Public Safety Best Practices: Talking Siren Technology

An Evaluation of U.S. Implementation of Early Warning Systems

Submitted by:
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Executive Summary

Background
The recent tsunami in Southeast Asia that killed over 221,000 people, and the threat of terrorism and memory of the events of September 11, 2001 have created a resurgence of interest in siren systems as methods of disseminating outdoor public warnings. Local governments across the U.S. are re-thinking the role of sirens as mechanisms for public alert. September 11th also resulted in all levels of government within the United States becoming engaged in a massive reorganization of domestic emergency management protocols. Early warning systems are also being put under the microscope. The detection/warning of extreme events that occur routinely or have the potential to occur unexpectedly has always been the responsibility of local government. These governmental units are acquainted with local risks and are aware that their constituents expect to receive warning of events that could put them in danger.

An essential element of public safety efforts is warning. Warnings and alerts bring issues of grave risk to the attention of citizens and are successful only when they allow them to secure their lives and property by taking protective actions. State-of-the-art siren technology now includes public address capabilities, a feature which greatly improves the chances of delivering successful warnings. Siren systems that provide this type of alerting capability can be used to inform the public of natural hazards, human-caused accidents, and terrorist acts. They can follow siren-based alerts with voice messages providing details about when and where, severity, and suggested protective actions. One important limitation though, is that talking siren systems are intended to reach people who are outdoors, not those inside their homes, offices, schools, etc.

Goal of this Study
This study investigates local government Best Practices in public safety-related warnings and alerts, with a special focus on the implementation of talking siren system technologies across the United States. These systems must first and foremost provide an effective delivery vehicle for warnings to reach a targeted public audience including special needs groups within the public at risk, such as non-English speaking, visually and hearing impaired, the physically and mentally disabled, and transients and tourists. This report undertakes to explore the means by which local government can best communicate emergency and public safety information to a targeted constituency group that is directly affected by disaster.

Best Practice Case Studies
Case studies of the uses of government and privately-owned siren warning systems located throughout the United States and a review of related literature on the topic were undertaken as the foundation of this Best Practices Study. Data for this study were generated through semi-structured, qualitative interviews conducted with the emergency management professionals responsible for the implementation and operation of siren-based early warning systems in their respective jurisdictions. A set of thirteen interview questions guided the telephone interviews and guided the discussion of the
insights of these emergency managers about the larger context of early warning systems and the use of their jurisdictional siren systems.

The findings of this Best Practices Study show that siren systems in the U.S. are primarily used to provide a communications capability in the face of three types of extreme events:

- Natural Hazards such as tornadoes and severe weather
- Geohazards such as tsunamis, mudslides and earthquakes
- Human-caused accidents around the sites of critical facilities such as nuclear plants, chemical storage sites, dams, oil refineries, etc.

An examination of the hazards prevalent in this region identified acts of terrorism as the most severe threat that would necessitate siren alerting capabilities in the NCR. The study found that employing this type of system primarily to warn of acts of terrorism is without precedent elsewhere in the country. That fact puts the National Capital Region at the forefront of vanguard thinking about public protection, warnings, and terrorism, which is certainly in part due to the impact the Pentagon incident had in this region.

The following municipalities, counties, or nearby regions were the focus of interviews about their early warning systems for the purposes of this study:

<table>
<thead>
<tr>
<th>Pine Bluff, Arkansas</th>
<th>Miami-Dade County</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York City and region</td>
<td>National Capital Region and the state of Maryland</td>
</tr>
<tr>
<td>Forth Worth, Texas</td>
<td>Puget Sound, Washington</td>
</tr>
<tr>
<td>Oklahoma City, Oklahoma</td>
<td>Austin, Texas</td>
</tr>
<tr>
<td>San Francisco, California</td>
<td>New Orleans, Louisiana</td>
</tr>
<tr>
<td>Wilmington, Delaware</td>
<td>Los Angeles, California</td>
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**Best Practice Examples**

The success of early warning systems can be best measured by the protective actions they enable endangered groups to take on their own behalf and by the ability they have to reach the greatest possible number of at-risk individuals quickly and efficiently. Out of the sub-set of siren systems that were examined, two systems demonstrated a high level of outreach/access and a high probability of alert and warning success. The first example is able to reach the public at any hour and has built in the capability to reach special needs groups.

**Pine Bluff Arsenal in Jefferson County, Arkansas**

The Pine Bluff Arsenal in Jefferson County has a combined electronic siren / tone alert radio system, which is a part of the Chemical Stockpile Emergency Preparedness Program (CSEPP) run by the U.S. Army and FEMA. The outdoor talking siren system includes 63 sirens with battery back-ups in case of a power failure. The system covers
approximately 450 mi² and 40,000 to 60,000 residents in the area. This siren system has been successfully used to provide tornado warnings.

In order to ensure that residents indoors were equipped with an equivalent alerting system, the intergovernmental team at Pine Bluff installed 9,000 tone alert radios with public address capabilities and battery back-ups in households, schools, offices, and public buildings throughout the same area. Each radio has an LCD display that provides information on the emergency in text form. These radios have also been adapted for the deaf and hard of hearing and outfitted with brilliant flashing strobe lights that alert this special needs group that an emergency has occurred.

Puget Sound, Washington

The region around Mount Rainier is listed as the single greatest volcanic threat to a human population by the USGS. One million to 1.5 million people could be affected by an eruption or mudflow. As a result, 40 sirens have been installed in populated areas near the mountain (Pierce County), all of which have public address capabilities. The public address functionality can be activated by police radios. The ability to broadcast messages to a single siren, a group, or all of them, allows the user to respond to urgency in specific geographic areas. The system is connected to NOAA weather radios, which are provided for facilities such as schools, care facilities, and some residences.

Pierce County’s Public Education campaign that accompanies this siren system is without parallel. The budget outlays for public information alone are between $300,000 and $500,000 each year. Public education is continuous and three staff positions are dedicated to this mission. The EMA emphasizes the need for residents to own NOAA weather radios in conjunction with the siren system. This was the first region in the nation to tie its siren capability to the NWS NOAA weather program.

Areas of Future Work

As the NCR considers the viability of siren-based early warning systems, the interoperability of current regional early warning systems in all 18 jurisdictions needs to be assessed. Technological solutions for complex siren systems are readily available, but what procedures and collaborative relationships (public/private) would need to be in place to ensure rapid notification of terrorist threats and the effective operation of such a system? A regional threat assessment would be a helpful tool to evaluate the need for a siren system in the NCR. A risk assessment could look at which regions are particularly susceptible to acts of terrorism, and how large catastrophic events would affect people across the region. The NCR covers come 3,020 square miles. It would be prohibitively expensive to cover the entire area with talking sirens. Further study could determine which areas would have to be the focus of such a public warning capability. Sirens can be an effective part of a warning system, but they are not stand alone solutions. Siren systems need to be part of an overall set of integrated public warning systems.
Introduction

Fundamental Elements of Early Warning Systems: Trust & Technology

This study on the local need for siren-based technological systems gives priority to the need for local government to have adequate vehicles to communicate emergency warnings to at-risk populations. The evaluation of these systems will take into consideration the needs of government to communicate, and the needs of at-risk populations to access, validate, and act on information that can save lives. Much emphasis is put on technology when evaluating siren-based warning systems, but warning and emergency communications systems are only partially about technology. There are three other major factors that impact the success of risk communications. First and foremost, public response to disaster warnings is dependent on a perception that the source of such messages is both credible and trustworthy. Directly following an alert, the public searches for independent corroboration of the publicized extreme event. Secondly, intergovernmental and private sector collaboration surrounding the timely dissemination of information is a means to provide the public the foundation for informed decision-making. The final element of successful intervention is public education and knowledge about the warning in question; an informed public is able to react quickly and cooperate with recommended actions. Public education provides for early involvement and active participation of the members of local communities.
Historical Overview

Siren-based Early Warning Systems in the United States

Sirens have been used to alert the public about emergencies for decades. They were initially designed to sound fire alarms as far back as 1905. They were later used to warn of air raids during WWII. During the Cold War, air raid sirens were adapted to warn citizens of the threat of an impending nuclear attack on U.S. soil. Siren systems were erected throughout urban and rural America as a protective measure and were re-named civil defense sirens after Stalin tested the USSR’s first atomic bomb in 1949.

