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High-Rise and Large/Complex Incident Communications Workshop

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National Institute of Standards and Technology • Technology Administration • U.S. Department of Commerce

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High-Rise and Large/Complex Incident Communications Workshop

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Abstract

On June 20 and 21, 2006, the National Institute of Standards and Technology (NIST) conducted a workshop to identify communication issues associated with high rise building incidents and to examine a variety of issues that confront public safety agencies handling large/complex incidents. The workshop brought together police, fire, and emergency medical personnel from eight cities along with federal law enforcement personnel, manufacturers, and researchers. Presentations were given on what is working to enable communications in different areas of the United States. Breakout sessions allowed for discussion leading to the following conclusions. (1) Progress is being made in addressing the challenges of radio communications in buildings, with many solutions presented by workshop attendees. (2) For interagency communications, interoperability is less about radio patches and more about developing good standard operating procedures. (3) For large and/or complex incidents, planning, training and the use of the National Incident Management System (NIMS) are the strongest factors in determining if the incident will be mitigated successfully. (4) With large incidents, strict radio discipline is important.

Keywords: commercial building; communication equipment; communication network; emergency responder; fire alarm systems; fire department, high rise building; incident command; interoperability

Introduction

Historically, high rise buildings have presented challenges to radio communications and over the years public safety agencies, such as police and fire departments, have been developing ways to overcome these challenges. Although the workshop focus was on high rise communications, the participants also discussed problems associated with other large buildings such as convention centers, underground structures such as parking garages, subway stations and tunnels, buildings designed to be blast proof with heavy concrete walls, buildings with solar reflecting film on windows that block radio signals, and buildings that are deliberately designed and built to block radio signals.

The concept of a complex incident is probably best defined as one that requires the response of many agencies. A complex incident does not have to be large in the sense that a large number of personnel from any one agency are involved. An example of a complex incident could be a call for an unknown chemical left behind in an abandoned apartment. The initial response could include local fire, police, and hazardous materials response teams. Upon arrival and assessment of the situation the response may be broadened to include state and federal agencies and possibly the National Guard Hazardous Materials Civil Support Team. Agencies from all these jurisdictions along with some private companies to transport and dispose of the material may work together to bring the incident to a successful conclusion. Although no one agency had a large number of personnel on the scene, the number of agencies responding makes command and control more difficult.

While fighting a fire in a high rise building is certainly a complex operation, fire incident handling may only involve personnel from fire and police departments. Similarly a hostage situation may require a large response from a police department with personnel from many different areas of the police department, yet may only have a small response from the fire or emergency medical services in the form of an ambulance to stand by.

Workshop Organization

The workshop provided a forum to discuss the strategies, procedures, best practices, research and technology that can improve communications during incidents in high rise buildings and incidents that are large, involving a large number of personnel or complex, involving a large number of responding agencies. The participants included experts from the emergency responder, manufacturer, and research communities. A list of participants and the workshop agenda are provided in Appendix 1 and Appendix 2 respectively. The workshop was divided into two primary activities: presentations and working group discussions. The purpose of the presentations was to provide the participants (fire, police, and emergency medical personnel) with an opportunity to give presentations on how communications work in their respective departments, and to identify their concerns and issues with communications in high rise buildings and large/complex incidents. The presentations also provided them with a means to address solutions to communication issues they have either implemented or plan to implement. The presentations also allowed for industry and researchers to present information from research that is currently in progress to improve communications and interoperability.

After the presentations were completed the participants were organized into two working groups to further discuss the topics being addressed with the objective of adding, subtracting and prioritizing the information from the presentations. The two groups worked in parallel and then assembled again to brainstorm and arrive at a final list of findings and objectives.

Background

This workshop is one component of the Building and Fire Research Laboratory's (BFRL) Building Networks and Public Safety Communications project sponsored by the Department of Justice via the NIST Office of Law Enforcement Standards and in support of SAFECOM efforts to provide a path towards nationwide interoperable public safety radio communications (http://www.safecomprogram.gov/SAFECOM/). The main objective of the Building Networks and Public Safety Communications project is to investigate the potential use of the building network infrastructures to facilitate public safety communications. BFRL has conducted basic research related to building network utilization to supplement radio communications.

Utilizing building network infrastructures could provide many benefits for enabling effective communications with emergency responders in buildings. Most commercial and institutional buildings have Information Technology (IT) networks, fire and security networks, and building automation system networks. These networks may provide an effective means for transmitting mission-critical voice communications from emergency responders inside the building out to incident command. Existing networks would likely require public safety specific enhancements, which might be incorporated into an existing IT network, or on the more protected fire or facility networks.

In addition, there is a wealth of critical information about the conditions within a building that is available through the building automation system that could be used by incident command to help plan effective responses to building incidents. In an earlier OLES-funded project [1, 2, 3] BFRL worked on identifying building information that is needed by emergency responders, and determining how to collect, format, transmit, and present that information. Information that was identified included:

- Status of fire, smoke and security alarms
- Temperature and air quality data
- Presence and location of building occupants
- Status of elevators
- Building video camera views

This workshop has focused on radio communication in buildings. Appendix 3 gives some background on the sources of radio frequency propagation problems in structures. It also presents background information on in-building wireless (IBW) systems. IBW solutions were implemented by the departments of some of the workshop presenters to address communication problems.

Review of Presentations

Presentation by James R. Lawson – National Institute of Standards and Technology
Investigation Findings of The Emergency Response at the WTC

The presentation consisted of an overview of the communication difficulties encountered by the New York City Police Department, the New York City Fire Department, and the Port Authority Police Department on September 11, 2001. There were two basic issues with radio communications. The first was that the radio signals were attenuated in steel and steel reinforced concrete high rise buildings. This radio signal attenuation blocked communications with personnel on the upper floors of the World Trade Center buildings which affected command and control at the incident. This degradation in radio signals also affected the situational awareness of the emergency responders working inside the buildings. It was stated that those emergency responders working inside the World Trade Center buildings, who could not see what was happening outside and had poor radio communications also had poor situational awareness. The second issue was the volume of radio traffic that morning. After the first aircraft struck the World Trade Center One building there was an approximate factor of 5 peak increase in radio traffic level over the normal level of emergency responder radio communications. This was followed by an approximate factor of 3 increase in communications traffic, above normal level, and this steadily elevated traffic level continued as the incident unfolded. This surge in communications traffic volume made it more difficult to handle the flow of communications and delivery of critical information. Analysis of radio communications records indicated that roughly 1/3 to 1/2 of the radio messages during surge conditions were not complete or understandable.

Presentation by John Cole – Fire Department City of New York
Emergency High-Rise Building Communications

Methods were presented that enhanced radio reception in high rise buildings and other large structures. Solutions discussed were the use of hard-wired telephones that are installed in office high rise buildings as part of the fire alarm system, or the use of the "Warden Phones" that are also installed in high rise office buildings. The keystone to their high-rise communications solution was described as a "Post Radio". This radio allows transmissions from the street level up into a high rise. The "Post Radio" weighs 10 kg (22 lbs) with its case and battery and transmits a signal at 45 watts. However, it does not solve the problem of fire fighters with hand-held radios communicating down to street level. In this case they must wait for someone who has another "Post Radio" to position the radio near the emergency to relay the information down to the lobby or street level. Other recommended uses for the "Post Radio" are large area buildings, subways, large ships, large malls, airport terminals, stadiums, parks, parades, and special events. It is a simple solution and it works. The fire department has control over the radios, so there is less concern as to whether or not they will work when needed.

Another solution is the use of a cross band repeater that is situated in a vehicle near the building. A repeater is basically a relay station. The purpose of a cross band repeater is the same as any radio repeater. It allows stations to communicate that ordinarily would not be able to do so because of the low initial output power coupled with distance, terrain or buildings, and other objects blocking the signal. A cross band repeater is similar in function to a standard repeater in that it contains a receiver and a transmitter that are linked together, but which operate on different frequencies. Voice signals that the repeater receives on its input frequency are automatically re-transmitted on its output frequency. A cross band repeater incorporates a dual frequency band radio. For example, a hand held radio would transmit on a VHF band and the cross band repeater would then re-transmit on a UHF band. Thus the name cross band repeater.

A cross band repeater is typically less expensive than a conventional repeater operating on a single radio band. With a conventional repeater the transmit and receive frequencies are only separated by a few hundred KHz requiring the radio receiver section to be isolated through the use of narrow band filters that may be large and expensive. The cost of a repeater drops significantly if its input and output frequencies are separated by several hundred MHz instead of a few hundred KHz. With a wide spacing between the input and output frequencies, expensive input filters are no longer required.

Presentation by Roy Ferguson and David Kinney – Dallas Fire and Rescue
Communication Challenges in D.A.R.T. Subway Tunnel

With the construction of a new subway station, Dallas Fire and Rescue found that communications to the station, which is located under a high rise building, was not adequate. They found that their duplex repeater channels did not work and that the simplex channels only worked from radio to radio, if they were on the same subway level. They attempted several solutions including the use of loaner radios from the subway system, but this required a relay through the subway command center. Other methods were to use the simplex radios in the tunnels, emergency telephones in the tunnels to talk to locations outside the subway, and setting up a relay system with radio to relay information up stairways. With these different systems communication was described as hit or miss at best. The Dallas Fire and Rescue Department, along with their Information Technology personnel continued to work with the subway management to find solutions. The procedure described was to identify the problem, conduct testing, cooperate with subway management to find an answer, and test out the solution to make sure that it is satisfactory. No one solution fixed all the communication issues. One method of successfully dealing with an issue was to re-program some of the hardware that controlled radio communications while another involved installing additional equipment such as radiating (leaky) antenna cable in subway tunnels, stairways, and storage areas. They reported that this new equipment will have to be tested and maintained to guarantee that it will work when needed.

Presentation by Brian Anderson and Raymond Vaughan – Miami Dade Fire Rescue
High Rise Building and Complex Incident Workshop

Some of the significant large incidents that have occurred in the Miami Dade Fire and Rescue area were Hurricane Andrew, the ValuJet Crash in the Florida Everglades, and the Fine Air Cargo Crash at the Miami International Airport. Some more common large incidents that they respond to are fires in mid and high rise structures, fires in warehouses and wild land fires. The difficulties in managing these incidents are the large organizational workload that is placed on the first arriving units, the assigning of units to specific tasks, and the tracking of units and individuals.

Other challenges are the time delays in the setting up of command posts for large incidents, the different communication procedures and style used by different agencies and the issue of unity of command. The term unity of command refers to the principle that a subordinate should have one and only one superior to whom he or she is directly responsible. That means, on a hierarchic tree, there should be only one person in absolute command. Unity of command is an important principle of an Incident Command System. Some improvements regarding interoperability and the set up of an adequate command post are the utilization of specialized communication and incident command vehicles. These vehicles have the communication capabilities that assist with communication interoperability between agencies at the scene of an incident and also provide an area where commanders/department heads from different agencies can meet face-to-face to discuss incident issues. A critical aspect of handling a large and or complex incident is training and the use of the National Incident Management System (NIMS).

The ability of an individual fire fighter to communicate is also affected by his or her personal protective clothing. It is difficult to manipulate buttons and knobs on a radio with gloved hands. Personal protective clothing such as protective hoods, helmets, etc., cover the individual's ears and reduce the sound levels. Some solutions attempted have been large frequency selections knobs installed on the radios, a push button for volume control, and a mask-radio interface device.

Presentation by Tom Brennan – Los Angles City Fire Department

High Rise Fire and Complex Incident Communication

An overview of the high rise structures in Los Angeles was given. They are categorized into three different groupings by the date in which they were built; those built pre-1960, those built between 1960 and 1974, and those built after 1975. The different eras in which these buildings were built determines the level of built in building and fire protection. However a fire in any of these high-rise buildings can be an intense incident that presents multiple communication challenges. The presentation focused on the situational awareness and damage assessments from the point of view of the 9-1-1 emergency dispatch center. Their belief is that incident communication does not start when fire or police apparatus are en-route or arrive on the scene; it starts with the first telephone call to the communications center. The communications center is the intelligence collection point. By having the communications center be the intelligence collection point it is felt that this lessens the overall burden on the Incident Commander. Any information that the communications center receives, either by telephone, video feeds from news organizations, radio, etc., is passed onto the Incident Commander. The challenge is how to sort and prioritize varying assessments and not discount information that ultimately may prove accurate. The information obtained by the communications center can be used for search and rescue operations, fire suppression, police operations, etc.

Presentation by Chris Holloway – National Institute of Standards and Technology

Propagation and Detection of Signals Before, During, and After a Building Collapse

Work described in this presentation is from a NIST project that investigated communications problems for first responders (fire fighter and police) in large public buildings and in terrorist situations, i.e. collapsed buildings. Studies were performed to investigate first responders' radio frequency propagation associated with large public buildings and various schemes for locating fire fighters and civilians who may have portable radios or cell phones and are trapped in voids of collapsed buildings. The work was conducted in buildings scheduled for demolition by implosion. This method of demolition was chosen because the radio transmitters can be covered with building debris during the implosion. Before the building implosion, radio transmitters were placed in various areas of the building. Radio propagation characteristics from the transmitters were measured before, during, and after the building implosions. The three experiments described were the implosions of an apartment house, a stadium, and a convention center. The references for the full report for each of these experiments can be found in the reference section at the end of this report. [4, 5, 6]

Presentation by Stu Overby – National Public Safety Telecommunications Council
Communications for In-Building and the Incident Scene

A description of the National Public Safety Telecommunications Council (NPSTC) In-Building Working Group which was formed in March of 2006 was given. The In-Building Working Group's mission is to promote the availability of affordable in-building and in-tunnel communications in ways that do not interfere with critical operations and to serve as the NPSTC liaison with other entities addressing in-building or in-tunnel communications. Presently they are working on developing best practices to minimize interference from in-building bi-directional amplifiers. An example of what can occur if an in building system is improperly installed was demonstrated. In this case a bi-directional amplifier was improperly installed. This caused 200 cell phone base stations to be interrupted causing 250,000 dropped calls of which a subset were calls to 9-1-1 centers.

Some future technologies were presented that included the ability to wirelessly connect to building security systems, the ability to access building cameras and sensors, and the possibility to remotely control building functions as part of an emergency response. The use of mesh and ad-hoc technologies will bring about true mobility to first responders in the field that is not now possible with wired technologies.

Presentation by Sharyn Buck – Los Angles City Police Department
Los Angeles Police Department Communications

The complexities of managing a large metropolitan police department's communications center were described. Los Angeles covers an area of 467 square miles, has a population of 4 million, and has 9300 police officers. The city is divided into two geographic areas for the purpose of police communications, the Metropolitan Communications Dispatch Center and the Valley Communications Dispatch Center. Each dispatch center is housed in its own building. Both buildings are designed to withstand an 8.2 magnitude earthquake, and both can operate for 72 hours on back up systems. From these two facilities over 1.7 million 9-1-1 calls were answered in 2005, with 98.6 % answered in less than 10 seconds. In order to staff these two communications centers, Los Angeles employs 600 personnel. The communications division is the largest division within the Los Angeles City Police Department.

One of the primary objectives of building these two dispatch centers was to design a pleasant and stress-reducing work environment for the 9-1-1 emergency operators who are known as Police Service Representatives (PSRs). To provide a stress-reducing work environment for the PSRs special consideration was given with regards to noise control, natural lighting sources, spacious work areas and high vaulted ceilings. Each console (work area) has 4 flat panel computer screens with a mouse, individual air/heat control, and additional lighting options. The PSR/9-1-1 dispatcher has the ability to work while sitting or standing. The computer panels can be tilted forward or backward to allow full visual range of the screens.

With respect to possible solutions to solve the police agency communications issues within high-rise structures, two possible solutions were given. The first is to provide funding for the agency to build up its infrastructure and the second was to mandate polices that high-rise structures be built to include the provision on in-building radio coverage. This would require building owners to provide adequate public safety radio reception in their buildings. One specific example of how the police department was able to find a solution to a specific communications issue was during a national political convention. Communications issues within the convention center were solved by placing two bi-directional amplifiers in the ceiling of the convention center.

Presently 700 police vehicles are equipped with mobile data computers, and by 2007 there should be 1600 in service. This will allow the patrol car to be a mobile office with wireless access for internet, email, and field reporting.

Presentation by Charles Dowd – New York City Police Department

N.Y.P.D. High-Rise Building and Complex Incident Emergency Responder Communications

Another solution is to build an infrastructure that provides adequate coverage within the jurisdiction. The New York City Police Department has been upgrading and building up their communications infrastructure. Some examples given were the increase in the number of transmitters from 85 to 146, and the number of receivers from 515 to 1,264. In a specific precinct in the city, coverage was expanded by adding an additional 9 receivers. It is believed that a well engineered network radio system will allow first responders to be independent of any single in-building system. The New York City Police Department's current radio network system provides 95 % in-building coverage without the need for in-building repeaters. However it was pointed out that in-building coverage is affected by the type of construction (i.e. concrete vs glass) and that larger concrete structures can reduce network coverage to 80 % to 85 %, the coverage typically being reduced on the lower floors and core areas of the building.

If an in-building system is installed and is properly engineered it has the potential to enhance in-building network coverage. It has to meet existing Police Department network requirements. Among these are a new and appropriate bi-directional amplifier technology that addresses time delay interference and Federal Communications Commission compliance. Other requirements include mandatory outage notifications regarding scheduled maintenance, upgrades or system failures, and that building management be responsible for annual system testing that is to be conducted by an independent contractor. The findings are forwarded directly from the testing contractor to the New York Police Department's Communications Division.

Presentation by Nelson Bryner - National Institute of Standards and Technology
Distributed Multi-Nodal Voice/Data Communication Systems
The goal of the Advanced Fire Service Technologies (AFST) Program is to enable a shift to an information rich environment for safer and more effective fire service operations through new technology, measurement standards, and training tools. The research currently sponsored by AFST focuses on fire fighter protective clothing, tactical decision aids, virtual fire fighter training, thermal imaging camera performance evaluation methods, localization and tracking of emergency responders, and radio communications. One area of particular interest has been the thermal environment in which electronic devices, including radios, carried by fire fighters are required to function in, from ambient conditions up to temperatures of 260 °C (500 °F) for some defined period of time.

Examples of different communication technologies that are being investigated are acoustic/sound for fire fighter location, infrared for possible use in digitized audio and fire fighter location, and radio frequency technology. The strength and weaknesses of distributed multi-nodal voice and data systems, wireless building sensors, radio frequency identification tags, and fire fighter sensor networks were also discussed. It was highlighted that NIST plays a role as a provider of fundamental science and measurement technology needed by standards organizations for developing test methods and standards for fire safety and the emergency response community.

Presentation by Steven Bushby - National Institute of Standards and Technology
Emerging Building Automation Technology and its Impact on Emergency Response
Today's modern buildings function with multiple control systems programmed to run different building systems, such as heating ventilation air-conditioning (HVAC), lighting, access control (physical security), and life safety (fire). Network communications carry commands from controllers to actuators and switches, and a host of sensors feed data back to controllers. Yet, for the most part, all this information is bottled up in the building even while it could provide tremendous situational awareness to those outside the building, telling them where a fire is, where smoke is, where occupants are, which devices are operating, which lights are on, or which doors are open.

The challenges are to develop standards for the collecting, moving and displaying of the real time building information to those who need it. This type of system would not only assist public safety in the management of the incident but may also provide a conduit for radio communications into and out of a high rise building with the ability to not only locate, but also track individual first responders.

Review of Breakout Discussions

High-Rise Building Communications

Techniques were presented and discussed on how to improve communications in high-rise buildings, other large buildings such as convention centers, and underground structures such as parking garages, subway stations, and tunnels. Not all the methods presented are applicable to all buildings since the era in which the building was built may determine if certain built-in fire alarm or fire protection systems are present. Also, a solution that may improve the communications in one type of building may not yield adequate results in another due to many reasons, among them the size of the building, height or depth below ground, construction materials used, and if in fact the building was designed and built with the purpose of blocking out any communications from the outside. The solutions presented included:

- The use of hard-wired telephones that are part of the fire alarm system
- The use of warden phones
- The use of a "Post Radio"
- The use of a "Cross Band Repeater"
- Sound powered phones
- The use of In-Building systems such as
    - Repeater systems
    - Bi-directional amplifiers
    - Leaky antenna cables
    - Distributed antenna system of amplifiers, fiber optic cable, coaxial cable, and radiating cable and/or discrete antennas installed on or inside the property.
- Building up the communication infrastructure within the jurisdiction to the point which satisfies the need for communications in these structures.
- Training the individual. Simply by having the user move to another location in the building such as a window, balcony, or elevator shaft may improve radio reception.
- Setting up a relay system of radios all on the same frequency.

For in-building systems maintenance was an issue. Consensus was that in-building systems may not work when needed since they are not constantly used.

A relatively new concept is the requirement that some municipalities have placed on building owners through legislation. They now require building owners to provide radio reception in buildings. Over thirty jurisdictions have this requirement and several model laws have been drafted for use by jurisdictions wanting to pursue this course. It appears that the number of jurisdictions that will pass some kind of legislation will increase, and should these in-building systems proliferate there needs to be standard way to test them. There will be a need for standards and codes to determine the number of times per year the systems need to be tested, guidelines for specifying the details of what the actual in-building requirements should be, percentage of area covered, how to measure reception, boundaries for coverage, etc. An example of such a requirement for radio communications in a building is that 95% of the area will have no more than a 21 dB reduction in signal upon building penetration. One thought was to put requirements for the installation of these in-building systems in the building code and the actual minimum requirements for installation, testing, and maintenance into an appropriate national standard.

Large and Complex Incidents

The group consensus was that for a large and or complex incident planning, training and the use of the National Incident Management System (NIMS) are the strongest factors in determining if the incident will be mitigated successfully. *There did not appear to be any technical solutions - technology may help, but it is not the solution.* Beyond radios, there is a need to be well trained in interagency issues. Organizations and individuals need to understand where they fit in. It was felt that interoperability is about developing good standard operating procedures, how to work together, who needs to be where doing what, and the need to develop interagency protocols.

There was discussion on the differences in an emergency event versus a planned event. For the emergency event there is not time to work out communication issues, they need to be worked out in advance. Training and discipline were constantly mentioned as being important for large and or complex operations. The standard operating procedures will generally determine who is in charge of an incident.

An example of a planned event was a past presidential inauguration in which the heads or commanders of 127 different agencies met to discuss and formulate plans. Once decisions were made the department heads or commanders of the agencies would then send out instructions to the individual people of each agency. For an event of this size there is a need for someone with the power to designate the lead agency.

It was felt that for both emergency and planned events that interoperability at the command level was essential for command and control. Command officers need the ability to communicate with each other and this is best performed face-to-face. Many jurisdictions are solving this issue by purchasing large mobile command vehicles that are taken to the scene of an incident. These vehicles are designed to be used as a multiple-agency mobile incident command vehicle. They are often equipped with the latest radio, microwave, satellite, telephone and wireless communications technology, which may include the ability to link all types of emergency radio systems in use by various public safety agencies. One such mobile command vehicle has the ability to interconnect 13 different emergency radio systems, phone systems, and data networks used by the various jurisdictions in which it serves.

However, for an emergency event it takes time to deploy and set up these mobile command vehicles. An example given was for an airliner crash in Florida in which it took over an hour and a half for the command center to arrive on scene and set up for operations. One city described the process taking one hour on a normal day to get their mobile command center vehicle to the location, setup and operating. Since police and fire are usually first on the scene what is needed is a good relationship between police, fire, and other agencies that may respond early on to an incident in order to develop the necessary command structure prior to the arrival of the mobile command vehicle.

With the ability to patch or interconnect different radio systems from different police, fire, emergency medical services and other responders comes the difficulty of developing a common language understood by everyone. It was felt that before patching everyone on the same channel that there is a need for the jurisdictions involved to have developed and trained on a protocol or else it will be chaos. Public safety agencies may have very specific jargon or codes that they use which may not be understood by individuals in other agencies. There needs to be protocols in place using the National Incident Management System. One possible solution given was to use plain talk without the use of any codes. Another concern when multiple radios from various agencies are patched or linked together is that there is now the problem of the channel becoming more crowded. Radio discipline is an important requirement. Everyone needs to be trained to know and understand the protocols.

Still, if command and control is working there are issues with capacity of both the system as well as of a human to process information. Information overload is when messages are being missed. The city of Los Angeles is working on addressing a protocol, for handling and processing information flow at large incidents. An example given is that the Fire Department may have information that needs to get back to the 9-1-1 call takers so that the information may be given to the public when they call.

For large incidents where there are many responders on the scene, the number of users on a particular frequency/channel/or talk group is not a good measure for scalability since discipline, procedures, training, and the nature of the incident are also strong factors. Even if we have 100 channels it will not solve all the communication issues. It was mentioned that the weak link in a communications system may be the person using the radio, someone who is not trained or who lacks discipline. Training and discipline are important for large scale operations.

Another challenge mentioned for a large incident is the possible loss of the community infrastructure, including electricity, water, food, lodging, etc., for a long period of time. Many agencies have a three day self-sufficient requirement when responding to a large incident. This may also include the community 9-1-1 center. Los Angeles City, for example, has two separate centers and each can run for three days on self-contained power. After recent storms some thought that agencies should plan for seven days of self-sufficiency. Some other issues mentioned were the ability to track individuals, difficulty in keeping a manageable span of control, logistics, and the ability to size-up the situation.

Workshop Summary

1. Solutions exist for in-building communications that work now for most building communication problems. A list was presented in the previous section, and more details were presented elsewhere earlier in the report. Different solutions are suitable for different building types and situations.
2. For interagency communications, radio frequency patches can tie radios together, but the real issues are not technical. Interoperability is about developing good standard operating procedures, how to work together, who needs to be where doing what and the need to develop interagency protocols.
3. For large and or complex incidents, the group consensus was that planning, training and the use of the National Incident Management System (NIMS) are the strongest factors in determining if the incident will be mitigated successfully. There are no technical solutions - technology may help, but it is not the solution.

