc advisory group consisting of representatives from other private nuclear plants. Because the consequences of the accident went beyond the plant itself and into the adjacent environment and beyond, the plant supervisor also notified the Pennsylvania Emergency Management Agency (PEMA), the regional office of the NRC, the local county, the parent company, the Brookhaven national laboratory, the Pennsylvania Bureau of Radiation Protection, and the State Police. The supervisor also dispatched on and off-site radiation monitoring terms.

The *Experts* used in responding to each of these accidents had similar tasks: control the accident, track and predict the radiation cloud/oil slick, and help control the consequences. At Bravo no a priori scientific roles for experts had been developed, and so had to be initiated by the scientists, while at TMI scientific roles developed for government nuclear facilities were transferred on request to the TMI situation. However, at Bravo, scientists generally agreed on the predictions and degree of adversity of the oil slick while at TMI considerable disagreement existed over the nature and consequences of the accident and its radioactive emissions. Industrial experts were directly involved in controlling the accident itself, while government experts concentrated on the bubble and off-site impacts. A priori and integrated roles had not been developed for these actors.

The total reliance on a locally untried single foreign outside expert for the key role of regaining control at Bravo could appear as a weakness in an effective accident management system. While the Red Adair Company has a world-wide reputation within oil company circles, the vast majority of its experience rests with killing blowouts on land where access to and space for amassing equipment to kill the blowing well is always available. The design, height and complexity of the larger North Sea offshore platform hinders the use of capping procedures. Therefore, a probability for prolonged accidents exists in the offshore and localized experience in developing internal, integrated expertise has been suggested.

Impactees for these two accidents were quite different: Bravo affected marine life and potentially threatened coastal communities via an ugly

mess, whereas TMI potentially threatened area residents' lives and health via an invisible cloud. However, in each of these accidents no major adverse impacts occurred to workers, residents or the biological environment. In fact, one would conclude that the off-site damages were nil in both cases. A priori roles were underdeveloped for potentially affected residents, and information links for most impactees were via the media.

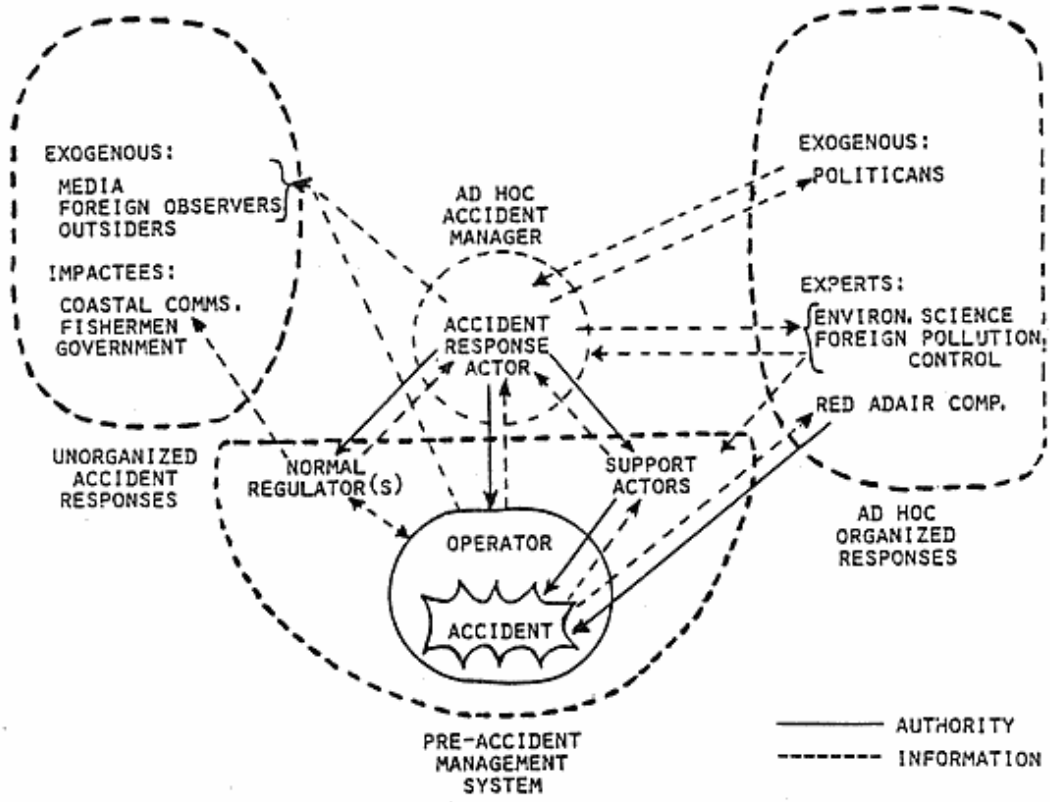
Assumed *exogenous* actors at Bravo and TMI became increasingly involved during the course of these two accidents. *Politicians* were essential actors in both of these accidents; however, the immediate appointment and confirmation of politically delegated authority at Bravo ensured the role of the Action Command as *the* accident manager. At TMI the two top politicians had to intervene during the accident to bring order out of seeming chaos created via conflicting information and recommendations. Site visits were made by the top politicians in both countries.

