



Managing Rapidly Developing Crises: Real-Time Prevention of Failures

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Introduction

Development of safety in engineered systems has traditionally used two fundamental approaches: proactive and reactive (Rasmussen, 1996). The proactive approach is analytical, depends on the predictability of the system, and is focused on infrequent accidents. A major difficulty with most proactive approaches (e.g., probabilistic risk analyses) is that they cannot adequately characterize and analyze complex future human and organizational interactions with systems. How can one develop an analytical model of what one can not characterize and predict? The reactive approach is fundamentally empirical, based on experience, focused on fixing the last accident, and primarily addresses frequently occurring accidents. Much of the field of worker and system safety has been built on the reactive approach.

There is a very important third approach to achieving quality and reliability in engineered systems. This is real-time management as the accident unfolds. This is management based on OODA (Observe, Orient, Decide, and Act) 'loops' (recursive trials), migrating decision making, divide and conquer deployment, and requisite variety in problem identification and solving. We specifically focus on crisis intervention and learning how to more frequently march backward from the precipice of crisis to 'near misses.'

Experience with complex technological systems indicates that behind each major accident is something of the order of 10 to 100 near-misses, and perhaps 100 to 1000 hazardous acts or events (Groeneweg, 1994; Wagganer, Groeneweg, 1988). It is obvious that people frequently interact with systems to produce safe operations. We want to increase the proportion of successful interventions, particularly as potentially high hazard or consequence events unfold.

The vast majority of high-consequence, low-probability accidents involving engineered systems such as ships, fixed platforms, mobile offshore drilling units, and pipelines, are caused by human and organizational factors. The fundamental problem in most cases is not hardware but 'humanware.' That most of these accidents could have been prevented even though they involve operator actions that contain fundamentally unpredictable combinations of events, is unsettling. Many of these accidents consist of rapidly unfolding sequences of events in which the pace of operations is dramatically increased and the normal organization structure rendered ineffective.

Many engineered accidents are fundamentally the result of human operators 'pushing the envelope,' and thereby breaching the safety defenses of an otherwise safe system (Bea, 1995; Moore, Bea, 1995). Today, frequently these breaches develop under pressure to 'out-source' (contract crews), save money, time, and work (Bea, 1996). Many actions that cause breaches can be termed violations, doing what we know we should not be doing (Dougherty, 1995). Often they include degradation of defenses. For example, maintenance of safety systems is insufficient, complacency replaces vigilance, and accidents follow (Reason, 1990; Weick, 1995a; Pidgeon, O'Leary, 1995).

Our research indicates that many of the accidents that have and are plaguing the engineered industries result from rapidly developing crises that are not appropriately recognized and managed. Most of these crises fundamentally are not predictable, and evolve so rapidly that optimum decisions and management are not possible (Nickerson, 1995).

Crisis Defined

We define a crisis as a rapidly developing sequence of events in which the risks associated with the system rapidly increase to a hazardous state (Figure 1). The crisis begins with a surprise warning of some type that the system is moving from a safe to an unsafe state. Crises involve potentially grave life and property threats.

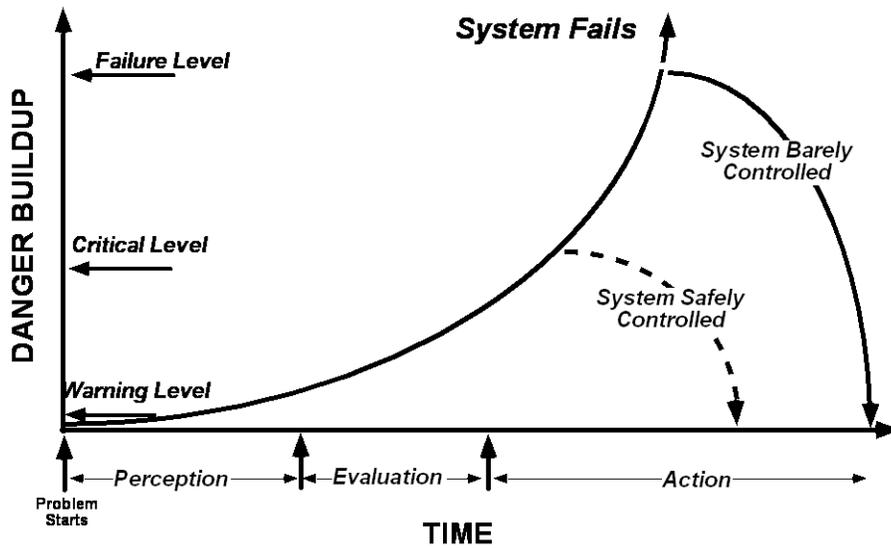


Figure 1 – Evolution of a crisis.