Legacy siren systems from the 1970’s and 1980’s era of civil defense were acoustic systems that could alert the public to an emergency. Civil defense sirens were electrically-powered mechanical devices that produced different tones that warned the public of an approaching danger and also sounded an “all clear” when the danger had passed. Due to extensive public education campaigns, the public knew where (dedicated civil defense radio frequencies) they were to immediately seek additional information on the event and learn of recommended protective actions.

Throughout the decades that the Cold War spanned, nuclear disasters failed to materialize. Enterprising emergency managers began to use the siren systems to warn the public about severe weather incidents and other natural hazards that threatened local communities. Tornado alley and other severe weather corridors in this country activated their siren systems to provide the public with audible signals that major storm systems were threatening and local radio and television providers broadcast information on protective actions to citizens using the Emergency Broadcast System (EBS). Local residents in areas where natural hazards were seasonal threats were well rehearsed in the expected protocol; they took shelter immediately and tuned to radio stations with threat information. These sirens became a mechanism for local government to communicate with the public and trigger desired behavior in the face of disaster.

In areas of the country where severe natural hazards were uncommon, the end of the Cold War brought with it major cutbacks in FEMA’s funding for the testing and maintenance of national siren systems. These systems were antiquated by the early 1990’s and without funds to maintain the sirens, they continued to deteriorate at a rapid rate. The collapse of the Soviet Union greatly diminished the chances of an air-born nuclear strike on the U.S., and as a result many communities allowed their air-raid siren systems to fall into total disrepair. Now, with the emergence of terrorism as a major threat, authorities are re-examining the role sirens can play in protecting the lives of citizens.

Legacy Siren Systems in the National Capital Region, Virginia, and Maryland

The end of FEMA’s funding streams for siren systems forced choices on local jurisdictions across the country. The local jurisdictions where the siren systems were located could take the sirens over and assume responsibility for the costs for their upkeep, or, using a small amount of funding that was offered through FEMA, they could dismantle and remove the sirens. In Maryland, about 80% of the sirens were taken down,
but many of the sirens in rural areas became rural warning systems. These rural siren systems were used to alert volunteer fire departments in case of fire emergencies. Baltimore kept its sirens also, and continued to test them on a weekly basis until the maintenance problems with the legacy systems became so severe that use of the systems was simply discontinued. The case of Maryland is typical of what occurred across the country.
The Complexity of Early Warning in the United States

The success of local alerts and warnings for catastrophic events is complicated by the role of the federal government, the primary gatherers of hazard information and the large number of private entities who build and operate technologies to deliver hazard information to the people at risk. The actual dissemination of emergency communications to the public is the subject of confusion due to the wide variety of public and private sources that issue warnings and alerts. “More than a dozen Federal agencies have some responsibility related to warnings and alerts, but no single Federal entity has the clear responsibility to assure that a warning infrastructure exists and is properly utilized.”

Hazard monitoring takes place in specialized technical and intelligence communities, which are ultimately responsible for evaluating and disseminating emergency event-related information. For local jurisdictions and state responding agencies, receiving *timely information about threats* in their communities determines to a large extent whether warnings, alerts, and other actions will be disseminated quickly to protect whatever portion of the public is at risk. The ability to convey this information to the public and the media will ensure the public is able to respond to the emergency notification with self-protective actions.

The ability to deliver a message quickly and effectively is important, but mobilizing a message that contains the right information and instructions is a complex activity. It involves managing the collection and analysis of information from multiple sources, the internal distribution of information leading to objective decision-making about warning needs, and finally, the synthesis of information into a concise message that is then externally disseminated to the at-risk public.

The Unique Situation of the National Capital Region

The NCR represents a level of complexity surrounding the implementation of successful early warning systems that is comparable to no other region in the United States. The levels of government and private entities with responsibilities for various aspects of public safety and national/homeland security are unparalleled. City, county, state and the vast majority of all federal governmental agencies are all housed in the region. Even the Department of Homeland Security has not been able to gather together all of the disparate federal entities responsible for preparedness, prevention, mitigation, response and recovery within a single organizational structure. On the one hand, the conglomeration of entities present in the NCR represents an array of available resources that is awe-inspiring. On the other, it represents many more levels of jurisdictional cooperation and collaboration that need to be coordinated, such that the task of interoperability and erecting expedited pipelines for threat information to reach local government begins to seem overwhelming.

While this study will try to relate best or “most frequent” practices from across the United States, and will compare other regions to the NCR, there is without a doubt,

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1 Media Security and Reliability Council Final Report, p.5.
no other region anywhere in the U.S. that begins to approximate the level of complexity
and the number of different stakeholders that are present here.

In order for Early Warning Systems to be effective, warnings must be part of a
comprehensive inter- and intra- governmental collaborative effort that receives threat
information, analyzes this information and disseminates it to local Emergency Operations
Centers (EOC’s). Current practice focuses on these EOC’s activating local warning
systems and advising citizens of appropriate actions to lessen the impact of extreme
events. The existing structures and processes that EOC’s have in place surrounding
emergency situations promote cross-jurisdictional coordination and communication
across all levels of government before, during, and after an incident. EOC’s are meant to
function as points where information pertaining to vital public safety issues is gathered so
that decisions about dissemination and protective actions can be made.

The Partnership for Public Warning (PPW)² developed “A National Strategy for
Alert and Public Warning” in May 2003, in which they advocated that all stakeholders
(government actors, industry, media, public, special needs groups, professional and trade
associations, non profits) be involved in evaluating alert and warning systems, and
developing interoperable standards and procedures. The strategy they propose focuses on
processes that will lead to an effective warning capability. This approach seems well-
suited to the stakeholder complexity in this region and would help to foment practical
consensus on local needs and the issue of siren-based warning systems.

Natural and Human-Caused Hazards in the National Capital Region

The National Capital Region is the United States’ fourth largest urban area with a
population of 4.4 million people. It houses the seat of American federal government and
all the concordant federal government facilities (231 federal departments & agencies).
The region is also a center for tourism with an average of 20 million tourists per year, and
it is an active center of business.

This region is blessed in that the major regional geohazards are not experienced
here with the same intensity as in other areas of the United States. Natural hazards
mapping of the region is done by entities such as the Virginia Department of Mines,
Minerals and Energy - Division of Mineral Resources (VDMR), the United States
Geological Survey (USGS), The Maryland Geological Survey, the District of Columbia
Emergency Management Agency, and the Virginia and Maryland Emergency
Management Agencies. Hazard assessment is based on historical data, frequency of
occurrences, damage statistics and the region's overall vulnerability to certain events.

