Trishna Dikshit

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# Emergency Management

## INTRODUCTION

There are many ways to describe emergency management and the importance of the tasks emergency managers perform. Indeed, in some respects, it hardly seems necessary to explain the need for a profession whose purpose is saving lives and property in disasters. It is likely that, while many people recognize their communities are exposed to environmental threats requiring a systematic programme of protection, only a few appreciate the magnitude and diversity of the threats. One can introduce the study of emergency management by noting losses from disasters—in the United States and the rest of the world—have been growing over the years and are likely to continue to grow (Berke, 1995; Mileti, 1999; Noji, 1997b).

Losses can be measured in a variety of ways—with deaths, injuries, and property damage being the most common indexes. The 1995 Kobe, Japan, earthquake killed more than 6000 people and left another 30,000 injured. In the previous year, the Northridge, California, earthquake resulted in approximately $33 billion in damages. These individual events are impressive enough, but the losses are even more dramatic when accumulated over time. Between 1989 and 1999, the average natural disaster loss in the US was $1 billion each week (Mileti, 1999, p. 5).

Furthermore, many costs must be absorbed by victims—whether households, businesses, or government agencies—because only about 17 per cent of losses are insured. Spectacular as they are, these past losses pale in comparison to potential future losses. Major earthquakes in the greater Los Angeles area or in the midwestern New Madrid Seismic Zone, which are only a matter of time, could generate thousands of deaths, tens of thousands of injuries, and tens of billions of dollars in economic losses. Indeed, the daily news seems to suggest the world is plagued by an increasing number and variety of types of disasters, an impression that is certainly heightened by what seem to be frequent, very large scale natural disasters—including earthquakes, floods, hurricanes, volcanic eruptions, and wildfires—all over the globe.

When we add to these events a wide range of severe storms, mudslides, lightning strikes, tornadoes, and other hazard agents affecting smaller numbers of people, one might conclude that natural disasters are increasing. Technological activities also initiate disasters. Hazardous materials are transported via road, rail, water, and air. When containment is breached, casualties, property loss, and environmental damage can all occur. Some technologies, such as nuclear power plants, pose seemingly exotic risks, whereas more commonplace technological processes such as metal plating operations use chemical agents that are very dangerous.

Even the queen of American technology, the space programme, has experienced disaster associated with system failures. Finally, we see terrorists operating on US soil—made forever visible by the attacks on the World Trade Center on September 11, 2001. At times, it seems as if humankind is living out the script of a Greek tragedy, with the natural environment exacting retribution for the exploitation it has suffered and an unforgiving modern technology inflicting a penalty commensurate with the benefits that it provides. Though such a perspective might make fine fiction—disaster movies are recurrent box office successes despite their many major scientific errors—it does not accurately portray events from a scientific and technological view.

The natural environment is, of course, not “getting its revenge”. Geophysical, meteorological, and hydrologic processes are unfolding as they have for millennia, beginning long before humans occupied the earth and continuing to the present. Given the eons-long perspective of the natural environment, it would be very difficult to identify meaningful changes in event frequency for the short time period in which scientific records are available on geological, meteorological, and hydrological phenomena. Event frequency, from an emergency management perspective, is not really the issue.

It is certainly true that, over the years, more people have been affected by natural disasters and losses are becoming progressively greater. The significant feature driving these observations, however, is the extent of human encroachment into hazard prone areas.

With increasing population density and changing land use patterns, more people are exposed to natural hazards and consequently our accumulated human and economic losses are increasing. Much of this exposure is a matter of choice. Sometimes people choose hazardous places, building houses on picturesque cliffs, on mountain slopes, in floodplains, near beautiful volcanoes, or along seismic faults.

Sometimes people choose hazardous building materials that fail under extreme environmental stresses—for example, unreinforced masonry construction in seismically active areas. Some exposure results from constrained choices; the cheap land or low rent in flood plains often attracts the poor. The point is that one need not precisely estimate event frequency to understand rising disaster losses in the United States. As Mileti (1999) writes in Disasters by Design, the increasing numbers of humans, our settlement patterns, the density with which we pack together, and our choices of location for homes, work, and recreation place more of us at risk and, when disasters occur, exact an increasing toll.

The pattern observed among technological disasters is somewhat different. Certainly more people are affected by technological threats simply because there are more people, and we often make unfortunate choices (as was the case with natural hazards) about our proximity to known technological hazards. However, the nature of the threat from technological sources also appears to be changing. The potential for human loss from technological sources increases with the growth and change of existing technologies and with the development of new technologies. For example, risks are rising from the increasing quantity and variety of hazardous materials used in industry, as well as from energy technologies such as coal and nuclear power plants and liquefied natural gas facilities. Such facilities and the processes they use pose a variety of risks for both employees who work in the facilities and those who live in nearby neighbourhoods.

Furthermore, as technologies develop it is sometimes found that what was thought not to be hazardous a decade ago does, in fact, have deleterious effects upon health, safety, and the environment. Yet, unlike natural events, advancing technology often produces an improved capability to detect, monitor, control, and repair the release of hazardous materials into the environment. Ultimately, as technologies grow, diversify, and become increasingly integrated into human life, the associated risks also grow.

Although terrorism has a long history (Sinclair, 2003), it has been a low priority that only recently become prominent on emergency managers' lists of threats to their communities (Waugh, 2001). Recent events, especially the 1995 bombing of the Murrah Federal Building in Oklahoma City and the 2001 attacks on the World Trade Center and Pentagon, have made it obvious that the outcomes of at least some terrorist attacks can be considered disasters.

Although some consider terrorism to be a hazard, this is not a very useful conceptualization. According to the Federal Emergency Management Agency (1996a, p. PH2.11), the Federal Bureau of Investigation defines terrorism as "the unlawful use of force against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives".

That is to say, terrorism is a strategy, not a hazard agent. Most of the technological hazard agents (chemical, radiological/ nuclear, or explosive/flammable) that could threaten American communities in terrorist attacks can also occur by means of accidents. As Winslow (2001) notes, terrorists have typically used explosive agents, sometimes used chemical agents, and have the potential to use radiological or biological agents. Thus, although radiological materials have not yet been used in terrorist attacks, emergency managers should be prepared to respond to their deliberate or accidental release. xSimilarly, concern has been expressed about terrorist attacks using biological agents, but these can also occur naturally. Biological hazards are normally the concern of public health agencies, but emergency managers should be knowledgeable about them because terrorist attacks involving these agents will require coordination between the two types of agencies.

It remains to be seen precisely how terrorism will be fitted into the lexicon of disaster research. Already, definitions of terrorism vary between the academic community and emergency managers (Buck, 1998). Nonetheless, emergency managers must address the consequences of terrorist attacks using the same basic approaches that are used in other emergencies and disasters. One major difference between most terrorist attacks and many other types of disasters such as floods and hurricanes is the uncertainty about the time, place, and magnitude of the event.

Advance detection is a prerequisite for forewarning, but experience to date indicates detection accuracy is not high even for the timing of an attack, let alone the place, magnitude, and type (chemical, biological, radiological/nuclear, explosive/ flammable) of agent involved. At the present, emergency management efforts must focus on prompt detection once an incident has occurred, along with preparedness for a timely response and recovery.

Even these strategies are complicated because it is so difficult to anticipate the competence of the terrorists. For example, the Aum Shinrikyo cult's attempt to disperse the nerve agent sarin in the Tokyo subway during 1995 underscored the importance of agent quality and diffusion effectiveness. Cult members carried bags of the liquid form of the agent onto subway cars and cut the containers as a means of initiating the release. Although Sarin is extremely lethal, the attack resulted in only twelve deaths and approximately 1,046 patients being admitted to hospitals (Reader, 2000). If the Sarin had been effectively aerosolized, the death and injury rates could have been phenomenal. Ultimately, whether terrorism and its consequences are increasing or not seems to be a matter of many factors that defy meaningful measurement at this time. Given the increasing toll from disasters arising from natural hazards, technological accidents, and terrorist attacks using technological agents, American society must decide whether the risks are “acceptable”. Moreover, given the limited amount of time and resources that can be devoted to risk management, decisions must be made about which risks to address (Lowrance, 1976).

When individuals, organizations, or political jurisdictions reach consensus that a given risk is unacceptable, resources can be marshaled to reduce the risk to some level deemed more acceptable. Such resources can be used to attempt to eliminate the source of the danger, or, alternatively, change the way people relate to the source of danger. For example, building dams or channeling streams can eliminate the risk of seasonal floods (at least for a time).

Alternatively, people and dwellings can be relocated outside the floodplain, or a warning and evacuation system could be devised to provide population protection (but generally not property) in times of acute flood threat. Emergency management is rooted in this process of identifying unacceptable risks, assessing vulnerabilities, and devising strategies for reducing unacceptable risks to more acceptable levels. Of course, emergency managers cannot perform all of these activities by themselves. However, they can act as “policy entrepreneurs” that propose strategies and mobilize community support for risk reduction.

In general terms, emergency management is “the discipline and profession of applying science, technology, planning and management to deal with extreme events that can injure or kill large numbers of people, do extensive damage to property, and disrupt community life” (Drabek, 1991a, p. xvii). Thus, emergency managers identify, anticipate, and respond to the risks of catastrophic events in order to reduce to more acceptable levels the probability of their occurrence or the magnitude and duration of their social impacts. In the United States, emergency management traditionally has been conceptualized as the job (if not the legal responsibility) of government—local, state and federal. Particularly since the middle of the 20th Century, private business organizations have taken an increasingly active interest in emergency management, especially as it relates to their own business continuity. Certainly as the 21st Century begins, emergency management is best conceived as relying on alliances among all levels of government and the broader private sector (including for-profit and non-profit organizations with a wide range of missions).

Many factors have contributed to the increasing salience of emergency management in American society. One important factor lies in changes in the principle of sovereign immunity at the state level in the last quarter of the 20th Century and the establishment of levels of tort liability for local and state governments (Pine, 1991). Although some levels of immunity persist, it is important that government liability can be established under state and federal law, particularly in cases where negligence (failure to plan where appropriate) can be contended successfully. Another factor promoting the importance and visibility of the emergency management is the professionalization of emergency managers.

A recognition of the need for specialized training and development for emergency managers has led to the establishment of professional associations, the use of training certifications (*e.g.* technician certificates for hazardous materials and emergency medical expertise, and general certificates in incident management systems), and of professional credentialing processes such as the Certified Emergency Manager programme promoted by the International Association of Emergency Managers.

These developments have contributed to the growth of an organized body of specialists who understand how to appraise and cope with a range of environmental threats. Still a third factor is a growing sensitivity to hazards on the part of the public-at-large that is driven by media attention to periodic catastrophes associated with the forces of nature and technology. Finally, private businesses have become increasingly sensitive to the fact that disaster losses can have significant negative consequences on business plans and performance, sometimes forcing bankruptcy, closure, or the loss of significant market share (Lindell and Perry, 1998). With such significant potential consequences, vulnerability assessment and disaster preparedness have become both imbedded in business planning and thriving businesses in themselves.

Collectively, these factors have generated a social environment in which governments' ethical and legal obligations to protect citizens, and private sector interest in self-protection, have attracted attention to emergency management.

## FUNDAMENTAL THEORIES OF DISASTER

Over the centuries, there have been four fundamental theories about disasters.

*These four theories have conceived of disasters as*:

- Acts of fate/acts of God,
- Acts of nature,
- Joint effects of nature and society,
- Social constructions.

### Acts of Fate/Acts of God

For millennia, disasters were considered to arise from impersonal and uncontrollable forces—either from unfortunate alignments of stars and planets or as acts of God that were beyond human understanding.

Both forms of this theory viewed a disaster as predetermined and, thus, completely beyond the victim’s control. A variation on this theory was that disasters were cosmic or divine retribution for human failings—personal disasters for personal failings and collective disasters for societal failings.

### Acts of Nature

Over time, increased scientific knowledge led many people to substitute natural causes for supernatural ones. Thus, floods occurred because the large amount of rainfall from a severe storm exceeded the soil’s capacity to absorb it. The rapid run-off exceeded the river basin’s capacity, so the excess spilled over the river banks, flooded buildings, and drowned people and animals. Accordingly, the term natural disaster came to refer to "an outside attack upon social systems that 'broke down' in the face of such an assault from outside" (Quarantelli, 1998, p. 266). The resulting conception of man against nature has been especially potent as the driving force behind attempts to "tame" rivers by straightening their channels and building dams and levees.

## Interactive Effects of Nature and Society

Still later, it was proposed that hazards arise from the interaction of a physical event system and a human use system. Thus, it takes both a hazardous physical event system and a vulnerable human use system to produce disasters. If either one is missing, disasters do not occur. According to Carr (1932, p. 211). Not every windstorm, earth-tremor, or rush of water is a catastrophe. So long as the levees hold, there is no disaster. It is the collapse of the cultural protections that constitutes the disaster proper.

According to this view, human societies adapt to the prevailing environmental conditions (*e.g.*, temperature, wind speed, precipitation, seismic activity) at a given location. Unfortunately, they fail to anticipate the variation in those environmental conditions. Consequently, their adaptation to normal conditions usually is inadequate for extreme events—blizzards, heat waves, tornadoes, hurricanes, and floods. This perspective is perhaps best illustrated by earthquake damage and casualties.

As earthquake engineers are fond of saying, earthquakes don't kill people, collapsing buildings kill people. According to this view, people can avoid disasters if they stay out of seismically active locations or, if they do move there, they must build structures that resist the extreme environmental events that will eventually occur.

## Social Constructions

Most recently, researchers have recognized that disasters are quite systematic in the types of people they harm, as well as the types of geographic locations and human use systems they strike. To the interactive effects theory's concerns about hazard exposure at specific locations and physical vulnerability of specific structures, social construction theory calls attention to the social vulnerability of specific population segments.

To say that hazard vulnerability is socially constructed does not mean people are vulnerable because they think the wrong thoughts—as most people would now categorize the belief that floods are caused by the alignment of the planets and stars. Rather, socially vulnerable population segments emerge because our psychological, demographic, economic, and political processes tend to produce them. Of course these processes have produced many good things.

Many residents of the US, in particular, have good jobs, comfortable lives, and we have enjoyed one of the most democratic governments in the world. Nonetheless, all of these conditions have changed over time—life now is much improved from what it was a century ago and there are many ways in which it can be improved still further.

Of particular concern to emergency managers should be the many ways in which our institutions can reduce the hazard vulnerability of those who have the least psychological resilience, social support, political power, and are the poorest economically.

## Theoretical Comparisons

These theories have, in one sense, succeeded each other over time as scholars have found later theories to provide a better account of the data from their research. However, scientific acceptance is different from popular acceptance. Each of the four theories is currently believed by at least some members of society. Indeed, the most cynical version of the Acts of fate/acts of God theory uses it to avoid responsibility for actions that are substantially within human control.

For example, representatives of the coal company that built a dam across Buffalo Creek West Virginia claimed the dam's collapse was an "Act of God" because the dam was "incapable of holding the water God poured into it" (Erikson, 1976, p. 19). This was clearly a feeble attempt to avoid admitting the company negligently built a non-engineered dam from unstable materials, thus risking the lives of downstream residents to maintain company profits. Each community throughout the world probably has at least some believers in each theory. Because each theory has different implications for environmental hazard management, the prevalence of each theory has significant implications for policy at the local, state, national, and international levels.

## HAZARDS, EMERGENCIES, DISASTERS AND CATASTROPHES

Hazards, emergencies, and disasters afflicted human societies much longer than either the profession of emergency management or academic disaster research has existed. Thus, many vernacular terms have arisen that refer to the negative consequences of environmental events—accident, emergency, crisis, disaster, catastrophe, tragedy, and calamity, to name a few. Over the years, many of these terms have become embedded in the American vocabulary, often introduced through the mass media or literary usage.

As such events have become the focus of academic study and professional emergency management, it has also become necessary to devise technical—as opposed to vernacular—meanings for them to communicate a standardized meaning for each of these terms. For the purposes of this introduction to emergency management, it is important to distinguish the meaning of three terms: hazards, disasters, and emergencies.

The environment humans occupy consists of natural and technological components, each of which contains elements that pose a variety of risks to the human occupants and their property. These risks include both health and safety dangers for the occupants themselves and dangers to the physical or material culture created by the occupants. The risks arise from the intrusion of the human use system into natural and technological processes.

The term hazard captures the notion that, to the extent that people co-exist with powerful natural and man-made processes, there is a non-zero probability that the natural variation in these processes will produce extreme events having very negative consequences (Burton, Kates and White, 1993; Cutter, 2001). The human danger posed by these hazards varies with the level of human intrusion and the knowledge and technology associated with the hazard.

Tsunami (seismic sea waves) hazard is non-existent in Ames, Iowa, because human occupancy at that location is so far from the runup zones near the ocean shore, but tsunami hazard is very significant along the Pacific coast—especially the Hawaiian islands. Hazards are inherently probabilistic; they represent the potential for extreme environmental events to occur. Thus, hurricane hazard refers to the potential for hurricanes to affect a given location.

Hurricane hazard does not describe the condition when a hurricane strikes a coastal community causing death, injury, and property destruction. Of course, to achieve long-term survival, humans must adjust to or accommodate both natural and man-made processes in some fashion. The classic definition of hazard adjustment focuses upon the modification of human behaviour (broadly speaking, to include even settlement patterns) or the modification of environmental features to enable people to live in a given place (or with a given technology) under prevailing conditions.

The term emergency is commonly used in two slightly different but closely related ways. The first usage of the term refers to an event involving a minor consequences for a community—perhaps a few casualties and a limited amount of property damage. In this sense, emergencies are events that are frequently experienced, relatively well understood, and can be managed successfully with local resources—sometimes with the resources of a single local government agency. Emergencies are the common occurrences we see uniformed responders managing—car crashes, ruptured natural gas pipelines, house fires, traumatic injuries, and cardiac crises.

They are managed via (usually government, but sometimes private) organizations with specially trained, specially equipped personnel. One commonly associates emergencies with fire departments, police departments, and emergency medical services (EMS) organizations. These events are "routine" in the sense that they are well understood and, thus, elicit standardized response protocols and specialized equipment (Quarantelli, 1987). Nonetheless, it is important to understand each emergency can present unique elements; experts caution there is no such thing as a "routine" house fire. The belief that each new fire will be like all the previous ones has a high probability of producing firefighter deaths and injuries (Brunacini, 2002). The second usage of the term emergencies refers to the imminence of an event rather than the severity of its consequences. In this context, an emergency is a situation in which there is a higher than normal probability of an extreme event occurring.

For example, a September hurricane approaching a coastal community creates an emergency because the probability of casualties and damage is much greater than it was in March before hurricane season began. The urgency of the situation requires attention and, at some point, action to minimize the impacts if the hurricane should strike.

Unlike the previous usage of the term emergency, the event has not occurred but the consequences are not likely to be minor and routine methods of response are unlikely to be effective if the event does occur. The term disaster is reserved for the actual occurrence of events that produce casualties and damage at a level exceeding a community's ability to cope. As Table below indicates, a disaster involves a very specific combination of event severity and time/probability.

Unlike the uncertain time of impact associated with a hazard (whether or not the impact would exceed community resources), a disaster reflects the actuality of an event whose consequences exceed a community's resources. Unlike imminent emergencies, the consequences have occurred; unlike routine emergencies having minor impacts, disasters involve severe consequences for the community.

By extension, a catastrophe is an event that exceeds the resources of many local jurisdictions—in some cases crippling those jurisdictions' emergency response capacity and disrupting the continuity of other local government operations. Hurricane Katrina's destruction of the local emergency response agencies and disruption of other local government agencies in Louisiana, Mississippi, and Alabama certainly qualifies for this designation. Prince's (1920) study of an explosion in Halifax, Nova Scotia was the first modern piece of disaster research, but it was twelve years later that Carr (1932) made the first attempt at a formal definition of disaster.

Presently, disaster is commonly defined as a nonroutine event in time and space, producing human, property, or environmental damage, whose remediation requires the use of resources from outside the directly affected community. This definition captures the two features that are minimally (and traditionally) cited as features of disasters: they are out of the ordinary events whose consequences are substantial enough to require that extra-community resources be marshaled to respond to and recover from the impact.

There are many different definitions of disaster present in the professional and academic literature, but most of them include the dimensions listed in this definition. In addition, some of the other definitions specify the mechanism that generates the event such as acts of God, social injustice, acts of nature, aspects of social organization, etc.

There are important distinctions to be made among different types of disasters and the ways in which emergency management strategies vary with the source of the disaster (Drabek, 1997). Whether one believes God, nature, social injustice, or purposeful encroachment produce disasters certainly affects the attitude we express towards victims. The academic community, in particular, is still debating the details of such distinctions and consensus about the specific details of different meanings is still developing (Quarantelli, 1998).

However, in the profession of emergency management, the focus is typically on the assumption that disasters are caused by the overlap of human use systems with natural and technological processes and the charge is to minimize the negative consequences. At least on this applied level, emergency managers can operate on a concise definition of disasters, while remaining cognizant that the concept can be extended in a variety of ways and has myriad dimensions.

**Table. Relationships Among Hazards, Emergencies, Disasters, and Catastrophes.**

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="3">Time/probability</th></tr>
<tr><th>Uncertain</th><th>Imminent</th><th>Occurred</th></tr>
<tr><td rowspan="2">Demand compared to community capacity</td><td>Less than</td><td>Hazard</td><td>Emergency</td><td>Emergency</td></tr>
<tr><td>Greater than</td><td>Hazard</td><td>Emergency</td><td>Disaster/ catastrophe</td></tr>
</table>

## THE DEVELOPMENT AND TASKS OF THE EMERGENCY MANAGEMENT SYSTEM

Most hazard/disaster researchers and emergency managers would probably agree that it presumes much to claim that an integrated emergency management system exists in the United States. Certainly this is so if by an integrated system one means a well-defined and clearly differentiated structure of components with mutually agreed upon roles interacting over time in a coordinated manner to achieve common goals. However, there is a loosely-coupled collection of organizations that perform relatively differentiated roles in planning for, responding to, and recovering from disasters. Indeed, a basic understanding of the emergency management system and the demands that shape it has existed only since the late 1970s.

Even this basic conception of emergency management continues to change and the rudiments of what may yet become an integrated system for managing emergencies continues to evolve. Clearly, even after the intense efforts to enhance the system after the 2001 attack on the World Trade Center and the Pentagon, much of what currently exists remains both fragmented and incomplete. In many respects, the old adage that "disasters are a local problem" seems as true now as it was thirty years ago (Perry, 1979). What is different today is the fact that there is a greater degree of consensus regarding how to assess and respond to the risks of natural and technological hazards. Concomitantly, there appears to be increasing agreement regarding the goals and structures by which federal, state, and local governments work with private organizations and the general public to develop an integrated emergency management system. By focusing upon an ideal emergency management system, the current state of the art, imperfect as it may be, can be described and placed into historical perspective. Since the primary aim here is to describe rather than evaluate, the purpose of the following section is to provide a picture of the organizations comprising the system as it has changed over time.

To some extent, the discussion will include what might be with respect to an emergency management system as well as what is. Consequently, instances will be noted in which organizational links are tenuous at best and where functions assigned to agencies (particularly at the federal level) are minimally fulfilled or in some cases completely ignored. What follows, then, is an attempt to describe in a very short space what is really a very complex and extensive constellation of agencies, programmes, and interrelationships. Although the limited space available here requires compressing and simplifying many complex issues, the next two sections will describe the history of emergency management organizations, followed by a discussion of the functions that comprise emergency management.

## A BRIEF HISTORY OF FEDERAL EMERGENCY MANAGEMENT

Since the founding of the United States, the responsibility for and the locus of emergency and disaster management has moved from one agency to another within the federal government (and the same is true for many state and local governments). Except for two pieces of legislation, however, very little systematic work was done that resembles modern emergency management until the 1930s. Drabek (1991b, p. 6) reports that the first national disaster management effort was the 1803 Fire Disaster Relief Act, which made funds available to help the city of Portsmouth and the state of New Hampshire recover from extensive fires.

The next piece of legislation came 125 years later when the Lower Mississippi Flood Control Act of 1928 was passed as a means of responding to the lower Mississippi River flooding in 1927 (Platt, 1998, p.38). It is important to note that both of these pieces of early legislation followed a disaster and were aimed at supporting recovery because this is a pattern that has been continued to the present day. An emphasis on reconstruction after disaster has characterized emergency response efforts at the federal level even in the 21st Century.

Federal disaster management, if we characterize it as concerted attempts to manage the negative consequences of natural forces, really began when President Franklin Roosevelt created the Reconstruction Finance Corporation in 1933 and authorized it to make loans for repairing public buildings damaged by earthquakes (Drabek, 1991b). In addition, many New Deal social programmes provided services and various types of financial aid to natural disaster victims. Aside from individual programmes, the National Emergency Council operated within the White House between 1933 and 1939, primarily to cope with the Great Depression, but also to oversee natural disaster relief.

The Flood Control Act of 1936 established the Army Corps of Engineers as an important agency in the management of American waterways. In 1939, when the worst part of the Great Depression had begun to subside, the National Emergency Council was moved to the Executive Office of the President and renamed the Office for Emergency Management. Natural disaster relief continued to be centered in this agency, which functioned as a crisis management team for national scale threats of various types.

The beginning of World War II demanded the full attention of the Roosevelt administration in much the same way as the Depression had previously. In addition to its responsibilities for natural hazards, the Office for Emergency Management became the President's agency for developing civil defence plans and addressing war-related emergencies on the home front. Many programmes devised by the Office for Emergency Management were based in the Department of War, under the Office of Civil Defence (directed by Fiorello La Guardia). This office was abolished in 1945, leaving the Office for Emergency Management again as the principal federal emergency agency. Following World War II, President Harry Truman initially resisted pressures to establish another civil defence agency, believing that civil defence should be the responsibility of the states (Perry, 1982). An Office of Civil Defence Planning was created in 1948 under the year-old Defence Department, and the Office for Emergency Management was again left to concentrate on natural disasters and other domestic emergencies. This separation of planning for civil defence versus natural and domestic disasters continued for nearly two years, but has reappeared over the decades with subsequent reorganizations of federal efforts.

After the Soviet Union tested its first atomic bomb in the summer of 1949, Truman relented and created the Federal Civil Defence Administration within the Executive Office of the President as a successor to the Office for Emergency Management. Responsibility for federal assistance in the case of major natural disasters became the responsibility of the Housing and Home Finance Administration. Legislation quickly followed with the passage of the Federal Civil Defence Act of 1950 and the Disaster Relief Act of 1950 (Blanchard, 1986, p. 2). It is noteworthy that this legislation continued to assign responsibility for civil defence and disasters to the states and attempted to spell out specific federal obligations. At the end of President Truman's administration on January 16, 1953, Executive Order 10427 removed natural disaster relief responsibility from Housing and Home Finance and added it to FCDA (Yoshpe, 1981, p.166).

This arrangement of functions and agencies persisted through both Eisenhower administrations, though the primary agency name changed first to the Office of Defence and Civilian Mobilization and then to the Office of Civil Defence Mobilization. The Office of Civil Defence Mobilization was the first emergency organization to be given independent agency status (in 1958) rather than being under another cabinet department or the White House. On the policy side, the Federal Civil Defence Act was amended in 1958 to make civil defence a joint responsibility of the federal government and state and local governments. This amendment also provided for federal matching of state and local government civil defence expenditures, which actually began to be funded in 1961 under the administration of President John F. Kennedy.

Thus, the Kennedy era saw the first rapid expansion of civil defence agencies at the state and local level. President Kennedy again separated federal responsibility for domestic disasters and civil defence in 1961 when he created the Office of Emergency Planning (in the White House) and the Office of Civil Defence (in the Defence Department). Kennedy's successor, Lyndon B. Johnson, moved the OCD to the Department of the Army in 1964, signaling a reduction in importance (and funding) for this function. This general separation of functions was maintained until 1978, although the Office of Civil Defence became the Defence Civil Preparedness Agency in 1972. Beginning with the creation of the Office of Emergency Preparedness under the Executive Office of the President in 1968, programmes dealing with natural and technological hazards began to be reconstituted and parceled out among a variety of federal agencies.

For example, the Federal Insurance Administration was established in 1968 as part of the Department of Housing and Urban Development. In 1973, President Richard M. Nixon dismantled the Office of Emergency Preparedness and assigned responsibility for post-disaster relief and reconstruction to the Federal Disaster Assistance Administration in the Department of Housing and Urban Development. General management and oversight of federal programmes was assigned to the Office of Preparedness, which was moved to the General Services Administration and, in 1975, became the Federal Preparedness Agency.

Throughout the 1970s, as new federal legislation or executive orders mandated federal government concern with different aspects of natural and man-made hazards, new programmes were created within a variety of federal offices and agencies. These were included in the Department of Commerce's National Weather Service Community Preparedness Programme (1973) and the National Fire Prevention and Control Administration (1974). Following the 1972 havoc wreaked by Hurricane Agnes, the Disaster Relief Act of 1974 was passed granting individual and family assistance to disaster victims (administered through the Federal Disaster Assistance Administration). In the late 1970s, four major programmes were established within the Executive

Office of the President: Dam Safety Coordination, Earthquake Hazard Reduction Programme, Warning and Emergency Broadcast System, and Consequences Management in Terrorism. Other technological hazards programmes also involved such agencies as the Environmental Protection Agency, Nuclear Regulatory Commission, and the Departments of Energy and Transportation.

This diffuse assignment of responsibilities for emergency management programmes to a diverse set of federal agencies persisted through the late 1970s and, as time passed, created a growing concern in the executive branch and the Congress that federal programmes for disaster management were too fragmented. Similar concerns by state and local governments became the focus of the National Governors' Association (NGA) Disaster Project in the late 1970s. The project's staff traced many state and local problems in emergency management back to federal administrative arrangements. They argued that federal fragmentation hampered effective preparedness planning and response, masked duplicate efforts, and made national preparedness a very expensive enterprise. The Director of the Federal Preparedness Agency, General Leslie W. Bray, acknowledged that when the emergency preparedness function was taken out of the Executive Office of the President and assigned sub-agency status, many people perceived that the function had been downgraded to a lower priority, and his job of coordinating became more complicated. The states argued that their job of responding to disasters was hampered by being forced to coordinate with so many federal agencies. In 1975, a study of these issues sponsored by the Joint Committee on Defence Production (1976, p. 27) concluded:

The civil preparedness system as it exists today is fraught with problems that seriously hamper its effectiveness even in peacetime disasters. . . It is a system where literally dozens of agencies, often with duplicate, overlapping, and even conflicting responsibilities, interact. In addition to the administrative and structural difficulties, there was also concern the scope of the functions performed as part of emergency management was too narrow, too many resources were devoted to post-disaster response and recovery, and too few resources devoted to the disaster prevention. When the federal response to the nuclear power plant accident at Three Mile Island was severely criticized, calls for reorganization became very loud (Perry, 1982).

Responding to these concerns in 1978, President Jimmy Carter initiated a process of reorganizing federal agencies charged with emergency planning, response, and recovery. This reorganization resulted in the creation, in 1979, of the Federal Emergency Management Agency (FEMA), whose director reported directly to the President of the United States. Far from being an entirely new organization, FEMA was a consolidation of the major federal disaster agencies and programmes. Most of FEMA's administrative apparatus came from combining the three largest disaster agencies: the Federal Preparedness Agency, Defence Civil Preparedness Agency, and Federal Disaster Assistance Administration.

Thirteen separate hazard-relevant programmes were moved to FEMA, including most of the programmes and offices created in the 1970s (Drabek, 1991b). These moves gave FEMA responsibility for nearly all federal emergency programmes of any size, including civil defence, warning dissemination for severe weather threats, hazard insurance, fire prevention and control, dam safety coordination, emergency broadcast and warning system, earthquake hazard reduction, terrorism, and technological hazards planning and response. Where FEMA did not absorb a programme in its entirety, interagency agreements were developed giving FEMA coordinating responsibility. These agreements included such agencies as the Environmental Protection Agency (EPA), Department of Transportation (DOT), National Oceanic and Atmospheric Administration (NOAA), and Nuclear Regulatory Commission (NRC).

At least on paper, the Executive Order made FEMA the focal point for all federal efforts in emergency management. Although FEMA remained the designated federal lead agency in most cases, there were 12 other independent agencies with disaster responsibilities. The EPA is the largest of these agencies, but others included the Federal Energy Regulatory Commission (FERC), the National Transportation Safety Board (NTSB), NRC, Small Business Administration (SBA), and the Tennessee Valley Authority (TVA). Because disaster related federal relief programmes were so scattered through the government, many small programmes remained in their home agencies. For example, the Emergency Hay and Grazing programme allows federal officials to authorize the harvesting of hay for emergency feed from land assigned for conservation and environmental uses under the Conservation Reserve Programme.

This programme is operated in the Farm Service Agency of the US Department of Agriculture. Ultimately, some emergency or disaster related programmes remained in thirteen cabinet level departments, including Agriculture, Commerce, Defence, Education, Energy, Health and Human Services, Housing and Urban Development, Interior, Justice, Labour, State, Transportation and Treasury. Certainly the creation of FEMA moved federal emergency management to a much more central position than it had ever been given previously, but it was not possible to completely consolidate all federal programmes and offices within the new agency.

The FEMA Director is appointed by the President of the United States and, until the establishment of the Department of Homeland Security, was part of the cabinet. The organization has a regional structure composed of ten offices throughout the United States plus two larger area offices. Although by far the most comprehensive effort, the establishment of FEMA represented the third time that all federal disaster efforts and functions were combined; the first was the National Emergency Council (1933-1939), followed by the Office of Civil Defence Mobilization (1958-1961).

The early history of FEMA was dominated by attempts to define its mission and organize its own bureaucracy. John Macy, the agency's first director, was faced with organizational consolidation as a most pressing task: converting thirty separate nation-wide offices to 16 and eight Washington, D.C. offices to five (Macy, 1980). Ultimately, creating a single bureaucracy (with a $630 million budget) from thirteen entrenched organizations proved to be a herculean task. The efforts to obtain an optimal structure for FEMA continued over the next two decades; later directors undertook major reorganizations of headquarters and FEMA's mission, like its structure, continued to evolve. The early years of FEMA saw much significant legislation and activity. In 1979, the NGA Disaster Project published the first statement of Comprehensive Emergency Management (CEM, the notion that authorities should develop a capacity to manage all phases of all types of disasters), and the concept was subsequently adopted by both the NGA and FEMA.

In 1980, the Federal Civil Defence Act of 1950 was amended to emphasize crisis relocation of population (evacuation of people from cities to areas less likely to be Soviet nuclear targets), signaling a fundamental change in US civil defence strategy. Also in 1980, the Comprehensive Environmental Response, Compensation, and Liability Act (called the Superfund Law) was passed, precipitated by the 1978 dioxin contamination of Love Canal, New York. In 1983, FEMA adopted the concept of Integrated Emergency Management System (IEMS) as part of the strategy for achieving CEM (Blanchard, 1986; Drabek, 1985).

The basic notion was to identify generic emergency functions—applicable across a variety of hazards—and develop modules to be used where and when appropriate. For example, population evacuation is a useful protective technique in the case of hurricanes, floods, nuclear power plant accidents, or a wartime attack (Perry, 1985). Similar generic utility exists is developing systems for population warning, interagency communication, victim sheltering, and other functions.

Thus, in the early 1980s, FEMA was formed, shaped by organizational growing pains, and also shaped through the adoption of new philosophies of emergency management. While FEMA's basic charge of developing a strategy and capability to manage all phases of all types of environmental hazards remained, the precise definitions of hazards, the basic conception of emergency management, and the organizational arrangements through which its mission should be accomplished continued to evolve through the end of the 20th Century. The end of the 1980s saw passage of the Superfund Amendments and Reauthorization Act (SARA Title III) in 1986 (Lindell and Perry, 2001) and President Ronald Reagan's Presidential Policy Guidance (1987) that became the last gasp of nuclear attack related civil defence programmes in the United States (Blanchard, 1986). Passage of the Robert Stafford Disaster Relief and Emergency Assistance Act of 1988 again boosted state and local emergency management efforts. The Stafford Act established federal cost sharing for planning and public assistance (family grants and housing).

The 1990s opened with controversy for FEMA. In 1989, FEMA response to Hurricane Hugo was criticized as inept—a charge repeated in 1992 when Hurricane Andrew struck Florida. In 1993, flooding in the mid-western US caused more than 15 billion dollars in damage and resulted in six states receiving federal disaster declarations.

President Clinton appointed James Lee Witt Director of FEMA in 1993, marking the only time a professional emergency manager held the post. Witt (1995) aggressively increased the federal emergency management emphasis on hazard mitigation and began a reorganization effort. Prior to this time, the federal emphasis had been largely upon emergency response and, to a lesser extent, short-term disaster recovery. Witt began the first real change in federal strategy since emergency management efforts had begun.

By the close of the 1990s, FEMA's organization reflected its critical functions. In 1997, there were seven directorates within FEMA: Mitigation, Preparedness, Response and Recovery, the Federal Insurance Administration, the United States Fire Administration, Information Technology Services, and Operations Support (Witt, 1997). As the 21st Century began, the overall emphasis of FEMA remained mitigation and both comprehensive emergency management and integrated emergency management systems remained concepts in force.

The most recent epoch in American emergency management began on September 11, 2001, when the attacks on the World Trade Center and the Pentagon shocked Americans and challenged government disaster response capabilities. The attack initiated a comprehensive rethinking of "security", "emergencies", and the appropriate role of the federal government. During October, 2001, President George W. Bush used Executive Orders to create the Office of Homeland Security (appointing Governor Tom Ridge as Director) and the Office of Combating Terrorism (General Wayne Downing as Director). On October 29th, President Bush issued Homeland Security Presidential Directive Number 1 (HSPD-1), establishing the Homeland Security Council, chaired by the President. In June of 2002, President Bush submitted his proposal to Congress to establish a cabinet level Department of Homeland Security (DHS), which was passed later that year.

Since the establishment of DHS, the department's mission has encompassed three goals: preventing terrorist attacks within the United States, reducing vulnerability to terrorism, and minimizing the damage and recovering rapidly from terrorist attacks (Bush, 2002, p. 8). Although not reflected in the mission statement, DHS would also retain the all hazards responsibilities assigned to FEMA. As was the case in the establishment of FEMA over two decades earlier, DHS incorporated a variety of agencies and programmes from many cabinet-level departments, including Agriculture, Commerce, Defence, Energy, Health and Human Services, Interior, Justice, and Treasury.

The US Secret Service reports directly to the Secretary of Homeland Security, as does the Coast Guard. The line agencies of DHS comprise four Directorates. The Border and Transportation Security Directorate incorporated the Customs Service from the Department of Treasury, Immigration and Naturalization Service from the Department of Justice, Federal Protective Service, the Transportation Security Agency from the Department of Transportation, Federal Law Enforcement Training Center from the Department of Treasury, Animal and Plant Health Inspection Service from the Department of Agriculture, and Office of Domestic Preparedness from the Department of Justice.

The Emergency Preparedness and Response Directorate was built around FEMA and also included the Strategic National Stockpile and National Disaster Medical System of the Department of Health and Human Services, Nuclear Incident Response Team from the Department of Energy, the Department of Justice's Domestic Emergency Support Teams, and the FBI National Domestic Preparedness Office. The Science and

Technology Directorate incorporates the Chemical, Biological, Radiological and Nuclear Countermeasures Programmes and the Environmental Measurements Laboratory from the Department of Energy, the National BW Defence Analysis Center from the Department of Defence, and the Plum Island Animal Disease Center from the Department of Agriculture. Finally, the Information Analysis and Infrastructure Protection Directorate absorbed the Federal Computer Incident Response Center from the General Services Administration, the National Communications System from the Department of Defence, the National Infrastructure Protection center from the FBI, and the Energy Security and Assurance Programme from the Department of Energy.

Since 2001, the President has issued additional HSPDs defining the fundamental policies governing homeland security operations (www.dhs.gov/dhspublic). Thirteen HSPDs were issued through mid-2006. Recent documents have established the National Incident Management System (HSPD-5), the Homeland Security Advisory System (HSPD-3), the Terrorist Threat Integration Center (HSPD-6), and a common identification standard for all federal employees (HSPD-12).

Other documents proposed strategies to combat weapons of mass destruction (HSPD-4), protect critical infrastructure (HSPD-7) and the agriculture and food system (HSPD-9), coordinate incident response (HSPD-8), and enhance protection from biohazards (HSPD-10). In addition, these documents have established policies for protecting international borders from illegal immigration (HSPD-2), promoting terrorist-related screening (HSPD-11), and securing maritime activities (HSPD-13). These developments make it clear that the President and the Congress consider homeland security to be much broader than emergency management.

Incorporation of FEMA into DHS's Emergency Preparedness and Response Directorate seems to imply FEMA is responsible only for preparedness and response (and perhaps disaster recovery if this is viewed as an extension of the emergency response phase). Consistent with this line of reasoning, one can interpret the mission of the Border and Transportation Security

Directorate and the Information Analysis and Infrastructure Protection Directorate in terms of incident prevention. This gives these directorates responsibilities analogous to what emergency managers call hazard mitigation. Even so, the DHS organization chart seems to indicate a significant loss in the priority given to mitigation of natural and accidental technological hazards.

At the present, many questions remain unanswered regarding the new department and the fate of the agencies and programmes that it absorbed. Of particular concern is FEMA's loss of high level access; there are now two positions between the FEMA Director and the President where before there were none. FEMA's poor performance during and after Hurricane Katrina has led members of Congress to consider restoring its independence.

However, it may be too early to draw meaningful conclusions about the degree to which DHS is accomplishing its mission regarding natural hazards and technological accidents. As a point of comparison, it took FEMA a decade after its establishment to become an effective organization even though FEMA was never more than a small fraction of the size of DHS.

## CHARACTERIZING EMERGENCY MANAGEMENT ACTIVITIES

Before discussing the tasks that constitute emergency management, it is important to briefly ground the discussion in the process of accomplishing emergency management. There have been years of dialogue regarding "who really does emergency management".

Although the history just reviewed focuses largely on federal efforts, it is both accurate and appropriate to conceive of emergency management as a local endeavor to influence events with local consequences. This is in keeping with FEMA's practice of attempting to make US emergency management a "bottom up" proposition.

Of course, the job can be done optimally only with intergovernmental communication and cooperation that links local, state, and federal efforts. In some cases—for example, biological threats—the full resources of the federal government are needed to even begin the management process. Certainly in a major incident, external support (particularly state and federal) of many forms is made available to local jurisdictions.

There is an inevitable time lag, however; currently the National Response Plan alerts local communities they must plan to operate without external help for approximately 72 hours after disaster impact.

In addition, when external support does arrive, the response proceeds most efficiently and effectively if there is a strong, locally devised structure in place into which external resources can be integrated (Perry, 1985). Taking these realities into account, the tasks of emergency management can be discussed more effectively if there is a structure into which to fit the discussion.

## THE LOCAL EMERGENCY MANAGEMENT SYSTEM

Figure below describes the elements of a local emergency management system with some of its intergovernmental connections. By reviewing the figure, one can place in context some of the tasks and the tools available for emergency management. This chart is not intended to capture all actors and processes but, rather, to indicate the critical elements in the emergency management system. Ultimately, of course, the processes and tasks described here take place at every level of government.

The process of emergency management should be based on a careful hazard/vulnerability analysis (HVA) that identifies the hazards to which a community is exposed, estimates probabilities of event occurrence, and projects the likely consequences for different geographic areas, population segments, and economic sectors (Greenway, 1998; Ketchum and Whittaker, 1982). It is important to emphasize that HVA is not a static activity because hazards are not static.

HVA is probably best conceptualized as a process that periodically reassesses the hazard environment so emergency managers can facilitate the challenging process of deciding which hazards are significant enough to require active management. This is a complex process that involves myriad considerations and input from a variety of actors.

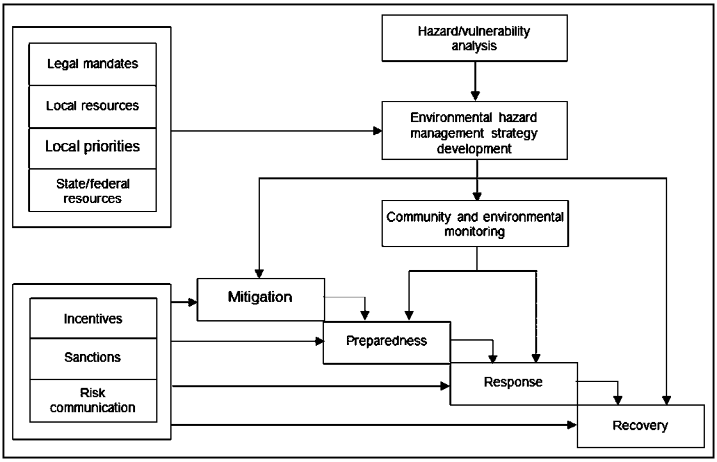


**Fig.** The Local Emergency Management System.

Hazard management decisions are influenced by multiple considerations. There are statutory and administrative mandates to manage certain hazards. The available hazard data, derived from national sources such as FEMA's Multi-Hazard Identification and Risk Assessment (Federal Emergency Management Agency, 1997) and supplemented by local sources such as Local Emergency Planning Committees (LEPCs) and State Emergency Response Commissions (SERCs), are also critical components of the decision process. In addition, decisions to manage hazards are determined by state and federal resources, local resources (including the jurisdiction's budget), and the local resource allocation priorities.

Once a decision has been made to actively manage one or more hazards, three processes are initiated concurrently. The first is a hazard management planning process that examines mitigation and preparedness strategies. That is, the community must consider whether it is possible to eliminate a risk or reduce it through some emergency management strategy. At the local level, these deliberations involve not just emergency managers but also departments of land use planning, building construction, engineering, public works, public health, and elected officials because mitigation and preparedness actions require significant commitments of resources to reduce community hazard vulnerability. At the same time, the process of judging hazard impact begins, using much of the same technical hazard data to create strategies and acquire resources for response and recovery when a disaster strikes. The local response usually centers on preparations for the mobilization of local emergency services (fire department, EMS, hazardous materials teams, police, transportation and public works departments, and emergency managers) under an agreed upon incident management system (Brunacini, 2001; Kramer and Bahme, 1992). Both response and recovery activities are organized in conjunction with support from external sources, particularly the state and federal government.

The purpose of this planning process is to institutionalize emergency response as much as possible while looking at disaster recovery as another path to sustainability or disaster resilience (in addition to mitigation). The third process to be initiated is environmental monitoring for the hazards to be managed. Typically, such monitoring is coupled with a warning system whose activation initiates response actions when disaster impact is imminent. The quality of the warning system depends upon the state of technology associated with the hazards to which the community is exposed and could provide days (in the case of hurricanes or riverine flooding) or minutes (in the case of tornadoes) of forewarning (Sorensen, 2000).

The nature of the warning system is also affected by jurisdictional mitigation, preparedness, and response plans. In many cases, hazard monitoring is beyond the technical and financial capability of most communities and assumed by federal agencies and programmes. In such cases—tsunamis, for example—the results of the monitoring programme are relayed to local jurisdictions. Furthermore, information regarding the state of the warning system (its ability to accurately forecast and detect hazards) is shared with hazard planning systems as a means of informing longer term risk management plans.

The community planning process generates hazard management strategies that incorporate knowledge about hazards derived from many sources, including the scientific community and state and federal agencies. The resulting hazard management strategies can be categorized as hazard mitigation, disaster preparedness, emergency response, and disaster recovery. As will be discussed in greater detail below, mitigation seeks to control the hazard source, prevent the hazard agent from striking developed areas, limiting development in hazard prone areas, or strengthening structures against the hazard agent.

These community hazard management strategies must be individually implemented by households and businesses, or collectively implemented by government agencies acting on behalf of the entire community. The individual strategies only reduce the vulnerability of a single household or business. These generally involve simple measures to mitigate hazards by elevating structures above expected flood heights, developing household or business emergency response plans, and purchasing hazard insurance. The collective strategies are generally complex—and expensive—technological systems that protect entire communities. Thus, they mitigate hazards through community protection works such as dams and levees and prepare for hazard impacts through measures such as installing warning systems and expanding highways to facilitate rapid evacuation.