4. Tools exist for improving incident command, among them: using the NIMS, using a command van, interagency planning, developing standard procedures, and training.
5. Even with excellent plans, large incidents put a strain on any radio network and demand strict radio discipline to keep channels open for the most important communications.

Appendix 1 - Workshop Attendees

Name	Affiliation	Email address
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Appendix 2 - Workshop Agenda

Agenda
High-Rise Building and Complex Incident
Emergency Responder Communications Workshop

June 20, 2006

8:00 a.m.	Registration & Coffee
8:15 a.m.	Welcome and Introductions – Bill Davis/Jim Hill
8:25 to 8:55	Overview Communications Issues from September 11, 2001 – James R. Lawson
8:55 to 9:20.	John Coloe - Fire Department of the City of New York
9:20 to 9:45	Roy Ferguson and David Kinney - Dallas Fire Rescue
9:45 to 10:10	Brian Anderson and Raymond Vaughan - Miami Dade Fire Rescue
10:10 to 10:25	Break
10:25 to 10:50	Tom Brennan - Los Angeles City Fire Department
10:50 to 11:20	Chris Holloway – NIST Boulder - Electro Magnetic Division
11:20 to 12:00	Stu Overby – National Public Safety Telecommunications Council
12:15 p.m.	Lunch
1:30 p.m.	Breakout sessions for High-Rise Issues
3:15 p.m.	Break and return to main meeting room
3:30 p.m.	Report on Breakout Sessions
4:30 p.m.	Adjourn for the day

June 21, 2006

8:15 a.m.	Reconvene & Coffee
8:30 a.m.	Opening on Large and/or Complex Incidents participant presentations

8:30 to 9:00	Sharyn Buck – Los Angeles City Police Department
9:00 to 9:30	Charles Dowd – New York City Police Department
9:30 to 10:00	Nelson Bryner – NIST Building and Fire Research Laboratory
10:00 a.m.	Break
10:20 a.m.	Breakout sessions on Large and/or Complex Incidents issues
12:00 p.m.	Lunch
1:15 to 1:45	Steve Bushby – NIST Building and Fire Research Laboratory
1:45 to 2:30	Report on Breakout Sessions
2:30 to 3:00	Review solutions, set priorities for issues, develop a road map
3:00 p.m.	Adjourn

Appendix 3 – Communication in Buildings

Factors contributing to building attenuation of RF signals

Radio interference by buildings can be traced back to the way that different objects and building materials interact with radio signals. Whereas we know experientially that radio signals are lost in interior spaces of a building (especially large concrete and metal structures) and underground, knowing the reasons in more details can help: in finding a signal when inside a building; in sizing up potential radio communication problems when arriving at a building; and in helping those involved with developing regulations for in-building radio reception.

There are multiple factors affecting radio reception. Building components will attenuate signals that pass through them. Walls attenuate, and thicker walls and denser walls generally attenuate more. Whereas a drywall stud wall has an attenuation of 15 dB, a reinforced concrete wall has attenuation of 30 dB [7]. Moving underground simply multiplies the number of walls and floors a signal must pass. One poured concrete floor or wall in a commercial office building is likely to mean the difference between an acceptable and weak signal. Several walls could mean no signal.

Metal walls have a stronger signal blocking effect, and also cause stronger reflections. Reflections result in overlapping signals that can cause dead spots or confuse radios. Just as a metal wall can block and reflect signals, so can metal objects in a room: shelves, partitions, file cabinets[8]. In addition to reflection, diffraction allows waves to bend around corners and objects in a signal path. These effects together often result in significant variation in signal strength even within a single room.

There are other interesting effects that can occur in indoor environments. Hallways and elevator shafts can act as waveguides to move signals further into a building. And there are differences in construction that are not visible but that can make a big difference in signal strength. Whereas some concrete floors are pre-cast and pass some signal, other concrete floors may be poured in place over a metal deck resulting in much worse signal transmission. Whereas we are familiar with moving toward a window to increase signal strength, if a window has a solar radiation blocking film, that same film may shield radio signals as well. Another effect is the impact of a surface near an antenna — signals to and from a handheld radio will be adversely affected by proximity to objects and walls. For this reason, standing away from walls, near open areas and hallways, and holding a radio away from one's body can all contribute to improved radio reception.

Building construction differs generally by building type/use and by age. Residential low-rise buildings, even large ones, are typically wood frame, plywood, and drywall. Commercial building stock has concrete floors, and a concrete and steel support structure that attenuates signals more rapidly. Industrial space may have larger rooms with less concrete but more metal walls and partitions and thus more reflections and interference on signals. Any high-rise will likely have issues with point-to-point communications from ground floor to higher floors, due to concrete and steel construction, even if there is good reception on any given floor of a signal from an outdoor tower coming through the side wall. Tunnels may allow good point-to-point connections along the tunnel, but no reception from one level to another or to the outside due to earth and concrete.

The summary of these varied observations leads one to some useful conclusions: in general, size and building construction are good indicators of the level of signal attenuation that will occur. However, while size is easily observable, construction details and materials within walls and floors are not. In addition, the layout of internal space (number and orientation of walls and open spaces) will affect propagation of signals into interior spaces. Two buildings may appear roughly equal in size and appearance on the outside but have very different levels of signal attenuation for any of the reasons mentioned above.

Some more technical details about radio propagation and the effects of obstacles in the path of radio signals can be found in [9, 10].

In-Building wireless systems

An in-building wireless system provides radio reception in a building that would otherwise lack radio coverage. Some material concerning in-building repeater solutions for public safety was discussed during the workshop, and good references for the various signal boosting options are presented in [11, 12]. However, in addition to these public safety oriented systems, there is currently a growing movement to install systems to provide cell phone service as well as WiFi coverage. Evidence of this can be seen in the formation earlier this year of the In-Building Wireless Alliance (IBWA, http://www.i-bw.org) who's members include leading companies in the fields of real estate, building controls and wireless communications. Their stated goal is to make the business case for in-building wireless systems in order to build the market for these systems. From a non-public safety perspective, the IBWA has done market research and concluded that in-building wireless systems will give a high return on investment to the building owner due to the willingness of tenants to pay for such features as ubiquitous cell and WiFi service. But the IBWA also recognizes the side benefits for public safety in that these same wireless systems might be designed to carry public safety radio communications.

The IBWA defines an in-building wireless system as a "set of solution elements that enables people and assets to communicate reliably, regardless of where they are inside of the building. As a result, operational objectives that rely on staying connected are achieved." What do these systems look like? Generally there is some kind of distributed antenna system (DAS) that connects to radio receivers. In the case of cell phone use, a "leaky coax" cable antenna could run along hallways and these antenna branches are brought together down to a telecom room where a cell receiver is located. In the case of WiFi, access points which use the DAS as their antenna are located several to a floor and connect to the wired Information Technology (IT) network to provide the necessary bandwidth and connection to IT systems.

This is essentially the same as what is done for public safety using a bi-directional amplifier. Signals from a radio are picked up on a distributed antenna, amplified, and then rebroadcast on the outside of the building with a directional antenna pointed at the nearest base tower. One difference with the above examples is that in the case of the cell phone application the building acts as a cell, while the public safety radio application rebroadcasts the signal to a tower some distance away. If a DAS is being installed in a building anyway, then it might be designed to provide coverage for public safety radio signals.

In-building wireless systems provide the only pathway for excellent in-building public safety radio reception in many buildings. As we look at what is working today, we see that more and more municipalities are requiring large building owners to provide indoor radio reception for public safety. If a municipality is considering requiring building owners to install in-building wireless systems to support public safety, and building owners are rapidly moving toward installing in-building wireless systems anyway to support tenant communication needs, then the public safety community should be working with groups like the IBWA to find ways to enable public safety communications to share the in-building wireless infrastructure, piggy-backing on the larger society trend and making the business case for the building owner even better, allowing the building owner to offer tenants not only cell and WiFi but also increased safety. And, in fact, the National Public Safety Telecommunications Council has started an In-Building Wireless group that is working with IBWA to address these issues (as introduced in Stu Overby's workshop presentation).

References

1 Jones, W.W., Holmberg, D.G., Davis, W.D., Evans, D.D., Bushby, S.T., Reed, K.A., "Workshop to Define Information Needed by Emergency Responders during Building Emergencies," NISTIR 7193 , January 2005.

2 Davis, W.D., Vettori, R.L., Reneke, P., Brassell, L., Holmberg, D.G., Kostecki, J., Kratchman, J., "Workshop on the Evaluation of a Tactical Decision Aid Display," NISTIR 7268, October 2005.

3 Holmberg, D.G., Davis, W.D., Treado, S. J. , Reed, K. A., 2006, "Building Tactical Information System for Public Safety Officials," NISTIR 7314, January, 2006

4 C.L. Holloway, G. Koepke, D. Camell, K.A. Remley, D.F. Williams, S.A. Schima, S. Canales, D.T. Tamura, "Propagation and Detection of Radio Signals Before, During, and After the Implosion of a 13-Story Apartment Building," Natl. Inst. Stand. Technol. Note 1540, May 2005.

5 C.L. Holloway, G. Koepke, D. Camell, K.A. Remley, D.F. Williams, S.A. Schima, S. Canales, D.T. Tamura, "Propagation and Detection of Radio Signals Before, During, and After the Implosion of a Large Sports Stadium (Veterans' Stadium in Philadelphia)," Natl. Inst. Stand. Technol. Note 1541, October 2005.

6 C.L. Holloway, G. Koepke, D. Camell, K.A. Remley, S.A. Schima, M. McKinley, R.T. Johnk, "Propagation and Detection of Radio Signals Before, During, and After the Implosion of a Large Convention Center," Natl. Inst. Stand. Technol. Note 1542, June 2006.

7 Faouzi Derbel, "Reliable Wireless Communication for Fire Detection Systems in Commercial and Residential Areas", IEEE Wireless Communications and Networking, WCNC, p.654-659, V.1, 2003

8 "An Introduction to Indoor Radio Propagation", Spread Spectrum Scene Magazine, http://www.sss-mag.com/indoor.html

9 Rappaport, T.S., "Wireless Communications: Principles and Practice", (2nd Edition), Prentice Hall PTR; December 31, 2001

10 Morrow, R., "Wireless Network Coexistence", McGraw-Hill Professional, August 1, 2004

11 Public Safety Wireless Network Program, "Public Safety In-Building/In-Tunnel Ordinances and Their Benefits to Interoperability Report", www.safecomprogram.gov November 2002.

12 Desourdis, Robert. I., et.al., "Emerging Public Safety Wireless Communication Systems", Artech House, 2002.

Appendix 4 - Presentations

Presentation by James R. Lawson – National Institute of Standards and Technology

Federal Building and Fire Safety Investigation

of the World Trade Center Disaster

Investigation Findings of the Emergency Response at the WTC

June 2006

High-Rise Building and Complex Incident Communications Workshop

James R. Lawson

Building and Fire Research Laboratory

National Institute of Standards and Technology

U.S. Department of Commerce

NIST

Radio Communications

- All three of the responding departments, FDNY, NYPD & PAPD experienced difficulties with radio communications.
- Each of the departments was aware of the shortfalls associated with their radio communications systems as it related to operations in high-rise buildings.
- Two basic issues with radio communications:

1. Normal function of the radio equipment in high-rise environments. (Radio signal attenuation in steel and steel reinforced concrete buildings)

2. The volume of radio traffic.

NIST

Emergency Responder Radio Systems

Simplex Communications - direct point-to-point, HT-to-HT, or HT-to-Base Station (HT = Handie-talkie)

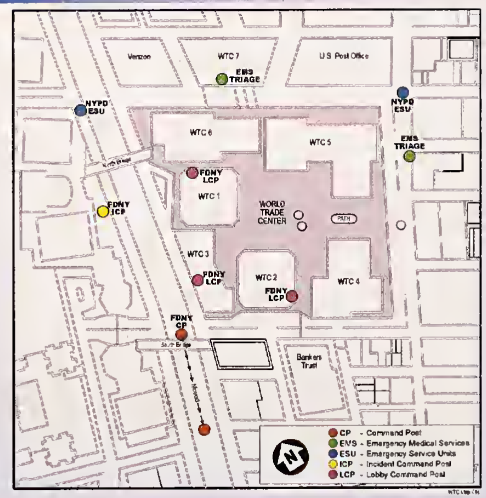
Duplex Communications - transmissions are channeled through a radio repeater.

PAPD Operations - Duplex through their dedicated WTC police department repeater.

FDNY Operations - Simplex for command channel and tactical operations
- Duplex through their dedicated WTC FDNY high-rise repeater.
- Cross-band through the Battalion Car repeater.

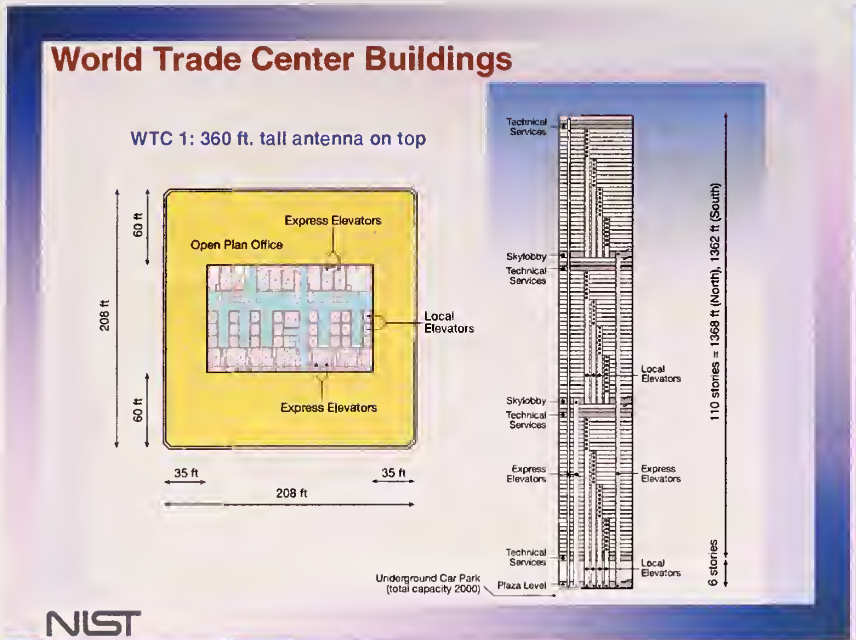
NYPD Operations - Simplex between ESU teams members and the ESU Mobilization Point.
- Duplex through the NYPD SOD and Div 1 repeaters.

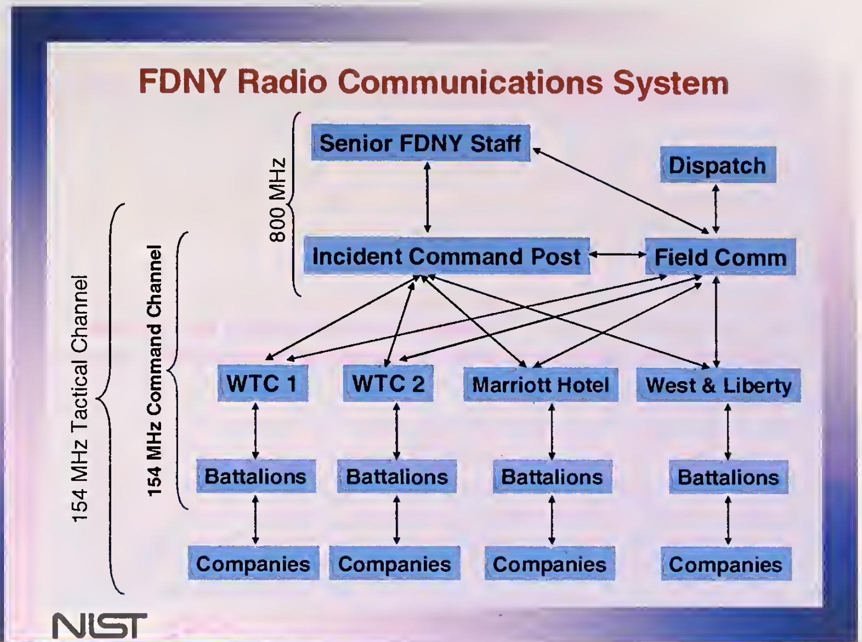
NIST

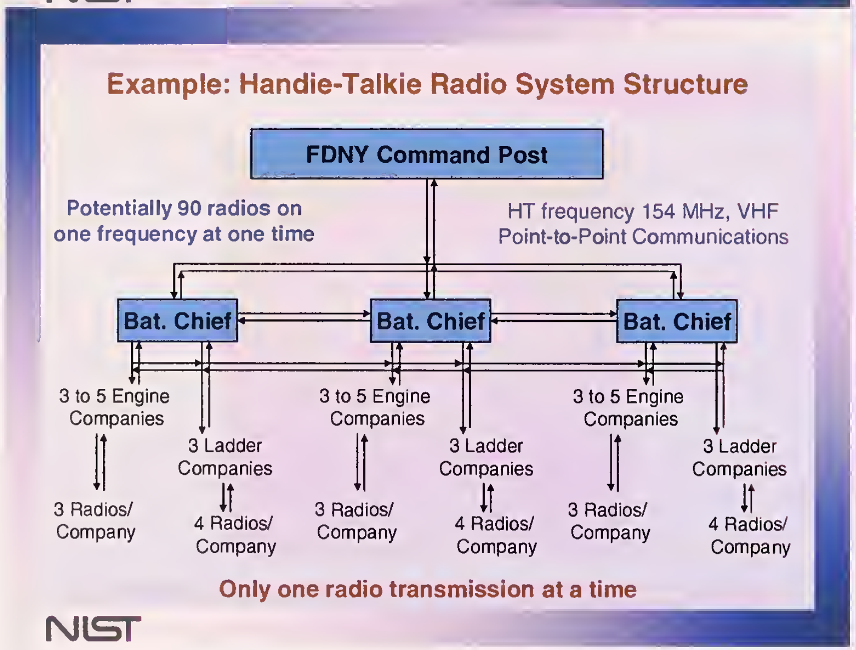


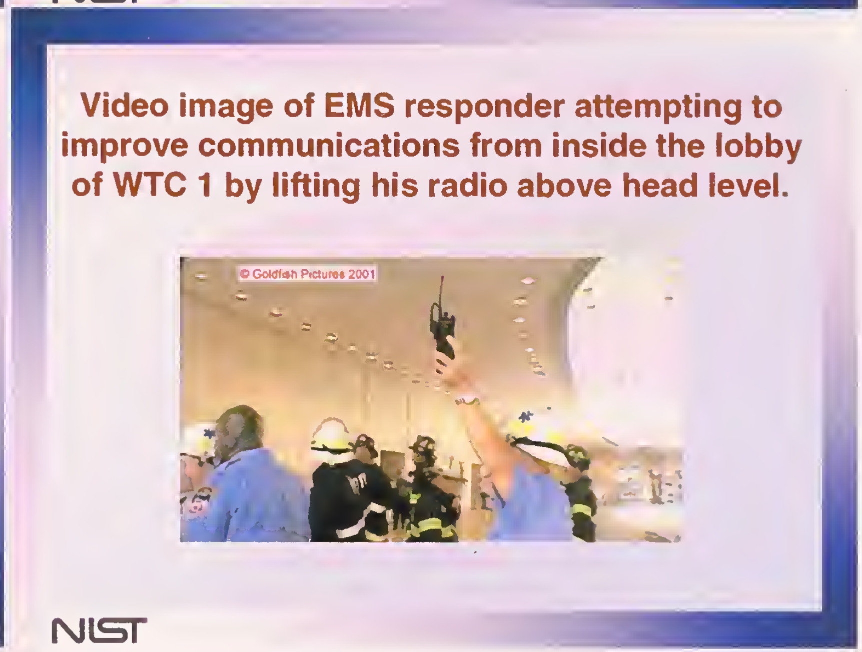
Locations of FDNY and NYPD Command Posts

NIST


World Trade Center Buildings
WTC 1: 360 ft. tall antenna on top
Open Plan Office
Express Elevators
Local Elevators
208 ft
60 ft
35 ft
Technical Services
Skylobby
Underground Car Park (total capacity 2000)
Plaza Level
110 stories = 1368 ft (North), 1362 ft (South)
6 stories
NIST


FDNY Radio Communications System
Senior FDNY Staff
Dispatch
Incident Command Post
Field Comm
WTC 1
WTC 2
Marriott Hotel
West & Liberty
Battalions
Companies
800 MHz
154 MHz Command Channel
154 MHz Tactical Channel
NIST


Example: Handie-Talkie Radio System Structure
FDNY Command Post
Potentially 90 radios on one frequency at one time
HT frequency 154 MHz, VHF Point-to-Point Communications
Bat. Chief
3 to 5 Engine Companies
3 Ladder Companies
3 Radios/ Company
4 Radios/ Company
Only one radio transmission at a time
NIST


Video image of EMS responder attempting to improve communications from inside the lobby of WTC 1 by lifting his radio above head level.
© Goldfish Pictures 2001
NIST

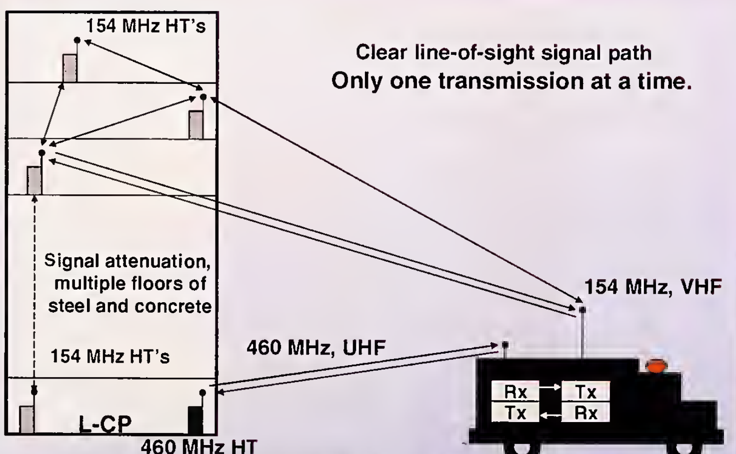
Graphic Showing the FDNY High-Rise Repeater Antenna Location Relative to the WTC Towers

NIST

Video Image of FDNY WTC 1 Lobby Command Post Showing a Repeater Phone

NIST

Example: Battalion Car Cross-band Repeater



Drawing by NIST base on document by Battalion Chief Orio J. Palmer and original drawing by FF Bill Kristoff, FDNY, WNYF, Repeater Systems, 3rd 1998.

NIST

Radio Communications, continued

- Even though the Battalion Car [illegible] approximately 9:07 a.m. and was [illegible] command post, there is no record th[illegible] repeater at the WTC sit[illegible] the repeater died with the [illegible]
- FDNY radio protocol specified that only one Battalion Car cross-band repeater was to be used at any incident. This was to prevent multiple repeaters at one site from interfering with each other.
- There is no evidence that the WTC 1 lobby Command Post used either the FDNY/ WTC high-rise channel 7 repeater or the cross-band repeater to communicate with other personnel up inside the tower.

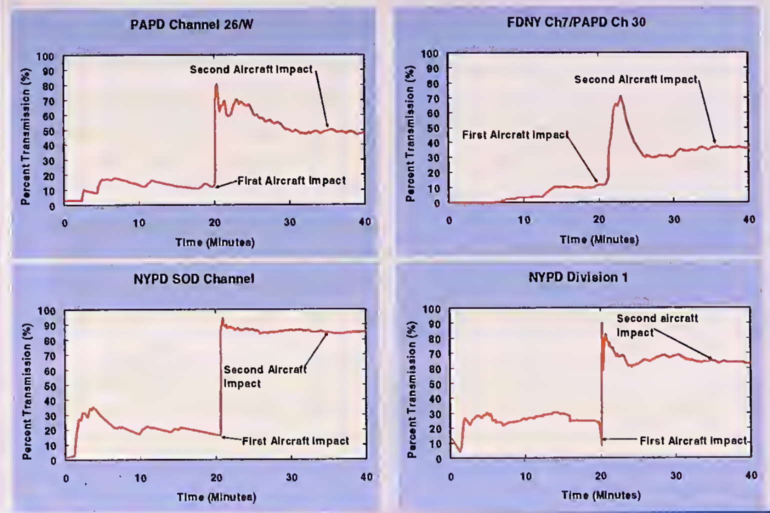
NIST

Radio Communications, continued

1. After the first aircraft struck WTC 1, there was an approximate factor of 5 peak increase in traffic level over the normal level of emergency responder radio communications, followed by an approximate factor of 3 steady increase in level of subsequent traffic.
2. A surge in communications traffic volume made it more difficult to handle the flow of communications and delivery of information.
3. Analysis of radio communications records indicates that roughly 1/3 to 1/2 of the radio messages during surge conditions were not complete nor understandable.

NIST

Radio Traffic Volume – T% = 100(Transmission Time/Total Time)



NIST

Radio Communications, continued

The following examples of radio communications relate to:

1) the surge in radio traffic
2) the inability of the radio systems to handle more than one message at a time, and
3) undesirable radio operations practices
4) radios not working well & open microphones

Between when the first aircraft hit and approximately 10:00 AM, emergency responder communications included the following types of messages:

- asking officers to stay off the air
- comments that messages were being cut-off, there was crossing or doubling, and messages were unreadable
- comments that multiple units were talking at the same time and requests that units talk one-by-one

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Radio Communications Readability Analysis

Readability, is a communications term used to define the ability of a person to hear and understand a radio transmission.

