LRN: 04D212I

Project Number: 2003 IQP JPH - 48

Assessment of Worcester Emergency Radio Communication

An Interactive Qualifying Project Report

Submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

by

Michael Kastanas

Joseph Peralta

Hisham Al-Beik

Date: May 10, 2004

Professor Hanlan, IQP Advisor

1. Worcester
2. Radio
3. Emergency

Abstract:

This project explores the emergency radio communications equipment presently available to, and utilized by, the safety or emergency response agencies serving the City of Worcester. After analyzing the available equipment, the project team conducted its assessment of the likely problems faced by the city in the event of an emergency situation or disaster. Through interviews, field testing and literature search, the project team collected information necessary from the different agencies serving the city. Furthermore, the IQP project team used the collected information to perform the following:

1) Assessment of assets each agency has regarding radio communications equipment and their operating effectiveness throughout the city;
2) Assessment of the efficiency of interagency communications; and
3) Where appropriate, propose future improvements to maximize the performance of Worcester's emergency radio communications.

Authorship

The IQP project team of M. Kastanas, J. Peralta and H. Al-Beik collectively conducted interviews and then shared the responsibility for documenting the results. While some report sections and the transcripts had contributory authors for the initial draft, most sections were a team effort. Examples of contributory authorship include: H. Al-Beik's special contribution involved development of the APCO 25 standard and audio quality issues with mobile radios; J. Peralta special contribution involved attributes of the EDACS system and RF propagation issues; and M. Kastanas special contribution involved the types of radio systems and methods of mobile communications.

The entire team was responsible for some section redevelopment, review and section editing (with the exception of the transcribed interviews). Finally, the overall organization and structure of this report was provided by M. Kastanas.

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1 Introduction

The purpose of this report was to assess the emergency communication needs of the City of Worcester, Massachusetts. The assessment was performed in terms of what communication obstacles the city would face and what features the system would need in order to perform its duties and overcome the identified communication obstacles.

This report will detail the background of emergency communication systems in Worcester, such as, which institutions it services and in what capacity as well as an assessment of problems and benefits of the current system. Once the background of each emergency communications system in the city was established, the report discusses the individual problems faced by the City of Worcester, such as signal propagation with hilly terrain and high-rise buildings. The explanation of the individual problems helps the IQP project team to identify, in this report, which communications features will be necessary for the City of Worcester to consider in the future. Whether it's keeping pace with changing levels of communications service or overcoming the current problems in emergency communications, which are identified in this report, the City of Worcester will have to deal with this issues if its communications systems are to remain viable. The results of this analysis will be made available to the City of Worcester for use when they are considering and evaluating new communications systems for the benefit of the greater Worcester community.

2 Goals:

The overall goals for this IQP project were:

- Assess current communications equipment and its capabilities.
- Assess efficiency of interagency communications.
- Identify state-of-the-art communications systems in order to compare to Worcester's current communications systems.
- Propose any future improvements to Worcester's emergency radio communications systems.

3. Background

Worcester, Massachusetts is quite a complex city for establishing effective radio communications systems. Some of the factors contributing to this include the city's rough terrain, large population, congested downtown high-rise buildings, harsh seasonal weather conditions, and other natural and man-made challenges to effective emergency communications. These factors can, collectively or individually, present technical challenges to those authorities having responsibility for establishing an efficient system. The improvement over the years in radio and computer technology has allowed towns and cities to overcome these obstacles.

3.1 Types of Radio Systems

Not every town or city needs to have large sophisticated radio communication services. In fact, there are many types of radio communications that offer effectiveness and simplicity. The most important basic services necessary in establishing effective radio communications are the following:

- Wide-Area Radio Paging
- Display Paging
- Private Mobile Radio (PMR)
- Analog Cellular
- Digital Cellular

These features are described as follows:

- **Wide Area Radio Paging** is a useful means of getting in contact with a single user. This service only allows for one-way communication and can usually send only numeric messages to the user. The draw back to this system is the inability to send conformation back to the sender in order to insure the message was received.[1]
- **Display Paging** is similar to the Wide Area Radio Paging system. This type of paging allows for text and numeric messages to be sent to a pager. Most updated pagers today allow for two-way communication thus allowing a conformation message to be sent back from the user to the sender.[2] (pg 112-113)

[1] Introduction to Radio…", Dole (Page 112)
[2] Introduction to Radio…", Dole (Page 112-113)

- **Private Mobile Radio** (PMR) services are typically beneficial to large scale groups that require all users to stay in contact. Major types of data that can be sent in a two-way direction are voice and packet data. This service is very flexible and upgradeable to meet most groups' specifications. Examples of groups that would use this system range from emergency response units to public transportation and public utility services. A FCC license is required by either a single user or organization to transmit on these frequencies.
- **Analog Cellular** is a service that allows any user to connect wirelessly through many base towers to make a telephone connection. Also, it is doable to connect to another cellular user at anytime he/she is in range of a base tower. Today this service is open to commercial use and does not require the user to acquire a special license. [3]
- **Digital Cellular** is similar to Analog Cellular. The most distinguishable difference between the two services is that Digital Cellular sends the voice signal in a digital format. This digital format is easy to encrypt for secure and private conversations. Cellular today is still fast growing system connection many users together on a global scale.[4] (pg 115)

[3] Introduction to Radio…", Dole (Page 114)
[4] Introduction to Radio…", Dole (Page 115)

While all these aforementioned radio-based services can be used for some basic level of emergency communications, the services that allow for the most transfer of information are Private Mobile Radio and Digital Cellular. The basis for this position is that these two systems have the ability to send voice information to either a specific individual or broadcast to a larger group of people with minimal delay time.

However, like all communication systems, there can be limitations depending on the capabilities sought by those responsible for communications planning. Private Mobile Radio works by providing users with a radio set or programmed to a specific or group of frequencies for everyone to tune in and listen on. The crucial benefit of this service is the ability for two users to communicate with each other directly (within line of sight) without any secondary connection system. Unlike cellular services, a connection to the secondary system (most likely towers and/or phone lines) prohibits the users from direct contact and presents a potential communications equipment problem.. Because PMR works mostly with line of sight communications, it is difficult to handle communications over a long distance or though obstacles in the direct path of a radio signal. The signal obstacles commonly encountered are buildings, hills, mountains, and foliage. These obstacles cause "black spots or dead zones," which are terms that describe a certain area where the transmitting signal can not be received.

In comparison, cellular services can offer the advantage of avoiding dead zones but only if there are sufficient towers or other signal receptors/transmitters to accommodate signal traffic. Consequently, many towers may be necessary in certain areas where the dead zones exist in order to assure wide area coverage. This also introduces another service and maintenance responsibility that may impact communications.

Generally, PMR services use Very High Frequencies (VHF) and Ultra High Frequencies (UHF). VHF frequencies range from 30MHz to 328MHz and UHF frequencies range from 328 MHz to 2.0 GHz. At these frequencies, the signal is able to reflect off of buildings and still able to be received by a user. Although with every reflected bounce, the strength of the signal diminishes. In a major city, it is unlikely to conduct a line of sight communication with a user in another part of the city. Thus, the use of a "repeating" tower, at a high elevation, is necessary and allows users to establish a connection.[5] (Pg 117)

3.2 Two Methods of Mobile Communications

As a basic requirement, any communication system must be able to support mobile communications. Mobile communications is defined as a radio operator that does not remain on one location at any given time. An example of mobile communications methods for accommodating mobile communications are: 1) A centralized radio base station (covering one large area) communicating to many mobile receivers, and 2) a cellular radio-type system which uses many base stations, each covering a small area.

[5] Introduction to Radio…", Dole (Page 117)

The centralized radio base station method requires the signaling equipment to be elevated to a point high enough to obtain the maximum area coverage. High hills/mountains, buildings, and towers can be used to achieve this height. This method does not guarantee signal coverage in all areas unless consideration is given to address obstructions by other buildings, foliage, and/or other elevated landforms. Otherwise, some mobile receivers will be unable to communicate with the base station or must be made aware of the signaling limitations. Overall, the benefits of this method are the ability to quickly setup a base station at any location and the simplicity of the equipment.[6]

The cellular radio-type method uses many base stations linked together to create one large antenna system with a profound range of coverage.. This method is typically used by "wireless" telephone companies to ensure that a cellular phone will be able to connect to their service. With the numerous towers, therefore, "dead" zones can be easily eliminated. Unfortunately, this type of setup requires much planning in the placement of the towers. The goal is to place the towers enough distant apart from each other in order to gain the maximum coverage area while developing a certain degree of overlap. One of the major drawbacks to this method is the increase in cost for specialized equipment. [7]

3.3 Summary Review of 'EDACS Explained'

The EDACS Explained document is an in-depth overview of the EDACS® (i.e., Enhanced Digital Access Communications System) system, and its features and benefits. The document is provided by ComNet Ericsson, the manufacturers of the EDACS® system and, thus, tends to look very favorably on the advantages of the system, while downplaying the system's disadvantages.

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[6] Introduction to Radio…", Dole (Page 115-116)
[7] Introduction to Radio…", Dole (Page 115-116)

This summary review will look at the main features of the EDACS® system as described within the document:

Ericsson, indicates that the EDACS® is a complex, yet incredibly flexible, communications system designed to provide secure, reliable two-way radio communications for public safety, utility, government, military, business, and industrial organizations.

The system's six main features include:

1. Group-oriented communications with special handling of emergency calls
2. Integrated voice and high-speed data (9.6kbit/s)
3. Trunked fast access (less than 0.5 seconds)
4. Wide-area capability
5. High fault tolerance
6. Modularity and expandability

These features are all important to the proper operation of a civil service radio system, such as the one we are analyzing in the city of Worcester, who currently uses a radio system based on the EDACS® system. According to Ericsson, each of these features offers at least one key advantage. The principle advantage for each feature are as follows:

Feature 1 - Group-oriented communications:

Principal advantage: Personnel can stay in touch with their colleagues at all times and emergency calls get through as quickly as possible. Communications are more efficient and safety is improved as there is always a reliable communication path between points of need and delivery of aid.

In addition, this feature incorporates "talk-groups" which divide the communications service into smaller communications groups that have separate channels. This also allows each member to talk among group members without impact from other groups.

Feature 2 - Integrated voice and high-speed data:

Principal advantage: Field personnel can obtain and save data in a central database. Mobile data facilities, in effect, bring the office out into the field, thereby improving effectiveness. This feature also allows the data information to share channels with the voice information. This is important because it reduces the number of channels necessary to convey information. The 9.6kbit/s data transfer rate allows predominantly text data to be transferred at a reasonable speed, but is somewhat slower for data involving graphics.

Feature 3 - 'Trunked fast access' capability

Principal advantage: The trunk system must has the channel selection performing in under 0.5 seconds. This allows the users to quickly access the radio channel. The short delay also improves efficiency because it allows less time spent by users in waiting for channel access.

Feature 4 - Wide-area coverage

Principal advantage: The capability here utilizes system scaling to cover the necessary area via multiple transmit/receive sites using several methods of scaling. These methods are: voted, simulcast and multi-site:

- The voted method uses multiple receive/transmit sites on the same frequency selecting the site to use based on quality of reception, the best site is selected.
- The simulcast is similar to voted except that all transmitters and receivers transmit and receive the same data. There is no selection process as to which transceiver site to use.
- The multi-site is an intelligent simulcast system. The system can detect which users are using which trunk sites and if there is no user on a trunk site who needs to receive a particular transmission it will not transmit the call onto that transceiver leaving it free for other use.