Collective hazard adjustments are relatively popular because they permit continued development of hazard prone areas, yet do not impose any constraints on individual households or businesses. In addition, their cost is spread over the entire community and often buried in the overall budget. Indeed, the cost is often unknowingly subsidized by taxpayers in other communities. For this reason, these collective hazard adjustments are often called “technological fixes”. By contrast, individual hazard adjustments strategies require changes in households’ and businesses’ land use practices and building construction practices. Such changes require one of three types of motivational tactics—incentives, sanctions, or risk communication.

Incentives provide extrinsic rewards for compliance with community policies. That is, they offer positive inducements that add to the inherent positive consequences of a hazard adjustment or offset the inherent negative consequences of that hazard adjustment. Incentives are used to provide immediate extrinsic rewards when the inherent rewards are delayed or when people must incur a short-term cost to obtain a long-term benefit. For example, incentives are used to encourage people to buy flood insurance by subsidizing the premiums. Sanctions provide extrinsic punishments for non-compliance with community policies.

That is, they offer negative inducements that add to the inherent negative consequences of a hazard adjustment or offset the inherent positive consequences of that hazard adjustment. Sanctions are used to provide immediate extrinsic punishments when the inherent punishments are delayed or when people incur a short-term benefit that results in a long-term cost. For example, sanctions are used to prevent developers from building in hazard prone areas or using unsafe construction materials and methods. The establishment of incentives and sanctions involves using the political process to adopt a policy and the enforcement of incentives and sanctions requires an effective implementation programme (Lindell and Perry, 2004).

By contrast, risk communication seeks to change households' and businesses' practices for land use, building construction, and contents protection by pointing out the intrinsic consequences of their behaviour. That is, risk communication explains specifically what are the personal risks associated with risk area occupancy and also the hazard adjustments that can be taken to reduce hazard vulnerability.

With this overview, discussion can be turned to the four principal functions or phases of emergency management: hazard mitigation, emergency preparedness, emergency response, and disaster recovery. Much of the development and systematization of this four-fold typology may be traced to the efforts of the NGA's Emergency Management Project. As this group grappled with what it means to manage emergencies, it generated considerable discussion and some controversy within both the disaster research and emergency management communities. Since being adopted by FEMA, it is now widely accepted as an appropriate model for understanding the activities of emergency management. This scheme consolidates emergency activities into four discrete but interconnected categories distinguished by their time of occurrence in relation to disaster impact. Mitigation and preparedness activities are generally seen as taking place before the impact of any given disaster, whereas response and recovery activities are seen as post-impact measures.

## HAZARD MITIGATION

Hazard mitigation activities are directed towards eliminating the causes of a disaster, reducing the likelihood of its occurrence, or limiting the magnitude of its impacts if it does occur. Officially, FEMA defines mitigation as “any action of a long-term, permanent nature that reduces the actual or potential risk of loss of life or property from a hazardous event” (Federal Emergency Management Agency, 1998a, p. 9). This definition is somewhat ambiguous because it encompasses the development of forecast and warning systems, evacuation route systems, and other pre-impact actions that are designed to develop a capability for active response to an imminent threat. Thus, Lindell and Perry (2000) contended the defining characteristic of hazard mitigation was that it provides passive protection at the time of disaster impact, whereas emergency preparedness measures develop the capability to conduct an active response at the time of disaster impact.

Since 1995, FEMA has emphasized mitigation as the most effective and cost-efficient strategy for dealing with hazards. Indeed, a recent study by the Multihazard Mitigation Council (2005) concluded investments in hazard mitigation return four dollars in losses averted for every dollar invested. The ways in which mitigation activities can reduce hazard losses can best be understood in terms of a model proposed by Burton, *et al*. (1993) that contends natural hazards arise from the interaction of natural event systems and human use systems. Thus, the potential human impact of an extreme natural event such as a flood, hurricane, or earthquake can be altered by modifying either the natural event system, or the human use system, or both.

In the case of floods, for example, the natural event system can be modified by dams or levees that confine flood water. The human use system can be modified by land use practices that limit development of the flood plain or building construction practices that floodproof structures. Although the amount of control that can be exercised over natural event systems is often limited, technological hazards are inherently susceptible to such controls. Chemical, biological, radiological/nuclear, and explosive/flammable materials can all be produced, stored, and transported in ways that avoid adverse effects to plant workers, local residents and the public-at-large.

However, this control can be lost, resulting in releases to the air, or to surface or ground water. It is possible to control the hazard agent by locating the system away from populated areas; designing it with diverse and redundant components or by operating it with smaller quantities of hazardous materials (known as hazmat), lower temperatures and pressures, safer operations and maintenance procedures, and more effective worker selection, training and supervision).

Alternatively, one can control the human use system by preventing residential and commercial development—especially schools and hospitals—near hazardous facilities and major hazmat transportation routes. The choice of whether to mitigate technological hazards by controlling the hazard agent or the human use system depends upon political and economic decisions about the relative costs and benefits of these two types of control. Specific questions include who has control over the hazards, what degree of control is maintained, and what incentives there are for the maintenance of control.

Attempts to mitigate natural hazards, or events over which there is little human control, involve controlling human activities in ways that minimize hazard exposure. Thus, land use practices restricting residential construction in floodplains are important mitigation measures against riverine floods. The Hazard Mitigation and Relocation Act of 1993, for example, allows FEMA to purchase homes and businesses in floodplains and remove these structures from harm's way. Although moving entire communities involves considerable stress for all concerned, an intense and systematic management process—characterized especially by close coordination among federal, state, and local agencies—can produce successful protection of large numbers of citizens and break the repetitive cycle of "flood-rebuild-flood-rebuild" that is so costly to the nation's taxpayers (Perry and Lindell, 1997b). Likewise, building code requirements are used to restrict construction to those designs that can better withstand the stresses of hurricane force winds or earthquake shocks.

## DISASTER PREPAREDNESS

Disaster preparedness activities are undertaken to protect human lives and property in conjunction with threats that cannot be controlled by means of mitigation measures or from which only partial protection is achieved. Thus, preparedness activities are based upon the premise that disaster impact will occur and that plans, procedures, and response resources must be established in advance. These are designed not only to support a timely and effective emergency response to the threat of imminent impact, but also to guide the process of disaster recovery.

*A jurisdiction's disaster preparedness programme needs to be defined in terms of*:

- What agencies will participate in preparedness and the process by which they will plan,
- What emergency response and disaster recovery actions are feasible for that community,
- How the emergency response and disaster recovery organizations will function and what resources they require,
- How disaster preparedness will be established and maintained.

Emergency managers can address the first of these questions—what agencies and what will be the process for developing disaster preparedness—by defining an emergency management organization. This requires identifying the emergency management stakeholders in the community and developing a collaborative structure within which they can work effectively. It also requires ensuring an adequate statutory basis for disaster preparedness and administrative support from senior elected and appointed officials.

Emergency managers can address the second question—what are the feasible response and recovery actions—by means of analyses conducted to guide the development of major plan functions. These include, for example, evacuation analyses to assess the population of the risk areas, the number of vehicles that will be taken in evacuation, when people will leave, and what is the capacity of the evacuation route system.

Emergency managers can address the third question—how will the response and recovery organizations function—in the emergency operations plan (EOP), the recovery operations plan (ROP), and their implementing procedures. These documents define which agencies are responsible for each of the functions that must be performed in the emergency response and disaster recovery phases. Some of the generic emergency response functions include emergency assessment, hazard operations, population protection, and incident management (Lindell and Perry, 1992, 1996b).

While developing the plans and procedures, emergency managers also need to identify the resources required to implement them. Such resources include facilities (*e.g.*, mobile command posts and emergency operations centers—EOCs), trained personnel (*e.g.*, police, fire, and EMS), equipment (*e.g.*, detection systems such as river gages and chemical sensors, siren systems, pagers, emergency vehicles, and radios), materials and supplies (*e.g.*, traffic barricades, chemical detection kits, and self-contained breathing apparatus), and information (*e.g.*, chemical inventories in hazmat facilities, congregate care facility locations and capacities, and local equipment inventories).

Emergency managers can also address the fourth question—how disaster preparedness will be established and maintained—in EOP and ROP. Sections of these plans should define the methods and schedule for plan maintenance, training, drills, and exercises. Training should always be conducted for emergency responders in fire, police, and EMS. In addition, training is needed for personnel in special facilities such as hospitals, nursing homes, and schools.

## Emergency Response

Emergency response activities are conducted during the time period that begins with the detection of the event and ends with the stabilization of the situation following impact. FEMA (1998b, p. 12) indicates the goal of emergency response is "to save lives and property by positioning emergency equipment and supplies; evacuating potential victims; providing food, water, shelter and medical care to those in need; and restoring critical public services". In many cases, hazard monitoring systems ensure authorities are promptly alerted to disaster onset either by means of systematic forecasts (*e.g.*, hurricanes) or prompt detection (*e.g.*, flash floods detected by stream gages), so there is considerable forewarning and consequently a long period of time to activate the emergency response organization. In other cases, such as earthquakes, pre-impact prediction is usually not available, but prompt assessment of the impact area is feasible within a matter of minutes to hours and can quickly direct emergency response resources to the most severely affected areas.

Some of the more visible response activities undertaken to limit the primary threat include securing the impact area, evacuating threatened areas, conducting search and rescue for the injured, providing emergency medical care, and sheltering evacuees and other victims. Operations mounted to counter secondary threats include fighting urban fires after earthquakes, identifying contaminated water supplies, or other public health threats following flooding, identifying contaminated wildlife or fish in connection with a toxic chemical spill, or preparing for flooding following glacier melt during a volcanic eruption. During the response stage, emergency managers must also continually assess damage and coordinate the arrival of converging equipment and supplies so they can be deployed promptly to those areas with the greatest need.

Emergency response activities are usually accomplished through the efforts of diverse groups—some formally constituted, others volunteer—coordinated through an EOC. Usually, local emergency responders dominate the response period. These almost always include police, firefighters, and EMS personnel, and often include public works and transportation employees. Uncertainty and urgency—less prevalent in mitigation, preparedness, and recovery—are important features of the response period. In the world of disaster response, minutes of delay can cost lives and property, so speed is typically essential. However, speed of response must be balanced with good planning and intelligent assessment to avoid actions that are impulsive and possibly counterproductive. Finally, emergency response actions need to be coordinated with disaster recovery. That is, life and property are priorities, but response actions foreshadow recovery actions. For example, damage assessments are later used to support requests for Presidential Disaster Declarations and debris removal might be concentrated on roadways that are essential for restoring infrastructure. The emergency response phase ends when the situation is stabilized, which means that the risk of loss of life and property has returned to precrisis levels.

## Disaster Recovery

Disaster recovery activities begin after disaster impact has been stabilized and extends until the community has been returned to its normal activities. In some cases, the recovery period may extend for a long period of time. The Federal Emergency Management Agency (1995a, p. XX) states "recovery refers to those non-emergency measures following disaster whose purpose is to return all systems, both formal and informal, to as normal as possible." The immediate objective of recovery activities is to restore the physical infrastructure of the community—water, sewer, electric power, fuel (*e.g.*, natural gas), telecommunication, and transportation—but the ultimate objective is to return the community's quality of life to at least the same level as it was before the disaster.

Recovery has been defined in terms of short-range (relief and rehabilitation) measures versus long-range (reconstruction) measures. Relief and rehabilitation activities usually include clearance of debris and restoration of access to the impact area, reestablishment of economic (commercial and industrial) activities, restoration of essential government or community services, and provision of an interim system for caring for victims—especially housing, clothing, and food. Reconstruction activities tend to be dominated by the rebuilding of major structures—buildings, roads, bridges, dams, and such—and by efforts to revitalize the area's economic system. In some communities, leaders view the reconstruction phase as an opportunity to institute plans for change that existed before the disaster or to introduce mitigation measures into reconstruction that would constitute an improvement upon the community's pre-impact state. Such an approach to reconstruction has been documented after the great Alaska earthquake of 1964 (Anderson, 1969a). After the eruption of Mt. Usu on the northern island of Hokkaido, Japan, local leaders convinced the central government to invest in a wide range of civic improvements aimed at enhancing the local area's economic viability as a tourist center (Perry and Hirose, 1982).

Finally, it should be noted that the bulk of the resources used in the recovery phase (particularly on reconstruction) are derived from extracommunity sources. In the United States, these sources include private organizations and state governments, but for the most part they come from the federal government. Furthermore, even after James Lee Witt began FEMA's emphasis on hazard mitigation, most of the money and resources for emergency management continued to be consumed in the recovery phase.

## EVALUATION OF THE EMERGENCY MANAGEMENT SYSTEM

The preceding discussion has examined the four principal functions of the emergency management system—mitigation, preparedness, response, and recovery. In summary, two points should be reiterated here. First, although the distinctions among these four functions are fuzzy (*i.e.*, the transition from one phase to the next is gradual rather than sharp), they are distinctly time phased. Mitigation and preparedness measures take place in advance of any specific disaster impact, whereas response takes place during and recovery occurs after disaster impact.

Therefore, practical problems accompany the development of mitigation and preparedness strategies because they must usually be accomplished during periods of normal activity, when environmental threats are not imminent. Historical evidence indicates that it has been difficult to mount efforts to engage in these sorts of activities. Response and recovery take place within the context of a disaster impact—clearly unusual times—and benefit from the operation of an emergency social system as well as from the high level of community cohesiveness that usually emerges in the immediate aftermath (Lindell and Perry, 1992). The second point is that, in the past, far more resources and emphasis have been allocated to response and recovery activities than to mitigation and preparedness.

This is consistent with a cycle, well known to disaster researchers and emergency management professionals, of citizen and governmental interest in disasters. Immediately after impact, the attention of both the public and community officials is riveted upon the physical devastation and social disruption. Considerable resources are made available for shelter, food, clothing, and financial aid to victims, as well as debris clearance and the physical restoration of critical facilities within the community. However, public attention declines significantly as time passes. Because considerable time is required to translate such concern into budget allocations and coherent programmes, many preparedness measures—and to an even greater extent mitigation measures—have simply failed to be implemented.

To a certain extent this differential emphasis has been a function of the difficulty citizens and political officials have in maintaining a high level of concern about disasters during times when they seem so remote. To do so requires that both citizens and leaders dwell upon negative events that may or may not occur sometime in the future—a task that is almost universally regarded as unpleasant and thus elicits procrastination. Perhaps equally important in the resource disparity, however, are the limitations posed by the technical state of knowledge regarding various hazards. The state of technology itself imposes limits on the types of mitigation and preparedness activities that can be undertaken.

If the location of a potentially catastrophic event cannot be defined in advance, the feasible set of mitigation actions is severely limited. For example, tornado risk is essentially uniform within each local jurisdiction. so land use regulation would achieve little reduction in hazard vulnerability. Furthermore, in the absence of a technology of detection and highly accurate impact predictions, many preparedness measures are not feasible—such as evacuation from unreinforced masonry (*e.g.*, brick) buildings immediately before an earthquake. Thus, in the past, it may have not been possible to devote resources anywhere other than to response and recovery. In the future, as more comprehensive forms of emergency management are implemented, the emphasis must shift towards the development of mitigation and preparedness measures within the limits of existing technology while pursuing research and development designed to advance the state of that technology.

## VISIONS OF EMERGENCY MANAGEMENT

This overview of emergency management in the United States has included a discussion of the kinds of organizations that operate within the emergency management system, the different patterns of responsibility and interaction among the components of that system, and the general time phases of emergency management. The development of a perspective on emergency management requires consideration of at least two additional topics. The first of these deals with the evolution of prevailing federal conceptions of how hazards are managed—especially the underlying assumptions that define what goals are important and that determine the creation and structure of emergency organizations. The second topic concerns the way in which hazards are conceptualized—whether one focuses upon the event itself or upon the demands that events place upon social systems.

### ALTERNATIVE CONCEPTIONS OF MANAGING HAZARDS

As one might infer from the history of emergency management organizations, there is a separation of emergency functions that has emerged and persisted over the years. With only a few exceptions, federal organizations charged with addressing wartime attacks have been different from those charged with concerns about natural disasters. This separation of functions has also been reflected in the research by social scientists on human performance in the face of disasters.

Historically, this is one of the earliest and, in terms of research and theory, one of the most fundamental distinctions in emergency management and research. Hence civil defence issues have been isolated, particularly since the advent of nuclear weapons. Although nuclear (or other wartime) attack involved functions—warning, protective action, emergency medical care, search and rescue, communications, and sheltering—similar to those addressed in natural disasters, the two were treated separately and usually under the auspices of different agencies. Indeed, Drabek (1991b, p. 3) concluded "the two principal policy streams that have shaped emergency management in the United States [are] responses to natural disasters and civil defence programmes".

This separation of emergency management systems appears to have spawned what has been called the philosophy of "dual use", a term that was first used officially when President Nixon created the Defence Civil Preparedness Agency in 1972 (Harris, 1975). At the federal level, this meant funding priority was given to research and planning that would be useful in coping with both natural disasters and nuclear attack. Perhaps the most persistent application of the dual use philosophy was found in the natural disaster research sponsored by the Defence Civil Preparedness Agency in the l970s.

As part of contract fulfillment, researchers were required to include an appendix to reports describing how their results applied to the nuclear attack setting. Although the dual use philosophy implied basic comparability between natural and technological disasters, this had little impact on the way either emergency managers or researchers partitioned such events. Even under dual use, the comparability issue was addressed largely after the fact (in the case of research, after the data collection and analysis were completed).

Conceptions of emergency management practice and disaster research continued to compartmentalize wartime threats and natural disasters. Of course, the compartmentalizing was not limited to this broad division; there was also a tendency to separate different types of natural disasters. Yoshpe (1881, p. 32) indicates that legislation sanctioned dual use by 1976: "[It was]…established as a matter of national policy that resources acquired and maintained under the Federal Civil Defence Act should be utilized to minimize the effects of natural disasters when they occurred."

Beginning with the classic study of the Halifax explosion (Prince, 1920), social scientists interested in disaster response sporadically studied events that were not products of the natural environment or wartime attacks. Although few in number, a 1961 catalogue of disaster field studies compiled by the National Academy of Sciences listed 38 research studies on technological incidents (Disaster Research Group, 1961). By the mid-1960s, a third distinct body of research was developing with respect to technological threats. These studies generally reflected the body of research conducted in connection with natural disasters and wartime attack. At the federal level, President Nixon's creation of the Environmental Protection Agency in 1970 (with a major emphasis on chemicals and chemical processes) solidified the concept of technological hazards as distinctly different phenomena.

By the late 1960s, each type of hazard or disaster had begun to be treated differently by policymakers, federal agencies, emergency management practitioners, and researchers. The separations were not analytic but largely reflected differences in the threat agent. Thus, there were lines of research on hurricanes, tornadoes, floods, explosions, mine collapses, wartime attacks, and so on. These divisions were also reflected in public policy for dealing with disasters; different organizations focused on different threats. An important consequence of this approach was the concentration on the distinctiveness of disaster agents and events. The prevailing idea was that disaster agents differ qualitatively, rather than just quantitatively, and that each of these hazards required its own unique mode of understanding and management.

This orientation was supported by the loosely coupled collection of federal agencies and programmes that addressed emergencies through the 1960s and most of the 1970s. As public policy, difficulties began to arise with "dual use" as a philosophy and an organizational strategy. The difficulties became the basis for the beginning of a radical change in the way disasters were conceptualized. In retrospect, at least three forces guided the change in thinking. First, the persistence of "dual use" as a principle for justifying the support of disaster research by civil defence agencies pressed scientists to make explicit comparisons among disaster events. Such justification was based upon two rationales—generalizability and cost-effectiveness. The generalizability principle held that, in the absence of real war, natural disasters provided the next best approximation to study human disaster response.

The cost-effectiveness rationale assumed that, by funding studies of one class of events, inferences could be made to other types of events at relatively small incremental cost—loosely described as "getting more knowledge for the research dollar". The cost-effectiveness rationale was to ultimately play a significant role in subsequent changes in emergency management philosophy. It was clear, however, that "dual use" forced researchers to think about and conduct cross-disaster applications of various emergency functions—emergency assessment, hazard operations, population protection, and incident management. Without a conscious intention of doing so, these comparisons began to build an empirical body of evidence regarding dimensions along which events normally thought to be quite distinct could be compared.

The second force that promoted changes in basic conceptions of emergency management was the rise of social scientific subdisciplines or specializations in disaster behaviour. An important factor in this development was the growth of the Disaster Research Center (DRC—which was located first at The Ohio State University and later at the University of Delaware) under Quarantelli and Dynes beginning in 1963. This institution trained social scientists to study events caused by a diverse set of natural and technological hazard agents and complying with the dual use demands for comparisons with nuclear attack. These researchers focused not on the differences among disaster agents, but upon the social management of the consequences of disasters. They linked these diverse studies using a theoretical framework that was marked by the designation of a focal social system and discussions of generic management issues, such as the problems of resource mobilization, interactions of system components, and the interrelationships of the focal system with external systems. An early and important contribution of the DRC studies was to focus research and management attention upon the demands a crisis imposes upon a social system. These were conceptualized as agent-generated demands (*i.e.*, tasks generated by a disaster as a function of impact—warning, search and rescue, emergency medical care) and response-generated demands (*i.e.*, those tasks necessary to meet agent-generated demands—communication, resource mobilization).

By focusing upon a disaster's demands and not on the physical characteristics of the disaster agent itself, this line of research posed a significant challenge to both the theoretical and operational perspectives that differentiated events based on the agent involved. It is important to point out that DRC did not ignore the effects of different types of hazard agents; each agent was acknowledged to produce its own distinctive pattern of demands. Instead, DRC's contribution lay in establishing a concern with social management of events within a systems perspective. This practice emphasized the problem of identifying and responding to different demands growing out of the crisis and set the stage for subsequent identification of generic or "common" management functions across disasters.

The third force for change came well after DRC began its operation. This was the NGA's emergency preparedness project. Primarily concerned with public policy associated with emergency management, these analysts focused first upon what they saw as the ineffective allocation of emergency management responsibilities among the federal agencies assigned to help states and localities cope with disasters. It was their contention that the presence of a bureaucratized and compartmentalized collection of federal disaster agencies made it difficult for lower levels of government to obtain necessary aid for both planning and recovery. Moreover, they emphasized the lack of cost effectiveness of the diverse constellation of federal programmes and agencies. Another contribution of the NGA project was its perspective on disasters. As members of state government who were sensitive to the problems experienced by local governments, their view of disasters was less compartmentalized than that of their federal counterparts. States and localities had long been forced to plan for and respond to disasters without the benefit of a bureaucracy that had as many specialized agencies as that of the federal government. Among other reasons, their revenues simply could not support much specialization. The same people who were called upon to deal with floods also dealt with explosions, hurricanes, hazmat incidents, and tornadoes. Over the years, state and local emergency response personnel developed an approach based upon managing all types of disasters without regard to the precipitating agent.

From a practical standpoint, their orientation meant that they focused on each disaster's demands and sought to manage those, making specific procedures apply to as many types of events as feasible. In one sense, this produces an emphasis upon the idea of developing organizational systems to perform generic functions. For example, warning systems, emergency medical care systems, evacuation plans, damage assessment procedures, communication systems, and search and rescue plans may all be applicable to crises associated with floods, hurricanes, nuclear power plant accidents, volcanic eruptions, earthquakes, and others.

Driven in part by economic need, the NGA project became strong advocates for an "all hazards" approach to emergency management—which they called comprehensive emergency management—and their efforts drew intellectual strength from the comparative research at the Disaster Research Center. Operating together, these forces gave rise to Comprehensive Emergency Management (CEM) as a basic conceptual approach to disasters and to managing emergencies. In 1979, NGA issued a Governor's Guide to Comprehensive Emergency Management (National Governors' Association, 1979) that provided an articulate statement of the philosophy and practice of CEM.

The approach was further legitimated through its adoption and promotion by FEMA in 1981. In 1993, when the US Congress repealed the Federal Civil Defence Act of 1950, a provision (Title VI) was added to the Stafford Act requiring the federal government to adopt the all-hazards approach inherent in CEM. In summary, CEM refers to the development of a capacity for handling emergency tasks in all phases—mitigation, preparedness, response, and recovery—in connection with all types of disaster agents by coordinating the efforts and resources of a wide variety of non-governmental organizations (NGOs) and government agencies. CEM is distinguished from previous conceptualizations—particularly dual use—by two important characteristics. First, CEM emphasizes comprehensiveness with respect to the performance of all disaster relevant activities by dictating a concern for mitigation, preparedness, response, and recovery.

The second distinguishing feature of CEM is its concern with the management of all types of emergencies whether technological, natural, or willful (including state sponsored and terrorist attacks). This characteristic is an outgrowth of the idea that an emergency may be seen as a disruption of the normal operation of a social system. To the extent possible, one would like to minimize the likelihood and magnitude of system disruptions in the first place and minimize their duration by creating the potential for quickly stabilizing the system and subsequently restoring it to its normal activities following an unpreventable disruption.

In this context, the cause of the disruption is less important than the nature and magnitude of its effects upon the social system. The only reason to distinguish among disrupting agents rests on the extent to which different agents impose distinctive demands on the system. For example, hurricanes can be distinguished as events that provide long periods of forewarning when compared with earthquakes.

In developing a framework for managing all phases of all types of disasters, CEM can be seen as an attempt to integrate emergency management by developing a body of techniques effective for managing the responses to multiple disaster agents. CEM represents an extremely significant departure from historical views of emergency management that make sharp distinctions among hazard agents and claim (either explicitly or implicitly) that a unique strategy must be developed for managing each of them. Furthermore, aside from the intuitive appeal of a more parsimonious theoretical approach, cost conscious officials at all levels of government are attracted to the more efficient use of resources promised by a comprehensive approach to emergency management (Quarantelli, 1992).

Once state and local governments began to adopt some variant of CEM, FEMA introduced the concept of Integrated Emergency Management Systems (IEMS) in 1983. The initial goal of IEMS was to facilitate the development of disaster management functions and (at the time it was introduced) to increase congressional support for a larger civil defence budget (Perry, 1985, p. 130). When pressed to distinguish IEMS from CEM, the principal reply was: "CEM is the long term objective, IEMS is the current implementation strategy" (Drabek, 1985, p. 85). It appears that the meaning of IEMS on a practical level derives from the term "integrated"—identifying the goal of addressing all hazards and consolidating emergency actions into a single office or organization within a jurisdiction. However, CEM remains the primary vision of disaster management in the US.

## CLASSIFYING HAZARD AGENTS

An emergency management vision that addresses all hazards must by necessity focus upon the concept of generic functions while acknowledging that special functions will be needed in the case of hazard agents that present unique or singular challenges. CEM implies a basic comparability across all types of disasters. Moving from emergency management to the academic study of disasters, one implication of comparability is that one should be able to distinguish hazard agents in terms of a common set of characteristics. A typology of hazard agents is a system for classifying them into categories within which the social management demands are similar. On a practical level, implementing CEM involves identifying generic emergency response functions and then specifying circumstances (tied to the impact of different disaster agents) under which they will need to be employed. If one could use such functions as key characteristics of disasters, then one could begin to develop meaningful taxonomies.

There have been few attempts to make systematic comparisons of human response to different disaster agents. Indeed, there has been a tendency among researchers to avoid examining relationships among different disaster agents, partly on the assumption that each “type” of event was simply unique. For example, the matter of comparing natural with technological threats rarely appeared in the professional literature at all until the 1970s. In part, this condition reflects the state of disaster research. For many years disaster studies were very descriptive in nature (Gillespie and Perry, 1976). Hence, attention often focused upon the event itself—the hurricane or the earthquake—and upon descriptions of specific consequences for disaster victims.

Therefore, the research literature provided illustrative accounts of earthquake victims crushed under rubble, fire victims plucked from rooftops, and hurricane victims drowned in the storm surge. In this context, researchers argued that different agents have different characteristics and impose different demands on the social system and as a result probably must be explained using different theories. A typology is actually a form of theory created through taxonomy or reasoning (Perry, 1989). Thus, human reactions to different disaster events were expected to be different.

In one sense, it is entirely correct to consider each disaster agent, as well as each impact of each agent, to be different. Floods present obvious differences from earthquakes and, indeed, the eruption of the Mt. St. Helens volcano on March 27, 1980, was very different from its eruption on May 18, 1980. Such comments reflect an essentially phenotypic classification system, focusing upon the surface or visible properties of an event. Emergency managers and disaster researchers are not so much interested in classifying disasters in these terms, however, because their goals are associated primarily with the behaviour of the affected social system.

It is human response to the natural environment, technology, or other humans that produces the disasters of hurricanes, tornadoes, hazmat releases, or wartime attacks. Thus, the goal is to distinguish among social causes, reactions, and consequences, not necessarily to distinguish hurricanes from chemical plants. There has been an increased concern with the development of conceptual schemes for explaining human behaviour in disasters. This theoretical concern directs one to identify characteristics of disasters that determine the nature and types of agent-generated and response-generated demands imposed upon stricken communities.

This leads to the creation of a classification system that characterizes disasters, not in phenotypic terms, but in terms of features that will have an impact on the kinds of assessment, preventive/corrective, protective, or management actions that might be used in disaster response. To pursue such a goal, one might begin by choosing a given function—population warning, for example—and examine the ways in which performance of that activity varies across disaster events as a function of differing agent characteristics such as the amount of forewarning provided by detection and forecast systems.

There has been much discussion and only limited consensus among academic disaster researchers regarding either definitions of disaster or classification schemes for distinguishing among different types of disasters. However, as Perry (1998) has pointed out, most definitions of disaster contain many common elements—disagreements among definers tend to lie in minor aspects of definition or in the logic that is used to develop a definition. From the standpoint of practicing emergency managers, such minor variations pose few operational difficulties. Most events that are characterized as disasters, whether they arise from natural forces, technology, or even deliberate attacks, fit most of the academic definitions of the term. As defined by Fritz (1961, p. 652), a disaster is any event:

Concentrated in time and space, in which a society or a relatively self-sufficient subdivision of society, undergoes severe danger and incurs such losses to its members and physical appurtenances that the social structure is disrupted and the fulfillment of all or some of the essential functions of the society is prevented. From this classic definition one can surmise that disasters occur at a distinguishable time, are geographically circumscribed and that they disrupt social activity. Barton has proposed a similar definition, but chose to focus upon the social system itself, arguing that disasters exist "when many members of a social system fail to receive expected conditions of life from the system" (1969, p. 38). Both Fritz and Barton agree that any event that produces a significant change in the pattern of inputs and outputs for a given social system may be reasonably characterized as a disaster. The important point to be derived from these definitions is that events precipitated by a variety of hazard agents—floods, chemical spills, volcanoes, nuclear power plant accidents, terrorist attacks—all fit equally well into these definitions as disasters.

At this level of abstraction, there is no compelling reason to differentiate among natural, technological, or other types of hazard agents. Given the breadth of most definitions of disasters, the analytic problem becomes one of determining the characteristics by which to distinguish among the events that do satisfy the definition. As noted earlier, such dimensions should not be restricted to physical characteristics of the hazard agent and its impact, but should also include attributes relevant to the effects of the event upon the social system and its consequences for management.

There has been some discussion among researchers regarding the lines along which natural disasters, technological accidents, and willful attacks might be meaningfully distinguished. While there remains much disagreement in the research community about which dimensions are meaningful, it is possible to begin to identify dimensions from the research literature. Much of this work can be traced to the staff of the Disaster Research Center who attempted to draw parallels between natural disaster response and possible response to nuclear attack (particularly between 1963 and 1972; see Kreps, 1981). Barton (1969) developed a scheme for identifying distinguishing features of disasters that characterize the nature of social system stress.

Barton's system defined four basic dimensions—scope of impact, speed of onset, duration of impact, and social preparedness of the threatened community. These dimensions have been used by a number of researchers in developing classification schemes (Lindell and Perry, 1992) and can be briefly explained here. Scope of impact is usually defined as the absolute geographic area (*e.g.*, in square miles) affected by a disaster but, it also can be defined in terms of the affected percentage of a jurisdiction's area (geographic scope), population (demographic scope), or economic production (economic scope). Aside from sheer size, this dimension has implications for resource mobilization within the affected social system and for the availability of supporting resources that might be drawn from nearby communities or higher levels of government.

Speed of onset refers to the interval of time between a physical event's first manifestation of environmental cues until its impact on a social system. Speed of onset varies both by the inherent nature of the hazard agent and the level of technological sophistication of the detection system. For example, earthquakes have a very rapid onset (there are often no detectable environmental cues before the initial shock), whereas droughts have a very slow onset (some take years to develop). In other cases, the technology to forecast meteorological hazards such as hurricanes has developed considerably over the course of the past 50 years so events, such as hurricanes, that could at one time occur with little or no forewarning are now routinely monitored and forecast days in advance.

Duration of impact refers to the time that elapses between initial onset and the point at which the threat to life and property has been stabilized. This can be a few minutes (short) in the case of a tornado, a few hours or days (moderate) in the case of riverine floods, persistent for years in the case of drought, or intermittent for years in the case of volcanoes. Finally, social preparedness is a dimension that attempts to capture the ability of the social system to anticipate the onset of an event, control its impact, or cope with its negative consequences. Obviously, this social preparedness dimension is precisely the objective of emergency management.

Anderson (1969b) contributed another comparative dimension from his research on the functioning of civil defence offices (now more commonly called emergency management departments) during natural disasters and attempted to extrapolate to the nuclear attack environment. In developing his analysis, Anderson (1969b, p. 55) concluded that in spite of obvious differences between nuclear threats and natural disasters:

These differences can be visualized as primarily ones of degree. With the exception of the specific form of secondary threat, *i.e.* radiation, and the probability that a wider geographic area will be involved, a nuclear [threat] would not create essentially different problems for community response.

Anderson's analysis introduced the issue of secondary impacts of disaster agents as an important defining feature. It should be remembered that virtually all hazards, whether natural or technological, accidentally or deliberately caused, entail some secondary impacts. Indeed, the secondary threat can be more devastating than the initial threat. Riverine floods tend to deposit debris and silt that persists long after the water has receded. Earthquakes often produce urban fires, and volcanic eruptions can melt glaciers or ignite forest fires.

By assembling lists of distinguishing characteristics such as those discussed above, one can compare or classify an apparently widely differing (in terms of superficial features) range of disaster events. As an example of how such comparisons might work, Table below compares three disaster agents—riverine floods, volcanic eruptions, and nuclear power plant accidents—in terms of the five distinguishing characteristics.

It is interesting to note that, at this analytic level, volcanic eruptions and nuclear power plant accidents are similarly classified. Both threats involve variable scopes of impact that are potentially widespread. Usually, a volcanic eruption's threats to human safety are limited to within a few miles of the crater. Life threatening levels of radiation exposure from a nuclear power plant accident is likely to be confined to the plant site or a few miles downwind from it (US Nuclear Regulatory Commission, 1978). Under special conditions, however, either type of event might involve a considerably greater scope of impact.

The May 18, 1980, eruption of Mt. St. Helens volcano spread a heavy layer of volcanic ash over a three state area and the Chernobyl nuclear power plant accident spread radioactive material over an entire region. The speed of onset for volcanic eruptions and nuclear power plant accidents is likely to be rapid, although each of them has the potential for a significant degree of forewarning prior to the onset of a major event. These two events are also similar with respect to the duration of impact of the primary threat to human safety.

**Table. Classification of Selected Hazard Agents**

| Hazard Agent Characteristic | Riverine Flood | Volcanic Eruption | Nuclear Power Plant Accident |
|---|---|---|---|
| Scope of impact | Highly variable long, and narrow | Highly variable broad area | Highly variable broad area |
| Speed of onset | Rapid: flash flood<br>Slow: main stem flood | Rapid | Variable |
| Duration of impact | Short | Long | Long |
| Health threat | Water inhalation | Blast, burns ash inhalation | Ingestion, inhalation, direct radiation |
| Property threat | Destruction | Destruction | Contamination |
| Secondary threats | Public health danger from water/sewer inundation | Forest fires, glacial snowmelt | Secondary contamination |
| Predictability | High | Poor | Variable ability to predict releases after accident onset |

In both cases, a volcanic eruption and a release of radioactive materials, the event could last from hours to days. Persistence of secondary impacts could, in each case, last for years, although the long-term health effects of volcanic ash are less significant than radiation. To the extent that volcanic eruptions continue in an eruptive sequence that lasts for years, the duration of impact can be said to be long. A nuclear power plant accident would be expected to be of moderate length although so few actual accidents have occurred that the empirical data are extremely limited. The accident at the Three Mile Island nuclear power plant, which is more accurately labeled as an emergency than as a disaster, involved a danger period that lasted for about six days. However, the Chernobyl accident severely contaminated areas that are still uninhabitable two decades later. Both volcanic eruptions and nuclear power plant accidents generate secondary threats. The sheer number of secondary threats associated with volcanoes is quite large; ultimately they involve long-term threats to public health, to the stability of man-made structures, and to plants and animals in land and water ecosystems. The most probable secondary threat of a nuclear power plant accident is associated with the effects of residual radiation exposure arising from ground deposition and water contamination by radioactive materials. In addition to the potential exposure by way of external gamma radiation and inhalation of radioactive materials, there is the threat of exposure by means of ingestion of contaminated vegetation or animal products (meat or milk).

Finally, the state of technology is such that neither volcanic eruptions nor nuclear power plant accidents can be forecast accurately far in advance. There is in both cases, however, a technology for detecting and monitoring events once they are in progress. In the case of some volcanoes, once an eruptive sequence has begun either seismic or geochemical cues can be used to make approximate forecasts of eruptive events. With nuclear power plants, monitoring instruments are designed to detect even minor aberrations early in order to facilitate the implementation of corrective action before more serious difficulties arise. Thus, although one might not be able to predict a power plant accident, instruments are designed to detect problems in their early stages before they can escalate to an atmospheric release of radioactive material.

Riverine floods differ from the other two hazard agents primarily in terms of two characteristics. First, floods are frequently predictable, often days in advance. Second, speed of onset typically is gradual (by definition requiring a minimum of six hours to reach a flood crest, although more rapid onset can occur during flash floods in mountainous areas). Another general point of distinction is the frequency with which floods occur; they are the most common geophysical hazard in the United States (Perry, Lindell and Greene, 1981). Thus, from the standpoint of both emergency managers and the public, riverine floods are a familiar threat.

Moreover, the duration of the primary flood impact is much shorter than a volcanic eruptive sequence or a nuclear power plant accident. Secondary impacts of floods include both public health threats and dangers to man-made structures, but in general the extent and duration of the effects of their secondary threats are less than either of the other two disaster agents. Finally, like a volcanic eruptive sequence or a nuclear power plant accident, the scope of impact of riverine floods is highly variable. Usually the scope of flood impacts is narrower than either of the other hazards, but there is a potential for widespread scope.

The preceding discussion demonstrates that it is possible to classify diverse disaster agents in terms of an underlying set of dimensions and then to discuss the agents in terms of functional emergency management activities. Such dimensions could include the physical characteristics of the hazard agent and its impact, as well as attributes relevant to the effects of the event upon the social system and its consequences for management. The characteristics derived from the disaster research literature have provided a systematic set of attributes that could be used to examine and compare riverine floods, volcanic eruptions, and nuclear power plant accidents. As indicated above, the differences between classification schemes in the academic literature tend to rest on differences between researchers regarding exactly which dimensions and how many dimensions are optimal in creating the typology.

The 21st Century has seen no more agreement than the 20th Century did, although there are two discernable trends in the literature. One trend, followed by only a few, involves attempts to elaborate on the analytic approach described here, adding or subtracting dimensions or otherwise changing the complexity of the approach (Kreps, 1989; Tobin and Montz, 1997). By far most disaster researchers have continued to ignore the issue of analytic typology and remained with some sort of phenotypic classification, most commonly with the classic categories of “natural disasters”, “technological accidents” and “willful attacks” (Cutter, 2001; Drabek, 1986).

Without regard to the low level of consensus among researchers, analytic classification systems are more than an abstract intellectual exercise. They provide an opportunity to demonstrate how, by means of careful examination, one can begin to identify differences among disaster agents with respect to their demands upon the emergency response system. An emergency manager might conclude that two protective measures might be used in all three events: population evacuation and the imposition of access controls to the threatened area. Because a volcanic eruption or a nuclear power plant accident could present a health threat resulting from inhalation of airborne materials (volcanic ash or radioactive gases and particulates, respectively), taking shelter indoors and using respiratory protection is feasible. Ad hoc measures for respiratory protection could be as simple as folding a wet towel and breathing through it.

The importance of developing a comparative perspective structured by disaster agent characteristics lies in the prospect of identifying a profile of disaster demands that, in turn, define the functions that the emergency response organization must perform. Thus, classifying hazard agents with respect to defining characteristics allows emergency managers to better define the ways in which generic functions (*e.g.*, emergency assessment, hazard operations, population protection, and incident management) should be implemented to achieve comprehensive emergency management. That is, the reason for identifying distinctive aspects of hazard agents is not to define each of them as "unique", but rather to highlight the ways in which generic functions must be adapted to the needs of a particular type of emergency.

By adopting this approach, emergency managers are better able to identify the range of hazard agents for which a particular emergency response action is appropriate or to identify the ways in which an emergency response action must be adapted to the constraints of a given hazard agent. For example, evacuation is an appropriate protective action in response to a wide range of hazards such as floods, hurricanes, and volcanic eruptions. However, authorities recommend sheltering in-place rather than evacuation during tornadoes because of the rapid onset and unpredictable track of the funnel cloud. In some cases, especially hazmat releases, the hazard agent's speed of onset is so variable from one incident to another that there is no general rule regarding evacuation versus sheltering in-place. Moreover, evacuation was listed as a protective measure in nuclear power plant accidents and it was noted that the primary health threat to citizens in such events was radiation exposure.

Research indicates that radiation hazard is feared as much or more than other natural and technological hazards (Lindell and Earle, 1983; Slovic, 1987). Assuming the conditions were appropriate for an evacuation warning, the emergency manager would be well advised of the possibility for a high level of spontaneous evacuation (people evacuating from areas that emergency managers consider to be safe). In turn, this alerts the emergency manager to a need for timely dissemination of information to the public about the characteristics of the impact and the potential personal consequences of exposure, thereby reassuring those who are not at risk that they are indeed safe.

## THE CONTRIBUTIONS OF MANAGEMENT THEORY AND PRACTICE TO EMERGENCY MANAGEMENT

Emergency today is a complex function involving public safety and security, business affairs, public and information affairs, information systems administration, communication technologies, mapping sciences and hazard modeling, legal affairs, and coordination with numerous other organizations. This diverse set of functions and activities requires emergency managers to be effective managers of programmes and operational managers of many direct disaster activities. The effective management of both programme and operational activities requires an understanding of management principles. This chapter examines the development of management theory and some of the major contributions that management theory has made to the field of emergency management. It discusses some of the major management concepts including the role of the manager, strategic planning, systems theory and contingency theory, which are critical to the practice of emergency management. The overlap between management theory and disasters may be seen in concepts associated with crisis management and the importance of values, diversity, and legal issues to both management theory and emergency management. A solid foundation in concepts of management will form the basis for any emergency management activity.

## THE DEVELOPMENT OF MANAGEMENT THEORY AND PRACTICE

The field of management grew in its formalization during the latter part of the Nineteenth Century and throughout the Twentieth Century along with the rise of the industrial revolution. The growth of management concepts was needed to guide the growth of industrial manufacturing in the United States and Europe. A similar growth in emergency management theory also evolved in response to the need for theory, concepts and proven practices in response to the devastating impacts of hurricanes, floods, earthquakes, and chemical spills. Our current focus on homeland security is also driving the development of even more concepts in this area.

Management theory provides a sound basis for supporting the emergence of emergency management theory utilizing the management process from planning, organizing, leading and controlling (Fayol 1916, Mintzbert 1973, Katz 1974, Koontz 1984). Taylor (1911) considered management a process and one that "if approached scientifically" would lead to success. His principles of scientific management initiated a revolution in how we viewed both the process and position of the manager. Many of the early writers in management contended that there was a right way of organizing work and accomplishing tasks (Gilbreth 1911). Others built on the engineering approaches to acknowledge the impacts of bureaucracies (Weber 1947). Mintzbert explained the role of the "manager" in directing the organization to achieving goals in a rational manner (1971). The interpersonal, informational, and decisional roles he characterized are mutually applicable to the emergency manager in the public, private and non-profit organizational setting.

The theory of management has grown over the past one-hundred years evolving from the time and motion studies of engineers to contributions from social scientists, the Hawthorne studies and a behavioural approach to more quantitative approaches that look for the "best" or optimum functioning of an organization or "total quality management (TQM)" (Gabor 1990). Emergency management has been influenced by the same developments in management theory in utilizing engineering to design the most efficient emergency operations center or emergency response routing for emergency services. The selection of emergency medical and law-enforcement units in response to 911 communication calls and the most recent traffic hurricane evacuation planning suggest that scientific management is applicable to problems today. The ongoing assessment of disaster response programmes using quantitative measurement criteria demonstrates that TQM can be used in emergency management.

The behaviour scientists have also been involved suggesting the necessity of involving community organizations in planning and mitigation strategies. Finally, emergency management has been influenced by those who stress the need for quality management and the efficient use of resources, even in a disaster.

The development of principles and concepts of management encouraged the formalization of schools of business during the Twentieth Century. We currently see the establishment of academic programmes in emergency management from concentrations, minors, certificates, and even majors from the associate to the advanced doctoral degree programmes.

The school of hard knocks is quickly evolving into formal academic programmes in emergency management and homeland security. One wonders if the future has academic departments or schools of emergency management and homeland security. The key is that the development of professionals in emergency management requires a formal educational process and an intentional exposure to emergency management theory and concepts. Today over one hundred colleges and universities offer some programme in emergency management. The standardization of these curriculums will evolve just as similar initiatives grew in response to a need for quality instructional programmes.

The contribution of organizational culture theory and the impact of environmental constraints is an important part of the growth of management theory over the past fifty years (Kotter 1992, Schien 1985). The impact of changes in organizational culture is so well illustrated in the Federal arena during the tenure of James Lee Witt. He led a charge to change FEMA's culture to one of responsive service delivery and proactive emergency response. The changing environment and the impact of the external environment on organizations is fundamental to business as well as government operations and so important in preparedness and mitigation of hazards / disaster (Tapscott 1998).

Finally, management has stressed the need to be aware of managing in a global environment (Adler 1996). Today, we see emergency management emerging from a local approach to one that examines on a regional basis and with the notion of national and international linkages. The need to monitor the external environment not only locally but on an international scale is becoming a more critical element of the emergency management literature.

## CONTRIBUTIONS OF MANAGEMENT TO EMERGENCY MANAGEMENT THEORY

Strategic Planning and the Changing Nature of the Organizational Environment: A major contribution of the strategic planning process to management and to emergency management is the need to monitor the nature and changing character of external forces and how they impact the operations of an organization. Environmental scanning clarifies how technology, the law, the press, elected officials, citizens, and the natural environment impact internal operations. Hurricane Andrew provides an excellent illustration of how the external environment changed emergency management theory and practice.

The catastrophic impacts of Andrew in Florida and Louisiana resulted in many changes in FEMA from an increased focus on mitigation and disaster reduction to broader operational planning. Disasters reveal not only the structural strengths and limitations of the physical environment of a community but also how local, state and national response organizations function effectively and ineffectively. Hurricane Andrew also reminded emergency managers that organizational change is often the result of external forces for change. Other external forces for change such as new technologies, laws and regulations as well as community and business needs were major factors pushing for changes in emergency management response and recovery programmes, planning tools and approaches to mitigation. The Role of the Manager: The view of the organization as a system suggests a very special role for managers in the emergency management system. For many years, management theory has suggested a rational or economic technical basis for organizational performance.

This is a closed system view and appropriate for the technical level but not for the organizational or institutional level. The view of the open system creates a more difficult role for management. It must deal with uncertainties and ambiguities and must be concerned with adapting the organization to new and changing requirements. Management is a process, which spans and links the various sub-systems. The basic function of management is to align not only people, but also the institution itself including technology, processes, and structure. It attempts to reduce uncertainty at the same time searching for flexibility. Management faces situations, which are dynamic, inherently uncertain, and frequently ambiguous. Management is placed in a network of mutually dependent relationships. Management endeavors to introduce regularity in a world that will never allow that to happen. Only managers who can deal with uncertainty, with ambiguity, and with battles that are never won but only fought well can hope to succeed.