The natural hazards in the NCR are:

- Hurricanes
- Floods

² The Partnership for Public Warning was a non-profit, public-private partnership established in 2002 to
save the lives and property of people at risk from natural disasters, accidents and terrorism by improving
the nation’s alert and warning capabilities.
• Earthquakes
• Tornadoes
• Winter Storms

Virginia, Maryland, and the District of Columbia are not threatened by category five hurricanes. The NCR lies far enough north along the East Coast that hurricanes are significantly weakened before they make landfall in the region. The weakening is partially due to cooler sea surface temperatures than those along the Southwest coast, but another major factor is the Outer Banks of North Carolina, which jut out and shelter our own coastline. In fact, only one major hurricane is known to have impacted Virginia since 1900.³

Hurricanes (downgraded to the form of tropical storms) and severe storms that do hit the NCR are most often associated with major floods. Hurricane Agnes in 1972 is the major historical event for the area. Flooding caused Maryland to make two disaster declarations in 1995-1996, and it is a common problem in the region.

Earthquakes occur throughout the National Capital Region, but the region is considered to be a seismically quiet zone. The risk of earthquake is there, but quakes tend to be felt only as mild tremors along the eastern seaboard.

Tornado data for the region provides a point of comparison with the rest of the country. “Virginia ranks number 29 for frequency of tornadoes, 25 for number of deaths, 26 for injuries and 28 for cost of damages.”⁴ “Maryland ranks number 33 for frequency of Tornadoes, 37 for number of deaths, 33 for injuries and 35 for cost of damages. The cost per person for tornadoes, in the state per year, is $0.23. This ranks the State number 38 in costs for tornadoes per person.”⁵

In terms of human-caused hazards, the region faces far more serious risks. The fact that the nation’s Capital and much of the major infrastructure of the Federal government is housed here makes the area a prime target for future terrorist attacks. The targeting of Washington, D.C. and Arlington on Sept. 11, 2001 are good indicators of the primacy of Federal government sites to be in danger of attack. If past persistent targeting of singular symbolic structures are any indication, as demonstrated by the multiple attacks on the World Trade Towers, the National Capital Region must consider terrorism a major threat to the public and the government. A simple listing of some of the most notable infrastructure housed in the region drives this point home.

• The White House, the Capital, the Supreme Court, the Pentagon, the headquarters for all the different agencies of the Federal Government, the World Bank, the OAS, the Red Cross, major embassies of the world, major non-governmental organizations of weight, etc.

³ http://www.hpc.ncep.noaa.gov/research/roth/vahur.htm, Virginia Hurricane History
⁵ http://www.disastercenter.com/maryland/tornado.html
Other human-caused hazards in the region could be accidental in nature, although major nuclear and chemical facilities are not housed directly in the region. The transportation of hazardous materials does pose a threat though, and the power failures that recently hit the East Coast have raised concerns about the recurrence of such blackouts.

The human-caused hazards in the NCR are:

- Terrorism
- Hazardous Materials (radiological and chemical)
- Utility Failures
Siren Systems and Terrorism: The Challenge

Pearl Harbor and the terrorist attacks of September 11, 2001, are two events that have driven home the devastating effects of the lack of warning of an attack in the United States. Yet, the character of terrorism is such that a surprise attack could present itself again.

“Unfortunately, our national ability to provide people at risk with useful information to reduce loss during all types of emergencies is severely limited. With the increased likelihood of terrorism and the possible use of weapons of mass destruction, the potential for catastrophic loss of life is great. When poison gas is drifting rapidly downwind or a dirty nuclear bomb has contaminated a region, thousands of lives could be saved if officials could quickly and effectively get the attention of people directly at risk and communicate how to get out of harm’s way.”

Public Warning Systems for Terrorism need to have four main objectives:

1. Assess potential terrorist threats through the monitoring of intelligence data,
2. Provide an alert and warning capability,
3. Inform the public about what has occurred,
4. Provide instructions on protective actions.

Early warning for terrorist threats requires intelligence data acquired from surveillance and monitoring efforts. This activity is reserved for a number of different agencies within the federal government and generally information about these threats is highly classified. Since 9/11, local emergency managers that need to make decisions about warnings and alerts have had much greater access to intelligence reports about terrorism. Despite this real progress, the question of the timeframe needed for threat information to reach the local actors that make decisions about public safety interventions (siren warnings and informational messages) remains when classified information is essential for the protection of the public.

Another difficulty that terrorism presents is that the exact timing and nature of terrorist events are designed to allow those that will come under attack no advance warning. The art of forecasting terrorist acts based on “chatter” is highly susceptible to inaccuracy. This is an issue of relevance to any discussion of alert and warning, as the public, once falsely alarmed, has a tendency to discount future warnings.

The idea of sirens being used as terrorist warning systems demands that we face the real possibility that a “successful” terrorist act is one that would provide no early warning. It is highly probable that the use of sirens would only occur after the fact. The public address capabilities of siren-based warning systems would then provide a messaging ability that could direct people to safer locations (as a response) or a crowd control mechanism. This would bolster route-alerting protocols for the mobile public address capabilities of police forces in the region.

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Another potential source of data that would allow a jurisdiction to distribute an early warning about terrorism could be based on information from sensor systems that track the urban environment for signs of chemical, biological and nuclear material that have been released. As sensor equipment is perfected, warnings may be issued based on the readings this technology provides.

Outdoor early warning systems in the United States have always been officially conceived of as a means of alerting the public of an attack (i.e. air raids), although siren systems have never been used for this purpose. The primary use of early warning systems has instead been to alert the public of severe weather conditions. For this reason, the American public is pre-conditioned to understand sirens as a way to communicate weather-related emergencies. The implementation of a siren system to address terrorism would have to include a public education campaign that would inform the public about the new uses of these systems.

**Local Government Responsibility for Alert and Warning Capabilities**

FEMA has a mandate to create nation-wide standards and protocols for talking siren systems and all hazards risk communication warnings. To date it has been more than two years and FEMA has not yet produced these guidelines on a national risk communication and hazard warning and alerting process. Local jurisdictions have been left to their own devices in evaluating and implementing options to ensure public safety and protect their constituents. Research shows that public expectations are that they will be informed, and barring federal leadership that would produce standards and guidelines, the onus for this burden falls to local governmental entities. There is a gap between public expectations and government capability in providing warning about dangerous situations.
Background on the Use of Siren Systems in the United States

The human environment around specific high threat infrastructure in the United States is at risk should a chemical or radiological emission occur. The Federal government has laid out strict regulations that include outdoor warning systems as a part of protective actions in and around this type of facility. Since terrorism has become a reality in the United States, the possibility that incidents at chemical sites or nuclear plants could be intentional and not accidental has increased concern about these facilities and the siren systems that protect the residents living in their shadow.

Chemical Stockpile Facilities

The Chemical Stockpile Emergency Preparedness Program (CSEPP) was started in 1988 and was directed at communities located in the vicinity of eight U.S. Army chemical stockpile sites. Disarmament policy means that each stockpile is being steadily neutralized, but until this goal is achieved, the U.S. Army and FEMA will provide and maintain siren systems intended to allow local responders and the public to be warned quickly and take protective actions should a chemical agent emergency arise. CSEPP programs include very well organized public education campaigns that ensure these communities have the knowledge and resources they need to keep themselves safe.

Nuclear Plants

The Radiological Emergency Preparedness (REP) Program was established as a reaction to the 1979 Three Mile Island nuclear power plant accident. This program transferred planning and preparedness activities for off-site radiological events around nuclear plants from the U.S. Nuclear Regulatory Commission (NRC) to FEMA. Radiological Emergency Preparedness was focused on the citizens who lived in the communities near these facilities. Its goals were:

- To ensure that the public health and safety of citizens living around commercial nuclear power plants would be adequately protected in the event of a nuclear power station accident, and
- To inform and educate the public about radiological emergency preparedness.