Feature 5 - High fault tolerance

Principal advantage: Communications capability is achieved through use of a system referred to as "Fail-soft." The system basically provides multiple, redundant levels of fault tolerance. Should any one particular site fail, the others will continue to process information for that site. The only change this protective process creates is that any unique coverage a site may have had will be omitted under fail soft conditions. Consequently, if the links between the multiple sites fail, the system can continue to operate in normal mode, but without the benefits of the multi-site controllers.

Feature 6 - Modularity and expandability

Principal advantage: This feature allows for system upgrade. The system uses modules to control each section. Consequently, the modules can be upgraded and replaced individually. This ability protects against system obsolescence and maintains the initial equipment investment longer by allowing the new modules to replace obsolete modules without having to replace the entire system. The system can also be expanded simply by adding new modules. All module replacements or addition are seamlessly configured based on the existing systems specifications..

3.4 APCO 25

Some of the issues that seem to plague existing systems as they get older and town/city demands grow larger include:

- Radio spectrum is becoming more congested
- Demand for data transmission is more pronounced
- Systems need increased functionality
- Secure communication is a growing necessity
- Improved voice quality is essential over more of the coverage area (Quality vs Coverage)

Some of the consequences that seem to plague existing systems as they try to resolve the issues above include:

- Time is limited to develop and perform an upgrade
- Work schedule and resources available to perform all tasks and limit disruptions
- Expenditures are restricted by governmental budget constraints

In the majority of these situations, digital systems offer the most promising choice in meeting the issues and consequences associated with system upgrades. However, there are different digital technologies on the market, requiring huge amount of research to determine the best choice for a governmental controlled communications system. Each digital technology has its own set of features that may or may not suit one or more the public safety organizations protecting a community.

The need for a universal standard is imperative for anyone reviewing competing digital systems. APCO 25 (i.e., Association of Public-Safety Communications Officials standard 25) is such a standard. It provides a set of recommended – voluntary - standards for uniform digital two-way radio technology. The standard development involved representatives from many agencies, who were responsible for evaluating the basic technologies in advanced land mobile radio. APCO 25 offers the mechanism to help determine the most appropriate system to meet the needs of the public safety marketplace. APCO 25 also encourages the participation of international public safety organizations. The aspiration is to make the APCO 25 standard a more world-wide recommended standard setting initiative.

As an overview, the APCO 25 process objectives include:

- Seeking new, two-way, digital radio technologies.
- Establish basic requirements to evaluate each technology.
- Invite vendors to participate in open and independent evaluation tests.

These objectives led to establishing open system standards that encouraged multiple vendors to make competing products that are compatible. This was not an easy task given the fact that all the technologies considered were privately owned or proprietary. Moreover, participating vendors that did agree to share their proprietary technologies, with other competing vendors, and underwent successful independent evaluation, had their technology adopted into the standard as a recommended technology.

The benefits of this standard to the public safety professional seeking performance, efficiency, capability and quality of two-way radio communications were:

- Enhanced functionality with equipment and capabilities focused on public safety needs.
- Improved spectrum efficiency
- Ensured competition among multiple vendors through Open System Architecture.
- Ability for more effective, efficient, and reliable intra-agency and inter-agency communications.
- Opportunity for end-users to mix and match equipment among APCO-25-compliant suppliers since their equipment will follow all basic standards

These benefits also allowed for the orderly migration from analog to digital technologies in some key ways:

- Basic requirement for new digital radio equipment is backward compatibility with standard analog FM radios.
- Backward compatbbility allowed for orderly and cost effective migration into mixed analog and digital systems, enabling users to gradually trade out radios and infrastructure equipment.
- Using APCO-25 compliant systems and products, agencies are assured that investments have clear migration path for the future.

4 Methodology

The primary goal of the project team was to investigate and assess the current emergency response communications system capabilities possessed by agencies and organizations that serve, predominantly, the City of Worcester. In order to accomplish this goal, the project team had to first plan, research and compile a list of publicly owned or controlled emergency services and agencies that have a responsibility to respond to an emergency, hazard or disaster, impacting the city area. Most of these emergency response agencies would include established city chartered agencies, such as police and fire departments. Other identifiable emergency services could have included privately owned public utilities and volunteer groups serving the city. It was also anticipated that the potential for discovery of other emergency response groups would come from those agencies first interviewed since agency interaction, in some form, was assumed.

In order to acquire the emergency response communications capabilities of each identified organization, the project team developed and utilized a common questionnaire to conduct interviews. The results from these interviews were analyzed for agency commonality and differences of operation. Depending on the agency's charter, agency-specific questionnaires were modified in order to capture information that may be only relevant to those agencies. Follow-up questions were considered depending on the results attained from the original questionnaires.

The major focus of the questionnaire was to ascertain what emergency communications equipment each emergency response entity utilizes to conduct its internal operations. The information obtained from each organization would then be used to independently review the technologies the agencies are presently using. This data was then further analyzed to determine the strengths and weaknesses of each system.

The second goal was to assess, external, interagency communications for mutual aid such as those coming from state and federal jurisdictions. The project team formulated a list of agencies from outside the city that could be called upon to respond during an emergency situation. This would have been accomplished through contacting city resources in order to determine which outside agencies are notified, and if there are multiple ways of notifying each outside agency. The outside agencies would have been contacted in order to determine how they maintained communications with the city's emergency response agencies during any given emergency situation. Eventually, these interagency communications systems would have been analyzed for their strengths and weaknesses.

Finally, the project team will make recommendations for improving deficiencies in any of the communication systems. Accomplishing this task will involve constructing models and charts representing the city's existing overall communication systems as derived from the questionnaires, interviews and other resources. This information will then be used as a guide to determine the deficiencies, if any, in the current communication system. Any discovered deficiencies will be addressed by the project team through researching state-of-the-art technologies to resolve these deficiencies in the system. A summary of the problem areas and the proposed improvements to the city's emergency communications system will be provided as a project deliverable.

4.1 Common Questionnaire

The Common Questionnaire was created for gathering communications system information during the interviews with emergency response sources and can be viewed in ***Appendix A***. The questionnaire attempts to address the different aspects of communication systems and their potential impact. This information gathering tool will mainly be used to help extract and identify similarities and/or differences as provided from each of the interviewees.

4.2 System Criteria

The system Criteria is described in a table displaying the major specifications that are important to radio selection and can be viewed in ***Appendix B***. There are three major types of radios that any radio communication system would utilize: Portable, Mobile, and Base-Station. Each radio type has different specifications depending on their size and function. This table will help us provide a basics and a weighing scale when comparing Worcester's radios to additional radios.

5 Data Collection

5.1 Agencies and Volunteer Considered for Report

Why we chose who we interviewed.

Appendix C shows a general listing of agencies and volunteer services that could possibly supply support during an emergency situation in Worcester. After creating this list, the team realized that it was not practical to interview each of the listed groups within the time constraints of the IQP.

The IQP team decided to seek out only those communication groups that indicated any involvement with emergency communications for the City of Worcester. These chosen entities are the:

1. Worcester Emergency Management (WEM)
2. Worcester Emergency Communication Team (WECT)
3. Worcester Communications Department.

The IQP team believes that these specific groups did provide us with enough relevant information and additional sources necessary to complete the IQP assessment.

5.2 Interviews Summaries

5.2.1 Mark Rubin: Worcester Communication's Team (WECT)

The interview with Mark Rubin, Director of Worcester Emergency Communication Team (WECT), covered many different topics from the organization of WECT, the role and responsibilities WECT has in Worcester's emergency communications system and the different capabilities that WECT possesses. Most important to this paper are the capabilities that WECT has that the city's departments lack, such as the ability to perform simplex operations without the use of a repeater, or

other like systems, and the difficulties that they have encountered when operating in an urban environment. Those problems would be the same that any other service will encounter when operating in the same environment and, therefore, are very relevant to our investigation. In addition to the problems he identified, he also identified data transfer as a capability key to his organization. This section will cover those things that have been identified as being relevant to our investigation while paying minimal attention to those that are not considered relevant.

The major capability that WECT has, that the city's current system lacks, is the ability to perform useful simplex operations. (A simplex operation is defined as a telecommunications system that allows communications in only one direction at a time, without the use of repeaters or other forwarding systems.) Simplex operations are, by definition, simpler than repeater or trunked systems because they do not rely on any systems other than the transceivers present at the sender and receiver's locations. Mr. Rubin said, that regardless of the presence or lack of a repeater in WECT's inventory, his organization will continue to practice simplex operations. Mr. Rubin's rational for this position is based on the fact that in an emergency situation the repeater system can find itself without power, thus forcing the group to rely on simplex operation anyway.

Given the fact that Mr. Rubin's group has received basic communications training as non-communications professionals, the simplicity and reliability of a simplex system, for his operation, is an appropriate and compelling case as assessed by this IQP project team.

While the advantage of simplex is based on the use of a simpler electronic system and without any outside support systems, it also has a disadvantage. Mr. Rubin notes that although his operators are slowly becoming better trained in operating in simplex environments, there are still problems with operators being unfamiliar with operating in such an environment so they tend to "double;" that is, talk over each other, or fail to follow proper operating protocols.

The problem here is that, as the electronics become simpler, the end-user versatility decreases and operators must be trained differently for adapting operations on a simplex radio system, which would not be necessary on a repeater-based or trunked system. However, if the city were to integrate a dual system, they would need to train their operators not only in the art of operating on a simplex system, but also train them in the proper use of a trunked or repeater-based system.

The WECT recognizes that the simplex system has the disadvantage of limited area coverage, which is not a restriction for repeater-based or trunked systems. However, Mr. Rubin's organization gets around this limitation utilizing what he calls OEFs, which are stations that are in a position to act as relays for weaker stations. This is an appropriate adaptation since city agencies would not likely have to use simplex over large distances, but are more likely to operate them in the immediate area of an emergency situation.

The difficulties of operating emergency communications in an urban environment are plentiful; however, there are a few major ones which will be addressed here. The primary problem for radio communications, in a city, is the fact that all short-range radio communications systems use very-high frequency (VHS) or ultra-high frequency (UHF) communications. These frequencies are affected by a line-of-sight issue, in that, the radio signal's progress is impeded by solid objects located between the transmitter and the receiver. This poses a major problem in a city environment which has many large, solid, objects, such as buildings, that city personnel must navigate in and around. Communications from inside the buildings is a problem because the signal from a small, low-power, radio has problems penetrating building walls that are, characteristically, non-conducive to radio transmissions. Along with this obstacle, radio signal interference can be affected by other operating electronic devices and the buildings own electrical and electronic wiring.

While transmitting in the area of a building is a problem, there are ways to overcome these problems; these solutions will be discussed in a different part of this project report.

Another problem that exists in the urban environment that Mr. Rubin presented to this IQP project team, was the problem of destructive interference caused by a multitude of sources. These sources include such things as: paging equipment, other radio services and user caused interference; that is, users who improperly use their equipment and as such are disruptive to the rest of the system. Some of these problems, such as user interference, can be solved with better training. However, other problems, such as the other radio services, must be carefully evaluated for solutions to be effective.

The ability to transfer large amounts of data over a distance is becoming more and more necessary in today's telecommunication systems. Mr. Rubin notes that his organization has the ability to transfer data over a packet-switched data network (i.e., packet network), which, although it is not currently being used, would be very important to the organization during an emergency situation. He identifies the primary responsibility of the packet network as accurate transfer of data. This would alleviate human operators from tediously attempting to capture and documents listed items such as equipment requests or casualty lists. These data transactions do not require action until their transmission has been completed and, therefore, should not occupy more personnel time than is necessary.