Management Systems Theory and Emergency Management: Systems theory evolved from the basic sciences but is utilized in the social sciences including management theory. A system composed of interrelated and interdependent parts arranged in a manner that produces a unified whole is critical in understanding all parts of the emergency management process. Viewing societies as complex open systems which interact with their environment provides such a critical view of the emergency management system (Barnard, 1938).

Systems theory is based on the idea that everything is part of a larger, interdependent arrangement. It is centered on clarifying the whole, its parts, and the relations between them (von Bertalanffy 1972). Some critical concepts that are applicable to emergency management include some of the following: open system, subsystems, synergy, interface, holism, strategic constituencies, boundaries, functionalism, interface, strategic constituencies, feedback and a moving equilibrium. Emergency management is composed of many parts including: local, state and national public, private and non-profit units.

These units interact in many independent ways and each has their own constituencies, boundaries, function, and sub-units. The units may interrelate in emergency management activities in an open environment with few organizational barriers or collaborative and cooperative efforts limited by specific organizational policies, rules and procedures. Emergency managers acknowledge that effective emergency response and recovery efforts require the cooperation of the entire community; emergency managers do not operate in isolation but as a part of a large open system.

Effective emergency response and recovery is dependent on cooperation between local public agencies, business enterprises, and community groups. Shelters are often sponsored by public and private schools and operated by the American Red Cross. Evacuation efforts are often supported by community transportation agencies and school systems. Special needs shelters are often staffed by local medical facilities, volunteers, and community organizations. Traffic control and security is a collaborative effort between numerous local law enforcement jurisdictions. Coordination is critical in linking multiple organizational efforts in a seamless response and recovery effort. An open system involves the dynamic interaction of the system with its environment.

This theory is fundamental to understanding hazards and emergency management for it maintains that everything is related to everything else. Emergency management has a dynamic relationship with the environment and receives various inputs, transforms these inputs in some way, and exports outputs. These systems are open not only in relation to their environment but also in relation to themselves; the interactions between components affect the system as a whole. The open system adapts to its environment by changing the structure and processes of the internal components. Systems are composed of sub-systems. That is, the parts that form the system may themselves be a system. The emergency management system includes police, fire, and emergency medical agencies; each agency with their own system (sub-system of the emergency services system). The emergence of homeland security makes this concept even more important in understanding how the parts relate and that each part has sub-parts that impact the functioning of the whole.

The combined and coordinated actions of the parts of the system achieve more than all of the parts acting independently. This concept known as "synergy" is critical to the field of management and equally to emergency management. The performance of an enterprise is a product of the interaction rather than sum of its parts, but it is entirely possible for the action of two or more parts to achieve an effect of which either is individually incapable. Synergy is characterized by the whole being greater than the sum of its parts. It explains why the performance of a system as a whole depends more on how its parts relate than on how well each part operates. Indeed, the inter-dependence of the parts is such that even if each part independently performs as efficiently as possible, the system as a whole may not. Synergy is an important concept for emergency managers in that it emphasizes the need for individuals, as well as departments to work together in a cooperative fashion (Bedeian, 1989). An emergency response is not just a single unit but many different parts that, when effective, understand how they work together to protect public safety and property.

Emergency management, as with the field of management is dependent on conceptual frameworks or models. As an example, management theory suggests that social organizations are contrived and constantly evolving and not static mechanical systems. They have structure, but the structure of events rather than physical components, cannot be separated from the processes of the system. The fact that social organizations are composed of humans suggests that they can be established for an infinite variety of objectives and do not follow the same life-cycle pattern of birth, maturity, and death as biological systems. Social systems are made of imperfect systems. The cement which holds them together is essentially psychological rather than biological. They are anchored in the attitudes, perceptions, beliefs, motivations, habits, and expectations of humans. Management systems theory notes that organizations are not natural as with mechanical or biological systems; they are contrived. They have structure or boundaries, but the structure of events rather than physical components. The human and organizational boundaries cannot be separated from the processes of the system. The fact that social organizations are contrived by human beings suggests that they can be established for an infinite variety of objectives and do not follow the same life-cycle pattern of birth, maturity, and death as biological systems. Social systems are made of imperfect systems. The cement which holds them together is essentially psychological rather than biological. They are anchored in the attitudes, perceptions, beliefs, motivations, habits, and expectations of human beings.

A systems approach does not provide a means for solving all problems. It is however, useful for viewing the relationships between interdependent parts in terms of how these relationships affect the performance of the overall system (Kast 1985; Freemont 1985). Systems theory provides emergency managers with a critical perspective to view and understand how to prepare for and respond to hazards and mitigate their adverse impacts.

The systems perspective to emergency management integrates the diverse interdependent (or interconnectedness of the system) factors including individuals, groups, formal or informal organizations, attitudes, motives, interactions, goals, status, authority. The job of an emergency manager is to ensure that all parts of the organization are coordinated internally and with external organization that are involved in emergency management activities. The emergency management thus is leading and directing many activities so as to achieve established organizational and community goals. A systems view of management suggests that all parts of the organization are interdependent. For example, if a service unit functions well, but the personnel section does not replace retired staff in a timely manner, the system malfunctions.

The open systems approach recognizes that organizations are not self-contained. They rely on their environment (including the social, political, technological, and economic forces) for life sustaining inputs and as sources to absorb their outputs. No organization can survive for long if it ignores government regulations, the courts, outside interest groups, private service providers, or elected officials. An organization should be judged on its ability to acquire inputs, process these inputs, channel the outputs, and maintain stability and balance. Outputs are the ends, where acquisition of inputs and processing efficiencies are means. If an organization is to survive over the long term, it must remain adaptive.

System concepts such as subsystems or units within units; synergy or that the group has greater outputs than each single unit, boundaries, holism or viewing the larger context rather than a narrow view, interface, and adaptive organizational mechanisms to change are crucial in marshaling community resources so critical in emergency management. The importance of leadership and adaptive behaviour are stressed by many writers (Lewin 2000; Toffler 1985; Garvin 1993; and Sugarman 2001) who stated that today's leaders including emergency managers must discover ways of creating order in a chaotic world.

Finally, chaos theory suggests that even in general management systems theory, organizations must adapt to complex change and institutionalize institutional learning through feedback systems. Chaos theory states that just a small change in the initial conditions may have significant change in the long-term behaviour of the system. The classic example quoted by many to illustrate the concept is known as the butterfly effect.

The flapping of a single butterfly's wing today produces a tiny change in the state of the atmosphere. Over a period of time, what the atmosphere actually does diverges from what it would have done. So, in a month's time, a tornado that would have devastated the Indonesian coast doesn't happen. Or maybe one that wasn't going to happen, does (Stewart, 1989). Individual response and rescue efforts in evacuating buildings in 911, illustrate that single acts can have dramatic impacts for a city, a country and the world. On a small local the disaster of 911 required public, private and non-profit organizations to adapt and form new relationships to recover from the terrorist attack. New recovery organizations evolved from local resources as illustrated by the St. Paul Episcopal Church support effort for workers in the World Trade Center pit.

The St. Paul response effort evolved from local resources, but was supported by public, private and other non-profit groups throughout the United States. Many studies from the 911 disaster provided lessons learned; each study noted that successful strategies were based on flexible ongoing adaptations to changing events (Kendra 2003, Rubin 2001, Sutton 2002, and Weber 2002). Chaos theory thus provides the emergency manager with a broad perspective for appreciating how other agencies and external organizations are interdependent with and impact emergency management operations.

Contingency Theory and Approach: Contingency theory suggests that management principles and practices are dependent on situational appropriateness. Luthans (1976) notes that "The traditional approaches to management were not necessarily wrong, but today they are no longer adequate. The needed breakthrough for management theory and practice can be found in a contingency approach." Different situations are unique and require a managerial response that is based on specific considerations and variables. The appropriate use of a management concept or theory is thus contingent or dependent on a set of variables that allow the user to fit the theory to the situation and particular problems. It also allows for management theory to be applied to an intercultural context where customs and culture must be taken into consideration (Shetty 1974). Adapting theory to the context is extremely important to a new homeland security international context.

For management and emergency management alike, the successful application of any theory or concept is greatly influenced by the situation. For example, a functional organization structure with many layers of management functions best in stable environmental conditions and routine operations. For emergency management, the operating environment is ever changing and must be flexible to accommodate the many different hazards that a community or business faces. Emergency managers must build an organizational culture and structure that improvises and acknowledges that each disaster is unique. As a result, a more dynamic organizational structure could be structured based on the nature of the problem (hazard) and who needs to be involved and the actions taken (Kreps 1991). Utilizing an organizational design that is rigidly structured regardless of the situation might not provide the appropriate basis for quick and comprehensive decision making in a crisis or disaster.

## THE OVERLAP BETWEEN MANAGEMENT THEORY AND DISASTERS

A major goal of emergency management is to minimize the adverse impact of a disaster on a business, community or large geographic area. The efforts of many organizations to build a more sustainable community, business or country are consistent with emergency management goals of hazard mitigation. Sustainability: In 1987 the United Nations World Commission on Environment and Development coined the term "sustainable development". It defined sustainable development as "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs". This means that while we are harvesting natural resources and developing our land we must do so in a manner that will allow other generations to have at least the same opportunities that we currently have.

Sustainable development is more of a compromise between the traditional standards of conservation and preservation. Conservation suggests that we should use the earth's natural resources while at the same time replacing them for future use. It focuses more on the renewable resources while for the most part ignoring exhaustible resources such as oil and natural gas. At the other extreme is preservation, which suggests that we leave nature alone. These two viewpoints are at opposite ends of the spectrum, which lends itself to small numbers of supporters from the general public. Sustainable development is a kind of middle ground between these two ideologies that is more likely to be accepted by a larger group of people. It is based upon a logical viewpoint that people will not want to diminish their quality of life or standard of living to preserve the environment. It takes into account that the economy will continue to grow and develop but also encourages ways to do this that will have as little negative impact on the environment as possible.

For many years society, the economy, and the environment were all seen as separate entities. The key to understanding sustainability is understanding the way in which these three issues link together. Sustainability deals with quality of life issues as well as achieving balance between the three. In order to be sustainable we must learn to manage economy and society in a way that doesn’t harm the environment while at the same time learning to live within our limits and divide resources equitably. Sustainability also is a fundamental theoretical contribution to our understanding hazards, disasters and their impacts (FEMA 2000, Livable 2000, and Burby 1998). Making rational choices concerning land use, development, and economic development has tremendous implications for dealing effectively with hazards and disasters.

## Crisis Management

Management theory has embraced as a part of the planning process the preparation of contingency plans and crisis management to address threats and hazards (Pearson 1998). The development of a crisis audit including “What if” questions and contingency plans when things go wrong are critical elements of business planning and analysis (Roberts 2001).

The management literature reflects an appreciation for the need for business to grow more aware of the need to provide some level of protection against an unplanned disaster (Myers1999). Management needs to know how to structure strategic planning to include plans to minimize disruptions in operations in times of crisis and disasters. The Harvard Business Review published a crisis management series on the best articles relating to disasters and business interruption (2000). Laye’s assessment of how to keep business going when catastrophe strikes (2002) is a reflection of the attention that hazards and disasters have had on the literature since 2001. Values Diversity and the Legal Environment: A critical element in the emergency management is the development of an understanding of potential impacts of a disaster. Vulnerability analysis focuses on physical, political, economic and social vulnerability (Cutter 2001). Mileti (1999) states that disasters can do more than impose deaths, injuries and economic losses, they can redirect the character of social institutions, alter ecosystems and impact the stability of political structures.

Blaikie *et al* (1994) note that some groups in society are much more vulnerable to disaster losses and suffer differently; variations of impact from disasters evolve from class, caste, ethnicity, gender (Enarson 1997), religion (Bolin 1986), disability, or age (Bolin 1983). Vulnerability is the susceptibility to hazard, disasters, or risk. And, it can also be a measure of resilience. In emergency management, there needs to be a balance in examining vulnerability and understand the social, economic and environmental impacts from disasters. Too often we see the damage to structures rather than the immediate and long term impacts of disaster to our environment or social systems. Our organizations must be inclusive and offer balanced perspectives rather than just a single perspective. It is not enough to just examine the economic impacts of flooding or earthquakes on local communities but examine other impacts such as social or environmental.

We need to encourage faculty to seek out alternative views in the forms of books, journals, and research reports and expose students to these perspectives. Management theory shares this view and encourages diversity and non-discrimination in employment and contracting. An appreciation of organizational values and potential conflicts in international operations must be acknowledged and addressed. In the traditional sense, equal opportunity in organizational performance can be applied both internally and externally in business affairs (Thomas 1990 and Hall 1993). Many disciplines have stressed individual privacy in their programmes and activities. State and federal privacy provisions are common in health care statues to protect the privacy of individuals. Emergency managers must understand and ensure that staff and volunteers know what personal identification information may be released to the public in disaster response and recovery. Public information cannot be obtained from the Centers for Disease Control (CDC) that provides any indication of the health and well-being of individuals in a community. Much of the data is only released in groups of 100,000 or greater. The aggregation of data is intended to protect the privacy of individuals.

A fundamental element of the practice of emergency management that is also present in the field of management is its evolution from many disciplines from engineering, business, sociology, psychology, political structures, and urban planning to name only a few. Management also grew from many disciplines, especially from engineering (scientific management), psychology, sociology, and quantitative methods. Emergency management draws from many disciplines and suggests that emergency management is an interdisciplinary process. An appreciation of organizational and group dynamics, individual motivation, leadership, programme and organizational assessment, and planning are all elements of both the emergency management and the management process.

## MANAGEMENT AND DISASTER-RELATED ISSUES AND CONCERNS

The unintended consequences of human action are described by Chiles (2001). He documents many examples of our failure to adequately manage technology. He shows that chain reaction catastrophes have occurred as the world has grown more technologically complex and our machines have become more difficult to control. He suggests that we may have a false value of technology and do not adequately place limits on its use. Emergency management should also share his suggestion that we acknowledge the potential adverse impacts technology and the need to ensure human assessment of technology. The terrorist attacks of 2001 have made the business community increasingly sensitive to the impacts of disasters and especially terrorism on domestic and international operations. Risk management is now a part of any large operation and a dependence on insuring risk is no longer the only contingency. Businesses are increasingly looking at avoiding disasters and identifying methods to mitigate disasters.

The insurance industry has adapted to this changing environment by excluding coverage for terrorism in business policies or calculating the potential costs associated with insuring this risk in their plans. Most organizations can no longer afford to insure for this risk. Insurance companies have also reassessed coverage for many natural hazards and taken steps to adequately cover their potential vulnerabilities. The increased costs to public and private organizations for insuring against hazards has increased to the point that it may impact business plans and future strategies.

## IMPROVING THE MANAGEMENT IN EMERGENCY MANAGEMENT

The field of management has stressed the need for the development of positive organizational culture and organizational learning. The management environment today and in the future will provide new challenges and organizational responses. The management literature has been sensitive to this need and been quite responsive. Emergency management must also acknowledge the need for organizational learning and the importance of a positive organizational climate to effective operations. Possibly more executive education would support the increasing interdependence between the Department of Homeland Security, the business community, as well as state and local operations.

During the past thirty years, the business community has focused on the importance of quality control and service. Emergency management operations must share this emphasis and adopt methods of organizational assessment and quality control to enhance all elements of the emergency management process. The management literature has for many years stressed the importance of strategic planning (Drucker 2002). A greater awareness of the value of environmental scanning and the broader impacts of international affairs on internal operations will be increasingly important to the emergency management community. Business may call on emergency management for help in identifying strategies to cope with a dramatically changing environment.

## RECOMMENDATIONS: EMERGENCY MANAGEMENT IN MANAGEMENT CURRICULUMS

Few business schools have embraced the contribution that emergency management theory and practice can make to the success of business operations. As a result, attention to hazards and disaster impacts are limited to crisis management and contingency planning. Few if any schools of business have worked with emergency management curriculums on their campuses and exposed their students to other disciplines that are so much a part of disaster research. Interdisciplinary courses that expose students from throughout the campus to the nature of hazards and disaster impacts are needed. Including students from business programmes will expose other hazard oriented coursework to the vulnerability of business operations and impacts well beyond financial considerations. An integrated approach to college and university curriculums will prepare students to understanding the changing nature of hazards and disasters in an increasingly interdependent world.

# 2

# Disaster Management and Elements of Emergency Planning

## WHY HAVE AN EMERGENCY PLAN?

A definite plan to deal with major emergencies is an important element of OH&S programmes. Besides the major benefit of providing guidance during an emergency, developing the plan has other advantages. You may discover unrecognized hazardous conditions that would aggravate an emergency situation and you can work to eliminate them. The planning process may bring to light deficiencies, such as the lack of resources (equipment, trained personnel, supplies), or items that can be rectified before an emergency occurs. In addition an emergency plan promotes safety awareness and shows the organization's commitment to the safety of workers.

The lack of an emergency plan could lead to severe losses such as multiple casualties and possible financial collapse of the organization. An attitude of "it can't happen here" may be present. People may not be willing to take the time and effort to examine the problem. However, emergency planning is an important part of company operation. Since emergencies will occur, preplanning is necessary to prevent possible disaster. An urgent need for rapid decisions, shortage of time, and lack of resources and trained personnel can lead to chaos during an emergency. Time and circumstances in an emergency mean that normal channels of authority and communication cannot be relied upon to function routinely. The stress of the situation can lead to poor judgement resulting in severe losses.

## WHAT IS THE OVERALL OBJECTIVE OF THE PLAN

An emergency plan specifies procedures for handling sudden unexpected situations.

*The objective is to reduce the possible consequences of the emergency by*:

- Preventing fatalities and injuries;
- Reducing damage to buildings, stock, and equipment; and
- Accelerating the resumption of normal operations.

You should also consider potential impact to the environment, and to the community in your emergency plan. Development of the plan begins with a vulnerability assessment.

*This results of the study will show*:

- How likely a situation is to occur;
- What means are available to stop or prevent the situation; and
- What is necessary for a given situation.

From this analysis, appropriate emergency procedures can be established. At the planning stage, it is important that several groups be asked to participate.

Among these groups, the joint occupational health and safety committee can provide valuable input and a means of wider worker involvement. Appropriate municipal officials should also be consulted since control may be exercised by the local government in major emergencies and additional resources may be available. Communication, training and periodic drills will ensure adequate performance if the plan must be carried out.

## What is a Vulnerability Assessment

Although emergencies by definition are sudden events, their occurrence can be predicted with some degree of certainty. The first step is to find which hazards pose a threat to any specific enterprise.

When a list of hazards is made, records of past incidents and occupational experience are not the only sources of valuable information. Since major emergencies are rare events, knowledge of both technological (chemical or physical) and natural hazards can be broadened by consulting with fire departments, insurance companies, engineering consultants, and government departments.

## What are Technological and Natural Hazards

Areas where flammables, explosives, or chemicals are used or stored should be considered as the most likely place for a technological hazard emergency to occur.

*Examples of these hazards are*:

- Fire
- Explosion
- Building collapse
- Major structural failure
- Spills of flammable liquids
- Accidental release of toxic substances
- Deliberate release of hazardous biological agents, or toxic chemicals
- Other terrorist activities
- Exposure to ionizing radiation
- Loss of electrical power
- Loss of water supply
- Loss of communications
- Environment agencies

*The risk from natural hazards is not the same across Canada but the list would include*:

- Floods
- Earthquakes
- Tornadoes
- Other severe wind storms
- Snow or ice storms
- Severe extremes in temperature (cold or hot)
- Pandemic diseases like influenza

The possibility of one event triggering others must be considered. An explosion may start a fire and cause structural failure while an earthquake might initiate all the events noted in the list of chemical and physical hazards.

## What is the Series of Events or Decisions that Should be Considered

*Having identified the hazards, the possible major impacts of each should be itemized, such as*:

- Sequential events (for example, fire after explosion)
- Evacuation
- Casualties
- Damage to plant infrastructure
- Loss of vital records/documents
- Damage to equipment
- Disruption of work

*Based on these events, the required actions are determined. For example*:

- Declare emergency
- Sound the alert
- Evacuate danger zone
- Close main shutoffs
- Ccall for external aid
- Initiate rescue operations
- Attend to casualties
- Fight fire

*The final consideration is a list and the location of resources needed*:

- Medical supplies
- Auxiliary communication equipment
- Power generators
- Respirators
- Chemical and radiation detection equipment
- Mobile equipment
- Emergency protective clothing
- Fire fighting equipment
- Ambulance
- Rescue equipment
- Trained personnel

## What are Elements of the Emergency Plan

*The emergency plan includes*:

- All possible emergencies, consequences, required actions, written procedures, and the resources available

- Detailed lists of personnel including their home telephone numbers, their duties and responsibilities
- Floor plans
- Large scale maps showing evacuation routes and service conduits (such as gas and water lines)

Since a sizable document will likely result, the plan should provide staff members with written instructions about their particular emergency duties. The following are examples of the parts of an emergency plan. These elements may not cover every situation in every workplace but serve they are provided as a general guideline when writing a workplace specific plan:

## OBJECTIVE

The objective is a brief summary of the purpose of the plan; that is, to reduce human injury and damage to property in an emergency. It also specifies those staff members who may put the plan into action. The objective identifies clearly who these staff members are since the normal chain of command cannot always be available on short notice. At least one of them must be on the site at all times when the premises are occupied. The extent of authority of these personnel must be clearly indicated.

## ORGANIZATION

One individual should be appointed and trained to act as Emergency Co-ordinator as well as a "back-up" co-ordinator. However, personnel on the site during an emergency are key in ensuring that prompt and efficient action is taken to minimize loss. In some cases it may be possible to recall off-duty employees to help but the critical initial decisions usually must be made immediately. Specific duties, responsibilities, authority, and resources must be clearly defined.

*Among the responsibilities that must be assigned are*:

- Reporting the emergency
- Activating the emergency plan
- Assuming overall command
- Establishing communication
- Alerting staff
- Ordering evacuation

- Alerting external agencies
- Confirming evacuation complete
- Alerting outside population of possible risk
- Requesting external aid
- Coordinating activities of various groups
- Advising relatives of casualties
- Providing medical aid
- Ensuring emergency shut offs are closed
- Sounding the all-clear
- Advising media

This list of responsibilities should be completed using the previously developed summary of countermeasures for each emergency situation. In organizations operating on reduced staff during some shifts, some personnel must assume extra responsibilities during emergencies. Sufficient alternates for each responsible position must be named to ensure that someone with authority is available onsite at all times.

*External organizations that may be available to assist (with varying response times) include*:

- Fire departments
- Mobile rescue squads
- Ambulance services
- Police departments
- Telephone company
- Hospitals
- Utility companies
- Industrial neighbours
- Government agencies

These organizations should be contacted in the planning stages to discuss each of their roles during an emergency. Mutual aid with other industrial facilities in the area should be explored. Pre-planned coordination is necessary to avoid conflicting responsibilities.

For example, the police, fire department, ambulance service, rescue squad, company fire brigade, and the first aid team may be on the scene simultaneously. A pre-determined chain of command in such a situation is required to avoid organizational difficulties. Under certain circumstances, an outside agency may assume command. Possible problems in communication have been mentioned in several contexts. Efforts should be made to seek alternate means of communication during an emergency, especially between key personnel such as overall commander, on-scene commander, engineering, fire brigade, medical, rescue, and outside agencies.

Depending on the size of the organization and physical layout of the premises, it may be advisable to plan for an emergency control centre with alternate communication facilities. All personnel with alerting or reporting responsibilities must be provided with a current list of telephone numbers and addresses of those people they may have to contact.

## Procedures

*Many factors determine what procedures are needed in an emergency, such as*:

- The degree of emergency,
- The size of organization,
- The capabilities of the organization in an emergency situation,
- The immediacy of outside aid,
- The physical layout of the premises,
- The number of structures determine procedures that are needed.

Common elements to be considered in all emergencies include pre-emergency preparation and provisions for alerting and evacuating staff, handling casualties, and for containing of the emergency.

Natural hazards, such as floods or severe storms, often provide prior warning. The plan should take advantage of such warnings with, for example, instructions on sand bagging, removal of equipment to needed locations, providing alternate sources of power, light or water, extra equipment, and relocation of personnel with special skills. Phased states of alert allow such measures to be initiated in an orderly manner.

The evacuation order is of greatest importance in alerting staff. To avoid confusion, only one type of signal should be used for the evacuation order. Commonly used for this purpose are sirens, fire bells, whistles, flashing lights, paging system announcements, or word-of-mouth in noisy environments. The all-clear signal is less important since time is not such an urgent concern.

*The following are "musts"*:

- Identify evacuation routes, alternate means of escape, make these known to all staff; keep the routes unobstructed.
- Specify safe locations for staff to gather for head counts to ensure that everyone has left the danger zone. Assign individuals to assist handicapped employees in emergencies.
- Carry out treatment of the injured and search for the missing simultaneously with efforts to contain the emergency.
- Provide alternate sources of medical aid when normal facilities may be in the danger zone.
- Containing the extent of the property loss should begin only when the safety of all staff and neighbours at risk has been clearly established.

## Testing and Revision

Completing a comprehensive plan for handling emergencies is a major step towards preventing disasters. However, it is difficult to predict all of the problems that may happen unless the plan is tested.

Exercises and drills may be conducted to practice all or critical portions (such as evacuation) of the plan. A thorough and immediate review after each exercise, drill, or after an actual emergency will point out areas that require improvement. Knowledge of individual responsibilities can be evaluated through paper tests or interviews.

The plan should be revised when shortcomings have become known, and should be reviewed at least annually. Changes in plant infrastructure, processes, materials used, and key personnel are occasions for updating the plan. It should be stressed that provision must be made for the training of both individuals and teams, if they are expected to perform adequately in an emergency. An annual full-scale exercise will help in maintaining a high level of proficiency.

## WHY PLAN FOR EMERGENCY

The designer designs a machine, an equipment or a procedure to job in a predefined manner and to produce pre-decided results. If everything will proceed just as to designer's plane and intentions there will be no emergency or if at all they happen there will be a few to trade with at extremely low stage. Though, the information of industrial life is that no matter how strong the recognition of hazards is, how well the scheduling to avoid hazard has been made and how adequately the machine, equipment and procedures have been intended and placed in service, the emergencies will still happen.

For this cause the scheduling to overcome emergencies necessity is in lay before they arise. Though, there is no intention in anyway to slacken the efforts on hazard minimization and avoidance. We cannot reduce the importance of hazard avoidance in favour of being emergency prepared. In information scheduling for minimizing hazards is slightly more significant than scheduling to minimize the effects of accidents. It will not be hard to agree to the suggestion that it will be futile to discover ways and means to effectively reduce the effects of an accident after it has occurred.

All as suggested, require is to fight an emergency so that it causes least damage through method of controlling and responding to it, all capabilities in men and equipment and training should be instituted in advance. The skill to plan, evaluate the plan, adjust quickly and implement the rescue operation cannot but be obtained only after well thought preplan and training.

The quick response to emergency is one of the mainly significant aspect of dealing with it. Loss of a minute to register the importance of sundry details may mean the variation flanked by life and death, or the variation flanked by minimal damage and maximum damage. All involved in these procedures necessity be able to respond to emergency without slightest hesitation. This can be achieved if all exigencies have been well planned, all planned procedures have been practiced, evaluated and improved. The quick response based upon proper preparation will prevent panic, reduce possibility of injury and damage and bring situation under manage in timely manner. Since no workplace is immune to emergency and accidents it is an significant safety management function to plan for emergencies.

## ORGANISATION FOR EMERGENCY AND COORDINATION OF DISASTER

There are many people who are expected to respond to emergency. In information these people can be easily grouped jointly based on profession. There are clusters of medical professionals, fire-fighters, safety personnel as well as specialist's clusters from dissimilar professions. The works to be performed through each group are dissimilar but all works are interdependent. Because of disparate nature of works organisation is extremely significant and because of heterogeneous nature of clusters the coordination is required at all stages of behaviours. It is imperative that keeping these major requisites in mind the company should identify clearly the clusters and personnel creation each group in its plan for emergency. For effective coordination one person necessity is recognized as coordinator and the management necessity ensure that the coordinator is acceptable to all emergency responders. The coordinator necessity is able to acknowledge the responsibilities of each group and its member and necessity also describe the connection flanked by responsibilities of dissimilar responder clusters.

The coordinator necessity either decides or be in full knowledge of the order of responses from all the clusters. A company's safety and health manager appears to be the appropriate choice to play the role of the coordinator.

*The organizing of scheduling will ensure that*:

- All scheduling is done under the supervision of one person.
- All emergency responders would know who is the coordinator.

- That every personnel responsible to respond to emergency will be allowed ample opportunity to practice in simulated circumstances which will be as secure to real circumstances as possible.

Big companies, particularly those prone to hazards have well coordinated emergency response programme involving clusters of medical technicians, nurses, doctors and manufacture workers who are assigned specifically spelt and emergency response duties and these programmes are coordinated through an emergency director. An significant effort is made in the direction of familiarizing physician and nurses with quickest and safest routes to emergency site. The emergency medical team necessity is trained in this aspect. Workers in the plant would be acquainted with the movement of people in the plant and approximately in the adjoining regions. They necessity also be well-known with exit points, routes to exit, emergency approaches and short routes to get out or reach the exit point. Emergency plans will extremely clearly describe the route to be taken through emergency medical team, the route to be followed through ambulance while nursing staff and medical technician will remain in communication but stationary at a pre-defined station to receive patients and provide advices as and when necessary.

It is understandable that in the event of emergency getting medical persons and fire fighters in and taking workers and injured persons out is an significant task to perform. A planned and coordinated response will not bring two clusters face to face which calls for an advanced scheduling of exits, passages, doors which necessity be clearly marked. The capability of each exist passage will be decided through the size of door, width and height and also non-encumbrance of the passage. The capability of each exist route is predetermined and estimates necessity match with the total number of workers working in a workplace.

## ORGANIZATION OF EMERGENCY MANAGEMENT

An emergency, as defined in CCA, "is a situation or series of events that threatens or causes serious damage to human welfare, the environment or security in the United Kingdom" (Cabinet Office 2005: 1). The data and historical path of emergencies proves one more time that the frequency of disasters is continuously increasing in the UK. Climate change, uncertainty of weather, and rising sea levels – due to the impact of high temperature – are some of the big threats for vulnerable society. Also, the potential future threat of terrorism, drugs, continuously changing demographics, novel technologies, and social problems creates unpredictability in establishing more sustainable and resilient society. Therefore, civil protection and emergency response and management system of UK has gone through massive changes and reforms. Nevertheless, the overall structure of disaster management has generally remained the same with the central government fulfilling the role of coordinator and providing guidance, while local agencies and governments deal with and respond to disasters (O'Brien & Read 2005).

The structure of emergency management in UK is decentralized. Most emergencies and incidents, based on scale or complexity, are handled at local level with no involvement of Central Government (Civil Contingencies Secretariat 2009a). Local agencies are always the first responders and the ones who carry the burden of emergency management. In most cases the police are considered one of the leading responding actors in local disasters. When police are given the task of responding to disasters at the local level, the Police Gold Commander is appointed by the local Chief Officer with the primary mission of managing the response.

The Police Gold Commander is usually chaired by Strategic Coordination Group (SCG) which comprises senior representatives and executive authority from local organizations. The SCG normally coordinates its activities with COBR, if activated, through Government Liaison Officer (GLO). However, in different disaster cases as animal disease outbreak, if local police are not the prime responding agency, the management of disasters is performed through local offices of the lead governments with the support from appropriate Government Offices (Cabinet Office 2005). If the impact of the emergencies is within the boundaries or capabilities of local government, appropriate local emergency services and authorities are being activated to take control of the situation. However, if the incidents and emergencies are of more consequential impact and casualties, the support, involvement and coordination of Central Government becomes necessary and vital (Civil Contingencies Secretariat 2009a).

The coordination and response of Central Government, through appropriate Lead Government Department (LGD), is provided when the impact degree, scale and complexity of disasters is relatively hard to manage. By the involvement of Central Government, the COBR is being activated to support coordination and decision making of LGDs (Cabinet Office 2005). The LGD or Developed Administration department is being designated, by the Central Government, for overall management and response to the incidents (Civil Contingencies Secretariat 2009a).

- *Emergency Response and Recovery*: Management and coordination of local operations: Emergencies and disasters are not sole problem of one agency or organization. On the contrary, it requires involvement and collaborative effort of large number of agencies. The management of local multi-agency response and recovery, from emergencies, is done through established national framework. This framework ensures that all responding agencies know and understand their roles and responsibilities in response and recovery actions. The framework of management of response and recovery comprises three tiers/levels which differ from each other based on their functions rather than rank, grade, or status (Cabinet Office 2009d). These three tiers can be described as:
  - *Bronze level*: Operational level. "Bronze is the level at which the management of immediate "hands-on" work is undertaken at the site(s) of the emergency or other affected areas" (Cabinet Office 2009e: 22; Cabinet Office 2009d: 1). Responders and agencies on the scene must act together and coordinate with all other agencies in order to sustain integrated effort. Bronze level responders will take immediate steps and provide possible

support within their area of responsibility and in specific tasks (Cabinet Office 2009e).

- *Silver level*: Tactical level. In order to achieve maximum effectiveness and efficiency Silver Level ensures that actions taken by bronze level are coordinated and integrated. In an incident situation silver commanders form incident command point located close to scene (Cabinet Office 2009d).
- *Gold level*: Strategic level. The Strategic Coordinating Group (SCG) is being formed that brings together golden commanders from appropriate organizations and agencies. Once they come together they establish framework and policy within which silver will work. Usually the police agency is leading body which chairs SCG. However, based on type and scale of disasters other agencies may take the lead (Cabinet Office 2009e).

- *Civil Contingencies Secretariat* (*CCS*): The CCS, which supports Civil Contingencies Committee (CCC) in dealing with terrorism and natural disasters, was established in July 2001, and is located within the Cabinet Office (Civil Contingencies Secretariat 2009b). Since its establishment, it became the lead emergency management organization in UK which functions under Minister of Interior (Sahin, Kapucu, & Unlu 2008). The core objective of CCS is to improve the UK's preparedness and response, and to build resilience to emergencies and disasters through identifying challenges, assessing and managing contingencies, and planning for future risk (Civil Contingencies Secretariat 2009b). The role and functions of CCS, under the leadership of CCC, is not to manage all crises but to "provide the central focus for the cross-departmental and cross-agency commitment, coordination and cooperation" (Cabinet Office 2008: 3), and to enable UK to successfully respond, recover, and deal with disaster challenges (Civil Contingencies Secretariat 2009b). When engaged, the CCS would report and inform appropriate Ministers and senior officials about strategic decisions concerning the emergency (Cabinet Office 2008). In the wide-range disaster events where one single department cannot provide needed response or where designation of right LGD is not clear, CCS becomes responsible for taking immediate action and ensuring promptly that one department is designated as LGD. However, if the incident is a cause of terrorism, the initial phase is led by the Home Office Terrorism and Protection Unit (Cabinet Office 2009b). In an emergency situation with big aftermath and impact, CCS will work with lead departments and:

- Provide an assessment of immediate needs, and support their provision.
- Establish possible scenarios up to worst case and plan for scaling up, logistical management and exit.
- Ensure that the centre and other interested departments are kept informed and are prepared to engage.
- Help establish structures, rhythms, routines and data flows for managing the response – in particular facilitating augmentation of the department's resources and public information systems.
- Connect the department with agencies able to provide specialist advice and information.
- Decide whether and when to approach the Chairman to convene a meeting of CCC, thereafter providing ongoing support from the centre (Cabinet Office 2008: 4).

While working and partnering close with lead departments, CCS supports them in preparing plans and integrating them with other departments, enhancing decision making, developing early warning systems, sharing knowledge with other core departments, developing management and professional expertise to maintain plans, testing developed plans, providing continuous improvements in developed plans, etc. (Cabinet Office 2008).

- *Lead Government Departments* (*LGD*): LGDs are designated for different numbers and categories of emergency situations. CCS maintains and updates list of LGDs based on their responsibilities and functions. In an emergency, if there is an ambiguous situation regarding which LGD should be involved and which is appropriate for management and response of the disaster, it becomes the role and judgement of Head of the Civil Contingencies Secretariat to make a decision and appoint the most appropriate LGD for this position (Civil Contingencies Secretariat 2009a).
- *Cabinet Office Briefing Room* (*COBR*): COBR, also referred as COBRA, is dedicated crisis management facility of the UK government, which is activated in the incidents or events of national significance. When the disaster affects big number of businesses and government departments, which requires a collective action, government maintains and activates COBR. Being situated in Whitehall, the COBR meetings are held in special secure rooms where Prime Minister, key authorities, Intelligence Officials, representatives from Ministry of Defence, officials from Department of Defence and Home Office, other senior Ministers, critical officials as Mayor of London and Metropolitan Police Commissioner, and representatives of relevant LGDs come together to make decisions and provide needed effective response and recovery disaster actions. COBR meetings are being held till the emergency situation is considered to be safe. Once the needed authorities come together, COBR identifies issues and proposes solutions and advice in order to respond to the emergency situation. The rooms where COBR meetings are held are provided with all necessary means of communication equipment, with

the core intent of providing timely and effective communication with all branches of government. COBR meetings are usually chaired and lead by the Prime Minister or Home Secretary, but it can change based on attribute and scale of the incident (Cabinet Office 2009c).

- *Levels of Emergency Management*: In addition to local emergencies or incidents – such as road accidents, small impact flood events, etc., (which are mainly handled by local authorities and first responders as police, fire, health organizations) – the engagement and response provision of UK central government is based on three different levels of emergencies. The specific functions and activation of government of department and ministers are done based on seriousness of disaster. In general, Level 3 is regarded as catastrophic emergency, Level 2 as serious emergency, and Level 1 as significant emergency level (Cabinet Office 2005).

## Challenges and Opportunities

As emergency management moves forward and faces the threat of different and new types of hazards and disasters, the central government of UK should ask questions of how to effectively engage in order to deal with these challenges and how to understand them well.

The frequency of the disasters, along with its size and impact, are growing, which requires more proactive central response. While historically having focus on disasters with relatively small impact, now the UK government should perceive the possibility of devastating incidents as 9/11 terrorist events or London Bombings of 2005.

Better education and awareness of citizens about vulnerability and disasters is crucial. The geographic location and continual climate change makes it certain for UK to continuously experience the risk and impact of natural hazards in the near future. For instance, the risk of floods would be at least increased four times by 2080 which may cause crucial economic and life casualties. People tend to be reluctant in accepting and recognizing the possibility of potential future risk of natural disasters that can affect their lives and property (Burningham, Fielding, & Thrush 2008). More emphasis should be put on prevention and education methods of citizens with the primary mission of building more resilient communities.

## DISASTER

A disaster is a natural or man-made (or technical) hazard resulting in an event of substantial extent causing important physical damage or destruction, loss of life, or drastic transform to the environment. A disaster can be extensively defined as any tragic event stemming from events such as earthquakes, floods, catastrophic accidents, fires, or explosions. It is a phenomenon that can cause damage to life and property and destroy the economic, social and cultural life of people.

In modern academia, disasters are seen as the consequence of inappropriately supervised risk. These risks are the product of a combination of both hazard/s and vulnerability. Hazards that strike in regions with low vulnerability will never become disasters, as is the case in uninhabited areas. Developing countries suffer the greatest costs when a disaster hits – more than 95 per cent of all deaths caused through disasters happen in developing countries, and losses due to natural disasters are 20 times greater (as a percentage of GDP) in developing countries than in industrialized countries.

## DISASTER CLASSIFICATION

Researchers have been learning disasters for more than a century, and for more than forty years disaster research. The studies reflect a general opinion when they argue that all disasters can be seen as being human-made, their reasoning being that human actions before the strike of the hazard can prevent it developing into a disaster.

All disasters are hence the result of human failure to introduce appropriate disaster management events. Hazards are routinely divided into natural or human-made, although intricate disasters, where there is no single root cause, are more general in developing countries. A specific disaster may spawn a secondary disaster that increases the impact. A classic instance is an earthquake that causes a tsunami, resulting in coastal flooding.

## Natural Disaster

A natural disaster is a consequence when a natural hazard affects humans and/or the built environment. Human vulnerability, and lack of appropriate emergency management, leads to financial, environmental, or human impact. The resulting loss depends on the capability of the population to support or resist the disaster: their resilience. This understanding is concentrated in the formulation: "disasters happen when hazards meet vulnerability". A natural hazard will hence never result in a natural disaster in regions without vulnerability.

Several phenomena like earthquakes, landslides, volcanic eruptions, floods and cyclones are all natural hazards that kill thousands of people and destroy billions of dollars of habitat and property each year. Though, natural hazards can strike in unpopulated regions and never develop into disasters. Though, the rapid growth of the world's population and its increased concentration often in hazardous environments has escalated both the frequency and severity of natural disasters.

With the tropical climate and unstable land shapes, coupled with deforestation, unplanned growth proliferation, non-engineered constructions which create the disaster-prone regions more vulnerable, tardy communication, poor or no budgetary allocation for disaster prevention, developing countries suffer more or less chronically through natural disasters. Asia tops the list of casualties due to natural disasters.

## Man-made Disasters

Man-made disasters are the consequence of technical or human hazards. Examples contain stampedes, fires, transport accidents, industrial accidents, oil spills and nuclear explosions/ radiation. War and deliberate attacks may also be put in this category. As with natural hazards, man-made hazards are events that have not happened, for instance terrorism. Man-made disasters are examples of specific cases where man-made hazards have become reality in an event.

## VULNERABILITY TO DISASTER

Vulnerability refers to the inability to withstand the effects of a hostile environment. A window of vulnerability (WoV) is a time frame within which suspicious events are reduced, compromised or lacking.

### General Applications

In relation to hazards and disasters, vulnerability is a concept that links the connection that people have with their environment to social forces and organizations and the cultural values that sustain and contest them. "The concept of vulnerability expresses the multi-dimensionality of disasters through focusing attention on the totality of relationships in a given social situation which constitute a condition that, in combination with environmental forces, produces a disaster". It's also the extent to which changes could harm a system, or to which the society can be affected through the impact of a hazard.

### Research

Within the body of literature related to vulnerability, major research streams contain questions of methodology, such as: measuring and assessing vulnerability, including finding appropriate indicators for several characteristics of vulnerability, up- and down scaling methods, and participatory methods. Vulnerability research covers a intricate, multidisciplinary field including development and poverty studies, public health, climate studies, security studies, engineering, geography, political ecology, and disaster and risk management. This research is of importance and interest for organizations trying to reduce vulnerability – especially as related to poverty and other Millennium Development Goals. Several organizations are conducting interdisciplinary research on vulnerability. A forum that brings several of the current researchers on vulnerability jointly is the Expert Working Group (EWG). Researchers are currently working to refine definitions of "vulnerability", measurement and assessment methods, and effective communication of research to decision makers.

## KINDS OF VULNERABILITY

### Social

In its broadest sense, social vulnerability is one dimension of vulnerability to multiple stressors and shocks, including abuse, social exclusion and natural hazards. Social vulnerability refers to the inability of people, organizations, and civilizations to withstand adverse impacts from multiple stressors to which they are exposed. These impacts are due in section to features inherent in social interactions, organizations, and systems of cultural values.

### Cognitive

A cognitive vulnerability, in cognitive psychology, is an erroneous belief, cognitive bias, or pattern of thought that is whispered to predispose the individual to psychological troubles. It is in lay before the symptoms of psychological disorders start to appear; after the individual encounters a stressful experience, the cognitive vulnerability forms a maladaptive response that may lead to a psychological disorder. In psychopathology, cognitive vulnerability is constructed from schema models, hopelessness models, and attachment theory. Attention bias is one mechanism leading to faulty cognitive bias that leads to cognitive vulnerability. Allocating a danger stage to a threat depends on the urgency or intensity of the threshold. Anxiety is not associated with selective orientation.

### Military

In military terminology, vulnerability is a subset of survivability, the others being susceptibility and recoverability. Vulnerability is defined in several ways depending on the nation and service arm concerned, but in common it refers to the close to-instantaneous effects of a weapon attack. In aviation it is defined as the inability of an aircraft to withstand the damage caused through the man-made hostile environment. In some definitions, recoverability (damage manage, firefighting, restoration of capability) is incorporated in vulnerability. Some military services develop their own concept of vulnerability.

## NATURAL DISASTERS

A natural disaster is a major adverse event resulting from natural procedures of the Earth; examples contain floods, severe weather, volcanic eruptions, earthquakes, and other geologic procedures. A natural disaster can cause loss of life or property damage, and typically leaves some economic damage in its wake, the severity of which depends on the affected population's resilience, or skill to recover.

An adverse event will not rise to the stage of a disaster if it occurs in an region without vulnerable population. In a vulnerable region, though, such as San Francisco, an earthquake can have disastrous consequences and leave lasting damage, requiring years to repair.

### Earthquakes

An earthquake is the result of a sudden release of power in the Earth's crust that makes seismic waves. At the Earth's surface, earthquakes manifest themselves through vibration, shaking and sometimes displacement of the ground. The vibrations may vary in magnitude. Earthquakes are caused mostly through slippage within geological faults, but also through other events such as volcanic action, landslides, mine blasts, and nuclear tests. The underground point of origin of the earthquake is described the focus.

The point directly the focus on the surface is described the epicenter. Earthquakes through themselves rarely kill people or wildlife. It is usually the secondary events that they trigger, such as structure collapse, fires, tsunamis (seismic sea waves) and volcanoes that are actually the human disaster. Several of these could perhaps be avoided through better construction, safety systems, early warning and evacuation scheduling. Some of the mainly important earthquakes in recent times contain: The 2004

Indian Ocean earthquake, the third main earthquake recorded in history, registering a moment magnitude of 9.1-9.3. The vast tsunamis triggered through this earthquake killed at least 229,000 people.

- The 2011 Tohoku earthquake and tsunami registered a moment magnitude of 9.0. The death toll from the earthquake and tsunami is in excess of 13,000, and in excess of 12,000 people are still missing.
- The 8.8 magnitude February 27, 2010 Chile earthquake and tsunami cost 525 lives.
- The 7.9 magnitude May 12, 2008 Sichuan earthquake in Sichuan Province, China. Death toll at in excess of 61,150 as of May 27, 2008.
- The 7.7 magnitude July 2006 Java earthquake, which also triggered tsunamis.
- The 6.9 magnitude 2005 Azad Jammu & Kashmir and KPK province Earthquake, which killed or injured above 75,000 people in Pakistan.

## Volcanic Eruptions

Volcanoes can cause widespread destruction and consequent disaster in many ways. The effects contain the volcanic eruption itself that may cause harm following the explosion of the volcano or the fall of rock. Second, lava may be produced throughout the eruption of a volcano. As it leaves the volcano, the lava destroys several structures and plants it encounters. Third, volcanic ash usually meaning the cooled ash - may shape a cloud, and settle thickly in surrounding sites. When mixed with water this shapes a concrete-like material. In enough quantity ash may cause roofs to collapse under its weight but even little quantities will harm humans if inhaled. Since the ash has the consistency of ground glass it causes abrasion damage to moving sections such as engines.

The main killer of humans in the immediate surroundings of a volcanic eruption is the pyroclastic flows, which consist of a cloud of hot volcanic ash which builds up in the air above the volcano and rushes down the slopes when the eruption no longer supports the lifting of the gases. It is whispered that Pompeii was destroyed through a pyroclastic flow. A lahar is a volcanic mudflow or landslide. The 1953 Tangiwai disaster was caused through a lahar, as was the 1985 Armero tragedy in which the city of Armero was buried and an estimated 23,000 people were killed. A specific kind of volcano is the super volcano. Just as to the Toba catastrophe theory 75,000 to 80,000 years ago a super volcanic event at Lake Toba reduced the human population to 10,000 or even 1,000 breeding pairs creating a bottleneck in human development. It also killed three quarters of all plant life in the northern hemisphere. The main danger from a super volcano is the immense cloud of ash which has a disastrous global effect on climate and temperature for several years.

## Hydrological Disasters

It is a violent, sudden and destructive transform either in excellence of earth's water or in sharing or movement of water on land below the surface or in atmosphere

### *Floods*

A flood is an overflow of an expanse of water that submerges land. The EU Floods directive defines a flood as a temporary covering through water of land not normally sheltered through water. In the sense of "flowing water", the word may also be applied to the inflow of the tide. Flooding may result from the volume of water within a body of water, such as a river or lake, which overflows or breaks levees, with the result that some of the water escapes its usual boundaries. While the size of a lake or other body of water will vary with seasonal changes in precipitation and snow melt, it is not a important flood unless the water covers land used through man like a village, municipality or other inhabited region, roads, expanses of farmland, etc.