Readability Scale:

1 – Unreadable
2 – Barely readable, occasional words distinguishable
3 – Readable with considerable difficulty
4 – Readable with practically no difficulty
5 – Perfectly readable

Note: This is a subjective scale related to a trained human's ability to hear and understand communications transmissions.

Ref: The ARRL Handbook for Radio Communications

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Readability Summary Before Attack

Dept.	Readability Scale 1	2	3	4	5
PAPD Ch 26/W Police Desk	8%	17%	19%	56%	0%
FDNY H-R Ch 7 (PAPD Ch 30) Repeater	n/a	-	-	-	-
NYPD Div. 1	2%	9%	8%	21%	60%
NYPD SOD	0%	0%	14%	23%	63%

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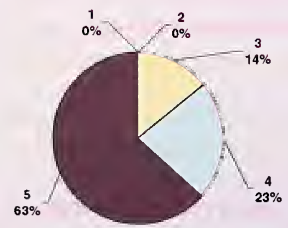
Readability Summary During Operations

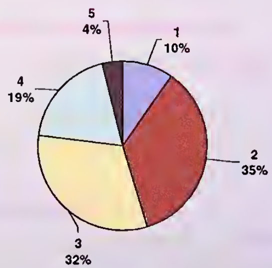
Department	Readability Scale 1	2	3	4	5
PAPD Ch 26/W Police Desk	9%	24%	43%	24%	0%
FDNY H-R Ch 7 (PAPD Ch 30) Repeater	10%	26%	42%	18%	4%
NYPD Div. 1	11%	26%	32%	23%	8%
NYPD SOD	10%	35%	32%	19%	4%

NIST

Radio Communications Readability Analysis NYPD Special Operations Division (SOD)



Before Attack



After Attack

NIST

Radio Communications, continued

- NYPD had relatively good radio communications on their point-to-point communications in the WTC towers because there were only six ESU teams working on the frequency, and
- NYPD's mobilization point that was communicating with ESU personnel inside the towers was set up more than a city block away from the towers allowing for more direct or line-of-sight communications with the towers.
- FDNY was attempting to operate communications systems from inside the WTC towers where building components attenuated radio communications signals.

NIST

Inter-Agency Cooperation

- A significant amount of evidence (first person interviews, [illegible] and photographic data) shows that the different agencies were working together during the WTC disaster
- Data also indicates that inter-agency operations were hampered by the loss of the OEM command center that was located inside WTC 7.
  - OEM functions became dispersed
  - The OEM communications center was lost
  - The computer systems and other equipment used to provide support for emergency response operations was lost
  - Unified operations structure for the emergency response was diminished
- [illegible]
- [illegible]

NIST

FDNY Incident Command Post Outside of World Financial Center 2 on West Street

NIST

Command and Control

- FDNY command and control was seriously affected by the lack of good communications.
- FDNY's system for maintaining records of unit assignments at each command post was not capable of managing the numbers of units and personnel being assigned to the incident.
- FDNY, NYPD, and PAPD: there was no means to back-up the unit assignment records generated at the command posts.

NIST

FDNY Command Board Located in the Lobby of WTC 1

NIST

First Person Accounts of Telephone Communications

- Before the attack at the World Trade Center both landline and cellular telephone systems were working.
- Moments after the first aircraft impacted WTC 1 the telephone systems were stressed by increased caller volume.
- Although there was impact damage and fires were burning in the two World Trade Center towers, some landline telephones were working in the buildings.
- After the collapse of WTC 2, a number of cellular phone systems were not functioning in lower Manhattan.
- After the collapse of WTC 2, there were still some landline telephones working within the city block areas adjacent to the World Trade Center.

NIST

Issues

Emergency Response - Communications

- Lack of rigorous pre-emergency inspection and testing of radio communications systems within high-rise buildings to identify performance gaps and inadequacies.
- Missed opportunities to better communicate information among the occupants, 911 operator dispatch, fire department dispatch, police department dispatch, emergency management service dispatch, and site security. (Inadequate situational awareness)
- Performance requirements for emergency communication systems in buildings.
  - Design, testing, certification standards
  - Maintenance and inspection requirements

NIST

Emergency Responder Operations

Situational Awareness:

- Emergency responders working outside of the WTC buildings that could view building conditions and communicate over radios had adequate situational awareness.
- Situational [illegible] and fires from outside the buildings [illegible] maintaining [illegible] the building.
- Emergency responders working inside of the WTC buildings, who could not see what was happening outside and had poor radio communications, had poor situational awareness.
- Emergency responders working inside of the WTC buildings who could not see what was happening outside and had good radio communications had better situational awareness over those with poor radio communications.

NIST

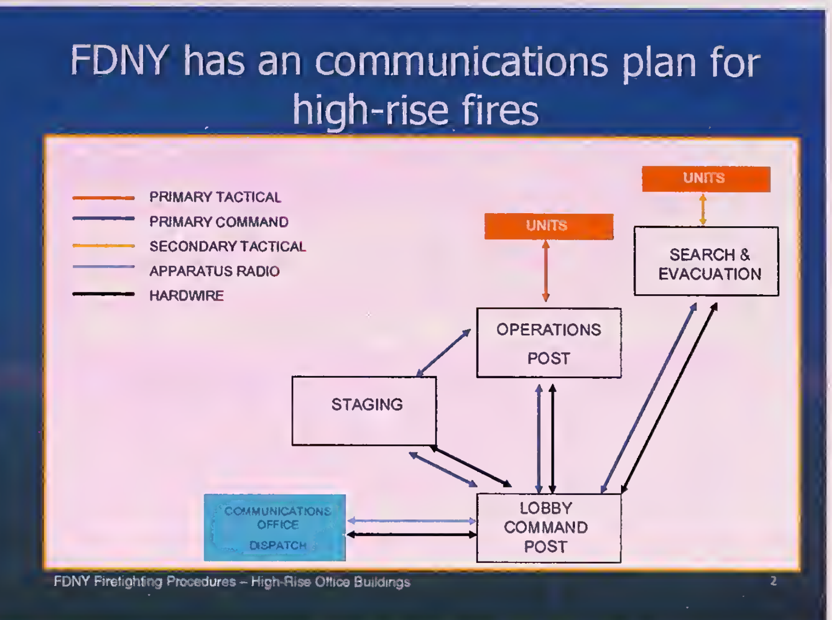
Issues

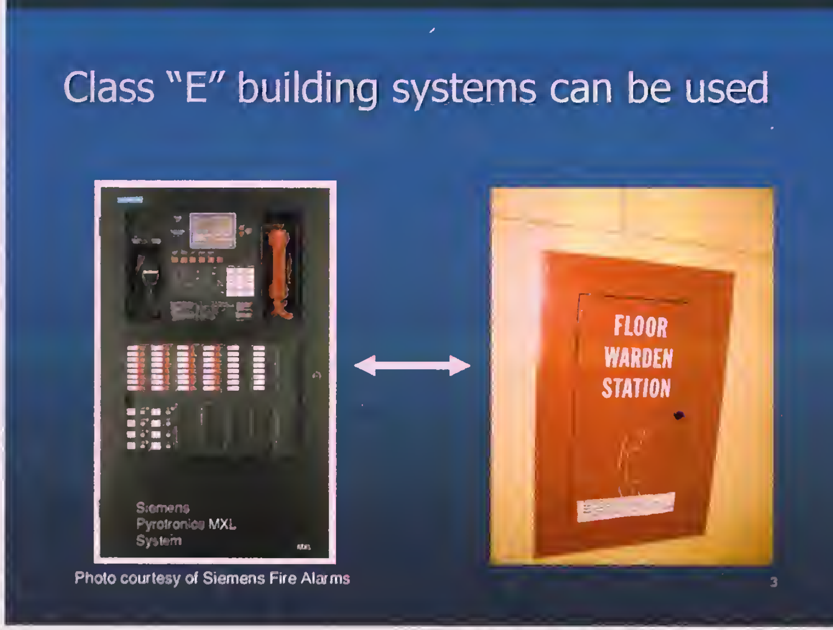
Emergency Response - Communications continued

- Lack of communications network architecture (interoperability) and operational protocols for intra- and inter-agency communication at all levels of organizational hierarchy. This includes:
  - Overall network architecture that covers local networking at incident sites, dispatching, and wide-area urban and rural networks
  - Scalability in terms of the number of first responders using the system and in providing radio coverage in large buildings with challenging radio frequency propagation environments
  - Interoperability with existing legacy emergency communications systems
  - Localization techniques to identify first responders within indoor building environments
  - Conventional two-way systems versus wireless network systems

NIST

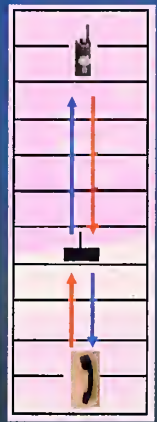

FIRE DEPARTMENT OF NEW YORK
EMERGENCY HIGH-RISE BUILDING COMMUNICATIONS
FIRE DEPARTMENT CITY OF NEW YORK
John A. Coloe
Chief of Communications
FDNY
20 June 2006
1


FDNY has an communications plan for high-rise fires
PRIMARY TACTICAL
PRIMARY COMMAND
SECONDARY TACTICAL
APPARATUS RADIO
HARDWIRE
UNITS
UNITS
SEARCH & EVACUATION
OPERATIONS POST
STAGING
COMMUNICATIONS OFFICE DISPATCH
LOBBY COMMAND POST
FDNY Firefighting Procedures – High-Rise Office Buildings
2


Class "E" building systems can be used
Siemens Pyrotronics MXL System
FLOOR WARDEN STATION
Photo courtesy of Siemens Fire Alarms
3

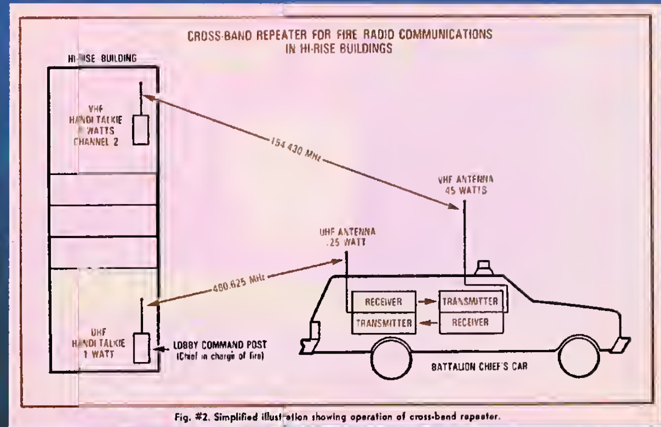

Sound-powered phones can be a reliable means to communicate
4

A few buildings have repeater systems for FD use



5

Specific units were equipped with "Cross-band Repeaters"

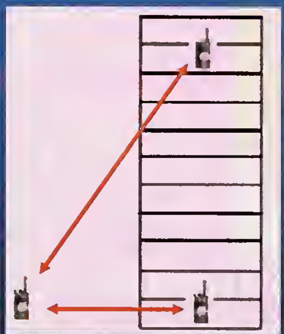


Pre-9-11-01

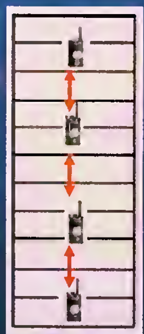
WNYF 1st Issue 1981

6

It often became necessary to improvise



"TRIANGULATION"



RELAY

STAND NEAR ELEVATORS

7

After 9-11-01 McKinsey & Co. did a study of the FDNY

McKinsey found that FDNY personnel often cannot communicate reliably in high-rise buildings, subways and tunnels

"Increasing FDNY's Preparedness"
McKinsey & Company, 2002

8

McKinsey had several recommendations

- Test and deploy portable, mobile, and air-based repeaters
- Pursue stationary communications infrastructure
  - Require high-rises to support first-responder communication
  - Evaluate deployment of additional city-owned infrastructure
  - Seek ways to leverage NYPD's infrastructure to meet FDNY's needs
- Improve communications in subways and tunnels

"Increasing FDNY's Preparedness"
McKinsey & Company, 2002

9

The Post Radio is "the keystone of our high-rise communications solution"



2' clearance required

FDNY Communications Manual, Ch. 12

10

Some Post Radio specs include:

- 16 channel Kenwood UHF Mobile TK8150
- 45 watts, 12 v., 18 amp hour sealed lead acid battery
- AC or 12 v. DC (cigarette lighter type) battery charge
- Estimated 4 to 7 hrs. operation
- 22 lbs.

FDNY Communications Manual Ch 12

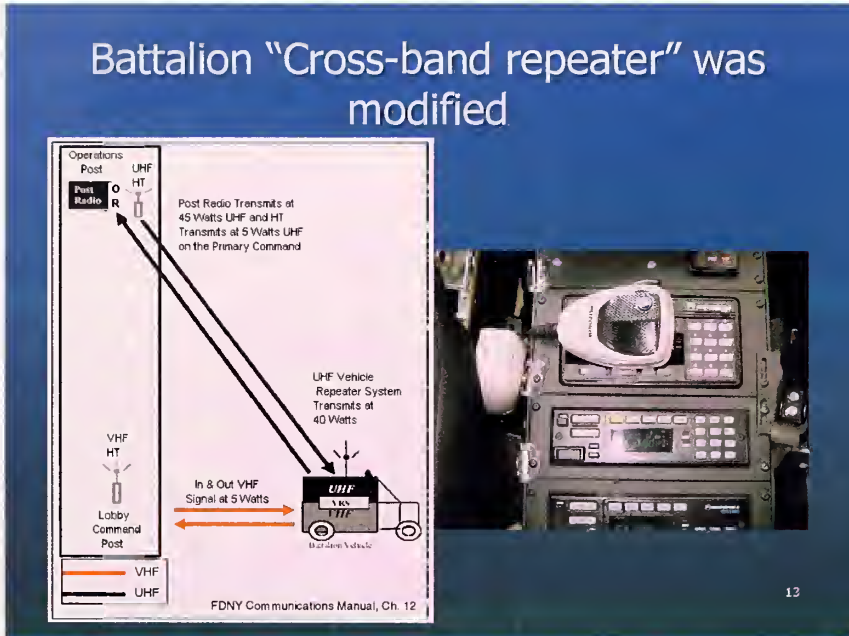
11

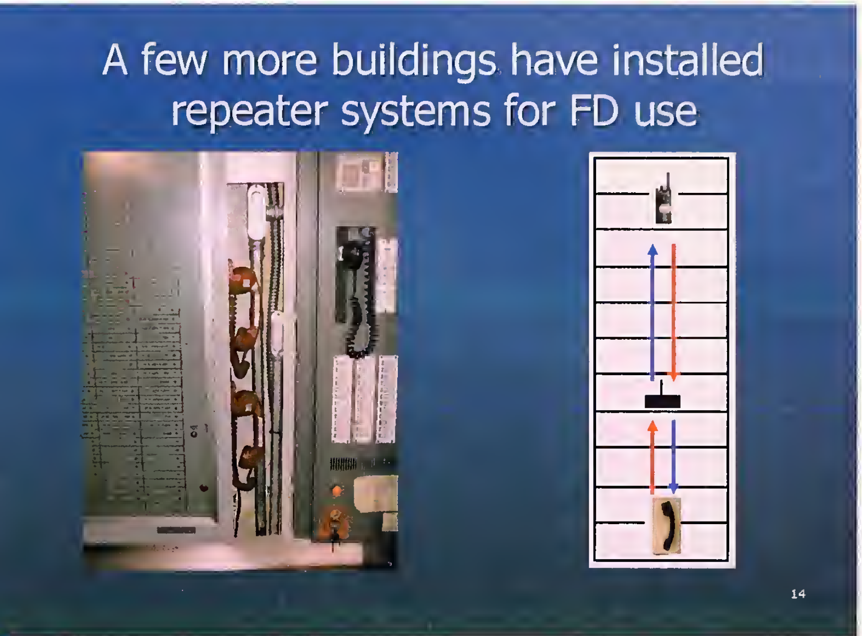
Additional recommended uses for Post Radio include:

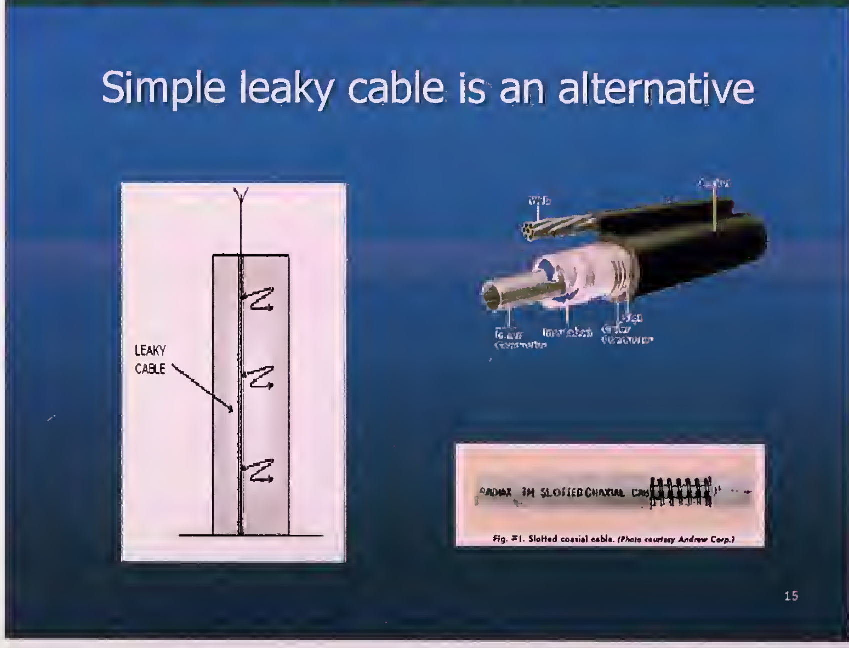
- Large area buildings
- Subways
- Large ships
- Large malls
- Airport terminals
- Large are brush fires
- Large indoor/outdoor venues
- Stadiums, parks, parades, special events

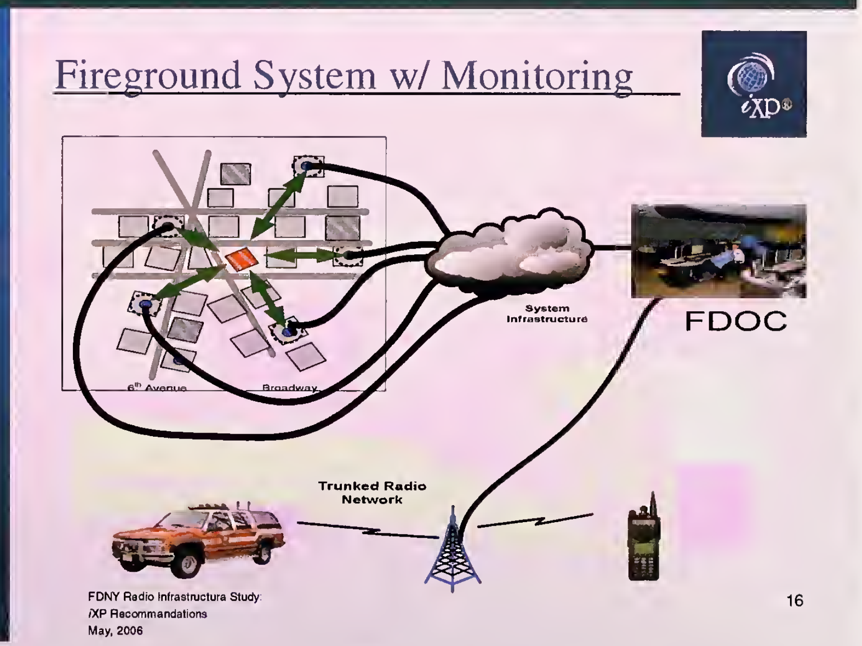
FDNY Communications Manual, Ch 12

12


Battalion "Cross-band repeater" was modified
Operations Post
Post Radio
O
R
UHF HT
Post Radio Transmits at 45 Watts UHF and HT Transmits at 5 Watts UHF on the Primary Command
UHF Vehicle Repeater System Transmits at 40 Watts
VHF HT
Lobby Command Post
In & Out VHF Signal at 5 Watts
UHF
VHF
VHF
UHF
FDNY Communications Manual, Ch. 12
13


A few more buildings have installed repeater systems for FD use
14


Simple leaky cable is an alternative
LEAKY CABLE
Fig. #1. Slotted coaxial cable. (Photo courtesy Andrew Corp.)
15


Fireground System w/ Monitoring
iXP
6th Avenue
Broadway
System Infrastructure
FDOC
Trunked Radio Network
FDNY Radio Infrastructura Study:
iXP Recommandations
May, 2006
16

Penn Station required long distance communication

17

Questions?

18

Dallas Fire-Rescue

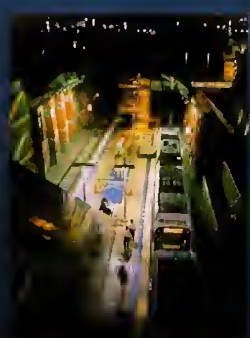
Communication Challenges
in D.A.R.T.
Subway Tunnel

D.A.R.T. Tunnel

- In 1995 D.A.R.T. began construction of a subway tunnel from the Central Business District to Mockingbird Lane.
- The D.A.R.T. tunnel is 2.3 miles long and approximately 100 ft. below grade.

Citiplace Tower Subway Sta.

- There is one subway station located below the Citiplace Tower.



DFR Communications Plan

- Station Radio - 1 Duplex Channel
- Fire Mobile Radios - 4 Duplex Channels
- Med Channels - 3 Duplex Channels
- Tactical Channels - 4 Simplex Channels
  - Typically use 1 tactical channel on high rise incidents. 2 concurrent incidents require use of second backup channel, etc.

Tunnel Buildout

Radio Testing Began.....

- Duplex channels (didn't work)
- Simplex channels in the tunnel
  - Worked but only radio to radio on the same level
- Loaner Radios
  - Worked somewhat but required relay through DART command.

Operations begin - 1996

- Began using hybrid system:
  - Simplex radios in tunnel
  - Emergency phones in tunnel to command
  - Duplex radios to relay information up stairways.
- Communications were hit and miss at best.

Installation of Radial

- DART installed an antenna cable that ran the length of the tunnel.
  - Designed to work as a repeater
  - Tuned to DART radios & Fire Duplex 4 and Medical Duplex 2
    - Still hit and miss
    - DART radios still seemed to work better
    - No reception in stairways and work rooms.

Meeting with DART

- Channel 4 still not working well
  - DART agreed to reprogram. FIXED
- Problems with stairways and storage rooms
  - DART agreed to install radial in stairways and storage rooms. FIXED

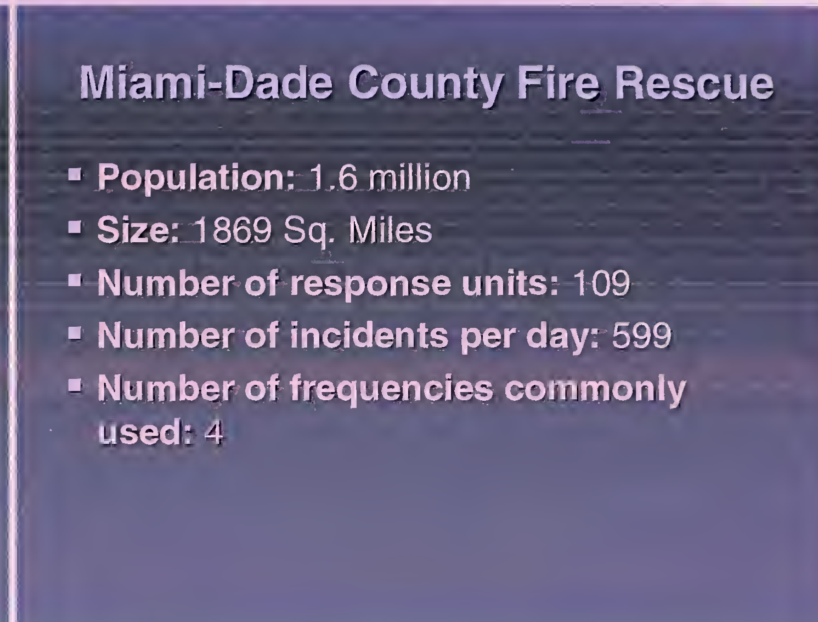
Current Procedures

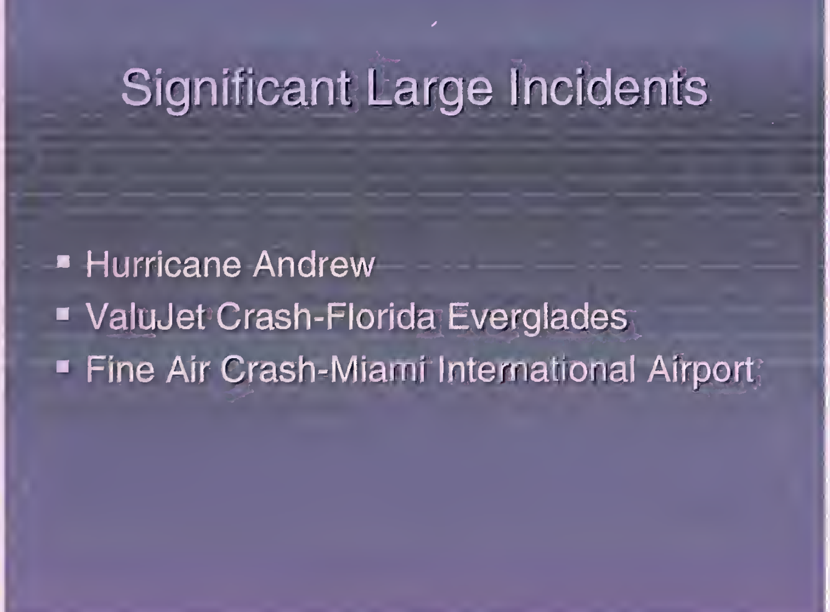
- Fire mobile use Channel 4 Duplex
- Medical mobile use Channel 2 Duplex
- Fireground simplex channels still available for use on track area.
- All telephones in tunnel are on automatic ringdown to DART command center.