The *media* were significant in relaying information to area residents, national citizens, and the world at large. The media consisted of local, national and foreign representatives, all of whom served different interests and made different demands on information sources. No a priori public information roles and facilities were developed before these accidents occurred. Consequently, both information sources and quality contributed to media confusion, particularly at TMI. Media representatives assigned to cover these two accidents did not have a priori technical knowledge to judge the content of the information nor to discern useful questions to be put to accident managers.

Outside experts used both of these accidents as vehicles to convey their views to the media on the representative technologies and their broader public impacts. Such views were used by the media for a variety of reasons, including lack of confidence in the accident managers' information. These reported views contributed to public alarm during the accident and to the decisions for temporary moratoria made by the politicians after the accident.

Foreign observers were present at each of these accidents, and their demands for information were high because of the actual and perceived consequences in their respective countries. At Bravo foreign observers were present throughout the accident and observed the conduct of the Action Command in its deliberations. In addition, foreign observers were present in aircraft tracking the direction and extent of the oil slick. Finally, foreign groups played essential roles in the pollution control effort to contain and capture the oil slick. The Bravo accident resulted in closer cooperation between Norway and the United Kingdom in the post-acci-

Figure 1. Principal Actors and Linkages involved at Bravo that formed the Accident Management System.

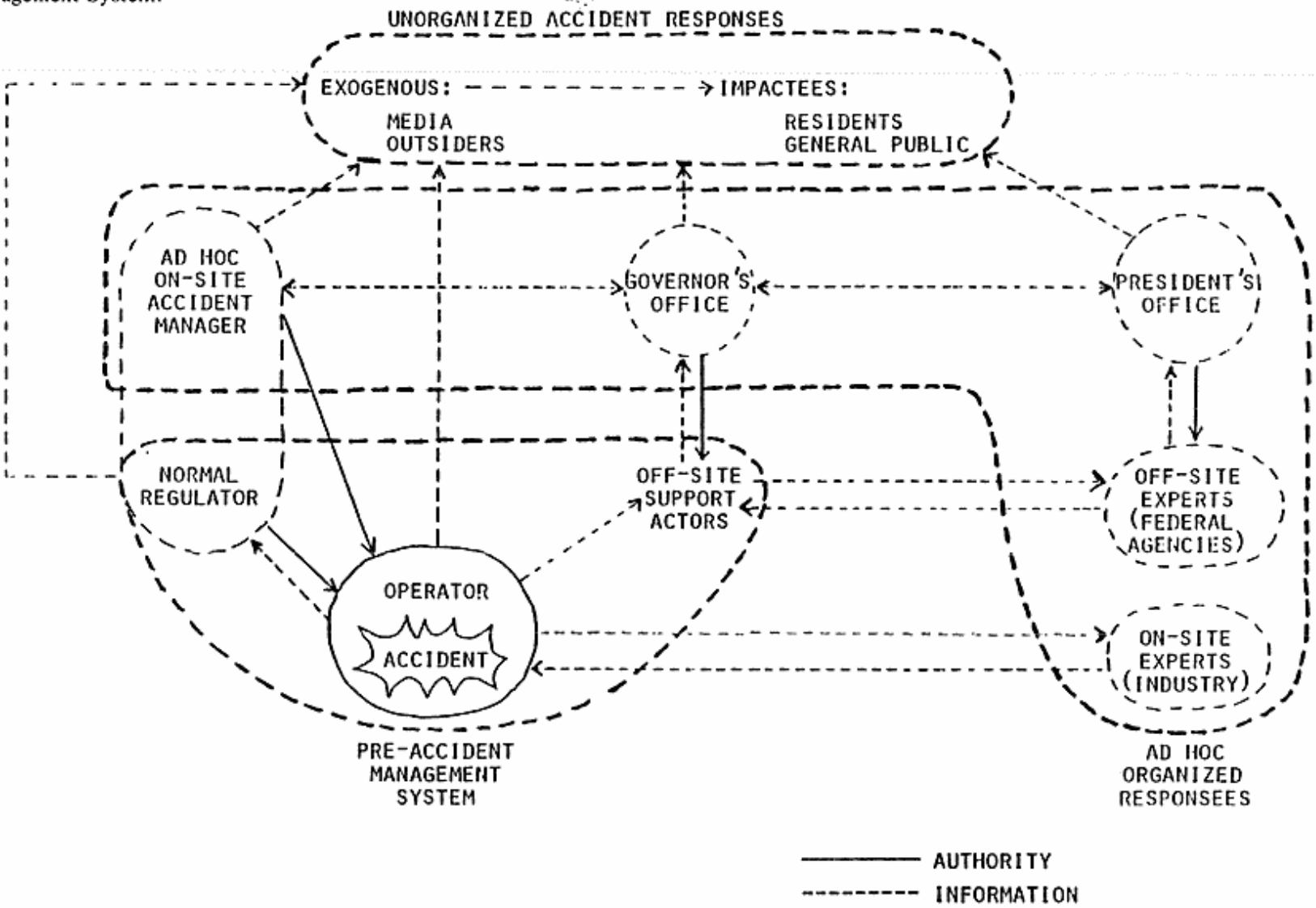


dent phase for the planning of integrated accident management responses. At TMI foreign observers were present at the NRC Washington office during and after the accident, and afterward at the plant itself. In addition, international agencies have deliberated over the implications of both of these accidents.

Figures 1 and 2 represent schematics which group the six actor types into the pre-accident management system, the ad hoc organized responses, and the unorganized accident responses. These three sets of accident responses existed at both Bravo and TMI and could, therefore, be expected to exist in future major accidents. Together these three sets of responses constitute the overall accident management system.

The arrangement at Bravo as shown in Figure 1 shows the central role of the accident manager. Even though it was established ad hoc it functioned well in its relations with the operator, normal regulators and politicians. Because the normal regulators were part of this ad hoc accident management actor and because on and off-site responses were under its authority, a prolonged accident would not have deterred from this organizational arrangement.