Lagadec (1993) describes crises as “events that do not play by the rules.” These destabilizing breakdowns seem to feed on themselves and overwhelm normal problem solving resources. Crises are characterized by a threatening of normal values and goals, pressures to decide quickly, short times to act, unexpected events that shock, confusion, pressures to innovate in solving the crisis, development of limited options, developments in which inaction produces undesirable consequences, incomprehensible developments, information overload, ambiguity and uncertainty, increased numbers of important demands, conflicts, limited resources, problems lumped together, exaggerated deviations, intense scrutiny, and loss of critical functions. Crises are traumatic affairs.

Lagadec further observes, “the ability to deal with a crisis situation is largely dependent on the structures ...developed before chaos arrives. The event can in some ways be considered as an abrupt and brutal audit: at a moment’s notice, everything that was left unprepared becomes a complex problem, and every weakness comes rushing to the forefront. The past settles its accounts.” Sarna (1996) characterizes crises as “...not the kind of incidents that occur on a regular enough basis to allow incident commanders to build a personal data base of experience.”

In its simplest terms, a crisis can be divided into three general stages (Figure 1): 1) perception, 2) evaluation, and 3) action. The first stage requires individuals to perceive and recognize warning signs

Note the potential effect of training in Figure 2 (other ‘short-cuts’ are possible but not shown). Training can help eliminate much of the cognitive processing required to determine what should be done (Hale, 1984). This allows effective alternatives to be rapidly defined and implemented.

Also, note the importance of observations. Observations provide clues to determine if implementation is producing the desired results. If it is not, the processes of identification and evaluation need to be repeated to help arrest the crisis. If clues indicate the crisis is being arrested, the process must be continued until the emergency is over. The process should not be stopped until adequate safety has been achieved.

Crisis Recognition

Perhaps no stage in a crisis is as important as the first stage: recognition or perception. Because the crisis is just unfolding, if the situation can be quickly and correctly recognized, there will be more opportunity and time to bring it under control.

Humans seem to have a fundamental difficulty accepting the potential danger of a situation under development. In a study of crew and passenger reactions to accidents onboard passenger vessels or ferries (Harbst, Madsen, 1995), it was found that 60% of the people (passengers, crew) ignored or misjudged the hazards, 30% investigated, and 10% accepted that hazards existed and initiated action. Once the hazard was recognized, something of the order of 10% to 25% panicked or went into shock (crisis paralysis), 50% to 75% behaved in confused helpless ways, and 10% to 30% made realistic evaluations and started positive corrective actions. These researchers observed that “people who have generally accepted the risks associated with an activity are not usually motivated to study or practice safety procedures or recognize early warning signs of a developing crisis.” They have become ‘risk habituated.’

Three classes of cognitive factors seem to govern how and how well people perceive a crisis (Cook, Woods, 1994):

- 1) knowledge - background that can be accessed when solving problems,
- 2) attention dynamics - control and management of mental workload, maintenance of situation awareness, and avoidance of fixations,
- 3) strategy development - successful trade-off between conflicting goals, dealing with uncertainty and ambiguity, avoidance of organizational double binds, and development of good priorities and decisions.

Developing and maintaining an awareness of potentially hazardous situations involves a constant process of detecting anomalies; things that are not right or don’t fit. This requires constant shifting of attention, a very limited resource, to modify a picture (mental model) of a system as a whole. Building and maintaining the picture of the system requires cognitive effort, which when it breaks down is called ‘loosing the bubble’ (Roberts, 1993). It is here that team work can provide additional information, attention capacity, and requisite variety (Weick, 1995a) in insights and potential solutions; and enable the team to recognize the early warning signs of the developing crisis and quickly implement effective control strategies.

How Crises Are Usually Studied and How They Should Be Studied

There are two common ways to develop safety practices in the engineered industry. One is to develop statistical predictive models based on past incident data. The data come from accident data bases or from case studies. Our research includes study of a wide variety of accident databases on engineered systems (Wagenaar, Groeneweg, 1987; Moore, Bea, 1995). We have not identified one database which adequately addresses initiating, contributing, and propagating factors, has incorporated an adequate human and organizational error (HOE) taxonomy, has addressed the identified five elements, or has utilized sufficiently well trained accident investigators over a sufficient period of time.

