6. CONCLUSIONS

6.1 WHAT ARE THE TECHNOLOGICAL CAPABILITIES OF PUBLIC-ALERT SYSTEMS IN USE AT THE SURVEYED FACILITIES AND COMMUNITIES

The technology of public-alert systems includes two types of equipment. The first are communication technologies used to exchange information between people in various organizations that are part of the system. These organizations include the facility and a variety of local government agencies such as emergency services, law enforcement, fire, and administrative offices. The second technology is for disseminating the alert and the notification to the public. The public includes residential, business and commercial, institutional, and transient populations.

The current technologies of communication for interorganizational alert are primarily commercial telephones and radios. More advanced technologies such as pagers, dedicated telephones, and automated alarms are found in only a few settings. The technologies in use will likely be adequate in many circumstances although the probability for failure is greater than with the more advanced technologies.

The current technologies used for alerting and notifying the general public are more varied. The two predominant systems are sirens, which serve as an alerting mechanism coupled with media dissemination of emergency information, and a combination of door-to-door and route notification techniques (vehicles with sirens and loud speakers) coupled with media dissemination of warnings. In a few locations, the more advanced technologies of tone-alert radios and automated telephone systems are used.

The current technologies in use for institutional populations are essentially the same systems. In a few communities, tone-alert radios or automated ring-down telephone systems have been installed to provide a rapid alert and notification. Most communities, however, seem to assume that no special efforts are needed to alert these facilities.

6.2 WHAT MANAGEMENT PRACTICES AND OPERATING PROCEDURES AFFECT THE CAPABILITIES OF THESE SYSTEMS?

Management practices and procedures vary by site. Most locations have some type of emergency plan. Research has shown, however, that possessing a plan is not a sole indicator of effective response. Several more important characteristics of effective systems include having clearly defined procedures, knowing who to communicate with, and having a cohesive interorganizational response network. Less than 50% of the communities studied had clearly defined procedures for receiving an alert, making a decision to warn, and making a protective action recommendation.

Many of the communities have initiated links with the facilities and know the name and title of the person at the facility who is responsible for notification. Furthermore, communities usually have someone assigned as the contact point. In communities where such interactions have not occurred, the chances for an ineffective or untimely warning are increased.

6.3 WHAT ARE THE TECHNOLOGICAL CAPABILITIES OF STATE-OF-THE-ART PUBLIC ALERT SYSTEMS?

A distinction exists between systems that provide an alert, provide a notification, or provide both alert and notification. The alert function of a warning is a signal that something out of the ordinary is occurring that requires people to seek more information. Notification is the process by which people are provided warning messages and information. A combined system serves both purposes. An example of alert technologies includes sirens and alarms. Examples of notification technologies include emergency broadcast systems (EBS), radio and television, and cable override. Examples of dual systems include tone-alert radios, telephone dialing systems, loudspeakers, and public address (PA) systems. Some systems, depending on how they are used, may not fall into precise categories. Helicopters equipped with loudspeakers are considered a dual system, but in reality, they typically do not provide notification because people cannot hear the broadcast message. In the following discussion, the pros and cons of existing technologies are summarized.

6.3.1 Personal Notification

Personal notification involves emergency personnel making door-to-door alerts or delivering personal warning messages to groups of people. This type of warning mechanism can be used in sparsely populated areas, in areas with a large seasonal or diurnal population such as a recreation area, or in areas that are not covered by electronic warning capabilities.

The primary advantage of personal contact is that people are more willing to respond to a warning because they are more likely to believe that a danger exists. The disadvantage is that it is time consuming, and it may require the commitment of many people and many vehicles.

To support implementation of this method, a plan should be developed for systematically traversing the threatened area and issuing the warning from the highest risk zone to the lower risk zones. A trial run helps to establish the warning time needed to notify the population at risk and a rate for different types of areas at risk.

6.3.2 Loudspeakers/PA Systems

It is feasible to use existing PA systems to notify people in areas that are covered by the systems. This may include various institutional populations or commercial establishments. Many schools, hospitals, prisons, nursing homes, sports arenas, theaters, and shopping centers have PA systems. In addition, portable loudspeakers can be used from vehicles to warn nearby populations. Often these are used in conjunction with personal notification procedures.