*Some of the mainly notable floods contain*:

- The Johnstown Flood of 1889 where in excess of 2200 people lost their lives when the South Fork Dam holding back Lake Conemaugh broke.
- The Huang He (Yellow River) in China floods particularly often. The Great Flood of 1931 caused flanked by 800,000 and 4,000,000 deaths.

- The Great Flood of 1993 was one of the mainly costly floods in United States history.
- The 1998 Yangtze River Floods, in China, left 14 million people homeless.
- The 2000 Mozambique flood sheltered much of the country for three weeks, resulting in thousands of deaths, and leaving the country devastated for years afterwards.
- The 2005 Mumbai floods which killed 1094 people.
- The 2010 Pakistan floods, damaged crops and infrastructure, claiming several lives.

*Tropical cyclones can result in long flooding and storm surge, as happened with*:

- Bhola Cyclone, which struck East Pakistan (now Bangladesh) in 1970.
- Typhoon Nina, which struck China in 1975.
- Hurricane Katrina, which struck New Orleans, Louisiana in 2005.
- Cyclone Yasi, which struck Australia in 2011.

## *Limnic Eruptions*

A limnic eruption occurs when a gas, usually CO2, suddenly erupts from deep lake water, posing the threat of suffocating wildlife, livestock and humans. Such an eruption may also cause tsunamis in the lake as the rising gas displaces water. Scientists consider landslides, volcanic action, or explosions can trigger such an eruption.

*To date, only two limnic eruptions have been observed and recorded*:

- In 1984, in Cameroon, a limnic eruption in Lake Monoun caused the deaths of 37 surrounding residents.
- At surrounding Lake Nyos in 1986 a much superior eruption killed flanked by 1,700 and 1,800 people through asphyxiation.

## *Tsunami*

Tsunamis can be caused through undersea earthquakes as the one caused through the 2004 Indian Ocean Earthquake, or through landslides such as the one which occurred at Lituya Bay, Alaska.

- The 2004 Indian Ocean Earthquake created the Boxing Day Tsunami.
- On March 11, 2011, a tsunami occurred close to Fukushima, Japan and spread through the Pacific.

## Meteorological Disasters

### *Blizzards*

Blizzards are severe winter storms characterized through heavy snow and strong winds. When high winds stir up snow that has already fallen, it is recognized as a ground blizzard. Blizzards can impact local economic behaviours, especially in areas where snowfall is unusual.

*Important blizzards contain*:

- The Great Blizzard of 1888 in the United States in which several tons of wheat crops are destroyed.
- The 2008 Afghanistan blizzard.
- The North American blizzard of 1947.
- The 1972 Iran blizzard resulted in almost 4,000 deaths and lasted for 5 to 7 days.

### *Cyclonic Storms*

Cyclone, tropical cyclone, hurricane, and typhoon are dissimilar names for the similar phenomenon a cyclonic storm system that shapes in excess of the oceans. The deadliest hurricane ever was the 1970 Bhola cyclone; the deadliest Atlantic hurricane was the Great Hurricane of 1780 which devastated Martinique, St. Eustatius and Barbados. Another notable hurricane is Hurricane Katrina which devastated the Gulf Coast of the United States in 2005.

### *Droughts*

Drought is unusual dryness of soil, resulting in crop failure and shortage of water for other uses, caused through significantly lower rainfall than average in excess of a prolonged era. Hot arid winds, high temperatures and consequent evaporation of moisture from the ground can contribute to circumstances of drought.

*Well-recognized historical droughts contain*:

- 1900 India killing flanked by 250,000 to 3.25 million.
- 1921-22 Soviet Union in which in excess of 5 million perished from starvation due to drought.
- 1928-30 Northwest China resulting in excess of 3 million deaths through famine.
- 1936 and 1941 Sichuan Province China resulting in 5 million and 2.5 million deaths respectively.
- In 2006, states of Australia including South Australia, Western Australia, New South Wales, Northern Territory and Queensland had been under drought circumstances for five to ten years. The drought is beginning to affect urban region populations for the first time. With the majority of the country under water restrictions.
- In 2006, Sichuan Province China experienced its worst drought in contemporary times with almost 8 million people and in excess of 7 million cattle facing water shortages.
- 12-year drought that was devastating southwest Western Australia, southeast South Australia, Victoria and northern Tasmania was "extremely severe and without historical precedent".
- In 2011, the State of Texas existed under a drought emergency declaration for the whole calendar year. The drought caused the Bastrop fires.

## *Hailstorms*

Hailstorms are falls of rain drops that arrive as ice, rather than melting before they hit the ground. A particularly damaging hailstorm hit Munich, Germany, on July 12, 1984, causing in relation to the 2 billion dollars in insurance claims.

## *Heat Waves*

A heat wave is a era of unusually and excessively hot weather. The worst heat wave in recent European history was the European Heat Wave of 2003. A summer heat wave in Victoria, Australia, created circumstances which fuelled the huge bushfires in 2009. Melbourne experienced three days in a line of temperatures exceeding 40°C (104°F) with some local regions sweltering through much higher temperatures. The bushfires, collectively recognized as "Black Saturday", were partly the act of arsonists.

The 2010 Northern Hemisphere summer resulted in severe heat waves, which killed in excess of 2,000 people. It resulted in hundreds of wildfires which causing widespread air pollution, and burned thousands of square miles of forest.

### *Tornadoes*

A tornado is a violent, dangerous, rotating column of air that is in get in touch with both the surface of the earth and a cumulonimbus cloud or, in unusual cases, the base of a cumulus cloud. It is also referred to as a twister or a cyclone, although the word cyclone is used in meteorology in a wider sense, to refer to any closed low pressure circulation. Tornadoes approach in several forms and sizes, but are typically in the shape of a visible condensation funnel, whose narrow end touches the earth and is often encircled through a cloud of debris and dust. Mainly tornadoes have wind speeds less than 110 miles per hour (177 km/h), are almost 250 feet (80 m) crossways, and travel a few miles (many kilometers) before dissipating. The mainly extreme tornadoes can attain wind speeds of more than 300 mph (480 km/h), stretch more than two miles (3 km) crossways, and keep on the ground for dozens of miles (perhaps more than 100 km).

*Well-recognized historical tornadoes contain*:

- The Tri-State Tornado of 1925, which killed in excess of 600 people in the United States.
- The Daulatpur-Saturia Tornado of 1989, which killed roughly 1,300 people in Bangladesh.

## Wildfires

Wildfires are big fires which often start in wild land regions. General causes contain lightning and drought but wildfires may also be started through human negligence or arson. They can spread to populated regions and can therefore be a threat to humans and property, as well as wildlife. Notable cases of wildfires were the 1871 Peshtigo Fire in the United States, which killed at least 1700 people, and the 2009 Victorian bushfires in Australia.

## Health Disasters

### *Epidemics*

An epidemic is an outbreak of a contractible disease that spreads through a human population. A pandemic is an epidemic whose spread is global. There have been several epidemics throughout history, such as the Black Death.

*In the last hundred years, important pandemics contain*:

- The 1918 Spanish flu pandemic, killing an estimated 50 million people worldwide
- The 1957-58 Asian flu pandemic, which killed an estimated 1 million people
- The 1968-69 Hong Kong water flu pandemic
- The 2002-3 SARS pandemic
- The AIDS pandemic, beginning in 1959
- The H1N1 Influenza (Swine Flu) Pandemic 2009-2010

*Other diseases that spread more slowly, but are still measured to be global health emergencies through the WHO, contain*:

- XDR TB, a strain of tuberculosis that is extensively resistant to drug treatments
- Malaria, which kills an estimated 1.6 million people each year
- Ebola hemorrhagic fever, which has claimed hundreds of victims in Africa in many outbreaks

## Legroom Disasters

### *Impact Events*

One of the main impact events in contemporary times was the Tunguska event in June 1908.

### *Solar Flares*

A solar flare is a phenomenon where the sun suddenly releases a great amount of solar radiation, much more than normal.

*Some recognized solar flares contain*:

- An X20 event on August 16, 1989
- A similar flare on April 2, 2001
- The mainly powerful flare ever recorded, on November 4, 2003, estimated at flanked by X40 and X45
- The mainly powerful flare in the past 500 years is whispered to have occurred in September 1859

## *Gamma Ray Burst*

Gamma ray bursts are the mainly powerful explosions that happen in the universe. They release an enormous amount of power in milliseconds or as extensive as ten seconds. They release as much or even more power than the Sun will in its whole life. Gamma ray bursts are not unusual events. They happen in relation to the once every day and are detected through telescopes, both on Earth and in legroom. Mostly big masses of stars, better than the Sun, can produce a GRB. A GRB of distances nearer than 8000 light years may cause a concern to life on Earth. Mainly Wolf-Rayet stars WR 104 can produce GRB. Astronomers do consider that the Ordovician–Silurian extinction, the third mainly destructive extinction on Earth, might have been due to a GRB.

## Protection Through International Law

International law, for instance Geneva Conventions defines International Red Cross and Red Crescent Movement the Convention on the Rights of Persons with Disabilities, requires that "States shall take, in accordance with their obligations under international law, including international humanitarian law and international human rights law, all necessary events to ensure the protection and safety of persons with disabilities in situations of risk, including the occurrence of natural disaster." And further United Nations Office for the Coordination of Humanitarian Affairs is shaped through Common Assembly Resolution 44/182. People displaced due to natural disasters are currently protected under international law.

## MEDICAL SUPPORT OF ACCIDENT SITUATION

Emergency is an accident situation. The accident will result in injury to a worker or a supervisor and response to emergency is to have single intention of reducing the misery of the victim and to manage the effects such that they are not lasting in the sense that debility or incapacity does not tend to set in permanently or for a extensive time.

The response to accident necessity centre approximately the clear motion that accidental situation or emergency arises without warning and the victim himself is totally unaware of reducing damage. This responsibility will exclusively rest with the persons who respond to the emergency. Indeed the desired response could be an outcome of thorough scheduling and training only. The outcome of the serious injury will depend upon how quickly the response came and in what manner it approached . The time for consulting a manual will not be accessible. The response has to be automatic and without loss of any time. The responders have to know that they will not be held liable for the outcome of their help.

In industrialized nations rules have been made which absolve persons of liability of outcome in an emergency if the respond to the situation. For this cause the industrial worker are desired to have full knowledge of first aid. They are required to undergo first aid training as a regular characteristic of their employment. The management is required to lay first aid kit in lay which is recognized to all workers and supervisors have to inspect the first aid kit from time to time to see that it is in order and supplies are required are there. The knowledge, the training and accessibility to first aid kits will not only help reduce time due to indecision but will also provide confidence to the responders of emergency.

It is indeed understood that the first aid is to be given only until the arrival of qualified medical staff such as doctors, paramedics or nurses. They will take in excess of as soon as they arrive on the scene and it requires that beside with a response in conditions of first aid there necessity be another response to send for medical help. In better plants and industries the doctors or nurses may be accessible on duty and they may take least possible time to reach the scene of accident. In case such facilities are not accessible a surrounding earmarked hospital with ambulance facility requires to be alerted. A premedical scheduling will be able to achieve these functions in quick succession. It is also essential that in such cases where medical facilities are not accessible either within the premises or in the neighbourhood a person exclusively trained in first aid necessity be accessible to take care of the victim until he is accepted to a hospital or a doctor is brought to him. This situation often arises in construction industry.

An significant aspect of providing immediate response to a victim of emergency is that the person responding should not become victim himself of the similar circumstances which caused emergency. It will always be better for the organisation to have one victim and not two. What it means is that people working approximately an accident spot require not only be aware of first aid or sending for expert help but also of reasons and extent of the hazard that urbanized the emergency. Several times it will require removing victim from the lay of accident. This should be done in method that the injuries and loss of capability are not aggravated. This will be easier to do if a quick survey of victim's body is made to ascertain if any body section would require a special attention.

## FIRST AID

Its management, its availability and training of workers in first aid have been accentuated. First aid becomes significant tool of saving life in the time gap of occurrence of the accident and arrival of qualified medical support. Providing first aid training to workers is an essential unit of scheduling for emergency. In sure cases the rules require that at least one worker on-location should be fully trained in first aid.

Such trainings are imparted through several colleges and Red Cross Organisations. Additionally the workplace should have well shocked first aid kit installed in accessible and visible location. There should be telephonic get in touch with medical support and all telephone numbers to be used in emergency necessity is visibly accessible. They are normally printed on wall or notice boards.

*The contents of a first aid box are*:

- Sterile gauze dressings
- Bandages, triangular, roll gauze and adhesive
- Adhesive tapes
- Absorbent cotton
- Sterile saline solution
- Mild antiseptic for mild/minor wounds
- Syrup to induce vomiting
- Activated charcoal powder to absorb swallowed poison
- Petroleum jelly
- Bicarbonate of soda (baking soda)
- Aromatic spirit of ammonia
- Scissors, tweezers, needles and sharp knife or 6lade
- Eye dropper
- Oral thermometer
- Ractal thermometer
- Hot water bag
- Safety matches
- Flashlight/torch
- Surgical gloves (Rubber)
- Face mask or mouthpieces

Identification of injuries that can be attended through first aid is yet another step in administering it.

## Unconsciousness

It can be due to heart attack, fainting or shock. Check for breathing. If no breathing and heart has stopped the first aid responder may provide an electric shock. When heart starts pumping cardiopulmonary resuscitation may be given. Mouth should be checked for any obstruction. The victim should be placed with face down with head turned to one face. This posture prevents choking in case the victim vomits. Care necessity be taken that air passage is not obstructed. Resuscitation is beneficial only after the heart has restarted. Shock is further reduced through giving oxygen to victim. An inhalator which assists the lung action may be used.

## Bleeding

It should not be allowed to remain uncontrolled. Bleeding is controlled through applying a compress which surrounds a body section through a bandage and can be tightened with sufficient pressure. Tournquet (bandage which can be tightened through screw) can be used if compress does not job. A tournquet should be used flanked by the heart and the wound. The wound should not be touched or allowed to become dirty.

## Electrical Shock

The immediate require will be in a freeze situation and rescue will require shutting of power in the route. If power shut is not possible the victim should be removed ' from get in touch with of live wire. The rescuer necessity uses protective equipment lest he becomes victims.

## Chemical Burn

The chemical should be washed off with flood of water. If the clothes are soaked they should be removed immediately and body should be washed with water.

## Internal Chemical (Non-corrosive) or Poisson

The victim should be made to vomit which can be induced through drinking a glass of water mixed with two tablespoon of salt. The vomiting can also be induced through touching back of throat with finger or spoon. The victim should be made to lie with face turned to allow discharge through the mouth.

## Third Degree Burns

Apply cold water or ice on the burn and cover the burnt region with sterile gauze or clean cloth. Save the burn from oil or grease.

## Trauma

Trauma is a state of shock especially often injuries which are life threatening. The man keeps silent and shows small or no reaction. It has been sea that a man in traumatic state gets up, walks a few steps, collapses and dies. The victims after severe injuries necessity are made to sit or lie (in case of head injury, while laying the head should be stage with body) while sitting the head should tilt low slightly to allow blood flow to head. The man often feels chill and tends to shiver in trauma.

The dress should be loosened and any strappings should be removed. The body may be sheltered with a blanket or coat. The victim should be made to feel comfortable as much as possible while keeping him quiet and warm. There are several injuries which are non-life threatening. These injuries may also be severe and may induce trauma yet the assistance may wait. Following is the account of such non-life threatening injuries and their first aid.

## Bone Fracture

The fracture of bone is better suspected than actually recognized but treat each suspected bone as if fracture has actually occurred. Avoid the body movement and treat affected section with great care and sympathy.

Treat the injury to have caused fracture if the body section has abnormal appearance in form, if body section cannot be moved, if the injured section appear tender and there is extreme pain in moving the section, or if there is swelling and transform in the colour of the skin. If a person trained in first aid can help through tying splint approximately broken bone or suspected to be broken bone, he necessity do it. The broken arm or hand may be suspended in a sling.

## Minor Bleeding

In case of light bleeding seal with group aid. If slightly profuse bleeding tie the compress.

## Eye Injury

Do not allow rubbing of eye. Use clean water to douse the eye after pulling the eyelid from eyeball. Do not use any other method to remove any dirt or particle from the eye. A paramedic or physician should only remove the dirt from the eye. For further examination of the eye the victim should be sent to the hospital.

## Heat Cramps or Prostration

This is effect of heat less than heat stroke. The victim should be given to drink a glassful of water mixed with 1/2 teaspoon of salt every 15 minutes after seating him in a cool lay. The victim should be shifted to hospital for further treatment.

## Severe Back Pain

Have the victim lie on a flat hard surface while keeping him warm and wait for doctor to attend. Should a victim be removed from lay to accident is a question which a first aid worker may have to answer. The strict of guideline is that do not move the injured if neck or back injury is suspected unless it is ascertained that if not moved the victim will suffer further.

*If it is essential to move an injured person keeps in mind to follow the following rules*:

- Call for professional medical help.
- Pull the body beside its axis and never sideways.
- If time permits, put a blanket under the victim and then pull the blanket. Heavy plastic sheet or tarpaulin can also be used.
- If the victim has to be lifted support all body sections so that body does not bend or jackknife.

## FUNDAMENTALS OF EMERGENCY PLANNING

Before a group of persons belonging to professions which can respond to emergencies start scheduling or preparing emergency action plan each member should attempt and get complete information on all hazards that may be present in a working environment of concerned organisation. Complete information on design of plants, security system, safety rules, safety equipment and protective devices necessity is made accessible. More than these the scheduling committee should be totally appraised of geographical site of the industry and possible natural hazards as earthquakes, floods, tornados, storms, rains, lightening, etc. All these factors will play roles in emergency action plan (EAP). An EAP will actually be the collection of individual plans for each kind of emergency such as arising from fire, explosion, spill of chemical, bursting of a boiler or pressure vessel, toxic emission, flood, train accident and likes.

*The essential elements of scheduling of emergency will be as follows*:

- Step through step procedure of action in case of each emergency. The unit is named as procedure. Procedures for controlling, isolating the legroom, raising alarm, etc. are decided.
- All responders to specific emergencies should be listed beside with their lay of duty and telephone numbers. The personnel should be recognized with the agencies or departments to which they belong and their availability outside working hours of their offices necessity be noted beside with phone numbers. The unit is named coordination and automatically calls for a coordinator who will stay all such records.
- Assigning responsibility is the after that step so that each participating agency and person knows what one is supposed to respond. A person responsible for calling medical help would know that if does not do his job medical support will not be accessible. Another necessity knows that he is to get in touch with the fire department. The person responsible for opening emergency exits should know what he is supposed to do. The person responsible for first aid would be ready to take the charge when require arises. The strength to such assignment of responsibilities will be provided if a back up team is also prepared simultaneously so that an alternative responder is accessible.
- The strategies to prevent hazards developing into emergencies may also be continuously examined under EAP so that their occurrence may be avoided or minimized. The steps taken through safety personnel in the direction of hazard minimization may be checked if information are accessible and correction in

EAP may be incorporated if felt necessary on observing actual situations.

- The emergency drills are significant section of EAP. The action planners should chalk out a schedule for such drills preferably without any perceptible pattern. The drills fixed on similar days and times may not make situation of responding to actual emergency. The times and dates of drills should vary so that they remain unpredictable and evoke right response.

The EAP should be checked after each coordination meeting. A checklist necessity is prepared to ensure that all essential have been measured and action plan made.

## EMERGENCY RESPONSE

Response to emergency involves all procedures listed in checklist. A team described emergency response team is shaped. This team will respond to emergency in a common method and also in localized region. Emergency plans should be site specific. Such plans prepared for dissimilar sites necessity be integrated jointly to create common plan for whole plant.

A local plan is based upon specific plant based upon a map indicating sites of exits, access points, evacuation routes, alarms, emergency equipment, first aid kits, shut down switches, manage centre and any other unit of EAP. The local emergency plan should indicate who would issue orders throughout emergency and who would act just as to the order. Usually the plan will describe who reports to whom.

The persons to be accounted and those to be described for responding to emergency necessity are recognized through their positions and phone numbers. It is the responsibility of the local ERI to stay the information on the personnel up-to-date through introducing changes if any transform occurs in organizational set up of the company.

The local ERT will uphold get in touch with common ERT on company stage and uphold records of all information’s and advices issued from there. The local ERT will also take care of training of personnel and practice drill just as to common ERT plans. The ERT for the whole plant or company will have inputs from all local ERT’s and will take the responsibility of coordinated behaviours pertaining to:

- Personnel evacuation,
- Personnel safety,
- Shutting down plant, structure services and utilities as per requires,
- Collaboration with responding civil authorities,
- Protection and salvaging of property,
- Evaluation of safety condition before permitting reentry.

In information the ERT membership will be given to those who answer to the question who will be responsible. ERT in mainly cases is totally company based but in sure situations when the behaviours of the company either in conditions of emission, incoming materials or outgoing products may affect the societies livelihood in surrounding regions the ERT's may also involve societies. A company ERT derives personnel from many of its departments such as manufacture, processing, maintenance, safety and security.

The size of ERT will depend upon the size of the company. A company while having its own ERT may encourage the societies to have their own ERT to which the company ERT will give all support and create sincere efforts to coordinate with. The external ERT will take cognizance of emergency arising out of the precincts of the company but because of the company action. For instance, chlorine carrying truck to the company meets an accident or a poisonous gaseous product of the company leaks into atmosphere. It has been concluded through several researches that the gas leaks happen in greater number at loading docks which are outside manufacture region.

ERT networking is a beneficial concept which is now being followed through many clusters of company. Under such networking ERT's of dissimilar companies in a given geographical area are coordinated as a consortium. In the event of emergency taking lay in any one company the company ERT can seek help, guidance or advice from network of ERT's. The networking is especially useful in case of an outside emergency. More importantly the networks give facilities of swap of experiences.

## Difficulties in Implementing EAP

It has been the emphasis of our discussion that hazards are integral section of industrial action however all efforts are made to minimize and avoid hazards. Under some unfavorable situations these hazards transform into emergency and accidents happen. After the emergency arises the Emergency Action Plan attempts to minimize injuries, damage to property and equipment and reduce losses.

Still people may be injured, life may be lost, property and equipment may be damaged, and economic losses may be incurred. The Emergency Response Teams with conditioned efforts attempt to minimize all of the losses and miseries. At times the failure becomes apparent. The mainly spectacular failure has been establish to happen in equipment such as warning system, water sprinkler or protective device used through a worker. Special care necessity is taken.

The second aspect of failure that has been observed is that exit doors do not open in time creating a jam and stampede or escape passages are not wide sufficient to accommodate all exiting personnel. Under some situation failing in rescue efforts the ERT may have to order evacuation. Delay in taking such action may also result in greater number of injuries. In a situation of evacuation it is often forgotten that some persons may be in toilet and not able to hear the warning sounds or there may be some handicapped persons not able to move fast without help. The placement of means of communication plays an significant role and under any emergency communication channel from local to company ERT and to network necessity be accessible.

The emergency should not block the passage to phone and in any case radio and cell phone communication necessity beck up the system. Transporting injured to hospital well in time can save life. It has been seen that proper transport not being accessible several times costs heavily. Likewise transport for moving emergency combating equipment to the size of emergency is not in time and perfect and battle is not fought properly. The shutting down of power, machines and equipment before they are damaged or they cause damage is delayed sometimes. Emergency power and lighting system should be relied upon throughout an emergency and should be put on. The thought of creation and ticking the checklist is precisely to see that all actions have been planned and special care has been taken of the worker regions. Training of responders and simulated emergency action play a great role in creation emergency action plan successful.

## COOPERATIVE EFFORTS IN EMERGENCY CONTROL

Throughout emergency the requires of personnel, equipment and procedure have now become self explicit. Naturally these characteristics necessity become the section of consideration while designing the plant and its operation. These requirement are hard to fit in an existing plant however not impossible. For instance, while designing physical facilities the site of first aid facility will have to be determined with participation and agreement of medical personnel and safety engineers.

The procedure planner will also be consulted. Therefore , the pre-scheduling of manage of emergency begins as a coordinated effort from the beginning. There has to operative coordination when the plant start working. The behaviours and facilities such as safety, security, fire fighting and medical services may job under individual heads if the organisation is big. The coordination meetings to oversee the preparedness to respond to emergency may be convened from time to time and changes if deemed necessary may be incorporated. In a little organisation a single individual may be responsible for all the services at a time and has to stay all of them in state of preparedness with the help of respective supervisors.

The preparation will still not exclude one person to be responsible for directing operations throughout emergency. Everyone will seem towards this in charge for instructions. Dissimilar responders working on their own in their ways may add to emergency rather than reducing its impact. Hence the coordinator necessity is a highly experienced man who would command both respect and power. The coordination can be effective if the coordinator is fully knowledgeable of circumstances and circumstances of operation obtaining in the region where emergency could arise. For instance, a workplace may have been provided with emergency exits but their opening at the right moment will require a perfect coordination. Many emergency occasions are on record to have resulted in deaths of persons who could not exit the emergency site because exits could not be opened in time.

In industrial plants keeping mobile or portable bins or heavy equipment against fire/emergency exit should be avoided. This requires a perfect coordination and cooperation flanked by the manufacture and safety supervisor. Beside with seeking cooperation of manufacture personnel the safety staff may use the emergency exits in their normal rounds. The security staff may also extend their cooperation through checking all entry and exit doors everyday. In information the security, manufacture, plant and safety supervisors and manager necessity stay secure connection in the middle of themselves and swap information regularly concerning general interest of safety. This action necessity continues at all times. But if an emergency occurs then cooperation in the middle of safety manager, fire fighting manager and medical staff is needed.

## RESPONSE TO TRAUMA

Trauma is a psychological shock which cause significant of decision creation power of a man. The people suffer from trauma after escaping a situation which they think would have certainly caused death. They may also from trauma when they see several people dying of emergency circumstances, throughout a disaster, in an accident or due to some one killing. The psychological state of mind may be dissimilar in dissimilar people and there are some who suffer from trauma after bearing that people were killed or burnt or died of accidents. Trauma has also been defined as a normal reaction of normal people to abnormal event.

Yet in several emergency responses dealing with trauma is neglected. It has been seen in I several-a-situation that typical approach is to lay emphasis on bringing the workplace to normalcy through following routine of controlling, taking care of injured through medical support, cleaning up the mess and getting back to job. Mainly emergency situations see management's anxiety to declare that everything was under manage and injured have been minimum and taken care of.

The person who saw others getting injured are subjected to more psychological shock than the injured person. The result of such other effects may be an inner feeling of dislike towards job and workplace resulting into loss of manufacture or bad service. The affected employees inwardly may turn against employers and supervisor resulting into disobedience and even quarrels. More importantly the trauma has extremely dangerous repercussion of ignoring safety rules and even sabotaging

Considering all the points brought up it appears imperative that actions necessity is planned and initiated to restore the confidence of workers in their job in those under whose guidance and supervision and for whom they job. Such efforts necessity be initiated within 24 hours of the emergency but should never be delayed through more than 72 hours. Specially trained people should be chosen to interact with the workers to explain them the events that led to emergency and events taken to respond. A trauma response team (TRT) is normally constituted in companies which consist of experienced people who have specially been trained in such job. A company depending upon its size may have doctors, psychologists and safety experts on its TRT.

The primary responsibility of TRT immediately after occurrence of emergency is to identify the persons who suffer from trauma and then refer them to scrupulous specialists. A great trade of reduction in trauma, after successful first aid is to let affected workers to know that they have passed through the worse and provide them opportunity to express their experience and impression of total episode.

Another significant aspect of the job of TRT is that those members who do not have the experience or qualified to counsel or to give mental health care should not do the similar. The TRT may also identify those who are less traumatized and their trauma is presently anxiety. These employees may be grouped jointly and given joint or group treatment to acknowledge the bad experience. This may also stay all or mainly of employees will informed and avoid their dependence on rumors and misbeliefes. The group treatments give opportunity to workers to express their feelings and experiences in relation to the emergency. Such frank and free expressions may soon rid them of trauma and bring back normalcy. If further then provides them chance to see that there are several others who suffered as they did and therefore removes the guilt feeling and thought that others were responsible for their sufferings.

# 3

# Biological Disaster Management

Biological Disaster could arise from a source located either inside the country or outside the country (warfare). Management of such a situation could be dealt effectively only if there is a disaster plan well integrated in the system and also there is mechanism of post disaster evaluation.

*Inter-disaster Stage:* This is the period between two disasters in which pre-disaster planning in terms of system development should be done. Action plan has following elements: One of the simplest and easy method to suspect is to take notice of a situation during which more patients with similar ailments from a particular locality start consulting health guide at village level.

- Constitution of a Crisis Management Structure.
  - Identification of Nodal Officers for Crisis Management at District, State and Central Level.
  - Identification of Focal points for control of epidemic at District, State and Central Level.
  - Constitution of advisory committees—Administrative and Technical.
  - Preparation of contingency plan including Standing Operating Procedure at District, State and Central Level.
- System of Surveillance.
  - System of information collection at District, State and Central Level.
  - System of data analysis.
  - System for flow of information from District to State and to Central Level during crisis period.

   - Establishment of control rooms at District, State and Central Level.
- System of Epidemiological Investigation.
   - System of field investigation.
   - System of active surveillance.
   - Arrangement for support facilities.
- Confirmation of pathogens by laboratory set up.
   - System of laboratory investigation at District, State and Central Level.
   - Quality Control of Laboratory Practices.
- Training to different level workers.

## PRE IMPACT STAGE OF WARNING (EARLY DETECTION)

Early identification of an outbreak of disease of international public health importance shall require knowledge of early warning signals amongst all the echelons of health care providers.

*Some of the suggested early warning signals which must command quick investigation by professionals may include followings:*

- Sudden high mortality or morbidity following acute infection with short incubation period.
- Acute fever with haemorrhagic manifestations.
- Acute fever with altered sensorium and malaria and JE excluded in endemic areas.
- Even one case of suspected plague or anthrax.
- Occurrence of cases which are difficult to diagnose with available clinical and laboratory support and their non-responsive to conventional therapies.
- Clustering of cases/deaths in time and space with high case fatality rate.
- Unusual clinical or laboratory presentations.

A comprehensive list of all the trigger events that shall attract immediate attention of local public health machinery need to be developed by a group of experts.

- By suspicion: Management Plan should aim to identify crisis situation at a very early stage preferably confined to a limited area. This can be done only by suspecting danger of impending disaster by local health employees at village by village health guide, at sub centre level by multi purpose worker and PHC level by doctors at PHC.

- Alertness of institution dealing with emergency health, medical services/ Confirmation by identified laboratories: If such a situation arises, after providing symptomatic treatment at PHC level, services of well established laboratory at district or medical college level may be requisitioned to identify the organism and also to seek guidance for specific treatment and management.
- Constant surveillance and monitoring till there is no risk of any outbreak.

*Disaster Stage:* When disaster strikes following actions would be needed:

*Public Health Control Measures:* Aim of control measures, is to contain the disease initially but eliminate ultimately by following public health measures:

- Identification of all infected individuals based on an established case definition.
- Eliminating or reducing source of infection (Isolation and treatment of patients) identified by epidemiological and laboratory studies.
- *Interrupting Transmission of disease:* Spread of disease depend of mode of transmission which could be prevented by:
  - Possibility of reducing direct contacts with patients.
  - *Vector control*: Rodents/Mosquitoes control.
  - Food control.
  - *Environmental control:* Transmitted by water/air.
  - Control through sewerage system.
- Protecting persons at risk (Community) Immunisation and Health Education plays major role in protecting person at risk.

*Trigger Mechanism:* The trigger mechanism is an emergency quick response mechanism like ignition switch when energised spontaneously sets the vehicle of management into motion on the road of disaster mitigation process.

- System of alert and mechanism of activation of Disaster Plan.
- Immediate organisation of field operation for curative and preventive medical care including immunization.
- Checking of initial information on an epidemic.
- Preliminary analysis of the situation.
- Arrangement for laboratory support.
- Emergency health services advisory committee meeting to take stock of the situation and to advise further action.
- Field investigation about:
  - Safety pre-cautions.
  - Case finding.

  (i) Deputation of Quick Response Teams:
  - Search for source of infection and contact tracing.
  - Special investigation for common source of infection.

  (i) Analysis of investigation data to identify type, source of out break and mode of transmission:
  - Ecological data.
  - Clinical data.
  - Epidemiological data.
  - Laboratory data.
  - Entomological data.

  (i) General control measures to prevent further out break:
  - Protective measure for contacts and Community.
  - Control of common source of outbreak like food water or mosquito etc.
  - Immunization, emergency mass immunization and specific immunization, mass chemoprophylaxis.

## Post Disaster Stage

Evaluation after disaster is most important step in disaster management in order to rectify deficiencies in the management and to record the entire operation for future guidance for which following measures are necessary:

- Evaluation of control measures.

- Cost effectiveness.
- Post-epidemic measures.
- Sharing of experience.
- System for documentation of events.

Management of Biological disaster on above principles and steps should be taken by the health authorities of the State Government with the available infrastructure.

## Future Plan

The followings are the some of the key issues and concerns across the globe that need to be included in the future plan of bio-terrorism management.

- Since vaccines against a number of potential biological warfare agents have already been developed and some have already been in use, mass immunization of the population would be done on a priority basis.
- Vaccines against remaining agents would have to researched and developed.
- Mass public awareness before, during and after such an attack must be emphasized upon.

The strategies that must be incorporated include accurate threat intelligence, physical countermeasures, medical countermeasures and education and training of physicians and ancillary health care providers including first-aid providers.

## DO's AND DON'Ts IN A BIOLOGICAL WAR ATTACK

### Before

- Children and older adults are particularly vulnerable to biological agents. Ensure from a doctor/the nearest hospital that all the required or suggested immunizations are up to date.

### During

- In the event of a biological attack, public health officials may not immediately be able to provide information on what you should do. It will take time to determine what the illness is, how it should be treated, and who is in danger. Close the doors and windows when a biological attack is imminent.

- Watch television, listen to radio, or check the Internet for official news and information including signs and symptoms of the disease, areas in danger, if medications or vaccinations are being distributed, and where you should seek medical attention if you become ill.
- The first evidence of an attack may be when you notice symptoms of the disease caused by exposure to an agent.
- Be suspicious of any symptoms you notice, but do not assume that any illness is a result of the attack.
- Use common sense and practice good hygiene.

*However, if you notice of an unusual and suspicious substance nearby*:

- Move away quickly.
- Cover your head and nose
- Wash with soap and water.
- Listen to the media for official instructions.
- Seek medical attention if you become sick.

*If you are exposed to a biological agent*:

- Ultra efficient filter masks can be used.
- Follow official instructions for disposal of contaminated items such as bag and cloths.
- Take bath with soap and put on clean clothes.
- Seek medical assistance. If required and advised, stay away from others or even quarantined.

## After

- Pay close attention to all official warnings and instructions on how to proceed. The delivery of medical services for a biological event may be handled differently to respond to increased demand. The basic public health procedures and medical protocols for handling exposure to biological agents are the same as for any infectious disease. It is important for you to pay attention to official instructions via radio, television, and emergency alert systems.

## THE IMPORTANCE OF DISASTER MANAGEMENT

Disasters are events that have a huge impact on humans and/or the environment. Disasters require government intervention. They are not always unpredictable. Floods take place in valleys and flood plains, droughts in areas with unstable and low rainfall, and oil spills happen in shipping lanes. This predictability provides opportunities to plan for, prevent and to lessen the impact of disasters.

Disasters arise from both natural and human causes, and the responses needed could stretch community and government capacity to the limit. For example, during 2000 we saw a series of disasters in South Africa: huge floods devastated the Limpopo Province, Mpumalanga and neighbouring countries; massive fires and an oil spill threatened Cape Town; and separate floods hit rural communities in KwaZulu-Natal and the Eastern Cape. In 2004 Cape Town experienced a drought disaster attributed to global warming. From April 2004 to January 2005, the province experiences 376 disasters, mostly fire and flood.

Disasters are inevitable although we do not always know when and where they will happen. But their worst effects can be partially or completely prevented by preparation, early warning, and swift, decisive responses. Disaster management aims to reduce the occurrence of disasters and to reduce the impact of those that cannot be prevented. The government White paper and Act on Disaster Management define the roles of Local Authorities as well as Provincial and National government in disaster management.

## THE ROLE OF MUNICIPALITIES IN DISASTER MANAGEMENT

Every municipality must have a disaster management plan as part of its Integrated Development Plans, just as to the Municipal Systems Act.

- *Structure and Mechanism*: This plan must set up the structure and mechanisms for dealing with disasters and it must anticipate future disasters. Plans must be developed to deal with disasters that occur regularly—for example flooding of informal settlements and roads.

Protection Services Department: In each municipality, the Protection Services department is responsible for Disaster Management. The department usually deals with traffic policing, fire brigades, law enforcement, and sometimes ambulances on an agency basis for provincial government, The role of Disaster Management is to coordinate the response to disasters and emergencies, ensuring that resources are applied effectively, whatever it may be. Fire services, ambulance services, emergency medical services, engineers and traffic services can all become involved in Disaster Management.

- *Capacity*: When a disaster exceeds the capacity of a local authority, the district, province or national can become involved, coordinating and facilitating the response and efforts of various local authorities. Other parties such as the SANDF as well as volunteer organisations such as the Red Cross, St. John's and the National Sea Rescue Institute can also be drawn in if needed.
- *Disaster Management Activities*: Disaster Management Activities include the co-ordination of disaster response agencies, the compilation and exercising of contingency plans, and Disaster Management education and training.

## PROFESSIONAL AND PHASES ACTIVITIES IN DISASTER MANAGEMENT

The nature of management depends on local economic and social conditions. Some disaster relief experts such as Fred Cuny have noted that in a sense the only real disasters are economic. Experts, such as Cuny, have long noted that the cycle of emergency management must include long-term work on infrastructure, public awareness, and even human justice issues. This is not important in developing nations. The process of emergency management involves four phases: mitigation, preparedness, response, and recovery.

### Mitigation

Mitigation efforts attempt to prevent hazards from developing into disasters altogether, or to reduce the effects of disasters when they occur. The mitigation phase differs from the other phases because it focuses on long-term measures for reducing or eliminating risk. The implementation of mitigation strategies can be considered a part of the recovery process if applied after a disaster occurs. Mitigative measures can be structural or non-structural. Structural measures use technological solutions, like flood levees.

Non-structural measures include legislation, land-use planning (*e.g.*, the designation of nonessential land like parks to be used as flood zones), and insurance. Mitigation is the most cost-efficient method for reducing the impact of hazards, however it is not always suitable. Mitigation does include providing regulations regarding evacuation, sanctions against those who refuse to obey the regulations (such as mandatory evacuations), and communication of potential risks to the public. Some structural mitigation measures may have adverse effects on the ecosystem.

A precursor activity to the mitigation is the identification of risks. Physical risk assessment refers to the process of identifying and evaluating hazards. The hazard-specific risk ($R_h$) combines both the probability and the level of impact of a specific hazard. The equation under states that the hazard multiplied by the populations' vulnerability to that hazard produces a risk Catastrophe modelling. The higher the risk, the more urgent that the hazard specific vulnerabilities are targeted by mitigation and preparedness efforts. However, if there is no vulnerability there will be no risk, *e.g.*, an earthquake occurring in a desert where nobody lives $R_h = H \times V_n$.

## Preparedness

In the preparedness phase, emergency managers develop plans of action for when the disaster strikes.

*Common preparedness measures include*:

- Communication plans with easily understandable terminology and methods.
- Proper maintenance and training of emergency services, including mass human resources such as community emergency response teams.

- Development and exercise of emergency population warning methods combined with emergency shelters and evacuation plans.
- Stockpiling, inventory, and maintain disaster supplies and equipment.
- Develop organisations of trained volunteers among civilian populations. (Professional emergency workers are rapidly overwhelmed in mass emergencies so trained, organized, responsible volunteers are extremely valuable. Organisations like Community Emergency Response Teams and the Red Cross are ready sources of trained volunteers. The latter's emergency management system has gotten high ratings from both California, and the Federal Emergency Management Agency (FEMA).)

Another aspect of preparedness is casualty prediction, the study of how many deaths or injuries to expect for a given kind of event. This gives planners an idea of what resources need to be in place to respond to a particular kind of event. Emergency Managers in the planning phase should be flexible, and all encompassing—carefully recognizing the risks and exposures of their respective regions and employing unconventional, and atypical means of support. Depending on the region—municipal, or private sector emergency services can rapidly be depleted and heavily taxed. Non-governmental organisations that offer desired resources, *i.e.*, transportation of displaced homeowners to be conducted by local school district buses, evacuation of flood victims to be performed by mutual aide agreements between fire departments and rescue squads, should be identified early in planning stages, and practised with regularity.

## Response Phase

The response phase includes the mobilization of the necessary emergency services and first responders in the disaster area. This is likely to include a first wave of core emergency services, such as firefighters, police and ambulance crews. When conducted as a military operation, it is termed Disaster Relief Operation (DRO) and can be a follow-up to a Non-combatant evacuation operation (NEO). They may be supported by a number of secondary emergency services, such as specialist rescue teams. A well rehearsed emergency plan developed as part of the preparedness phase enables efficient coordination of rescue. Where required, search and rescue efforts commence at an early stage. Depending on injuries sustained by the victim, outside temperature, and victim access to air and water, the vast majority of those affected by a disaster will die within 72 hours after impact. Organizational response to any significant disaster—natural or terrorist-borne—is based on existing emergency management organizational systems and processes: the Federal Response Plan (FRP) and the Incident Command System (ICS). These systems are solidified through the principles of Unified Command (UC) and Mutual Aid (MA).

## Aim of the Recovery Phase

The aim of the recovery phase is to restore the affected area to its previous state. It differs from the response phase in its focus; recovery efforts are concerned with issues and decisions that must be made after immediate needs are addressed. Recovery efforts are primarily concerned with actions that involve rebuilding destroyed property, re-employment, and the repair of other essential infrastructure.

An important aspect of effective recovery efforts is taking advantage of a 'window of opportunity' for the implementation of mitigative measures that might otherwise be unpopular. Citizens of the affected area are more likely to accept more mitigative changes when a recent disaster is in fresh memory. In the United States, the National Response Plan dictates how the resources provided by the Homeland Security Act of 2002 will be used in recovery efforts. It is the Federal government that often provides the most technical and financial assistance for recovery efforts in the United States.

## FACETS OF DISASTER MANAGEMENT

Natural disasters are a tragic interruption to the development process. Lives are lost; social networks are disrupted; and capital investments are destroyed. In recent years, however, the development community has been making the links between disasters and development. This evolution would seem inevitable when one considers the disproportionately high costs that developing countries pay for disasters. Moreover, natural disasters impact developing countries in other ways than developed countries.

During a disaster, it is critical to have the right data, at the right time, displayed logically, to respond and take appropriate action. Disasters can impact all or a number of government departments. The different associated departments can share information through databases on computer-generated maps in one location.

The major problem in such situation is valuable "Time" which is going to be lost for the sake of 'searching for Information'. This results disaster responders having to guess, estimate or performance without loss of much time and effort. A comprehensive approach is adopted for data collection, organizing and display logically to determine the size and scope of disaster management Programmes.

The government's should take an initiative to prevent the loss of human lives, severe damage to ecology and economy of a region. The development plans should develop and additional aid is to be directed to relief and reconstruction needs to get the country "back on track" towards economic and social development. This is the time for the policy-makers to identify the GIS as "Recipe to Relief" for sustaining lives of mankind and the environment.

## DISASTER MANAGEMENT AND RECONSTRUCTION

The scope of disaster management and post reconstruction covers both natural and man-made disasters, including seismic events, drought, flood, war and famine.

The World Bank's Hazard Management Unit aims to reduce human suffering and economic losses caused by natural and technological disasters through providing a more strategic and rapid response to disasters, and promoting the integration of disaster prevention and mitigation efforts into the range of development activities.

## DISASTER MANAGEMENT TOOLS

### Abnormal Situation Management

Abnormal Situation Management is a comprehensive process or system for improving performance which addresses the entire plant population. It promotes effective utilization of all available resources—*i.e*. hardware, software, and people, to achieve safe and efficient operations.

#### *Situation/Benefits*

Since the early 1970's process Industries were faced with an alarming number of incidents causing undesired effects ranging from reduced profits to loss of lives. Industry began doing studies into the causes of these incidents and found that human factors had a significant impact. From the alertness level of operators, to poorly designed alarm systems and operator interface, to inappropriate staffing levels, to poorly designed work environments, human factor issues were a significant contributor to major and minor incidents. Incidents such as Three Mile Island and Texaco Pembroke were caused as a direct result of "human error."

#### *Abnormal Situations*

Abnormal situations encompass a range of events outside the "normal" plant operating modes, *e.g*. trips, fires, explosions, toxic releases, human error, or just not reaching planned targets.

#### *Abnormal Situation Management Consortium*

The Abnormal Situation Management Joint Research and Development Consortium conducts research and shares experiences on factors contributing to the successful reduction of abnormal situations in petrochemical processes, and develops, evaluates and proves new solutions to reduce risks even further. The ASM Consortium was informally established in 1992 as an outgrowth of an effort to define improvements to current DCS alarm system technologies. Realizing that the alarm system was but a part of the larger issue of the management of unexpected process upsets, a number of companies teamed with Honeywell to develop a problem statement and a vision for the solution. The ASM team has conducted many additional formal site studies, and other, less-formal, on-site analyses, to further develop our understanding of ASM best practices and deliver benefits to our Consortium member companies.

*The Best Practices Guidelines currently contain criteria in seven areas of interest*:

- Understanding of Abnormal Situation.
- Management Structure and Policy.
- Training and Skill Development.
- Communications.
- Procedures.
- Control Building Environment.
- Process Monitoring and Control Applications.

The ASM Consortium has agreed to share these best practices through paid site assessment studies to consortium and non-consortium members. The current members of the Consortium are BAW Architecture, Celanese, ChevronTexaco, ConocoPhillips, ExxonMobil, Honeywell, Shell, TTS Performance Systems, UCLA. Ian Nimmo, President of User Centred Design Services, INC, was the ASM Programme Director from it's inception until December 1999. User Centred Design Services was an Associate member from 2000 to 2005. The ASM Consortium operates a website that contains a large collection of public documents on the research Programme and solution elements.

### *Benefits*

These studies by Abnormal Situation Management Consortium® indicated that companies who achieved Best Practice in operations improve their productivity by 5 - 12 per cent.

### *Objectives*

The ASM Consortium achieves its mission with three Programmes—Research, Development and Deployment, and Communications—each has specific, interrelated objectives. In alignment with these high-level objectives, the ASM Consortium

Executive Steering Committee develops detailed objectives on an annual basis to focus activities in specific areas where there is a potential to significantly improve ASM practices. The amount of emphasis given to projects in each focus area is determined jointly by members of the Consortium.

Research Objectives Programme activities seek to identify, develop, evaluate and prove the feasibility of new solutions and associated enabling technologies to reduce risks even further; and facilitate technology transfer to user member sites and the Development Programme. Development and Deployment Objectives The objective of the development and deployment Programme is to capture the knowledge represented in and developed by the Consortium and to return it to customers in the form of products and services that are successfully deployed. The driving force of these developments will be to further the mission of converting ASM knowledge into practice.

Communications Objectives A primary objective of the ASM Consortium continues to be the exchange of information within the Consortium membership to enhance the understanding and use of effective ASM practices within Consortium member organisations. As appropriate, the Consortium publishes externally in the public domain to influence the global adoption of ASM solution concepts. The Consortium has recently increased its focus on external communications, and will begin public release of guideline documents in late 2008.

## BiPu

BiPu which is also known as “Bioremediation Infield Personnel Unit”, is a sanitation method suitable for disaster relief and for temporary or isolated locations. It consists of flat-packed plastic panels which fit together to make a box, which is buried in the ground, and a large plastic bag to be placed inside the box. It is quick to set up but also suitable for longer term use if required.