The implication is that existing accident databases cannot be relied upon to provide objective and definitive information on HOE in engineered systems. Much database development has its roots in the nuclear power and chemical processing industries and in the military (organizations which are developing a healthy skepticism about the quality of such data). Our research results indicate a prevalent tendency to over-use or over-believe quantitative or ‘hard’ approaches (e.g., probabilistic risk analyses based on event trees, fault trees, and influence diagrams). The qualitative or ‘soft’ approaches frequently lack rigor and consistency.

The other approach is to use experienced based empirical methods that utilize information from past accidents to help remedy causes of infrequently occurring accidents. A large body of experience is the basis for identifying and implementing effective safety measures. Many work safety practices were derived from such methods.

Information from infrequently occurring accidents can provide insights to identify progressive changes to remedy accident causes. Regulations and safety measures put in place following major accidents are symptomatic of this approach. Both of these retroactive strategies represent a fallback position based on the near impossibility of studying accidents in the making ‘real time.’

Because of their rarity, management of very-low-probability, high-consequence events generally must rely on predictive analysis of possible accidents. Traditional experienced based empirical and analytical safety and accident prevention approaches should not be relied on exclusively in developing strategies to manage high consequence, low probability accidents.

The approach developed during this research relies on real-time management of safety. This approach is focused on managing unfolding combinations of ‘weird’ events that pose catastrophic hazards or risks to engineered systems. It involves detecting the hazardous developments in the systems, evaluating and defining appropriate responses, and returning the systems to safe states. Alerts and the weeding out of near-misses and incidents are symptomatic of the success of this second approach. Our work and the work of others (e.g., Lagadec, 1993; Huey, Wickens, 1993; Cook, Woods, 1994; Boeing, 1996) indicates that such real-time management is frequently responsible for keeping systems running safely on a day-to-day basis. A purpose of our research is to understand how to enhance real-time management strategies and techniques.

Many accident investigations stop with identification of the initiating events or factors and fail to examine or identify the contributing or propagating factors. Our research identifies the vital

importance of the contributing events in determining the initiating events and the compounding events in allowing the initiating events to escalate or propagate to catastrophic proportions (Bea, Roberts, 1994). This identification is critical to the development of proactive accident prevention measures and crisis management measures (focus on both initiating and propagating events).

The majority of the initiating events involve individual errors of commission (approximately 80%) in which the action or actions carried out by individuals are erroneous (Reason, 1990). Application of more sophisticated classification systems (taxonomies) indicate that these errors of commission most frequently involve communications, selection and training, cognitive (information processing), and violation (intentional) errors. Sliced another way, skill based and knowledge based actions and violations are principally involved in these initiating events.

The majority of the contributing events involve organizational errors (approximately 80%). These errors include those of incentives (rewarding ‘A’ while hoping for ‘B’) (Kerr, 1975), communications (who knows what and when) (Bea 2008), management (planning, organizing, leading, and controlling to avoid errors) cognitive processing, and violations. Similarly, the majority of contributing events involve organizational errors (Roberts, 1993).

Qualitative, quantitative, and ‘mixed’ auditing or assessment approaches have been developed and applied in accident prevention. Each has its powers and weaknesses and each is being further developed as a part of this research (Bea, 1996).

The most frequently overlooked and underappreciated element involves the user or auditor applying any one of these approaches. Any of the tools are only as good as the people who apply them and interpret their results. However, all of these tools if properly used can be used to good advantage in certain circumstances in the attempt to proactively evaluate or assess systems, identifying potentially ‘weak links’, and then identifying how best to improve their safety.

Improving Crisis Prevention

The usual approach to investigating crises in the interests of improving crisis prevention is to look for maintenance and design failures to equipment, particularly in the engineered industry. If the human element is considered at all it is the hands-on (directly involved) ‘operators.’ The investigation is usually closed after operator blame is established, particularly if the operator fails to survive and is, therefore, out of the picture.

If one accepts our definition of crisis, this focus on operators is clearly misleading. A rapidly developing sequence of events in a system implies the contribution of more than a single or a few operators to the outcome. The term system suggests the simultaneous activities of many system sub-units. The five critical elements in engineered failures discussed previously also alert attention to the larger system with its many players.

The three stages of crisis discussed (perception, evaluation, and action) direct attention to the importance of perceiving organizational activities appropriately. In perceiving organizational activities people come to make sense of their perceptions. In recent years a considerable amount of attention has been directed to the process of sense making in organizations (Weick, 1995a).

For purposes of reducing risk or improving crisis prevention we need to look at two aspects of sense making, how individuals make sense of things and how groups and organizations make sense of things. We need to tease out of these implications for management policy and future research needs.