Existing PA systems supplement other warning-system communication networks because they are useful in reaching small segments of the population in confined settings. To be effective, a communications link to the operators is needed to ensure quick and accurate message dissemination.

Portable loudspeakers increase the speed of warning populations that have no other means for receiving the warning. They are particularly useful during nighttime hours when many people are asleep. Their primary disadvantages are that it is often difficult to hear a warning broadcast from a moving vehicle, and it is difficult to confirm the warning, particularly if only a part of it is heard.

6.3.3 Radio

Radio is a major channel for disseminating warning information because it can quickly reach a large number of people during non-sleeping hours. Certain radio stations have been designated emergency broadcast stations as part of the National Warning System (NAWAS). These stations usually have arrangements with local civil defense offices or other government agencies to broadcast emergency warnings for most hazardous situations. Also, other radio stations usually broadcast warnings in most hazardous situations.

The use of radio as a warning channel will continue to be a major practice in emergencies. Prearranged plans for notification and use of standardized messages accelerate the speed with which a warning can be issued over the radio. One disadvantage of the radio is that often a broad area is covered by the broadcast including areas that are not at risk. Second, all information must be conveyed verbally, which excludes the use of graphic materials. Third, radio reaches only a small portion of the population during nighttime hours. Fourth, because of the private operations of stations, problems can arise in priorities regarding warning broadcasts, although this can be largely eliminated with formal agreements and exercises.

6.3.4 Tone-Alert Radio/Pagers

Tone-alert radios are specialized warning devices that can be remotely activated. In addition to providing a warning signal, some types can subsequently broadcast a verbal warning message. The radio operates in a standby condition and upon receipt of a code, the radio emits a tone and broadcasts a prerecorded or read message. The code and message are broadcast from a radio transmitter that typically has a range of 40 miles. Some radio receivers operate on normal electrical power, and some have battery backups.

An example of an existing tone-alert system is National Oceanic and Atmospheric Administration (NOAA) weather radio. This system covers most of the country's population. Its chief function is to provide continuous weather forecasts. The NWS, however, can activate radio receivers to issue warnings regarding severe weather. This system can, by prearrangement with the NWS, be used to issue warnings for other hazards such as nuclear attack or nuclear power accidents.

The advantages of the tone-alert systems include quick dissemination time, the combination of an alerting signal with specialized messages, and round-the-clock availability. Disadvantages include maintenance problems, power failures, limited broadcast ranges, and difficulties in outdoor use. The radio receivers are relatively inexpensive, costing less than $50 for NOAA radio receivers to about $300 for special dedicated receivers with a battery backup.

6.3.5 Television

Warnings are also broadcast over commercial television. This can be done by interrupting normal programming or by displaying scrolled text on the bottom of the screen. Television reaches a large number of people, particularly in the evening hours. Like radio, it is a poor channel during sleeping hours.

Television is particularly good for warnings of slowly developing events. It is likely to take longer to issue a warning over television stations except where prewritten scrolled messages are used. One major advantage of television is the ability to use graphic information such as maps or diagrams in the warning.

6.3.6 Cable Override

In many urban areas people watch cable television; therefore, local stations play a less significant role in reaching the public. As a result, systems have been developed for a scrolled or broadcast message over all cable channels. Thus, a person in Cheyenne, Wyoming, watching a Chicago station or a movie channel could receive a tornado warning. Usually the override systems are operated by local civil defense offices in coordination with a cable television station. This requires prearranged conditions and agreements on the use of such system. The same advantages and disadvantages of normal television apply.

6.3.7 Telephone -- Automated Dialers

Two types of automated dialers currently exist: switching and computerized dialing equipment. These systems have the potential to reach a large number of people in a relatively short time. Recently developed switching technology is capable of simultaneously calling hundreds to thousands of exchanges using automatic switching equipment. Some systems will automatically cancel calls on phones in use and block out incoming calls during the transmission of the emergency message. These systems make use of existing private party phone lines and telephones. Most all of the modifications and special equipment are installed at the phone company. These systems can play prerecorded messages that can be updated fairly quickly, or they can broadcast messages that provide timely information. It is feasible to have them equipped with a special ring that acts as an alerting function or combine them with telephone hot-lines to provide specialized information.