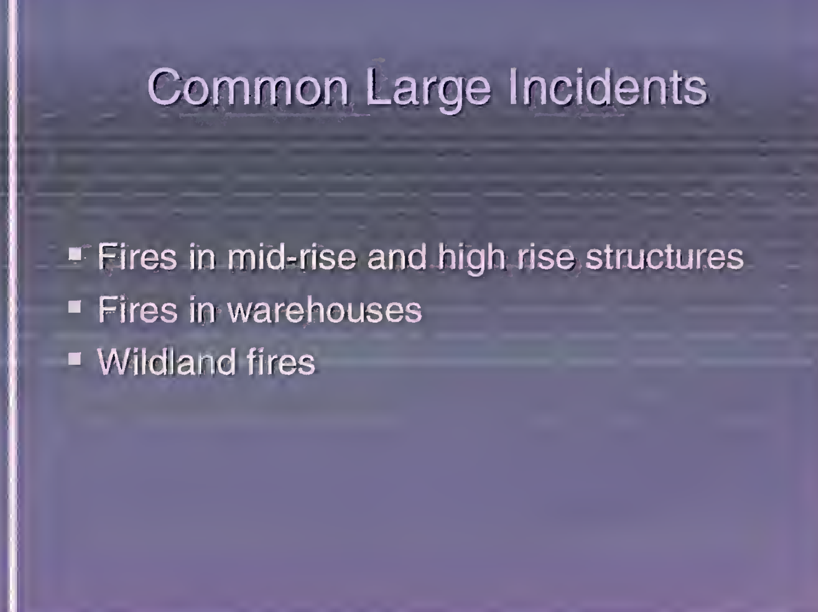
Summary

- Problem identification
- Testing
- Cooperation with DART
- Continued Testing
- Solution

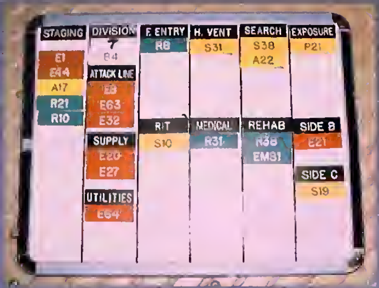
Presentation by Brian Anderson and Raymond Vaughan, - Miami Dade Fire Rescue







Challenges
Large and Complex Incidents

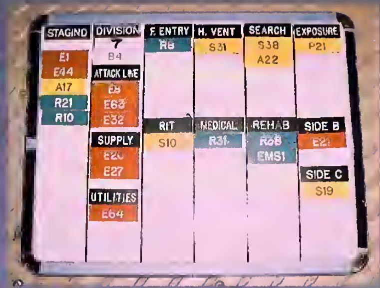


- Large organizational workload on first arriving units
- Time compressed
- Assigning units
- Tracking units
  - Location
  - Function

Improvements
Large and Complex Incidents

- Simple, integrated command board
  - Electronic version of magnetic command board
  - Easy to use
  - Separate tablet
- Command software
  - http://www.fieldsoft.com

Improvements
Large and Complex Incidents



- Low tech command boards

Challenges
Interoperability

- Time delay in set-up
- Communications procedures and style
- Unity of Command issues

Improvements in **Interoperability**

- Specialized communications units
- Large incident command vehicles
- Incident Command System
  - Unified Command
  - Liaison

Challenges **Large structures**

- Structural mass:
  - Blocks transmissions
  - Blocks reception
  - Degrades transmissions
- Utilization of building communications systems
  - Public Address
  - Phone system

Current solutions **Large structures**

- Structural mass:
  - Crew members transmit on Simplex
  - Relocate in structure
    - Random repositioning
    - Balcony
    - Open window

Current solutions **Large structures**

- Utilization of built-in systems
  - Public Address system useful
  - Phone systems are of limited use

Ideas for Large structures

- Utilization of built-in systems
  - Instructions posted on hardware.
  - Phone system modifications:
    - Speaker system
    - Speaker phone

Challenges Personal Gear

- Sound reduction caused by protective clothing

Challenges Personal Gear

- Manipulation of equipment

Improvements in Personal Gear and Hardware

- Large frequency selection knobs
- Push button volume control
- Mask-radio interface devices: voicemitters

Ideas for
Personal Gear and Hardware

- Bilateral PTT buttons on lapel microphones
- Lapel microphones that attach to mask
  - Less hardware
  - Less weight
  - Multifunction

High Rise Fire and Complex Incident Communication

Thomas Brennan

Battalion Chief

Los Angeles City Fire Department

Overview-Los Angeles

- Over 750 High Rise Structures
- Categorized Pre-1960, 1960-74, 1975 to present
- Different levels of fire protection, occupancy and complexity
- Resource intense incidents
- Multiple Communication Challenges

Communications

- When does incident communications *start*?
- When the first unit gets on scene?
- NO-It starts with the first telephone call to the communication center
- What is your comm. center?
  - Intelligence collection point
  - Lessen the burden of the Incident Commander

Comm. Center

Intelligence Gathering

Intelligence Gathering

- Situational awareness and damage assessments.
- This information can be used with search and rescue ops, fire suppression ops, police ops, etc.
- *Challenge*-How do you sort and prioritize varying assessments and *not* discount information that ultimately proved accurate?

11. H/S Evac Unk
10. H/S Trpd Rm 1004
9. H/S Trpd Rm 905
8. H/S Fire Rm 801 Evac
7. L/S Evac
6. L/S Evac
5. L/S
4. Clear
3. Clear
2. Clear
1. Clear

Communications-Global Picture

- Who does the Comm. Center pass the intelligence to?
- Incident Commander
  - Information Overload-Radio, Comm Center and face to face
  - Unified Command
  - Intelligence Officer-Who within unified command fulfills this position?

- 1,2,3-Div. Operations
- 4-Metro Rescue
- 5-Admin-FPB, AR
- 6-Emergency Trigger-*Mayday*
- 7-Metro Fire
- 8-Valley Fire/EMS
- 9-Alternate
- 10-EMS-City
- 11-Command
- 12-18 Tactical
- INTL, SP, Ver
  - 19-ICALL
  - 20-ITAC1
  - 21-ITAC2
  - 22-ITAC3
  - 23-ITAC4
  - FIREMARS
  - CLEMARS

Basic Functions

- Terminology
  - Fire Attack
  - Lobby Control
  - Staging-two floors below the fire
  - Base

First On Scene Resource

- Fire Attack
- Are they going to put a high rise fire or complex fire out?
- Reality
  - Point Person
  - Intelligence gathering
  - Determine scope and magnitude of incident
  - Fire Attack is now setting the logistical processes.

Questions

Contact Information

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Presentation by Chris Holloway – National Institute of Standards and Technology

Propagation and Detection of Signals Before, During, and After a Building Collapse

Christopher L. Holloway

G. Koepke, D. Camell, K. Remley, and D. William

Electromagnetics Division
National Institute of Standards and Technology (NIST)
U.S. Department of Commerce, Boulder Laboratories
Email: holloway@boulder.nist.gov, phone: 303-497-6184

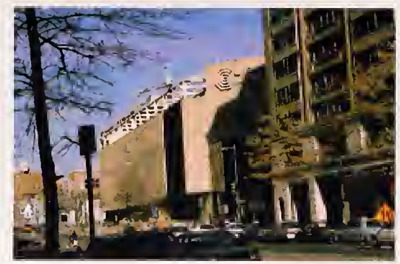
New Orleans Building Implosion

Implosions

Apartment Building

Sport Stadium

Convention Center



Acknowledgements

- Office of Law Enforcement Standards (OLES)
- Department of Home Security (DHS)
- Community Oriented Policing Services (COPS), a program through the Department of Justice
- Members of the Technical Staff of 818.02

NIST in the NEWS

Frequencies of Interest

- Public Safety Frequencies
- Cell phone Frequencies

Government Frequency Bands

- 49.60 MHz, 49.66 MHz, 49.72 MHz
- 162.00 MHz, 162.09 MHz, 162.485 MHz
- 226.0 MHz, 226.09 MHz, 226.65 MHz
- 448.6 MHz, 448.7 MHz, 448.8 MHz
- 902.0 MHz, 902.6 MHz
- 1832.5 MHz, 1832.6 MHz

Purpose of Research

In this project NIST will investigate communications problems for first-responders (firefighters and police) in large public buildings and in terrorist situations (i.e., collapsed building).

- Perform field study to investigate RF propagation issues associated with first responders in large public buildings.
- We will also be investigating various schemes for locating firefighters and civilians who may have portable radios or cell phones and are trapped in voids in the collapsed building.

Building Implosion: Why

1. We can simply cover transmitters with building debris
   - However, we would like to know how the propagation characteristics of transmitters change once a building collapses
2. Load Building with transmitter before implosion
   - Can now investigate propagation characteristics of transmitter before, during, and after a building collapse

Once I had the idea of performing measurements in a building scheduled for implosion, I contacted a few implosion companies.

It was very surprising how willing the implosion companies were to allow us to work with them.

Transmitter Requirements

- Survive a collapsing building
- Self contained power source

Galen came up with the following

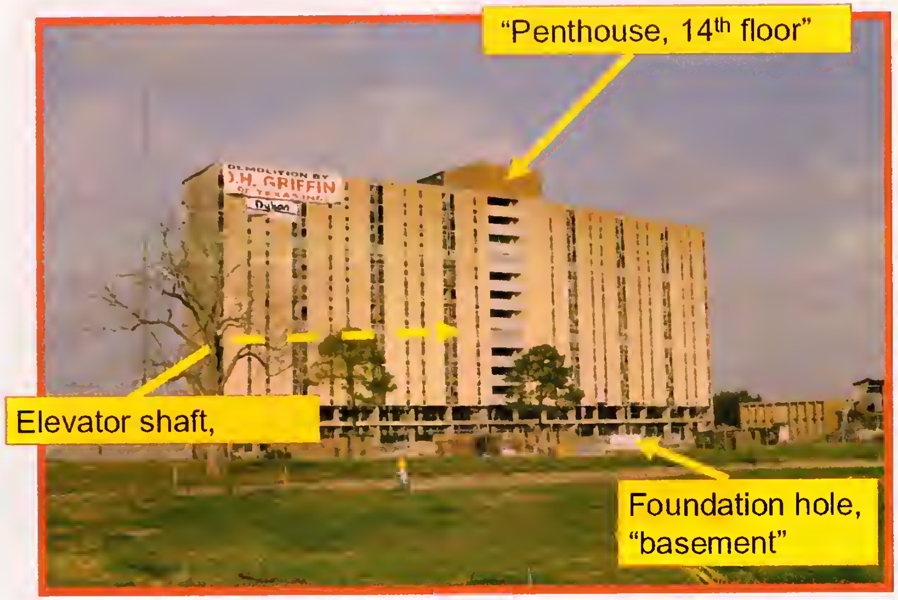
Measurement System

Pre-Blast Measurement Sites: Fixed and Portable

Pre-Blast Work

- Determining transmitter locations for blast today
- Performing initial propagation measurements
- De-bugging all three systems
- Installing anchor bolts for transmitters
- Digging holes for transmitters
- Installing pipes and cables

Back side of the building – prepared for implosion



Location 1: Elevator Control Room

Location 3: 3rd Floor Elevator

Location 3: Hole in Ground Floor

Location 1: Prep and Final Set-Up

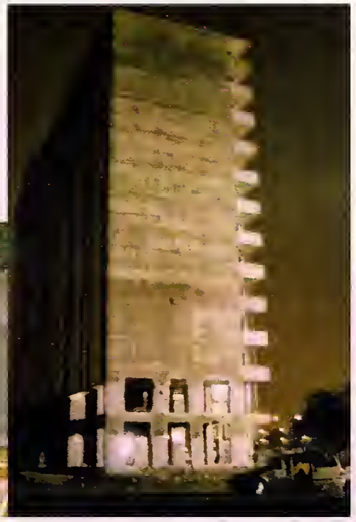
Location 2: Prep and Final Set-Up

Location 3: Prep Hole

Location 3: Prep and Final Set-Up

Photos from Pre-Blast Measurements

Photos from Morning of the Blast

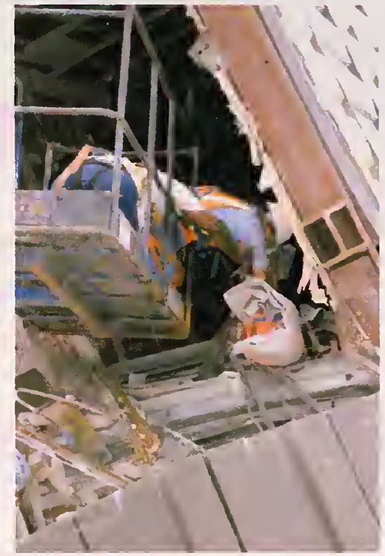


Building Implosion: Video

Before and After

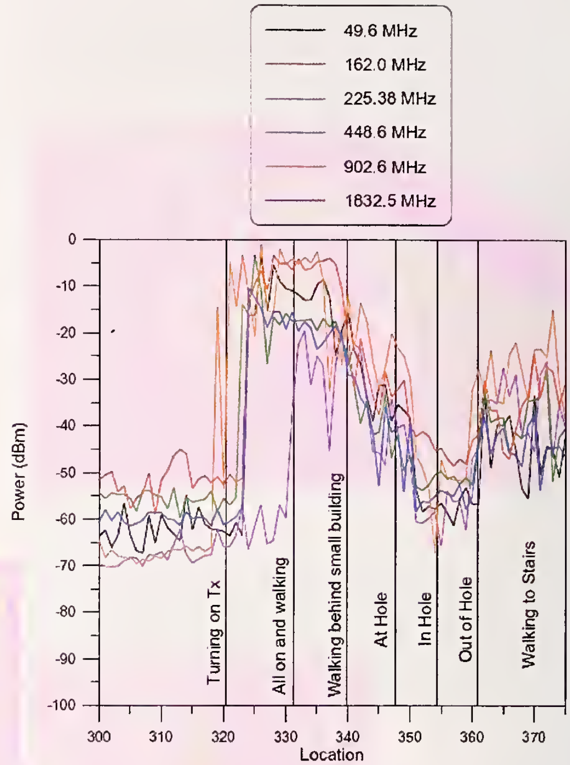
Photos from Post-Blast Measurements

Photos form Transmitter Recovery



Pre-Blast Propagation Data

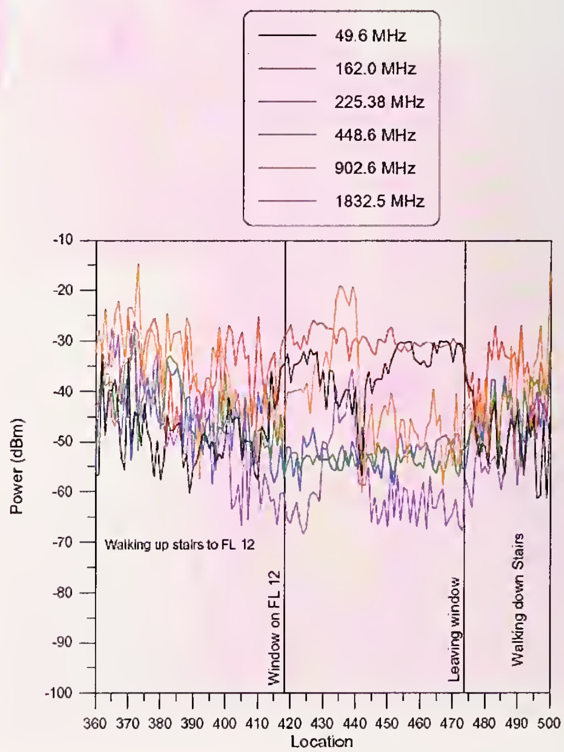
Friday 1-23-04: Rx at manhole



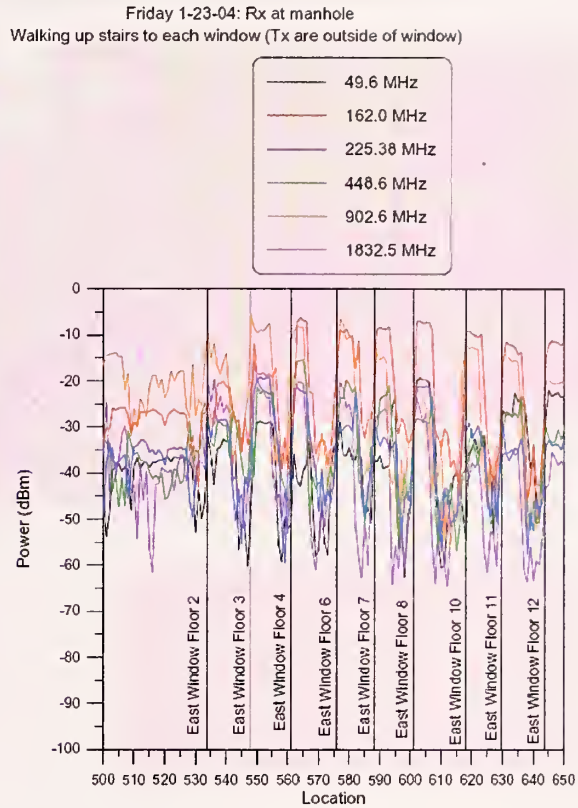
Pre-Data: Stairs

Friday 1-23-04: Rx at manhole

Walking up/down stairs



Pre-Data: Windows



Summary of Building Walk-Through

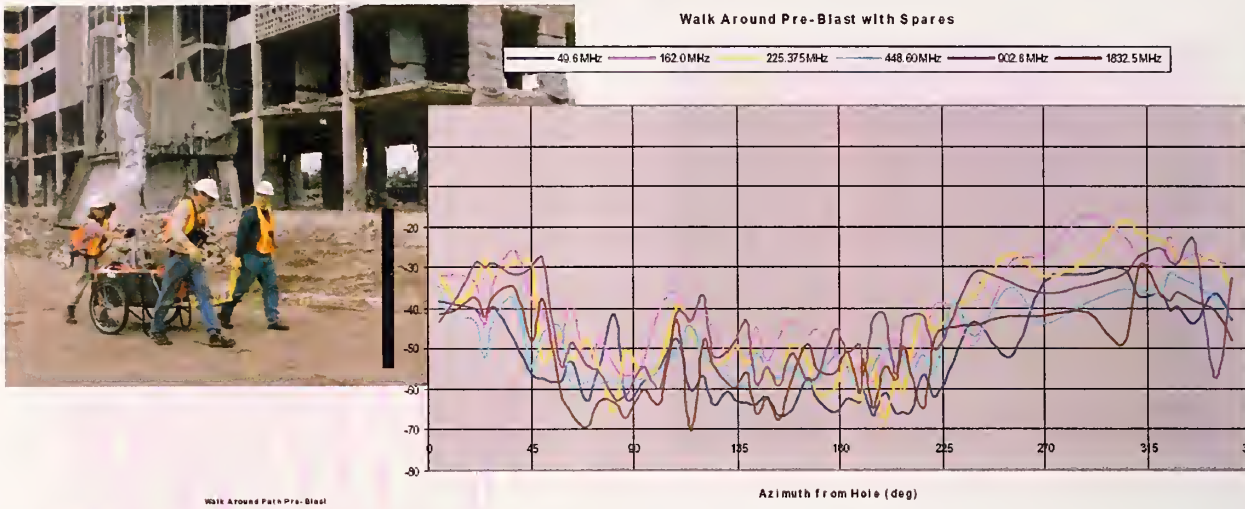
Table 7: Mean and Standard Deviation of the Received Signal Strengths for Transmitters Located in the Building with Windows in LOS

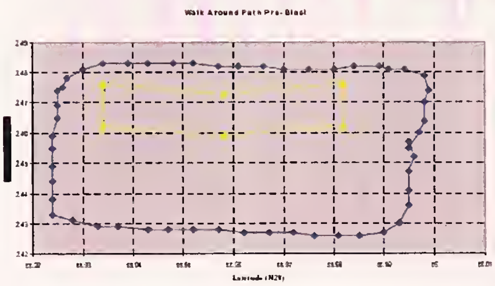
Frequency (MHz)	Mean (dB)	Standard Deviation (dB)
49.6	-35.0	10.2
162.0	-21.6	10.4
225.375	-26.9	8.9
448.6	-32.5	9.3
902.6	-24.6	12.4
1832.5	-28.4	12.5

Table 9: Mean and Standard Deviation of the Received Signal Strengths for Transmitters Carried throughout Building without Window Stops

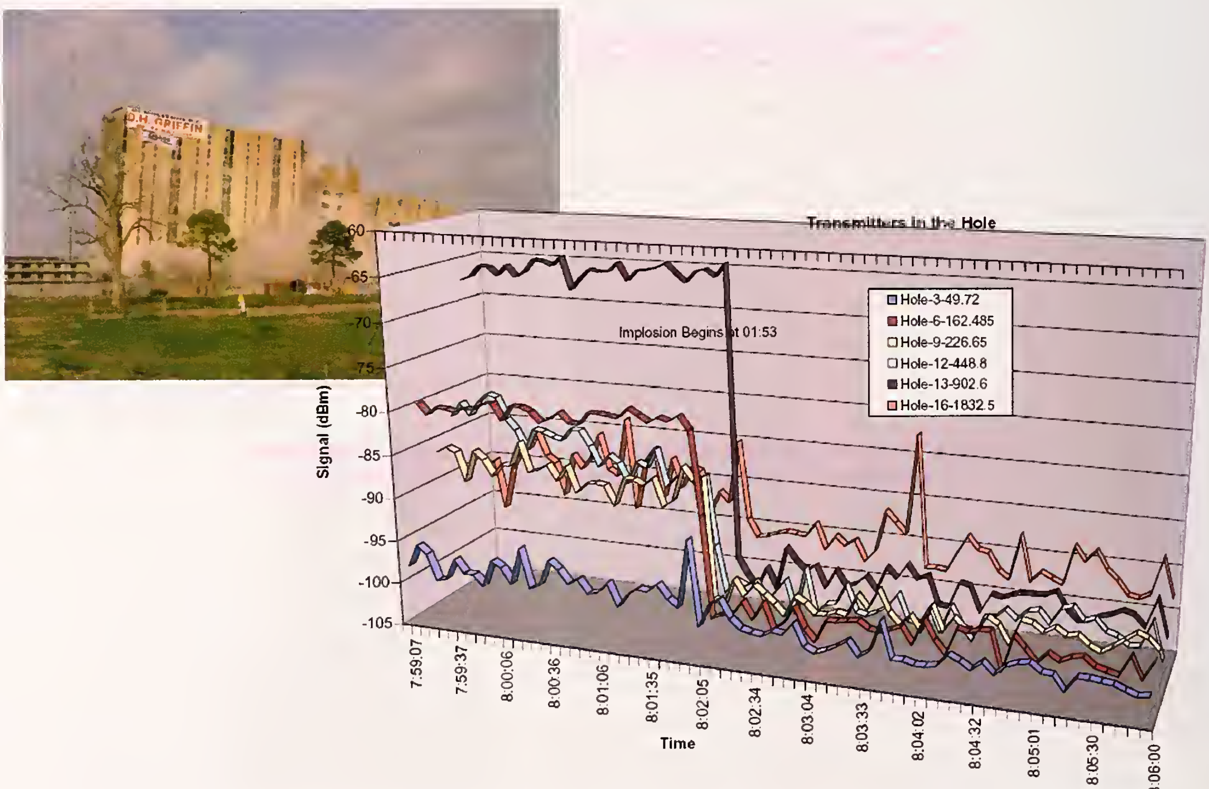
Frequency (MHz)	Mean (dB)	Standard Deviation (dB)
49.6	-49.1	8.6
162.0	-38.9	6.8
225.375	-41.4	6.8
448.6	-45.7	5.9
902.6	-42.3	10.5
1832.5	-43.5	10.8