The power plants are responsible for the funding and maintenance of electro-mechanical siren warning systems and the NRC regulates the performance level these sirens must achieve. FEMA regulates state and local government emergency preparedness activities in the local communities which are situated around nuclear power plants. These programs, like the CSEPP variety, place a premium on investing in thorough and clear public education campaigns,

Severe Weather and Tornadoes

Some of the cities that are part of this best practices study are located in Tornado Alley, which is the part of the United States where tornadoes are a common occurrence in the spring and summertime. A great number of the communities that are threatened by these violent storms install tornado sirens as a way to warn residents of approaching
funnel clouds. Common procedure when tornado sirens sound is to take shelter in a safe area, preferably below ground, and tune a battery-operated NOAA weather radio to a local station that will be broadcasting warnings and information from the National Weather Service. NOAA weather radios come outfitted with both a battery backup and a tone-alert feature that automatically alerts you when a watch or warning is issued.

On average, there are 800 tornadoes a year throughout the country. Generally tornadoes cause 80 deaths and over 1,500 injuries annually. Tornadoes can wipe out everything in their paths with wind speeds of 250 mph plus.

**Lahars and Mudslides**

Lahars are volcanic mudflows that travel down valleys and threaten areas that are densely populated. They behave like flowing concrete and destroy most structures they encounter in their path. They can reach speeds of 45-50 mph and depths of 100 feet or more. At Mount Rainier and other volcanic areas, lahars are the single greatest hazard to local communities. USGS research shows that there may be no advance warning for the next lahar flow in this area.

Mudslides occur on non-volcanic mountain slopes or steep hills. They are caused when water from unusually heavy and persistent rains collects and fails to drain off a slope. This accumulation of water in the soil destabilizes the underlying mass of earth and rock, which eventually plunges to the floor of the valley below, picking up rocks, trees, houses, and cars along the way. Often deforestation and housing construction add to the destabilization of mountainsides and make them more susceptible to this problem. Both geohazards are capable of causing huge numbers of casualties and immense physical destruction.

**Tsunamis, Earthquakes**

Most tsunamis occur in the Pacific Ocean, due to the high level of seismic activity and underground earthquakes that occur there. Tsunami monitoring watches seismic activity (earthquakes), and changes in sea level that can be detected by a series of buoys floating off a coastline. Sirens are considered the most effective tsunami warning systems. Unfortunately, tsunami detection is complicated due to the fact that these tidal waves are not very tall in height when they are out at sea.

New seismic activity sensor technology has made it possible for primary (p)-waves that precede the destructive motion of an earthquake to be detected. In some parts of California, these sensors will cause siren systems to send out immediate alerts, which could provide a 5-50 second advance warning before the most damaging earthquake waves arrive. Few of these systems are installed and fewer have been tested, but in theory, they should provide enough advance warning for alerted residents to undertake protective actions.

**Force Protection**
The Navy has purchased a number of sirens for early warning to provide force protection and mitigate an impending disaster on their bases and other facilities. They foresee using them for instances of terrorism, flooding, and hurricanes.

**Figure 1:** The hazards the different siren systems investigated in this Best Practices Study have been installed to address

<table>
<thead>
<tr>
<th>Hazard</th>
<th># of Siren Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tornadoes</td>
<td>3</td>
</tr>
<tr>
<td>Chemical Stockpile</td>
<td>3</td>
</tr>
<tr>
<td>Nuclear Plant</td>
<td>3</td>
</tr>
<tr>
<td>Mudslides</td>
<td>1</td>
</tr>
<tr>
<td>Tsunamis, earthquakes</td>
<td>1</td>
</tr>
<tr>
<td>Hazardous Materials</td>
<td>1</td>
</tr>
<tr>
<td>Force Protection</td>
<td>1</td>
</tr>
</tbody>
</table>
# Sirens Project Overview