A latrine, (Western style, or Asian squat style) pour-flush latrine, is placed over the top. The water seal improves hygiene, compared to pit latrines. The box is open at the bottom so that rising water tables do not damage the BiPu.

## Catastrophe Modelling

Catastrophe modelling is the process of using computer-assisted calculations to estimate the losses that could be sustained by a portfolio of properties due to a catastrophic event such as a hurricane or earthquake. Cat modelling is especially applicable to analysing risks in the insurance industry and is at the confluence of actuarial science, engineering, meteorology, and seismology.

### *Perils Analysis*

*Natural catastrophes include*:

- Hurricane (main peril is wind damage; some models can also include storm surge)
- Earthquake (main peril is ground shaking; some models can also include fire following earthquakes and sprinkler leakage damage)
- Tornado
- Flood
- Wind storm/hail
- Wildfire.

*Other catastrophes include*:

- Terrorism events
- Warfare
- Casualty/liability events
- Displacement Crises

### *Lines of Business Models*

- Business personal property
- Commercial property
- Workers' compensation
- Automobile physical damage
- Leasehold improvements
- Limited liabilities
- Product liability

### *Input*

The input into a typical cat modelling software package is information on the properties being analysed. This is referred to as the exposure data, since the properties are exposed to catastrophe risk.

*The exposure data can be categorized into three basic groups*:

- Information on the site locations, referred to as geocoding data (street address, postal code, county/ CRESTA zone, et cetera).
- Information on the physical characteristics of the structures (construction, occupancy, year built, number of stories, et cetera).
- Information on the financial terms of the insurance coverage (coverage value, limit, deductible, et cetera).

### *Output*

The output is estimates of the losses that the model predicts would be associated with a particular event or set of events. When running a probabilistic model, the output is either a probabilistic loss distribution or a set of events that could be used to create a loss distribution; probable maximum losses (PMLs) and average annual losses (AALs) are calculated from the loss distribution. When running a deterministic model, losses caused by a specific event are calculated; for example, Hurricane Katrina or "a magnitude 8.0 earthquake in downtown San Francisco" could be analysed against the portfolio of exposures.

### *Uses*

Insurers and risk managers use cat modelling to assess the risk in a portfolio of exposures. This might help guide an insurer's underwriting strategy or help them decide how much reinsurance to purchase. Some state departments of insurance allow insurers to use cat modelling in their rate filings to help determine how much premium their policyholders are charged in catastrophe prone areas. Insurance rating agencies such as A. M. Best and Standard and Poor's use cat modelling to assess the financial strength of insurers that take on catastrophe risk. Reinsurers and reinsurance brokers use cat modelling in the pricing and structuring of reinsurance treaties. Likewise, cat bond investors, investment banks, and bond rating agencies use cat modelling in the pricing and structuring of catastrophe bond.

### *Demand Surge*

Some cat models allow the user the option of including demand surge in the loss estimates, which is post-event inflation. After a large disaster, construction material and Labour can temporarily be in short supply, so construction costs are inflated. The larger the impact of the event on the local economy, the larger the effect of demand surge. For example, an event that causes a $5 billion insurance industry loss might cause demand surge to increase construction costs by 5 per cent, while an event that causes a $40 billion insurance industry loss might cause demand surge to increase construction costs by 25 per cent.

## Disaster Informatics

Disaster Informatics is the study of the use of information and technology in the preparation, mitigation, response and recovery phases of disasters and other emergencies. At the School of Informatics and Pervasive Technology Labs at Indiana University, a uniquely qualified faculty of social informaticians, science informaticians and computer scientists are tackling problems in this area. Here are listed the disaster informatics projects that are currently underway.

### *LEAD-Linked Environments for Atmospheric Discovery*

The Linked Environments Atmospheric Discovery project seeks to create a high-speed computing and network infrastructure that would help meteorologists make more timely and accurate forecasts of hurricanes, tornadoes and other dangerous weather conditions. The national effort seeks to build a “faster-than-real time” system that could save lives and help the public take cover and safety officials better prepare for looming natural disasters.

### *Real Time Geospatial Disaster Prediction*

Hurricane Katrina demonstrated the usefulness of private citizen blogging as a tool for emergency information collation and dissemination. We are developing web-based applications that allow the integration of alerts and blog entries from official, trusted and unrestricted public sources in a combined map-enabled tool for assessing emerging situations and for the public to find local, relevant information. We are currently prototyping this system in the Bloomington community, with an emphasis on weather-related emergencies. We then hope to develop a completely independent, mobile kit that can be deployed in disaster areas, to allow logging of alerts and reports even when critical infrastructure is down.

### *Documenting Grassroots Efforts and Information Flows*

What can disaster relief teach us about harnessing amateur expertise? We are currently working with Harold Feld of the Media Access Project to look at one successful post-Katrina grassroots initiative and the lessons it can teach us: the deployment of wireless Internet service in the regions affected by the hurricane, and their role in facilitating relief and rescue work. We want to understand these complex information flows and the role of computer-mediated communication, the "recruitment" of individuals and their role in this initiative, the nature of technical and other expertise needed to make this happen, and evaluate the deployment of these ISPs and their impact on rescuers and evacuees.

We feel that this successful case study can teach us much about disaster preparedness, but also about the social networks, the role of grassroots volunteerism in telecommunications work, and the integration of academic and activist interests.

## HAZUS

HAZUS is a geographic information system-based natural hazard loss estimation software package developed and freely distributed by the Federal Emergency Management Agency (FEMA). In 1997 FEMA released its first edition of a commercial off-the-shelf loss and risk assessment software package built on GIS technology. This product was termed HAZUS. The current version is HAZUS-MH MR4 where MH stands for 'Multi-Hazards'. Currently HAZUS can model three types of hazards: flooding, hurricanes, and earthquakes. The model estimates the risk in three steps. First it calculates the exposure for a selected area, second, it characterizes the level or intensity of the hazard affecting the exposed area, and third, it uses the exposed area and the hazard to calculate the potential losses in terms of economic losses, structural damage, etc. Although it was developed with the US continent in focus, the HAZUS toolset has been adopted by emergency management organisations worldwide.

## Hexayurt

The Hexayurt is a simplified disaster relief shelter design. It is based on a geodesic geometry adapted to construction from standard 4×8 foot sheets of factory made construction material. It resembles a panel yurt, hence the name.

### *Design*

The basic model is 166 square feet (15.4 $m^2$) in size and uses 12-18 sheets of foil-covered polyisocyanurate insulation, or hexacomb cardboard. Buildings are held together with half-foot-wide foil-surfaced duct tape and anchored to the ground like tents. A plastic tarp provides a floor. This building's design is in the Buckminster Fuller lineage of using contiguous triangles to maximize the load-bearing ability of simple structures. The basic construction principle is to use full sheets for the walls. Sheets cut from one corner to the opposite corner provide right triangles. Each pair of right triangles can be assembled into a symmetric triangular roof panel.

Tape forms hinges for doors and windows. Window covers are hinged at the top to form window shades. Although construction is easy, plastic foam panels contain too much open space to fit many efficiently in a shipping container. The designer plans to use the expanding cardboard panels to solve that problem. Hexayurts can be fabricated from four-by-eight foot sheets of foam or hexacomb cardboard and duct tape. The cost has been estimated at $1,000 each. Plans are being developed to equip them with high-efficiency wood stoves, composting toilets and fluorescent lights. The instructions are available on Appropedia and are released as public domain by the inventor Vinay Gupta.

## *Hexayurt Infrastructure Package*

*The project makes suggestions for infrastructure*:

- For cooking and heat: Utilise a portable wood-gasifying stove with an AA- battery-powered fan. These burn ordinary materials like twigs and grass ten times more efficiently than an open fire, and three times more efficiently than the most efficient unpowered clay pot stoves.
- Use solar recharging of AA-size batteries to provide power for the stove, cold-cathode LED flashlights, and portable radios.
- Provide water via solar water disinfection.
- A portable composting toilet sanitizes human waste.
- The designer utilized a commercially-available inflatable satellite antenna for telecommunications.

## *Networked Domestic Disaster Response*

The hexayurt is integral to the Networked Domestic Disaster Response project, which focuses on public coordination of disaster relief efforts, offloading the responsibility largely from the state or government, which unites several cheap and readily available technologies to perform tasks that have been historically left to highly trained teams with expensive apparatus.

The plan outlines a system of cellphone-accessible databases which would collocate raw materials, displaced people, host families and volunteer building teams to rapidly provide temporary accommodations for people made homeless by a natural disaster or man-made circumstances. The plan has been positively reviewed by the American Red Cross and the Federal Emergency Management Agency.

The key feature to the use of hexayurts in the plan is that materials used for hexayurt construction are widely used in the American building industry. PIMA 4 billion board feet of polyisocyanurate insulation boards are used annually, which is enough to shelter 600,000 people if one day's worth of boards were converted into hexayurts. However, polyisocyanurate is less used in building industry outside North America.

## Human Impact Planning

Human Impact Planning is a facilitated planning process that produces a comprehensive plan for identifying and developing the policies, plans and procedures you feel are most important in helping your employees during a crisis. A Human Impact Plan is crucial for the effective management of critical incidents, emergencies, and crises, and for the recovery and sustainability of business operations; Human Impact Planning™ picks up where Business Continuity Plans leave off.

*Too often organisations wait until the middle of a crisis to make decisions regarding questions such as*:

- Will we pay death benefits to family members? How much? What's the process?
- Can we get our employees to work if they're afraid of a pandemic or terrorist attack?
- Will we cover the costs of housing if our employees must relocate to continue our operations? Do we have the proper alliance partners to house them?
- Do we have a system for identifying where our employees are at all times?
- How well-trained and prepared is our EAP to address psychological trauma?
- How do we maintain morale among employees?
- How do we establish a communication plan that actually works?

## Innovative Emergency Management

Innovative Emergency Management (IEM) is a Baton Rouge, Louisiana-headquartered risk management company founded in 1985. It is headed by CEO Madhu Beriwal. IEM has eight offices strategically located around the United States. Their areas of specialty include homeland security and emergency management, information technology, Defence support, and Programme integration support. On June 3, 2004 IEM was contracted by the Department of Homeland Security/Federal Emergency Management Agency to support development of a catastrophic hurricane response plan for Southeast Louisiana, including the City of New Orleans. The contract award for this plan was approximately $500,000. To develop the plan, IEM created a model of a simulated category 3 hurricane called Hurricane Pam and its associated consequences. The last exercise using Hurricane Pam was conducted on August 24, 2005. Hurricane Katrina made landfall on August 29, 2005, less than a week after this last exercise. Hurricane Pam was intended to be a series of exercises to develop a comprehensive emergency response plan and was only partially completed prior to Hurricane Katrina. Greg Palast IEM could not produce a copy of its hurricane evacuation plan for New Orleans a year after Hurricane Katrina hit.

However, a review of IEM's contract for Hurricane Pam indicates that an evacuation plan for New Orleans was never supposed to be developed as part of the contract. On December 14, 2009, Madhu Beriwal announced that IEM will be moving its corporate headquarters to the Research Triangle Park area near Raleigh, North Carolina. The move will occur by the end of September in 2010.

## Search and Rescue Optimal Planning System (SAROPS)

Search and Rescue Optimal Planning System (SAROPS) is a comprehensive search and rescue (SAR) planning system used by the United States Coast Guard in the planning and execution of almost all SAR cases in and around the United States and the Caribbean. SAROPS has three main components: The Graphical User Interface (GUI), the Environmental Data Server (EDS) and the Simulator (SIM). Using the Commercial Joint Mapping Tool Kit's (C/JMTK) government licensing of the Geographic Information System (GIS) SAROPS can be used in both a coastal and oceanic environment. Built into the simulator is the ability to access global and regional wind and current data sets making SAROPS the most comprehensive and powerful tool available for maritime SAR planners. Throughout the substance, the acronym SAR stands for search and rescue and can sometimes be confused with synthetic-aperture radar.

### *Motivation for the Development of SAROPS*

The U.S. Coast Guard uses a systematic approach for search and rescue operations. There are five SAR stages for any case: Awareness, Initial Actions, Planning, Operations and cease. Upon becoming aware of a case from a "MAYDAY" call or other form of communication, SAR controllers work to gather data about the case and more often than not, there are many uncertainties in the initial report. The controller, then, must develop a search area based upon the information, estimate resource availability and capability, promulgate the search plan and deploy the resources. While the assets are conducting a search, the controller begins the process again by gathering additional information, developing a subsequent search, deploying resources and evaluating already searches.

This process continues until the survivors are found and rescued or proper authorities suspend the SAR case. Consequently, there is a need for a tool that is fast, simple, minimizes data entry, minimizes potential for error, can access high-resolution environmental data, and create search action plans that maximize the probability of success. Furthermore, the National Search and Rescue Plan of the United States (2007), challenges search and rescue communities in the following passage. Recognizing the critical importance of reduced response time in successful rescue and similar efforts, a continual focus will be maintained on developing and implementing means to reduce the time required for: a. Receiving alerts and information associated with distress situations; b. Planning and coordinating operations; c. Facility transits and searches; d. Rescues; and e. Providing immediate assistance, such as medical assistance, as appropriate.

If this is not motivation enough, a USCG rotary-wing aircraft costs $9-14K per hour and a USCG cutter costs $3-15K per hour to operate. Reducing the time an aircraft is airborne or a cutter is in a search area can considerably reduce taxpayer costs as well as save lives and property. The U.S. Coast Guard contracted Northrop Grumman Corporation, Applied Science Associates (ASA), and Metron Inc., to develop a comprehensive system that included the latest graphical divergence parametres, Leeway divergence parametres, and Monte-Carlo methods to improve the probability of success of search cases. SAROPS meets and exceeds these expectations by minimize planning and response time frames.

### *SAROPS Components*

SAROPS is made up of the Graphical User Interface (GUI), the Environmental Data Server (EDS) and the Simulator (SIM).

### *Graphical User Interface*

The Graphical User Interface uses the Environmental Systems Research Institute (ESRI) Geographic Information System (ArcGIS) an has been altered to include U.S. Coast Guard specific applications such as the SAR Tools Extension and SAROPS Extension. The applications have a wizard-based interface and work within the ArcGIS layered environment. Vector and raster charts are available for display as well as search plans, search patters, search areas environmental data, probability maps. Finally, the GUI provides reports on all search operations.

### *Environmental Data Server (EDS)*

The Environmental Data Server (EDS) collects and stores environmental information for use within SAROPS. Local SAROPS servers around the United States request environmental information from the EDS based upon the area of interest. Different environmental products are catalogued on the server ranging from observational systems to modelling products. Observations include sea surface temperature, air temperature, visibility, wave height, global/region tides and currents to name a few. High-resolution model output from operational forecast models like the hybrid coordinate ocean model (HYCOM) and Global NRL Coastal Ocean (NCOM) provide temporally and spatially varying wind and current information. Lastly, the EDS is capable of providing objective analysis tools and aggregation. The list of available products is always changing as researchers in the Navy, local universities and research Centres continually improve the accuracy and reliability of products and make them available on a consistent basis.

### SAROPS Simulator

*Definitions*:

- *Probability of Containment (POC)*: The likelihood of the search object being contained within the boundaries of some area. It is possible to achieve 100 per cent POC by making the area larger and larger until all possible locations are covered.
- *Probability of Detection (POD)*: The likelihood of detecting an object or recognizing the search object. Different aircraft, environmental conditions and search object types can give a different probability of detection. Generally, the probability of detection decreases with increasing distance from the search object.
- *Probability of Success (POS)*: The likelihood that a search object will be found. POS depends upon the POC and the POD. POS = POC × POD.

### Simulator Wizard

The simulator wizard makes use of multiple pages of scenario descriptions that are entered by the user in order to compute the possible distress positions and times, subsequent search object drift trajectories, and the effect of completed searches on the search object probabilities. The simulator captures uncertainty in positions, time environmental inputs and leeway parametres.

Upon receiving all of the information pertinent to the case, the simulator, using Markov Monte Carlo techniques, simulates the drift of up to 10,000 particles for each scenario. For every 20 minutes of drift, the simulator accounts for changes in water current, wind leeway and leeway divergence. The simulator displays the results as a probability density map that can be animated over the drift duration.

The ensemble trajectory model, random walk and random flight model governing equations are fully explained in Breivik and Allen (2008) and Spaulding, *et al*. (2005) that is located within O'Donnell, *et al*. (2005). In short, the goal of the simulator is to maximize the probability of success.

### *Optimal Planner Wizard*

The optimal planning wizard takes the probability map information as well as another set of user inputs such as the type of resources, on scene conditions and sweep width values to develop search areas that maximize the POS. The search areas can be adjusted by the SAR controller to further maximize POS. Armed with the best possible fit given available resources, the SAR controller can then transmit the search pattern to the search assets. If the search object is not found on the first search, the optimal planning wizard will account for already unsuccessful searches when recommending subsequent searches.

### *Applications Outside of Search and Rescue*

SAROPS may be expanded to include other applications outside of search and rescue. These applications may include but are not limited to the projection of fisheries stocks and oil spill projections.

## Unified Victim Identification System (UVIS)

The Unified Victim Identification System (UVIS) is an Internet-enabled database system developed for the Office of Chief Medical Examiner of the City of New York (OCME) in the aftermath of the September 11 attacks on New York City and the crash of American Airlines Flight 587. It is intended to handle critical fatality management functions made necessary by a major disaster. In the event of a mass casualty event, it will initially be used by New York City's 311 call Centre operators, the New York Police Department, and OCME to gather key information to facilitate compiling an accurate list of missing persons. UVIS will also be used by the OCME to track decedents and collect postmortem findings to facilitate the identification process after a disaster. UVIS also contains a Pandemic Flu module to prepare against such an eventuality. UVIS was built for the OCME by Trumbull, Connecticut-based consulting firm Sapphire

International. Developed with public funds, UVIS is available to municipalities, counties, states, and other governmental agencies without charge, under license from New York City.

### *Ante-Mortem Section*

The Ante-Mortem Section relates to activities carried out before an individual is absolutely known to be deceased. These include recording key information about the missing individual and managing interactions with the missing person's family members.

### *Call Centre Module*

Mass casualty events generate numerous calls to government agencies: for example, the 2005 London subway bombing generated some 42,000 calls to the UK. Casualty Bureau call Centres within the Bureau's first hour of operation. The Call Centre module can handle tens of thousands of calls from individuals reporting or enquiring about missing persons, and record basic information about both the missing person and the caller.

### *Missing Persons Module*

The Missing Persons module enables NYPD Missing Persons detectives to conduct detailed interviews of family members, friends, and acquaintances of missing persons, and can store extremely detailed data ranging from clothing to physical characteristics such as eye and hair colour to tattoo or scar information.

### *Family Assistance Centre Module*

The UVIS Family Assistance Centre module manages Family Assistance Centres (FACs), which are established to provide services to, and capture information from, the family and friends of injured, missing, or deceased disaster victims. Services generally provided at a FAC include: grief counselling; childcare; religious support; facilitation of family needs such as hotel, food, and transportation; ante-mortem data collection by the investigative authorities and the medical examiner or coroner;

and notification of death to the next of kin. The UVIS Family Assistance Centre module tracks all interactions and appointments with the family of missing persons, and can manage the personal items of victims received from family members for identification purposes.

### *Records Module*

The Records modules handles requests for records from family members, lawyers, and public administrators, providing "Chain of Custody" for all records.

### *Post-Mortem Section*

The Post-Mortem Section deals with human remains recovered from mass casualty sites.

### *Field Operation Module*

The Field Operations module can help users to manage incidents, field investigation, and the collection of remains and evidence, as well as maintaining records and documentation about remains and evidence. Because internet connectivity will often be unavailable at disaster sites, the Field Operations module has a Microsoft Windows-based client version that can capture data off-line and synchronize with the main database when connectivity is available.

### *Disaster Mortuary Management Module*

The Disaster Mortuary Management module provides mortuary management functionality. It supports the accessioning of remains, both check-in and check-out; the examination of remains by Medical Examiner and Anthropology; the tracking and documentation of autopsies and individual remains; and the final disposition of remains to funeral homes.

### *Disaster Victim Identification Module*

This module has bidirectional one-to-many search capabilities based on multiple criteria. It possesses considerable identification tracking capabilities including DNA, fingerprint, radiology, and dental. The module enables identification review and verification, including DNA re-sampling. It also enables the consolidation of fragmented remains as they are uncovered. The Disaster Victim Identification module can conduct notification tracking, including communication both with family members and media about a given decedent. It is capable of issuing death certification either when remains are found or not. It also maintains a log of all family communications, and can schedule and track family visits.

### *UVIS Dental Identification Module (UDIM) Module*

A Forensic Odontology add-on complex and advanced search, and the ability to look for anomalies.

### *Pandemic Influenza Module*

Pandemic influenza remains a serious threat. The U.S. Health and Human Services Department forecasts that if a lethal flu pandemic strikes, deaths could range from 209,000 to 1.9 million.

Table. Number of Episodes of Illness, Health Care Utilization, and Death Associated with Moderate and Servere Pandemic Influenza Scenarios

| Characteristic | Moderate (1958/68-like) | Severe (1918-like) |
|---|---|---|
| Illness | 90 million(30%) | 90 million(30%) |
| Outpatient medical | 45 million(50%) | 45 million(50%) |
| Hospitalization | 865,000 | 9900000 |
| ICU care | 128750 | 1485000 |
| Mechanical Ventilation | 64875 | 742500 |
| Deaths | 209000 | 1903000 |

Estimates based on extrapolation from past pandemics in the United States. Note that these estimates do not include the potential impact of interventions not available during 20th century pandemics.

- If an influenza pandemic occurs, the magnitude of the event would demand a response from the NYC OCME to assist any governmental health care facilities as well as to support facilities in the private sector. Health care facilities which would be affected by a flu pandemic include public and private hospitals, nursing homes, retirement facilities, prison health clinics, public health clinics, and mental health hospitals.

- During a flu pandemic causing mass fatalities, the limited morgues and decedent storage space at most health care facilities will be quickly overwhelmed. The proposed solution consists of temporary morgues, known as Body Collection Points (BCPs), at health care facilities. These would be either refrigerated 18-wheel trailers or refrigerated CONEX containers.
- The UVIS Pandemic Flu module enables health care facility morgue managers to administrate BCPs, allowing them.
- Create a report for a set of remains, entering such information as the decedent's medical antiquity, usual residence, and next of kin, as well as report notes and the reporting physician's information. Creating a report automatically assigns a specimen number to the remains.
- Search for a decedent using the specimen number, last name, first name, and/or date of death.
- Check remains into or out of a BCP, storing them until they are ready to be released to a funeral home or funeral director. Remains can also be moved from one BCP location to another.
- Browse through all BCPs at the health care facility to locate remains.
- Create a request for a BCP storage unit.

The Pandemic Flu module also enables medical examiner personnel to handle health care facilities' requests for BCPs, managing the location and distribution of storage units at health care facilities, police precincts, or any other designated location. If necessary, they can place a request on behalf of a facility. As well, Pandemic Flu module enables medical examiner personnel to create reports for decedents and to search for decedents using the specimen number, last name, first name, and/or date of death. They can also track and record the progress of a decedent's case. Currently, the system tracks remains that are awaiting investigation, awaiting disposition, and transportation. UVIS tracks time elapsed in each state and colour-codes each record, giving an immediate visual indication of the status of each case. NYC OCME personnel can also search the New York State Electronic Death Record System (EDRS) for decedents. As part of UVIS, the Pandemic Influenza module's data is available for search within the system.

### *Administrative Section*

The Administrative Section allows users to create incidents, to which missing persons are attached; conduct records management; and carry out other system administration tasks.

### *Technical Description*

UVIS is a multi-tiered, browser- and Windows-based application, written in Microsoft-based technology, and running on a minimum configuration of Microsoft Windows Server 2003 and Microsoft SQL 2000/2005 as the database engine.

## Sahana FOSS Disaster Management System

The Sahana Free and Open Source Disaster Management System was conceived during the 2004 Sri Lanka tsunami. The system was developed to help manage the disaster and was deployed by the Sri Lankan government's Centre of National Operations (CNO), which included the Centre of Humanitarian Agencies (CHA). A second round of funding was provided by the Swedish International Development Agency (SIDA).

The project has now grown to become globally recognized, with deployments in many other disasters such as the Asian Quake in Pakistan (2005), Southern Leyte Mudslide Disaster in Philippines (2006) and the Jogjarkata Earthquake in Indonesia (2006).

Following the Tsunami, the system was rebuilt from scratch in Apache, MySQL, and PHP/Perl. The system is available for free for anyone to download and Customise and is distributed under the GNU Lesser General Public License (LGPL). The Project is now being ported to Python as an experimental fork SahanaPy so that the software can be extended.

### *Sahana Project Goals*

*The social goals of the Sahana project are*:

- *Primary:* Help alleviate human suffering and help save lives through the efficient use of IT during a disaster.
- Enhance collaboration between diverse set of actors from Government, Emergency Management, NGOs, INGOs, spontaneous volunteers and victims themselves in responding effectively to a disaster.
- Empower the victims and their next of kin and better enable them to help themselves.
- Protect victim data and reduce the opportunity for data abuse.
- Provide a Free and Open Source solution end-to-end available to everyone.

### *Functionality and Features*

The Sahana project aims to provide an integrated set of pluggable, Web-based disaster management applications that provide solutions to large-scale humanitarian problems in the relief phase of a disaster. Subsequent phases are planned to extend the scope to the prevention, rehabilitation and reconstruction phases. The Sahana project currently has 8 mature modules that address common disaster coordination and collaboration problems.

*They are*:

- Missing Person Registry.
- Organisation Registry.
- Request/Pledge Management System.
- Shelter Registry.
- Inventory Management.
- Catalogue.
- Situation Awareness.
- Volunteer coordination.

Sahana can also be deployed with a small sub-set of these modules.

### *Sahana Missing Person Registry*

The Missing Person Registry is an online bulletin board of missing and found people. It captures information about the people missing and found, and also the information of the person seeking them.

### *Sahana Organisation Registry*

The Organisation Registry is a collaborative “Who is doing what, where” tool which enables tracking of the relief organisations and other stakeholders working in the disaster region. It captures information about the places where each organisation is active and the range of services being provided.

### *Sahana Shelter Registry*

This sub-application of Sahana keeps track of the location and basic data of all the shelters in the region. It also provides a geospatial view to plot the location of the camps in the affected area.

### *Sahana Request/Aid Management System*

The Sahana Request/Aid Management System is a central online repository where all relief organisations, relief workers, government agents and camps can effectively match requests of aid and supplies to pledges of support. It tracks aid provision from request to fulfilment.

### *Sahana Volunteer Coordination System*

The Volunteer Coordination System helps NGOs keep track of all their volunteers, their contact information, project allocation, availability and skills to help them allocate them effectively especially in a disaster.

### *Sahana Situation Awareness*

This module gives an overview of the situation and allows people to add information on what is happening on the ground. It features the ability to plot a note and a photo with additional information on a Map, so that people can collaboratively capture the current disaster situation.

### *Technical Features*

After the Tsunami, the Sahana system was rebuilt from scratch under the Free and Open Source technology stack, LAMP.

*The new architectural framework provides the following features*:

- *Plugin Architecture:* Allows for the independent development modules by 3rd party groups easy whilst making integration simple.
- *Portable USB:* Can run without installation from a USB drive as a Portable Application where the Programme and code is contained in the USB flash drive.
- *Localization Ready:* Allows for the system to be translated into any language.
- *Granular Security:* Access Control can be specified by role, module and action performed.
- *Adaptable User Interface:* Allows for the look and feel of the system to adapt to the device that views it and it can be viewed through a PDA.

### *Flexible Deployment Strategy*

The Sahana system can be deployed on a variety of models, ranging from operating totally within a single notebook computer to a fully distributed, networked platform.

### *Large-scale Deployment*

Often the disaster coordination hub is far from the affected region, making network-based operation possible even though the affected region might have their telecommunications infrastructure destroyed.

Access can be provided in the affected region with the support of groups such as Ericsson who provide satellite-based wireless LAN connectivity to networks.

### *Lightweight Deployment*

If such infrastructure does not exist, Sahana, being a "lightweight" solution, can efficiently scale down to a standalone laptop and a secured portable wireless access point for short-range network collaboration. Such a requirement is often the case in a disaster coordination hub when there is no Internet or power during the initial moments post-disaster. The Sahana system has been tested to work with the above equipment at about 130W, which can be easily supported by a solar panel should power not be available.

Additionally none of the applications depends on being connected to the Internet. Sahana also has the ability to synchronize data between multiple instances of Sahana. This allows for responders or district offices to capture data on victims in the field and seamlessly exchange the data with the other field offices, headquarters or responders, using USB flash drives or CDs.

*Past Deployments*:

- *Tsunami*: Sri Lanka 2005—Officially deployed in the CNO for the Government of Sri Lanka
- *AsianQuake*: Pakistan 2005—Officially deployed with NADRA for the Government of Pakistan
- *Southern Leyte Mudslide Disaster*: Philippines 2006—Officially deployed with the NDCC and ODC for the Government of Philippines
- *Sarvodaya*: Sri Lanka 2006—Deployed for Sri Lanka's largest NGO
- *Terre des Hommes*: Sri Lanka 2006—Deployed with new Child Protection Module
- *Yogjakarta Earthquake*: Indonesia 2006—Deployed by ACS, urRemote and Indonesian whitewater association and Indonesian Rescue Source
- *Peru Earthquake*: Peru 2007—Deployed and localized into Spanish
- *Myanmar Cyclone*: Myanmar 2008- Currently working in progress to deploy and localize into Burmese
- *Haiti Earthquake*: Haiti 2010- Currently working in progress to deploy and localize into Port-au-Prince and Haiti

## *Sahana Structure*

The Sahana organisation structure includes a Sahana board, a Project Management Committee (PMC), Committers and the larger Community.

- *Board of Directors*: The Sahana Board is responsible for sustaining and promoting the adoption and growth of the Sahana. The Sahana Board will actively seek to engage with private sector, academic institutions and public sector partners in promoting the adoption and support of Sahana. The Sahana Board will establish a mechanism for evaluating the success of Sahana deployments and for capturing issues about Sahana development and implementation.
- *Project Management Committee (PMC)*: The role of the Project Management Committee (PMC) is to ensure that the community is behaving and governing itself in a manner that is consistent with the objectives of making Sahana a successful open source project. This includes operational, legal and procedural oversight on Sahana releases.
- *Committers*: Committers are those individuals who have gained the trust of the main contributors to Sahana and have direct access to contribute to the code, documentation or other Sahana resources.
- *Community*: The largest group in Sahana consists of the larger community of about 200+ people helping to promote, provide feedback and apply Sahana.
- *Sponsors*: The organisations and groups that keep us operational and running by donating funds, infrastructure and resources.

### *Humanitarian-FOSS Community*

Sahana also spawned a concept and community founded by a humanitarian consultant, Paul Currion, and the Sahana project lead, Chamindra de Silva, based on the more generic ideals of Humanitarian-FOSS where the ideals of FOSS are applied for building humanitarian-ICT applications or applications built to help alleviate human suffering.

The community consists of a mailing list and a WIKI with membership reaching 250+ Emergency Management practitioners, Humanitarian Consultants, Crisis Management Academics and Free and Open Source developers from around the world. Domain representation in this group includes members from ISCRAM, UNDP, Red Cross, IBM, Saravodaya, Australian Fire Services, etc. The concept has also been recognized specifically by the Free Software Foundation (FSF), where it inspired a new FSF Award for Projects of Social Benefit, which is broader in coverage than humanitarian-FOSS and by the UNDP IOSN on their Humanitarian-FOSS Portal.

### *Research*

The project has also spurred research in diverse areas. Louiqa Raschid, University of Maryland also the current Chair of the Sahana board, is leading/guiding the team in Sahana and Disaster Management research. Sahana has been presented at numerous conferences/workshops/events and already has one paper accepted for an international conference.

- A paper on Sahana and Disaster Management was accepted for the 2nd International Conference on Information and Automation 2006.

Research plays an important role in Sahana due to lack of already research in ICT for Disaster Management.

# 4

# Biological Warfare

Biological warfare (BW)—also known as germ warfare—is the use of biological toxins or infectious agents such as bacteria, viruses, and fungi with intent to kill or incapacitate humans, animals or plants as an act of war. Biological weapons (often termed "bio-weapons", "biological threat agents", or "bio-agents") are living organisms or replicating entities (viruses, which are not universally considered "alive") that reproduce or replicate within their host victims. Entomological (insect) warfare is also considered a type of biological weapon.

Biological weapons may be employed in various ways to gain a strategic or tactical advantage over an adversary, either by threats or by actual deployments. Like some of the chemical weapons, biological weapons may also be useful as area denial weapons. These agents may be lethal or non-lethal, and may be targeted against a single individual, a group of people, or even an entire population. They may be developed, acquired, stockpiled or deployed by nation states or by non-national groups. In the latter case, or if a nation-state uses it clandestinely, it may also be considered bioterrorism.

There is an overlap between BW and chemical warfare, as the use of toxins produced by living organisms is considered under the provisions of both the Biological Weapons Convention and the Chemical Weapons Convention. Toxins andPsychochemical weapons are often referred to as midspectrum agents. Unlike bioweapons, these midspectrum agents do not reproduce in their host and are typically characterized by shorter incubation periods.

## HISTORY OF BIOLOGICAL WARFARE

Biological weapons include any organism (such as bacteria, viruses, or fungi) or toxin found in nature that can be used to kill or injure people. (Toxins are poisonous compounds produced by organisms.) The act of bioterrorism can range from a simple hoax to the actual use of these biological weapons, also referred to as agents. A number of nations have or are seeking to acquire biological warfare agents, and there are concerns that terrorist groups or individuals may acquire the technologies and expertise to use these destructive agents. Biological agents may be used for an isolated assassination, as well as to cause incapacitation or death to thousands.

*If the environment is contaminated, a long-term threat to the population could be created*:

- *History*: The use of biological agents is not a new concept, and history is filled with examples of their use.
  - Attempts to use biological warfare agents date back to antiquity. Scythian archers infected their arrows by dipping them in decomposing bodies or in blood mixed with manure as far back as 400 BC. Persian, Greek, and Roman literature from 300 BC quotes examples of dead animals used to contaminate wells and other sources of water. In the Battle of Eurymedon in 190 BC, Hannibal won a naval victory over King Eumenes II of Pergamon by firing earthen vessels full of venomous snakes into the enemy ships.
  - During the battle of Tortona in the 12th century AD, Barbarossa used the bodies of dead and decomposing soldiers to poison wells. During the siege of Kaffa in the 14th century AD, the attacking Tatar forces hurledplague-infected corpses into the city in an attempt to cause an epidemic within enemy forces. This was repeated in 1710, when the Russians besieging Swedish forces at Reval in Estonia catapulted bodies of people who had died from plague.

- During the French and Indian War in the 18th century AD, British forces under the direction of Sir Jeffrey Amherst gave blankets that had been used by smallpox victims to the Native Americans in a plan to spread the disease.
- Allegations were made during the American Civil War by both sides, but especially against the Confederate Army, of the attempted use of smallpox to cause disease among enemy forces.

• *Modern times*: Biological warfare reached sophistication during the 1900s.
  - During World War I, the German Army developed anthrax, glanders, cholera, and a wheat fungus specifically for use as biological weapons. They allegedly spread plague in St. Petersburg, Russia, infected mules with glanders in Mesopotamia, and attempted to do the same with the horses of the French Cavalry.
  - The Geneva Protocol of 1925 was signed by 108 nations. This was the first multilateral agreement that extended prohibition of chemical agents to biological agents. Unfortunately, no method for verification of compliance was addressed.
  - During World War II, Japanese forces operated a secret biological warfare research facility (Unit 731) in Manchuria that carried out human experiments on prisoners. They exposed more than 3,000 victims to plague, anthrax, syphilis, and other agents in an attempt to develop and observe the disease. Some victims were executed or died from their infections. Autopsies were also performed for greater understanding of the effects on the human body.
  - In 1942, the United States formed the War Research Service. Anthrax and botulinum toxin initially were investigated for use as weapons. Sufficient quantities of botulinum toxin and anthrax were stockpiled by June 1944 to allow

unlimited retaliation if the German forces first used biological agents. The British also tested anthrax bombs on Gruinard Island off the northwest coast of Scotland in 1942 and 1943 and then prepared and stockpiled anthrax-laced cattle cakes for the same reason.

– The United States continued research on various offensive biological weapons during the 1950s and 1960s. From 1951-1954, harmless organisms were released off both coasts of the United States to demonstrate the vulnerability of American cities to biological attacks. This weakness was tested again in 1966 when a test substance was released in the New York City subway system.
– During the Vietnam War, Viet Cong guerrillas used needle-sharp punji sticks dipped in feces to cause severe infections after an enemy soldier had been stabbed.
– In 1979, an accidental release of anthrax from a weapons facility in Sverdlovsk, USSR, killed at least 66 people. The Russian government claimed these deaths were due to infected meat and maintained this position until 1992, when Russian President Boris Yeltsin finally admitted to the accident.

## BIOTERRORISM AND BIOWARFARE TODAY

- *Bioterrorism and biowarfare today*: A number of countries have continued offensive biological weapons research and use. Additionally, since the 1980s, terrorist organizations have become users of biological agents. Usually, these cases amount only to hoaxes. However, the following exceptions have been noted:
  – In 1985, Iraq began an offensive biological weapons programme producing anthrax, botulinum toxin, and aflatoxin. During Operation Desert Storm, the coalition of allied forces faced the threat of chemical and biological agents. Following the Persian Gulf War, Iraq disclosed

that it had bombs, Scud missiles, 122-mm rockets, and artillery shells armed with botulinum toxin, anthrax, and aflatoxin. They also had spray tanks fitted to aircraft that could distribute agents over a specific target.

– In September and October of 1984, 751 people were intentionally infected withSalmonella, an agent that causes food poisoning, when followers of the Bhagwan Shree Rajneesh contaminated restaurant salad bars in Oregon.
– In 1994, a Japanese sect of the Aum Shinrikyo cult attempted an aerosolized (sprayed into the air) release of anthrax from the tops of buildings in Tokyo.
– In 1995, two members of a Minnesota militia group were convicted of possession of ricin, which they had produced themselves for use in retaliation against local government officials.
– In 1996, an Ohio man attempted to obtain bubonic plague cultures through the mail.
– In 2001, anthrax was delivered by mail to U.S. media and government offices. There were four deaths.
– In December 2002, six terrorist suspects were arrested in Manchester, England; their apartment was serving as a "ricin laboratory." Among them was a 27-year-old chemist who was producing the toxin. Later, on Jan. 5, 2003, British police raided two residences around London and found traces of ricin, which led to an investigation of a possible Chechen separatist plan to attack the Russian embassy with the toxin; several arrests were made.
– On Feb. 3, 2004, three U.S. Senate office buildings were closed after the toxin ricin was found in a mailroom that serves Senate Majority Leader Bill Frist's office.

## WHAT ARE BIOLOGICAL AND TOXIN WEAPONS

Biological weapons are complex systems that disseminate disease-causing organisms or toxins to harm or kill humans, animals or plants. They generally consist of two parts – a weaponized agent and a delivery mechanism. In addition to strategic or tactical military applications, biological weapons can be used for political assassinations, the infection livestock or agricultural produce to cause food shortages and economic loss, the creation of environmental catastrophes, and the introduction of widespread illness, fear and mistrust among the public.

Almost any disease-causing organism (such as bacteria, viruses, fungi, prions or rickettsiae) or toxin (poisons derived from animals, plants or microorganisms, or similar substances produced synthetically) can be used in biological weapons. The agents can be enhanced from their natural state to make them more suitable for mass production, storage, and dissemination as weapons. Historical biological weapons programmes have included efforts to produce: aflatoxin; anthrax; botulinum toxin; foot-and-mouth disease; glanders; plague; Q fever; rice blast; ricin; Rocky Mountain spotted fever; smallpox; and tularaemia, among others. Biological weapon delivery systems can take a variety of forms. Past programmes have constructed missiles, bombs, hand grenades and rockets to deliver biological weapons. A number of programmes also designed spray-tanks to be fitted to aircraft, cars, trucks, and boats. There have also been documented efforts to develop delivery devices for assassinations or sabotage operations, including a variety of sprays, brushes, and injection systems as well as means for contaminating food and clothing. In addition to concerns that biological weapons could be developed or used by states, recent technological advances increase the likelihood that these weapons could be acquired or produced by non-state actors, including individuals and terrorist organizations.

For more information about recent scientific and technological advances relevant to the Convention. The 20th century saw the use of biological weapons by individuals and groups committing criminal acts or targeted assassinations, biological warfare conducted by states, and the accidental release of pathogens from laboratories. There were also several false accusations of biological weapons use, highlighting the difficulty in differentiating between naturally-occuring disease, accidents, and deliberate use.

| Natural disease outbreak | Unintended consequences | Accidents | Negligence | Vandalism/ sabotage | Deliberate use of BW |
|---|---|---|---|---|---|

In practice, should a suspicious disease event occur, it would be difficult to determine if it was caused by nature, an accident, sabotage, or an act of biological warfare or terrorism. Consequently, the response to a biological event, whether natural, accidental or deliberate, would involve the coordination of actors from many sectors who together posses the capability to determine the cause and attribute it to a specific source. Likewise, the preparedness for and prevention of such an event should also involve multi-sectoral coordination. For more information about preparing for and responding to disease outbreaks and biological weapons attacks, please see the frequently asked questions published by the World Health Organization. Because of the wide spectrum of potential biological hazards, efforts to manage the risks should be multi-disciplinary, multi-sectoral, and above all, coordinated. As such, the BWC relies primarily on a network approach based on coordination with international, regional, and non-governmental organizations and initiatives as well as other non-proliferation regimes in order to address the interconnected nature of biological threats in a holistic manner.

Under the framework of the BWC, improved coordination would provide positive externalities for managing disease, whatever the cause. Such an approach ensures that resources are used optimally to provide benefits for many. In this sense, for example, building capacities across sectors to monitor disease would not only strengthen the ability to detect and respond to a biological attack, but it would provide states with the capacity to track and mitigate naturally occurring disease thus vastly improving public health worldwide.

## HISTORICAL ASPECTS OF BIOLOGICAL WARFARE AGENTS

Biological weapons include any organism or toxin found in nature that can be used to incapacitate, kill, or otherwise impede an adversary. Biological weapons are characterized by low visibility, high potency, substantial accessibility, and relatively easy delivery.

The potential spectrum of bioterrorism ranges from hoaxes and use of non–mass casualty agents by individuals or small groups to state-sponsored terrorism that employs classic biological warfare (BW) agents and can produce mass casualties. Such scenarios would present serious challenges for patient treatment and for prophylaxis of exposed persons. Environmental contamination could pose continuing threats. The use of biological agents is not a new concept, and history is replete with examples of biological weapon use.

*Before the* 20th *century, biological warfare took on 3 main forms*:

1. Deliberate poisoning of food and water with infectious material.
2. Use of microorganisms or toxins in some form of weapon system.
3. Use of biologically inoculated fabrics.

Attempts to use BW date back to antiquity. Scythian archers infected their arrows by dipping them in decomposing bodies or in blood mixed with manure as far back as 400 BC. Persian, Greek, and Roman literature from 300 BC quote examples of the use of animal cadavers to contaminate wells and other sources of water. In 190 BC, at the Battle of Eurymedon, Hannibal won a naval victory over King Eumenes II of Pergamon by firing earthen vessels full of venomous snakes into the enemy ships.

In the 12th century AD, during the battle of Tortona, Barbarossa used the bodies of dead soldiers to poison wells. In the 14th century AD during the siege of Kaffa, the attacking Tarter force hurled the corpses of those who died of plague into the city to attempt to inflict a plague epidemic upon the enemy. This was repeated in 1710 when the Russians besieging Swedish forces at Reval in Estonia catapulted plague cadavers. In the 18th century AD during the French and Indian War, British forces in North America gave blankets from smallpox patients to the Native Americans to create a transmission of the disease to the immunologically naïve tribes. In 1863, a confederate surgeon was arrested and charged with attempting to import yellow fever–

infected clothes into the northern parts of the United States during the Civil War.

Biological warfare became more sophisticated against both animals and humans during the 1900s. During World War I, the Germans developed anthrax, glanders, cholera, and a wheat fungus for use as biological weapons. They allegedly spread plague in St Petersburg, infected mules with glanders in Mesopotamia, and attempted to do the same with the horses of the French Calvary.

In 1925, the Geneva Protocol was signed by 108 nations, including the 5 permanent members of the United Nations Security Council. This was the first multilateral agreement that extended prohibition of chemical agents to biological agents. No method for verification of compliance was addressed. During World War II, the Japanese operated a secret BW research facility in Manchuria and carried out human experiments on Chinese prisoners. They exposed more than 3000 victims to plague, anthrax, syphilis, and other agents. Victims were observed for development of disease, and autopsies were performed.

In 1942, the United States formed the War Research Service. Anthrax and botulinum toxin initially were investigated for use as weapons, and sufficient quantities of botulinum toxin and anthrax cattle cakes were stockpiled by June 1944 to allow limited retaliation if the Germans first used biological agents. The British tested anthrax bombs on Gruinard Island off the northwest coast of Scotland in 1942 and 1943 and then prepared and stockpiled anthrax-laced cattle cakes. The United States continued research on various offensive biological weapons during the 1950s and 1960s. From 1951-1954, simulants (Bacillus globigii,Serratia marcescens) were released off both coasts of the United States to demonstrate the vulnerability of American cities to biological agent attacks. This vulnerability was tested again in 1966 when the simulant B globigii was released in the New York subway system. A US testing facility and the United States Army Medical Research Institute of Infectious Diseases building are shown in the photos below.

The "eight ball" 1 million litre test sphere at Fort Detrick, Maryland. This aerobiology chamber was used before 1969 when the United States was performing offensive biological warfare research. Animals were tethered within the sphere while aerosolized agents were aerosolized. Front of main building at the United States Army Medical Research Institute of Infectious Diseases (USAMRIID) on the grounds of Fort Detrick, Maryland.

In 1957, the British government decided to end its offensive BW capabilities and destroy its weapon stockpiles. The United States terminated its offensive biological weapons programme in 1969 for microorganisms and in 1970 for toxins. The United States is a signatory nation of the Biological Toxin Weapons Convention of 1972. This convention addressed the prohibition of the development, production, stockpiling, and destruction of bacteriologic and toxin weapons. Signatories to this agreement are required to submit information annually to the United Nations concerning facilities where biological defence research is being conducted, scientific conferences that are held at specified facilities, exchanges of scientists or information, and disease outbreaks. American stockpiles of biological weapons were destroyed completely by 1973.

During the Vietnam War, Vietcong guerrillas used punji stakes dipped in feces to increase the morbidity from wounding by these stakes. The Soviet Union (USSR) continued to develop biological weapons from 1950-1980. In the 1970s, the USSR and its allies were suspected of having used "yellow rain" (trichothecene mycotoxins) during campaigns in Loas, Cambodia, and Afghanistan. In 1979, an accidental release of anthrax from a weapons facility in Sverdlovsk, USSR, killed at least 66 people. The Russians denied this accident until 1992. Since the 1980s, terrorist organizations have become users of biological agents. The most frequent bioterrorism episodes have involved contamination of food and water. In September and October of 1984, 751 persons were infected withSalmonella typhimurium after an intentional contamination of restaurant salad bars in Oregon by followers of the Bhagwan Shree Rajneesh.

In 1985, Iraq began an offensive biological weapons programme producing anthrax, botulinum toxin, and aflatoxin. During Operation Desert Shield, the coalition of allied forces faced the threat of chemical and biological agents. Following the

Persian Gulf War, Iraq disclosed that it had bombs, Scud missiles, 122-mm rockets, and artillery shells armed with botulinum toxin, anthrax, and aflatoxin. They also had spray tanks fitted to aircraft that could distribute 2000 L over a target. Currently, 10 countries are suspected of having an offensive BW programme. In 1992, 20 people were administered chemoprophylaxis after a Virginia man sprayed his roommates with a substance that he claimed was anthrax. In 1994, a Japanese sect of the Aum Shinrikyo cult attempted an aerosolized release of anthrax from the tops of buildings in Tokyo. In 1995, 2 members of a Minnesota militia group were convicted of possession of ricin, which they had produced themselves for use in retaliation against local government officials. In 1996, an Ohio man was able to obtain bubonic plague cultures through the mail.