People construct events. “How they construct what they construct, why, and with what effects are the central questions for people interested in sense making (Weick, 1995a, p. 4).” “In real world practice, problems do not present themselves to the practitioners as givens. They must be constructed from the materials of problematic situations which are puzzling, troubling, and uncertain. In order to convert a problematic situation to a problem, a practitioner must do a certain kind of work. He must make sense of an uncertain situation that initially makes no sense (Weick, 1995a, p.9).” To engage in sense making is to construct, filter, and frame perception into something more concrete (Turner, 1978). In dealing with crisis prevention it is in part parsing activities into those which might be initiating, contributing, and propagating events.

At the heart of sense making is the sense maker who says according to Weick, “how can I know what I think until I see what I say?” Weick cautions that no individual acts as a single sense maker. He or she is in fact, a myriad of persons. He or she thinks of an audience even when inventing monologues. Thus, sense making is grounded in the identity construction of the sense maker. It has six other characteristics. It is retrospective in the sense that it makes sense of events after they happen. It enacts sensible environments and is driven by plausibility rather than accuracy. People extract cues from their environments from which they draw sense and they try to produce the environments they're in. It is social and ongoing suggesting that the individual never really makes sense of things alone.

These seven characteristics of sense making have some implications for people who must perceive changes in risk in their organizations. One implication is that people need to talk constantly with one another to see what they say. They need to create a climate in which differences in perceptions are accepted and the acknowledged work is to develop as rich a picture of the organization as possible that includes all of its interacting participants. Organizational members need to clearly understand that each of them brings a different set of identities to the task. They need to be alerted to the fact that their prescriptions of future events are based on sense making of the past. Writ large, this acknowledges what militaries have long known; in practicing for the next war they fight the last war. They should also be aware of the facts that they draw limited cues from their environments and that environments may not be as sensible as they enact them to be, but that trying to draw some order from chaos may have positive implications in terms of directing otherwise turbulent activity. It may be artificial to parse activities as initiating, contributing, and propagating factors but this parsing provides a framework on which to develop a control plan. The social and ongoing nature of sense making draws our attention to the fact that an individual in isolation is almost never the total sensing unit. About as close as one comes to that is in sense making in isolation with only thoughts about other people's reactions, inputs, etc.

Enter the Organization

Wiley (1988) discusses three levels of sense making above the ‘individual’ level. In ascending order they are inter-subjective, the generic subjective, and the extra-subjective (Weick, 1995, p.70). Intersubjective meaning occurs when a person's thoughts, feelings, and intentions are merged into

conversation in which the individual is transformed from me to us. People are joined or merged. Organizations are included at the next level, the level of social structure. “Social structure implies a generic self, an interchangeable part - as filler of roles and follower of rules-but not concrete, individualized selves (Weick, 1995, p.71).” Sense making through generic subjectivity is the main work of the organization. In stable times generic subjectivity takes many forms, including scripts or SOP’s (Standard Operating Practices). When something happens to disrupt stability, such as the introduction of a new technology, the current form of generic subjectivity no longer works. Inter-subjectivity is the focus of sense making because new views of what's going on emerge and have to be synthesized.

Weick argues that organizing is the umbrella over the movement from inter-subjective to generically subjective. Organizing is a mixture of inter-subjective understandings and understanding that can be picked up, expanded, enlarged, perpetuated, etc., by people who did not participate in the original inter-subjective construction. Organizations are adaptive social forms. As inter-subjective forms they create, preserve, and implement innovations that arise from contact. Generic subjectivity focuses and controls the energies of that intimacy. That control drives out innovation and one needs to worry about keeping a balance between the two. Inter-subjective processes detect through monitoring, cues about potential destabilizing forces. Inter-subjective and generic subjective processes develop control plans or actions and steps for implementing those plans and actions. Together these processes can extend the time of increased performance in high stress situations.

If organizations are understood to be nets of collective action undertaken to shape the world, with interlocking routines and habituated actions that allow for substitutability, we might look at crisis prevention in a different light than we do now. First, we would almost never look to the human operator as the single source of failure. Returning to Rasmussen's six stages of crisis decision making, our monitoring and detection systems would focus on the content of inter-subjective interactions. We would begin to build taxonomies of content interaction that do and do not result in safe performance. Our interpretations of the current state of things would focus on the innovative inter-subjective interaction and the generic subjectivity controls. We would look for accord as well as tensions between the two. Our control plan might be formulated with many more possibilities than we usually see, because we would reward the flowering of a thousand visions knowing that generic subjectivity is the mechanism for enhancing as well as pruning those visions. Feedback would be obtained in a different way relying as it would on assessment of its ability to mirror the collective action.