The primary advantage of telephone warning systems is the ability to quickly disseminate a message to people in their homes. Automatic dialing systems are expensive; therefore, their use is limited by cost factors. The fraction of a large local area phone system that can be contacted simultaneously is not clear. Another problem to consider is that people who are not near a phone will not receive a message. Because of these issues, the current use of automatic telephone systems is primarily to warn within an interorganizational network such as emergency response personnel or institutional facilities at risk. Recent developments make this an attractive option for small communities or for areas of a community where a prompt warning is needed.

6.3.8 Sirens/Alarms

Considerable information and data exist on the technology of siren and alarm systems and will not be repeated here. Technology exists to provide an audible signal to most populations at risk, although it may be expensive to implement. These types of warning devices are designed to provide a very rapid alert to the potentially threatened population. A few types of sirens have PA capabilities, but most only sound a noise.

Siren systems are limited in their use by the lack of instructional messages. At best they warn the public to seek further information. Some areas have an intensive program of public education to instruct people in the actions that should be taken when the signal sounds. This may be possible in situations where the same response is desired every time a warning is issued. Multiple signals, such as a wavering signal versus short blasts, are rarely differentiated by the public. The use of different signals as a warning strategy is not very reliable.

Other problems that constrain the use of sirens and alarms are false alarms caused by technical failures, equipment failures in emergencies, maintenance problems, coverage problems (particularly in adverse weather), difficulties in propagating sounds into buildings, and public indifference to sirens. Despite all these problems, siren systems are a main component of many warning systems in use today.

6.3.9 Signs

Often warnings cannot be directly communicated to the public in remote hazardous areas. This has prompted the use of permanent warning signs to instruct people in recognizing the onset of a hazard and what to do if one is occurring. Signs can be effective warning devices if they are located properly and if they are visible at the time a disaster occurs. In addition, signs may serve as a valuable educational device; people who see them frequently may learn what to do in an emergency without needing a specialized warning. Problems with signs include periodic maintenance and replacement and identifying proper locations to place the signs.

6.3.10 Modulated Power Lines

Existing electrical power distribution technology enables specialized warning systems that use power line modulations to activate an alert system. When the system frequency (hertz) is altered, devices linked to electrical circuits can be activated to turn on a radio, a warning light, or a buzzer or siren. Many of the advantages of tone-alert systems are the same for this type of warning device. Modulated power line technology, however, is relatively expensive to install, test, and maintain. In addition, it cannot be used if electrical systems fail.

6.3.11 Aircraft

In special cases, airplanes and helicopters can be used as part of the warning process. Sirens or bullhorns can be carried by low-flying aircraft to provide an alert or warning message. In addition, prepared leaflets containing a warning message can be dropped. This type of warning channel is useful in reaching remote populations or populations that cannot be reached by normal communication channels. Disadvantages include access to aircraft, maintenance, and cost. Another problem is obtaining sound systems capable of broadcasting a message that can be heard over the noise of the aircraft.

6.3.12 Current State-of-the-Art

The current state-of-the-art warning system for a chemical emergency must be able to provide both an alert and a notification in a short time because of the potentially rapid speed at which a chemical can be dispersed. The state-of-the-art in a facility-to-community alert would involve the use of an automated alarm with a dedicated telephone line or a tone-alert radio/pager system. Both would require some form of backup such as a 911 emergency system and a two-way radio.

The current state-of-the-art for public warning depends on the proximity of the public to the facility. For people in close proximity to the plant (within 1 to 2 miles), the state-of-the-art system would involve tone-alert radios or a telephone dialing system coupled with a siren and emergency media message dissemination. For more distant populations (5 miles), any one of these three technologies may be adequate.

6.4 WHAT ARE STATE-OF-THE-ART MANAGEMENT PRACTICES AND PROCEDURES?

No standards exist for state-of-the-art management practices or procedures. Research suggests that state-of-the-art is not indicated by a set of paper plans but rather by a planning process that creates knowledge and communications ability among key responders and decision makers. Management requires both control and flexibility; procedures are needed to guide, but not limit, response; communications need to be established and kept open. Such criteria cannot be operationalized in an easy way so as to permit an evaluation of each community studied.