Pre-Data: Data From Walking Cart

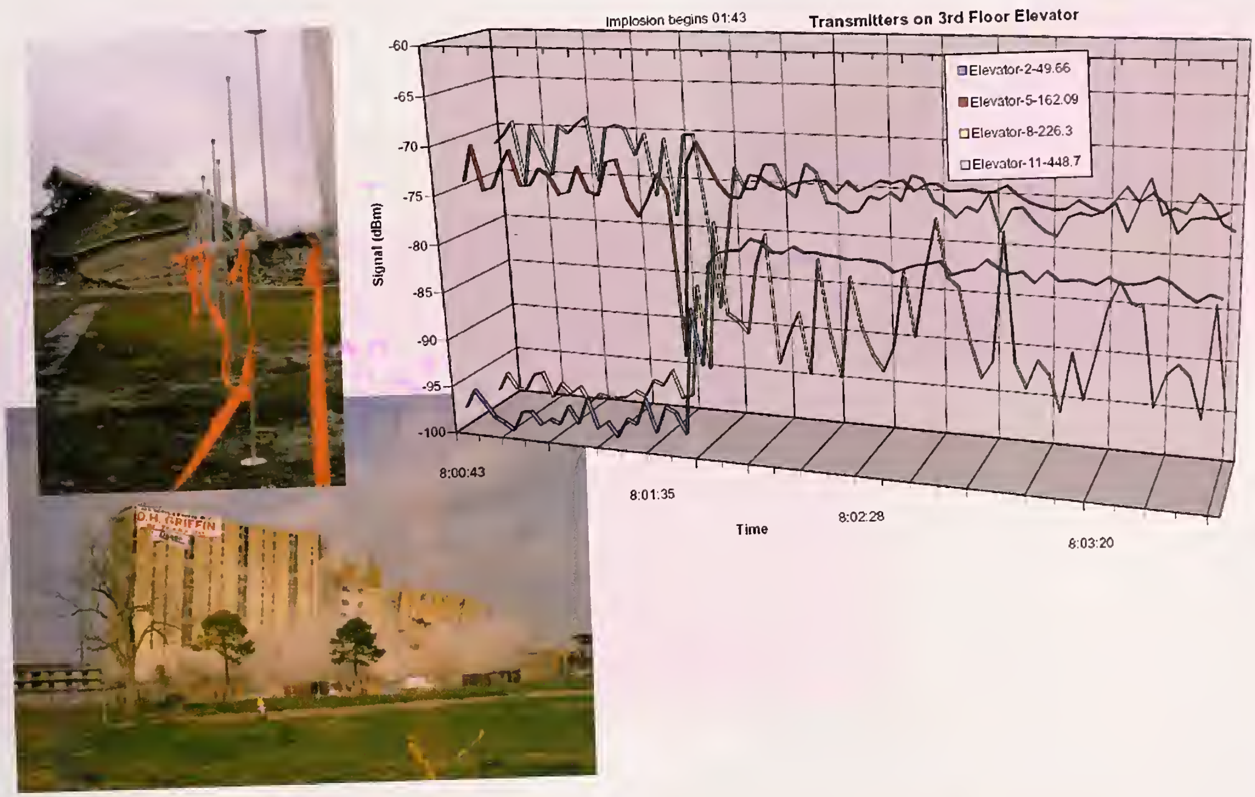




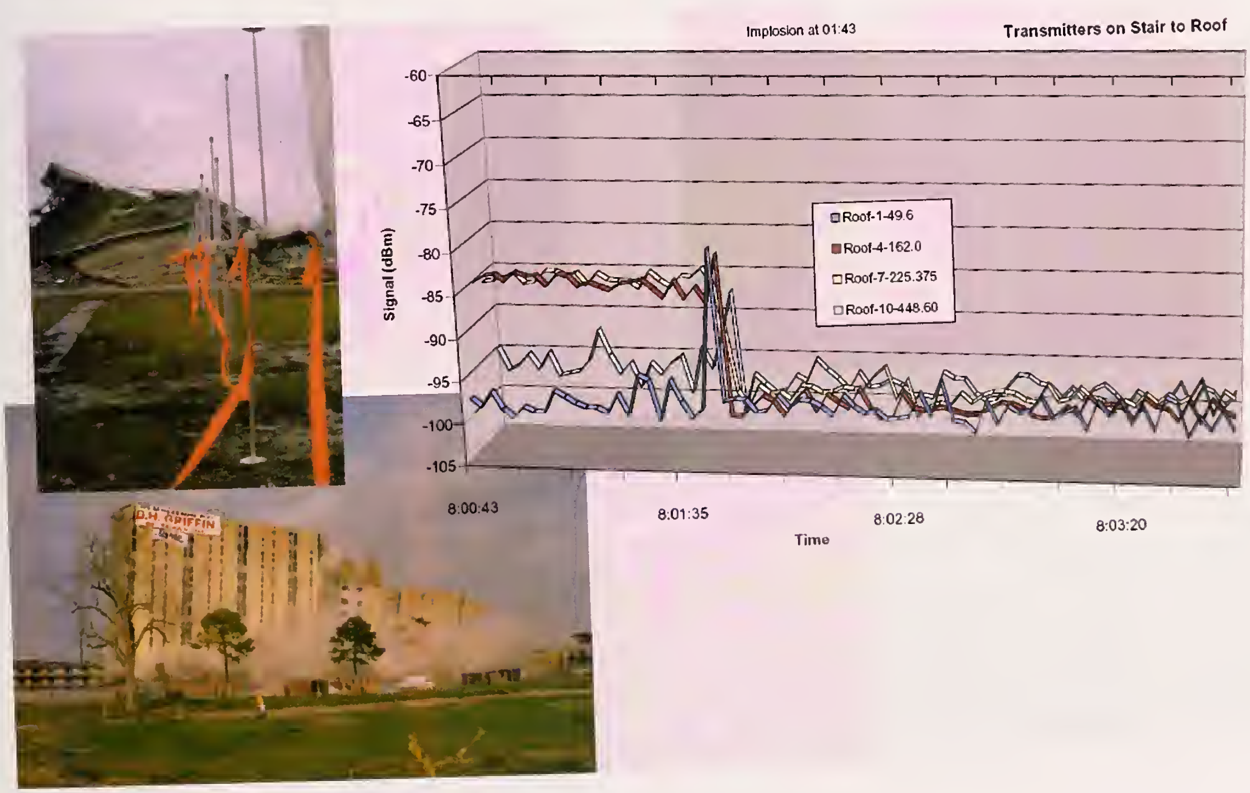
Blast Data: NIST Van (Tx in Hole)



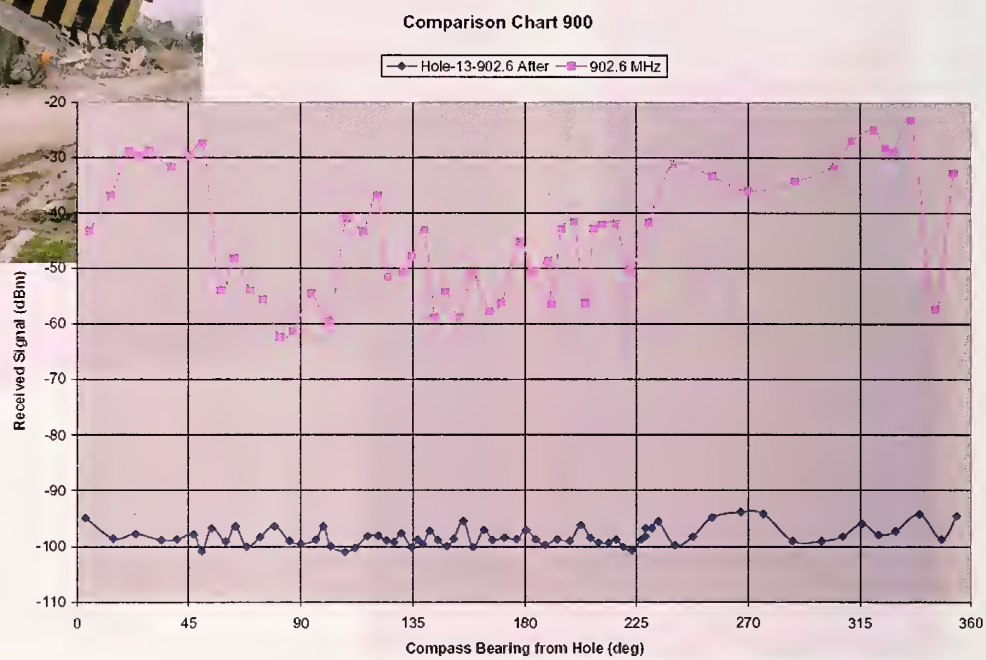
Blast Data: Unmanned Site (Tx in Elevator)



Blast Data: Unmanned Site (Tx in Roof)



Blast Data: Walk Around with Cart

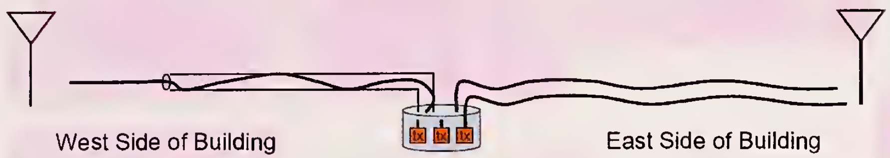


Post Blast: Conductive Measurements

Veteran's Stadium

Debris Radiator Experiment

Can we use conduit or cables to improve reception compared to directional antenna?



West Side of Building

	Antenna	Cable
Pre-Blast	-28 dBm	-34 dBm
Post Blast	-100 dBm	-104 dBm

East Side of Building

	Antenna	Cable
Pre-Blast	-35 dBm	-58 dBm
Post Blast	-94 dBm	noise

Preliminary Results Show:

1) Antenna and cable comparable in controlled situation (cable protected by pipe)

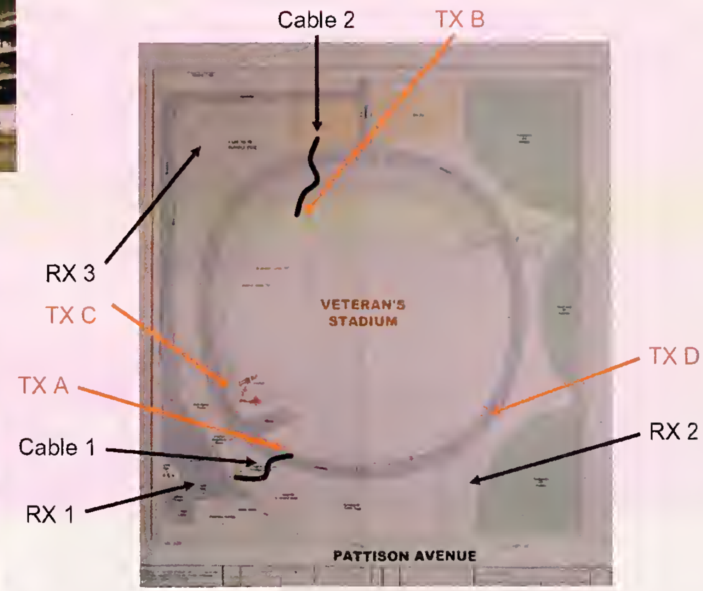
2) Attenuation due to debris 60-70 dB for antenna, 70 dB or more for cable

3) Detection of weaker signals would be of benefit

Results shown here are for 162 MHz. Similar results for 225 MHz. 450 MHz had lower levels.

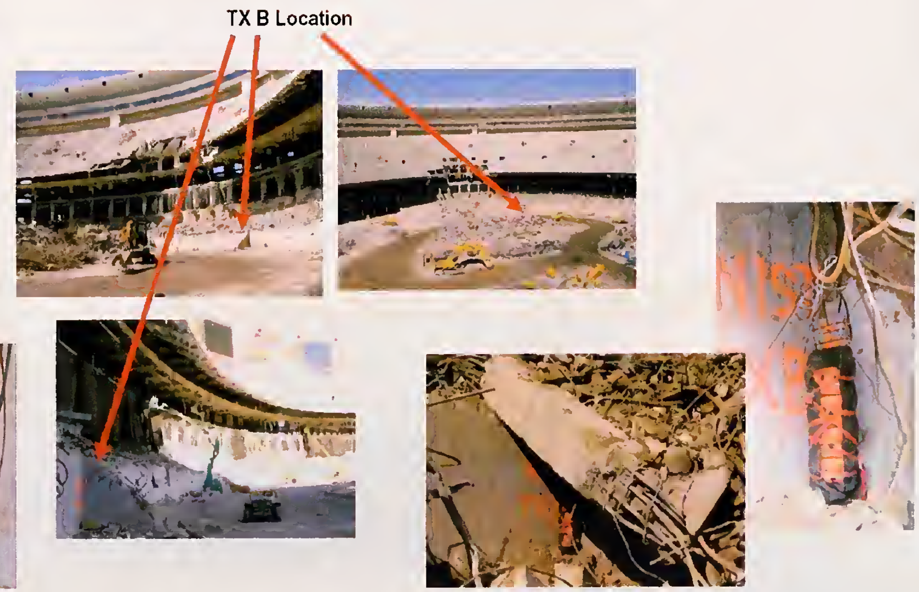
Veteran's Stadium

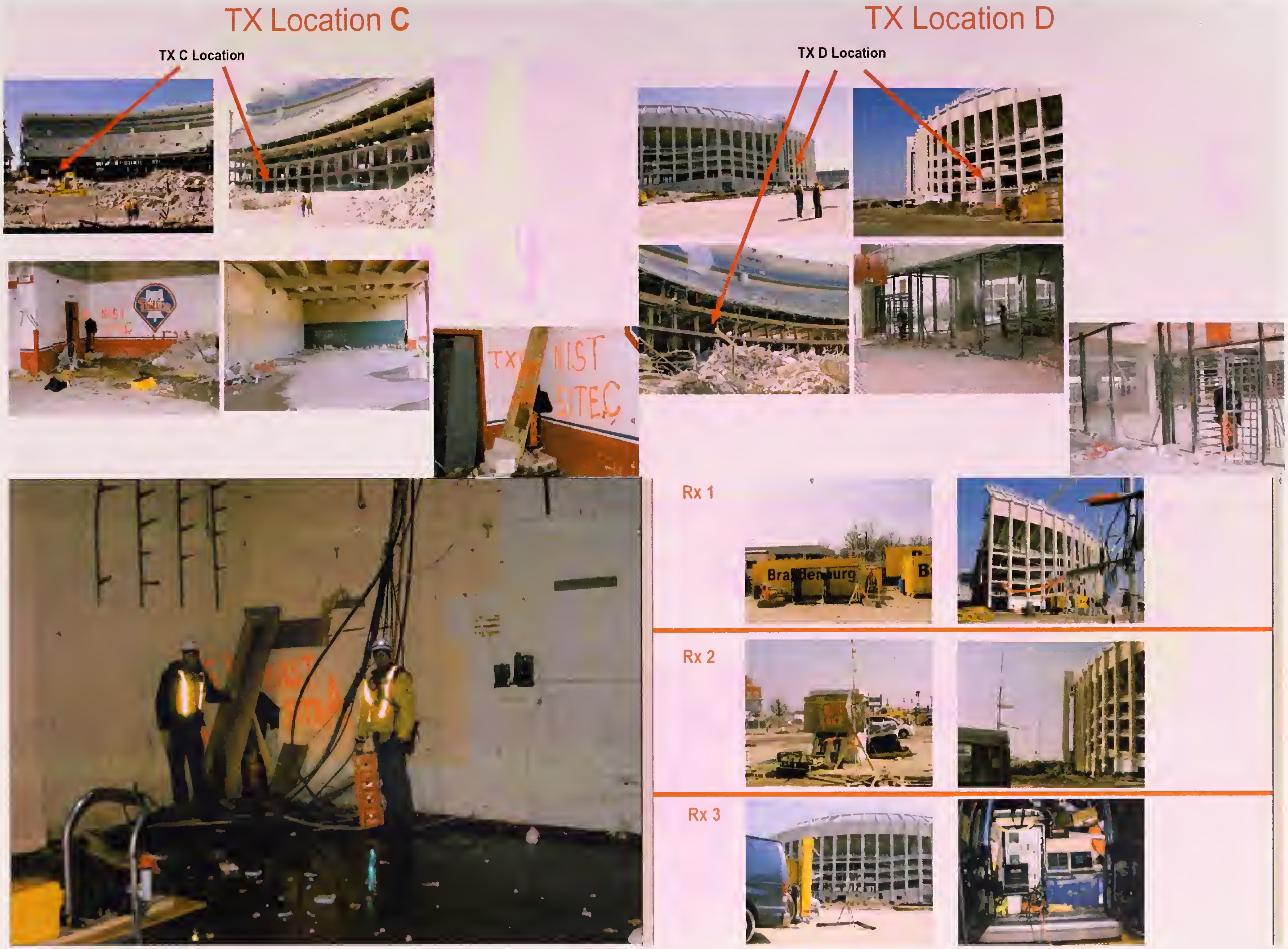
Transmitter Locations



TX Location A

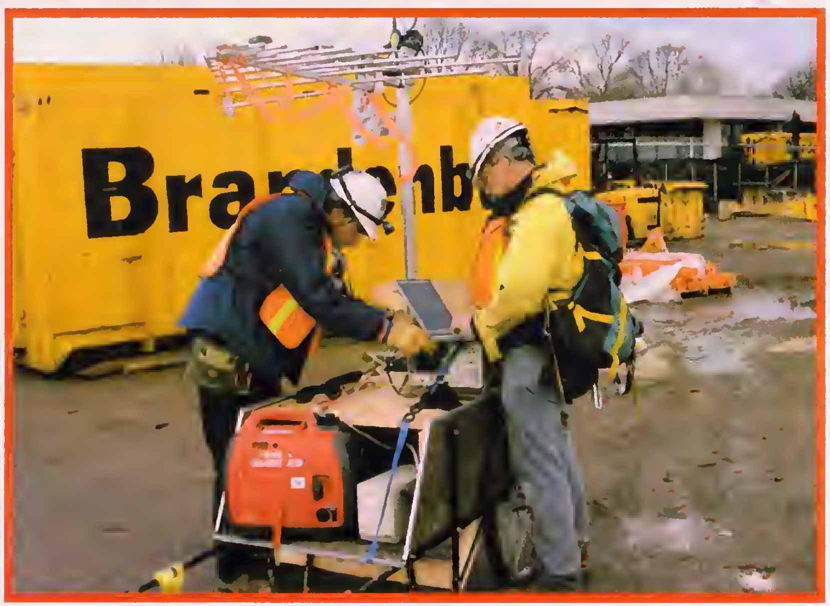
TX Location B





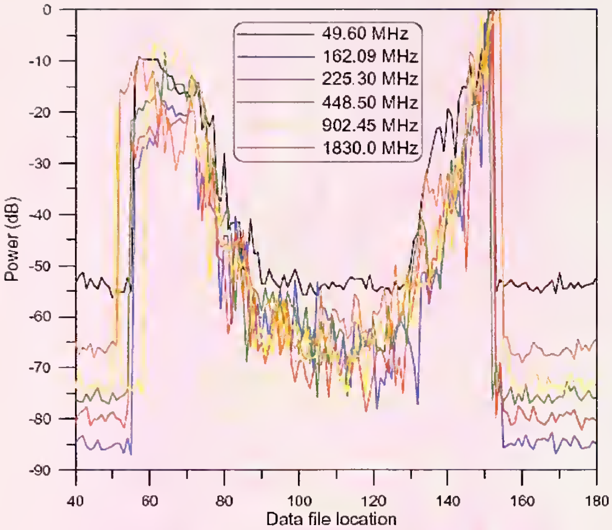
TX Location C
TX C Location
TX Location D
TX D Location
TX NIST SITE C
Rx 1
Rx 2
Rx 3

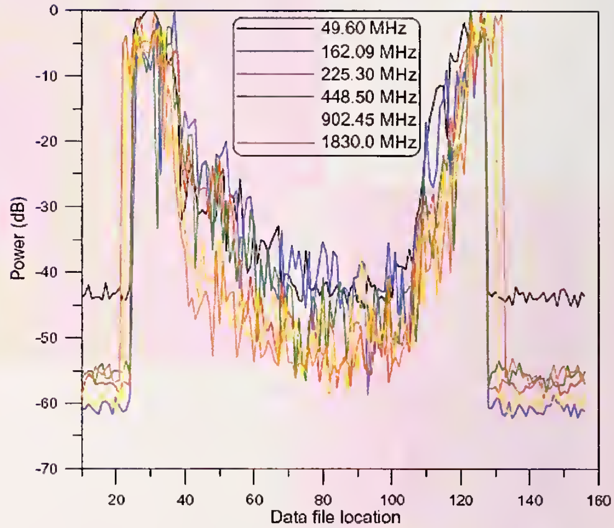

6487



Mobile cart: antenna, generator, UPS, laptop & spectrum analyzer

Stadium perimeter walk

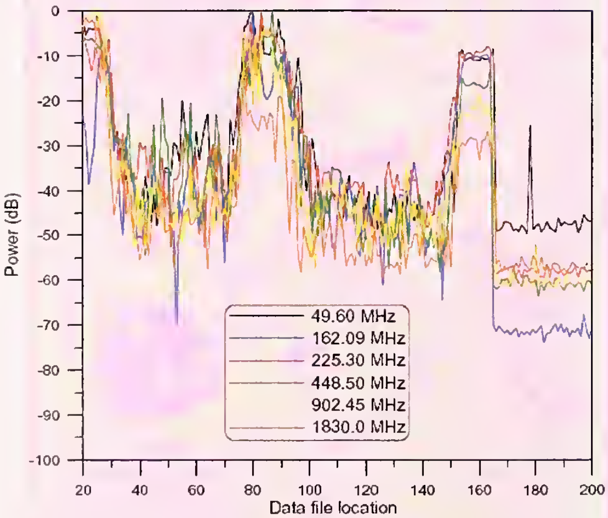




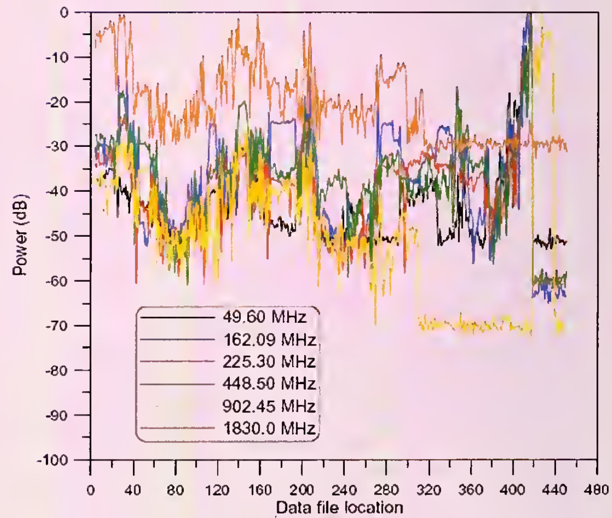
60 to 70 dB of attenuation

Stadium walk-through

Inside



Playing field



50 to 60 dB of attenuation

Histograms

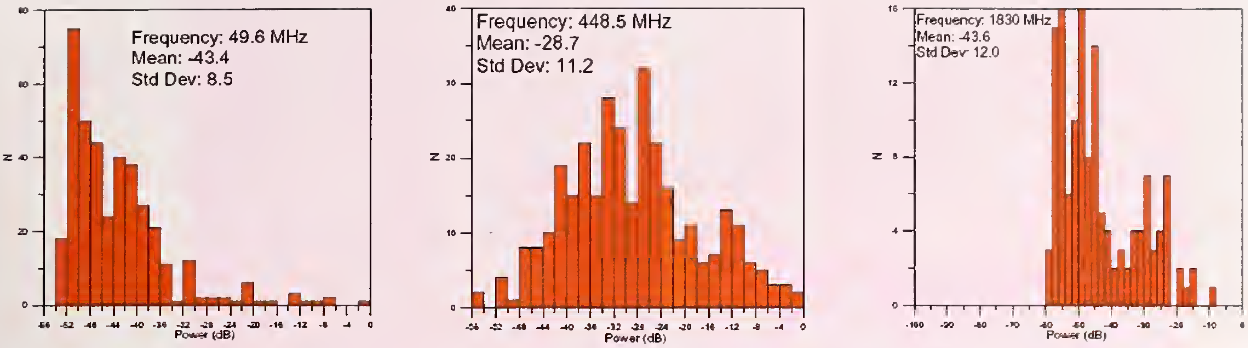
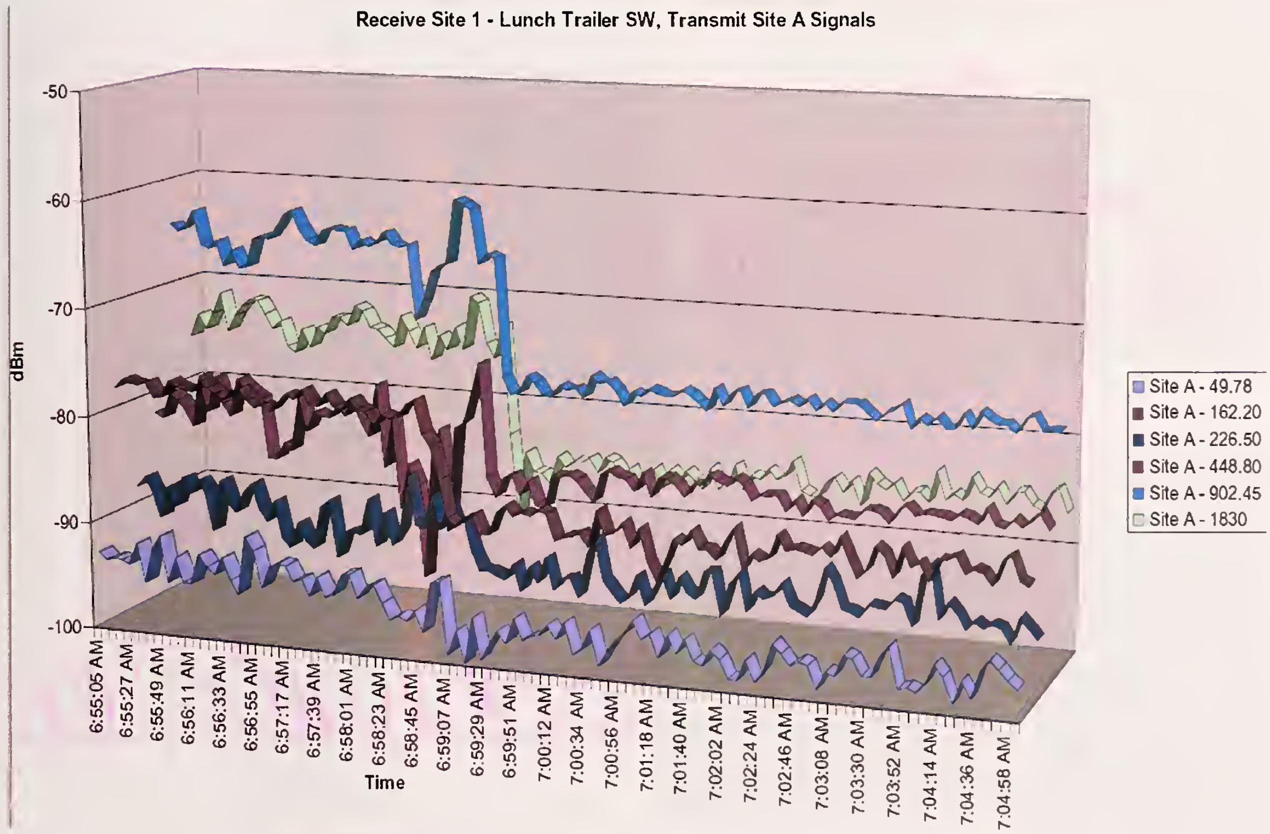
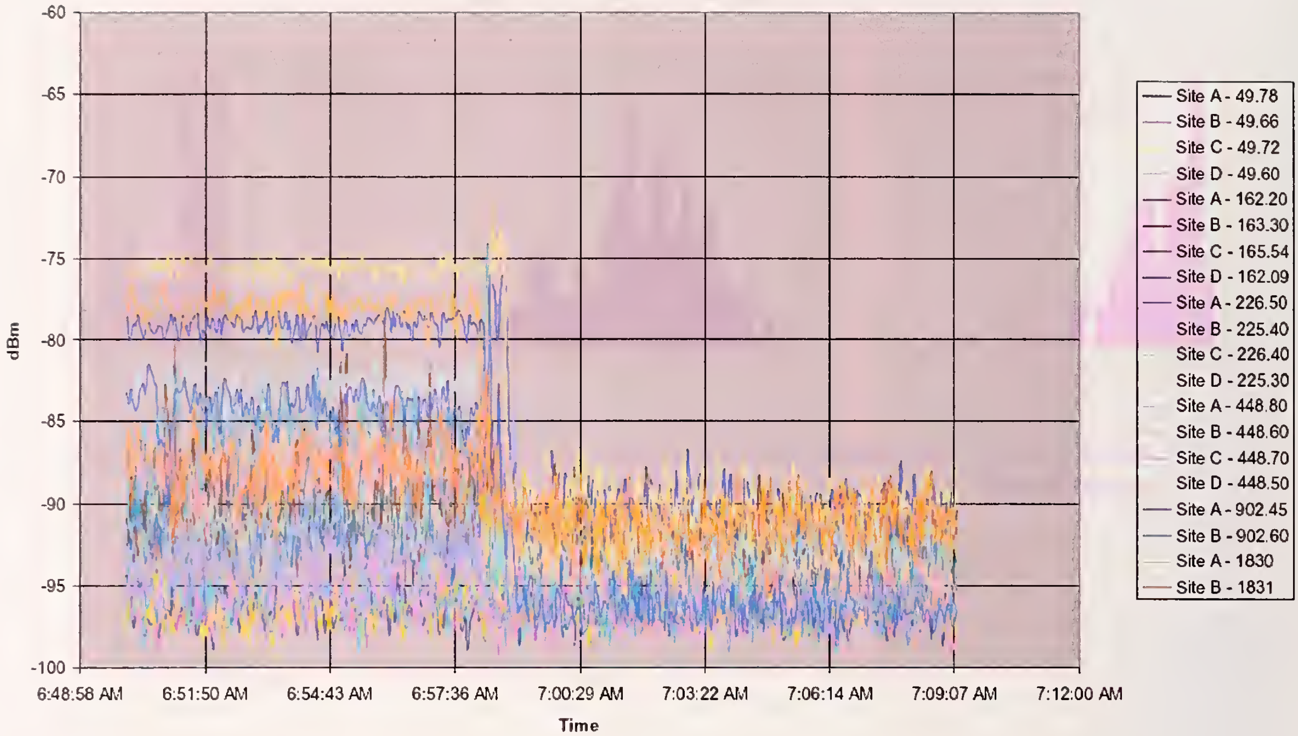


Table 8. Mean and standard deviation of the received signal strengths for the upper level measurements for horizontally polarized receiving antennas.