<table>
<thead>
<tr>
<th>Site</th>
<th>Population and Land Mass</th>
<th>Hazards</th>
<th>Siren System</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York City</td>
<td>The system covers an area of approximately 2,300 acres and 45,000 people in the port area during a normal working day. Sirens cover 298,000 residents in a 10 mile radius around the plant.</td>
<td>Weather warnings; evacuations, and terrorism alerts</td>
<td>New York/New Jersey Port Authority has installed 18 sirens at the Port Newark Elizabeth Marine Terminal. Located in Westchester County, Indian Point Nuclear Facility is 30 miles from New York City. The 156 are electro-mechanical, rotary sirens and have no public address potential. Matrikon developed the SCADA control system and the sirens are American Signal.</td>
<td>$600,000 includes 18 sirens, 60’ siren poles, bollards, computer control system. No idea what the system originally cost in 1983. It cost $3.5 million just to replace the control system for the siren system in 2002.</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>Pop. 17,545,623 (metro area) 498.3 mi²</td>
<td>Earthquakes, Brush Fire, Flood, Landslide, Tsunami, Drought, Severe Weather, Health Issues, Human-caused hazards, Terrorism.</td>
<td>None, but focused on a tsunami warning system for which Federal funds will probably be made available due to a recent Congressional mandate.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Site</td>
<td>Population and Land Mass</td>
<td>Hazards</td>
<td>Siren System</td>
<td>Cost</td>
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<td>------------------</td>
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<tr>
<td>Oklahoma City</td>
<td>The system serves ¾ of a million people across 620 mi²</td>
<td>Tornadoes, Severe Storms, Flooding, Terrorism</td>
<td>182 battery-powered sirens went online in April, 2002. Two types of sirens: In urban areas, omni-directional sirens (talking systems) were installed. In rural areas, rotating sirens resembling the old-style ‘air-raid’ sirens were used. All the sirens are electronic.</td>
<td>$4.5 million in technology costs in 2002, $200,000/year in maintenance costs</td>
</tr>
<tr>
<td>New Orleans</td>
<td>Pop. 1,337,726 (metro area) 350.2 mi²</td>
<td>Tropical storms / hurricanes, Floods, Severe weather, Wildfires, Dam failure</td>
<td>None</td>
<td>N.A.</td>
</tr>
<tr>
<td>San Francisco</td>
<td>Pop. 800,000 49 mi²</td>
<td>Fire, Tsunami, Earthquake, Severe weather, Flooding, Terrorism</td>
<td>65 sirens covering all neighborhoods throughout San Francisco. This is a state of the art wireless, digital system with public address capabilities. Broadcasts can be made in multiple languages. The sirens are battery-powered and weather resistant. Solar panels or electricity-powered batteries. All sirens are electronic.</td>
<td>$2 million for technology in 2004, $100,000 for public education, and since system is brand new, no maintenance costs have been accrued yet.</td>
</tr>
<tr>
<td>Site</td>
<td>Population and Land Mass</td>
<td>Hazards</td>
<td>Siren System</td>
<td>Cost</td>
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<tr>
<td>Miami-Dade County</td>
<td>137,000 residents are covered in the 10 mile radius around the plant.</td>
<td>Chemical Emergencies, Floods, Hurricanes, Terrorism, Tornados, Wildfires.</td>
<td>Turkey Point Nuclear Power Plant has a rotary speaker system, electronic sirens with public address capabilities. Messages in multiple languages possible.</td>
<td>$600,000 in 1982, $300,000 annually in maintenance costs</td>
</tr>
<tr>
<td>Austin, Texas</td>
<td>Pop. 656,562 258.4.3 mi²</td>
<td>Floods, Severe Storms, Tornadoes, Wildfire, Winter Storms, Extreme Heat and Drought, Man-Made Hazards</td>
<td>None</td>
<td>N.A.</td>
</tr>
<tr>
<td>Puget Sound, Washington</td>
<td>The siren system covers 30,000 to 100,000 residents depending on the magnitude of the lahar event. 35-40 mi²</td>
<td>Lahars or Mudslides due to Mount Rainier.</td>
<td>The system is the newest type of digital warning technology. 40 total sirens. It can be activated by remote control or by receiving an EAS message. Certain EAS codes activate the system. These sirens have a public address capability. The public address functionality can be activated by police radios and can be used to broadcast information to the public at up to 160 decibels. Federal Signal is the vendor.</td>
<td>$1.6 million total system cost. Maintenance is around $10,000 a year. Each new siren can costs between $40,000 and $60,000. The cost of public education is approximately $300,000 - $500,000 a year.</td>
</tr>
<tr>
<td>Site</td>
<td>Population and Land Mass</td>
<td>Hazards</td>
<td>Siren System</td>
<td>Cost</td>
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<tr>
<td>National Capital Region</td>
<td>Not certain about area of coverage and # of people protected. 65,000 residents covered. 7.5 mile radius around the CSEPP site was protected.</td>
<td>Terrorism, Floods, Hurricanes</td>
<td>The Naval District of Washington system is called the Federal Signal Personal Alert System. 18 digital, electronic sirens with public address capabilities and battery back-ups are located in the NCR.</td>
<td>$606,511.36 for the sirens in the NCR, this does not include Annapolis.</td>
</tr>
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<td></td>
<td>Just less than 50,000 residents are covered in a 10 mile radius around the plant.</td>
<td>Radiological Disaster</td>
<td>Outside NCR: (Calvert County) Calvert Cliffs Nuclear Power Plant, 73 sirens. 10 mile radius around the plant. Just less than 50,000 residents are covered. It is an electro-mechanical, rotary system. No public address capability. Brand new system. The sirens have no backup systems currently, they run on power only.</td>
<td>$2 million in 2003. $40,000 a year on public education.</td>
</tr>
<tr>
<td>Calvert Cliffs Nuclear Power Plant</td>
<td>(Calvert County) 73 sirens. 10 mile radius around the plant. Just less than 50,000 residents are covered.</td>
<td>Chemical Emergency primary, but sirens are used for all hazards warning.</td>
<td>(Harford County) CSEPP** 15 sirens. The system was hard-wired with a battery back-up. The neutralization of the chemical agents was completed in March, 2005 and system is being converted for weather use.</td>
<td>$1.4 million in 1994.</td>
</tr>
<tr>
<td>Site</td>
<td>Population and Land Mass</td>
<td>Hazards</td>
<td>Siren System</td>
<td>Cost</td>
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<tr>
<td>Pine Bluff, Arkansas</td>
<td>About 40,000-60,000 people are covered. The system covers approximately three-hundred square miles in Jefferson County and approximately one-hundred-fifty square miles in Grant County.</td>
<td>Priority Hazard is Chemical Emergency. These sirens are also used for the following hazards: Tornadoes, Floods, Earthquakes, Landslides, Severe winter weather, Hazardous materials.</td>
<td>CSEPP** In-home <strong>Tone Alert Radios</strong>, Pine Bluff Arsenal, Jefferson County. Our tone alert radio system has public address capabilities. There are a number of different tones for each type of emergency. There is a LCD display on the radios used to alert the deaf and hard of hearing.</td>
<td>$2.3 million in 2005</td>
</tr>
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<td>CSEPP** <strong>Siren System</strong> at Pine Bluff Arsenal, Jefferson County. The system has eleven sirens inside the city limits of Pine Bluff, twenty-six sirens located in western Jefferson County, six sirens in Grant County which lies just west of Jefferson County and twenty-located within the Pine Bluff Arsenal perimeter. Whelen electronic sirens with public address capability.</td>
<td></td>
<td>$2.6 million in 2005</td>
</tr>
<tr>
<td>Fort Worth, Texas</td>
<td>Pop. 618,600 298.7 mi²</td>
<td>The main purpose is to warn the residents of Fort Worth of severe weather.</td>
<td>132 electronic sirens with public address capability.</td>
<td>$3 million in 2004</td>
</tr>
<tr>
<td>Site</td>
<td>Population and Land Mass</td>
<td>Hazards</td>
<td>Siren System</td>
<td>Cost</td>
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</tr>
<tr>
<td>Wilmington, Delaware</td>
<td>Daytime population of 150,000, nighttime population 70,000, and 15.5 sq. mi. coverage.</td>
<td>All hazards, man-made and natural disasters, general safety awareness.</td>
<td>16 Federal signal audio &amp; voice message system</td>
<td>$363,000</td>
</tr>
</tbody>
</table>

* All population figures are taken from the 2000 Census or were given by the emergency managers responsible for these systems.
* Chemical Stockpile Emergency Preparedness Program
Post 9/11 Urban Area Implementation of Siren-based Early Warning Systems:

**Best Practice Examples**

The success of early warning systems can be best measured by the protective actions they enable endangered groups to take on their own behalf and by the ability they have to reach the greatest possible number of at-risk individuals quickly and efficiently. Out of the sub-set of siren systems that were examined, two systems demonstrated a high level of outreach/access and a high probability of alert and warning success. In most cases, the siren systems investigated had never been used to warn of real world disasters, so that an evaluation of intervention performance had never been done. Only those systems in use for tornado and severe weather warning had actually had real world tests.

Another issue that was a focal point of this study was whether any of the siren systems in use throughout the country were reaching members of special needs groups, such as the hearing impaired and non-English speaking demographics. Siren systems alone cannot reach the deaf and hard of hearing, and other special needs groups may be unable to comprehend or act upon aural warnings. In addition, siren systems are passive systems intended to provide warnings and information only to those outdoors, but reaching those that are indoors with similar passive system remains a concern. Although technology is in the pipeline that would allow common household appliances, such as televisions, radios, stereos, computers, and cell phones to turn themselves on automatically to broadcast emergency warning messages, this type of technology is not yet the state-of-the-art in the U.S.

One local jurisdiction that was part of this study has surmounted these problems and implemented a combination system capable of reaching the entire population in the specific geographical area targeted. The system is able to reach the public at any hour and has built in the capability to reach special needs groups.

**Pine Bluff Arsenal in Jefferson County, Arkansas**

Pine Bluff Arsenal in Jefferson County has found an answer to these dilemmas. This combined siren/tone alert radio system is a part of the Chemical Stockpile Emergency Preparedness Program (CSEPP) run by the U.S. Army and FEMA around eight chemical stockpile sites throughout the United States. CSEPP has implemented a comprehensive integrated system designed to reach the largest possible portion of the affected public. The first system is an outdoor talking siren system with battery back-ups in case of a power failure. The system has 63 total sirens that cover approximately 450 mi² and 40,000 to 60,000 residents in the rural area. Although the system was installed to address chemical stockpile emergencies, the local jurisdiction and their federal partners have adopted an all hazards approach to the use of the sirens. This siren system is located in a region that is routinely exposed to severe weather and tornadoes and the sirens have been sounded for this type of emergency in many instances with great success.