Figure 2. Principal Actors and Linkages Involved at TMI that Formed the Accident Management System.



The organizational set-up at TMI in Figure 2 shows a dispersed arrangement that existed at the end of the accident. At the beginning of the accident, conflicting information sources and a lack of understanding of the nature of the accident led to a loss of credibility publically to the operator and politically to the regulator. These problems led to a three-way division of responsibility: an ad hoc on-site manager was created; the Governor's Office was used to direct off-site responses; the President's Office directed federal agency emergency support. Had the accident persisted over time, this arrangement could be expected to be further centralized into one authority handling all responses.

3. Accident Management Actors and Organization

Certain experiences with those responding to the Bravo and TMI accidents have been briefly described and compared. The responses of the six actor types which were used as the thrust for this paper can now be collated as the basis for stating 'conclusions'. These 'conclusions' should not be viewed as absolute, but as interpretations of the responses to the two accidents. Certainly, these 'conclusions' are issues that have been raised through the responses of these actor types and as such warrant discussion beyond this paper.

One major conclusion or issue is the *lack of a priori roles* for accident management by all of the actor types involved. For both Bravo and TMI even the Accident Response Actors were not prepared for immediate active involvement both on and off-site. While a major Norwegian response system had been legislated and was being prepared, no a priori plans existed during the interim before the planned system could be completed. The NRC Washington Office, on the other hand, did not have preparations for active involvement with appropriate backup in an uncontained nuclear accident. The lack of agreed a priori roles also extends to the planned use of the normal regulator, the operator, industry and government experts, scientific experts, the politicians, the media, the outside experts, and those impacted upon by the accident.

Little foresight for active a priori accident management and supporting actor roles seems to stem from accidents being viewed as preventable. While both the Bravo and TMI accidents were found to be wholly preventable, still these two accidents happened. Thus, one must conclude that preventable accidents cannot always be prevented and that a priori roles must be developed for expecting the unexpected. In addition, since transition periods always exist, it would seem important for alternative a

priori roles also to exist for ensuring effective responses, regardless of the posited roles at the end of the current transition.