Despite such caveats, plans and procedures offer a surrogate measure of state-of-the-art. While plans are not a prerequisite or guarantee of effective response, they are positively associated with better responses. As such, the clarity and presence of plans are indicators of the quality of management practices.

6.5 HOW DO THE CAPABILITIES OF PUBLIC-ALERT SYSTEMS COMPARE TO STATE-OF-THE-ART SYSTEMS?

Few communities in the study used state-of-the-art communication equipment or warning system technologies. It is clear that some communities do not need such equipment because the risk most likely does not justify the expense. In other communities, the differences are more critical because of more severe threats and a larger number of people and institutional facilities at risk. Overall, the ability of the majority of systems to provide a timely alert and notification is questionable, particularly in a rapid-onset event.

With respect to management practices, few communities had well-developed plans and procedures to guide emergency response. Notably lacking were the capabilities to make decisions. Both lack of procedures and, more basically, knowledge about the information necessary for making a decision suggest major problems with issuing a timely warning. Also lacking were preplanned warning messages and public information programs.

6.6 WHERE CAN SIGNIFICANT IMPROVEMENTS BE MADE IN PUBLIC-ALERT SYSTEMS TECHNOLOGY?

The goal of a warning system is to provide a reliable alert and notification in a short time to as close to 100% of the affected population as possible. Several types of improvements can bring warning technology closer to that ideal.

First, tone-alert radios are theoretically capable of being the ideal indoor warning system. Current effectiveness is chiefly hampered by human factors and not by the system technology. The technology can be improved to reduce human factor problems. One major constraint is that many radio receivers have multiple channels. A single-channel, fixed-frequency radio would ensure that it was always tuned to the proper channel. Many radios need to be reset after a test to receive another signal. An automatic reset would help to ensure that the radio was always ready to receive. In addition, radios are moved around or given away. A means of permanent attachment (like a smoke alarm) would help to ensure that they remained where they were needed.

Second, electronic sirens are now capable of delivering voice messages. Problems still exist in configuring a system that produces an articulated message. Additional development of such technology is needed for an effective outdoor alert and notification system that is not dependent on the media for delivery of the notification.

Third, sirens that produce the tone and volume of an alert signal that is most effective in alerting people indoors and at greater distance are driven by electricity. Sirens that are driven by battery power lack both the range and ability to penetrate buildings. A battery operated siren can be located virtually anywhere and is not subject to power system failures. Improved battery driven sirens would increase the flexibility and reliability of siren alert systems.

Fourth, the major cause of a siren failure is in the radio controls that activate the sirens. This problem occurs from moisture shorting-out the radio receiver. Improvements could be made to produce a more reliable radio control.

Fifth, one of the major mechanisms currently used to alert the public is route notification. Very little information on the effectiveness of alternative strategies of route notification is available. Additional information is needed to define a state-of-the-art route alerting technology and procedure. Such information would include the type of loudspeaker or siren, the orientation of the electronics on a vehicle, the speed at which the vehicles move and other related factors that may influence the effectiveness of the technology.

Sixth, technologies have been developed to use radios in a way similar to tone alerts. The further development of that technology could provide a widespread capability to alert people in a variety of settings.

Finally, little experience with the automated telephone dialing systems exist, particularly as they apply to use in densely populated areas. Additional documentation of the technology is needed before such systems become a proven warning technology.

6.7 WHAT ARE THE CURRENT ECONOMIC FACTORS ASSOCIATED WITH PUBLIC-ALERT SYSTEMS IN CURRENT USE AND WITH STATE-OF-THE-ART SYSTEMS?

Most of the current systems in use rely on existing community resources. Therefore they require no additional expenditures to be applied to a chemical emergency. The majority of these systems are: civil defense alerting systems, emergency broadcast and other media base technology, route and mobile alerting, tone-alert radios, and telephones. In a limited number of cases, special systems for a chemical emergency have been installed. These systems include sirens, tone-alert radios, and telephone ring-down systems.

The economic factors associated with any given system are variable. They depend on the area covered, the population density and distribution, topography, and the type of warning system used. Even given a single warning technology, variations in costs can be attributed to the choice of equipment. Installation, maintenance, and operations in costs are variables in computing a total warning system cost.