Wiley's (1988) final level of analysis, culture is extra-subjective. A generic self that occupies roles is now replaced by 'pure meanings' (Popper, 1972) without a knowing subject. This is a level of symbolic reality such as we might associate with capitalism or mathematics, each viewed as a subject-less batch of culture (Weick, 1995, p.72). Again, returning to Rasmussen, his stage of crisis decision making we failed to address previously is determining the implications of the current state of affairs. To do this, decision makers in the organization need to look well beyond the organization's skin to identify those institutional aspects of society that both infiltrate the implications and may be impacted by those implications. Some possibilities are the values a society places on the loss of life and property, and the values it places on selection and education that in the current crisis or pre-crisis state is needed by the organization.

Our research clearly shows that the culture of an organization has important influences on its ability of to operate safely. Others have found the same thing (Pidgeon, O’Leary, 1994; Zohar, 1980;

Turner, 1978; Woods, 1990; Weick, 1995a; Wenk, 1988). The culture of an organization is not a simple thing to define, characterize, or measure. It is rooted in the organization's history and the society in which it exists. Culture has many potential layers and facets. Organization cultures are extremely resistant to change. Many researchers would contend that organization cultures are impossible to change rapidly.

Organization culture can be defined as a system of observable expectations, incentives, and behaviors (Rohner, 1984). Alternatively, organization culture can be defined as a system of meanings or a shared cognitive system (Turner, 1978).

In this second context, a 'safety culture' can be characterized as the "set of beliefs, norms, attitudes, roles, and social and technical practices within an organization which are concerned with minimizing the exposure of individuals, both within and outside the organization, to conditions considered to be dangerous (Pidgon, O'Leary, 1994)." Study indicates that a safety culture can be translated to five categories of activities by the organization:

- 1) Commitment to 'safety first' at a strategic management level that results in a real and long-term demonstration of concern and action (top-down),
- 2) Distributed attitudes of care, concern, and action that permeate the entire organization (bottom-up),
- 3) Appropriate norms, rules, and procedures that remove explicit and implicit conflicts in safety versus production or service, promote proactive safety, and provide for real-time management of crises,
- 4) Ongoing reflection, audit, critique, and feedback on the health and well being of the system (including its human parts); and
- 5) Timely, effective, thorough, and honest communications (verbal, non-verbal) that effectively bind individuals, teams, and the organization together.

Our work clearly indicates that the existence of a strong safety culture is one of the first requirements for an organization to be able to successfully manage rapidly developing crises. The marriage of different organizations in performing operations frequently leads to severe problems because of the clash of cultures (Libuser, Rousseau, 1995). Here again, the use of subcontractors whose organization culture is very different from that of the owner can lead to dramatic problems in managing rapidly developing crises.

Improving Real-Time Crisis Management

Two fundamental approaches to improving crisis performance are: 1) providing people support, and 2) providing system support (Bellamy, 1994).

People Support

People support strategies include such things as selecting personnel well suited to address crises, and then training them so they possess the required skills and knowledge. Re-training is important to

maintain skills and achieve vigilance. The cognitive skills developed for crisis management degrade rapidly if they are not maintained and used.

Crisis management teams should be developed that have the requisite variety to manage the crisis and have developed teamwork processes so the necessary awareness, skills, and knowledge are mobilized when they are needed. Auditing, training, and re-training are needed to help maintain and hone skills, improve knowledge, and maintain readiness (Hale, 1984). Crisis management teams need to be trained in problem ‘divide and conquer’ strategies that preserve situational awareness through organization of strategic and tactical commands and utilization of ‘expert task performance’ (specialists) teams. Crisis management teams need to be provided with practical and adaptable strategies and plans that can serve as useful ‘templates’ in helping manage each unique crisis. These templates help reduce the amount and intensity of cognitive processing that is required to manage the crisis.

System Support

Improved system support includes factors such as improved maintenance of the necessary critical equipment and procedures so they are workable and available as the crisis unfolds. Data systems and communications systems are needed to provide and maintain accurate, relevant, and timely information in ‘chunks’ that can be recognized, evaluated, and managed. Adequate safe haven and life saving measures need to be provided to allow crisis management teams to face and manage the crisis, and if necessary, escape. Hardware and structure systems need to be provided to slow the escalation of the crisis and re-stabilize the system. Safety system automation needs to be provided for the tasks people are not well suited to perform in emergency situations.