In 1997, the Defence Against Weapons of Mass Destruction Act directed the Department of Defence to establish a domestic preparedness programme to improve the ability of local, state, and federal agencies to respond to biological incidents. During 1998 and 1999, multiple hoaxes occurred involving the threatened release of anthrax in the United States that resulted in decontamination and antibiotic prophylaxis for the intended victims. Nearly 6000 persons across the United States have been affected by these threats. According to a study by the Centers for Disease Control and Prevention (CDC), an intentional release of anthrax by a bioterrorist in a major US city would result in an economic impact of $477.8 million to $26.2 billion per 100,000 persons exposed.

From September to November 2001, a total of 23 confirmed or suspected cases of bioterrorism-related anthrax (10 inhalation, 13 cutaneous) occurred in the United States. Most cases involved postal workers in New Jersey and Washington DC, and the rest occurred at media companies in New York and Florida, where letters contaminated with anthrax were handled or opened. As a result of these cases, approximately 32,000 persons with potential exposures initiated antibiotic prophylaxis to prevent anthrax infections. The threat that biological agents will be used on military forces and civilian populations is now more likely than at any point in all of history.

## DELIVERY, DISSEMINATION, AND DETECTION OF BIOLOGICAL WARFARE AGENTS

Biological agents are easy to acquire, synthesize, and use. The small amount of agents necessary to kill hundreds of thousands of people in a metropolitan area make the concealment, transportation, and dissemination of biological agents relatively easy. In addition, BW agents are difficult to detect or protect against; they are invisible, odourless, and tasteless, and their dispersal can be performed silently.

Dissemination of BW agents may occur by aerosol sprays, explosives (artillery, missiles, detonated bombs), or food or water contamination. Variables that can alter the effectiveness of a delivery system include particle size of the agent, stability of the agent under desiccating conditions, UV light, wind speed, wind direction, and atmospheric stability.

The use of an explosive device to deliver and disseminate biological agents is not very effective, since such agents tend to be inactivated by the blast. Contamination of municipal water supplies requires an unrealistically large amount of agent and introduction into the water after it passes through a regional treatment facility.

To be an effective biological weapon, airborne pathogens must be dispersed as fine particles less than 5μ m in size. Infection with an aerosolized agent usually requires deep inspiration of an infectious dose. Advanced weapons systems (eg, warheads, missiles) are not required for the aerosolized delivery of biological agents. Low-technology aerosolization methods including agricultural crop-dusters; aerosol generators on small boats, trucks, or cars; backpack sprayers; and even purse-size perfume atomizers suffice. Aerosolized dispersal of biological agents is the mode most likely to be used by terrorists and military groups. Detection of biological agents involves either finding the agent in the environment or medical diagnosis of the agent's effect on human or animal victims. Early detection of a biological agent in the environment allows for early specific treatment and time during which prophylaxis would be effective. Unfortunately, currently no reliable detection systems exist for BW agents. The

US Department of Defence has placed a high priority on research and development of a detector system. Methods are being developed and tested to detect a biological aerosol cloud using an airborne pulsed laser system to scan the lower altitudes upwind from a possible target area. A detection system mounted on a vehicle also is being developed. This system will analyze air samples to provide a plot of particle sizes, detect and classify bacterial cells, and measure DNA content, ATP content, and identify agents using immunoassays.

A BW agent attack is likely to be covert. Thus, detection of such an attack requires recognition of the clinical syndromes associated with various BW agents. Physicians must be able to identify early victims and recognize patterns of disease. This requires integrated epidemiologic surveillance systems performing real-time monitoring with information shared at many levels of the health care system (eg, ED to ED, ED to public health officials).

*Preliminary criteria for suggestive outbreaks of disease that could provide indications of a possible biological weapons event include the following*:

- Disease (or strain) not endemic
- Unusual antibiotic resistance patterns
- Atypical clinical presentation
- Case distribution geographically and/or temporally inconsistent (eg, compressed time course)
- Other inconstant elements (eg, number of cases, mortality and morbidity rates, deviations from disease occurrence baseline)

*Indications of possible BW agent attack include the following*:

- Disease entity that is unusual or that does not occur naturally in a given geographic area or combinations of unusual disease entities in the same patient population
- Multiple disease entities in the same patients, indicating that mixed agents have been used in the attack
- Large numbers of both military and civilian casualties when such populations inhabit the same area

- Data suggesting a massive point-source outbreak
- Apparent aerosol route of infection
- High morbidity and mortality rates relative to the number of personnel at risk
- Illness limited to fairly localized or circumscribed geographic areas
- Low attack rates in personnel who work in areas with filtered air supplies or closed ventilation systems
- Sentinel dead animals of multiple species
- Absence of a competent natural vector in the area of outbreak (for a biological agent that is vector-borne in nature)

## Protective Measures

Protective measures can be taken against BW agents. These should be implemented early (if warning is received) or later (once suspicion of BW agent use is made). Currently, available masks such as the military gas mask or high-efficiency particulate air (HEPA) filter masks used for tuberculosis (TB) exposure filter out most BW particles delivered by aerosol. Multilayered HEPA masks can filter 99.9 per cent of 1- to 5-μ m particles, but face-seal leaks may reduce the efficacy by as much as 10-20 per cent. Individual face-fit testing is required to correct seal leak problems.

Most aerosolized biological agents do not penetrate unbroken skin, and few organisms adhere to skin or clothing. After an aerosol attack, simple removal of clothing eliminates a great majority of surface contamination. Thorough showering with soap and water removes 99.99 per cent of the few organisms left on the victim's skin after disrobing. The use of sodium hypochlorite is not recommended over soap and water. The use of special suits by health care providers is not necessary. Normal clothing provides a reasonable degree of protection against dermal exposure.

Latex gloves and universal precautions provide sufficient protection when treating most infected patients. Place patients in a private negative-pressure room and practice proper sanitation with universal precautions. Proper disposal of corpses is essential. In the case of anthrax spores, this should be performed by incineration. Of the potential BW agents, only plague, smallpox, and viral hemorrhagic fevers are spread readily person to person by aerosol and require more than standard infection control precautions (gown, mask with eye shield, gloves). Regardless, place all potential victims of BW agents in isolation. Medical personnel caring for these patients should wear a HEPA mask in addition to standard precautions pending the results of a more complete evaluation.

Broad-spectrum intravenous antibiotic coverage is recommended initially for victims when a BW agent is suspected. Institute this even prior to the identification of the specific BW agent. Vaccinations currently are available for anthrax, botulinum toxin, tularemia, plague, Q fever, and smallpox. The widespread immunization of non-military personnel has not been recommended by any governmental agency. Immune protection against ricin and staphylococcal toxins may be feasible in the near future.

## BIOLOGICAL THREAT AGENTS

### ANTHRAX

### Fact Sheet

Anthrax is a zoonotic disease caused by Bacillus anthracis. There are three types of this disease: cutaneous anthrax, inhalation anthrax, and gastrointestinal anthrax. About 95 per cent of the human anthrax cases in the United States have been in the former category. Cutaneous anthrax develops when a bacterial organism from infected animal tissues becomes deposited under the skin. When a patient contracts cutaneous anthrax, he develops a small elevated lesion on his skin which becomes a skin ulcer, frequently surrounded by swelling or edema. The lymph gland near the lesion may also swell from the infection. If the lesion occurs on the neck or on or about the eye, it may cause complications. The incubation period for cutaneous anthrax is from one to seven days. When a patient does not receive an effective antibiotic, the mortality rate for cutaneous anthrax is 10-20 per cent. With treatment, the mortality rate falls to less than 1 per cent. Inhalation anthrax develops when the bacterial organism is inhaled into the lungs. A progressive infection follows. Since inhalation anthrax is usually not diagnosed in time for treatment, the mortality rate in the United States is 90-100 per cent. A biological attack with anthrax spores delivered by aerosol would cause inhalation anthrax, an extraordinarily rare form of the naturally occurring disease.

A lethal dose of anthrax is considered to be 10,000 spores; 80 per cent of a population that inhaled such a dose would die. Less than one millionth of a gram is invariably fatal within five days to a week after exposure. According to an estimate by the U.S. Congress's Office of Technology Assessment, 100 kilograms of anthrax, released from a low-flying aircraft over a large city on a clear, calm night, could kill one to three million people.

The disease begins after an incubation period varying from 1-6 days, presumably dependent upon the dose of inhaled organisms. Onset is gradual and non-specific, with fever, malaise, and fatigue, sometimes in association with a non-productive cough and mild chest discomfort. In some cases, there may be a short period of improvement. The initial symptoms are followed in 2-3 days by the abrupt development of severe respiratory distress with dyspnea, diaphoresis, strider, and cyanosis. Physical findings may include evidence of pleural effusions, edema of the chest wall, and meningitis. Chest x-ray reveals a dramatically widened mediastinum, often with pleural effusions, but typically without infiltrates. Shock and death usually follow within 24-36 hours of respiratory distress onset.

An epidemic of inhalation anthrax in its early stage with non-specific symptoms could be confused with a wide variety of viral, bacterial, and fungal infections. Progression over 2-3 days with the sudden development of severe respiratory distress followed by shock and death in 24-36 hours in essentially all untreated cases eliminates diagnoses other than inhalation anthrax. The presence of a widened mediastinum on chest x-ray, in particular, should alert one to the diagnosis. Other suggestive findings include chest-wall edema, hemorrhagic pleural effusions, and hemorrhagic meningitis. Other diagnoses to consider include aerosol exposure to SEB; but in this case onset would be more rapid after exposure (if known), and no prodrome would be evident prior to onset of severe respiratory symptoms. Mediastinal widening on chest x-ray will also be absent. Patients with plague or tularemia pneumonia will have pulmonary infiltrates and clinical signs of pneumonia (usually absent in anthrax).

Almost all cases of inhalation anthrax in which treatment was begun after patients were symptomatic have been fatal, regardless of treatment. Historically, penicillin has been regarded as the treatment of choice, with 2 million units given intravenously every 2 hours. Tetracycline and erythromycin have been recommended in penicillin-sensitive patients. The vast majority of anthrax strains are sensitive *in vitro* to penicillin. However, penicillin-resistant strains exist naturally, and one has been recovered from a fatal human case. Moreover, it is not difficult to induce resistance to penicillin, tetracycline, erythromycin, and many other antibiotics through laboratory manipulation of organisms. All naturally occurring strains tested to date have been sensitive to erythromycin, chloramphenicol, gentamicin, and ciprofloxacin.

Vaccines are available against some forms of anthrax, but their efficacy against abnormally high concentrations of the bacteria is uncertain. A licensed, alum-precipitated preparation of purified B.anthracis protective antigen (PA) has been shown to be effective in preventing or significantly reducing the incidence of inhalation anthrax. Limited human data suggest that after completion of the first three doses of the recommended six-dose primary series (0, 2, 4 weeks, then 6, 12, 18 months), protection against both cutaneous and inhalation anthrax is afforded. As with all vaccines, the degree of protection depends upon the magnitude of the challenge dose; vaccine-induced protection is undoubtedly overwhelmed by extremely high spore challenge.

If there is information indicating that a biological weapon attack is imminent, prophylaxis with ciprofloxacin (500mg orally twice a day), or doxycycline (100mg orally twice a day) is recommended. If unvaccinated, a single 0.5mL dose of vaccine should also be given subcutaneously. Should the attack be confirmed as anthrax, antibiotics should be continued for at least 4 weeks in all exposed.

## Diagnosis - Anthrax

The most critical aspect in making a diagnosis is a high index of suspicion associated with a compatible history of exposure. Consider cutaneous anthrax following the development of a painless, pruritic papule, vesicle, or ulcer. This area often is associated with surrounding edema that develops into a black eschar. With extensive or massive edema, such a lesion is almost pathognomonic. Gram stain or culture of the lesion confirms the diagnosis. A punch biopsy of the leading margin can be used for immunostaining. The differential diagnosis should include tularemia and staphylococcal or streptococcal species.

The diagnosis of inhalation anthrax is extremely difficult because no rapid-screening tests are available, but suspect the disease with a history of exposure to a B anthracis –containing aerosol. Early symptoms are entirely non-specific. The development of respiratory distress in association with radiographic evidence of a widened mediastinum due to hemorrhagic mediastinitis and the presence of hemorrhagic pleural effusions or hemorrhagic meningitis should suggest the diagnosis. Sputum Gram stain and culture usually are not helpful because pneumonia is an uncommon feature of illness. Gram stain of peripheral blood may be positive for gram-positive bacilli, often seen in short and long chains, and should be performed.

GI anthrax also is exceedingly difficult to diagnose because of the rarity of the disease and non-specific symptoms. Diagnosis usually is confirmed only with a history of ingesting contaminated meat in the setting of an outbreak. Once again, cultures generally are not helpful in making the diagnosis. Meningitis from anthrax is clinically indistinguishable from meningitis due to other etiologies. A distinguishing feature is that the spinal fluid is hemorrhagic in as many as 50 per cent of patients. Identification of the organism in the spinal fluid by microscopy, culture, or both confirms the diagnosis.

Serology can be used to make a retrospective diagnosis.

Antibody develops in 68-93 per cent of reported cases of cutaneous anthrax and 67-94 per cent of reported cases of oropharyngeal anthrax. A positive skin test result to anthracin also has been used to make a retrospective diagnosis of anthrax.

The most useful microbiologic test is the standard blood culture, which is almost always positive in patients with systemic illness. Blood cultures should show growth in 6-24 hours. If the laboratory has been alerted to the possibility of anthrax, biochemical testing and review of colonial morphology should provide a preliminary diagnosis 12-24 hours later. However, if the laboratory has not been alerted to the possibility of anthrax, B anthracis may not be identified correctly.

New rapid diagnostic tests for B anthracis and its proteins include polymerase chain reaction (PCR), enzyme-linked immunoassay (ELISA), and direct fluorescent antibody (DFA) testing and can be utilized on blood and body fluid specimens. Currently, these tests are only available at national reference laboratories.

## Treatment - Anthrax

The recommendations provided do not all represent uses currently approved by the FDA but are a consensus based on best available information of recent studies. Given the fulminant course of inhalation anthrax, early antibiotic administration is essential to maximize patient survival. Given the difficulty in achieving timely microbiologic diagnosis of anthrax, all persons with fever or evidence of systemic disease in an area where anthrax cases are occurring should be treated empirically for anthrax until the disease is excluded.

No clinical studies exist of the treatment of inhalation anthrax in humans. Most naturally occurring strains of anthrax are sensitive to penicillin, and penicillin historically has been the preferred therapy for the treatment of anthrax. Penicillin and doxycycline are FDA-approved antibiotics for anthrax. Doxycycline is the preferred option from the tetracycline class of antibiotics because of its proven efficacy in monkey studies. Other antibiotics for which naturally occurring strains of anthrax are susceptible include meropenem, imipenem, quinupristindalfopristin,daptomycin, linezolid,rifampin, vancomycin, clindamycin, erythromycin,azithromycin, clarithromycin, chloramphenicol, first-generation cephalosporins, and the aminoglycosides.

When anthrax susceptibilities are unknown, begin therapy with ciprofloxacin 400 mg IV bid or doxycycline 200 mg IV loading dose followed by 100 mg IV bid. To either of these, add 1 or 2 other antibiotics effective against anthrax. Antibiotics can be changed over to oral therapy as clinically indicated for a total duration of therapy of at least 60 days.

Traditionally, ciprofloxacin and other fluoroquinolones are not recommended for use in children younger than 16-18 years because of a link to permanent arthropathy in adolescent animals and transient arthropathy in a small number of children. Balancing these small risks against the real risk of death and resistant strains of B anthracis, experts recommend that ciprofloxacin be given to a pediatric population for initial therapy or postexposure prophylaxis following anthrax attack. In children, ciprofloxacin at 20-30 mg/kg/d IV in 2 daily doses (not to exceed 1 g/d) is recommended. If antibiotic susceptibility testing allows, substitute intravenous penicillin for the fluoroquinolones. For adults and children older than 12 years, penicillin G at 4 million U IV q4h is recommended for 60 days. For children younger than 12 years, penicillin G is dosed 50,000 U/kg IV q6h for 60 days.

In experimental models, antibiotic therapy during anthrax infection has prevented development of an immune response. This suggests that even if the antibiotic-treated patient survives anthrax infection, risk of recurrence remains for at least 60 days. Oral therapy should replace intravenous therapy as soon as a patient's clinical condition improves.

Historically, the treatment of cutaneous anthrax has been oral penicillin. Recent recommendations suggest that oral fluoroquinolones or tetracycline antibiotics, as well as amoxicillin, are suitable alternatives if antibiotic susceptibility is proven. Although previous guidelines have suggested treating cutaneous anthrax with 7-10 days of therapy, recent recommendations suggest treatment for 60 days in the setting of bioterrorism, given the presumed exposure to the primary aerosol. Treatment of cutaneous anthrax generally prevents progression to systemic disease, although it does not prevent the formation and evolution of the eschar.

In pregnant women, experts recommend that ciprofloxacin be given for therapy and postexposure prophylaxis following an anthrax attack. Substitute intravenous penicillin for the fluoroquinolones if microbiologic testing confirms penicillin susceptibility.

## Prevention/Prophylaxis - Anthrax

For postexposure prophylaxis, experts recommend the same oral regimen as that recommended for treatment of mass casualties. For adults, administer ciprofloxacin 500 mg PO bid for 60 days. Ciprofloxacin may be changed to amoxicillin at 500 mg PO tid or doxycycline 100 mg PO bid for 60 days if microbiologic testing confirms such antibiotic susceptibility. In children, administer ciprofloxacin at 20-30 mg/kg/d PO taken twice daily (not to exceed 1 g/d) for 60 days. If the strain is susceptible to penicillins and the patient's weight is greater than 20 kg, amoxicillin may be given at 500 mg PO tid. For a child who weighs less than 20 kg, amoxicillin is administered at 40 mg/kg/d divided tid for 60 days.

A licensed vaccine, an aluminum hydroxide-absorbed preparation, is derived from culture fluid supernatant taken from an attenuated strain. The current vaccination series consists of 6 subcutaneous doses at 0, 2, and 4 weeks, then at 6, 12, and 18 months, followed by annual boosters. Insufficient data are available regarding efficacy against inhalation anthrax in humans, although studies in rhesus monkeys indicate that it is protective.

If information indicates that a BW attack is imminent or may have occurred, prophylaxis of unimmunized individuals with ciprofloxacin (500mg PO bid) or doxycycline (100mg PO bid) is recommended. Initiate the vaccination series for unimmunized individuals. Should an anthrax attack be confirmed, continue chemoprophylaxis for at least 60 days or for 1-2 weeks after persons exposed receive 3 doses of vaccine (at 0, 2, and 4 wk).

Patients currently immunized (including annual boosters) need only continue antibiotic prophylaxis for 30 days.

## BOTULINUM TOXIN

Botulism is caused by intoxication with any of the seven distinct neurotoxins produced by the bacillus, Clostridium botulinum. In humans, disease results from only four (A, B, E, and F) of those seven types of neurotoxins. The toxins are proteins with molecular weights of approximately 150,000, which bind to the presynaptic membrane of neurons at peripheral cholinergic synapses to prevent release of acetylcholine and block neurotransmission. The blockade is most evident clinically in the cholinergic autonomic nervous system and at the neuromuscular junction. A biological attack with botulinum toxin delivered by aerosol would be expected to cause symptoms similar in most respects to those observed with food-borne botulism.

In pure form, the toxin is a white crystalline substance that is readily dissolvable in water, but decays rapidly in the open air. Symptoms of inhalation botulism may begin as early as 12-36 hours following exposure or as late as several days. Initial signs and symptoms include ptosis, generalized weakness, lassitude, and dizziness. Diminished salivation with extreme dryness of the mouth and throat may cause complaints of a sore throat. Urinary retention or ileus may also occur. Motor symptoms usually are present early in the disease; cranial nerves are affected first with blurred vision, diplopia, ptosis, and photophobia. Development of respiratory failure may be abrupt. Mucous membranes of the mouth may be dry and crusted. Neurological examination shows flaccid muscle weakness of the palate, tongue, larynx, respiratory muscles, and extremities. Deep tendon reflexes vary from intact to absent.

The occurrence of an epidemic with large numbers of afebrile patients with progressive ocular, pharyngeal, respiratory, and muscular weakness and paralysis hints strongly at the diagnosis. Single cases may be confused with various neuromuscular disorders such as atypical Guillain-Barr syndrome, myasthenia gravis, or tick paralysis. The edrophonium (tensilon) test may be transiently positive in botulism. Respiratory failure secondary to paralysis of respiratory muscles is the most serious complication and, generally, the cause of death. Reported cases of botulism prior to 1950 had a mortality of 60 per cent. With tracheotomy and ventilator assistance, fatalities should be <5 per cent. Intensive and prolonged nursing care may be required for recovery (which may take several weeks or even months).

A pentavalent toxoid of Clostridium botulinum types A, B, C, D, and E is available under IND status. This product has been administered to several thousand volunteers and occupationally at-risk workers and induces serum antitoxin levels that correspond to protective levels in experimental animal systems. The currently recommended schedule (0, 2, and 12 weeks, then a 1 year booster) induces solidly protective antitoxin levels in greater than 90 per cent of those vaccinated after 1 year.

## BRUCELLOSIS

Brucellosis is a systemic zoonotic disease that, in humans, is caused by one of four species of bacteria: Brucella melitensis, B. abortus, B. suis, and B. canis; virulence for humans decreases somewhat in the order given. These bacteria are small gram-negative, aerobic, non--motile coccobacilli that grow within monocytes and macrophages. They reside quiescently in tissue and bone-marrow, and are extremely difficult to eradicate even with antibiotic therapy.

Their natural reservoir is domestic animals, such as goats, sheep, and camels (B. melitensis); cattle (B. abortus); and pigs (B. suis).Brucella canis is primarily a pathogen of dogs, and only occasionally causes disease in humans upon contact with an infected dog's blood, semen, or placenta. Humans are infected when they ingest raw (unpasteurized), infected milk or meat, inhale contaminated aerosols, or have abraded skin or conjunctival surfaces that come in contact with the bacteria.

Laboratory infections are quite common, but human-to-human transmission is rare, occurring through breastfeeding. Therefore, isolation of infected patients is not required. Brucella species long have been considered potential candidates for use in biological warfare. The organisms are readily lyophilized, perhaps enhancing their infectivity. Under selected environmental conditions (for example, darkness, cool temperatures, high $CO_2$), persistence for up to 2 years has been documented. When used as a biological warfare agent, Brucellae would most likely be delivered by the aerosol route; the resulting infection would be expected to mimic natural disease.

Brucellosis presents after an incubation period normally ranging from 3-4 weeks, but may be as short as 1 week or as long as several months. Clinical disease presents typically as an acute, non-specific febrile illness with chills, sweats, headache, fatigue, myalgias, arthralgias, and anorexia. Cough occurs in 15-25 per cent, but the chest x-ray usually is normal. Complications include sacroiliitis, arthritis, vertebral osteomyelitis, epididymo-orchitis, and rarely endocarditis. Physical findings include lymphadenopathy in 10-20 per cent and splenomegaly in 20-30 per cent of cases. Untreated disease can persist for months to years, often with relapses and remissions. Disability may be pronounced. Lethality may approach 6 per cent following infection with B. melitensis, but the disease is rarely fatal (0.5 per cent or less) after infection with other serotypes (usually after endocarditis develops).

The initial symptoms of brucellosis are usually nonspecific, and the differential diagnosis is therefore very broad and includes bacterial, viral, and mycoplasmal infections. The systemic symptoms of viral and mycoplasmal illnesses, however, are usually present for only a few days, while they persist for prolonged periods in brucellosis. Brucellosis may be indistinguishable clinically from the typhoidal form of tularemia or from typhoid fever itself. The disease in humans is characterized by a multitude of somatic complaints, including fever, sweats, anorexia, fatigue, malaise, weight loss, and depression. Localized complications may involve the cardiovascular, gastrointestinal, genitourinary, hepatobiliary, osteoarticular, pulmonary and nervous systems. Without adequate and prompt antibiotic treatment, some patients develop a ‘chronic’ brucellosis syndrome with many features of the ‘chronic fatigue’ syndrome. The recommended treatment is doxycycline (200 mg/day) plus rifampin (900 mg/day) for 6 weeks. Alternative effective treatment consists of doxycycline

(200 mg/day) for 6 weeks plus streptomycin (1 gm/day) for 3 weeks. Trimetho-primsulfame-thoxazole given for 4-6 weeks is lesseffective. In 5-10 per cent of cases, there may be relapse or treatment failure. Laboratory infections with brucellosis are quite common, but there is no human-to-human transmission and isolation is not required.

Killed and live attenuated human vaccines of unproven efficacy have been available in many countries, but not in the U.S. and many parts of Europe. There is no information on the use of antibiotics for prophylaxis against human brucellosis.

## CHOLERA

Cholera is a diarrheal disease caused by Vibrio cholera, a short, curved, gram-negative bacillus. Humans acquire the disease by consuming water or food contaminated with the organism. The organism multiplies in the small intestine and secretes an enterotoxin that causes a secretory diarrhea. When employed as a BW agent, cholera will most likely be used to contaminate water supplies.

It is unlikely to be used in aerosol form. Without treatment, death may result from severe dehydration, hypovolemia and shock. Vomiting is often present early in the illness and may complicate oral replacement of fluid losses. There is little or no fever or abdominal pain. Watery diarrhea can also be caused by enterotoxigenic E. coli, rotavirus or other viruses, non-cholera Vibrios, or food poisoning due to ingestion of preformed toxins such as those of Clostridium perfringens, Bacillus cereus, or Staphylococcus aureus.

Treatment of cholera depends primarily on replacement of fluid and electrolyte losses. This is best accomplished using oral dehydration therapy with the World Health Organization solution (3.5g NaCl, 2.5g NaHC03, 1.5g KC1 and 20 g glucose per litre). Intravenous fluid replacement is occasionally needed when vomiting is severe, when the volume of stool output exceeds 7 litres/day, or when severe dehydration with shock has developed. Antibiotics will shorten the duration of diarrhea and thereby reduce fluid losses. Improved oral cholera vaccines are presently being tested. One vaccine, which has been discontinued in the U.S., is a killed suspension of V. cholera provided about 50 per cent protection that lasts for no more than 6 months. The initial dose is two injections given at least 1 week apart with booster doses every 6 months.

## CLOSTRIDIUM PERFRINGENS TOXIN

Clostridium perfringens is a common anaerobic bacterium associated with three distinct disease syndromes; gas gangrene or clostridial myonecrosis; enteritis necroticans (pig-bel); and perfringens food poisoning. Each of these syndromes has very specific requirements for delivering inocula of C. perfringens to specific sites to induce disease, and it is difficult to imagine a general scenario in which the spores or vegetative organisms could be used as a biological threat agent. There are, however, at least 12 protein toxins elaborated, and one or more of these could be produced, concentrated, and used as a weapon. Waterborne disease is conceivable, but unlikely. The alpha toxin would be lethal by aerosol. This is a well characterized, highly toxic phospholipase C. Other toxins from the organism might be co-weaponized and enhance effectiveness. For example, the epsilon toxin is neurotoxic in laboratory animals.

Gas gangrene is a well-recognized, life-threatening emergency. Symptoms of the disease may be subtle before fulminant toxemia develops, and the diagnosis is often made at postmortem examination. The bacteria produce toxins that create the high mortality from clostridial myonecrosis, and which produce the characteristic intense pain out of proportion to the wound. Within hours, signs of systemic toxicity appear, including confusion, tachycardia, and sweating.

Most Clostridia species produce large amounts of $CO_2$ and hydrogen that cause intense swelling, hence the term "gas" gangrene, resulting in gas in the soft tissues and the emission of foul-smelling gas from the wound. Clinical features include necrosis, dark red serous fluid, and numerous gas filled vesicles. The infection may progress up to 10 cm per hour, and early diagnosis and therapy are essential to prevent rapid progression to toxemia and death. Pulmonary findings might lead to confusion with staphylococcal enterotoxin B (SEB) initially. Liver damage, hemolytic anemia, and thrombocytopenia are not associated with SEB and the pulmonary findings should be reversible in SEB.

No specific treatment is available for C. pefringens intoxication. Early antibiotic treatment is effective, if undertaken before significant amounts of toxins have accumulated in the body. If not treated the bacteria enter the bloodstream causing fatal systemic illness. The organism itself is sensitive to penicillin, and consequently, this is the current drug of choice. Recent data indicate that clindamycin or rifampin may suppress toxin production and provide superior results in animal models. Prompt surgical debridement and broad spectrum, intravenous antibiotics are the mainstay of therapy. Hyperbaric oxygen has been seen as effective in prolonging survival in animal studies when coupled with other treatments. There is no available prophylaxis against most C. perfringens toxins. Toxoids are being used to prevent enteritis necroticans in humans, and veterinary toxoids are in wide use.

## CRIMEAN-CONGO HEMORRHAGIC FEVER

Crimean-Congo hemorrhagic fever (CCHF) is a viral disease caused by the Nairovirus. The virus, first characterized in the Crimea in 1944, is transmitted by ticks, principally of the genus Hyalomma, with intermediate vertebrate hosts varying with tick species. In 1969 it was recognized that the pathogen causing Crimean hemorrhagic fever was the same as that responsible for an illness identified in 1956 in the Congo, and linkage of the two place-names resulted in the current name for the disease and the virus. The disease, next found in the Congo, occurs also in the Middle East, the Balkans, the former USSR, and eastern China. Little is known about variations in the virus properties over the huge geographic area involved.

Humans become infected through tick bites, crushing an infected tick, or at the slaughter of viremic livestock. Even in epidemics, cases do not show narrow clustering and person-to-person spread is rare, though possible through contact with infectious blood or bodily fluids. CCHF would probably be delivered by aerosol if used as a BW agent.

The length of the incubation period for illness appears to depend on the mode of acquisition of the virus. Following infection via tick bite, the incubation period is usually one to three days, with a maximum of nine days. The incubation period following contact with infected blood or tissues is usually five to six days, with a documented maximum of 13 days. Typical cases present with sudden onset of fever and chills 3-12 days after tick exposure. There is severe headache, lumbar pain, nausea and vomiting, delirium, and prostration. Fatal cases are associated with extensive hemorrhage, coma, and shock. Mortality among cases recognized as hemorrhagic fever is 15-30 per cent, with death occurring in the second week of illness. In those patients who recover, improvement generally begins on the ninth or tenth day after onset of illness. Convalescence in survivors is prolonged with asthenia, dizziness, and often hair loss.

Diagnosis of suspected CCHF is performed in specially-equipped, high biosafety level laboratories. Other viral hemorrhagic fevers, meningococcemia, rickettsial diseases, and similar conditions may resemble full-blown CCHF. Most fatal cases and half the others will have detectable antigen by rapid enzyme-linked immunosorbant assay (ELISA) testing of acute serum samples. IgM ELISA antibodies occur early in recovery. Polymerase chain reaction has recently been used in diagnosing CCHF. Supportive therapy with replacement of clotting factors is indicated. Crimean-Congo hemorrhagic fever virus is sensitive to ribavirin *in vitro* and clinicians have been favorably impressed in uncontrolled trials. Immune sera have also been used for therapeutic purposes several times, but its value has not been demonstrated.

When patients with CCHF are admitted to the hospital, there is a risk of nosocomial spread of infection. In the past, serious outbreaks have occurred in this way and it is imperative that adequate infection control measures be observed to prevent this disastrous outcome. Patients with suspected or confirmed CCHF should be isolated and cared for using barrier nursing techniques. Because of several well-defined outbreaks within hospitals, protective measures for medical personnel are an issue. The weight of evidence points to large droplets or fomites as the mediators of transmission and so strict barrier nursing is indicated and probably sufficient for the care of naturally acquired disease. The virus is aerosol-infectious and additional precautions (for example, respirators) might be considered in a biological warfare setting.

Although there is little field experience and no definitive data on efficacy, the sensitivity of the virus to ribavirin and the severity of disease suggest that prophylaxis of high-risk exposures is indicated. In the case of a suspected biological attack, ribavirin could be considered for prophylaxis, but there is insufficient information to make a firm recommendation for dosing. An inactivated mouse-brain vaccine is used on a small scale in Eastern Europe, but there is no safe and effective vaccine widely available for human-use.

## EBOLA HEMORRHAGIC FEVER

Ebola hemorrhagic fever is one of the most virulent viral diseases known to humankind, causing death in 50-90 per cent of all clinically-ill cases. Consequently, it has figured prominently in popular discussions of biological weapons, although its practical applications as a biological threat agent remain speculative. The disease has its origins in the jungles of Africa and Asia and several different forms of Ebola virus have been identified and may be associated with other clinical expressions, on which further research is required.

The Ebola virus is transmitted by direct contact with the blood, secretions, organs or semen of infected persons. Transmission through semen may occur up to 7 weeks after clinical recovery, as with Marburg hemorrhagic fever. Health care workers have frequently been infected while attending patients. In the 1976 epidemic in Zaire, every Ebola case caused by contaminated syringes and needles died.

After an incubation period of 2 to 21 days, Ebola is often characterized by the sudden onset of fever, weakness, muscle pain, headache and sore throat. This is followed by vomiting, diarrhea, rash, limited kidney and liver functions, and both internal and external bleeding. Specialized laboratory tests on blood specimens (which are not commercially available) detect specific antigens or antibodies and/or isolate the virus. These tests present an extreme biohazard and are only conducted under maximum containment conditions. No specific treatment or vaccine exists for Ebola hemorrhagic fever. Severe cases require intensive supportive care, as patients are frequently dehydrated and in need of intravenous fluids. Experimental studies involving the use of hyperimmune sera on animals demonstrated no long-term protection against the disease after interruption of therapy.

Suspected cases should be isolated from other patients and strict barrier nursing techniques practiced. All hospital personnel should be briefed on the nature of the disease and its routes of transmission. Particular emphasis should be placed on ensuring that high-risk procedures such as the placing of intravenous lines and the handling of blood, secretions, catheters, and suction devices are done under barrier nursing conditions. Hospital staff should have individual gowns, gloves, and masks. Gloves and masks must not be reused unless disinfected. Patients who die from the disease should be promptly buried or cremated.

As the primary mode of person-to-person transmission is contact with contaminated blood, secretion, or body fluids, any person who has had close physical contact with patients should be kept under strict surveillance, *i.e.* body temperature checks twice a day, with immediate hospitalization and strict isolation recommended in case of temperatures above 38.3°C (101°F). Casual contacts should be placed on alert and asked to report any fever. Surveillance of suspected cases should continue for three weeks after the date of their last contact. Hospital personnel who come into close contact with patients or contaminated materials without barrier nursing attire must be considered exposed and put under close supervised surveillance.

The Ebola virus was first identified in a western equatorial province of Sudan and in a nearby region of Zaire in 1976 after significant epidemics in Yamkubu, northern Zaire, and Nzara, southern Sudan. Between June and November 1976 the Ebola virus infected 284 people in Sudan, with 117 deaths. In Zaire there were 318 cases and 280 deaths in September and October. An isolated case occurred in Zaire in 1977 and a second outbreak in Sudan in 1979. In 1989 and 1990, a filovirus, named Ebola-

Reston, was isolated in monkeys being held in quarantine in laboratories in Reston, VA, Alice, TX, and Pennsylvania. In the Philippines, Ebola-Reston infections occurred in a quarantine area near Manila for monkeys intended for exportation. A large epidemic occurred in Kikwit, Zaire in 1995 with 315 cases, 244 with fatal outcomes. One human case of Ebola hemorrhagic fever and several cases in chimpanzees were confirmed in C?te d'Ivoire in 1994-95. In Gabon, Ebola hemorrhagic fever was first documented in 1994 and recent outbreaks occurred in February 1996 and July 1996. In all, nearly 1,100 cases with 793 deaths have been documented since the virus was discovered. The natural reservoir of the Ebola virus seems to reside in the rain forests of Africa and Asia but has not yet been identified.

Different hypotheses have been developed to try to uncover the cycle of Ebola. Initially, rodents were suspected, as is the case with Lassa Fever whose reservoir is a wild rodent (Mastomys). Another hypothesis is that a plant virus may have caused the infection of vertebrates. Laboratory observation has shown that bats experimentally infected with Ebola do not die and this has raised speculation that these mammals may play a role in maintaining the virus in the tropical forest.

## MELIOIDOSIS

Melioidosis is an infectious disease of humans and animals caused by Burkholderia pseudomallei (formerly Pseudomonas pseudomallei), a gram-negative bacillus. It is especially prevalent in Southeast Asia but has been described in many countries around the world. The disease has a variable and inconstant clinical spectrum. A biological warfare attack with this organism would most likely be by the aerosol route.

Infection by inoculation results in a subcutaneous nodule with acute lymphangitis and regional lymphadenitis, generally with fever. Pneumonia may occur after inhalation or hematogenous dissemination of infection. It may vary in intensity from mild to fulminant, usually involves the upper lobes, and often results in cavitation. Pleural effusions are uncommon. An acute fulminant septicemia may occur characterized by rapid appearance of hypotension and shock. A chronic suppurative form may involve virtually any organ in the body. Antibiotic regimens that have been used successfully include tetracycline, 2-3g/day; chloramphenicol, 3g/day; and trimethoprim-sulfamethoxazole, 4 and 20mg/kg per day. Ceftazidine and piperacillin have enjoyed success in severely ill patients as well. In patients who are toxic, a combination of two antibiotics, given parenterally, is advised.

There are no means of immunization. Vigorous cleansing of abrasions and lacerations may reduce the risk of disease after inoculation of organisms into the skin. There is no information available on the utility of antibiotic prophylaxis after potential exposure, but before the onset of clinical symptoms.

## PLAGUE

Plague is a zoonotic disease caused by Yersinia pestis. Under natural conditions, humans become infected as a result of contact with rodents, and their fleas. The transmission of the gram-negative coccobacillus is by the bite of the infected flea,Xenopsylla cheopis, the oriental rat flea, or Pulex irritans, the human flea. Under natural conditions, three syndromes are recognized: bubonic, primary septicemia, or pneumonic. In a biological warfare scenario, the plague bacillus could be delivered via contaminated vectors (fleas) causing the bubonic type or, more likely, via aerosol causing the pneumonic type.

- In bubonic plague, the incubation period ranges from 2 to 10 days. The onset is acute and often fulminant with malaise, high fever, and one or more tender lymph nodes. Inguinal lymphadenitis (bubo) predominates, but cervical and axillary lymph nodes can also be involved. The involved nodes are tender, fluctuant, and necrotic. Bubonic plague may progress spontaneously to the septicemia form with organisms spread to the central nervous system, lungs (producing pneumonic disease), and elsewhere. The mortality is 50 per cent in untreated patients with the terminal event being circulatory collapse, hemorrhage, and peripheral thrombosis.
- In primary pneumonic plague, the incubation period

is 2 to 3 days. The onset is acute and fulminant with malaise, high fever, chills, headache, myalgia, cough with production of a bloody sputum, and toxemia. The pneumonia progresses rapidly, resulting in dyspnea, strider, and cyanosis. In untreated patients, the mortality is 100 per cent with the terminal event being respiratory failure, circulatory collapse, and a bleeding diathesis.

In cases where bubonic type is suspected, tularemia adenitis, staphylococcal or streptococcal adenitis, meningococcemia, enteric gram negative sepsis, and rickettsiosis need to be ruled out. In pneumonic plague, tularemia, anthrax, and staphylococcal enterotoxin B (SEB) agents need to be considered. Continued deterioration without stabilization effectively rules out SEB. Plague may be spread from person to person by droplets. Strict isolation procedures for all cases are indicated. Streptomycin, tetracycline, and chloramphenicol are highly effective if begun early. Significant reduction in morbidity and mortality is possible if antibiotics are given within the first 24 hours after symptoms of pneumonic plague develop.

A formalin-killed Y. pestis vaccine that was produced in the United States and extensively used is no longer manufactured. Efficacy against flea-borne plague was inferred from population studies, but the utility of this vaccine against aerosol challenge was unknown. Immunity was maintained through boosters every 1-2 years. Live-attenuated vaccines are available elsewhere but are highly reactogenic and without proven efficacy against aerosol challenge.

## Pathophysiology - Plague

Y pestis is a gram-negative, non–acid-fast, non-motile, non-sporulating coccobacillus. The bacteria may remain viable for days to weeks in water, moist soil, grain, and buried bodies. Its bipolar appearance is best appreciated when Wright-Giemsa, Wayson, or Gram stains are used. Y pestis grows optimally at 28°C. Biochemically, the plague bacillus produces no hemolysins, is positive for catalase, and is negative for hydrogen sulfide, oxidase, and urease.

The known virulence factors of Y pestis are encoded on the chromosomes of its 3 plasmids. The pH6 antigen, a protein located on the surface of the bacterium, is necessary for complete virulence. It is induced *in vivo* at sites of inflammation and cellular necrosis and within phagocytic cells. The low calcium response (LCR) plasmid, which is homologous in Y pestis and the other 2 Yersinia pathogens,Yersinia pseudotuberculosis and Yersinia enterocolitica, codes for several secreted proteins and is also necessary for virulence.

As few as 1-10 organisms of Y pestis are sufficient to infect rodents and primates via the oral, intradermal, subcutaneous, or intravenous routes. After being introduced into the mammalian host by a flea, the organism is thought to be susceptible initially to phagocytosis and killing by neutrophils. However, some of the bacteria may grow and proliferate within tissue macrophages. Within the human host, several environmental signals (temperature of 37°C, contact with eukaryotic cells, location within mononuclear cells, pH) are thought to induce the synthesis and activity of a multitude of factors that contribute to virulence. Bacteria become resistant to phagocytosis and proliferate unimpeded extracellularly.

During the incubation phase, the bacilli most commonly spread to regional lymph nodes, where supportive lymphadenitis develops, producing the characteristic bubo (1-10 cm in diameter). Dissemination from the local site is thought to be related to the action of both plasminogen activator and Yop M. Infection progresses if untreated; septicemia develops, and the infection spreads to other organs. The endotoxin probably contributes to the development of septic shock, which is similar to the shock states observed with other causes of gram-negative sepsis.

Tissues most commonly infected include the spleen, liver, lungs, skin, and mucous membranes. Late infection of the meninges also occurs, especially if suboptimal antibiotic therapy has been administered. Primary pneumonic plague, the most severe form of the disease, arises from inhalation of an infectious aerosol. Primary pneumonic plague is more rapidly fatal than the secondary form, because the inhaled droplets already contain phagocytosis-resistant bacilli, which have arisen from their growth in the vertebrate host. Primary septicemia plague can arise from direct inoculation of bacilli into the bloodstream, bypassing initial multiplication in the lymph nodes.

## Clinical Features - Plague

Plague presents in 3 predominant forms. In the United States, most patients (85-90 per cent) with human plague present clinically with the bubonic form, 10-15 per cent with the primary septicemia form, and 1 per cent with the pneumonic form. Secondary septicemic plague occurs in 23 per cent of patients who present with bubonic plague, and secondary pneumonic plague occurs in 9 per cent. If Y pestis were used as a BW agent, it most likely would be inhaled as an infectious aerosol and result in primary pneumonic plague (epidemic pneumonia). If fleas were used as carriers of disease, bubonic or septicemic plague would result.

Bubonic plague:Buboes manifest with a 1- to 8-day incubation period after infected by a fleabite. Their appearance is associated with the onset of sudden fever, chills, and headache, which often are followed by nausea and vomiting several hours later. Presenting symptoms include severe malaise (75 per cent), headache (20-85 per cent), vomiting (25-49 per cent), chills (40 per cent), altered mentation (26-38 per cent), cough (25 per cent), abdominal pain (19 per cent), and chest pain (13 per cent).

Buboes occur in the groin (90 per cent femoral, more frequent femoral than inguinal), axillary, or cervical regions, depending on the site of inoculation, 6-8 hours after the onset of symptoms. Buboes become visible within 24 hours and are characterized by severe pain. Untreated, mortality is 60 per cent.

Septicemia develops in 2-6 days in 25 per cent of patients who are untreated. Approximately 5-15 per cent of patients with bubonic plague develop secondary pneumonic plague. Septicemia plague:Septicemia plague may occur primarily or secondarily as a result of hematogenous dissemination of bubonic plague. Presenting signs and symptoms of primary septicemic plague are essentially the same as those for any gram-negative septicemia and include fever, chills, nausea, vomiting, and diarrhea; later, purpura, disseminated intravascular coagulation (DIC), and acrocyanosis and necrosis occur. The mortality rate is nearly 100 per cent without treatment, and this is reduced to 30-50 per cent if treated.

- *Pneumonic plague*:Pneumonic plague may occur primarily from inhalation of aerosols or secondarily from hematogenous dissemination. Humans contract this form from domestic cats in 28 per cent of the cases (25 per cent of these are veterinarians or their assistants). Patients typically have a productive cough with blood-tinged sputum within 24 hours of symptom onset. The findings on chest radiographs are variable, but bilateral alveolar infiltrates appear to be the most common findings in pneumonic plague. Human-to-human spread is unusual; in fact, it has not occurred in the United States since 1925. Untreated, the mortality rate is nearly 100 per cent.
- *Plague meningitis*:This form is observed in 6-7 per cent of patients. The condition manifests itself most often in children after 9-14 days of ineffective treatment. Symptoms are similar to those of other forms of acute bacterial meningitis.

## Diagnosis - Plague

The diagnosis of bubonic plague should be made readily on clinical grounds if a patient presents with a painful bubo, fever, prostration, and history of exposure to rodents or fleas in an endemic area. However, if the patient presents in a non-endemic area or without a bubo, then the diagnosis can be difficult to make. When a bubo is present, the differential diagnosis should include tularemia, cat scratch disease, lymphogranuloma venereum, chancroid, TB, streptococcal adenitis, and scrub typhus.

The differential diagnosis of septicemic plague also includes meningococcemia, gram-negative sepsis, and rickettsioses. A presentation of systemic toxicity, a productive cough, and bloody sputum suggests a large differential diagnosis. However, demonstration of gram-negative coccobacilli in the sputum readily should suggest the correct diagnosis, because Y pestis is perhaps the only gram-negative bacterium that can cause extensive, fulminant pneumonia with bloody sputum in an otherwise healthy, immunocompetent host. In addition, Y pestis has unique bipolar, safety-pin morphology. In patients with lymphadenopathy, perform a bubo aspiration. Air-dry the aspirate on a slide for Gram, Wright-Giemsa, or Wayson stain. If available, obtain a DFA stain of the aspirate for the presence of Y pestis capsular antigen. A positive DFA is more specific for Y pestis than the other stains listed. Perform cultures of blood, bubo aspirate, sputum, and cerebrospinal fluid (CSF). Tiny 1- to 3-mm beaten copper colonies appear on blood agar in 48 hours. It is important to remember that colonies may be negative at 24 hours.

Complete blood cell counts (CBCs) often reveal leukocytosis with a left shift. Platelet counts may be normal or low, and activated partial thromboplastin times (aPTTs) may be increased. When DIC is present, fibrin degradation products are elevated. Because of liver involvement, alanine aminotransferase, aspartate aminotransferase, and bilirubin levels may be increased.

Most naturally occurring strains of Y pestis produce an F1-antigen *in vivo*, which can be detected in serum samples by immunoassay. Because fractional antigen and antibody do not occur early in the infection, perform titers for both on several sequential blood specimens. A 4-fold rise in antibody titer in patient serum is retrospectively diagnostic. PCR is very specific and sensitive but is not widely available as a diagnostic test.

## Treatment - Plague

Because the risk of human-to-human transmission, isolate patients with plague for the first 48 hours after treatment initiation. If pneumonic plague is present, continue isolation for 4 days. Since 1948, streptomycin has been the treatment of choice for bubonic, septicemic, and pneumonic plague. Administer it in a dose of 30 mg/kg/d IM divided bid. In patients with meningitis or hemodynamic instability, add intravenous chloramphenicol (50-75 mg/kg/d) divided qid. Gentamicin (5 mg/kg/d IM or IV) has had much less clinical usage but can be used as an alternative to streptomycin. Continue treatment for a minimum of 10 days or 3-4 days after clinical recovery. In patients with very mild bubonic plague who are not septic, tetracycline can be used orally at a dose of 2 g/d divided qid for 10 days. Doxycycline, ciprofloxacin,ofloxacin, chloramphenicol, andceftriaxone may be used as alternatives.