Based on the experience in installing these warning technologies in the nuclear industry, it is possible to estimate some average costs on a unitized basis. A typical state-of-the-art siren system would cost \$50,000 to \$100,000 for a 1-mile radius; \$150,000 to \$200,000 for a 2-mile radius; and \$600,000 to \$1,000,000 for a 5-mile radius. Costs for tone-alert radios are between $300 to $500 per household. While less experience exists with telephone systems, the cost of installation is estimated at $50 to $75 per household plus a yearly use fee of $30 to $120. In addition to the capital equipment and installation costs, each system requires expenditures for maintenance.

6.8 ARE PUBLIC-ALERT TECHNOLOGIES AND MANAGEMENT UNIFORMLY APPLIED ACROSS SURVEYED FACILITIES?

Public-alert technologies are not uniformly distributed across the communities and facilities studied. Some approach state-of-the-art while, at the opposite end of the spectrum, some have virtually no established capabilities in place. Management practices also vary among communities.

6.9 WHAT ARE THE REASONS FOR VARIABILITY IN THE USE OF ALERT SYSTEMS?

We have yet to analyze the variability in the use of systems. Based on our initial impressions from the data, we hypothesize that such variations are explained by the size of the community, the financial resources available to the community, and the extent of the overall chemical threat to the community (e.g., the number of facilities, geographical location, and facility size). The communities with poor alert capabilities appear to be smaller towns or rural counties without much money to spend on emergency preparedness or emergency planning personnel. Furthermore, they probably do not have an extensive concentration of industry or very large facilities run by major companies. We suspect that the rural south and midwest are more likely to have a greater number of communities with poor alert systems.

6.10 WHERE ARE THE OPPORTUNITIES FOR WIDER DISSEMINATION OF PUBLIC ALERT TECHNOLOGIES, PROCEDURES, AND MANAGEMENT PRACTICES?

The opportunities, in order of priority within each category, initially appear to be as follows.

6.10.1 Technology

1. Improved communication technologies between facilities and communities with additional backup capabilities.

2. Improved public warning technologies in high-risk and densely populated areas.

3. Better communication links between community EOCs and institutionalized populations.

4. Adoption of computerized emergency planning and management systems and decision aids.

5. Improved communications equipment within community emergency response organizations.

6.10.2 Procedures

1. Use of a standardized information protocol to guide community information collection and dissemination during the initial notification from the facility.

2. Adoption of SOPs for initial response to alerts, warnings, decisionmaking, and protective-action recommendations.

3. Adoption of state-of-the-art warning message protocols for both English and non-English speaking populations.

6.10.3 Management Practices

1. Implementation of exercises in communities not conducting exercises and more frequent exercises in other communities.

2. Improving the working relationships between personnel at the facilities and officials within the community emergency response structure.

3. Developing and implementing improved public information programs.

4. Improving the organizational interface and coordination between federal, state, and local planning agencies.

The methods of achieving improved practices are varied and require careful consideration. Among the possible mechanism are improved planning guides, new training courses, video conferences, seminars, workshops, and working through existing programs such as Community Awareness/Emergency Response (CAER) to develop improved planning and management practices.

6.11 WHAT IS THE FEASIBILITY OF IMPROVED PUBLIC-ALERT SYSTEMS?

The improvement of public-alert systems is feasible without the development of new technologies. The problem of diffusing existing technology and knowledge is greater at present than the problems created by the lack of appropriate technology. Unless new technologies lead to low-cost equipment that could rapidly alert and notify the public and is easily installed and maintained, further technological advances would only increase the gap between practices and the state-of-the-art.

At a local level the feasibility of improvement relies on two factors. The first is the dissemination of information on low-cost or no-cost improvements and improvements in procedures and management practices. Major improvements in management practices and procedures can be achieved without major expenditures.

The second is providing funds for improved communication and warning system equipment. It is unlikely that communities have the funds to completely install new communication devices or new warning systems. Improvements in these areas will require assistance to the communities or cost sharing.

At this point, it appears that the improvement of management practices and the development of better procedures to make decisions and to initiate the warning process is more critical than the promotion of better technology, although both are important. The most sophisticated equipment is relatively useless unless it can be used properly. Improvements in decision-making capabilities and communication among decision makers is a prerequisite to implementing state-of-the-art technology.

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