Accident management bodies are also temporary substitute decision-making actors, and these actors were prominent in both accidents, particularly at Bravo with its ad hoc Action Command for overall management and the Red Adair Company which managed the accident control process. However, even at TMI, substitute decision-makers included the ad hoc active roles of politicians and the ad hoc industry and regulatory responses. The use of substitute decision-making actors raises such questions as authority, responsibility, liability, appropriate alternatives, and future working patterns, all of which impact on the relationships between the operator and the normal regulator.

Reliance on substitute actors of any type, whether decision-makers or supporting experts, can lead to difficulty in the post-accident phase. Once the accident is over or otherwise under control, the substitute actor has completed its task, leaving the normal regulator and operator to cope with and adjust to the consequences of its actions. In addition, the appointment of a temporary investigatory actor in the post-accident phase existed at both Bravo and TMI, and such an actor can further disrupt the regulator-operator relationship. If substitute actors work through or with the normal regulators and operators, then accident management would be more reinforced as an issue requiring greater attention by both regulator and operator. Also, a smoother transition to the post-accident phase would ensue as well as a strengthening of the prevention or pre-accident phase.

Previously assumed exogenous actors were involved in both of these accidents. Politicians, the media, outside experts and foreign observers all played important roles during and after these two accidents. No a priori roles existed for these actors, and one can conclude that they were initially viewed as exogenous by all pre-accident actor groups. However, both Bravo and TMI showed that these actor types can occupy significant roles in accident management and should therefore be integrated into the pre-accident, accident and post-accident phases. Consideration of these actors and assessments of their responses before an accident can lead to greater management effectiveness and reduced stress by on- and off-site accident response actors during the accident itself. Lack of these exogenous actors being included a priori led to unforeseen political consequences on later energy development, more alarming media reports, and a heightened anxiety among the general public.

An additional conclusion appears to be the necessity for a *centralized organizational form* as near to the scene as possible for responding to

accidents. The TMI accident showed the confusion and loss of political and public credibility that can occur from a decentralized system that is at varying distances away from the actual accident. In addition, such confusion can be abetted through ad hoc arrangements to create a different organizational form during the accident, including the move to a more centralized system nearer to the accident. The loss of credibility can also extend well beyond the áccident itself to limit the role of the use of the technology in question, as has occurred with the current moratorium on nuclear energy in the U.S. and elsewhere.

On the other hand, the Bravo accident demonstrated that a centralized system where accident response actors and normal regulators are merged together into one body can be a workable arrangement. Under this form, media information sources, directions and advice to the operator, as well as advice to impactees and politicians, are all centralized. In this way, both political and public confidence could be maintained even in the face of an evolving or expanding accident with an uncertain outcome.

Another major conclusion from this overview of the Bravo and TMI accidents is the need for research based on *systems analysis using social scientists* as an integral part of the research process. Any accident management system is based on individual and organizational actors, and the cause of the Bravo and TMI accidents has been investigated and attributed to weaknesses among the actors responsible for preventing these two preventable accidents. Viewing these accidents from a wider perspective based on a recognition of at least these six actor types, as suggested in this paper, requires a systems point of view based on social science. The more that is left out of an analysis, the less that is subject to change; and both the Bravo and TMI accidents reveal that the fundamental human and organizational relationships and values had not been previously subject to study and hence to change for preventing these two accidents. Systems analysts and social scientists should examine their own implicit assumptions of doing research and integrate their roles into a more applied focus on accidents and their social consequences. Certainly, such research can and should be an integral part of the premises used for creating a total accident management system.

Thus the extent of actual damage to impactees cannot be viewed as the most significant factor in these accidents. Both at Bravo and TMI the off-site damages sustained were nil, yet both accidents resulted in political decisions for temporary moratoria for further development. Technical defense in depth for containing the consequences of an accident only appears to reduce the immediate effects on impactees. The politicians,