Another benefit of sending such information over a packet network rather than via voice communications is security. Mr. Rubin notes that although any person has the ability to go to the store and buy a scanner to listen to voice communications, they will most likely not buy a packet modem and the other equipment necessary to demodulate the data signal. Also, in Mr. Rubin's opinion, the people that do have this equipment are generally the types who would not leak the information being transferred on the packet network to the media. Mr. Rubin believes that, although his system is not encrypted, it would be significantly more secure with a packet network than with voice communications. The IQP project team concludes from this security perspective that city agencies, like the WECT, would select the ability to use encryption on their data networks, if they could, in order to make their data transmissions more secure than transferring the information by voice. Certainly, it would be a key feature for any radio system that the city would purchase in the future.

Mr. Rubin's information proved very valuable to the research in regards to the problems faced by radio operations in an urban setting, including communications interference and the potential advantages of transferring large amounts of data on a non-voice system.. The proposed solutions to these problems will be covered more in-depth in other sections of this report.

5.2.2 Lt. Trotter and Mr. Bedard: Worcester Emergency Management

The IQP project team interview with Worcester Emergency Management (WEM) had taken place at the Worcester Emergency Operation Center (EOC), which is located at the Air National Guard on Green Hill in Worcester. The Director and Deputy-Director of Worcester Emergency Management are Lt. Trotter and Dick Bedard, respectfully.

WEM is not a responder to physical assist with an emergency situation, like the fire or police department. Rather, their main purpose is to coordinate the response of the various city departments and organization during a declared emergency. The staff of WEM is trained and skilled in managing emergency events of different magnitudes and locations. WEM is also responsible for organizing and conducting safety and test drills for Worcester to ensure that the city departments are prepared.

Minor or everyday emergencies are conducted by the dispatchers at the Communications Department located at the police center. These dispatchers receive 911 phone calls or information from first responders and organize the necessary equipment and personal to handle the emergency situation. Unlike the dispatchers at the police station, WEM can relocate its base location, known as incident command, to other locations such that they may operate more efficiently.

Physically, WEM is divided into two large size rooms. This first room, called the Emergency Operations Center (EOC), is used in an emergency to organize many city departments and organizations from one location. The second room is called the Emergency Communications Center (ECC) for gathering and sending information using telephones and radios. The EOC does not have to be the base location of WEM during an emergency. WEM is capable of establishing a command post in a mobile location during a situation that could have rendered the EOC inoperable.

Because the IQP project team's knowledge of the communication system was limited, the team asked how the system was setup throughout Worcester. Worcester's previous radio system was organized by Motorola. Unfortunately, Worcester had a bad service record with Motorola and decided to go with the GE Erickson system.

The system Worcester currently uses is the 800MHz radio system developed by GE Erickson. Worcester's contract was later purchased by M/A Comm. This system, known as the Enhanced Digital Access Communications System (EDACS), provides many users two-way or group communication with anyone using the system. In Worcester, every agency is linked into this system. Within the individual agencies are many talk groups pre-assigned to a set of radios allowing only users from their group to send and receive voice communications to their group. This is known as "trunking".

The Worcester EDACS system has 11 different frequencies, ten voice frequencies and one data frequencies. The ten voice frequency allow for up to 10 users to communicate at the same time. All the radios listen to the one data frequency which controls the assigning of what frequencies to receive or transmit on. As an easy example lets say a user of group A is transmitting on freq 1. The data frequency would then tell all the radios assigned to group A to change frequencies to listen to freq 1 (or the next available frequency).

Now, if another user from group B happens to transmits at the same time, the system will recognize that freq 1 is in use. The data frequency would then tell all the radios assigned to group B will change frequencies to listen to freq 2 (or the next available frequency). All the groups are pre-assigned and require reprogramming of the system to change who is in one group. In the case that many users need to communicate to others outside their groups, the system is configured providing special "Event" groups allowing any user to receive and transmit on this group.

The major drawback to Worcester's EDACS system is that the radios can only be used inside the city. Surrounding towns of Worcester use a different radio system and different frequencies and can not interact with the EDACS system. EDACS radios can be used within Worcester because they need to communicate with the EDACS antenna towers. "Patches" or modifications to the system have been installed in the Worcester EDACS system, which allows for some communications between different radios systems. Not every outside radio system can be patched into the Worcester EDACS system.

During an emergency, in might be necessary to provide more people with radio communications. Massachusetts Emergency Management Agency (MEMA) has a supply of radios that can be distributed to areas that need radio assistance. These are State Police 800MHz radios. WEM/EOC has one base station radio in their facility to communicate with the state police system. The state has set aside a special frequency that can to be used for these radios. Hospitals have their own radios all ready supplied.

If Worcester places a request to MEMA for the additional radios, it would take approximately 30mins for about 20 radios to be available in Worcester. One can assume it will take longer if they radios are being transported by car. Central Massachusetts Amateur Radio Association (CMARA) can provide a communication system of 40-50 radios. They provided communication services during the great Worcester warehouse fire.

Not all the radios in Worcester are the same. Different model types of radios are needed to satisfy the conditions the radios would be used in. For example, the police and fire use different radios. Firemen require waterproof radios because their environment interacts with a lot of water. They also wear thick gloves for protection against the fire. These gloves require the need for switches instead of push buttons for easier operation.

The State of Massachusetts is currently conducting a survey to determine what radios system will be used state wide. This is manly because of the lack of interoperability at the World Trade Center incident. Interoperability is new terminology used to define communications between two or more agencies.

Dispatchers are very important to the communication network. They provide information and organization to the responding emergency units. Dispatchers have a high stress jobs and very odd hours. Apparently, it's hard to find qualified trained personal for this job. Dissipaters are usually trained on-the-job.

During the World Trade center incident, the emergency agencies and first responders did not setup a unified command structure, also known as the incident command (IC). The objective is to organize the agencies in order for them to work in concert with each others efforts. Each agency had setup their command posts in different locations, both inside and outside the building. The police department had a helicopter relaying communications about the buildings condition. When a helicopter told the police to evacuate the building, no one ever communicated with the fire department to evacuate. If a unified command was established, more lives could have been saved.

The goal of this state-wide survey is to try an increase the level of inter-operability between every town. They have decided so far not to have one type of radio system thought the state. The more ideal implementation would be to split Massachusetts into regions. The regions will be networked and patchable so all regions are compatible. Not every town needs a very sophisticated radio system, especially small towns. These smaller populated towns would find funding problems for the expensive radios systems.

5.2.3 John Ruggiero

John Ruggiero is a dispatcher at Massachusetts State police, who also works as a part-time dispatcher at the WPI Campus Police. In addition to this, he is the Emergency Medical Communication Engineer for the Worcester Emergency Communications Team. Our first concern or question to him was about the trunk system Worcester uses for Public Safety communication.

His response was interesting given the fact that it should work pretty well if it is used as designed. One problem the State police and other public safety organizations face is when using the system to the system's capacity.

The system utilizes ten channels. One channel is for data, and the other channels are dedicated to groups. For example, when one personnel in the fire department starts talking on the radio, the system recognizes him as the fire department, and chooses the first free channel and places him on that channel. It also takes the other radios that are indicated as fire department and places them on that channel, which allows them, as group, to listen to his transmission. Since the system has only nine available channels at a time, if ten groups decide to talk at the same time, one group will be rejected by the system no matter how much of an emergency that group is in.

Another problem faced by the trunk system is solid obstacles. For example, when a firemen or a police officer enters a building and attempt to communicate to others on their radios, their signal must first be able to penetrate through the building in order to interact with the trunk tower.

"The placement of the trunk repeater system was not the optimum choice. First it is out of the way, and second its all too high for them," comments Mr. Ruggiero. He also notes, "It's true that the system has more capacity than they used to have with the old system [but it has more uses than the department utilizes."

One good solution that the public safety agencies can use is the BDA repeater (i.e., the Bi-Directional Amplifier repeater). The repeater works on 800-900 MHz. It has two antenna inputs in it. One directional antenna can be placed outside the building while the other is placed inside the building. This can be accomplished by using a stream of cable with grooves in it to expose the conductor called a "leaky coax." The coax will then act as a radiating antenna (radiax). As a result, what is inside the building gets amplified outside and vice versa.

One problem with that system is that it repeats everything in that range of frequencies giving you, affecting paging systems, cell phones and any thing in that range. Sometimes if a paging transmitter is within range, such a on the roof of a high rise buildings, it can end up overloading what goes in there and result in all kinds of intermodulation. It is very tricky to implement. But if engineered correctly and install properly, it works well.

One situation involved Airborne Express in Shrewsbury, MA. Airborne utilized Nextel for all their PDAs and couldn't get Nextel coverage inside their warehouse. Unfortunately, the BDA was installed in an unprofessional manner, and ended up taking down a couple of state police trunk system down. When the state police radio technician went to the warehouse to investigate the problem; they found out that the two antennas were connected to the BDA, but both antennas were outside the building and next to each other. This made the BDA retransmit everything it receives, plus what it transmitted from the other antenna, which resulted in the overload.

When Mr. Ruggiero was asked if had used any of the trunk systems and, if so, could he comment on the quality of its use. He mentioned that its easy to use and it works well. But the problem is that these are considered commercial radios and have licensing restrictions.

6 Specification Analysis

6.1 Propagation

Propagation, when referenced to radio transmissions, is defined in Webster's Dictionary, as "the act of traveling through space or material – use of wave energy (as light, sound, or radio waves)." When used by radio operators, it refers to the ability of a signal to travel from one point to another and the quality of the signal at the point of reception. This section of the report will cover how propagation affects the radio communications of the city of Worcester, MA. Concepts covered involve terrain issues, such as buildings, hills, the dead zones they create, and operation inside of buildings. This section will propose the problems that are faced and also offer potential solutions as to how these problems could be rectified or mitigated. This section will also cover the

various modes of operation that it is possible to use for a communications system. The modes considered will include simplex, repeater and trunked operation. The advantages and disadvantages of each will be discussed.

A dead zone is a sub-area inside an area of operations where radio signals are not detectable or receivable from certain sources by certain equipment for various reasons. The City of Worcester contains many of these areas, which are caused mainly by hills and buildings. The reason these dead zones exist is that radio communications used by the city are in the ultra-high frequency (UHF) portion of the radio spectrum. Radio operations at these frequencies tend towards acting like light, that is, they are absorbed and reflected by solid structures rather than passing through them. While a certain amount of the radiated signal does pass through the buildings and hills, more does not. This causes the signal to fail to propagate into the area of indented reception. Due to the fact that all civil radios operate in the very-high frequency (VHF) portion of the spectrum, and which exhibits similar traits as UHF, the UHF portion of this problem cannot be overcome by shifting frequency.

One solution to this problem is to use higher gain antennas on all radios used by city officials who are expected to have the ability to use their radios at all times. Gain is defined as "the signal-gathering ability of an antenna." What a higher gain antenna would do for the radio system is allow the system to detect and hold weaker signals than normal. The drawbacks to this solution are that higher-gain antennas are usually incumbently taller and cost more money.

Another solution to the problem of dead zones is the installation of repeaters in various areas of the city to increase the overall coverage of the system. Repeaters are devices which listen on a specific frequency and retransmit whatever they receive on that frequency onto another frequency. Repeaters can be linked so as to provide overlapping coverage. Therefore, as you leave one repeater's ability to hear the signal, another repeater picks up the signal and relays it in place of the original one.

Repeaters would be a necessity in any system used in the city. The sheer fact that the city would need the signal to reach the city's limits is a very difficult proposition without a repeater system. For instance, the police department, and its communications facilities, is in the midst of several hills which severely limit the ability of signals to propagate from the police department to points over the hills surrounding it.

An alternative to repeater operation would be a multiple node trunked system. Very similar to repeater operation, a trunked system would allow multiple points of reception set up around the city to be rebroadcast to the rest of the city. This rebroadcast could occur over radio frequencies, via landlines (e.g., fiber-optic cables) or a combination of both. While the system would be more reliable and fault tolerant using a radio frequency rebroadcast, such a system could lead to frequency crowding.