One would think that improved system support would be highly developed by engineers. This does not seem to be the case. A few practitioners recognize its importance (Kleitz, 1991; Bea, 1992), but generally it has not been incorporated into general engineering practice or guidelines. Systems that are intentionally designed to be stabilizing (when pushed to their limits, they tend to become more stable) and robust (damage and defect tolerant) are not usual. Some provisions have been made to develop systems that slow the progression of some crises. Fire deluge systems, heat insulation on critical structural elements and fire walls, and blast pressure relief panels are examples of some of the provisions. Our work indicates that system robustness is achieved through a combination of redundancy (alternative paths to carry the loads), ductility (ability to redistribute loads and deform without compromising safety), excess capacity (to carry the redistributed loads), and appropriate correlation (relationships) (Bea, 1992). These guidelines also apply to the organizational or people components of systems (Bea 2008).

Effective early warning systems and crisis information and communication systems have not received the attention they deserve in providing engineered system support for crisis management. Systems need to be designed to clearly and calmly indicate when they are nearing the edges of safe performance. Once these edges are passed, multiple barriers need to be in place to slow further degradation and there should be warnings of the breaching of these barriers. More work in this area is definitely needed.

Organization for Crisis Management

Empirical studies have been conducted to determine the effectiveness of cognitive skills training for both individuals and operating teams (Roth, et al., 1994). Even with training, there is wide variability in individual and team performance characteristics. The most outstanding characteristic of teams which accurately and quickly managed unusual and rapidly evolving crises was a ‘divide and conquer’ strategy. Using this strategy, members of the team were assigned management of different aspects of the evolving crisis (Figure 3).

The teams organized into three components: 1) strategic command, 2) tactical command, and 3) task performance. The strategic command acted as a mega-brain central point for information, verifications, planning, and situation awareness. The incident commander maintained the bubble, accessed the necessary requisite variety to understand the overall problem and identify the alternatives available to solve the problem/s.

Tactical command determined resources, their locations, operational procedures, and served as a central communications link. Strategic command determined what should be done, and tactical command determined how it should be done (procedures), who should do it (personnel), and what would be required (hardware, system support). Most importantly, tactical command acted as a central communications link between the strategic command and the task performance team/s.

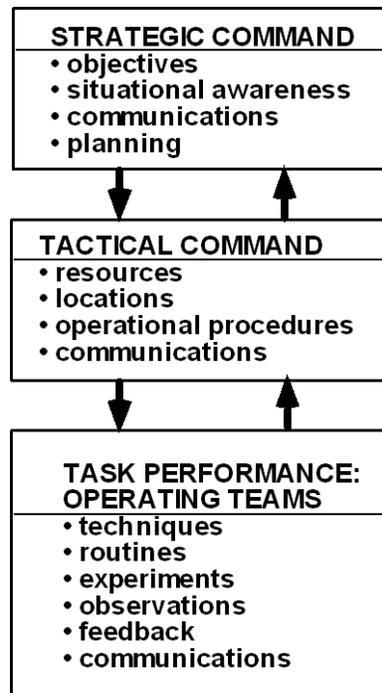


Figure 3 – Divide and conquer crisis management team organization.

Task performance was relegated to the operating teams that provided techniques, routines, observations, feedback, and ‘experiments’ with alternative measures to help arrest development of the crisis. The operating teams had to possess highly developed operating skills, had to utilize rule-based behavior and adopt this behavior to the unique circumstances of the crisis (improvisation), and had to have basic knowledge of the system that was managed.

The degree of success of crisis management team depends on an accurate assessment of the nature of the problem/s at hand. This ‘sensemaking’ is obtained through pattern recognition, a basic mechanism in learning. Pattern recognition relies on past experience in which the new problem may look something like a problem previously encountered. This permits the team to recognize applicable solutions or adaptations much earlier in the crisis. This is the reason that training and experience are so important. Experienced people bring pattern recognition skills with them. This enables them to identify the crucial pieces of information from the mass of information that floods in during a crisis and the crucial pieces that may be missing. Inexperienced personnel can only process protocols and execute available skill-based behaviors.

A team-related crisis management technique used successfully by the airline industry is Crew Resource Management or (CRM) (Helmrich, 1994, 1995; United Air Lines, 1996a; 1996; Boeing, 1996). This technique has been successfully applied on the flight deck and on the tarmac (ground teams), and successfully extended to hospital operating rooms (Helmrich, 1994).

Helmrich identifies the following factors that influence how teams perform in crisis situations: individual aptitudes, personality and motivation, physical and emotional states, composition of the team, organizational climate and norms, time pressures, and the environmental conditions. The critical performance factors in CRM include information, inquiry (assertion, advocacy), management (briefings), technical procedures, communications, workload distribution (avoidance of distractions), decision processes, situation awareness, and resolution of conflicts.