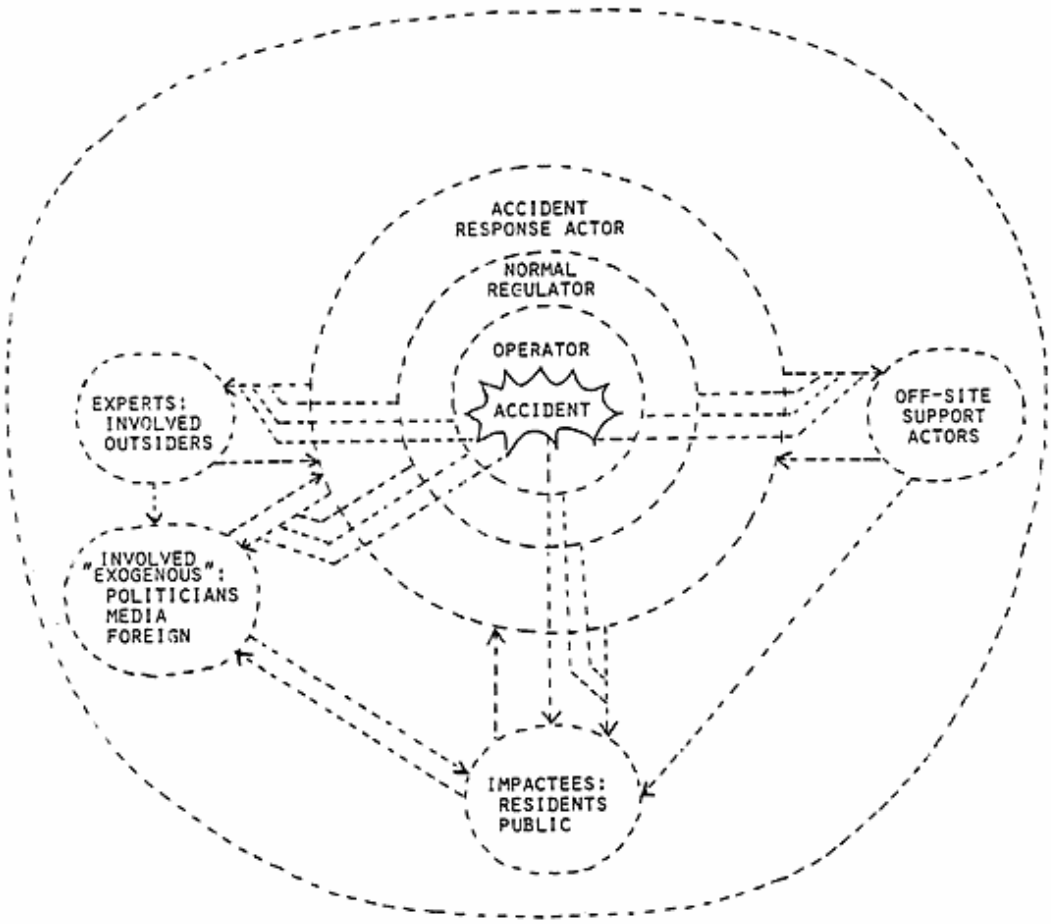
media and general public can generate long-range effects for temporarily stopping further oil and nuclear energy development, regardless of the energy benefits involved. Therefore, wider creation of a priori consultations, open two-way flows of information, and participatory roles for heretofore exogenous actors may be useful for reducing the political consequences of moratoria on energy development.

4. Recommendations for Organizing for Accident Management

Figure 3 is an attempt to portray an accident management system that displays *a priori roles and linkages* based on a *centralized organizational form* for the actor types discussed in this paper. Such a management system recognizes roles for the responses of all actors generated by a major accident before it happens. This a priori framework is important for setting the formal basis for necessary ad hoc actions and informal bargaining that arise during an accident. The organizational system must be arranged so that the roles occupied and the performances in these roles are rewarded or penalized by an incentive system at least equal to the severity of the consequences expected in an accident. Separation of roles in the pre-accident phase and ad hoc emergence of new roles in the accident phase imply that individual incentive systems can color accident responses more than the needs of the accident as a whole. A more rational a priori system with an integrated set of incentives for integrated management responses would seem to be the basis for more effective accident management. Additive individual capacities to respond to an accident cannot be expected automatically to fulfil the needs for adequate responses. Such a figure suggests that because ad hoc and unorganized or exogenous actors will emerge and become involved with a previously organized system in a major accident, it is important to integrate their expected (and unexpected) responses into a total accident management system.

Regardless of the formal creation of a priori roles among the various actors that can be expected to become involved in a major accident, one encounters professional ideologies from such actors that can inhibit their operation. One such bias is that regulators and operators become enamored with the third-party benefits of energy and tend to lose sight of the third-party costs involved. For example, the responses to intermediate multi-cause accidents involving the man-machine interface have not been the subject of much study. One reason for this oversight is that the

Figure 3. A Suggested Accident Management System for Recognizing and Organizing Responses in the Pre-Accident Phase.



technological prevention of a total or massive accident has occupied much of the research resources. Many references contrast a total accident with total prevention, with the result that little is known about intermediate accidents and their appropriate, alternative intermediate responses.