Landlines have the benefit of not crowding useful radio frequencies; however, they suffer the disadvantage that communications via a landline system can be interrupted rather easily. The best solution is a combination of the two systems. A landline would be used first and when it is not possible to do so, the system would switch to using radio frequencies. Note that repeater operation can also use landline forwarding rather than radio frequency forwarding with the same advantages and disadvantages.

The problem of operation inside a building is much the same as that caused by operation in close proximity to buildings, but much worse. When inside a building, the propagation restrictions not only involve all side walls, but also include the ceiling above and the floor below. Radio signals can also be influenced by electronic devices, such as computers, lights, and televisions of which there are many in buildings today. This problem gets even worse when operating inside of high-rises where there are many floors between you and the outside world.

There are three solutions that are easy to implement for this problem. The first solution is the in-building repeater. This is a device much like the repeaters discussed in the previous section; however it listens over a broad range of frequencies inside the building and repeats them to the outside world. These systems have an antenna in the building they're to be used in and an antenna on the roof to get the signal out of the building. A system like this could be implemented in every high-rise in the city, or could be made a requirement for the buildings to have per the fire code. This would allow firefighters the ability to enter any building in the city and expect to be able to talk to those outside of the building. The disadvantage of this system is, like the others, cost. However, this system would be necessary in any building that is a certain height, particularly those in the downtown area where there are many buildings in close proximity of each other. This further prevents signals at the ground level from reaching outside and high enough to get to the towers.

The other option for a solution to the problem of building is that of local talk-about. This system removes the radio in question from the overall system and puts them on a local channel with only other operators in the area. In this case, there is a user outside of the building who can hear the radio communications inside the building and, if necessary, relay communications to the rest of the communications network. This system is much less cost prohibitive than the first. However, it can be much less useful in certain situations such as when a firefighter attempting to signal to the ground floor from a higher floor in a high-rise.

Lastly is the idea of an in-car repeater. This device performs the same function as a repeater, except on a smaller scale. When activated by the operator this device takes all the operator's radio transmissions from their portable device and forwards them to the rest of the city at higher power and from outside the building. It also listens to everything the operator would hear on the channel they are listening on and rebroadcasts that to the officer's portable device from a closer range, thus improving incoming signal reception as well. The benefit of this system is that, unlike the in-building repeater, it improves both incoming and outgoing reception without requiring two separate devices, and it is not nearly as complex operationally as the idea of local talk-about groups.

6.2 Modes of Operation:

The first mode of operation, simplex, is the simplest mode of the three that will be discussed in this paper. Simplex operation is half-duplex communication (i.e., you are either speaking of listening, but not both at the same time) using a single frequency and no automatic forwarding systems. In simplex operation the only way to relay a message to a distant station is via an operator with shared coverage of the two stations repeating the message. This is the oldest mode of operation and requires the least complex radio equipment, but most complex operational procedure to follow, particularly if messages have to be passed between to parties who are out of direct contact with each other. In a simplex system only one person can be talking per frequency. Simplex systems can be expanded by using multiple, different frequencies for each service.

The benefits of simplex operation are first its simplicity. It requires no equipment other than the radios themselves. The radios can be set to use a single frequency, thus reducing operational confusion. As for its usefulness, in modern-day systems Mark Rubin, Director of Worcester Emergency Communication Team, exclusively uses simplex when running his emergency communications drills. The reason for this, as he says is "...the assumption is that if it's a drastic emergency there will be no power to the repeaters." Simplex has no similar power reliability issues.

The disadvantage of simplex, however, is that it is considered short-range with respect to the other modes of operation and suffers greatly from such things as blocked line-of-sight due to trees and buildings. Due to Worcester's great number of hills, and the thickly settled downtown areas, it may be particularly difficult to get a functioning city-wide simplex system going if the base of operations is located at the current police station.

The main use of simplex then, in a civil service system, would be in times of emergency when there was no power to the repeater or trunk sites. It could also be implemented to act as a local talk-about system as discussed in the section on in-building operations. It would not be the primary mode of operation for the radio. However, the radio should have the ability to operate in a simplex manner should the need arise.

Repeater operation is very similar to simplex operation in the manner in which it is conducted. The only difference is that it uses repeaters which were discussed previously to extend the range of the system. A system such as this would use multiple repeater sites throughout the city to provide coverage of all possible areas.

The benefit of repeater operation is that it provides a way to extend the range of a simplex system beyond line-of-sight. Repeaters are usually placed at high altitudes, such as on hills or on the roofs of high-rises. This allows them not only to see outward, but also to see down into their coverage areas. The outward range benefits for simplex systems can be upwards of 50 miles, which is well more than enough to cover the entirety of Worcester. Using multiple repeaters covering the same area you also decrease the number of internal gaps in coverage as discussed above.

Repeater operation's disadvantage is that repeaters are vulnerable to attack, power outage and other unforeseen disasters. If using the repeaters is the only way the radios can function, and there is loss of all the repeaters in the system, the radio coverage throughout the city will be adversely affected or there could complete loss of communications capability. This would be disastrous in an emergency situation when the ability to communicate is critical to successfully managing emergency operations.

To combat these disadvantages, the options are: applying repeater redundancy, or equipping the radios with the ability to operate without the repeaters, such as with in-car repeaters to extend the range of portable radios, when the repeaters are inoperable.

The first method is costly because the repeaters themselves are not inexpensive devices and such a system would require a significant number based on a catastrophic scenario. The second method is less expensive because the in-car repeaters cost less than a large number of full-size repeaters. The in-car repeater is also more fault tolerant because it is not reliant on a power grid or fixed position repeaters.

Trunked operation is similar to repeater operation in that it involves the use of towers and is fixed to a power grid of some sort. The difference is that unlike repeater based operation which uses fixed frequencies, a trunked system allows multiple services to share the frequencies by assigning a set of frequencies that rotate through the service using them as necessary. Worcester is currently using a trunked radio system based off the Ericsson EDACS system, which is one of the two main trunked systems currently in use. The other is the Motorola system currently being used by the Massachusetts State Police.

The benefit of a trunked system is that it allows a large number of agencies to share a smaller amount of frequencies, which is good given the limited amount of band space available on the radio bands that civil service radio equipment use. The trunked system that Worcester currently uses is fault tolerant to certain extents and can operate to a certain degree without the assistance of the trunking system. This is obviously preferable to a repeater system where the system will fail without the presence of the repeaters. However, the portable radios will still lose range without trunk nodes to repeat their signal.

The disadvantages of the trunked system are in the way it functions. Trunked systems have a limited number of frequencies which cannot support all the clients that could potentially use it at any one time during a catastrophic emergency. If more clients attempt to use the system than there are frequencies available, the system will reject their call. This system is best under normal usage and begins to suffer dramatically only during emergency operations when the communications tempo is robust.

The trunked system also suffers the disadvantages that repeaters suffer. Similarly, they are expensive, require a fixed location, and subject to loss of power, and if connected via fiber optics, loss of communication usefulness.

In summary, there are many things affecting a radio's ability to operate effectively in an urban environment such as that of Worcester. Fortunitly, there are also ways to overcome these difficulties. The choices made in deploying any new system are very important to its eventual functionality or dysfunction at critical times. The choice of backbone for the system also contributes to how well the system is going to operate, and should be carefully considered before any new system is implemented.

6.3 Types of Power systems

From the moment the radio is turned on, the radio begins consuming power. Even listening to the noise of the radio's frequency draws power, regardless if its a fraction of the power usage for transmission. There are three main power systems that radios can rely on for power. These power sources are Batteries, Fuel Generators, and Commercial Power.

Batteries store large amounts of electrical energy and can be discharged at different rates and voltages levels to power electrical devices, such as a radios. A battery supply for a portable radio is very small compared to the battery supply necessary to drive a mobile or base station radio. This is why portable radios are more commonly associated with battery power. Their small and light size makes batteries a great energy source for mobile communications. A more detailed description of batteries is discussed in section 6.4.

Fuel Generators are necessary power sources at any location that lacks a power source. They are especially an ideal power source for emergencies because it can supply uninterrupted power to vital communication systems. Generators convert the mechanical energy from, typically, a fossil fueled engine as it spins a coupled motor, with wire windings, into electrical energy. Many generators can provide 1000's of watts continuously at 120v AC and 220v AC. Liquid fuel generators can typically run off of simple unleaded gasoline engines to drive the generator. A large size fuel tank can be stored on the facility to power the generator and could supply power for days (depending on the power consumption). As more power is required, the motor consumes more fuel to drive the generator faster. Remote locations can also benefit from fuel generators.

The same power requirements can be supplied in a smaller size generator for mobile use. The cost of the generators can be expensive and require maintenance to ensure operation when needed.

Commercial power is electricity generated and distributed from a power plant facility to individual homes and businesses over great distance. These power plant facilities produce electricity from generating facilities that have fuel sources such as nuclear fission of uranium, as well as fossil fuels like gas, oil or coal. Then the electricity is distributed over girds and power lines to service areas providing millions of watts to customers. Under normal conditions, commercial power can be used as a reliable energy source. In some emergency situations, commercial power could be disrupted by power lines that are unsupported and lying on the ground.

The largest power consumption the radio draws is when the radio is transmitting. Most portable radios transmit from ¼ Watt to 5-10 Watts of power where mobile and base station radios can transmit 10s to 1000s of Watts of power (i.e., assuming the mobile and base station radios are using power amplifiers). Generally, the more power you can transmit with, the farther the distance your signal can travel.

Batteries meet the power requirement for portable radios and mobile radios can be powered by larger batteries, but with a limited output transmit power. Higher transmitting power of mobile and base station radios require a large power source, like fuel generators and commercial power.

Radio repeater(s) in Worcester require the use of electricity to amplify the retransmitted signal over a larger distance. If the repeater were to lose its commercial power, then unified communication system would fail. Installing fuel generators near the repeater(s) can provide an alternative power source to ensure the uptime of the communication system.

6.4 Batteries

Batteries are a common everyday item whose only purpose is to store an electrical energy so that it can be later converted into useable energy for the driving of electrical components. For radio communications, batteries can be used to power different size radio systems from small portable (handheld) radios to large base stations. Batteries have many different types of properties, composition and specifications. The most important information you need to know before choosing a battery are the system power consumption, battery/service lifespan, size/weight requirements, environmental conditions and cost

Since radio power consumption and battery specifications differ depending on the requirements for each, there is no one or right standard answer in battery selection. The selection process involves an understanding of the specific operating requirements in order to reduce the selection to a few possible choices. Certainly, determining the rate and amount of power consumption is required by the radio system is an essential first step. Then establishing the amount of time the radio system must operate, before its battery system must be recharged, is critical to sustaining uninterrupted communications without power loss.

The battery's power producing lifespan requirement is dictated by the total hours of radio operation. Radio operating situations involving 12+ hours of operation require a cost/benefit analysis to determine if multiple batteries are required to sustain operations. This must be balanced with the knowledge that batteries have different chemical compositions, which generate different electrical potentials, and require differing rates and times for recharging before they are, again, ready to be a power source for the radio system.

Storage and service life of the batteries are also very important when choosing a battery. Unfortunately, batteries have a certain shelf life depending on their chemical composition. Service life of the battery depends on how many times you can recharge the battery before the battery begins to lose its ability to retain a charge. It also depends on the batteries storage conditions which are greatly influenced by certain environmental factors. Depending on use, expected service life of a battery is generally a few years.

Common environmental conditions that affect a battery's performance are temperature and humidity. This is because the discharge rate increases as temperature and humidity increases. Depending on the batteries chemical composition, environmental conditions can cause stress on a battery and reduce its useful life.