United Airlines’ C/L/R (Command / Leadership / Resource) management program (Hutchings, 1996) addresses command authority, crew climate, crew member training and development, communications, problem definition, decision making, inquiry, advocacy, conflict resolution, critique (feed-back), workload management, situation awareness, and use of resources (United Airlines Inc., 1996a, 1996b).

Management of the crisis action plan starts with the premise: keep the plane flying (maintain the vital functions). It is followed with displaying options and essential objectives; anticipation and taking the initiative; tracking down gaps, mistakes, and weak points in the plan; recognizing, resolving, and managing contradictions; and keeping the airplane flying (Hutchings, 1996).

Training in simulators in which the crew behavior is videotaped has proven to provide valuable feedback on how crisis situations are managed (the camera doesn’t blink). A formal training program to impart knowledge, skills, and observable behaviors has been documented and carried out, and the process institutionalized through flight operations policies. United Airlines contends this program has proven itself to be extremely valuable and it is now being used for ground crew operations (Boeing, 1996).

Given this background, it is no wonder that there have been and will continue to be problems in crisis management operations involving ‘contract crews.’ Often, although not always, these crews do not possess the requisite variety and knowledge of the system or the training to deal with it. Experience with the system, requisite skills and knowledge are frequently lacking. In addition, at the interfaces between the parent operating organization and the contract crew/s, communications breakdowns and inefficiencies can and should be expected (Libuser, Rousseau, 1996). The different organization cultures and motivations can lead to important communications barriers. Interfacing

different organization cultures and motivations can lead to important communications breakdowns and breaching safe operating barriers (Meshkati, 1995).

Deployment of Resources

A critical issue in management of crises is deployment of resources (Figure 4). Boney (1995) organized resources into three general categories: personnel, procedures, and equipment.

The first step in determining how resources should be deployed is to identify the critical functions that have to be maintained to allow the crisis to be managed. In the case of a building fire, these functions might consist of provision of water for the fire fighters and provision of non-toxic air for the occupants. In the case of a medical crisis, this might consist of maintenance of blood pressure and breathing (Cook, Woods, 1994).

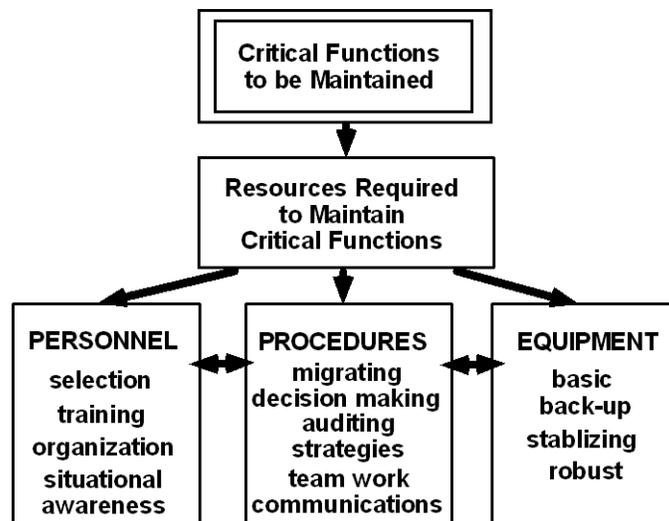


Figure 4 – Deployment of resources.

The next step is to define the resources required to maintain these critical functions. Review of past accidents and incidents permitted London Fire Brigade teams to identify the basic types of equipment required to enable them to manage the vast majority of crises. Back-up equipment was provided for the vast minority of crises and for the basic types of equipment. This permitted teams to focus on provision of and maintenance of a far smaller subset of tools. This allowed the deployment of fewer specialized personnel and tools for crisis management. Most importantly, this allowed scarce training resources to be focused on the proper use and maintenance of the basic equipment.

Procedures for crisis management then focused on issues such as team work, migrating decision making (discussed in next section), auditing strategies, and communications. The procedures addressed problems of resolution of conflicting goals or critical functions using OODA loops (Orr, 1983). OODA loops consist of repeated cycles of Observing (actions and effects), Orienting (to the unfolding situation), Deciding (on next actions), and Acting (implementing the actions). The crisis operating team personnel focused on the specifics of their particular situation. The OODA loops provide the operating team's requisite variety in acting to solve the problem and provide feedback

on the activities and effects. This operating strategy provides a ‘fluid’ deployment of personnel to take advantage of special operating skills and knowledge, and yet permit continued communications and situation awareness.