In pregnant women, use streptomycin or gentamicin unless chloramphenicol specifically is indicated. Streptomycin is also the treatment of choice for newborns and children (15 mg/kg IM bid up to max of 2 g/d). Doxycycline or ciprofloxacin are considered alternatives for both pregnant woman and children.

If treated with antibiotics, buboes typically recede in 10-14 days and do not require drainage. Patients are unlikely to survive primary pneumonic plague if antibiotic therapy is not initiated within 18-24 hours of symptom onset.

## Prevention/Prophylaxis - Plague

All plague control measures must include insecticide use, public education, and reduction of rodent populations with chemicals such as cholecalciferol. Fleas always must be targeted before rodents, because killing rodents may release massive amounts of infected fleas.

Treat contacts of patients with pneumonic plague and individuals who have been exposed to aerosols with oral doxycycline or ciprofloxacin for 7 days. Chloramphenicol is an alternative. In addition, previously vaccinated individuals should also receive prophylactic antibiotics if they have been exposed to a plague aerosol. No vaccine for plague has been available since 1998; however, a F1-V antigen vaccine is currently under development by the US Army.

## Q FEVER

Q fever is a zoonotic disease caused by a rickettsia, Coxiella burnetii. The most common animal reservoirs are sheep, cattle, and goats. Humans acquire the disease by inhalation of particles contaminated with the organisms. A biological attack would cause disease similar to that occurring naturally.

Following an incubation period of 10-20 days, Q fever generally occurs as a self-limiting febrile illness that includes headache, fatigue, and myalgias and lasts from 2 days to 2 weeks.

Pneumonia occurs frequently, usually manifested only by an abnormal chest x-ray. A non-productive cough and pleuritic chest pain occur in about one-fourth of patients with Q fever pneumonia. Patients usually recover uneventfully.

Q fever usually presents as an undifferentiated febrile illness, or a primary atypical pneumonia, which must be differentiated from pneumonia caused by mycoplasma, Legionnaire's disease, psittacosis or Chlamydia pneumonia. More rapidly progressive forms of pneumonia may look like bacterial pneumonias including tularemia or plague. Tetracycline (250 mg every 6 hr) or doxycycline (100 mg every 12 hr) for 5-7 days is the treatment of choice. A combination of erythromycin (500 mg every 6 hr) plus rifampin (600 mg per day) is also effective.

Vaccination with a single dose of a killed suspension of C. burnetii provides complete protection against naturally occurring Q fever and >90 per cent protection against experimental aerosol exposure in human volunteers. Protection lasts for at least 5 years. However, neither this vaccine nor any other is commercially available in the U.S. Administration of this vaccine in immune individuals may cause severe cutaneous reactions including necrosis at the inoculation site. Newer vaccines are under development. Treatment with tetracycline during the incubation period will delay but not prevent the onset of illness.

## RICIN

Ricin is a glycoprotein toxin (66,000 daltons) from the seed of the castor plant. It blocks protein synthesis by altering the rRNA, thus killing the cell. Ricin's significance as a potential biological threat agent relates to its availability worldwide, ease of production, and extreme pulmonary toxicity when inhaled.

Overall, the clinical picture seen depends on the route of exposure. All reported serious or fatal cases of castor bean ingestion have taken approximately the same course: rapid onset of nausea, vomiting, abdominal cramps, and severe diarrhea with vascular collapse; death has occurred on the third day or later. Following inhalation, one might expect non-specific symptoms of weakness, fever, cough, nausea, and hypothermia followed by hypotension and cardiovascular collapse. High doses by inhalation appear to produce severe enough pulmonary damage to cause death. In oral intoxication, fever, gastrointestinal involvement, and vascular collapse are prominent, the latter differentiating it from infection with enteric pathogens. With regard to inhalation exposure, non-specific findings of weakness, fever, vomiting, cough, hypothermia, and hypotension in large numbers of patients might suggest several respiratory pathogens.

Therapy is supportive and should include maintenance of intravascular volume. Standard management for poison ingestion should be employed if intoxication is by the oral route. There is presently no antitoxin available for treatment. There is currently no prophylaxis approved for human use. Active immunization and passive antibody prophylaxis are under study, as both are effective in protecting animals from death following exposure by intravenous or respiratory routes.

## RIFT VALLEY FEVER

Rift Valley Fever (RVF) is a viral disease caused by RVF virus. The virus circulates in sub-Saharan Africa as a mosquito-borne agent. Epizootics occur when susceptible domestic animals are infected, and because of the large amount of virus in their serum, amplify infection to biting arthropods. Deaths and abortions among susceptible species such as cattle and sheep constitute a major economic consequence of these epizootics, as well as providing a diagnostic clue and a method of surveillance. Humans become infected through the bite of mosquitoes, contact with infected blood, bodily fluids, or organs, or exposure to virus-laden aerosols or droplets.

The human disease appears to be similar whether acquired by aerosol or by mosquito bite. A biological attack, most likely delivered by aerosol, would be expected to elicit the rather specific spectrum of human clinical manifestations and to cause disease in sheep and cattle in the exposed area. If disease occurred in the absence of heavy vector populations or without domestic animals as amplifiers of mosquito infection, a BW attack would also be a likely cause. The incubation is two to six days and is usually followed by an incapacitating febrile illness of similar duration. The typical physical findings are fever, conjunctival injection, and sometimes abdominal tenderness. A few petechiae or epistaxis may occur. A small proportion of cases (approximately one per cent) will progress to a viral hemorrhagic fever syndrome; mortality in this group is roughly 50 per cent. A small number of infections will lead to a late encephalitis. After apparent recovery from a typical febrile illness, the patient develops fever, meningeal signs, obtundation, and focal defects. Death is uncommon.

The occurrence of an epidemic with febrile disease, hemorrhagic fever, eye lesions, and encephalitis in different patients would be characteristic of RVF. Demonstration of viral antigen in blood by ELISA is rapid and successful in a high proportion of acute cases of uncomplicated disease or hemorrhagic fever. Other methods of diagnosis include polymerase chain reaction and virus propagation. In hemorrhagic fever, supportive therapy may be indicated for hepatic and renal failure, as well as replacement of coagulation factors. The virus is sensitive to ribavirin *in vitro* and in rodent models. No studies have been performed in human or the more realistic monkey model to ascertain whether administration to an acutely ill patient would be of benefit.

Avoidance of mosquitoes and contact with fresh blood from dead domestic animals and respiratory protection from small particle aerosols are the mainstays of prevention. An effective inactivated vaccine for humans is not licensed for public use, but is available in limited quantities, particularly to laboratory and veterinary personnel.

## SAXITOXIN

Saxitoxin is the parent compound of a family of chemically related neurotoxins. In nature they are predominantly produced by marine dinoflagellates, although they have also been identified in association with such diverse organisms as blue-green algae, crabs, and the blue-ringed octopus. Human intoxications are principally due to ingestion of bivalve mollusks which have accumulated dinoflagellates during filter feeding. The resulting intoxication, known as paralytic shellfish poisoning (PSP), is known throughout the world as a severe, life-threatening illness requiring immediate medical intervention. In a BW scenario, the most likely route of delivery is by inhalation or toxic projectile. In addition, saxitoxin could be used in a confined area to contaminate water supplies.

After oral exposure, absorption of toxins from the gastrointestinal tract is rapid. Onset of symptoms typically begins 10-60 minutes after exposure, but may be delayed several hours depending upon the dose and individual idiosyncrasy. Initial symptoms are numbness or tingling of the lips, tongue and fingertips, followed by numbness of the neck and extremities and general muscular incoordination. Nausea and vomiting may be present, but typically occur in a minority of cases. Respiratory distress and flaccid muscular paralysis are the terminal stages and can occur 2-12 hours after intoxication. Death results from respiratory paralysis. Clearance of the toxin is rapid and survivors for 12-24 hours will usually recover. There are no known cases of inhalation exposure to saxitoxin in the medical literature, but data from animal experiments suggest the entire syndrome is compressed and death may occur in minutes.

Routine laboratory evaluation is not particularly helpful. Cardiac conduction defects may develop. Differential diagnosis may require toxin detection. Diagnosis is confirmed by detection of toxin in the food, water, stomach contents or environmental samples.

Management is supportive and standard management of poison ingestion should be employed if intoxication is by the oral route. Toxins are rapidly cleared and excreted in the urine, so diuresis may increase elimination. Incubation and mechanical respiratory support may be required in severe intoxication. Timely resuscitation would be imperative, albeit very difficult, after inhalation exposure on the battlefield. No vaccine against saxitoxin exposure has been developed for human use.

## SMALLPOX

Smallpox virus, an orthopoxvirus with a narrow host range confined to humans, was an important cause of morbidity and mortality in the developing world until recent times. Although the World Health Organization declared the virus eradicated in

1980, eradication of the natural disease was completed in 1977 and the last human cases, associated with laboratory infections, occurred in 1978. The virus exists today in only 2 laboratory repositories, one in the U.S. and the other in Russia. Appearance of human cases outside the laboratory would signal use of the virus as a biological weapon. Under natural conditions, the virus is transmitted by direct (face-to face) contact with an infected case, by fomites, and occasionally by aerosols. Smallpox virus is highly stable and retains infectivity for long periods outside of the host. A related virus, monkeypox, clinically resembles smallpox and causes sporadic human disease in West and Central Africa.

The incubation period is typically 12 days (range, 10-17 days). The illness begins with a prodrome lasting 2-3 days, with generalized malaise, fever, rigours, headache, and backache. This is followed by defervescence and the appearance of a typical skin eruption characterized by progression over 7-10 days of lesions through successive stages, from macules to papules to vesicles to pustules. The latter finally form crusts and, upon healing, leave depressed depigmented scars. The case fatality rate is approximately 30 per cent in unvaccinated individuals. Permanent joint deformities and blindness may follow recovery. Vaccine immunity may prevent or modify illness.

The eruption of chickenpox (varicella) is typically centripetal in distribution (worse on trunk than face and extremities) and characterized by crops of lesions in different stages on development. Chickenpox papules are soft and superticial, compared to the firm, shotty, and deep papules of smallpox. Chickenpox crusts fall off rapidly and usually leave no scar. Monkeypox cannot be easily distinguished from smallpox clinically. Monkeypox occurs only in forested areas of West and Central Africa as a sporadic, zoonotic infection transmitted to humans from wild squirrels. Person-to-person spread is rare and ceases after 1-2 generations. Mortality is 15 per cent. Other diseases that are sometimes confused with smallpox include typhus, secondary syphilis, and malignant measles. Skin samples (scrapings from papules, vesicular fluid, pus, or scabs) may provide a rapid identification of smallpox by direct electron microscopy, agar gel immunoprecipitation, or immunofluorescence. There is no specific treatment available although some evidence suggests that vaccinia-immune globulin is of some value in treatment if given early in the course of the illness. Vaccinia virus is a live poxvirus vaccine that induces strong crossprotection against smallpox for at least 5 years and partial protection for 10 years or more. The vaccine is administered by dermal scarification or intradermal jet injection; appearance of a vesicle or pustule within several days is indication of a "take." Vaccinia-immune human globulin at a dose of 0.3 mg/kg body weight provides ≥70 per cent protection against naturally occurring smallpox if given during the early incubation period. Administration immediately after or within the first 24 hours of exposure would provide the highest level of protection, especially in unvaccinated persons. Patients with smallpox should be treated by vaccinated personnel using universal precautions. Objects in contact with the patient, including bed linens, clothing, ambulance, etc.; require disinfection by fire, steam, or sodium hypochlorite solution.

## STAPHYLOCOCCAL ENTEROTOXIN B

Staphylococcal Enterotoxin B (SEB) is one of several exotoxins produced by Staphylococcus aureus, causing food poisoning when ingested. A BW attack with aerosol delivery of SEB to the respiratory tract produces a distinct syndrome causing significant morbidity and potential mortality.

The disease begins 1-6 hours after aerosol exposure with the sudden onset of fever, chills, headache, myalgia, and non-productive cough. In more severe cases, dyspnea and retrosternal chest pain may also be present. But cough may persist 1-4 weeks. In many patients nausea, vomiting, and diarrhea will also occur. In moderately severe laboratory exposures, lost duty time has been <2 weeks, but, based upon animal data, it is anticipated that severe exposures will result in fatalities. In foodborne SEB intoxication, fever and respiratory involvement are not seen, and gastrointestinal symptoms are prominent. The non-specific symptoms of fever, non-productive cough, myalgia, and headache occurring in large numbers of patients in an epidemic setting would suggest any of several infectious respiratory pathogens, particularly influenza, adenovirus, or mycoplasma. In a BW attack with SEB, cases would likely have their onset within a single day, while naturally occurring outbreaks would present over a more prolonged interval.

Treatment is limited to supportive care; humidified oxygen and steroids for pain control. No specific antitoxin for human use is available. There currently is no prophylaxis for SEB intoxication. Experimental immunization has protected monkeys, but no vaccine is presently available for human use.

## TRICHOTHECENE MYCOTOXIN

The trichothecene mycotoxins are a diverse group of more than 40 compounds produced by fungi. They strongly inhibit protein synthesis, impair DNA synthesis, alter cell membrane structure and function, and inhibit mitochondrial respiration. Secondary metabolites of fungi, such as T-2 toxin and others, produce toxic reactions called mycotoxicoses upon inhalation or consumption of contaminated food products by humans or animals. Naturally occurring trichothecenes have been identified in agricultural products and have been implicated in the animal disease moldy corn toxicosis, or poisoning.

There are no well-documented cases of clinical exposure of humans to trichothecenes. However, strong circumstantial evidence has associated these toxins with alimentary toxic aleukia (ATA), the fatal epidemic seen in Russia during World War II, and with alleged BW incidents ("yellow rain") in Cambodia, Laos, and Afghanistan.

Consumption of these mycotoxins results in weight loss, vomiting, skin inflammation, bloody diarrhea, diffuse hemorrhage, and possibly death. The onset of illness following acute exposure to T-2 (intravenously or through inhalation) occurs in hours, resulting in the rapid onset of circulatory shock characterized by reduced cardiac output, arterial hypotension, lactic acidosis and death within 12 hours.

Clinical signs and symptoms of ATA were hemorrhage, leukopenia, ulcerative pharyngitis, and depletion of bone marrow. The purported use of T-2 as a BW agent resulted in acute exposure via inhalation and/or dermal routes, as well as oral exposure upon consumption of contaminated food products and water. Alleged victims reported painful skin lesions, lightheadedness, dyspnea, and a rapid onset of hemomhage, incapacitation and death. Survivors developed a radiation-like sickness including fever, nausea, vomiting, diarrhea, leukopenia, bleeding, and sepsis. Specific diagnostic modalities are limited to reference laboratories. Because of their long "half-life" the toxic metabolites can be detected as late as 28 days after exposure.

General supportive measures are used to alleviate acute T-2 toxicoses. Prompt soap and water wash within 5-60 min of exposure significantly reduces the development of the localized destructive, cutaneous effects of the toxin. Oral exposure management should include standard therapy for poison ingestion. Ascorbic acid (400-1200 mg/kg, inter-peritoneal (ip)) works to decrease lethality in animal studies, but has not been tested in humans. While not yet available for humans, administration of large doses of monoclinal antibodies directed against T-2 and other metabolites have shown prophylactic and therapeutic efficacy in animal models.

## TULAREMIA

Tularemia is a zoonotic disease caused by Francisella tularensis, a gram-negative bacillus. Humans acquire the disease under natural conditions through inoculation of skin or mucous membranes with blood or tissue fluids of infected animals, or bites of infected deerflies, mosquitoes, or ticks. A BW attack with F. tularensis delivered by aerosol would primarily cause typhoidal tularemia, a syndrome expected to have a case fatality rate which may be higher than the 5-10 per cent seen when disease is acquired naturally.

A variety of clinical forms of tularemia are seen, depending upon the route of inoculation and virulence of the strain. In humans, as few as 10-50 organisms will cause disease if inhaled or injected intradermally, whereas $10^8$ organisms are required with oral challenge. Under natural conditions, ulceroglandular tularemia generally occurs about 3 days after intradermal inoculation (range 2-10 days), and manifests as regional lymphadenopathy, fever, chills, headache, and malaise, with or without a cutaneous ulcer. Gastrointestinal tularemia occurs after drinking contaminated ground water, and is characterized by abdominal pain, nausea, vomiting, and diarrhea.

Bacteremia may be common after primary intradermal, respiratory, or gastrointestinal infection with F. tularensis and could result in septicemia or "typhoidal" tularemia. The typhoidal form also may occur as a primary condition in 5-15 per cent of naturally-occurring cases; clinical features include fever, prostration, and weight loss, but without adenopathy. Diagnosis of primary typhoidal tularemia is difficult, as signs and symptoms are non-specific and there frequently is no suggestive exposure history. Pneumonic tularemia is a severe atypical pneumonia that may be fulminant, and can be primary or secondary.

Primary pneumonia may follow direct inhalation of infectious aerosols, or may result from aspiration of organisms in cases of pharyngeal tularemia. Pneumonic tularemia causes fever, headache, malaise, substernal discomfort, and a non--productive cough; radiologic evidence of pneumonia or mediastinal lymphadenopathy may or may not be present. A biological warfare attack with F. tularensis would most likely be delivered by aerosol, causing primarily typhoidal tularemia. Many exposed individuals would develop pneumonic tularemia (primary or secondary), but clinical pneumonia may be absent or non-evident. Case fatality rates may be higher than the 5-10 per cent seen when the disease is acquired naturally.

The clinical presentation of tularemia may be severe, yet non-specific. Differential diagnoses include typhoidal syndromes (*e.g.*, salmonella, rickettsia, malaria) or pneumonic processes (*e.g.*, plague, mycoplasma, SEB). A clue to the diagnosis of tularemia delivered as a BW agent might be a large number of temporally clustered patients presenting with similar systemic illnesses, a proportion of whom will have a non-productive pneumonia. Identification of organisms by staining ulcer fluids or sputum is generally not helpful. Routine culture is difficult, due to unusual growth requirements and/or overgrowth of commensal bacteria. Streptomycin (1 gm every 12 hours intramuscularly (IM) for 10-

14 days) is the treatment of choice. Gentamicin also is effective (3-5 mg/kg/day parenterally for 10-14 days). Tetracycline and chloramphenicol treatment are effective as well, but are associated with a significant relapse rate. Although laboratory-related infections with this organism are very common, human-to-human spread is unusual and isolation is not required.

A live, attenuated tularemia vaccine is available as an investigational new drug (IND). This vaccine has been administered to more than 5,000 persons without significant adverse reactions and is of proven effectiveness in preventing laboratory-acquired typhoidal tularemia. Its effectiveness against the concentrated bacterial challenge expected in a BW attack is unproven. The use of antibiotics for prophylaxis against tularemia is controversial.

## VENEZUELAN EQUINE ENCEPHALITIS

Eight serologically distinct viruses belonging to the Venezuelan equine encephalitis (VEE) complex have been associated with human disease; major human outbreaks have been associated with subtype 1, variants A, B and C. These agents also cause severe disease in horses, mules, and donkeys (Equidae). Natural infections are acquired by the bites of a wide variety of mosquitoes; Equidae serve as the viremic hosts and source of mosquito infection. In natural human epidemics, severe and often fatal encephalitis in Equidae always precedes that in humans. A BW attack with virus disseminated as an aerosol would cause human disease as a primary event. If Equidae were present, disease in these animals would occur simultaneously with human disease. Secondary spread by human-to-human transmission has not been demonstrated. However, a BW attack in a region populated by Equidae and appropriate mosquito vectors could initiate an epizootic/epidemic.

Nearly 100 per cent of those infected suffer an overt illness. After an incubation period of 1-5 days, onset of illness is extremely sudden, with generalized malaise, spiking fever, rigours, severe headache, photophobia, myalgia in the legs and lumbosacral area. Nausea, vomiting, cough, sore throat, and diarrhea may follow. This acute phase lasts 24-72 hours. A prolonged period of aesthenia and lethargy may follow, with full health and activity regained only after 1-2 weeks. Approximately 4-14 per cent of children and <1 per cent of adults during natural epidemics develop signs of central nervous system infection, with meningismus, convulsions, coma, and paralysis. These necrologic cases are seen almost exclusively in children. The overall case-fatality rate is <1 per cent, but in children with encephalitis, it may reach 20 per cent.

An outbreak of VEE may be difficult to distinguish from influenza on clinical grounds. Clues to the diagnosis are the appearance of a small proportion of neurological cases or disease in Equidae, but these might be absent in a BW attack. There is no specific therapy. Patients who develop encephalitis may require anticonvulsant and intensive supportive care to provide adequate ventilation, maintain fluid and electrolyte balance, and avoid complicating secondary bacterial infections.

An experimental vaccine, designated TC-83 is a live, attenuated cell culture-propagated vaccine which has been used in several thousand persons to prevent laboratory infections. Approximately 10 per cent of vaccines fail to develop detectable neutralizing antibodies, but it is unknown whether they are susceptible to clinical infection if challenged. A second investigational product that has been tested in humans is the C-84 vaccine, prepared by formalin-inactivation of the TC-83 strain. Both vaccines are not licensed for general public use. In experimental animals, alpha-interferon and the interferon-inducer poly-ICLC (lysine-polyadenosine) have proven highly effective for post-exposure prophylaxis of VEE. There are no clinical data on which to assess efficacy in humans.

# 5

# Chemical Warfare-Detection of Chemical Weapons

## INTRODUCTION

This chapter begins by describing chemical warfare and the agents used. The detrimental effects of these agents on the environment demand continuous experimentation and invention of new detection systems. The paper presents an overview of some of the existing detection systems, highlighting the specific uses and benefits of each system and where applicable, developments. The underlying law and policy helps the reader to understand the context of these developments. The paper then sets out some new inventions designed to modify and improve existing systems.

## CHEMICAL WARFARE

Chemical warfare (CW) involves using the toxic properties of chemical substances as weapons. This type of warfare is distinct fromnuclear warfare and biological warfare, which together make up NBC, the military acronym for nuclear, biological, and chemical (warfare or weapons), all of which are considered "weapons of mass destruction" (WMD). None of these fall under the term conventional weaponswhich are primarily effective due to their destructive potential.

Chemical warfare does not depend upon explosive force to achieve an objective. Rather it depends upon the unique properties of the chemical agent weaponized. A lethal agent is designed to injure or incapacitate the enemy, or deny unhindered use of a particular area of terrain. Defoliants are used to quickly kill vegetation and deny its use for cover and concealment. It can also be used against agriculture and livestock to promote hunger and starvation. With proper protective equipment, training, and decontamination measures, the primary effects of chemical weapons can be overcome. Many nations possess vast stockpiles of weaponized agents in preparation for wartime use. The threat and the perceived threat have become strategic tools in planning both measures and counter–measures.

## WHAT IS CHEMICAL WARFARE

A current definition of chemical warfare is the "aspects of military operations involving the employment of lethal and incapacitating chemical munitions or agents."

## THE BASICS OF CHEMICAL WEAPONRY

A chemical weapon utilizes a manufacturered chemical to incapacitate, harm, or kill people. Strictly speaking, a chemical weapon relies on the physiological effects of a chemical, so agents used to produce smoke or flame, as herbicides, or for riot control, are not considered to be chemical weapons. Although certain chemical weapons can be used to kill large numbers of people (*i.e.*, as weapons of mass destruction), other weapons are designed to injure or terrorize people. In addition to having potentially horrific effects, chemical weapons are of great concern because they are cheaper and easier to manufacture and deliver than nuclear or biological weapons.

## TYPES OF WEAPONS

A earliest chemical weapon wasn't an esoteric chemical concoction. During World War I, chlorine gas was used as a chemical weapon, released in massive clouds by the German army to cause lung damage and terror downwind of its release.

*Modern chemical weapons include the following types of agents*:

- Choking Agents (*e.g.*, phosgene, chlorine)
- Blister Agents (*e.g.*, nitrogen mustard, Lewisite)
- Nerve Agents (*e.g.*, Tabun, Sarin, VX)

## HOW CHEMICAL WEAPONS WORK

Chemical agents may be released as tiny droplets, similar to the action of a bug bomb used to release insecticide. For a chemical weapon to cause harm, it must come in contact with the skin or mucous membranes, be inhaled, or be ingested. The activity of the chemical agent depends on its concentration. In other words, below a certain level of exposure, the agent won't kill. Below a certain level of exposure, the agent won't cause harm.

## PROTECTIVE MEASURES

The best protective measure you can take against chemical weapons is to become educated about them. Most of us don't have gas masks or atropine (an injectible used in cases of nerve agent exposure) and won't be on a battlefield, so the recommendations presented here are intended for the general public.

### Don't Panic

Yes, chemical weapons are more likely to be used in a terrorist scenario than nuclear or biological weapons. However, there are several steps you can take to minimize exposure and protect yourself in the event you encounter a chemical agent. Realistically speaking, you are more likely to witness an accidental chemical spill than a chemical attack. Your best defence is to face the situation with a level head.

### Seek High Ground

Chemical agents are more dense than air. They sink to low-lying areas and will follow wind/weather patterns. Seek the highest storey of a building or the top of a natural land formation.

### Seek Open Spaces or Seek a Self-Contained Air Supply

From the point of view of a terrorist, a heavily populated area is a more attractive target than a sparsely populated region. Therefore, the threat of a chemical attack is lessened in rural areas.

In the event of an attack, there is some sense in isolating your air supply. Most chemical agents disperse after a certain amount of time, so refraining from contacting exposed air may be a good protective measure.

## Use Your Senses

How do you know if you have been exposed to a chemical agent? You may not be able to see or smell one. In their pure forms, most chemical weapon agents are clear liquids. Impure chemicals may be yellowish liquids. Most are odourless and tasteless, but some have a slightly sweet or fruity smell. Skin irritation, respiratory distress, and gastrointestinal upset all may signal exposure to a chemical agent. However, if you don't die within minutes, you probably won't die at all. Therefore, if you believe you have been exposed to a chemical agent, wait until you feel secure before seeking out medical attention (but do seek it out).

## Use Common Sense

Have a radio (with batteries) and keep up with the news. Pay attention to civil defence advisories and think before acting.

## CHEMICAL WARFARE AGENTS

A United Nations report dated 1969 defines chemical warfare (CW) agents as "... chemical substances, whether gaseous, liquid or solid, which might be employed because of their direct toxic effects on man, animals and plants ...". The Chemical Weapons Convention defines chemical weapons as including not only toxic chemicals but also ammunition and equipment for their dispersal. Toxic chemicals are stated to be "... any chemical which, through its chemical effect on living processes, may cause death, temporary loss of performance, or permanent injury to people and animals".

*In order to be considered a CW agent the following must be satisfied*:

- The presumptive agent must not only be highly toxic but also "suitably highly toxic" so that it is not too difficult to handle.

- The substance must be capable of being stored for long periods in containers without degradation and without corroding the packaging material.
- It must be relatively resistant to atmospheric water and oxygen so that it does not lose effect when dispersed.
- It must withstand the heat developed when dispersed.

The first nerve gas was invented by the Germans, it is odourless and colorless and attacks the body muscles, including the involuntary muscles. The gases classified as chemical warfare agents are characterized by poisonous or corrosive nature.

*These gases can be categorized according to the portal of entry into the body and their physiological effects*:

- Vesicants or blister gases- these produce blisters on all body surfaces. Examples include lewsite and mustard gas. About 10 milligrams of mustard gas in the lungs will kill a person.
- Lacrimators such as tear gas produce severe eye irritation.
- Sternutators also called vomiting gases cause nausea.
- Nerve Gases inhibit proper nerve function.
- Lung irritants which attack the respiratory tract, causing pulmonary edema.

## Nerve Agents

Nerve agents affect the transmission of nerve impulses within the nervous system. They belong to the compound group known as organo-phosphorous compounds (OP). OP compounds are stable, easily dispersed, highly toxic and have rapid effect. In their pure state they are colorless liquids with varying volatiles. Nerve agents enter the body through inhalation or through the skin, the port being important for determining the time the agent takes effect.

Since nerve agents are fat-soluble they can penetrate the outer layers of the skin so it takes some time before the poison reaches the blood vessels. On the other hand when it enters through the respiratory system the effect is rapid since the lungs contain numerous more blood vessels facilitating rapid assimilation and transportation to the key organs.

Nerve agents include physostigmine (reversible) and organophosphorus (irreversible) cholinesterase inhibitors, which disable enzymes responsible for the transmission of nerve impulses.

Initial incapacitating effects of organophosphorus agents occur within 1-10 minutes of exposure, and death occurs within 15 minutes for Tabun, Sarin, and Soman and from 4-42 hours for VX.

*Some nerve agents include*:

- Tabun (NATO military designation, GA)
- Sarin (NATO military designation, GB)
- Soman (NATO military designation, GD)
- GF (Cyclohexyl methylphosphonofluoridate)
- VX (Methylphosphonothioic acid S-(2-(bis(1-methylethyl) amino)ethyl) O-ethyl ester)
- GE (Phosphonofluoridic acid, ethyl-, isopropyl ester)
- VE (Phosphonothioic acid, ethyl-, S-(2-(diethylamino) ethyl) O-ethyl ester)
- VG (Amiton)
- VM (Phosphonothioic acid, methyl-, S-(2-(diethylamino) ethyl) O-ethyl ester)

## Blister/Vesicant Agents

Vesicant agents cause blisters on skin and damage the eyes, mucous membranes, respiratory tract, and internal organs. Through chemical processes, mustard agents destroy different substances within cells of living tissue.

Initial effects are somewhat delayed for mustards, occurring 12 to 24 hours after exposure, but are rapid for other agents. Symptoms are variable and acute mortality is low, but death can occur from complications after lung injury.

*Some blister agents include*:

- Lewisite (L)
- Mustard-Lewisite (HL)
- Nitrogen mustards (HN-1,HN-2, HN-3)
- Phosgene oxime (CX)
- Sulfur mustards (H, HD, HT)

## Blood Agents

Agents are highly volatile, but rapidly acting agents that cause seizures, respiratory failure, and cardiac arrest through interference with absorption of oxygen into the bloodstream.

*Some blood agents include*:

- Cyanogen chloride (CK)
- Hydrogen cyanide (AC)

## Pulmonary Agents

Such agents are liquids dispersed in a gaseous form that damage the respiratory tract and cause severe pulmonary edema in about four hours, leading to eventual death. Effects are variable, and can be rapid or delayed depending on the specific agent.

*Some pulmonary agents include*:

- Chlorine
- Chloropicrin (PS)
- Diphosgene (DP)
- Phosgene (CG)

## SARIN- AN EXAMPLE OF HOW A CHEMICAL WARFARE AGENT WORKS

Sarin is a nerve agent. Once inside your body it affects the signaling mechanism that nerve cells use to communicate with one another. Sarin is a cholinesterase inhibitor — it gums up the cholinesterase enzyme which your nerve cells use to clear themselves of acetylcholine.

When a nerve cell needs to send a message to another nerve cell (for example, to cause a muscle to contract), it sends the message with the acetylcholine. Without cholinesterase to clear the acetylcholine, muscles start to contract uncontrollably, which eventually causes death by suffocation (since the diaphragm is a muscle).

Sarin is probably the most feared chemical agent because it has actually been used by terrorists to kill people. In 1995, the group Aum Shinrikyo released sarin gas in the Tokyo subway, wounding thousands and killing 12 people. It is not particularly difficult to manufacture, and about 1 milligram in the lungs will kill a person.

## COST OF CHEMICAL WEAPONS

Perhaps the most dangerous and worrying feature of chemical weapons is that they are relatively easy and inexpensive to manufacture and deploy. For this reason they are called "the poor man's atomic bomb."

One group of experts has estimated the cost of killing people using chemical weapons would be about $600 per square kilometer, compared with $2,000 per square kilometer using conventional weapons. Chemical weapons could be dispersed from a crop dusting plane, from aerosols, or by distributing the chemical in water supplies.

Sarin, in particular, poses a large threat because it is fairly easy to manufacture. A thimble-sized portion of sarin can kill a person in minutes; a few particles can produce death in 24 hours.

## USE OF CHEMICAL WARFARE

Chemical warfare was first used effectively in World War I, when the Germans released chlorine gas against the Allies. Later in the War they used mustard gas. Soon both sides were using chemical warfare extensively leading to the introduction of gas masks.

The fear of the detrimental effects of chemical warfare caused many countries to abstain from using it and except for the use of poison gas by the Italians in the war against Ethiopia (1935-36) and by the Japanese against Chinese guerrillas (1937-42), chemical warfare was not employed after World War I. This is not to say however, that the military powers of the world did not continue to develop new gases.

It is well known that chemical warfare was used in the Iran-Iraq War. In fact, Iraq has used poison gas on its own civilians, in particular the Kurds. In the Persian Gulf War, the UN troops were equipped with antidotes for nerve gas, protective clothing, and gas masks in case Iraq used poison gas. Then there was the release of sarin in a Tokyo subway station in 1995.

## CONTROL OF CHEMICAL WARFARE AGENTS

In recognition of the unbridled and disastrous effects of chemical warfare the international community has negotiated a number of treaties aimed at prohibiting the use of chemical weapons. The first significant attempt was as early as 1925 with the signing of the Geneva Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare. The treaty which went into force in 1928 merely condemned the use of chemical weapons but did not ban the development and stockpiling of chemical weapons.

Many States signed the Geneva Protocol, but expressed the reservation that they should maintain the right to retaliate in kind with chemical weapons, should they or any of their allies be attacked in such a method. Many signatory States also reserved the right to use chemical weapons against non-signatories to the protocol.

In 1990, the United States and the Soviet Union agreed to cut their arsenals by 80 per cent in an effort to create a climate of change that would discourage smaller nations from stockpiling and using such lethal weapons. The most recent and significant treaty is the United Nations Chemical Weapons Convention (CWC) signed in 1993. This treaty bans the production, stockpiling and use of chemical weapons and calls for the establishment of an independent organization to verify compliance. As of 12th February 2001 174 states had signed or acceded to the treaty and 143 of them had deposited their ratification.

## DETECTION OF CHEMICAL WARFARE AGENTS

The Organization for the Prohibition of Chemical Weapons (OPCW) implemented at the Geneva Convention in 1992 organises exercises such as Round Robin Tests to verify the presence of Chemical Weapon Agents. The next step is to develop and test existing and new procedures or methods to further the implementation of the chemical weapons convention. Sarin and Soman are listed in Schedule 1 of the United Nations Chemical

Weapons Convention which means that they are chemicals that are deemed to pose a high risk to the purposes of the CWC, but have very limited, if any, commercial applications. Methylphosphponic acid (MPA) is formed by hydrolsis of these nerve agents. Since MPA is a more stable product than the nerve agents it is more useful for detection purposes.

It indicates the prior presence of Sarin or Soman. The challenge is that MPA does not lend itself easily to direct analysis since it is also highly polar and involatile. Present methods for detection of methylphosphonic acids are gas chromatography(GC), liquid chromatography (LC) and capillary electrophoresis (CE).

Using these methods means that the acid must first be derived via sample preparation and analysis. This is very time consuming. What is needed is a simple portable and inexpensive immunoassay kit which would be valuable to monitor various treaty compliances and during military operations. One method developed is the ELISA procedure which unlike other methods requires only a minimum of sample preparation.

## DETECTION SYSTEMS

### Electrospray Mass Spectrometry

Electrospray mass spectrometry (ES-MS) has been evaluated to determine whether it provides a time-efficient method of detection and analysis of chemical warfare degradation products. It was considered a suitable candidate because it has been shown to be ideal to the analysis of polar non volatile compounds in aqueous matrixes. These tests revealed that use of ES-MS to analyze degradation products of chemical warfare agents extracted from soil samples.

### AIRIS

The Adaptive InfraRed Imaging Spectroradiometer (AIRIS) can be used to get wide spectral coverage at a spectral resolution consistent with the detection of molecular absorption or emission band. AIRIS systems are developed by Physical Science Inc. (PSI) under internal corporate research and development as well as U.S. Army BMDO and Air Force Sponsorship. The existing AIRIS systems can detect vehicle plume emissions and camouflaged targets in cluttered environments as well as the observation and quantification of absorption or emission from specific airborne hazardous chemicals. A LWIR AIRIS system is being developed for remote standoff detection of chemical vapor plumes. This can be used in battlefield detection of chemical warfare agent plumes, fugitive emissions monitoring of chemical production facilities and hazardous wastes sites.

The scientific basis of PSI's AIRIS systems is based on a low order Fabry-Perot interferometer. The benefits of this low order system are wide free spectral range combined with narrow spectral bandwidth, flexible and adaptive sampling and processing of the image to isolate spectral features or signatures, high spatial resolutions and radiance sensitivity. The PSI system is particularly useful because it combines all of this into a compact instrument.

## Millimeter Wave Technology

Unlike existing FTIR remote sensing, millimeter wave technology is highly specific and so allows detection of chemical warfare agents in complex mixtures such as water vapor and smoke. The emphasis is on technologies with highly sensitive detection and discrimination capabilities with low false alarm rates.

The scientific base is the remote sensing of hazardous wastes based on their millimeter wave rotational signature since rotational spectra are very specific to molecular structures. The technique is called the 'Fourier Transform Microwave (FTMW) spectroscopic and it has been proven to have some advantages in detection of chemical warfare agents.

## Chemical Agent Monitors

Chemical Agent Monitors (CAMS) are a well known detection system. It's characteristic feature is its portability. As stressed throughout this chapter, portability is an overriding issue in chemical detection systems. The CAM has been used by military operations in several countries throughout the world. The CAM draws samples in continuously . It uses very little power and can detect atmospheric contaminants.

## The Use of Electrokinetic Injection in Capillary Electrophoresis

Capillary Electrophoresis (CE) is a method of separating compounds within complex matrixes. It was introduced by Jorgenson. The CE method is recognized as a ' a powerful separation technique' which can be used successfully with small samples. By employing a buffer system that is highly stable and inexpensive, the CE method reverses the electroosmotic flow and provides excellent separation efficiencies within a three minute run. CE uses compact lightweight equipment smaller samples and reduced wastes. It is therefore well suited for use in mobile laboratory are the first line of detection and analysis in emergency situations such as a chemical warfare attack. The problem is that the separational efficiency of the CE method requires a high standard of efficiency from the other processes used in analyzing samples such as the injection. Since samples can only be injected in limited volumes there is a problem of low concentration sensitivity.

Electrokinetic injection is proposed as a viable injection method (13) because it does not require extra equipment nor add to analysis time. It therefore does not decrease the efficiency and mobility of the CE method and so complements the beneficial usage of CE. When compared with pressure injection, electrokinetic injection analysis offers increased analysis sensitivity with very minimal sample, preparation steps. It's simplicity, inexpensiveness mean it is suitable for use with the CE method in mobile detection units.

## Surface Acoustic Wave (SAW) Chemical Sensor Systems

SAW chemical sensors systems have been developed since 1981 and are conceptually similar to the bulk acoustic wave sensor reported in 1964 by King . SAW detects and identifies chemical agents and other toxic gases or vapors. A SAW chemical sensor is a functionalized polymer, a Saw device is coated with a chemoselective material. This coating is gas specific and causes the gas to concentrate on the surface of the SAW device. When the device is in operation, a wave passes across its surface, the sorption of the gas molecules causes the velocity of the SAW to be perturbed. The monitoring of this surface acoustic wave leads to ready detection of gases. The Naval Research Laboratory has developed a "NRL-SAWRHINO" system which is an application of the Saw system designed specifically for vehicular mounted field applications. It is described as "an automated chemical agent detector and alarm, designed for autonomous operation with rapid and reversible responses from low to high concentrations of G-nerve and H-mustard agents."

The NRL SAWRHINO also called a 'nose for toxic gases' is comprised of a temperature controlled 3-Saw array with an automated dual gas sampling system which has two pneumatic pathways. This means that the device has both immediate detection capability and periodic detection capability. Periodic detection capability is achieved by the use of a trap and purge gas-solid chromatographic column. As the name suggests this traps gases which are then sent to the SAW sensors for detection.

The coating used in the device is specific to a number of nerve and blister agents and can discriminate against a wide range of interferent vapors and gases. Tests of the device commend it with a robust operational performance evidenced by 100 per cent accurate identification of agents with no false alarms. Note that while experimentation and sampling was done using a 3-Saw array, research at the Naval Research Laboratory indicates that real time detection is better achieved by using a 5-SAW array.

## INVENTIONS

### Alarm System for Hand Held Chemical Monitor

This invention is an alarm system designed for use with chemical agent monitors. Chemical agent monitors are hand held soldier operated devices, post attack devices for monitoring chemical agent contamination on people and equipment. The alarm system will connect to these monitors so it is important that they complement their present structure and operation. The inventor aims at providing an alarm system with low power consumption that permits soldiers to easily and quickly detach parts while wearing protective gear.

The major components are pins, twist lock mechanical connectors, circuit board, a power source, ceramic disk, voicemitter and a housing. When the CAM/ICAM senses the presence of a chemical agent it emits a electric signal to the indicator which emits an audible alarm. This warns of the presence of chemical contamination in an environment. The invention does not take electricity from the CAM/ICAM until it is in alarm and the total power consumption is 6 volts or less.

## Analytical Methodology for Qualitative and Quantitative Determination of Chemical Agent Vapor

The claim is for a method of generating and sampling chemical agent vapor by placing the liquid chemical agent in a reservoir purging the chemical agent using dry air and analyzing the air stream exiting the reservoir. The invention is directed to determining VX vapor under various humidity conditions. Since VX is extremely toxic its detection is best accomplished at lowest possible concentrations.

When testing chemical detectors using VX vapor it is important to minimize the presence of impurities. Impurities of about 5 per cent can affect detector testing. The challenge is that impurities may become the major constituent in a vapor mixture when it is vaporized. Existing methods used to quantify a VX sample lack the ability to separate or distinguish the relationship between the impurities and VX. It is therefore desirable to develop an improved methodology for sampling VX.

The invention is a method which starts with placing the liquid agent in a reservoir, the temperature of which is maintained in order to allow vaporization of the contaminants in the chemical agent. The contaminant is then purged with dry air. The dry air is then removed which removes the contaminant leaving the retained chemical agent. Conditioned air is then passed over the retained chemical agent and carries the agent vapors to a sample port where the mixture of conditioned air and chemical agent vapors is analyzed. Unlike existing methods it allows the analysis of VX vapor under various humidities.

## Broad Spectrum Bio-detection of Nerve Agents

The principal thrust of this invention is to provide a method of real time or near real time detection of nerve agents. As discussed above nerve agents take rapid effect particularly when the route is via the lungs, therefore it is vital that detection equipment can produce results as soon as possible. The invention recognizes that existing methods of detection are slow or too bulky which impedes their use where it is needed, on the front line.

*It seeks to provide a method and apparatus that* :

- Provides rapid detection of nerve agents in air and water
- While being portable and inexpensive enough to be issued to each individual
- Be a broad band detector which is responsive to a wide variety of OP compounds

The invention rests on the scientific observation that protein complexes can be used with colorimetric compounds to detect the presence of very low concentrations of chemical warfare agents. The instant invention applies this observation to obtain real time detection of chemical warfare agents. The electron distribution in a colorimetric compound is altered by its immediate environment. Therefore an indicator to detect hazardous substances may be created by monitoring specific lights wavelengths in the spectrum of a specific colorimetric compound.

Optical changes in the colorimetric indicator are made using preferably both absorbance and fluorescence in the visible region. However the invention uses difference spectra which allows very small wavelength shifts and minute absorbance changes to be identified. This means that over 7700 different analytes can be identified and their concentration levels can be quantified to very small ranges. The second part of the invention is an apparatus which monitors the transforming optical spectrum of a specific colorimetric compound. It uses real time measurement of the changes in the spectral substrate to indicate the presence of organophospahates. The major components of the apparatus are a light source, a colorimetrically responsive surface and an optical sensitive detector directed towards the illuminated surface. The light source an detector operate continuously in order to achieve immediate identification of changes in the absorptive properties of the detection surface.

The apparatus may be as small as a badge so it can be worn continuously by individuals and incorporate some sort of warning element. Additionally the light source and detector may be maintained separately from the detection surface so that identification tests are conducted at at central location. The invention aims at detection in both aqueous and air samples.

## Remote Sensor of Chemicals

The invention is a passive remote device and method using differential absorption radiometer (DAR) or notch filter correlation radiometer (NFCR) technology to detect chemical weapons. Such a device was deemed necessary because of a number of factors. The first is the spread of chemical warfare technology around the world. There is also the concern about the effects of industrial and vehicular emissions and environmental pollution from pesticides.

Existing systems such as the Chemical Agent Monitor and the Enhanced CAM, both manufactured by the same company, operate on the principle of ion mobility. The limitation of these systems is that they need continuous sampling at the point of measurement and therefore can only detect a gas if the sensor is immersed in it. The SAW system discussed above is criticized as lacking specificity and the ability to determine the specific identity of a gas. The invention addresses these deficiencies and the shortcomings of other conventional remote chemical detection techniques. The major components are a first optical path, a second optical path, light collecting optics and a sample filter assembly. The sensor mal also include a reference filter assembly which will be positioned in the path of the second optical path after the light collecting optics. The invention also includes a method of determining the presence, concentration and optical density of a target species. This is accomplished by directing the light that has been absorbed from a target species along the two optical paths. A detector output comparison device is then used to compare the sample signal to the reference signal. This produces a signal which indicates the absorption or emission of the light by the target species.

## HISTORY OF CHEMICAL WARFARE AND CURRENT THREAT

The use of biological weapons and efforts to make them more useful as a means of waging war have been recorded numerous times in history. Two of the earliest reported uses occurred in the 6th century BC, with the Assyrians poisoning enemy wells with rye ergot, and Solon's use of the purgative herb hellebore during the siege of Krissa. In 1346, plague broke out in the Tartar army during its siege of Kaffa (at present day Feodosia in Crimea). The attackers hurled the corpses of those who died over the city walls; the plague epidemic that followed forced the defenders to surrender, and some infected people who left Kaffa may have started the Black Death pandemic which spread throughout Europe. Russian troops may have used the same plague-infected corpse tactic against Sweden in 1710.

On several occasions, smallpox was used as a biological weapon. Pizarro is said to have presented South American natives with variola-contaminated clothing in the 15th century, and the English did the same when Sir Jeffery Amherst provided Indians loyal to the French with smallpox-laden blankets during the French and Indian War of 1754 to 1767. Native Americans defending Fort Carillon sustained epidemic casualties which directly contributed to the loss of the fort to the English.

In this century, there is evidence that during World War I, German agents inoculated horses and cattle with glanders in the U.S. before the animals were shipped to France. In 1937, Japan started an ambitious biological warfare programme, located 40 miles south of Harbin, Manchuria, in a laboratory complex code named "Unit 731". Studies directed by Japanese General Ishii continued there until 1945, when the complex was leveled by burning it. A post World War II investigation revealed that numerous organisms had received Japanese research attention, and that experiments had been conducted on prisoners of war. Slightly less than 1,000 human autopsies apparently were carried out at Unit 731, most on victims exposed to aerosolized anthrax. Many more prisoners and Chinese nationals may have died in this facility - some have estimated up to 3,000 human deaths. In 1940, a plague epidemic in China and Manchuria followed reported overflights by Japanese planes dropping plague-infected fleas. By 1945, the Japanese programme had stockpiled 400 kilograms of anthrax to be used in a specially designed fragmentation bomb.

In 1943, the United States began research into the offensive use of biological agents. This work was started, interestingly enough, in response to a perceived German biological warfare (BW) threat as opposed to a Japanese one. The United States conducted this research at Camp Detrick (now Fort Detrick), which was a small National Guard airfield prior to that time, and produced agents at other sites until 1969, when President Nixon stopped all offensive biological and toxin weapon research and production by executive order.

Between May 1971 and May 1972, all stockpiles of biological agents and munitions from the now defunct U.S. programme were destroyed in the presence of monitors representing the United States Department of Agriculture, the Department of Health, Education, and Welfare, and the states of Arkansas, Colorado, and Maryland. Included among the destroyed agents were Bacillus anthracis, botulinum toxin, Francisella tularensis, Coxiella burnetii, Venezuelan equine encephalitis virus, Brucella suis, and Staphylococcal enterotoxin B. The United States also had a medical defensive programme, begun in 1953, that continues today at USAMRIID.