Usually, the larger the power requirements of the radio are, the larger the battery size will be. Portable radios - commonly called handheld radios for obvious reasons - should not be too heavy or large in size. The dimensions and weight of the radio and battery can directly affect the radio operating performance of the user and, thus, interfere with proper communications.

Since batteries only have a limited shelf-life, there will come a time to dispose of the battery. Battery packs are not to be disposed in common waste facilities because they cause environmental contamination of the ground due to the leaking out of the batteries chemical and container compositions. Rather, use of designated recycling facilities, which charge a fee, should be used to safely dispose or recycle discarded batteries.

Depending on the power source budget, cost can greatly influence the overall selection a battery for the portable radio. As the performance and characteristic specifications of the battery increase the price of the battery also increases. Usually, when purchasing a portable radio transceiver, one battery is supplied with the radio. An extra supply of batteries will require an additional purchase cost depending on recharging requirements. Batteries can be charged by either the internal radio battery charger and/or and external battery recharging station. The internal radio battery charger requires the use of a wall transformer to plug into the radio, usually with the radio turned off. This will consume many outlets and space and limit the number of radios you can use.

The more cost effective approach for recharging capabilities would be to use an external battery recharging station. These recharging stations can hold and charge many spare batteries at once, requiring only one outlet per station. This would allow for the continuous radio operation and limit the length of interruptions just for battery recharging.

Batteries are very important for emergency communications because they can power radios when electrical outlets in buildings or in vehicles are not available to accommodate the radio's power adapter. This is beneficial to Worcester's emergency response or safety personnel who must enter buildings or travel through forests carrying portable radios without the need for external power sources.

Emergency batteries can also work as an uninterrupted power supply when commercial power fails. Batteries can, temporarily, provide a constant flow of power when transitioning from commercial power to an on site fuel generated power source. Base station radios can use the uninterrupted power system to ensure steady communication with other radios in the system.

Depending on the battery and its use, the battery will need to be replaced after a certain amount of time for recharging. During an emergency, there is no time to wait 4-12 hours to recharge the battery. Purchasing sufficient spare batteries with the same specifications, and periodically charging the spare batteries, is the most practical solution to keep communications on-line. The amount of batteries purchased for each radio depends on the expected utilization time of each radio. For example, if a portable radio must operate 12 hours and the batteries last only 6-7 hours, then one spare battery should be purchased, in addition to the one battery that already comes with the radio.

6.5 Human Interface

The human interface of any radio device is very important to its successful operation. This is particularly true when the radio is being used in life or death situations. If the radio is difficult to operate, the operator may lose precious communications time which could cost him, or others, their lives. This section will analyze the different components of the human interface involved with radio communications, describe why each is important, and make suggestions as to which types of each particular component are preferable. The analyzed features will be the radio's controls, the radio's ability to give feedback to the controls, and ease of programming the radio to do what is necessary.

The controls on a radio consist of buttons, switches and knobs. These controls are used for adjusting the volume, squelch (i.e., the radio's ability to reject weak signals), ease and ability for changing channels, turning the radio on or off, and activating the radio's transmitter.

Buttons are usually used for channel changing and modifying the settings of a radio. Buttons have the advantage of being harder to inadvertently press, and can be made smaller to fit the unit. This allows you to have one button per function rather than many functions per button that depend on context. Things that change function based on context are innately harder to use, longer for users to train with and understand, and inconvenient to operate during emergency operations than things that simply perform one function. Buttons can also be held down to perform the same action repeatedly, such as changing channels.

The main disadvantage of buttons is their size. Buttons are usually rather small and can be difficult to find in a stressful situation. This disadvantage, however, is mitigated somewhat by the fact that most of the functions that buttons perform are not necessary in everyday operation. Thus, buttons should be reserved for non-mission critical functions on the radio.

Knobs on radios tend to be used for squelch, volume and channel changing. The advantage of knobs is that they are analog rather than digital and provide direct control over the potentiometers that control the volume and squelch. Knobs can also be digital. However, these digital types are usually used for menu control and channel changing where the items are discrete and an analog knob would not be appropriate. Knobs are generally large enough and placed in a prominent enough location to avoid confusion and misuse. The disadvantage of knobs, particularly analog knobs, is they are very easy to, inadvertently, knock out of position, unless there is a function on the radio to lock them in position. Knobs also tend to have multiple functions if used as the primary method of controlling radio operations.

The last form of control method on radios is the switch. The primary use of a switch on a radio is to be able to trigger the transmitter, called the push-to-talk (PTT) switch. This switch is a common feature to almost all radios. The main alternative to PTT is voice-activated transmission (VOX). This causes the transmitter to activate whenever the operator speaks in a fashion that the radio's microphone can detect it. This is usually not the preferred method of operation for civil service radios because it would cause much unnecessary clogging of channels. The radio should keep with the standard PTT methodology.

There are many varieties of ways that radios show their status to their operators, most of them some form of LCD display. These displays convey important information to the operator, such as current channel, battery amount left and signal quality. For civil service use there is no need for a large LCD display and a single line display should suffice. However, this display should have the capability to display alphanumeric names for channels and not simply the frequency the radio is on. The reason for this display arrangement is that portable radios are associated with one service and, therefore, there is no need for continuous display of radio frequency. Also, it is much easier for people to remember channel names than frequencies.

6.6 Audio Quality, Durability, and Size

Sound quality of radios can mean the difference between life and death for victims of emergencies and emergency personnel, as well as, for protecting property from damage or destruction. Clear communications between personnel contributes to effective and efficient emergency response objectives. The requirements for clear communications are many and each can interfere with the sound quality of transmission. Power, radio frequency (RF) propagation, sound processing in the radios, the effectiveness of the radios speakers and microphones, and the use of either digital and/or analog transmissions can all affect collectively, and individually, the quality of the transmitted sound.

The necessary hardware requirements for transmitting and receiving optimum sound quality are the selection of good microphones and speakers. Selection should be sensitive particularly to a microphone's ability to distinguish between background noise and the person who is speaking into it. Both microphone and speaker should be able to filter noise from actual transmitted voice.

With ports on the handheld to place an external microphone and headset, there is greater flexibility and convenience in handling the radio during communication exchanges. The user can place the radios on their belts and use an extended microphone and headset to communicate efficiently. However, choosing to utilize an external microphone for reasons other that than the ability for producing good sound transmitting quality, is neither a convenience nor a benefit, and in fact can easily turn into a liability at critical times.

Fortunately, today's sound processors, found within the radios themselves, have the ability to detect the level and frequency range of background noise and eliminate it while keeping the user's voice transmission intact. Sound processors can process these audio inputs either digital or analog form. The topic of digital versus analog filtering is a bigger topic than can be fully addressed in this report. However, there exists a variety of both manufacturer and technical literature available to discuss it in more detail. For this report, it is sufficient to know that there are more advantages with digital sound processing than there are for analog sound processing or filtering.

Analog filter circuit components have characteristics that are subject to drift and are dependent on temperature. Unlike analog filter circuits, digital filters are more stable and temperature independent. Another other important difference between these technologies, is that analog filters have the ability to easily filter high-frequency signals while digital filters are more accurate with low frequencies Digital filters, which use a DSP chip (Digital Sound Processor Chip), are programmable. This means that either a computer chip in the device or an associated memory storage bank can contain written programming (i.e., coded software) to better manage the filtering process for all sorts of anticipated sound conditions. This ability to easily program, or reprogram, is not available in analog filters, which require physical redesign of part, if not all, of its circuit or large variable components. Most portable and mobile radios purchased today use DSP chips which allow for the radio to be smaller and more compact in design. Certainly, digitally equipped filtering devices can be more readily mass produced than analog devices. In theory, this reduces their cost and makes them more available.

The use of either digital or analog filtering technology can be very distinguishable and recognizable in their capacity to transmit sound. Analog filtered signals are always easily understood and easy to implement in radios, but require more radio bandwidth to transfer the data., but in turn it use up a lot of power Digital filtered signals use much less radio power bandwidth and require more complex components to convert in and out of this format. While professionally trained and practicing radio operators can use either technology to hear or recognize the transmitted voice over noise signals, the general preference is towards digital filtering because the aid of computers and microprocessor (DSP chips) improves the response time for acquiring a signal.

Radio durability is particularly important in adverse weather conditions if it is to operate properly. Though it's a small county, Worcester has a varying terrain that attracts various weather conditions. The terrain varies between open and hilly to flat valleys, with embedded building, clustered, areas in each. The open areas usually encounter a lot of winds blowing at varying high speeds. The weather variations in Worcester are very large. According to the *www.weather.com* web site, ,the average temperature ranges from 16°F to 61°F, with a record low of -13°F.

These weather conditions impact a radio's components in various ways. High winds contribute to background noise that a radio's microphone picks up when a person is speaking. Extremely low temperatures can impact batteries in mobile operations causing the battery to freeze and stop generating enough power to operate. Either the purchase of batteries that can withstand anticipated weather conditions or storage of the radio in a warmer environment can solve this type of situation.

Snow and rain are the most important weather conditions that affect radio operation. If the radio is not water proof, then the potential for rain and snow to enter the radio circuitry area is great. Water inside the radio could cause short circuits and stop operating or damage the radio. A short circuit can also lead to over discharging the battery and shorten the life of the battery.

The last consideration in radio functionality is the size of the radio. While bigger may be better, it is not necessarily convenient for the application or the end-user. Base radios, for instance, are usually large in size to accommodate the radio equipment needed to transmit within the area they must serve. Certainly, multiple broad ranging frequencies may warrant larger capacity radio cabinets to house all the hardware for

reception and transmission at respective frequencies. Added to this sizing issue are the physical accommodations and environmental conditions that must be provided for good operations of all the related equipment. Ergonomics considerations must be include for the human operators.

For mobile operation, human ergonomics absolutely dictate the size of the radio selection. Carrying bulky, multifunctional, radios by emergency first responders (e.g., firemen and police) that must enter a hazardous area or assist victims at an emergency event, is impractical and even dangerous for those that attempt to use them. Also these individuals will probably be wearing gloves or bulky outerwear. As a result, first responder's radios should be small and light in weight plus have the convenient and accessible controls to modify the radios functions, such as increasing the volume or changing frequencies.

Mobile units can be mounted in a vehicle or trailer to be used for command post type operations. The radio equipment for mobile units can be larger in size, more versatile in frequency transmitting and receiving capability, and require a larger power supply then portable radios. However, these radios should not overpower the confined space that these command posts are limited too. This can impact the human ergonomics for operators that have multiple tasks (e.g., event logging or even driving) besides radio operations that could need desk space for laptops and other information gathering equipment.

6.7 Storage

When backup radios are not in use, they will need to be stored in secure locations. It is important when storing the radios to ensure that they are in a status of operational and ready to use in the event of an emergency or necessary circumstance. Types of storage locations and containers, storage temperature/humidity, battery condition, and miscellaneous equipment are issues that must be addressed when storing the radios.

They are many places that backup radio equipment can be stored. Commonly, they are stored at an emergency facility, such as a police or fire station. These locations guarantee that the radio equipment is accessible to the requesting emergency organization and/or operators.

Security is also important when choosing a storage location. The radio equipment should be locked up at all times to limit the possibility of theft. However, the locked facility should be rapidly accessible by those needing the equipment. A simple battery powered electronic combination lock would be the ideal security device because the combination can be changed at anytime and the combination can be distributed more efficiently then with keys.

Containers and bins are great for organizing and transporting radio equipment. The containers should be padded with foam or other static-free packaging material to reduce the shock during transporting.