The shortcomings of siren systems are that they are only intended to reach the portion of the affected public that are outdoors at the time an alert is sounded. In order to
ensure that residents indoors were equipped with an equivalent passive alerting system, the intergovernmental team at Pine Bluff has installed 9,000 tone alert radios with public address capabilities and battery back-ups in households, schools, offices, and public buildings throughout the same area. Each radio has an LCD display that provides information on the emergency in text form. The radios function as both NOAA weather radios and CSEPP radios. The radios have a flashing light that goes off after an emergency alert has been issued to alert those residents that were outdoors that there is information about the emergency for them to read on the LCD display. These radios have also been adapted for the deaf and hard of hearing and outfitted with brilliant flashing strobe lights that alert this special needs group that an emergency has occurred and they need to read the LCD display on their radios for more information. Both radios and sirens have a number of different tone capabilities, and each tone signifies a different hazard.

The public education campaigns for this integrated system have reinforced local resident’s awareness of the importance of personal emergency preparedness, another benefit of the systems that local emergency managers praise. Radio, print and television were used to introduce the system and periodic use of the same media ensures continued understanding of expected public reaction to the use of the system. The CSEPP program also prints and distributes an annual calendar to residents that has full information on all emergency procedures and contact information. The system has also become a central feature of joint exercises with the Army, local fire and police departments, the EMA, and a variety of other actors.

Both systems are tested weekly and the tests poll the systems as to their functioning and provide information on individual units back to the technicians / emergency managers. The EAS system provides a follow-up to putting out warnings on sirens and tone alert radios. EAS would bring the broadcast media into the picture.

Puget Sound, Washington

The region around Mount Rainier is listed as the single greatest volcanic threat to a human population center in the U.S. by the USGS. One million to 1.5 million people could be affected by an eruption or Lahar activity. As a result, 40 sirens have been installed in populated areas near the mountain (Pierce County), ten of which are AHAB (All Hazard Alert Broadcast) sirens that have public address capabilities. As funding becomes available, the older Civil Defense sirens will be replaced with the newer AHAB Sirens. The AHAB’s are digital electronic sirens from the Federal Signal Corporation with omni-directional speakers. The public address functionality can be activated by police and fire radios and can be used to broadcast information to the public at up to 160 decibels. This functionality is extremely valuable in case of evacuations or public warnings near certain sirens. The ability to broadcast messages to a single siren, a group, or all of them, allows the user to respond to urgency in specific geographic areas.

The newest technology to be introduced to update this system is called the “All Hazard Alert Broadcast System”, or AHAB. The system is programmed to receive Alert & Warning event codes from both the NOAA Weather Radio system, and the Emergency Alert System (EAS). Additionally Pierce County Emergency Management has provided
NOAA All-Hazard Weather Alert Radios for facilities such as schools, care facilities, and some residences that are in areas that would be dangerously affected by a lahar. There are also five lahar-detection systems (acoustic flow monitors) that monitor the mountain and can detect mud flow motion within instants.

Pierce County’s Public Education campaign that accompanies this siren system is without parallel. Public Education is seen as the key to all early warning efforts in this region and efforts are continuous. When the siren system was initiated, an aggressive program to educate all the communities in the valley about the hazard that Mt. Rainier represents was started. The goal was to have the public know how to react when and if sirens go off. Basic public education was begun in the schools, because there was an understanding that for each child educated, five adults would be reached as an extension of that effort. From there, the regional approach to public education included outreach to different community groups and a team of a scientist, emergency manager, and a local fire or police chief was sent out to speak to these groups and provide information. People were given basic emergency education about emergency supplies, evacuation routes, the actual hazard, etc.

Once a year, the region also reaches out to the public through volcano awareness month, doing presentations at town councils, schools, etc. An annual test of the siren system is done during this month and school evacuations are exercised at this time also. The Pierce County Department of Emergency Management distributes calendars filled with comprehensive emergency information each year and also sends out brochures and does regular TV spots.

Pierce County Neighborhood Emergency Teams (PC-NET) were the next step in the public education process. These nationally recognized outreach units go beyond speaking to people about what they need to do and think about; they actually organize neighborhoods to practice evacuation drills and complete preparedness planning. By targeting neighborhoods, small groups are taught all hazard preparedness and actually run through a drill, so that they have a plan and know exactly what to do as soon as sirens go off. Public Information Officers lead and train these teams. The Pierce County public education team consists of one full-time Public Information Officer (PIO), but also has two other staff supporting all the public information efforts.

Budget outlays for public information programs are between $300,000 and $500,000 each year. The EMA emphasizes the need for residents to own NOAA weather radios in conjunction with the siren warning system. This was the first region in the nation to tie its siren capability to the NWS NOAA weather program. There are also crisis web-sites in place that can go live to all the media outlets and reach the public quickly if an incident occurs. A conference bridge for key actors to coordinate and get on the same page before they go live in interviews is in place, and a Joint Information Center (JOC) can be quickly stood up to pull all the responding parties together and work with the media.
Talking Siren Systems

Technology Description

A new generation of sirens, referred to as talking sirens, do more than just notify the public of an emergency. Following the alerting siren, these advanced technology siren systems feature a short acoustic message that can be broadcast to the segment of the population within hearing range advising the public on appropriate self-protective actions. The goal of these systems is to trigger immediate behavioral responses amongst at-risk populations, be they sheltering in place, evacuation, etc.

Siren systems are referred to as “passive emergency communication systems” in that they do not require the public to acquire any devices or take any action to receive an alert. These systems enable government to advise the public of catastrophic events quickly and with ease. Other examples of passive systems are media communications to the public via television and radio.

“Active systems”, such as NOAA weather radios and emergency text messaging services, such as Roam Secure, have proven to have disappointing rates of public adoption. Much of this poor public reception is probably dependent on public awareness of these tools, but cost issues have dictated the extent to which this awareness level can be addressed. A recurrent theme, educating the public is the key to the success of emergency communications.

Before turning to the question of how effective sirens may be, the differences in siren technologies must be examined. Modern, state-of-the-art sirens are very different from their predecessors of the Cold-War era. In the past sirens were mechanical, meaning they emitted different tones by periodically interrupting a flow of compressed air. The frequency of a mechanical siren’s tone is determined by how often the flow of compressed air is interrupted. More recent innovations in siren technology have led to state-of-the-art electronic sirens. According to the American National Standard Institute (ANSI), these sirens produce “tonal sounds by amplifying the output of an electronic signal generator,” and then broadcast “the amplified signal from one or more electrodynamic loudspeakers.” Most electronic sirens also have the ability to broadcast voice messages, both live and pre-recorded. These messages can instruct citizens to turn on their radios or televisions for specific information regarding the pending emergency.

The most common siren systems in use today are the newer electronic sirens, which include public address capabilities. These sirens generate tones and broadcast them through loudspeakers. Electronic amplifiers intensify the sound before it is broadcast. Many of these systems are now digital, offering great enhancements for polling and testing siren functioning.

New siren systems can be either omni-directional or rotating. Omni-directional sirens emanate sound that spreads 360° around the sirens, despite being stationary. According to ANSI, a rotating siren consists of a directional siren (one which emits most
of its sound in a beam pointing in a specific horizontal direction) that contains a mechanism to slowly rotate its beam of sound about a vertical axis.

Omni-directional sirens typically consist of a number of speaker “cells” or “modules” stacked on top of each other in a vertical column. The number of cells the tower has determines how powerful and far-reaching the sound it produces will be. Another difference in siren technology concerns the contents of each individual cell, particularly the number and strength of the “drivers” in each cell. Drivers are essentially the speakers of the siren system. Some siren models (such as Federal Warning Systems’ “Modulator” siren) include four 100-watt drivers per cell. Others (such as Whelen Engineering Company’s “WPS 2800 Series” siren) contain a single, but more powerful 400-watt driver in each cell. Whelen Engineering Company claims using one 400-watt driver per cell eliminates “distortion and power loss that occurs from mixing the outputs of multiple speaker drivers in a cell—as found in competitive systems.”