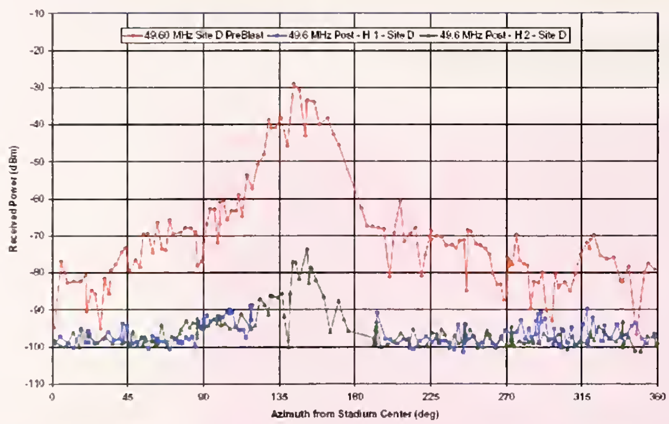
Frequency (MHz)	Mean (dB)	Standard deviation (dB)
49.60	–30.6	15.0
162.09	–34.4	15.2
225.30	–30.0	13.9
448.50	–33.5	14.4
902.45	–37.2	13.8
1830.00	–43.6	12.0

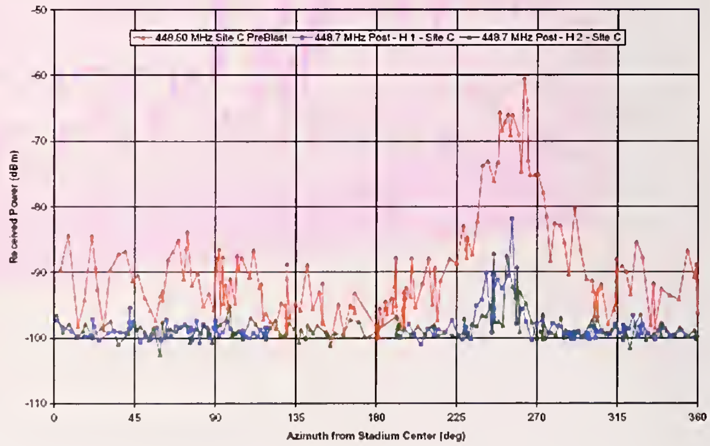


Site 3 - Crusher NW



Comparison of pre- and post-implosion mobile cart perimeter measurements





Washington DC Convention Center

Washington DC Convention Center


TX 3 Location
TX 4 Location
NIST
Xmtr4
Rx 1
Rx 2
Rx 3

Resulted in a partially collapsed structure

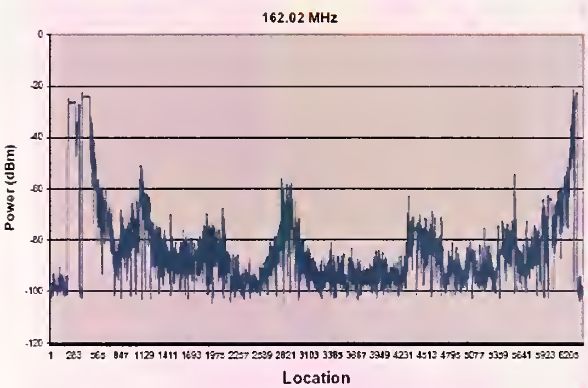
Resulted in a partially collapsed structure

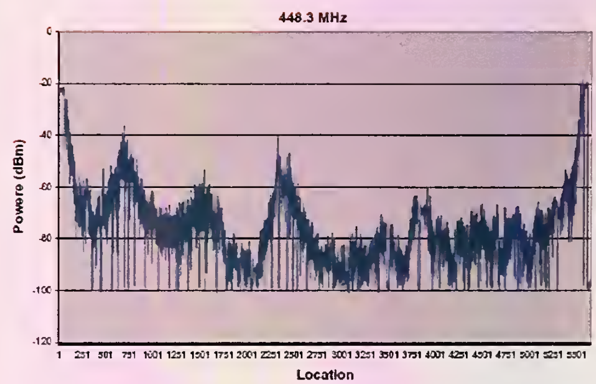
Cart Measurements

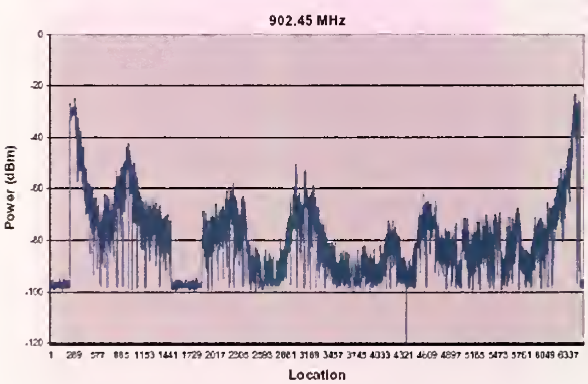
Pre-Measurements

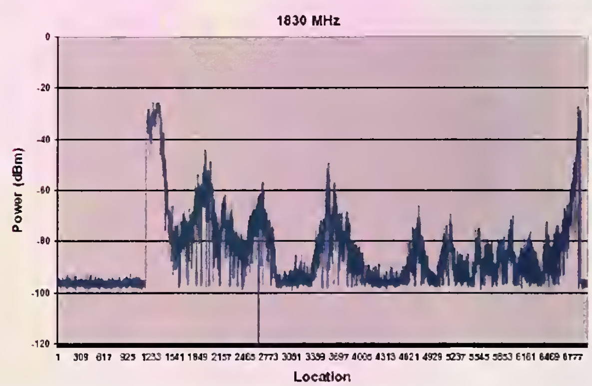
Post-Measurements

Walk-Through Measurements



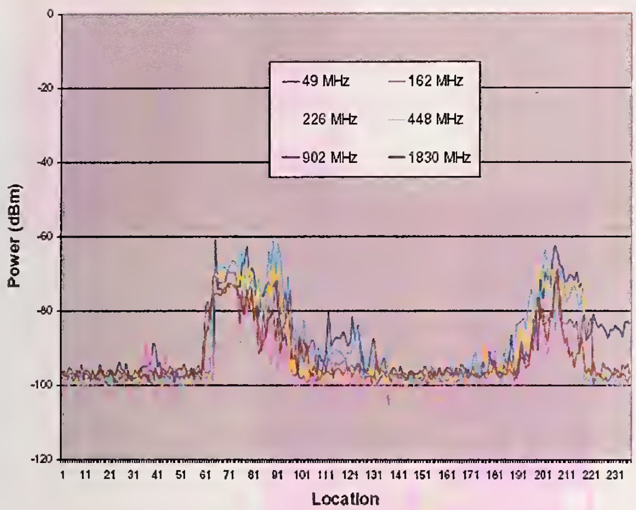




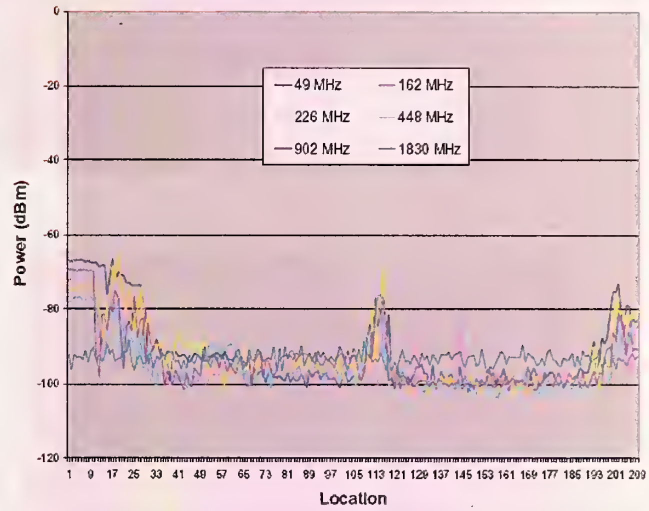


Pre- and Post-Cart Measurements

Pre: Tx 2 location



Post: Tx 2 location



Summary of Implosion Measurements

Apartment Building

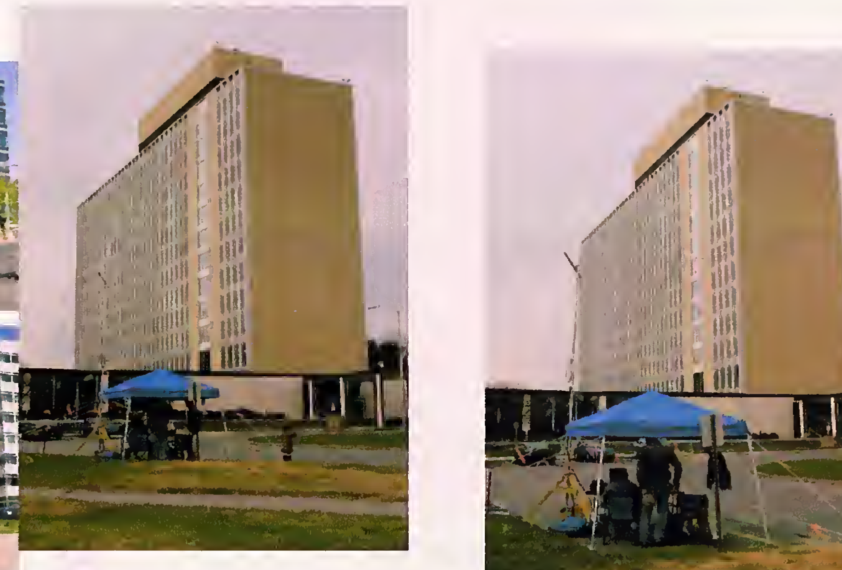
- The mean signal attenuation for a wide range of locations throughout the standing building ranged from 25 to 50 dB.
- The standard deviation ranged from 6 to 14 dB, depending on frequency.
- Some signals experienced large amounts of attenuation, while other signals increased after the implosion, depending on whether the transmitters ended up on top of the debris pile or buried beneath building rubble.
- Large amounts of building rubble caused at least 60 to 80 dB of signal attenuation. The true attenuation was not established since we measured only noise.

Sport Stadium

- Maximum signal attenuation on the order of 75 dB was observed by just moving the transmitters around the outside perimeter of the stadium while monitoring signals at external receive sites.
- The mean signal attenuation for a wide range of transmitter locations located in the interior of the standing stadium to an external receive site ranged from 25 to 50 dB.
- The standard deviation for the standing-building propagation measurements ranged from 6 to 14 dB, depending on frequency.
- Some signals experienced large amounts of attenuation (some greater than 80 dB, at the noise floor of our receivers), while other signals increased during the implosion (up to 20 dB), depending on the receiving site and location of the transmitter cache.
- Large amounts of building rubble caused at least 30 to 50 dB of signal attenuation. The true attenuation was not established in several cases since we measured only noise.

Other Structures

- NIST Building

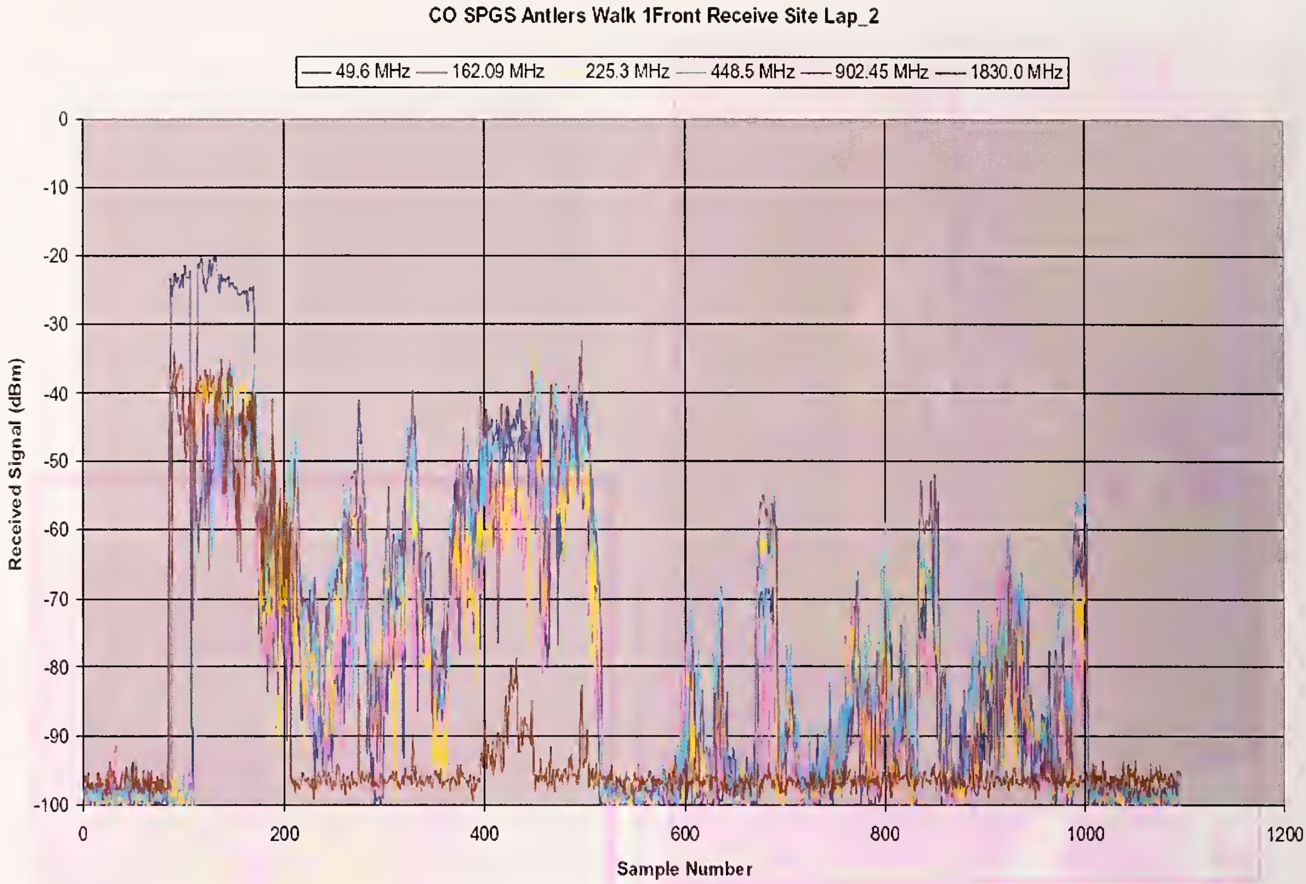


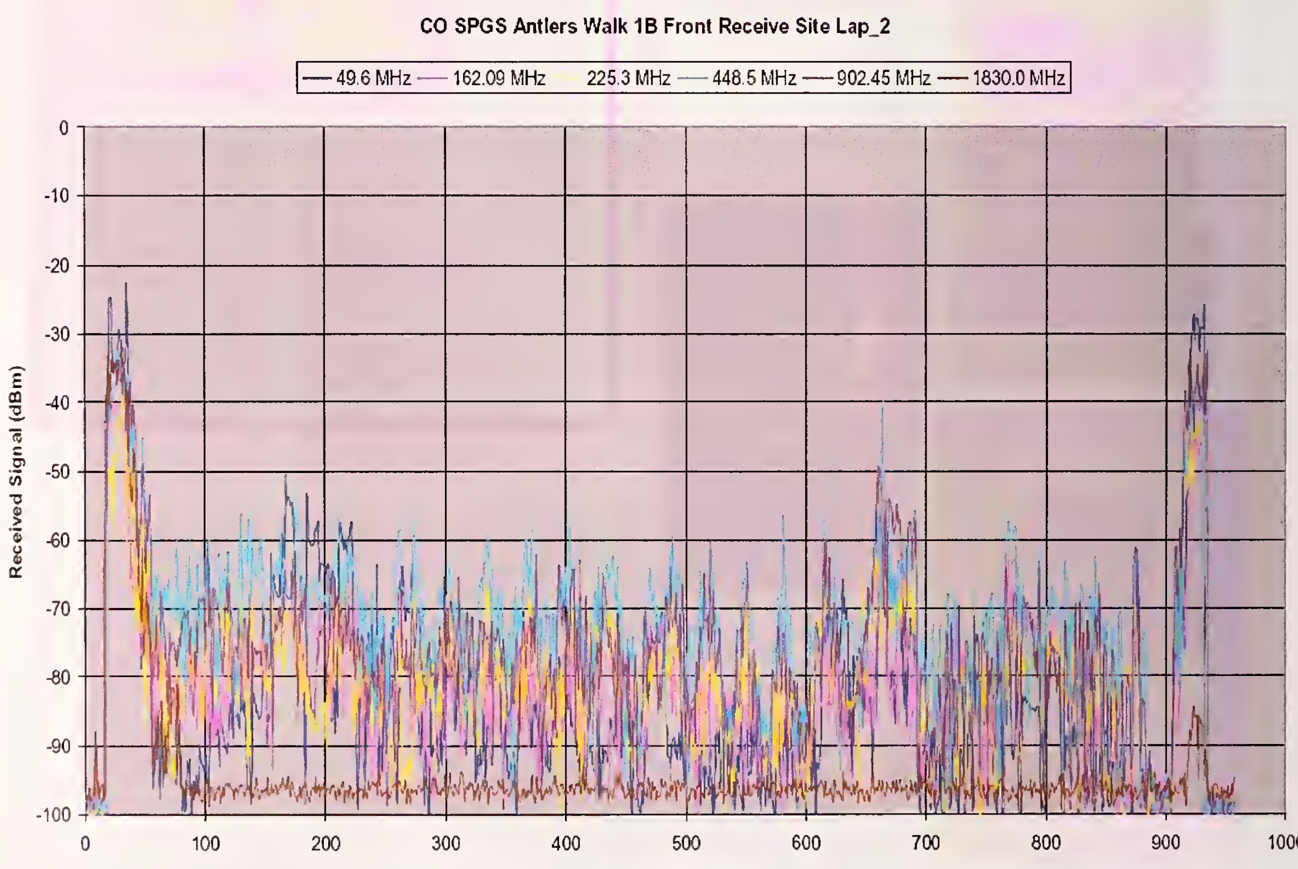
King Soopers: Boulder, CO

Mall

Discovery

Colorado Springs, Adams Mark Simulation of Hotel Emergency


CO SPGS Antlers Walk 1Front Receive Site Lap_2
49.6 MHz
162.09 MHz
225.3 MHz
448.5 MHz
902.45 MHz
1830.0 MHz
Received Signal (dBm)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0
200
400
600
800
1000
1200
Sample Number


CO SPGS Antlers Walk 1B Front Receive Site Lap_2
49.6 MHz
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Received Signal (dBm)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0
100
200
300
400
500
600
700
800
900
1000
Sample Number

Boulder County Wildfire, Firefighter Communications

The Next Building Experiment?

Acknowledgements

- Office of Law Enforcement Standards (OLES)
- Community Oriented Policing Services (COPS), a program through the Department of Justice
- Members of the Technical Staff of 818.02

Presentation by Stu Overby, - National Public Safety Telecommunications Council

Communications for In-Building and the Incident Scene

Stu Overby

Chair, NPSTC In-Building WG

Chair, IBWA WG

Director, Global Spectrum Strategy, Motorola

June 20, 2006 Gaithersburg, MD NIST High-Rise Emergency Communications Workshop

NPSTC

- National Public Safety Telecommunications Council In-Building Working Group Formed March '06

  Mission: To promote the availability of affordable in building and in-tunnel communications in ways that do not interfere with critical operations and to serve as the NPSTC liaison with other entities addressing in-building or in-tunnel communications.

- Action Underway: Developing Best Practices to Minimize Interference from In-Building BDAs

  http://www.npstc.org/documents/conference/Dekolink%20NPSTC%20Presentation-public.pdf

BDA: Bi-Directional Amplifiers, i.e., Signal Boosters

June 20, 2006 Gaithersburg, MD NIST High-Rise Emergency Communications Workshop

BDA Installation and Implementation

Case Study: Tier 1 PCS operator, NYC

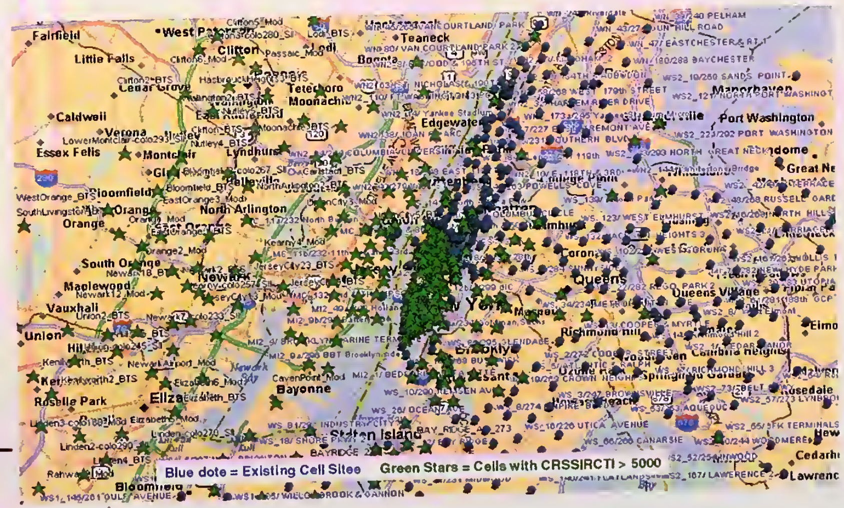
- Carrier's customer improperly self installed system
- Donor antenna and coverage antenna too close resulting in not enough isolation
- System Oscillated causing spurious emissions
- One single RF carrier affected
- 200 base stations interrupted
- **250,000 calls dropped**
- Subset of calls were 911

Courtesy Dekolink, Americas, Inc.