Radio equipment, especially batteries, can be effected by changing temperature and humidity within the storage room. Temperature specifications on each item stored should be documented. Generally, room storage temperature should range from 60-75°F. It is advised to store the radio equipment in a room that can sustain and be monitored for the appropriate room temperature. In addition, high humidity can damage the

components in the radio and also diminish their operational value. Using a dehumidifier can keeping the room in a dry state and your equipment functional. Consequently, efforts to control and maintain appropriate levels of heat and humidity helps to guarantee functionality after storage.

Another integral part of radio storage is storing its power supply. Stored batteries self discharge over long periods of time. Depending on the battery type, a stored battery can diminish its charge potential by 10% or more per month. Obviously, this can be detrimental if the battery has discharged to the point that it cannot supply the necessary power when needed.

One solution to this situation is to strip charge the batteries over a shorter period of time, such as every two weeks (or as specified in the charging instructions for the type of battery). Batteries, like the rest of the radio equipment, are sensitive to storage temperature because excessive heat can cause the battery to expand and leak. It is always advised to read the storage specifications on each battery type to ensure long life of the battery.

There are other miscellaneous radio components that must be stored. Spare parts, other power supplies, antennas, coax cable, spare microphones and speakers, and battery chargers are just some of the miscellaneous equipment needed to be stored with the radios. All these items can contribute to the functionality of the radio. These items should also be stored into organized, padded, containers; with all wires untangled to optimize distribution.

6.8 Transportation

Not all cities and towns are equipped to handle communications for large scale disasters. This may be limited to the number of radios and/or the number of radio operators. Federal and State emergency management agencies can supply a disaster area with additional radio equipment, operators and/or an alternative communication support. Examples of federal and state organizations are the Federal Emergency Management Agency (FEMA) and the Massachusetts Emergency Management Agency (MEMA), respectively. Essential items that would be included in the containers are radios, extra batteries, and chargers.

Emergency management agencies can supply numerous amounts of radios if requested by cities and towns. The equipment usually arrives in bulk filled storage creates, ready for use. The transporting of the containers can either be sent by ground or air transportation. Ground transportation, such as cars or trucks, can carry large amounts of equipment.

The disadvantage to this backup radio supply approach is the necessary time delay between the request for additional radio equipment and the time of needed delivery. If the disaster is affecting a city area, the cars and trucks providing ground delivery might run into traffic jams and, as a result, add considerable delayed to the much needed equipment.

Air transportation is a faster way to transport the equipment, such as by helicopters or airplanes (for long distances). However, air transportation may not always be possible due to adverse weather conditions, restricted or unavailable landing areas, and air carrier availability.

Regardless of which method is used for transporting the additional radio equipment, the commanders of the disaster should only need to utilize this additional equipment if the emergency is of long enough duration that the equipment and personnel will be available. Planning and performing simulated emergency operations for such catastrophic events, will prepare everyone involved for what can and cannot be accomplished in any reasonable time. This should include mutual aid agreements with abutting communities that can offer help and equipment in a much quicker time period.

7 Conclusion

In terms of achieving its goals, the IQP project team came to the following conclusions:

Assessment of current communications equipment and its capabilities

After researching the system though interviews and literature, the IQP project team's assessment suggests that Worcester's EDACS "trunking" system will be effective most of the time when, and only when, the radios are used within the City of Worcester. In order for the EDACS system to be functional, a series of complex systems and equipment must be in operational at all times.

The Worcester EDACS system is a fairly accommodating communications system. This system can provide up to 10 simultaneous conversations to whatever group the user would like to talk to. The implementation of the group organization allows for the numerous Worcester based agencies and personal to communicate efficiently with little confusion. Simplex and multi-channel repeater systems, unlike the EDACS system, would require the user to interface with the radio and make adjustments to communicate with others on this large scale. The EDACS system handles all operations of frequency

allocation and allows the user to easily select which group he/she would like to communication with.

Assess efficiency of interagency communications

According to the IQP project team's information, there are only two towers supporting the EDACS system. The EDACS radios have a restricted communication range limited by the receiving and transmitting distance from the towers. Generally, this means the EDACS radios can only be used within the Worcester city limits.

The IQP project team's research indicates that no other non-EDACS radios can use the EDACS towers, and that no non-EDACS tower can use EDACS radios. Of course modification or "patching" of the EDACS system can allow for other radio systems to interface with the EDACS system. However, this would only allow neighboring towns to interact within Worcester, but still limit the ability for EDACS radios to truly work outside the city's communications area.

Identify state-of-the-art communications systems in order to compare to Worcester's current communications systems

When the IQP project team began to research the details of Worcester's communication system, the team's efforts to access critical design information was limited because of security restrictions as a result of post-9/11 policies. This is understandable and the team was respectful of these policies. As a result of these security restrictions, the team was unable to acquire more specific information about the communication system for a state-of-the-art comparison. The Worcester communications department did provide us with very little, high level, information. Much of what was

given to us was already known and was sent, by the department, much too late in this project for any further consideration.

However, based on today's standards, this much can be said about Worcester's communications system design: The EDACS system is similar to a cellular phone system where the radio must always be in communication with the tower(s) to operate efficiently. If the tower should fail, the system would not function as designed. Moreover, in the event of a tower or system failure, the EDACS system can function in "fail-soft" mode, which allows for communication in simplex mode on a single frequency.

8 Recommendations

In terms of its goals, the IQP project team evaluated a number of key problems and offers the following recommendations for their resolution:

Propose any future improvements to Worcester's emergency radio communications systems.

Problem 1: Worcester has two transmitting towers in different positions to gain maximum coverage. Each tower provides coverage over one division of Worcester. A failure of one of the towers would result in a radio blackout of half the city and a failure of both towers would ultimately cause a radio blackout of the entire city. Should failure of the two towers occur, Worcester's communications operations may default to the Simplex mode of communications.

Recommendation 1: Operation in simplex mode for the City of Worcester is not practical because the operators are not experienced enough, many hill formations prohibit the signal to carry long distances, and there are simply too many operators that need to

communicate over the one frequency. Consideration should be given to identifying failure scenarios and probabilities, and then evaluate what practical solutions can be implemented.

Problem 2: Buildings and "dead zones" can restrict the communication with the tower. Worcester has many buildings that can prohibit the radio's signals from effect escaping the building. It appears that fire fighters are mostly affected by this situation.

Recommendation 2: The IQP project team recommends that the most practical and most cost efficient action, over building multiple towers, could involve the addition of an in-building repeater, and/or utilization of a mobile repeater, for increasing reception to the existing towers.

Problem 3: It is the job of the communication operators working at the incident command post to create interoperability during an emergency. Currently, some form of interoperability exists, but only within the boundaries of the City of Worcester. Communicating with emergency responder organizations outside of the city is non-existent with the current radio communications system. Therefore, depending on the magnitude of a catastrophic emergency, communicating to other agencies outside the city for the benefit of mutual aid is a crippling deficiency.

Recommendation 3: Interoperability is especially important for communicating time-critical information between multiple groups and locations. Common and interlinking radio systems will dramatically increase response time by efficiently communicating with the many people that are assisting the emergency.

The IQP project team has discovered that the State of Massachusetts is conducting its own investigation and assessment of interoperability capability with each and every town and city in the Commonwealth. Given that the State is conducting such an extensive communications study, it would be presumptuous on the part of the IQP team to recommend to the City of Worcester what system or equipment specification it should consider to achieve interoperability. However, the team does recommend that Worcester give serious consideration to developing interoperability in the near future.

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Appendix

A Common Questionnaire

Common Questionnaire to Be Used When Interviewing Different Agencies In Worcester

Questions for gaining more information need to assess the current communications equipment and its capabilities:

What equipment do they currently have?

-Handheld Radios (any band), Pagers, Scanners, etc
-Do they have charging stations and/or extra batteries?
-See attached file "System Criteria" for a detailed assessment for each equipment item.

How long has the equipment been around?

-When where the radios purchased.
-Do you have any old model radios (within 5, 10, 15+ years)
-Are there any unused features that the radios have?

Location and Accessibility of equipment:

-Where are these devices located? (Cars, trucks, charging bases)
-Is there enough radio equipment for every personal?
-Who distributes, manages and maintains the radios/equipment for you?

Features and modes of transmission questions:

-Are there any additional features that you would like?
-Do all the radios and features used by every unit in an agency have the ability to talk to other units with in that agency?
-What type of data (information) do you need to transfer?
-Are your transmissions encrypted?
-What type of mediums do you need to transmit into?

Emergency situation questions:

-Is backup power available for all base and tower stations?
-Have you encountered any safety risk when using the equipment?
-If the trunk system goes down, what is the alternative backup?

-How long does it take to bring up the back up system after it has failed?
-How accessible is the back up equipment?

Questions pertaining to past issues and/or problems:

-Have there been any problems encountered in the past relating to:
  -blackouts
  -dead zones
  -bad equipment
  -insufficient power supply
  -interference
  -maintenance issues
  -purchasing radios (insufficient funds)

Questions for gaining more information need assess efficiency of interagency communications.

-What systems are available for your use to contact other agencies?
  -Within Worcester
  -Within the State or Federal Level
  -What equipment is necessary for each of those systems?
-Does this system(s) have backup power?
-How efficient has this system(s) been in the past?

B System Criteria

Station	Mobile	Portable
-Power Life (Backup)	-Power Life (Battery/ Backup)	-Power Life (Battery)
-Signal Quality -distance -outdoors -indoors -dead zones -etc	-Signal Quality -distance -outdoors -indoors -dead zones -etc	-Signal Quality -distance -outdoors -indoors -dead zones -etc
-Ease of use -ability to clearly understand communication	-Ease of use -ability to clearly understand communication -size -antenna length	-Ease of use -ability to clearly understand communication -weight -size -antenna length
-Mode of transmission -simplex -repeater -trunk -etc	-Mode of transmission -simplex -repeater -trunk -etc	-Mode of transmission -simplex -repeater -trunk -etc
-Max # of connections	-Max # of connections	-Max # of connections
-Extra or Special Features	-Extra or Special Features	-Extra or Special Features

C Emergency Agencies and Volunteer Groups

State and federal agencies:

Massachusetts State Police
Massachusetts Emergency Management Agency (MEMA)
Federal Bureau of Investigation FBI
Federal Emergency Management Agency (FEMA)
Homeland Security

City agencies:

Communications Dept.
Police Dept.
Fire Dept.
Worcester Emergency Management (WEM)
Airport Dept.
Parks Dept
Public Works Dept.

Volunteer groups
American Red Cross
Worcester Emergency Communication Team (WECT)
Central Mass Amateur Radio Association
SKYWARN
Western Massachusetts Amateur Radio Emergency Service (ARES)

D Interview with Mark Rubin (WECT)

ICS is a structure that the city uses along with other cities and towns in the state. It's a good structure. It originated out in CA in 1972 due to massive forest fires that were taking place. It was a way to pool resources and to have a unified command structure. So you have one commander, an incident commander usually a police or fire chief. In the city of Worcester it's a fire chief or battalion commander, whoever shows to the event becomes IC basically. He appoints people; the ICS can expand or contract as much as it needs to, to meet the needs of the emergency.