Like the number of cells a siren contains, the frequency of the sound emitted by the sirens also has an effect on how far its sound will travel. Typically, low frequency sounds travel farther than higher frequency tones, which lose power as they travel over long distances. Therefore, when determining which siren system to buy, it is important to keep in mind that a siren capable of producing 124 decibels (dB) at 100 feet with a 500-hertz (Mhz) tone will travel farther than a similar siren (which produces 124 dB at 100 feet) with a 1000-Hz tone.

Sirens can either be mounted on a pole or a flat surface, such as the roof of a building. Typically, sirens should be installed about 50 feet above ground level. The height of the siren mount also influences how far the siren’s warning will travel. If mounted lower than 50 feet above ground level, the siren’s tone will be much more intense in the area immediately surrounding the siren, but the tone’s intensity will decrease significantly at greater distances. Conversely, the tone of a siren mounted higher than 50 feet above ground level will maintain more intensity as it travels farther away, but will be less intense in surrounding areas and may even “skip over” the area directly around the siren.

Sirens operate on electric power—whether from an AC (alternating current) power source, batteries, or solar power. Different companies offer different options; some sell batteries and/or solar capabilities separately from the siren system itself. These system enhancements have a significant impact on overall costs, as sirens as Early Warning Systems (EWS) are particularly advantageous when power outages preclude other modes of communication with an affected public. Sirens relying purely on AC power are vulnerable to failure because they will not operate in the event of a power outage. Because sirens can be used as a warning for severe weather conditions, it is important to have a backup power source. Of these, batteries are the most common. Some companies also offer solar panels that can fully recharge the batteries after about 15 hours of direct sunlight.
Warning the Public: Education and EWS

Public/Private Partnership: Government Warnings & Media Corroboration

The media continues to play a significant role today in delivering warnings and alerts through such vehicles as the Emergency Alert System (EAS). In addition, the media – with television, radio and more recently the Internet - has the means to educate and inform the public, provide real-time coverage of events, and to quickly reach citizens at risk. These vehicles of communication are integral parts of most households, making the mass media’s ability to reach the public formidable. Government partnerships with the media surrounding Early Warning Systems result in the greatest saturation of target groups, no matter which EWS system option is under consideration.

All levels of government (federal, state, and local) have the responsibility to plan and execute disaster interventions. Emergency communication and warnings are only effective though, when they are disseminated to the public in standardized, actionable formats. An actionable emergency communication is one that has been preceded by a public education campaign that informs local constituencies about threats and the warning system itself and allows them to corroborate the information they receive through independent channels. Public reaction to disasters is documented to be initially marked by the behavior of denial and citizens expect to be able to confirm governmental warnings and instructions for protective action with major media reports that corroborate the level of seriousness of the event in question and the protective actions that have been recommended.

An example of public reaction to EWS alerts was studied by the Public Entity Risk Institute in March 2005. The importance of government/media partnership is well documented in this investigation of public reaction to an incorrect Emergency Broadcast System warning. On February 1, 2005 at 2:00 p.m., the Connecticut Emergency Broadcast System broadcast an erroneous statewide emergency message advising all citizens in the state to evacuate immediately. Public reaction to this message was the subject of research, which found that confirmation-seeking was the primary immediate activity of an overwhelming majority of the people surveyed about their response to the alert. Tuning into mainstream media sources produced no confirmation of there being any emergency whatsoever, which led 39% of Connecticut residents to express no sense of concern about the warning. Modes of confirming the emergency warning to evacuate were tuning into some form of major media (radio, TV, Internet); calling a friend, neighbor, or relative; looking outside; and calling local emergency personnel.

Once the credibility and seriousness of the threat are established, citizens react as proscribed to large extent. Government tends to have the information and details about disasters that the media desires to communicate to the public. Disasters are the stuff of good media “stories”, a fact which helps emergency managers as they try to reach those in harm’s way. The types of channels that are available to the media for communicating with the public are too expensive for local jurisdictions to duplicate, thus public-private coordination to communicate warnings to the public represent optimal partnerships.
Background on the Integrated Use of Siren Systems

Sirens are usually used as part of an integrated warning system that automatically links sirens with other warning media such as the radio and TV. The national Emergency Alert System (EAS) is the major vehicle for transmitting emergency broadcasts to local radio, television, and cable stations in threatened areas. In 1996, the national EAS system was updated with Specific Area Message Encoding (SAME) technology, which allowed the emergency broadcasts to be limited to the counties and regions at risk. The Federal Communications Commission (FCC) adopted the NWS-SAME protocol in January 1997, replacing EBS with the Emergency Alert System (EAS). Finally on June 30, 2004, the NWS began implementing SAME/EAS warning codes for non-weather events and broadcasting them over NOAA Weather Radio.

SAME codes delimit the recipients of a message to those in the actual area in danger. Prior to this point, an entire state was often alerted to a hazard, including many residents that were not in imminent danger. This factor, over time, led to false warning for a large percentage of the public and many people learned to tune out EAS warnings, not trusting their credibility. The improved system intends to eliminate these false warnings.

EAS signals are also used by the National Weather Service (NWS) on NOAA Weather radios. NOAA weather radios are battery-operated and considered to be an important method for the NWS to broadcast severe weather warnings to their audiences almost immediately. A Consumer Electronics Association Study of November 17, 2004, found that household penetration of NOAA weather radios has increased significantly from 13 percent in 2002 to 17 percent at the date of the study.7

Other tools for of reaching the public in the integrated warning toolbox are telephone alerting systems, such as reverse 911, and wireless alerting systems, such as cell phone and Internet text messaging. At this point in time, text messaging subscription services still have a limited ability to reach the public, because they have not been accompanied by large public awareness campaigns and a small number of citizens are actually signed up and using these options. Roam Secure is one such text messaging service that is now in place in all 18 jurisdictions in the NCR. This service could enhance the capability of NCR jurisdictions to communicate with their citizens. The challenge this region faces, as so many others do, is to convince citizens to register for this service.

The modern integrated approach to early warning systems just described is considered to be highly effective due to its redundancy. Having emergency messages reach the public through a variety of channels enhances the credibility of warnings and reduces the risk of their being dismissed as false alarms by corroborating the warning messages.

National Capital Region Siren System Requirements

The NCR consists of 18 jurisdictions covering over 3,020 square miles. The area an emergency siren system for the entire NCR would cover would require a huge number of powerful sirens and be cost prohibitive. A decision based on equitably blanketing the entire region would ignore specific threats to parts of the region more likely to be the target of terrorist attacks.

There are a number of factors that help determine the location of each siren. The population density map below demonstrates practical considerations that relate to siren promulgation. Factors that affect the propagation of sound from sirens, such as the terrain and other obstructions (especially tall buildings), the availability of electrical power, ease of installation and maintenance, and security against vandalism must be weighed. It should also be noted that weather conditions and wind can affect the strength and reach of a siren’s warning. The first step to determining how many sirens are necessary is to complete a threat assessment. The areas found to be most vulnerable would then be mapped and a promulgation study (siren coverage map) for these areas would be completed. The number of sirens required to cover the area will also depend on the capability of the sirens purchased and where public address capabilities, which have a shorter range than sirens themselves, are desired. The range of a siren’s warning and public address capability is dependent on the number of cells each siren houses, the frequency of the siren tone, and the height of the siren mount.