In 1972, the United States and many other countries signed the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction, commonly called the

Biological Weapons Convention. This treaty prohibits the stockpiling of biological agents for offensive military purposes, and also forbids research into such offensive employment of biological agents. The former Soviet Union and the government of Iraq were both signatories to this accord. However, despite this historic agreement among nations, biological warfare research continued to flourish in many countries hostile to the United States. There were also several cases of suspected or actual use of biological weapons. Among the most notorious of these were the "yellow rain" incidents in Southeast Asia, the accidental release of anthrax at Sverdlovsk, and the use of ricin as an assassination weapon in London in 1978.

Testimony from the late 1970's indicated that the countries of Laos and Kampuchea were attacked by planes and helicopters delivering aerosols of several colours. After being exposed, people and animals became disoriented and ill, and a small percentage of those stricken died. Some of these clouds were thought to be comprised of trichothecene toxins (in particular, T2 mycotoxin). These attacks are lumped under the label "Yellow Rain". There has been a great deal of controversy about whether these clouds were truly biological warfare agents: some have argued that the clouds were nothing more than bee feces produced by swarms of bees.

In late April of 1979, an incident occurred in Sverdlovsk (now Yekaterinburg) in the former Soviet Union which appeared to be an accidental release of anthrax in aerosol form from the Soviet Military Compound 19, a microbiology facility. Residents living downwind from this compound developed high fever and difficulty breathing, and a large number died. The final death toll was estimated at the time to be between 200 and 1,000. The Soviet Ministry of Health blamed the deaths on the consumption of contaminated meat, and for years controversy raged in the press over the actual cause of the outbreak. All evidence available to the United States government indicated a massive release of aerosolized anthrax. In the summer of 1992, U.S. intelligence officials were proven correct when new Russian President Boris Yeltsin acknowledged that the Sverdlovsk incident was in fact a large scale accident involving the escape of an aerosol of anthrax spores from the military research facility. In 1994, Meselson and colleagues published an in-depth analysis of the Sverdlovsk incident (Science 266:1202-1208). They documented that all of the 1979 cases occurred within a narrow zone extending downwind in a southerly direction from Compound 19. A total of 77 patients were identified by Meselson's team, including 66 fatalities and 11 survivors.

Before the Sverdlovsk incident, in 1978, a Bulgarian exile named Georgi Markov was attacked in London with a device disguised as an umbrella which injected a tiny pellet filled with ricin toxin into the subcutaneous tissue of his leg while he was waiting for a bus. He died several days later. On autopsy, the tiny pellet was found and determined to contain the toxin. This assassination, it was later revealed, was carried out by the communist Bulgarian government, and the technology to commit the crime was supplied to the Bulgarians by the former Soviet Union.

In August of 1991, the first United Nations inspection of Iraq's biological warfare capabilities was carried out in the aftermath of the Gulf War. On August 2, 1991, representatives of the Iraqi government announced to leaders of United Nations Special Commission Team 7 that they had conducted research into the offensive use of Bacillus anthracis, botulinum toxins, and Clostridium perfringens (presumably one of its toxins). This was the first open admission of biological weapons research by any country in recent memory, and it verified many of the concerns of the U.S. intelligence community publicly. Iraq had extensive and redundant research facilities at Salman Pak and other sites, many of which were destroyed during the war.

In 1995, further information on Iraq's offensive programme was made available to United Nations inspectors. Iraq conducted research and development work on anthrax, botulinum toxins, Clostridium perfringens, aflatoxins, wheat cover smut, and ricin. Field trials were conducted with Bacillus subtilis (a simulant for anthrax), botulinum toxin, and aflatoxin. Biological agents were tested in various delivery systems, including rockets, aerial bombs, and spray tanks. In December 1990, the Iraqis filled 100 R400 bombs with botulinum toxin, 50 with anthrax, and 16 with aflatoxin. In addition, 13 Al Hussein (SCUD) warheads were filled with botulinum toxin, 10 with anthrax, and 2 with aflatoxin. These weapons were deployed in January 1991 to four locations. All in all, Iraq produced 19,000 litres of concentrated botulinum toxin (nearly 10,000 litres filled into munitions), 8,500 litres of concentrated anthrax (6,500 litres filled into munitions) and 2,200 litres of aflatoxin (1,580 litres filled into munitions).

The threat of biological warfare has increased in the last two decades, with a number of countries working on offensive use of these agents. The extensive programme of the former Soviet Union is now controlled largely by Russia. Russian president Boris Yeltsin has stated that he will put an end to further offensive biological research; however, the degree to which the programme has been scaled back, if any, is not known. Recent revelations from a senior BW programme manager who defected from the FSU in 1992 outlined a remarkably robust biological warfare programme including active research into genetic engineering, binary biologicals and chimeras. There is also growing concern that the smallpox virus, eliminated from the face of the earth in the late 1970's and now stored in only two laboratories at the CDC in Atlanta and the Institute for Viral Precautions in Moscow, Russia, may have been "bargained" away by desperate Russian scientists seeking money.

There is intense concern in the West about the possibility of proliferation or enhancement of offensive programmes in countries hostile to the western democracies, due to the potential hiring of expatriate Russian scientists. It was reported in January 1998 that Iraq had sent about a dozen scientists involved in BW research to Libya to help that country develop a biological warfare complex disguised as a medical facility in the Tripoli area. In a report issued in November 1997, Secretary of Defence William Cohen singled out Libya, Iraq, Iran, and Syria as countries "aggressively seeking" nuclear, biological, and chemical weapons.

There is also an increasing amount of concern over the possibility of terrorist use of biological agents to threaten either military or civilian populations. There have been cases of persons loyal to extremist groups trying to obtain microorganisms which could be used as biological weapons. The Department of Defence is leading a federal effort to train the first responders in 120 American cities to be prepared to act in case of a domestic terrorist incident involving WMD. Certainly the threat of biological weapons being used against U.S. military forces is broader and more likely in various geographic scenarios than at any point in our history. Therefore, awareness of this potential threat and education of our leaders and medical care providers on how to combat it are crucial.

## A CHEMICAL WEAPONS ATLAS

Few states admit that they possess chemical weapons. In recent years, only the United States, Russia, Iraq, and now India, have done so. The United States, which has started to destroy its chemical weapons, has a stockpile of about 30,000 tons. Russia has declared 40,000 tons. Iraq, which acknowledged after the Gulf War that it had such weapons, claims that its chemical agents and munitions were destroyed during and after the war. India recently admitted to having chemical weapons, but only for "defensive" purposes.

In any event, four nations make a short list indeed. And now that the Chemical Weapons Convention has entered into force, many people believe that the struggle to banish lethal chemical munitions has been won. But it is too early to celebrate. Developing and dealing in chemical weapons has always been a back-alley business that nations have mainly conducted in secret. And it could continue in much the same way, unless members of the international community are willing to speak up in public about chemical-weapons activities.

Yet states largely refuse to do so. Even the new Organization for the Prohibition of Chemical Weapons (which is implementing the Chemical Weapons Convention) keeps the mandatory declarations of past and present chemical weapons activities confidential. Such secrecy, however, is misguided, because it keeps the public ignorant of the true extent of the proliferation problem and allows states that have or are developing chemical weapons to continue to manufacture and stockpile them. In the United States, the discussion of the proliferation of chemical weapons is highly politicized. Typically, U.S. officials will only point their fingers at the current list of "rogue nations." For instance, in testimony before the Senate Select Committee on Intelligence last February, CIA Director George Tenet said that some 20 countries, among them Iran, Iraq, and Syria, have or are actively developing chemical and biological weapons. By identifying only three states by name, Tenet chose, or was directed, to name one less state than his predecessor John Deutch had named the year before. He omitted North Korea. This omission is particularly troubling in light of the testimony—at the same Senate hearing—by the director of the Defence Intelligence Agency (DIA), Lt. Gen. Patrick Hughes, that "a Korean war scenario remains our primary near-term military concern."

The public deserves to be fully informed about the proliferation of chemical weapons and should have the same on-the-record information U.S. policy makers use. Chemical weapons threaten not only soldiers, who may have protective gear, but also civilians. Consider what happened when the United States failed to respond to Iraq's use of chemical weapons in the early 1980s. Recently declassified intelligence reports indicate that the United States knew by 1983 that Iraq had—and had used—lethal agents. It also knew that, with the help of foreign firms, Iraq was building a major new chemical weapons facility. Yet the United States and its allies continued to support Iraq with loans and other forms of assistance. Unrestrained, Iraq used chemical weapons repeatedly during the Iraq-Iran War. Later, it attacked Kurdish villagers in northern Iraq with mustard and nerve gas.

The failure of the international community to condemn Iraq for using chemical weapons and the failure to control the trade in chemicals had other unforeseen consequences. As a Defence Department report indicates, Iran initiated a chemical warfare programme "in response to Iraq's use of mustard gas against Iranian troops." And, partially as a result of the U.S. government's earlier silence, American troops faced the prospect of Iraq's chemical and biological arsenal in the Gulf War. This also encouraged other governments to believe they would not be censured if they initiated chemical weapons programmes. As a 1992 DIA report concludes, Third World countries believed they were free to stockpile chemical weapons "without the fear of repercussions from the international community." Perhaps this attitude will change as the Organization for the Prohibition of Chemical Weapons does its work, but the process might be speeded up if the U.S. government disclosed what it knows about chemical weapons activities throughout the world.

Meanwhile, how much can be known without more government disclosure? Through official documents released under the Freedom of Information Act and press reports citing U.S. government officials, it is possible to identify most of the states suspected of trading in or manufacturing chemical weapons.

There are two caveats about using these sources: Intelligence reports often characterize a state as having a "chemical warfare capability" without indicating whether that state is developing weapons or already has a stockpile of chemical munitions. Then, too, it is difficult or impossible to verify U.S. intelligence reports independently. Nonetheless, they are on-the-record assessments that U.S. policy makers use and often share with NATO partners and other allies.

## The Middle East

The Middle East and North Africa are enmeshed in a destabilizing arms race. Here the belief that one state possessed weapons of mass destruction prompted another to establish its own programme, which led to another state acquiring chemical weapons, that led another state, and so on. The race has gone on in earnest since the 1960s, and currently more than half of the states in the region have, or are suspected of having, offensive chemical weapons.

- *Egypt*: According to a Special National Intelligence Estimate, "Implications on Soviet Use of Chemical and Toxin Weapons for U.S. Security Interests," a 1983 report representing the judgement of the CIA, the DIA, the National Security Agency, and the intelligence arms of the State and Treasury Departments, Egypt was "the first country in the Middle East to obtain chemical weapons training, indoctrination, and matériel." (Egypt may or may not have been motivated by Israel's construction of the Dimona nuclear reactor in 1958.)

Egypt was also the first Middle Eastern country to use chemical weapons. It employed phosgene and mustard agent against Yemeni Royalist forces in the mid-1960s, and some reports claim that it also used an organophosphate nerve agent. A 1990 DIA study, "Offensive Chemical Warfare Programmes in the Middle East," concluded that Egypt was continuing to conduct research related to chemical agents. The report identified a production facility, but details were deleted.

- *Israel*: According to the same DIA study, Israel developed its own offensive chemical weapons programme in response to a perceived Arab chemical-weapon threat. In 1974, Lt. Gen. E. H. Almquist told a Senate Armed Forces Committee that the Israeli programme was operational. The 1990 DIA study reports that Israel maintains a chemical warfare testing facility. Newspaper reports suggest the facility is in the Negev desert.
- *Syria*: Syria began developing chemical weapons in the 1970s, in response to the Israeli threat, according to a 1993 DIA report, "Chemical Warfare Assessments Syria." The 1990 DIA survey reports that Syria received chemical weapons from Egypt in the 1970s, and indigenous production began in the 1980s.

  Today, Syria is believed to have a large stockpile of chemical munitions. It allegedly has two means of delivery: a 500-kilogram aerial bomb, and chemical warheads for Scud-B missiles. The 1990 DIA report named two chemical munitions storage depots, at Khan Abu Shamat and Furqlus, and indicated that the Centre D'Etude et Recherche Scientifique, near Damascus, was the primary research facility. Recent newspaper articles, citing U.S. reconnaissance, report that Syria is building a new chemical-weapons factory near the city of Aleppo.

- *Iran*: According to the 1990 DIA report, Iran's programme was developed in response to the Iraqi use of chemical weapons during the Iran-Iraq War. The DIA concluded that by the end of the war the Iranian military had been able to field mustard and phosgene, although it reportedly used them in limited quantities only.
  The same report stated that Iran had artillery shells and bombs filled with chemical agents. A 1992 DIA report, "Weapons Acquisition Strategy Iran," added that Iran was developing ballistic missiles with the assistance of China and North Korea, both of which are reported to have chemical-agent warheads for their surface-to-surface missiles.
- *Iraq*: Since the end of the Gulf War, U.N. specialists have destroyed more than 480,000 litres of Iraq's chemical agents and 1.8 million litres of precursor chemicals. But this may not be the full extent of that country's large and sophisticated chemical weapons programme. Iraq is believed to have a number of secret depots where agents or precursors are stored.
  Rolf Ekeus, the former head of the U.N. Special Commission charged with eliminating Iraq's weapons of mass destruction, said in a June 24 interview with the New York Times that he doubts the entire stockpile has been found. Iraq has made repeated attempts to import proscribed equipment and attempted to hide chemicals, munitions, and equipment from U.N. inspectors. "We have documentary evidence about orders from the leadership to preserve a strategic capability," Ekeus said. He believes that Iraq wants "to keep the production equipment ready to produce at any given moment." A 1995 DIA assessment concluded that Iraq was still conducting research and development.
- *Libya*: According to a publicly released Defence Department survey, "Proliferation: Threat and

Response," Libya obtained its first chemical agents from Iran, using them against Chad in 1987.

Libya opened its own production facility in Rabta in 1988. The report concludes that the Rabta facility may have produced as much as 100 tons of blister and nerve agent before a suspicious fire closed it down in 1990. Many newspaper reports, citing U.S. intelligence sources, indicate that Libya is building a second facility in an underground location at Tarhunah.

- *Saudi Arabia*: U.S. analysts suspect that Saudi Arabia has a limited chemical warfare capability in part because it acquired 50 CSS-2 ballistic missiles from China. These highly inaccurate missiles are thought to be suitable only for delivering chemical agents.

The sections on Saudi Arabia in the declassified portions of the 1992 and 1993 editions of the DIA's annual assessment of weapons of mass destruction (prepared for the Senate Select Committee on Intelligence) are heavily deleted. In addition, Gulf War-related documents recently released by the Defence Department indicate that the United States suspected at that time that Saudi Arabia had chemical agents.

## Asia

There are many chemical-weapon suspects in Asia. China, India, Pakistan, North Korea, and Taiwan appear to have developed chemical weapons in response to regional tensions. Burma, on the other hand, apparently wanted chemical weapons for domestic use.

- *North Korea*: North Korea's chemical weapons stockpile is probably the largest in the region. According to a 1995 DIA assessment, "Worldwide Chemical Warfare Threat Current and Projected," North Korea has had a chemical weapons programme since the 1960s. The 1996 Defence Department survey concludes that North Korea can produce "large quantities" of blister, blood, and nerve agents.

  North Korea could deliver these agents by artillery, rocket launcher, mortar, and spray tank. The Defence

Department notes that the North Korean military has been trained to operate in a chemical environment and North Korean civilians have been trained in chemical defence.

- *South Korea*: South Korea is also suspected by U.S. intelligence of having chemical weapons. South Korea has the chemical infrastructure and technical capability to produce chemical agents, and newspaper reports from the late 1980s cite U.S. government sources claiming that South Korea had a chemical weapons programme. A 1986 U.S. Army Scientific and Technical Intelligence Bulletin, "Expanding Chemical Warfare Capability: A Cause for Concern," included a heavily edited section on South Korea. South Korea is regularly included in the annual DIA assessments of the proliferation of weapons of mass destruction, but details are deleted. (U.S. chemical munitions may also be stockpiled in South Korea.)
- *India*: According to a 1991 DIA assessment, India has the technical capability and industrial base needed to produce precursors and chemical agents, and it is expected to acquire chemical weapons over the next two decades. Development is expected to be "paced by the parallel Pakistani programme." As required of a party to the chemical weapons treaty, India admitted this year that it had produced and stockpiled chemical munitions for "defensive purposes."

  Several Indian companies have been implicated in highly suspicious chemicals shipments and are involved in the construction of chemical plants in states that are developing chemical weapons. The United States has sanctioned some Indian companies for these activities.
- *Pakistan*: The 1996 Defence Department report indicates that Pakistan can produce chemical agents and munitions with dual-use chemical precursors procured from foreign sources. Its goal now is to achieve self-sufficiency in producing precursors. According to a

1993 DIA report, "Weapons Acquisition Strategy Pakistan," Pakistan has artillery projectiles and rockets that can be made chemical-capable.

- *China*: China has a mature chemical warfare capability, according to the 1996 Defence Department report on proliferation. Given China's advanced technical know-how, it must also be assumed that China can field its chemical agents in a wide variety of munitions, including ballistic missiles. China is also a serious proliferation concern, and a number of Chinese companies and individuals have been sanctioned by the U.S. government for their proliferation activities.
- *Taiwan*: The 1983 Special National Intelligence Estimate, cited in the Defence and Foreign Affairs Handbook, reported that Taiwan had "an aggressive high-priority programme to develop both offensive and defensive capabilities"--but that information was deleted from the declassified version. In 1988, the director of naval intelligence told a congressional committee that Taiwan was developing a chemical weapons capability, and in 1989, he reported that it may be operational.
- *Burma*: Another Asian state thought to produce chemical weapons is Burma (Myanmar). Its programme, under development in 1983, may or may not be active today. U.S. officials told Congress in 1988 and 1991 that Burma was developing or had developed chemical weapons. According to the 1992 DIA survey produced for the Senate Select Committee on Intelligence, Burma has "chemical weapons and artillery for delivering chemical agents." On the other hand, the 1993 edition of the DIA report indicates that Burma is no longer developing chemical weapons. There have been many reports that Burma used chemical agents against insurgents.
- *Vietnam*: In congressional testimony in 1988, the director of naval intelligence indicated that Vietnam was in the process of developing, or already had, chemical weapons. Newspaper reports suggest that

Vietnam may have obtained chemical weapons from the former Soviet Union. Vietnam also captured large stocks of U.S. riot control agents during and at the end of the Vietnam War. No public references have been made recently to an indigenous production capacity.

## Europe

During the Cold War it was generally assumed that all the NATO and Warsaw Pact states had access to the superpowers' chemical weapons, and it was an accepted idea that chemical warfare would be likely in the event of a war between the two alliances. Since the dissolution of the Soviet Union and the Warsaw Pact and the withdrawal of U.S. chemical munitions, it is unclear which European states may still have access to chemical weapons.

According to U.S. intelligence, the only European states that developed indigenous production capabilities were Yugoslavia, Romania, the former Czechoslovakia, and France. (Britain produced large quantities of chemical weapons in the World War II-era, but it disposed of them in the 1950s, dumping some in the sea and incinerating the rest.) Some other states, including Bulgaria, may still retain munitions left behind by Russian forces.

- *The former Yugoslavia*: The former Yugoslavia has a "CW production capability" according to the Defence Department's Bosnia Country Handbook, issued in 1995. After a year-long research project, Human Rights Watch concluded that before the breakup of Yugoslavia, the Yugoslav National Army produced and weaponized sarin, sulfur mustard, BZ (a psychochemical incapacitant), and irritants CS and CN. The army apparently had also developed and/or produced bombs, artillery shells, and rockets to deliver these munitions, some of which it produced in quantity.

  When Yugoslavia broke apart, much of the programme was inherited by the army of the Federal Republic of Yugoslavia (Serbia). The programme apparently remains active. Bosnian officers interviewed by Human Rights Watch reported that the Bosnian government also produced crude chemical weapons during the 1992-95 war.

- *Romania*: The declassified version of the DIA's 1995 "Chemical Warfare Assessment Romania" is heavily edited, but the U.S. National Ground Intelligence Agency did identify research and production facilities and chemical weapons stockpiles and storage facilities in Romania. A 1982 classified report, the army-commissioned "Warsaw Pact Scientific Resources of Chemical/Biological Defence," indicated that Romania had a large chemical warfare programme, adding that it had developed a cheaper method for synthesizing sarin.

  The former Czechoslovakia. According to the 1992 and 1993 DIA assessments, the Czech Republic and Slovakia had confirmed pilot-plant chemical capabilities that probably included sarin, soman, and possibly VX, but the study concluded that they did not appear to be producing chemical agents at the time.
- *France*: France probably does not have an active programme, but it presumably has a stockpile of chemical weapons. In a heavily censored 1978 report, "Chemical and Biological Capabilities NATO Countries (France, Italy and West Germany)," U.S. intelligence concluded that France had produced and stockpiled a number of chemical agents and munitions, including aerosol bombs. During the 1980s, France was identified as having chemical weapons in surveys published by the New York Times, the Christian Science Monitor, and the Wall Street Journal, all citing U.S. intelligence sources.

  In 1987, Foreign Minister Jean-Bernard Raimond announced that France had decided to acquire new chemical weapons, but it is not known how far this programme had advanced before the Chemical Weapons Convention was signed in Paris in 1993.
- *Bulgaria*: According to the declassified version of a 1995 DIA report, "Chemical Agent Threat Current and

Projected," Bulgaria has a stockpile of chemical munitions of Soviet origin, but no indigenous production capability. Details of the stockpile were deleted.

## Sub-Saharan Africa

South Africa is the only state in southern Africa with a possible chemical weapons programme. The 1992 and 1993 DIA reports mentioned South Africa, but details were deleted. Public evidence suggests that at one point South Africa had an active programme. Justice Minister Dullah Omar told a June 10, 1996 press conference that South Africa had initiated a well-funded chemical programme in 1980, with procurement of equipment and materials handled through a sophisticated network of front companies.

Lt. Gen. Niel Knobel, the surgeon general of the South African Defence Force, claims that "all lethal, incapacitating, and irritating chemical and biological agents" were destroyed in 1990, but this claim has not been verified. Newspaper reports citing U.S. intelligence sources suggest that former employees of South Africa's chemical weapons programme may have helped Libya and other states develop chemical weapons.

## LOOKING TO THE FUTURE

Many of the countries described in this survey have signed and/or ratified the Chemical Weapons Convention. Now that it is in force, the treaty, and its implementing body, the Organization for the Prohibition of Chemical Weapons, should do much to counter current proliferation tendencies, and it should reduce the number of states with chemical warfare capabilities. All parties to the convention are required to declare past and present chemical weapons research, development, production, and stockpiling, although their declarations will remain confidential unless the states independently publicize their declarations. (Britain released much of its declaration and India has recently admitted to having a programme.) The policy of confidentiality is unfortunate, because it is openness that will stop the proliferation of chemical weapons. Much of the success of the Chemical Weapons Convention will rest on states' willingness to cooperate and freely exchange information about current and past shipments of the precursors and equipment that are used to produce military agents and munitions.

Acknowledging the spread of weapons and information on suspected chemical weapons programmes will make it much more difficult to conceal illegal programmes or to maintain stockpiles. Public investigation of neighbors' allegations will also reduce the incentive for countries neighbouring suspected chemical weapons-capable states to develop chemical weapons.

Under the provisions of the Chemical Weapons Convention, an accused state must allow a thorough investigation. If it denies inspectors access, it will face both sanctions and the stigma that comes with being identified as a potential possessor of chemical weapons. Under the treaty, neighbouring states can also request international assistance to protect their populations, eliminating the need to develop their own weapons as deterrents.

Any attempt to control the proliferation of chemical weapons, however, must be linked to an objective assessment of their spread. The United States should establish a firm policy that no state--no matter how close an ally--should be allowed to maintain a secret capability to produce and use chemical munitions. It should therefore reveal the identities of all states it believes have chemical weapons programmes.

# 6

# Information Disasters and Disaster Information

## INTRODUCTION

Information flows across space and time in unpredictable ways, creating new structures and forms as the situation requires (McDaniel, 1997). Unprocessed information is intangible and non-consumable, yet a plentiful resource that can be refined and used as a public or private good. Information is inherently more abundant than most resources because it is found in every person, place, and thing—it is the entirety of known data, facts and ideas. Information, in my opinion, is any meme, message, or meaning that influences, directly or indirectly, how persons understand their situations.

It is the principle element of omniscience, and therefore the resource from which all knowledge is extracted. Knowledge includes units of systematic subjects, noted for their oneness, objectivity, respected social implications, usefulness, and resistance to obsolescence. Knowledge is mined and refined into the integrated disciplines the world calls wisdom—valued public goods like anthropology, information technology (IT), medical research, and universal religion (Cleveland, 1982).

As unprocessed public goods, information flows between and among people and groups in the form of verbal, non-verbal, or written interactions—whether memes, messages, or meanings—that serve as precursors to problem-solving and decision-making. Interactions instigated directly or indirectly by a disaster could be deemed disaster information.

As processed public goods, information—whether a meme, message, or meaning—influences the lives of those who experience it. When life-sustaining or life-fulfilling information is absent, inaccessible, or useless because it is inaccurate or interrupted as the result of a hazard—natural, civil, or technological, the persons affected may be said to be experiencing an information disaster. An information disaster hinders the access to or effective use of disaster information.

Information is a vital public good whether processed or unprocessed. How people encounter information, a phenomenon called information-seeking behaviour or information behaviour by information scientists, is the subject of extensive research (Case, 2002). The study of disaster information behaviour—the actions or attitudes that affect encountering, needing, finding, choosing, or using disaster information—appears to be scant or absent in the literature.

This deficiency in the study of disaster information behaviour may exist because studying information behaviour involves field study—an option not always available to researchers in times of disaster. In addition, many researchers cannot afford the time and expense demanded by qualitative research, the preferred approach to effective information behaviour studies. A further challenge for researchers is the inherent elusiveness of information itself. The form it assumes or the direction it will flow is not always apparent (Burlando, 1994). What is apparent, however, is that information, as the essence of all knowledge, and subsequently the essence all wisdom—is the basis for all disciplines of study, including information science and emergency management. Its pervasiveness alone demands interdisciplinary observation.

## INFORMATION ABOUT DISASTERS

Disasters fall into two major categories. These include man made and natural disasters. There is a major difference between these two and it is important to learn more about the same in order to increase your knowledge on the occurrence and causes of each and hence ensure that your disaster preparedness is heightened.

For starters, natural disasters are brought about by change in natural phenomenon or what is known as acts of God. The extent of loss experienced is dependent on the vulnerability of the population. As such, this means that this can only occur in areas that are susceptible to vulnerability. On the other hand, man made disasters are influenced by humans and they are often as a result of negligence and human error among other factors.

- *Natural disasters*: Natural disasters include things such as floods, volcanic eruptions, earthquakes, floods, tornadoes, landslides and hurricanes.
- *Man made disasters*: These can be divided into different categories and they include technological hazards, sociological hazards and transportation hazards among others.

Despite the difference between these two, it is ideal to note that they can cause irrevocable damage if the right measures are not put in place to avoid the same. This is where the need for disaster preparedness comes in. It goes a long way to cushion people from the after effects of such happenings. There are several sources that provide useful resources that make it possible to meet this end. Whether the disaster is natural or man made, the manner in which action is taken goes a long way to determine how people fair from the experience. In both instances, casualties should be treated immediately and the best way to meet this end is placing the necessary measures in place that counteract this. Note that the costs associated with handling of the man made and natural disasters run to billions of shillings every year and this negatively affects the economy.

**Fig.** Man Made Disasters

Man made disasters are also known as anthropogenic disasters and they as a result of human intent, error or as a result of failed systems. As mentioned earlier, these are broken down into several categories and while this is the case, there are some that cause more pronounced damage when compared to others. A good example is to look at man made disasters such as transportation. These are divided into different categories which include aviation, rail, road and space among others. Often these are as a result of neglect or ignorance and over the years, they have claimed several lives.

Another type of disaster that falls in this category is nuclear bomb. When this occurs, it is often as a result of intent and the end results are even more catastrophic with a large percentage of those involved losing their lives or alternatively ending up with major defects or long term injuries. Other types of man made disasters which are just as catastrophic include chemical spill, oil spill, arson and terrorism. There are also some technological hazards which include power outages structural collapse, industrial hazards and fire. In cases of the last example, thousands of kilometers of land can be destroyed and anything else that is in the wake of the fires path.

Over the years, fires have come to be known as rampant man made disasters and they are also divided into different categories such as bush fires, mine, wild and firestorms. One of the most famous man made disasters in the form of fire was the Pennsylvania fire which was recorded in 1962. It left major distraction in its wake by destroying a town and to date, such fires continue to burn. Whenever people suffer injuries due to any of the mentioned man made factors, the condition is further aggravated if they don’t get any immediate health care. It is for this reason that it is considered important to take learn more about fire preparedness and the most logical strategies to use to reduce causalities percentages and aggravation of the situation.

The extent of damage caused by man made disasters varies greatly and while this is the case, it is important to state that others have notably high costs when compared to others. This is especially true when it comes down to responding and recovering. When you carry out a basic search, you will come across several resources that highlight these costs and hence, this will give you a clearer glimpse of what damage is caused by such occurrences. Additionally, there are different factors which influence the costs such as location. For instance, if this were to occur in densely populated but wealthy countries, the end result might prove to be huge. However, if the same were to occur in densely populated but poor countries, the after effect costs might prove to be lower and this is in part closely tied to insurance.

The death toll caused by man made disasters will also vary in accordance to geographical location and in this regard, the poorer countries are hardest hit when compared to the richer ones. This is attributed to the fact that the richer countries have what it take to respond with speed to calls of distress, and can implement the proper safety measures needed from a distance to handle things safely and rapidly. Modern technology plays a very important part in the way you respond and prepare for distasters. With financial backing, it is easy to meet this end. On the other hand, the poorer countries have no resources or assets to respond with. There are several resources that categorically highlight the casualties in such incidences and it is advisable to look into the same in order to become more informed.

**Fig.** Natural Disasters

The causes of natural disasters are as mentioned earlier. Disasters only occur when hazards come face to face with vulnerability. As such, when natural occurrences that bring about damage and there are no casualties, then it is not referred to as natural disasters. There are people who are of the school of thought that there is a difference between hazards and disaster and while this is the case, the after effects and casualties are almost always the same.

There are some which have been termed as the most famous natural disasters and by learning more about them it becomes easier to handle the calamity when disaster strikes. In this category, some of the popular incidences include fires, tsunami, earthquakes, tornadoes and the floods. As a matter of fact, there are incidences when it is important to expound on some of these natural disasters in order to ensure that in case of any eventuality you are well prepared.

For instance, earthquakes are known to occur in areas that are earthquake prone. This is defined as the shaking of earth crust and it is brought about by shifting of the tectonic plates. While this is a sudden and unanticipated shake, the magnitude varies and this is what determines the after effects and whether or not a large percentage of the population suffers from the same. Additionally, earthquakes are known to affects humans and animals alike.

While the earthquake itself is not responsible for this, secondary effects which occur after the quake do. In most cases, this leads to collapse of buildings, triggering of fires and volcanoes among other man made disasters. Some of the quakes that went down history books as worst natural disasters include the Indian Ocean quake which is the third strongest world wide.

It had a magnitude of 9.1-9.3. It is known to have triggered one of the most major tsunamis which claimed the lives of more than 229,000. The most recent one has to be the 2011 Tohuku quake and this one recorded a magnitude of 9.0. The death tool in this case is recorded to be more than 13,000 and to date more than 12,000 people are still recorded as missing. Other quakes worth noting include the java earthquake in 2006, the Chile quake in 2010. The last one was accompanied by tsunami that claimed more than 550 lives. Large buildings like land based casinos were reported to have been torn down like they were made of paper, as oneonline casino directory site reports.

Floods are also known to cause some of the worst natural disasters and this is especially true when they are accompanied by hurricanes. Hundreds of thousands of lives have been lost due to this and consequently, it is ranked among the most dreaded occurrences.

These often occur in areas that are flood prone and for this reason it is always advised to avoid living in such areas. Other types of natural disasters that are just as disastrous include blizzards, droughts, fires, health disasters and space disasters among others. The manner in which each of these incidences is handled varies in accordance to the magnitude of the natural disaster and how well people cope with the same.

While natural disasters are an act of God and unstoppable, having the necessary precautionary measures in place to ensure that people are well prepared for the same goes a long way to ease the burden associated with such burdens making it less difficult to handle. What is more, if more people seek to get educated on such aspects, it becomes easier to handle any eventualities. The same could not be said about our ancestors before us. It is precisely due to these facts that the importance of preparedness cannot be overstressed. To cap it all, the world should unite in handling such occurrences to ease the burden placed on individual countries and especially those termed as third world countries.

## IS THEORY, INFORMATION, AND DISASTERS

The flow of information within the management of disasters can be investigated using several methods found in the interdisciplinary domains of IS. Many theories have evolved including theories of individual and collective information behaviour (information seeking and processing). Collective information behaviour has been studied in the context of group research (information flow in both task and emergent groups). Task groups—individuals who accept a collective charge to form decisions and/or solve problems—dominate research of information flow in groups.

Emergent groups—individuals that meet incidentally and collaborate—have appeared in recent IS research with an emphasis on conversational problem-solving (O'Connor, Copeland and Kearns, 2003). Emergent behaviour—a more intense form of problem-solving—has been the subject of some EM studies within the context of disaster scenes (Drabek and McEntire, 2003).

## Information Flow and Small Group Studies

Knowing and testing the varying properties of information flow in groups may be vital to the success of EM teams at the local, state, and national level, within all the disaster phases (preparedness, response, recovery, and mitigation) identified by Drabek (1986). Emergent groups that exist at disaster scenes warrant study, as do EM decision-making groups that contribute to the future health and survival of our governments, communities, and citizens. Within the last decade, the Communications discipline has introduced several ethnographic studies of group information flow, although the study of groups has traditionally been performed in laboratory settings. These contrived experiments cannot reveal the properties of real group information flow.

Although the small group remains the oldest and most prevalent of the concepts in all social organization (Fisher, A., 1974), the disciplines that study information flow in small groups are diverse and disconnected. Research of information flow in groups has matured despite independent studies by scholars in psychology, sociology, management, communication, education, social work, political science, public policy, urban planning, and IS. The absence of convergence within the fields, however, has not prevented small group research from accumulating enough solid theory in the past 50 years to establish its own discipline of study (Poole, M., 2004).

The formal study of information flow in groups can be traced to 1898 when psychologist Norman Triplett tested the hypothesis that the presence of others in a group would facilitate the problem solving of an individual (Hare, A. Paul, 1962). By studying group behaviour, educators and politicians believe people can collectively solve common problems in the communities (Gouran, D., 2003a).

## Group Properties

Small group research became recognized in the late 1940s and early 1950s by an increasing number of references in the social science literature (Ellis and Fisher, 1994; Fisher, A., 1974; Gouran, D., 1999; Hare, A. Paul, 1962; Harris and Sherblom, 2002; Hartley, 1997). Although there are many more, 13 major properties, identified through theoretical studies and worthy of further study, may be depicted as an acronym, GROUP DYNAMICS. Understanding these properties of real groups in action provides descriptive and prescriptive methods that may enhance decision-making capabilities in EM organizations.

The GROUP DYNAMICS. properties emerged because of studying the information flow in groups as a process. The group as a process led to groups being studied from the systems approach.

## Information Flow and Systems Theory

Open systems of interaction, originally applied to biological systems, provides a compelling symbolic foundation for an IS study of EM decision-making. Many IS studies found basis for systems of information flow using Shannon and Weaver's 1947 communications / information systems model to describe group communication systems.

Lewin, Lippitt, and White (1939) introduced the systems approach to studying the group information process; however, scholars did not embrace the theory until Bales (1950) enhanced it. Bales compared groups—like those found in EM—to an open system that is, from inception to outcome, a cyclical process—dynamic, continuous, and evolving. EM organizations can be viewed as a subsystem within the larger social system—an open system.

An open system is a set of interrelated components that operate together as a whole with three major elements: input, process, and output. Multiple subsystems of transactions, called processes, characterize a system of interaction, called information flow. These processes are between and among people, components who continually and simultaneously send output and receive input. The purpose of these transactions is to achieve a mutual goal, a successful outcome. IS studies of information behaviour, flow, and processes as systems could contribute to the success of EM organizations, who interact by consulting and researching national organizations—for example, the Federal Emergency Management Agency (FEMA)—to gain information (input), and then make suggestions (output) to local EM members and EM researchers to solicit feedback. The feedback then becomes further input and shapes the subsequent suggestions made by all EM information contributors until a decision is reached. Systems theory is also the framework for a newer theory, the Bona Fide Group Perspective (BFGP) that can be used to demonstrate the relationship of EM as a whole to information flow. BFGP is one of four contemporary theories that describe information flow.

The systems metaphor, however, remains the basis for textbook study of group information flow(Arrow, Poole, Henry, Wheelan and Moreland, 2004; Bales, 1999). The IS application of systems theory overlaps with communications, cognition, small group research, management, and therefore demonstrates the potential for integration into EM research.

## Information Sharing

The Intelligence Reform and Terrorism Prevention Act of 2004 was intended to mobilize IT for counterterrorism information sharing (Dizard, 2004). The law created two influential positions: Director of National Intelligence and Director of the National Counterterrorism Center—both entrusted with the task of increasing information sharing (Office of the Press Secretary, 2004). Senator Susan Collins introduced the final version of the bill. She said the Commission found that "various agencies had pieces of the puzzle that [if assembled] might have allowed them to prevent the attacks... the bill will foster a new culture of information sharing in the intelligence community” (Dizard, 2004).

Information sharing is also being addressed by a few individual efforts including the March 2004 introduction of OSIS (Open Specification for Sensitive Information Sharing) by RAINS

(Regional Alliances for Infrastructure and Network Security). RAINS, a not-for-profit public/private partnership that has promised to advance ground-breaking technology for homeland security, created OSIS for the safe sharing of sensitive information across state, local and national security systems. Unfortunately, the nation has not introduced a consistent strategy to address information sharing nation-wide.

The U.S. National Commission on Libraries and Information Science (NCLIS), however, has proposed an unusual solution to President George W. Bush and Congress. Trust and Terror is an NCLIS proposal that envisions public libraries as an information center for crisis information dissemination and management. NCLIS claims that public libraries provide an appropriate forum for crisis information dissemination because the public considers libraries trustworthy sources that are already efficiently structured, aware of cultural diversity, many times employ multi-lingual staff, and accessible to local communities. Although libraries also can offer the information from anywhere in the world in real time in numerous formats (NCLIS, 2002), new law would be needed to authorize and equip libraries for access to secure information related to terrorism—the most prominent civil hazard currently threatening the security of information.

## Communications Interoperability

Failed communications interoperability contributed to America’s complacency during the 9/11 terrorist attacks. Consequently, thousands of civilians died alongside hundreds of first responders: emergency personnel including police, emergency medical technicians, and firefighters, who were trained and willing to save lives.

Don Eddington, chief of the Center for IT Integration at the Defence Information Systems Agency admitted that "DOD (the Department of Defence) couldn't talk to state officials; state officials couldn't talk to city officials" (Onley, 2002). Unfortunately, first and second responder organizations had adopted many different information systems for their specific information sharing needs—and some that were ready to use were never implemented. Firefighters, police, and other emergency personnel at the Pentagon and in New York City could not find common radio frequencies to communicate—cell phone networks flooded frequencies and further hindered information flow in the hours following the attacks (Riley, 2003).

The 9/11 Commission was enlisted to research and report the situations and events surrounding the attacks. The Commission found that civilians, firefighters, police officers, emergency medical technicians, and emergency management professionals demonstrated "steady determination and resolve under horrifying, overwhelming conditions ...Their actions saved lives and inspired a nation ..." However, the Commission also found that the "Port Authority's response was hampered by the lack of standard operating procedures and radios capable of enabling multiple commands to respond to an incident in unified fashion." The Commission made the following recommendation:

Make homeland security funding contingent on the adoption of an incident command system to strengthen teamwork in a crisis, including a regional approach. Allocate more radio spectrum and improve connectivity for public safety communications, and encourage widespread adoption of newly developed standards for private-sector emergency preparedness—since the private sector controls 85 per cent of the nation's critical infrastructure (The 9/11 Commission, 2004).

Communications interoperability among officials from community first responders to high-level information security officers within the federal government is a major concern with the growing threats of terrorism and cyberterrorism. Recommendations for the development of shareable information systems have emerged from both public and private institutions. Creative solutions for integrating information technologies provide U.S. leaders with choices and challenges—for instance, what do they choose and how do they choose it? Congress passed the Homeland Security Act in November 2002 specifically to address these and other questions about shareable information.

*Private and public sectors are busy introducing a mishmash of information sharing products including software for*:

- Three-dimensional mapping of cities.
- Disaster management simulations.

- Analysis of phone calls and other communications to help first responders make better decisions in emergencies.
- Interpretation of garbled speech recordings.
- Extraction of unstructured text.
- Discovery of non-obvious relationships (background checks deluxe).
- Disparate systems queries (police, courthouse, homegrown databases, etc.) (Batzler, 2002; Mena, 2004).

Serious submissions are subject to SAFETY (Support Anti-Terrorism by Fostering Effective Technologies Act of 2002) guidelines (DHS Press Office, 2003). IS should collaborate with EM to further these goals.

## INFORMATION DISASTERS AND DISASTER INFORMATION

### THE STUDY OF INFORMATION DISASTERS

Unprocessed information is impervious. It does not deplete with use or corrode with time. However, people can forget it or disregard it, and representations of it can be easily lost or destroyed. These intangible or tangible surrogates that hold and/or display information are quite vulnerable to disaster. Hazards—in the form of terrorism, vandalism, heating/air conditioning failure, user error, computer viruses, hackers, power failures, cyberterrorism, information warfare, cultural power struggles, or even careless or impulsive law-making/enforcement—all threaten the security and effectiveness of information. Because all organizations house information, it is imperative that all organizations implement disaster recovery plans that include recovery of information vital to the existence of the organization.

Studies that focus on the disruption and destruction of information have become more prevalent, especially in the management fields where chronicled information is vital to management operations. Useful human and/or artificially transmitted messages were recorded as early as 3000 B.C.E. when the Sumerians created and stored common cuneiform symbols by inscribing them into soft clay with a stylus. The Sumerians, as have societies since, used common symbols with technology to transfer information (Drucker, 1995). Information Science (IS) studies have shown that for information to be managed effectively, people must employ a premise from sociology—for example, culturally accepted standards and symbols—with technology—for example, stylus and clay or keyboard and computer.

Otherwise, information cannot be physically or electronically organized, stored, processed, recorded, disseminated, preserved, or retrieved. Because of the urgency to preserve and retrieve informational records, organizations are incorporating information preservation into their business continuity plans (Shaw, 2005). A sub-discipline of IS, librarianship, has long implemented these disaster recovery plans, (DiMattia, 2001; Muir and Shenton, 2002; Ruyle and Schobernd, 1997; Tennant, 2001) to protect and preserve the physical and electronic representations of information in library holdings.

## The Study of Disaster Information Flow

Determining how information flows among organizations before, during, and after disasters can lead to new models of sound practice for Emergency Management (EM) practice to adopt. The continued omission of the study of information flow may allow the implementation of unsound practices and hastily enacted policies and decisions. IS methods from information flow research, including systems theory and small group interaction, may hold particular application for further study of information flow in EM.

The study of disaster information flow has been virtually ignored by IS researchers, despite its importance in EM and society. Research regarding information flow—the human and/or artificial information transactions that affect decisions—is of especial interest to EM where decisions affect the well-being of whole communities. EM decision-makers determine who is heard or not heard and what is done or not done regarding disaster planning and response—a vital public service that impacts communities socially, economically, and legally. People reach decisions through the processes of information flow during formal or informal meetings. Information flow in meetings of EM organizations may or may not be conducive to optimal disaster management; and researchers have not provided conclusive evidence either way. It is imperative that EM researchers know if methods employed in decision-making—the result of the information flow—are increasing or decreasing the vulnerability of a community to disasters.

EM concentrates on the preparedness, response, recovery, and mitigation of disasters. McEntire (2004b) defines disasters as the "disruptive and/or deadly and destructive outcome or result of physical or human-induced triggering agents when they interact with and are exacerbated by vulnerabilities from diverse but overlapping environments." Teams within EM organizations may struggle for long periods—or be forced to decide quickly how best to approach disasters. During these times of decision-making, the members of a team participate, either consciously or unconsciously, in creating and modifying information flow. Productive information flow is vital to ensure that EM teams reach sensible decisions. Sensible decisions aid in the prevention and mitigation of disasters.

## HISTORY OF INFORMATION SCIENTISTS

Information scientists historically seek solutions to problems regarding information in the broad disciplines of technology and sociology. The birth of this blend of technology and sociology in IS can be attributed to inspiration from "As We May Think," an article written by Vannevar Bush at the close of the second World War. Bush, a respected MIT scientist and director of the United States (U.S.)

Wartime Office of Scientific Research and Development, believed that the scientists who had been busy devising methods to defeat U.S. enemies would now have time to devise methods to mitigate the chaos already evidenced by the explosion of information. He predicted scientific and social disaster if scientists did not address "the massive task of making more accessible a bewildering store of knowledge" (Bush, V., 1945a).

Bush had a suggestion—a technological knowledge management system in the form of a machine that would emulate human thought using "association of ideas." The Memex would link thoughts "in accordance with some intricate web of trails carried by the cells of the brain"—a concept remarkably similar to contemporary hypertext (1945a)! The postwar scientists were unsurprisingly fascinated with Bush's proposal and accepted the technological challenge.

Fortunately, Congress funded the scientists, with incentive from President Theodore Roosevelt who enlisted Bush to write a report to justify the financial support. Bush's report to Roosevelt, "Science the Endless Frontier" (1945b), provided the basis for the creation of the National Science Foundation (NSF) by means of the NSF Act of 1950. One of the Act's mandates was "to further the full dissemination of information of scientific value consistent with the national interest" (P.L. 81-507), a plan that eventually led to the study of information flow that generates important decisions.

## Information Scientists: Technology and Sociology

NSF scientists quickly developed two major IS directions—technologically-based information retrieval and sociologically-based human information behaviour—and by the 1960s, a few researchers were defining the term IS. When the American Documentation Institute, founded in 1937, decided to change its name to the American Society for Information Science, definitions abounded. Borko (1968) wrote one of the most enduring definitions, one that roots IS firmly in technology by stating that it is "an interdisciplinary science that investigates the properties and behaviour of information, the forces that govern the flow and use of information, and the techniques, both manual and mechanical, of processing information for optimal storage, retrieval and dissemination" (Borko, 1968).

Researchers gradually revised the more technologically-based definitions to reflect IS roots in sociology. The IS scope would be defined by Wersig and Nevelling who wrote that "transmitting knowledge to those who need it" is a "social responsibility" (1975). Belkin and Robertson would continue the technology-sociology theme by stating that the purpose of IS is to "facilitate communication of information between humans" (Belkin and Robertson, 1976). Eleven years later, Vickery and Vickery (1987) emphasized the role of sociology in IS by identifying IS as "the study of the communication of information in society."

Buckland and Liu would once again combine technology and sociology when they asserted that IS "is centered on the representation, storage, transmission, selection (filtering, retrieval), and the use of documents and messages, where documents and messages are created for use by humans" (1998). Bates clarified, however, by writing that IS is primarily, but not solely focused, "on recorded information and people's relationship to it" (Bates, 1999). With all the progress in determining the definition of IS, however, the definition of information—the focus of IS—remained somewhat elusive.

## The Value of Information

The value of information is best determined by what Repo calls value-in-use—"a benefit the user obtains from the use and the effect of the use" (1983). Value-in-use is subjective and specific to a user—so the value of information could be defined simply as contingent upon its usefulness to an individual. The value of information therefore is relative to the level of satisfaction directly or indirectly received from an information good, service, or resource.

Consider, for instance, contrasting views of those who receive a stack of 1820s newspapers from a ghost town. The litterbug casually tosses the papers outside—to the litterbug, the papers are trash to be burned. The recycler carefully collects the papers in a bag—to the recycler, the papers are cash to be earned. The librarian gladly accepts the papers from the recycle shop—to the librarian, the papers are documents that must be sorted. The professor delightedly enquires about the papers from the library—to the professor, the papers are history to be reported. The value of information is therefore determined by its user and its intended application.