You have an IC, and he appoints people. … And the other one I think is a liaison, a PIO if I recall. He deals with public information, the press and all that. Then there's the command structure. The FD, the PD, they all have a box and there's people off of that. Somewhere off of here, under logistics, and that's where we fit in. Communications, that's us. It could be a bunch of things. Anyways, I'm doing a crappy job. Nevertheless we're under here. Some incidents, they don't need all this stuff. A small fire, for example, you have an incident commander, and then as the fire grows you just grow the ICS. In a big fire, like the Worcester Fire almost all these functions will be involved. There's one group I left out, that's the financial group, the bean counters. But we're under logistics. The logistics people are very important, that's your public safety, all these groups are important behind the scenes. The DPW, the people that have to bulldoze an area so you can get in. It's not just the fire department and police. We utilize that system. If public utilities were involved they would be under logistics. Logistics is a big area. I recommend that you do check the website (www.fema.gov) and the course on ICS. You don't have to take it, but you can go look at it online, print out the documents. It's relatively short, it won't take long, but it's a good thing to know. There are two areas that we push here at WECT, that's one of them, knowing ICS. Because the city emergency management dept., who we report to, are big on that. The second thing is that we want to have a basic level playing field set of skills that we can use. And that's why we teach these ARES level 1 communication classes. So we can have that basic program. For $45.00 you sign up at the ARRL online, the course has been very packed. They're always filled within 24-48 hours. They're very hard to get into. But there's plenty available, so if you miss one now you can get one a month from now. It's an online program you can take two weeks if you want, some people take 8-10 weeks. We taught one here, a hybrid. We're thinking of teaching another one here this spring. We want everybody to be on the same "level" playing field. Level 1 talks about the basics, who are ARES, who's RACEs, what is a net, how to run a net? Its 20 chapters, about 160 pages. There's a bunch of activities you have to do, one of them is send a piece of traffic on a net. And I was so nervous the first time I

did it. A lot of people are. But now it's like doing it like drinking a glass of water. So we promote those two programs, I can't make you take it, but I'd like you to take it. If you depended on me for something, if I had some leeway over you I'd make you take it. So it's a loose req. it's something we hope you'll take. It helps us, it helps you. And I don't discourage you from taking level 2 or level 3. Those are more involved, more in depth and you can take those at your leisure too. It's a good program. $45 is not a lot of money and right now it's all being covered by grant money if you pass the class (and you have to be real dumb, or real busy not to). Some people are so busy they're too busy, but some people are just real morons. You get your money back. So those are the two training goals we have for this year. We'd like to see 100% compliance. We have 55 members; we'd like to see everyone take the level 1.

And the other training things we do are: the drills, the simplex net, those are training devices, live operations. The drills give us practice in public service communication using the EMA as the go ahead agency. So when we did the shelter drills last summer, we did three of them basically. We deployed to shelters thought the city, we test communications we wanted, and we did that at the behest of the city. They wanted us to establish communications between this location and the shelters. And it worked on simplex. Not that it wouldn't work. We also did some other drills with other EOCs in the 8 or 9 communities around the city. Those are the Ring 1 communities. Then there's the Ring 2, there are 13 or 14 communities, maybe there's 22 communities surrounding Ring 1, those are communities like Clinton, Spencer, Northboro, Westboro, Northbridge, those are the Ring 2s. So one of our goals this year, I'm not sure how we're going to accomplish it but we're going to try, is to build up RACES organization in the Ring 1 communities, and probably the Ring 2 communities if we can. We're trying to double our membership. We're 55 members right now, 55 good members. About 25-30 of those members show up to our drills. Some never show up, we may have to drop those members from our roster. So probably 30 good members, 55 total members. That's it as far as training and what we do. I'm open to suggestions. We have a website which needs a lot of updates.

We're looking for a liaison; at the quarterly meeting we talked about I want to get a liaison with the Salvation Army. Salvation Army is out here in Worcester, but they don't have SATERN. That's the Salvation Army communication group. There's one out in Boston. They have a nice website. We'd like to have a contact through Worcester and directly to them so we can do more with them. See, Worcester Emergency Management, Lt. Trotta is the director, and Dick Bedard (W1FIX) who, as you can tell from that, is a ham [amateur radio operator] is the deputy director. Basically, that's all they have, they're the only two employees right now. They had a secretarial person, but she was laid off. So, they don't have a big staff, that's why the use volunteers like us. When we do these drills, like the weapons of mass destruction drill all these people were there, the Red Cross, the FBI, National Guard, Salvation Army, etc. I'd like our team to more directly interface with these agencies, like the Red Cross, my wife works for the Red Cross, so kind of by default, she's a RACES operator and a ham, and she's going to be the liaison for the Red Cross. However, the Red Cross has a communications group with a ham, headed by a ham, Dave Tangretti, whose call sign eludes me. He's out of Milford, but he's based in Worcester. He lives in Milford. I'd like someone to work with Dave, join their group, and sort of be an infiltrator. Well, someone who is actually in the Red

Cross but also in WECT, not to report on them, but to tell them what we're doing and coordinate with them. So we can do more stuff. And those are the key agencies in Worcester that I'd like to see us working with. Obviously we work with emergency management they're our primary boss. So everything else goes through them. Police, fire, they don't have any use for us anyway. We're just a bunch of hams, wannabes who want to help out. [Q: So WECT doesn't actually help out [the police and fire directly?]] No, we help out Worcester emergency management, and basically by doing that we're helping out these other agencies. Whether they want to pat us on the back or not, I don't lose sleep over. Emergency management knows our value. They recognize us as a bunch of dedicated volunteers, ok? It has to do with money and funding, it's not that they wouldn't ask for our help if there was a major disaster of 9/11 proportions. They wouldn't hesitate to ask. At that point it's just get the help you can get. If you can get a bunch of trained people who will bring their own equipment, use their own equipment, know how to use the equipment and can function in emergencies am I going to say no? You'd have to be an idiot to say no… well there are some idiots out there, but most of them aren't, ok? The point is that they would use us. It has to do with they have to justify overtime for their people; you know they're looking at having to cut people start using volunteers, people say "Why don't we use more volunteers?" Worcester emergency management was not always friendly with the ham community. We had a few people out there who had egos, well, everyone has egos, but some have more ego than others. Some of the RACES officers, the last one or two had some serious ego problems and they butted heads with Lt. Trotta. He has an ego too, you know, we all do. And you know it's like the last guy, my predecessor wasn't going to take orders from Lt. Trotta and he was trying to tell Lt. Trotta how to do things. Well, Lt. Trotta said "Your nuts," and didn't want any part of him. He didn't allow any hams. This is what happens with the fire and police in some of the smaller communities around the city [Worcester]. They're the emergency management directors; it's not a separate function, it's a dual role. And so they form opinions, and you know perception is reality and so if this guy is a loser all hams are losers. You know, what are you going to do? How do you overcome that? Police and fire have their own issues between each other, but in an emergency they have to come together. And differences get left behind, it's the times leading up to the emergencies, the practices, the drills when people are not as cooperative as they could be. And it's just typical, it's human nature.

But the bottom line here is that, we have good fan in Worcester Emergency Management, DD Bedard and Lt. Trotta himself too, although Dick is more adept around hams, being a ham himself. He has joined CMARA [Central Massachusetts Amateur Radio Association] in the last year so he's good for us. He's the one who got our name out for the weapon of mass destruction drill and for this airport disaster drill. He's going to be meeting here this month, in this room or maybe in the big room. You're invited if you'd like to come. We're going to have a speaker to speak about disaster plans. I've got to have a conversation with Dave Tangretti about emergency communications. Big chance here to get our name out there, and that's a good thing, we want our name out there. We want name recognition because that way we'll get more events to do, and we'll get more credibility. We don't have enough credibility right now. We have credibility, we're capable people, but you build credibility and legitimacy by doing things, getting accepted in the community, people realizing we're not just a bunch of yahoos running

around with radios who just want to play police and firemen. We want to help and it's about helping to save lives and protect property. That's what it's about, and protecting our community that we live in.
IQP: With WECT what equipment do you currently have available?

MR: We have the equipment that you see in the radio room. We have a 2m/440/6m radio, we have a 2m/220 packet station, and some of this equipment is loaner. We also have a 10m Radio Shack radio.

IQP: Do you keep an inventory of the equipment you have available?

MR: Yeah, at the last meeting we assigned a quartermaster that's Gil (WK1EMH) and I'm going to be bringing him up to speed. We have to take an inventory of the cabinet and this room here, a lot of the stuff we have in here is like paper supplies, connectors, cables, we do have a 10m radio in there, it needs a little bit of work, but it works. And we're trying to build that inventory. We have inventories, but they haven't been well maintained.

We submitted equipment lists to the city. We submitted two, one for the short term, about $2500 worth of equipment, mostly for the EOC here that we need, such as filters, power supplies, radios or whatever to replace loaner equipment that we have, and we identified about $13,000 of equipment that would be mostly for mobile NCS stations, a generator and a bunch of go-kits. We had hoped to have six go-kits that were standardized so that in an emergency if you had to come to the EOC and you were coming from work or from school and you didn't have time to go home and get your go-kit assuming that you don't want to leave a lot of expensive equipment in your car you could come up here and you could sign out a standardized go-kit. The go-kit would have a radio, backup power, an antenna, a first aid kid, a space blanket, some of the basic stuff you might find in a go-kit. This would all be paid for by Homeland Security grants, I'm hopeful, not optimistic, but hopeful that at least the short term list will get acted on soon. The long-term would be nice, it's all for the city. I have no problem with hams bringing their own equipment, but why should you have to risk your own? And what if you're coming from work or school? And the equipment is at home or at work, what are you supposed to do? You come here and you're well meaning so we should try to equip you somehow.

IQP: The equipment you have now, how old is it?

MR: Most of it is brand new, acquired in the last year, donated brand new stuff. Some of it is homebrew, that's mostly antennas. We have a V2000 that was donated last April or March. The radio we use is brand new, it's a discontinued radio, a Yaesu 2600M that was phased out last December. I donated that. There's also a brand new Icom 2720 in there.

IQP: Do you have any old radios?

MR: We have the 220 [MHz] radio which I think was bought by one of the former RACES officers about ten years ago, but it works great. I think it's incorporated in the packet station now. And we have two ten-year-old power supplies but that's basically it.

IQP: Are any features of these radios unused?

MR: I'm sure we do, nothing comes to mind. You know the 2600M has lots of possible features, but the uses that we dedicated for these radios are such that they're focused and narrow, we're not going to use all the features. And maybe there's some that we should use, but nobody has bothered up until this point.

IQP: So, all of your equipment is located in this building?

MR: Correct, the only equipment that isn't located in the building is whatever people bring to the table for themselves. We all bring our own HTs, we don't have HTs here. We all bring our own backup go-kits and all that.

IQP: Is there enough equipment for everybody?

MR: No, I have one 2m, I've got one 2m/440 [MHz], I've got a 6m and I've got a 10m radio. And I've got a 220 [MHz] packet station. That's not enough equipment, that's enough for two or three operators who would be bumping into each other to operate. They would operate in shifts. I don't need a lot of equipment because this is a fixed station. It covers the need, in a real disaster, and I'm talking humongous, I'm not talking about a truck turned over on 290 causing part of the roadway to collapse, but more like Seabrook or Pilgrim nuclear plant gets destroyed or damaged. I might have to have two or three stations. That's why I have the OEF stations, I've got four OEF stations, and WPI is one of them. I've got W1KT, he's on a hill over in the northeast part of Worcester, KA1ZEX, he's up in the western part of Worcester, and N1WAS who's down near the Highland Street area, and even though he's not on a hill he's got a huge powerful station, what he doesn't have is backup power. We have three powerful OEFs and any one of those, and WPI of course, I can rely on in an emergency, but I don't need more equipment, I need my OEFs to be available.

IQP: Do you have backup power here?

MR: No, and that's a laughing stalk, it's sad but the National Guard is more and more coming back into this facility and they have stated that they are going to provide generator power for the whole building. I just don't have the timeframe. We also have the generator we used field day. Mine. Of course if I needed to I would bring that up here, unless of course it was 20 below zero and my wife wanted to be warm.

IQP: Can all of your radios communicate with each other?