Figure 2: Map of COG Region Population Density
Federal Siren Corporation Estimate of Cost of COG Region Siren System

This figure below represents a preliminary plan to cover an area of DC with voice capable sirens to provide an example for regional contemplation. The attached map shows an initial siren placement plan and rough coverage. Federal Siren Corp. is working on a sound propagation study which will show more detailed coverage contours (not circles). They are having trouble with this software, so this will be delivered at a later date.

This proposed system includes 7 smaller sites in & near the Mall (our model MOD-2008 siren, 112 dBc@ 100 ft max). 8 larger sirens (model MOD-4016, 118 dBc @ 100ft), 2 control points, control software & complete installation. The budgetary cost of this system is $413,600.00.
Conclusion

All warning systems have weaknesses that will limit their effectiveness in specific situations. A NOAA weather radio alert will reach next to no one at 3:00 a.m., while a siren warning that is used during a thunderstorm may also fall upon deaf ears. In fact, a large number of those interviewed for this Best Practices Study, including siren manufacturers, emphasized that expectations about siren systems are often unrealistic. Being clear about what a siren system can and cannot do for any group looking to invest in such a system was seen as paramount to later satisfaction with a system’s performance.

The mantra of many interviewees that took part in this study was, “sirens are outdoor warning systems”. Interviewees stressed that there is an unfounded belief amongst some emergency managers and many members of the public that these systems will be able to awaken people in their homes at night or even be audible indoors at any time day or night. Countless narratives recounted how this is often not the case.

“…Sirens should only be part of an overall “warning system”. A major con of using sirens is that they are intended to warn individuals outdoors. Many citizens rely on hearing the sirens while indoors.” Fort Worth, TX.

“Weather is your greatest problem with the sirens. High winds can change your propagation capabilities and reduce the reach of siren tones to a few hundreds yards. This makes these systems very weather-dependent in terms of their alerting capability…. The siren system was not as helpful a communication mechanism as was originally hoped. Residents complained that they could hear the siren, but not the voice over instruction.” Harford County, MD.

“The siren system has dead zones where residents are not able to hear the sirens. The sirens cannot be heard indoors.” Indian Point Nuclear Plant, NY

“Then, there is the issue of indoor warning. How do we reach these people? This is an outdoor warning system.” San Francisco, CA.

Representatives of siren manufacturing companies also cautioned that one of their primary jobs is to make sure that clients have realistic expectations of what these systems can provide. Voice messages, they maintain, are only intelligible within a certain range. This range is about ½ mile in rural areas and even less in urban areas. The issue of voice intelligibility is a two edged sword. A message heard and understood can save lives and reduce the damage a disaster can inflict. An unintelligible message can cause people to go outside and expose themselves to exactly the danger the siren intends to prevent. Sirens can also be irritating, their decibel levels eardrum shattering, and all of these issues are part and parcel of system deliberations.

There is also the issue of when to issue a warning and what reaction it could engender. When considering the type of terrorist event that happened in London on July 7, 2005, sounding a siren might cause more hysteria and panic than is already prevalent amongst victims and those in danger. There is also the question of potential secondary explosions that the public might be exposed to.
All these factors being duly stated, it must also be said that sirens are an extremely effective way to alert as many people as possible as quickly as possible. The London attack caused communications failures throughout the city, land lines and cell phone networks were completely overwhelmed and went down. This type of instance would make the public address capabilities of both siren systems and route alerting on police vehicles helpful ways to communicate with people outdoors.

The key to siren systems is to supplement these early warning systems with other ways to reach the public. These systems must be coupled with another indoor warning system, such as NOAA weather alert radios or tone alert radios. Redundancy in terms of different media and means of reaching any audience helps to mitigate the failure of any single system. The interoperability of current alerting technologies that are present in the region to deliver all-hazard information to many different segments of the public and response community should be evaluated. The Regional Incident Communications and Coordination System (RICCS) is an outstanding example of regional interoperability surrounding response. A definition of the desired features a siren system would have as part of the local integrated public warning system and a delineation of the processes that would be needed to support the operation of such a system would move the region towards the same level of alert and warning capability for the public as RICCS has provided governmental entities.

Events that do not take place during normal waking hours present a quandary, and with or without siren systems, emergency management professionals will always worry about their ability to alert those in harm’s way in the middle of the night. Reverse 911 is bound to have limited effectiveness if the communication device that is called into is turned off, re-charging, or simply ignored. With more people using cellular phones and getting rid of their land lines, consumers have the choice not to receive incoming calls.

Looking to the future, there is a multiplicity of high-tech appliances that have already been designed to include emergency “wake-up” technology that would help to circumvent this problem. This technology can override normal functioning in these devices and turn them on for the purpose of broadcasting rare warnings and alerts and these messages can be programmed to occur only in the geographic area impacted by a potential disaster. The many different early warning options that exist now and some that are soon to become state-of-the-art will continue to increase the ability of local jurisdictions to reach ever larger portions of their constituency with warnings.
References:


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Appendix 1: Sirens Project Research Questions

1.) What kind of siren system is your area using and what are the features of the system?

2.) What is the number of sirens in the system, the number of residents covered by the siren system, and the number of square miles the siren system covers?

3.) What purpose and goals was this system chosen to address?

4.) What major hazard(s) was this system meant to address in the region/area?

5.) When was the system launched?

6.) Did a public education campaign accompany the system erection? How do residents learn what action to take when the siren sound (i.e. turn on the radio to a particular station or other)?

7.) What issues surround the sustainability and maintenance of the system?

8.) What kind of system testing and training programs are in place?

9.) Has there been an incident that has provided a real world test of the system?

10.) How would you rate the performance of the system? (pros & cons)

11.) What was the cost of the system? (technology, public education, and training)

12.) Was this investment a good use of public funds in your opinion? Is your region better prepared for catastrophic events? Safer?

13.) What, if any, are your local lessons learned with these systems?
Appendix 2: Interview Texts
Appendix 3: Special Needs Groups

Special needs groups such as the deaf and physically or mentally disabled pose particular challenges both for spreading the warning and for ensuring that these groups are able to follow suggested protective actions. Early warning systems must address underserved and disadvantaged groups in the communities they serve, not only reaching the able-bodied and those connected to communication devices (able to access the media). The Northern Virginia Resource Center for the Deaf and Hard of Hearing (NVRC) pleads for its special needs groups to be included in emergency planning processes from the get-go, not as an ad-hoc consideration.

- Homeless
- Deaf and Hard of Hearing
- Mentally and Physically Disabled
- Frail Seniors
- Tourists
- Illegal Immigrants
- Non-English speaking

This group of individuals present a dilemma. Some may receive emergency alerts and warnings and be unable to act upon the advice contained in warning messages. Other groups within these demographics may remain unaware of emergency situations and thus be precluded from taking personal protective actions. Emergency alert and warning systems must be designed to reach as many groups as possible, which is why a toolbox of different early warning technologies offers the best proscriptive solutions. The interweaving of a system of systems means that multiple warning systems are triggered in the case of any catastrophic incident. This, combined with contingency plans and emergency planning for special needs groups, provides a comprehensive alerting potential.

Siren systems are tailored to provide audible notification of an extreme event. Yet, as logical as this approach seems, large portions of the public cannot be reached by sirens and their new public address functionalities. Siren system manufacturers are the first to acknowledge and point out these systemic shortcomings.

In order to address these groups, the following factors must be identified:

1. Who they are
2. What type of media they can access
3. Form in which the group communicates (language)
4. What instructions they can actually follow