June 20, 2006 Gaithersburg, MD NIST High-Rise Emergency Communications Workshop

Impacted Cell Sites

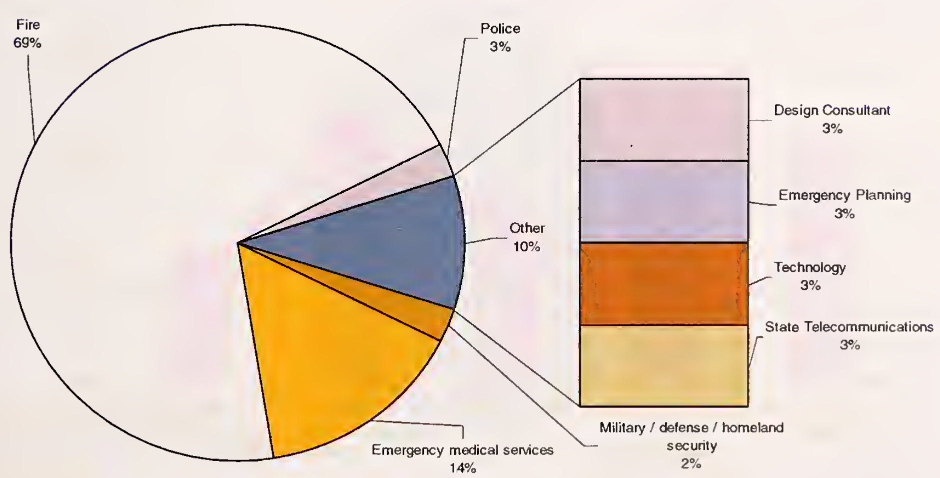
Courtesy Dekolink, Americas, Inc.



IBW Alliance
Stay Connected. Everywhere.

- In-Building Wireless Alliance: An Industry Group Promoting Improved In-Building Communications
- Focus is primarily commercial multi-tenant buildings
- Led by PRTM Consulting; includes real estate interests, communications carriers & manufacturers
- Participate in IBWA Public Safety requirements survey:
  - http://www.pmgbenchmarking.com/public/survey/surveyintro.asp?SID=218&bReg=0&bTool=0
- IBWA developing several in-building pilot tests incl. both commercial and public safety communications

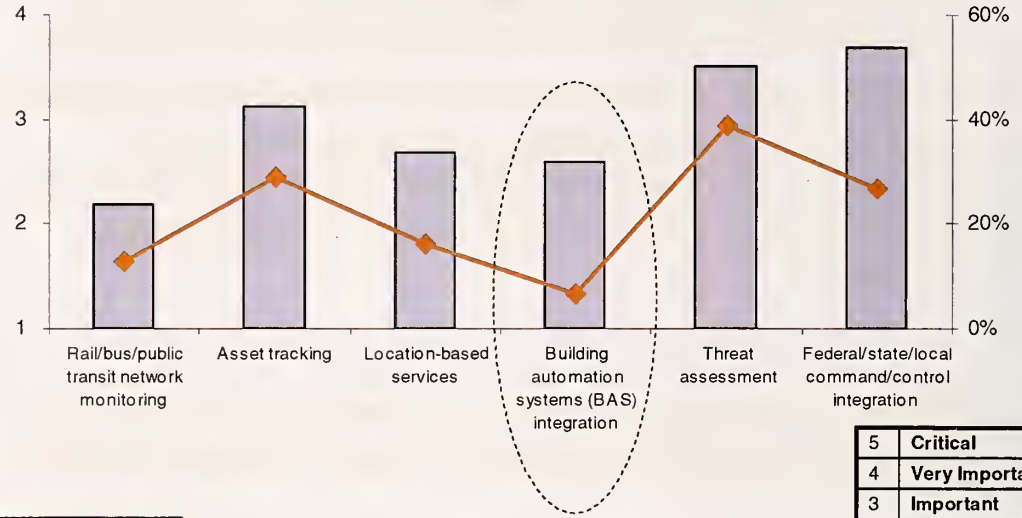
Preliminary Responses to the IBWA In-building Survey



Courtesy, IBWA

Preliminary IBWA In-Building Public Safety Survey Results

Please Indicate How Important the Following Applications or Services Are to Your Entity and % having the capability



5	**Critical**
4	**Very Important**
3	**Important**
2	**Somewhat Important**
1	**Not Important**

Courtesy, IBWA

June 20, 2006 Gaithersburg, MD   NIST High-Rise Emergency Communications Workshop

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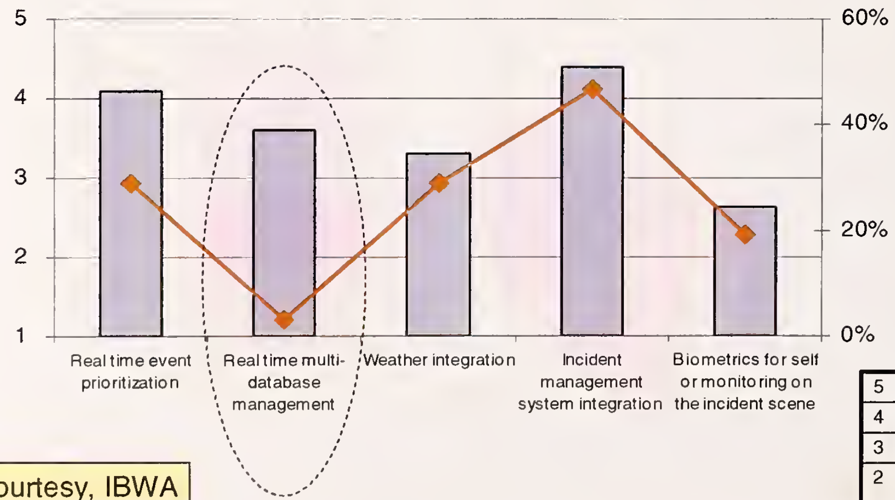

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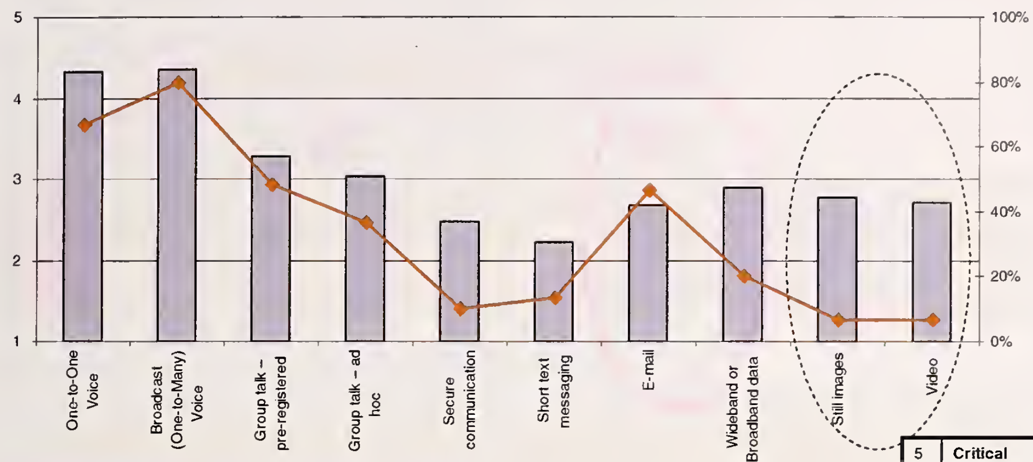


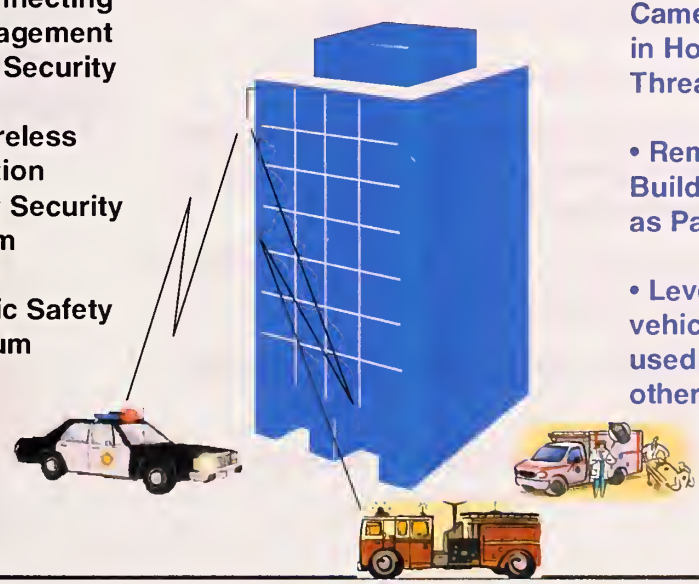
5	Critical
4	Very Important
3	Important
2	Somewhat Important
1	Not Important

Courtesy, IBWA

Potential Technology Tools Examination by National Sheriff's Association Crime Prevention & Private Security Committee

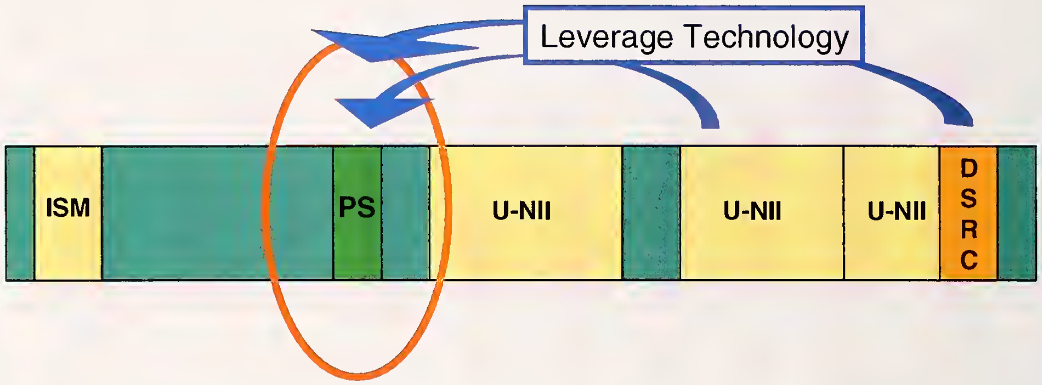
Example: Connecting Incident Management with Building Security

Secure Wireless Connection To In-Building Security System via 4.9 GHz Public Safety Spectrum



- Access Building Cameras & Sensors in Hostage or Bomb Threat Incidents
- Remotely Control Building Functions as Part of Response
- Leverage 4.9 vehicle equipment used for access to other PS hotspots
- Over 700 agencies have 4.9 GHz licenses

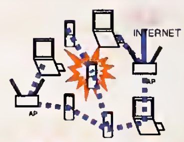
4.9 GHz Band: 50 MHz of Broadband Spectrum Dedicated to Public Safety

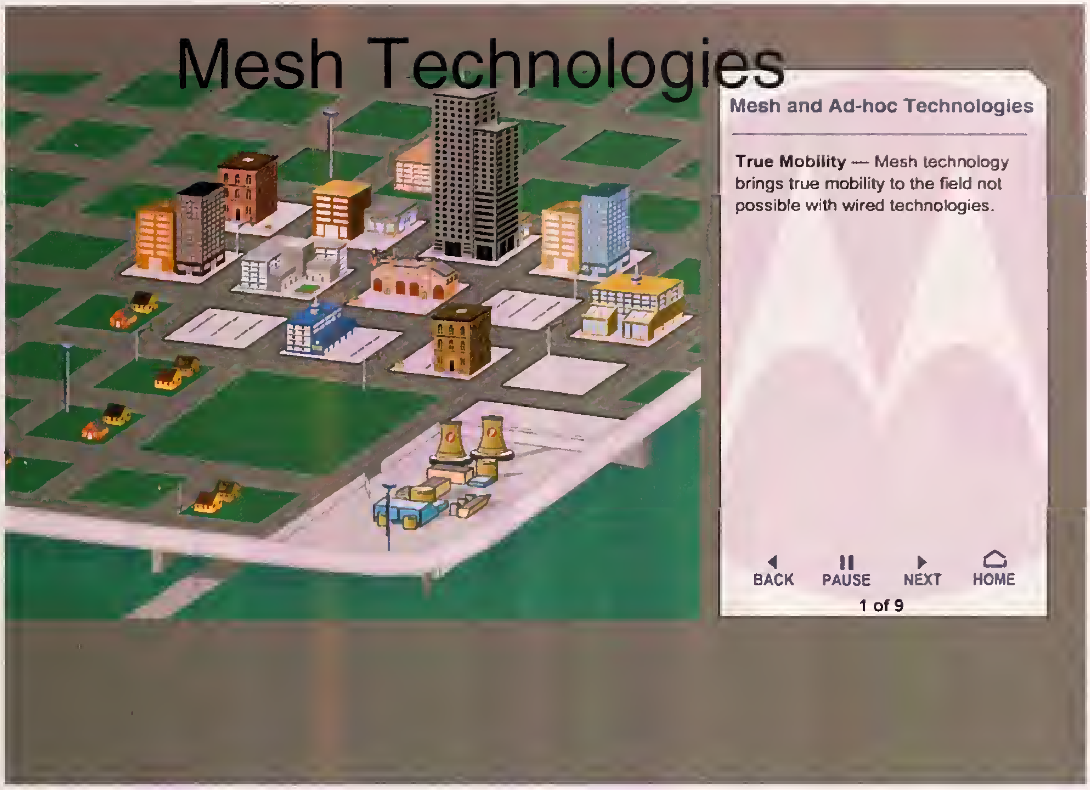


PS - Public Safety Licensed Spectrum: 50 MHz of dedicated spectrum
UNLI - Unlicensed Broadband Spectrum
DSRC - Digital Short Range Communications Spectrum

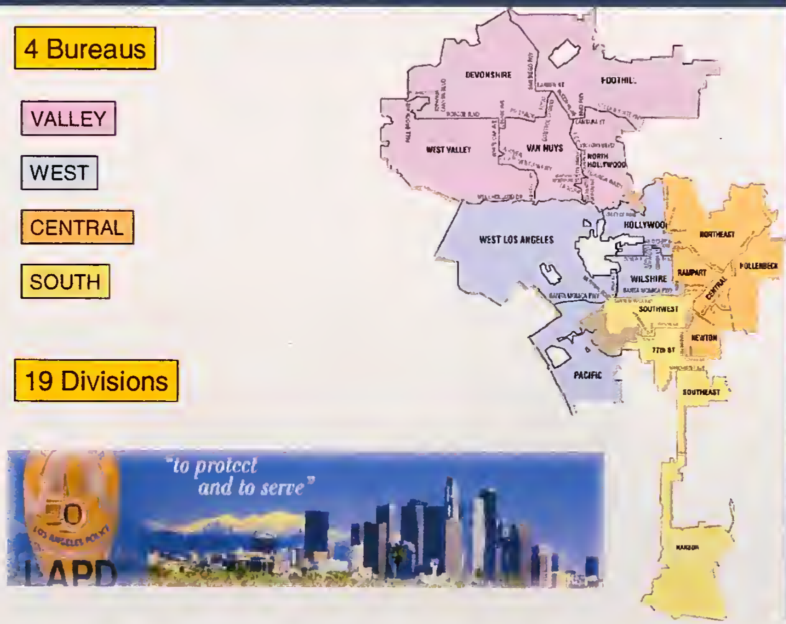
Mesh Technology

- Integrated Multi-radio access points available to cover 4.9 GHz and 2.4 GHz bands
- Data and video applications
- 1 MBps data connectivity at fringe of access points, even at 200mph. Rate is increased as the user approaches an access point
- Self-Healing, Self Forming & Self Balancing to match mission critical needs
- Built in location & <u>INDOOR LOCATION</u> with MESHTRACK
- Supports “Zero Infrastructure” Ad Hoc Networks




Mesh Technologies
Mesh and Ad-hoc Technologies
True Mobility — Mesh technology brings true mobility to the field not possible with wired technologies.
BACK
PAUSE
NEXT
HOME
1 of 9

Presentation by Sharyn Buck - Los Angeles City Police Department



In 2005 -

1,717,016 – 911 calls

1,469,021 – Non emergency calls

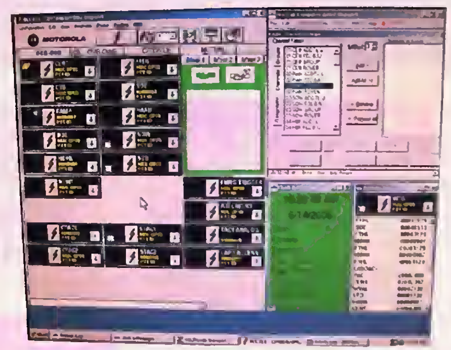
93.6% of all 911 calls answered within 10 seconds.

Communications Division dispatches an average of 1 million calls per year.

Out of 600 employees, 517 are PSR's, of which 216 are assigned to VCDC.

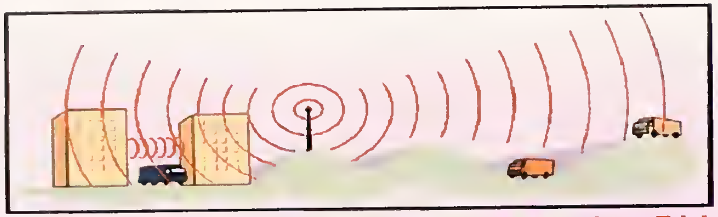
In 2002, LAPD spent $60 million dollars to change from Analog to Digital, and $20 million dollars for new radios.

LAPD has over 100 radio channels, 57 used for daily operations.



5 mutual aid channels for major incidents.

A practical number of radios on one frequency is 70, if channels are patched, that number could double.



Communication Challenges in High Rise Bldgs:

The city of Los Angeles has 743 high rise buildings

Some of the buildings are built with concrete and steel, limiting the officers ability to have radio communication within the building.

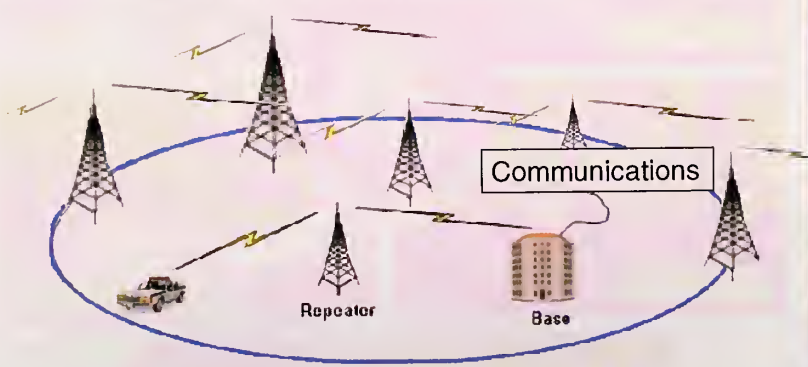
2 possible solutions to solve police agency communication problems within high-rise buildings;

- Funding $$$
- Mandated policies that high-rise structures be built to include in-building radio coverage

LAPD currently has over 30 mountain top radio sites, of which 24 of them are remote communications sites.

Typically, LAPD does not have problems allocating radio frequencies during complex or large incidents, we utilize tactical frequencies designed for large incidents to handle field operations.

Incidents with challenging communication issues, LAPD assigns a tactical channel and can patch frequencies for the incident if needed.



DEMOCRATIC NATIONAL CONVENTION 2000

INSIDE:

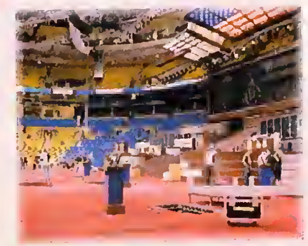
SOLID CONCRETE

NO WINDOWS

Critical Communication Problems

2 portable repeaters (BDA) were tied to the rafters 80 feet above the floor.

Enabled local and federal police to communicate with each other.



MDC

Manufactured by DELL

Presently there are 700 police vehicles equipped with MDCs.

By the next fiscal year there will be 1600 LAPD police vehicles with MDCs.

In the future the patrol car will be a mobile office.

- Deliver Wireless Network
- Internet capabilities
- Email access
- Field reporting

Controls . . .

Temperature
Fan
Heater
Noise Reduction
Light

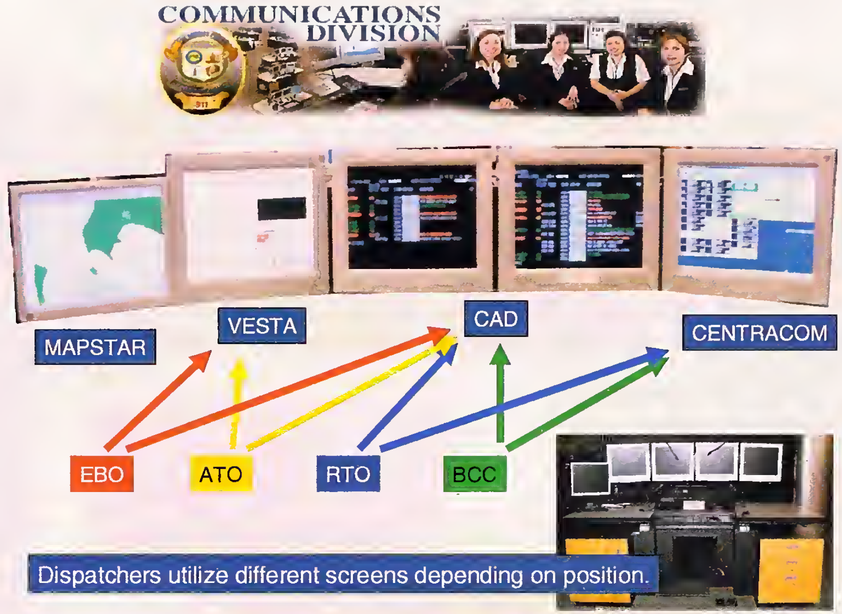
Environmental and Electronic Control Unit

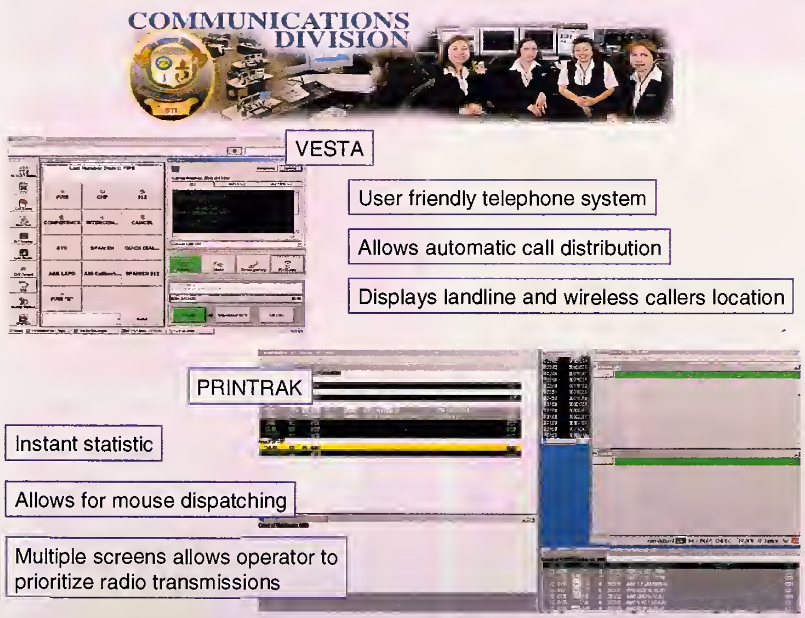
BEFORE . . .

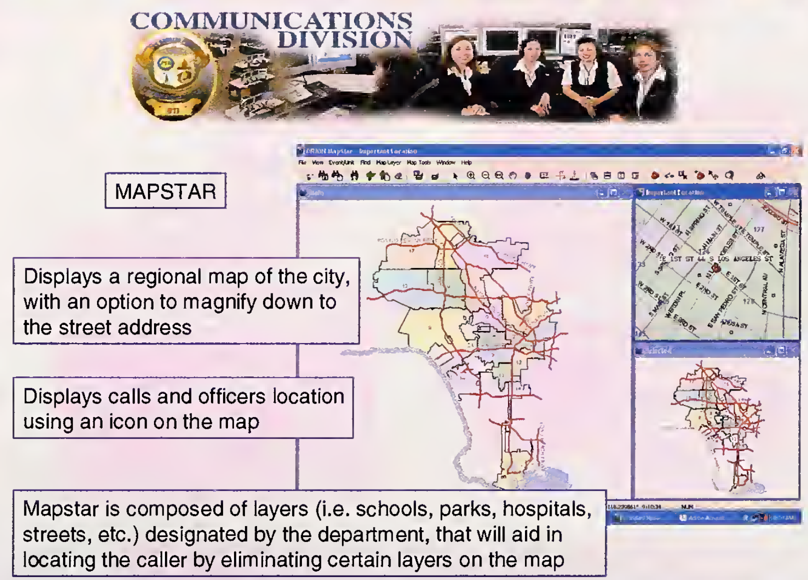
. . .AFTER

80 consoles on the floor in each center


COMMUNICATIONS DIVISION
EBO
Emergency Board Operator
Answer 911 and Non emergency calls
Dispatches 911 calls
RTO
Radio Telephone Operator
Handles Officers request
Manage calls for service in a certain area
ATO
Auxiliary Telephone Operator
Answer alarm companies calls
Call back the reporting party for further information
BCC
Bureau Communications Coordinator
Oversees the RTO's of a certain Bureau
Assists in any request from Officers during emergencies (Pursuits, Help calls, etc.)