When it comes to the ideologies surrounding accident management, my hypothesis is that the greater the implicit consensus among actors, the greater my concern for gaps in their responses. Each organization has a dominant professional bias and its own collective wisdom or 'mindset'. Such devices are important for minimizing normal uncertainties internal to the individual actor, but these values and assumptions also lead to greater uncertainties within the overall accident management system. Explicit and implicit value differences exist between each of the actors that can be expected to be involved in responding to a major accident. The more the

implicit values and assumptions separating these actors can be discovered and questioned, the more differences and hence gaps between actors will appear. Such a questioning can lead to greater self-examination both individually as an actor and collectively as part of an accident management system. However, the more fundamental the issues and need for self-examination, the less is the willingness by each to do so, especially with other actors in the management system. Thus the externally appointed investigatory body in the post-accident phase plays a very essential role in requiring this questioning process and in attempting to see the pre-accident phases together as a system of inter-connected responses. The real need, however, is to create and structure this fundamental questioning process in the pre-accident phase rather than *after* an accident occurs.

Figure 3, of course, is a static picture and some process for questioning the values inherent in developing such a system is necessary. A *dialectical planning process* is one way of attempting to create a more comprehensive and realistic accident management system. Such a process can lead to the fundamental questions of which actors should be involved in the system, how they should be involved, and which (unexpected) responses should be planned for before they occur. The pre-accident planning approach suggested here could prove useful in determining a priori sources of conflict in ideologies and using them creatively in the design of the entire management system. Certainly, a dialectical planning approach is one way to overcome the existence of a rigid 'mindset' or attitude which the Kemeny Commission found to be at the core of the issues surrounding the TMI accident. In addition, one organizational expert has noted: '. . . we know how to cope with continous change but not with discontinous change . . . when discontinuities do occur, they upset things in a big way because then the underlying assumptions of the past no longer apply.' (Handy, 1980, p. 115–6.)

One attitude that I have found prevalent among regulators and operators in my research on these two accidents in the oil and nuclear industries has been that of uniqueness. Each accident was viewed as 'impossible' because of the employment of safety technologies in-depth and generally superior safety requirements when compared to the past or to some other industries. In addition, each accident after the fact was viewed as 'unique' or as the result of a particular one-time configuration of weaknesses that in combination led to the accidents. Thus it was assumed that such weaknesses had now been accounted for and that organizational-administrative weaknesses would no longer be an issue. I would suggest that the ideology of uniqueness is a myth and that the experiences of these two accidents

show a comparative systems analysis of accident management would prove useful.

Why should the management of near and actual accidents have been down-played in the organization and administrative practices surrounding the design, construction, licensing, operation, and servicing of offshore platforms and nuclear reactors? Such a question can be partially studied via two further questions:

1. What is the fundamental professional ideology, administrative outlook or attitude toward safety and accident management by the industry and its regulators?
2. How are complex questions of safety and accident management formed and put forth or merchandised to others by the industry and its regulators?

This short paper could not hope to approach these two significant questions, but it is my hope that subsequent research on actor behavior can bring greater analysis to bear on these questions.

NOTE

1 For descriptions of the accidents and the sequence of events for each accident as well as for the discrepancies in the underlying preventive systems between the regulator and regulatee, see the investigative reports of the Royal Commission of Inquiry for Bravo and the Presidential Commission for Three Mile Island as listed under the references at the end of the paper.

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I. Interviews with the following individuals:

A. Bravo accident:
1. Hans Chr. Bugge, Director of Action Command for the Bravo blowout and Director of Pollution Control Authority.
2. Arne Flikke, Director of Oil Pollution, Pollution Control Authority.
3. Dag Meier-Hansen, Director of Operations, Oil Directorate.
4. Bjørn Myklatun, Senior Surveyor, Det Norske Veritas.
5. Torvald Sande, Director of Safety, Oil Directorate.

B. Three Mile Island accident:
1. Robert Arnold, Director of Recovery Operations at TMI, Metropolitan-Edison and General Public Utility.
2. Harold Collins, Asst. Director of Emergency Preparedness, Nuclear Regulatory Commission.
3. Oran Henderson, Director of Pennsylvania Emergency Management Agency.

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