A critical crisis management resource is information. Those faced with crisis need to be provided with an autonomous information gathering capability, must seek to validate incoming information (eliminate erroneous signals), and must develop information on the initial events and other hazards that may be developing, the effects of events and the way they are changing, and available reaction and control capabilities. Most important is the development of information on what else can happen in order to develop a dynamic view of the unfolding crisis and the reactions it is triggering or may trigger.

The concept of ‘migrating decision making’ (Figure 5) (Roberts, Stout, Halpern, 1994) is a particularly important concept that has been integrated into many successful crisis management procedures and organizations. For normal daily operations, where the pace or tempo of operations is low, a hierarchical, bureaucratic type of management with centralized authority is attractive. In these operations, the emphasis is on normal and daily operating skills. As the pace or tempo of the operations picks up and approaches emergency and crisis operations, there is a need to change the operating organization. The shift is toward highly decentralized authority; hence migrating decision making or decisions made by those with the requisite knowledge and skills. There is an emphasis on high expertise operations in which knowledge, rules, and skills must be successfully integrated in control strategies.

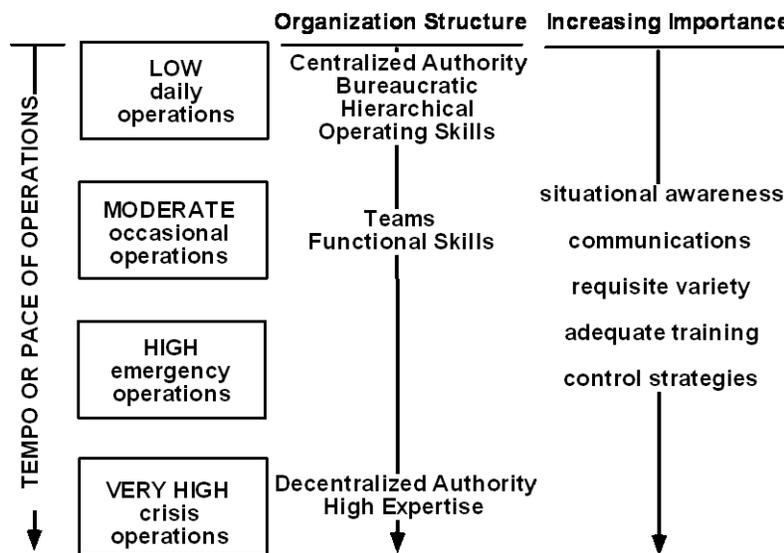


Figure 5 – Migrating decision making.

The final resource is personnel. Here, considerations are with selection, training, and organization of the crisis management team.

Conclusions

From our research we have learned the pervasive importance of the organizational influences on safety and reliability. Some industries, such as the engineered industries, fail to realize this because

they often subjugate the goals of safety and reliability to the goals of production and profitability. This is a problem, because there must be profitability to have the necessary resources to achieve safety and reliability. Perhaps, with present high costs of lack of safety and reliability, these two goals are not in conflict. Safety and reliability can help lead to production and profitability. One must adopt a long term view to achieve the goals of safety and reliability, and one must wait on production and profitability to follow. However, often we are tempted for today, not tomorrow.

The second important thing we learned is the importance of selecting, training, and organizing the ‘right stuff’ for the ‘right job.’ This is much more than job design. It is selecting those able to perform the daily tasks of the job within the daily organization required to perform that job. Yet, these people must be able to re-organize and re-deploy themselves and their resources as the pace of the job changes from daily to unusual (it’s improv time!). Given most systems, they must be team players. This is no place for ‘super stars’ or ‘aces.’ The demands for highly developed cognitive talents and skills is great for successful crisis management teams. In its elegant simplicity, Crew Resource Management has much to offer in helping identify, train, and maintain the right stuff. If properly selected, trained and motivated, even ‘pick-up ball teams’ can be successful crisis management teams. If not, expect disaster.

The physical systems must provide adequate support and security for crisis management teams to accomplish their tasks. They must provide adequate warning of approaching danger and important data that do not overload cognitive resources. The systems must provide protection, and if finally necessary, a good chance of escape. Most important, these systems must be tolerant of human errors through the incorporation of adequate measures of robustness and stability.

Our research has not identified how to preserve readiness for crisis management for the crisis that may never happen (low probability, high consequence events). The results of training degrade rapidly when the results are not used. Apathy can develop relatively quickly in the normal pace of daily activities, particularly when these activities are successful (crisis and incident free). Vigilance is replaced by complacency. Identifying mechanisms to help preserve the right degree of crisis management readiness is an area for future research.

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