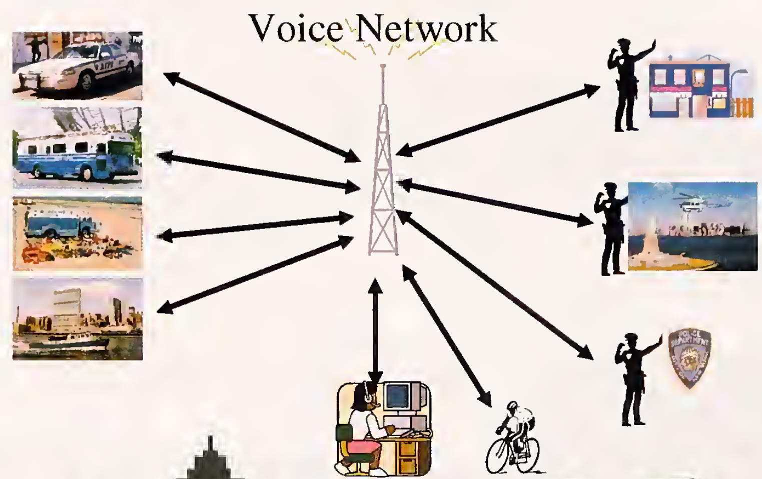

COMMUNICATIONS DIVISION
MAPSTAR
VESTA
CAD
CENTRACOM
EBO
ATO
RTO
BCC
Dispatchers utilize different screens depending on position.

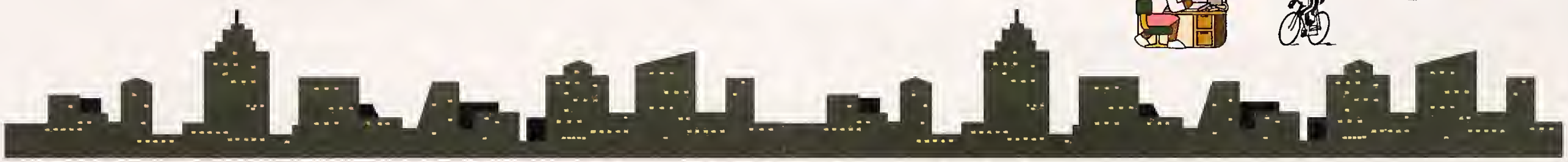

COMMUNICATIONS DIVISION
VESTA
User friendly telephone system
Allows automatic call distribution
Displays landline and wireless callers location
PRINTRAK
Instant statistic
Allows for mouse dispatching
Multiple screens allows operator to prioritize radio transmissions


COMMUNICATIONS DIVISION
MAPSTAR
Displays a regional map of the city, with an option to magnify down to the street address
Displays calls and officers location using an icon on the map
Mapstar is composed of layers (i.e. schools, parks, hospitals, streets, etc.) designated by the department, that will aid in locating the caller by eliminating certain layers on the map


FUTURE
Technology for LAPD will include the wireless world, Broadband wireless and 700 mhz and 4.9 ghz bands.
“SMART” car technology in all police vehicles
Develop inter agency protocols for handling terrorist activities in high rise buildings

N.Y.P.D.
HIGH-RISE BUILDING AND COMPLEX INCIDENT EMERGENCY RESPONDER COMMUNICATIONS





System Infrastructure

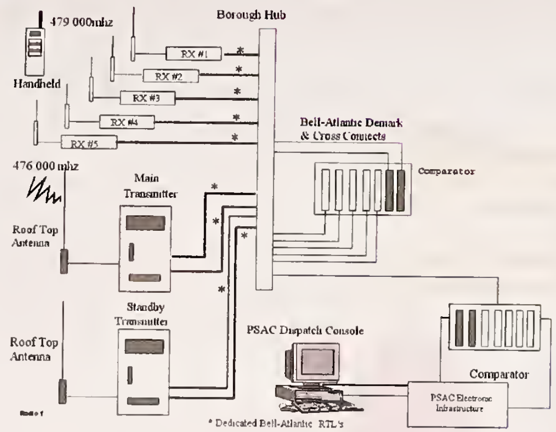
	PREVIOUS	EXPANDED
Precinct Radio Zones	24	35
City Wide	14	15
Borough Systems	0	13
Dispatch Centers	1	2 (PSAC II to be built)
Transmitters	85	146
Radio Receivers	515	1,264
Radio Equipment Sites	168	301
Electronic Technicians Rooms (Staffed 24 x7)	1	3
Radio Telephone Lines	1,218	2,386

Clear Radio Systems

- Thirty Five (35) Patrol Zones
- Nine (9) City Wide Channels
- Eight (8) Patrol Borough Channels
- Six (6) Inter-Operability Channels

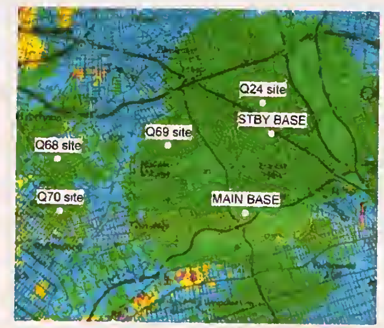
•CityWide 1,2 &3
•SOD
•Traffic
•Detective 1
•OCCB 1
•SPIN
•CDCW

A RADIO TRANSMISSION



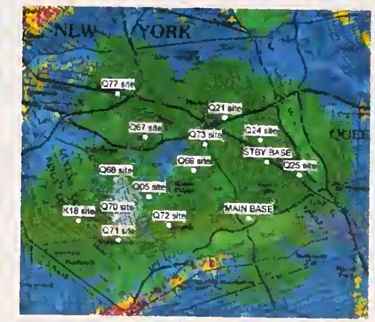
PATROL ZONES

108 & 112 Pcts. Old Receiver Coverage



Four (4) Receivers & Two (2) Transmitters

108 & 112 Pcts. New Receiver Coverage



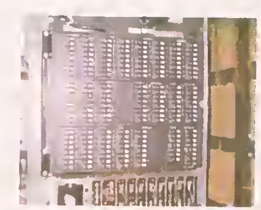
Thirteen (13) Receivers & Two (2) Transmitters

Inter-Operability Channels

COMMAND AND ALARM SYSTEM

MOSCAD

MOTOROLA SUPERVISORY CONTROL AND DATA ACQUISITION



HIGH-RISE COMMUNICATIONS

- Well engineered network radio systems allow first responders to be independent of any single in-building system
- N.Y.P.D's current radio network systems provide 95% in-building coverage without the need for in-building repeaters
- In-building coverage is affected by the type of construction (i.e. concrete vs glass)
- Larger concrete structures can reduce network coverage to 80-85%, typically reducing coverage in lower floors / core areas
- If ***properly engineered,*** in-building systems have the potential to enhance in-building network coverage

IN-BUILDING SYSTEM REQUIREMENTS

- Independent system (components / Radiax) from building commercial system
- New / appropriate BDA technology to address TDI (interference) and FCC compliance
- Full-time "system on"
- On / Off control
- System power management on a per-channel basis (balanced system)
- Meet existing P.D. network requirements (i.e. time-out feature)
- In-building system generator / battery (UPS) protected

IN-BUILDING SYSTEM REQUIREMENTS Cont……

- Outage notifications (mandatory) regarding scheduled maintenance / upgrades or system failures
- Building management responsible for annual system testing conducted by an independent contractor with report of findings forwarded (directly from contractor) to the N.Y.P.D's Communications Division

Presentation by Nelson Bryner – National Institute of Standards and Technology

NIST High-Rise Building and Complex Incident Emergency Responder Communications Workshop

Distributed Multi-Nodal Voice / Data Communication Systems

Nelson Bryner and Dave Stroup
Fire Fighting Technology Group
Building and Fire Research Laboratory

June 20 - 21 , 2006
Gaithersburg, MD 20899

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

Overview

- **Introduction**
  - Communication
    - who, what, where, under which conditions
  - Radio systems – why not?
- **Distributed Multi-Nodal Voice/Data Communication -**
  - Wireless Sensors
    - **Building**
    - **Fire fighter**
  - Networks
    - **Fixed**
    - **Ad-Hoc**
- **Summary**

Communication – Who & What?

- Who is “communicating” in building?
  - First responders
    - Fire fighters
    - Law enforcement
  - Incident commander
  - Rapid Intervention Teams
  - Rehab Team
- What is the information needed for?
  - Tactical
    - Fire ground – suppression and venting
    - Searching for victims/suspects
    - Rapid intervention teams (RIT)
  - Staging of additional resources

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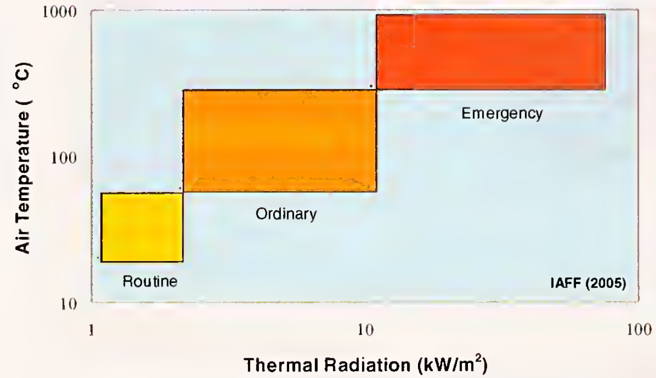
    - Fire ground – suppression and venting
    - Searching for victims/suspects
    - Rapid intervention teams (RIT)
  - Staging of additional resources
  - **Locating/tracking first responders**
  - **Fire conditions – fire spread**
  - **Bio-metrics – heat stress**

Where or what building type ?

- Type I or Fire-Resistive (NFPA)
  - High rise office, shopping centers, or residential units
  - Reinforced concrete, structural steel (protected)
- Type II or Noncombustible
  - Office buildings, warehouses, auto repair shops
  - Metal frame with metal walls, metal frame with masonry walls, masonry walls with metal roof
- Type III or Ordinary
  - Office buildings, retail stores, mixed occupancy, apartment buildings
  - Noncombustible bearing walls and combustible roofs
  - Most buildings are of this type
- Type IV or Heavy Timber
  - Exterior noncombustible or limited combustible, masonry
  - Interior structural members, walls, columns, floors and roofs are large timbers
  - Common in the New England area
- Type V or Wood Frame
  - Single family dwelling, restaurants, retail stores
  - Log, post & beam, balloon, platform, and plank & beam
  - Structural members are wood and exterior walls are combustible

Under what conditions ?



Under what conditions ?

Thermal Class	Maximum Time (min)	Maximum Temperature (°C)/(°F)	Maximum Flux (kW/m²)
I	25	100/212	1
II	15	160/320	2
III	5	260/500	10
IV	<1	>260/500	>10

Radio Communication – Why not?

- **Radio Frequency Based Systems**
  - VHF – 30 MHz to 300 MHz
  - UHF – 300 MHz to 3 GHz
  - UWB – 2.4 GHz – 5.4 GHz
- **Simplex – point to point**
- **Duplex -**

- **Signal Attenuation–**
  - Construction materials absorb
    - Varying degrees
  - Metals or metal containing materials block transmission
    - Siding or roofs
    - Solar radiation coatings
    - Aluminum foil on insulation

Communication Technology

- **Wide range of technologies**
  - Acoustic/sound
  - Radio frequency
  - Infrared signal
- **Source of Technologies**
  - Military
  - Security and surveillance industry
  - NASA
  - Mining Industry

Communication Technology

- **Wide range of technologies**
  - Acoustic/sound
  - Infrared signal
  - Radio frequency
- **Source of Technologies**
  - Military
  - Security and surveillance industry
  - NASA
  - Mining Industry
- Commercial market
  - Fire Service Equipment
    - Limited due to the market size/funding

Communication Technology

- **Wide range of technologies**
  - Acoustic/sound
  - Infrared signal
  - Radio frequency

Communication Technology

Acoustic / Sound Systems

- Transmitter/receiver system
  - Acoustic or sound waves
  - Not in range of human hearing
- Data communication
  - Not voice
  - Locates fire fighter
- Commercially available
  - Summit Safety

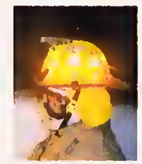
- Issues-
  - Reflections –
    - Must compare strength of signal
    - Materials reflect differently
    - Multiple reflections
  - No tracking

Communication Technology

- **Wide range of technologies**
  - Acoustic/sound
  - Infrared signal
  - Radio frequency

Communication Technology

Infrared / Laser Signal



- Transmitter/receiver system
  - Light signal
  - Not in range of human vision
- Data communication
  - Not voice, but could be digitized audio
  - Can be used to locate fire fighter
- Commercially available
  - Relume, Inc.
- Issues-
  - Reflections –
    - Materials reflect differently
    - Multiple reflections
  - No tracking

Communication Technology

- **Wide range of technologies**
  - Acoustic/sound
  - Infrared signal
  - Radio frequency

Communication Technology

- **Distributed Multi-Nodal Voice / Data Systems**
  - Each sensor or package a "node"
  - More than one node – "multi"
  - Can transmit voice in real time
  - Can transmit data in real time
- **May or may not be in network arrangement**

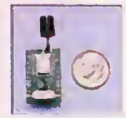
Distributed Multi-Nodal Voice / Data Systems

- Building Sensor Nodes
  - System performance – heat, AC, etc.
    - Network
    - Equipment specific
  - RFID tags/readers
- Fire Fighter Nodes
  - Network
  - RFID tags/readers
  - Multi-hop
  - Ad hoc


Wireless Building Sensors

- Building Sensors or Nodes
  - In place to track building performance
    - Attached to specific equipment
    - Designed for months/years of service
  - Locate and track
    - Sample frequency
      - Buildings – samples / hours
      - Fire fighters – samples / second
- Issues –
  - Need complete building coverage
    - Not just equipment spaces
  - Require pre-wiring of building
  - Adaptive sampling?





Wireless Fire Fighter Sensors cont'd

•RF Identification Tags

•Reader and Tag uniquely identified

•RFID readers in building
- •Each fire fighter is tagged
- •Walmart tracking merchandise in warehouse
- •Nursing homes – patients

•RFID tabs in building
- •Each fire fighter has reader
- •Readers more expensive



Wireless Fire Fighter Sensors cont'd

RFID Tags cont'd

•Issues-

•Pre-wiring of readers/tags

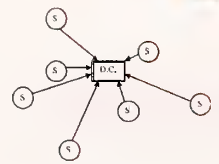
•Signal
- •Coverage
- •Penetration/attenuation
- •reflections



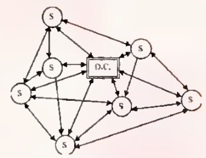
Wireless Fire Fighter Sensors cont'd

Fire Fighter Sensor Networks

- •Fixed
  - •Pre configured
  - •Data paths established
- •Ad Hoc
  - •Self healing or reforming
- •RF systems
  - •802.15.4 ZigBee
  - •Bluetooth



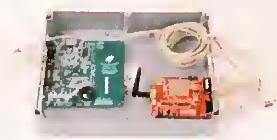
Star or Point-to-Point

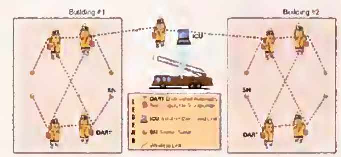


Mesh Network

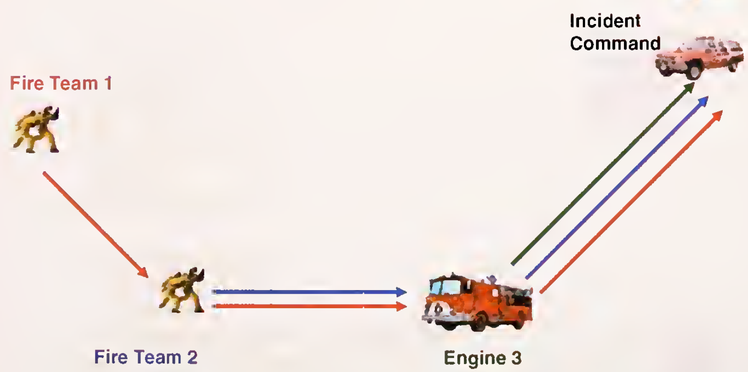
Wireless Fire Fighter Sensors cont'd

- •Fixed networks
  - •Multi-hop
  - •Voice/data communication
    - •Williams-Pyro (SBIR)
  - •Not locating/tracking
    - •Strength of signal
    - •TOF
- •Issues-
  - •Limited ability to dynamically add new nodes/sensors
  - •Short range
  - •Node drop-out



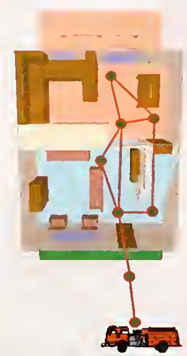


Multi-hop Network – fixed path

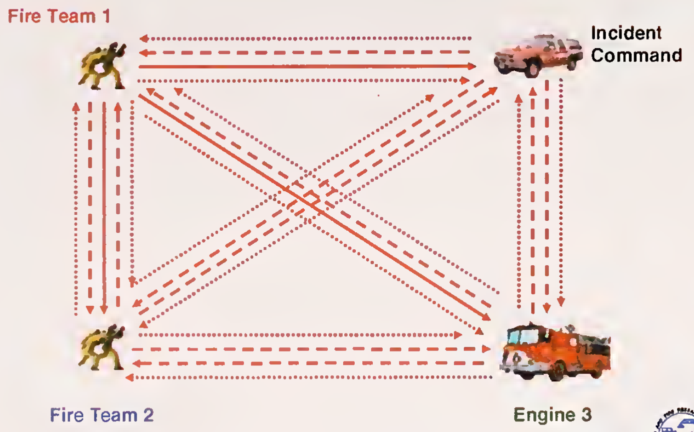


Wireless Fire Fighter Sensors cont'd

- •Ad Hoc Networks
  - •Self-forming/re-forming
  - •Data communication
    - •Locating and tracking
      - •GPS
    - •Physiology sensors and dosimeters
    - •Siemens (USAF)
- •Dynamically add sensors/nodes
  - •Data paths established on the fly
  - •Repetitive pinging to locate nearby nodes
- •Issues-
  - •Short range
  - •Path determination
    - •Ping, ping, ping, ping, ping, ping
  - •Data, but not voice



Ad Hoc Network – Two Pings



Distributed Multi-Nodal Voice/Data Summary

- **Building Sensors**
  - Interior of Structure
  - Commercial systems for indoor use
  - Pre-wired for limited coverage
- **Fire Fighter Nodes**
  - Interior and exterior of structures
  - Downed fire fighter
- **Currently no commercially available system**
  - Voice, data and video
  - Inside and outside
  - Locate and track
  - Fire responders
  - Occupants

Communication Technology Future Work

- Assist in development of new technology
  - Technical expertise
  - Internal research funds
  - Grants
- Evaluate current systems
  - Laboratory-scale tests
  - Full-scale fire exposure tests
  - Collaborate with Fire Service
- Standards & testing protocols
  - Representative building types
  - Representative exposure conditions

Communication Technology

- Questions?

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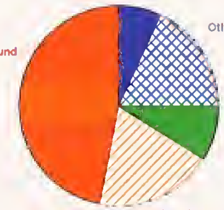
www.bfrl.nist.gov

Why Invest in Distributed Multi-Nodal Voice/Data Technology ?

- Firefighter Fatalities –
  - 117 in 2004 (USFA)
- Total Injuries –
  - 80,800 in 2004 (NFPA)
  - Fireground – 37,976 injuries



- Magnitude of U.S. Annual Losses ~ $128 billion total cost
- Tracking fire fighters allow
  - Better tactical decisions
    - Faster suppression
    - Decreased property losses

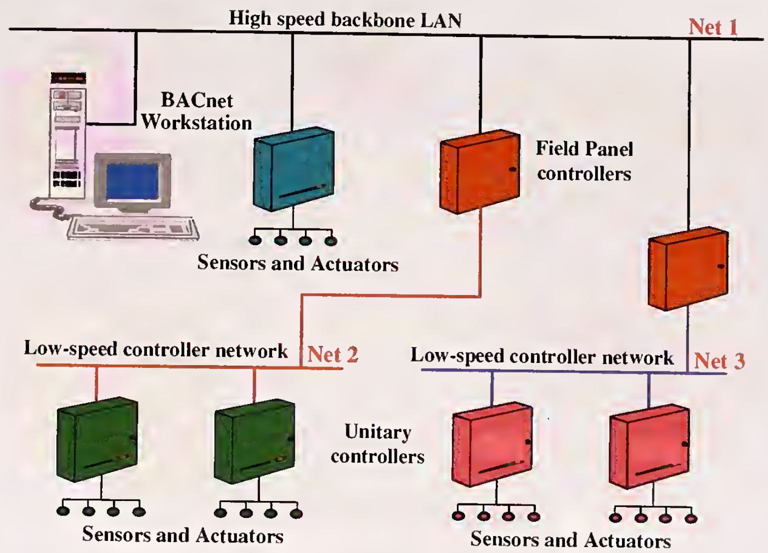
Communication Technology

- Roles of NIST
  - Fundamental Science
    - Measurement or metrology
    - Signal penetration
    - Sensor design
    - Combustion Science
  - Building performance
  - Fire Environment
  - Performance Standards and Testing Protocols
    - Signal quality
    - Sensor interfaces/performance
    - Thermal exposure testing
    - Network design
  - Develop new technology where expertise exists

Emerging Building Automation Technology and its Impact on Emergency Response

Steven T. Bushby

NIST
National Institute of Standards and Technology

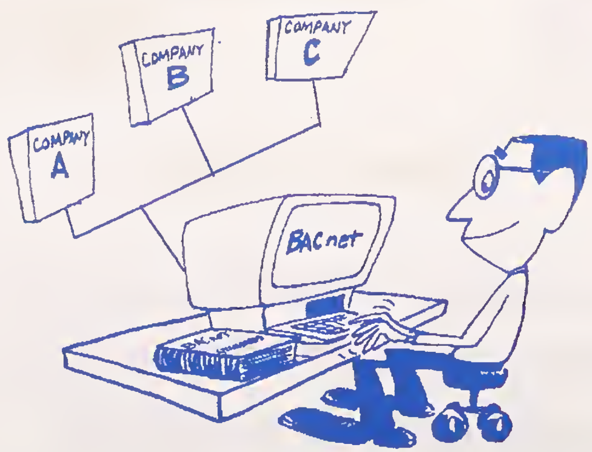


Why Integrate Building Automation Systems?

- Competitive bidding projects
- Single seat operation
- Reduced operator training costs
- ...

Why Integrate Building Automation Systems?

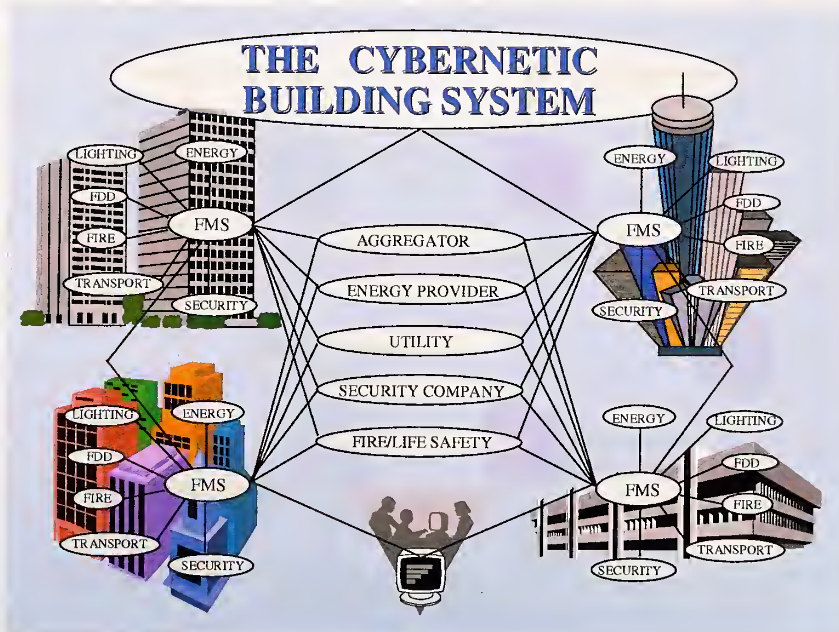
- Interconnect HVAC, fire, lighting, & access control systems for more efficient operation
- Tennant billing
- Shared sensor data
- Link multiple buildings



BACnet =

A Data Communication Protocol for Building Automation and Control Networks

Only standard protocol specifically for buildings.

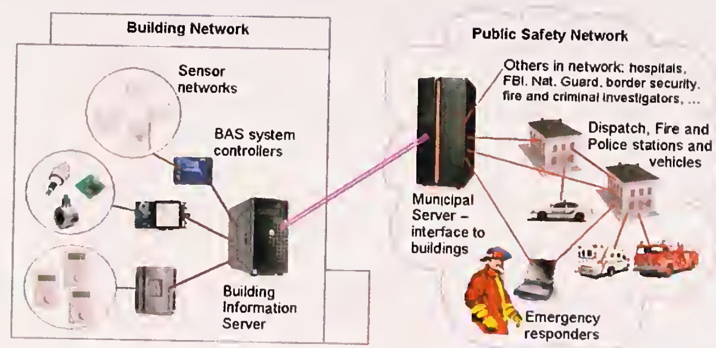


BACnet – Embraced Around the World

Exciting BACnet projects are happening all over the world

Why does building automation technology matter to emergency responders?

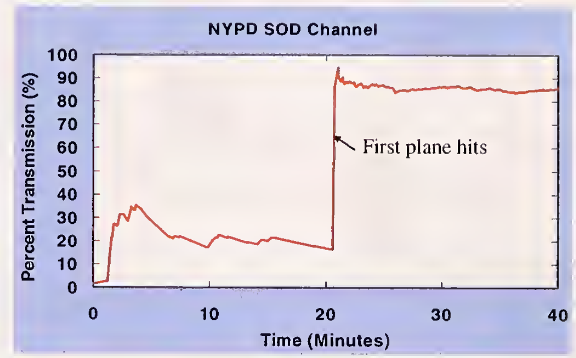
Buildings have a lot of information that could aid an emergency response!



www.bfrl.nist.gov/ibr

Integrated BAS Enable development of decision support tools

Can building automation systems assist in voice communications within a building?



WTC public safety dispatch comm channel

Summary

- Communication standards for building automation are being adopted around the world and increasingly used in real products
- Integrated building automations systems based on standards can be an asset to emergency responders