Yes, if they're on the same frequency, such as 147.525 [MHz] VHF 2m or if we have dual-band, we had a 440 [MHz] frequency which eludes me right now; it's not a

dedicated one. Right now simplex is our backbone, that may change, but right now our backbone is simplex on 147.525 MHz and alternates of 146.595 MHz and 146.580 MHz. In an emergency you should tune to 147.525, the assumption is that if it's a drastic emergency there will be no power to the repeaters. If there's no power you're going to have to rely on simplex and we want everyone to be in the habit of going to 147.525 and waiting for instructions. As we get smarter and more developed we'll look into dual-band capability, cross-band repeat, etc. We are in the process of getting a repeater. If we get a repeater I think emergency management wants us to do more with the repeater. I don't know if that's a good idea, because even if the repeater is here what if the plane crashes into the EOC? What do you have to fall back on? Simplex.

IQP: Are there any features that you would like to see added to the radios that you would find useful?

MR: Well I'd like to see more dual-band, but not everyone has the money for that. That's why I'm trying to get standardized go-kits that we can maintain here and issue out. I'd like to see more cross-band repeating capabilities, if everyone had $400 I'd tell them to go out and buy FT-8900s [Yaesu FT-8900] and the appropriate antennas. That would be the standardized equipment for our group. But I can't tell people to do that, if I had the money I'd buy it and issue it out. That's what I'd like to see, more standardization. If I knew that out of our 55 members 29 of them had the 8900 we'd have an 8900 programming party, bring them in and we'd have a laptop with the 400 or 500 frequencies we are going to use and everyone would get those and keep them set.

IQP: WECT has a packet station, correct? What sorts of information do you use that for?

MR: Right now, nothing; just general traffic. The capability is not what's on there right now, but what could be on there. It's more secured, less likely to be monitored by the media. We would use it to send out requests for equipment, such as "I need 200 blankets to the shelter" or casualty lists, that type of thing.

IQP: Is that data encrypted?

MR: No. And we can't encrypt it; it's against the amateur regulations. But only other hams for the most part, and people who are technically adept would have access to that, and you would hope that wouldn't leak it out, however we have no way to control that. You have to careful that way too; maybe we won't put casualty lists on it. This is last resort; we're talking like a huge earthquake that hasn't happened since people have lived in New England. Boston's down, parts of Worcester are down, at that point you have backup power, you have a packet station, you have a bunch of dedicated hams; no one's really going to care. Someone leaking a little information off the packet network to the media is the least of my worries.

We look at the range of possible scenarios, these systems are in place for the littlest things from blizzards to the biggest, those things you don't want to see happen. In the big picture is encryption going to matter on this system? No. Is it going to work? Yes.

IQP: What types of environments do you operate your equipment in?

MR: We're in a city. It's mostly an urban setting. So you have to deal with those types of issues. That's the type of thing some of our drills dealt with. In the shelters with an HT, even with a flexible antenna running five watts simplex you have to be in certain areas of the building away from computer equipment, anything can impact your signal. If I had more time and equipment I would've set up a magmount or something, but sometimes we don't have that luxury. Our drills test the basic stuff out: are we able to communicate? Can we pass traffic? The answer is yes. If we were to do the drill again, and we may likely do it again this summer we may test it in a more prepared manner, where we tell you that you have two hours or an hour to get set up and see how that works. The buildings, the location, in an urban setting you have desensitizing from other equipment that might be in place, it's not so much forests and stuff like that.

Then you have issues with simplex, such as holes and gaps. You might be near a building or something; I was talking simplex on the net last week in a truck park for my second job. I was in the midst of 20 or so box trucks, something in there was desensing my radio and I couldn't hear anything, but if I moved my radio two or three feet away it was fine. These are the things you have to deal with.

IQP: Are there any safety risks in using the equipment?

MR: There are always safety risks, but I think there are more safety risks in deploying. It all depends on how well the operator is trained. We encourage safety. But the safety risk is more along the line of the following example: a plane crashes at the airport and there's a huge fire and I send you down there and you actually go. The risks from the disasters we respond to are worse than the RF exposure dangers. We're not going to intentionally send anyone into harm's way. And yes there are some dangers to operating the equipment, such as climbing the ladder to the roof hatch when working on the antennas. The RF issues are minimal, we are very careful about that, making sure antennas are disconnected, and everything is powered off. How much RF do you actually get from a five watt HT? And as to deployment we aren't first responders, I'm not going to send you down to a radioactive situation without a suit. I wouldn't send you even with a suit.

IQP: Have you had any problems in the past relating to the following?

- Blackouts?

MR: No. Some brownouts, none at the EOC.

- Dead zones?

MR: Dead zones we talked about with simplex, we try to compensate for that by changing your location, keeping in mind safety of course.

- Bad equipment?

MR: It all depends; most of the equipment is people's own equipment. People don't usually buy bad equipment, although sometimes people will buy budgeted equipment. It's not so much bad equipment as bad operators, for example checking into a simplex net with one watt. But we're trying to get past that by getting people training, we talked about that already. Sometimes people don't understand their equipment, even I'm guilty of that sometimes. You buy a new radio and you shouldn't be using it for a deployment or a simplex net if you don't know how to use it.

- Insufficient Power Supply?

MR: Not so much insufficient power supply as lack of backup batteries, if you think ahead that won't happen.

- Interference?

MR: We have interference we create by people not following procedures, doubling, tripling. We have interference from random idiots out there like The Heckler who willfully create interference. And then you have interference from lots of antennas in the same area, we can't really do anything about that.

- Maintenance Issues?

MR: We don't really have any maintenance issues right now. Ultimately we will and again we hope the city will help us as we don't have a budget. Purchasing radios, we don't have any funds. Right now we rely on donations of: money, equipment and people's time. We had some very big corporate sponsors. In the long run we are going to need some sort of budget to keep the organization in operation. I'd like to supply everyone with jackets and badges, but I can't do that because we don't have the money.

IQP: Do you have any role in the contacting of agencies at the state and/or federal level and do you have the proper equipment to do this?

MR: Yes and no. We don't do most of the contacting, Worcester Emergency Management (WEM) does most that and we report to WEM, we'll do whatever they ask, if they want us to contact other agencies we'll do that. Lt. Trotta and DD Bedard will interface with the city agencies. The only agency I can see us interfacing with is MEMA, because we've done that before at the behest of WEM, or maybe a hospital or two. We would do that more at the request of WEM more than on our own. The equipment needed for that is the MEMA radio that is in the communications center.

IQP: If the Worcester trunking system were to fail would WECT be able to provide all of Worcester's emergency communication needs?

MR: No, I don't think we could. I don't think they'd even let us. I don't think the police or fire want anything to do with us. They see us as more of a nuisance. If something legitimately happened and the trunking system did go down they'd be in tough shape. We

could help, but we don't have the manpower right now. We have 55 people and about 30 show up all the time. If we could deploy all 55 members I don't think that would be enough, I don't think being able to deploy 110 members would be enough. We'd need about 200 or 300 hams.
IQP: Are you familiar at all the Worcester trunking system?

MR: Somewhat.

IQP: Can you explain it to us?

MR: I may not be the best to explain it to you, but I can try. Basically the first major flaw in it is that someone sold the city something that no one else uses in the state. It's standalone for the city of Worcester. It has dedicated channels: one for police, one for fire, one for EMS, but they can't talk to each other. That's where we can come in; we can help the talk to each other. Interoperability has become a big buzzword: it is basically the ability for one agency to know what the other agency is doing in real-time. This system doesn't allow for that.

IQP: Do you know how old the system is?

MR: I'm not sure but I'd say about 10-12 years old.

IQP: Can WECT provide interoperability communications for the city?

MR: We can help, but we can't cover everything. It would be picking and choosing the key areas, like a triage system. Maybe if there's a massive fire and the fire department has to communicate with the police for cordons or what have you WECT could coordinate with the two. But it would be slow. It could be done, but it is untried and untested.

IQP: Can you provide information on the past drills? Or is it confidential?

MR: It's not confidential; I just don't know how you would get the information. Which drill are you referring to?

IQP: Most particularly the Green Hill Park drill.

MR: I don't have that information. Lt. Trotta might be able to give you that information, but he might not. I know from reading the results that communication was a big thing for them. Communications is always a key item, there's no question about it. If they can't communicate how do they function?

IQP: In your personal opinion, is Worcester ready, communications-wise, for a major emergency?

MR: It all depends what the emergency is. The last "big" emergency was the Worcester fire of 1999. I wasn't involved with that, I was a spectator basically, watching the fire from Bancroft Tower, and it was pretty bad. I was monitoring it on my police scanner. They did a pretty good, but they couldn't talk to each other. Could WECT have helped? Maybe. Would it have changed the outcome? Maybe not, probably not. It just may have provided more real-time information. It all depends on the emergency, and if it's a huge mega-scale emergency I don't think anyone is ever ready. The reason we participate in these drills is because they mimic certain aspects of real life. That way when a real emergency occurs you respond a little faster, think a little faster because you can make comparisons to what happened in drills. I don't think any community is absolutely ready. How far are we on the curve? I don't think we are that far. I think we could do better. And I don't think it's just a question of money and resources, it's a question of the community's willingness to support the resources. I was at the planning session for the airport drill and the fire chief was there and he was cautioning them "Don't plan something too lofty because it takes more resources that we don't have and more manpower than we can throw at it." So they're downscaling this disaster to fit the available resources. The bottom line is that we're not as prepared as I'd like to see. If a tanker truck rolls off 290 and hits a small diner tomorrow, yeah we can deploy a dozen hams to cover the disaster. It's a small disaster. If Boston is evacuating because an LNG tanker blew up in the harbor and everyone was flooding to Worcester would we be ready? No. The best we could do would be to open up our 11 shelters and coordinate the shelter movements. We could support communications for maybe 72 hours, but after those 72 hours people are going to want to go home. Do I have the resources? No I don't.

IQP: Do you think any city in Massachusetts is more ready than Worcester?

MR: I can't answer that question. I don't know that information.

IQP: Thank you.

E Interview Transcript with WEM

WEM: What's your focus?

IQP: Our focus is to see if Worcester's Radio is prepared to handle a large scale emergency. We are looking to see if the radios system that Worcester presently owns is capable of handling an emergency.

WEM: Ok I get it, and what do you know about it already?

IQP: We nows that Worcester uses a trucking system as their backbone. We know that WECT provides backup communications. We are hoping you can fill in some of the gaps.

WEM: Now you haven't gone to the communication department yet, no right?

IQP: Not yet

WEM: Alright, let me give you a little background. What's unique about Worcester is that it has the 800MHz system. Which means one city department is on one radio network. If it's in the city is fine; if you go outside the city it complicated. They bought the system from GE Erickson originally. Everybody else is on Motorola. There is a lot of patching to be done.

IQP: What do you mean by patching?

WEM: If they are going to patch into the other systems. Some people have accomplished it others haven't. So what they do is a lot of outside communities monitor Worcester and the plan that is in effect in a disaster, the state has cache of radios with 6 radios in them. We have a base station over here for that. It's on the state police 300MHz. There's a special channel for that. See during a disaster you call the state police and they turn that channel on they bring you caches to you. Sevre has them, Umass hospital, and south bridge has some. You can probably get 18 here with in a half hour if we need them. On the other hand we can get additional radios for MEMA, Massachusetts Emergency Management Agency, and in a big disaster like in the fire....actually CMARA came in with a communication network. They had like 40-50 radios we can use. We are planning on the police department is buying new radios right now and they are going to give us their older radios and we are going to program them to the civil defense channel and if we get outside agencies that are not first responders and we need to communicate with them, we can give them those radios. That's basically where we are at.

WEM: Here is the break down of the 800MHz radio system. Those are all the channels that are available to everybody. The base station you see behind me has everything that's on there. Bill and I and one other radio have portables that have every thing that's on there also. So we can talk to anybody in the city. However the other people in the city can't talk to everybody. They can only talk to their own group. So for example if you look at the fire column, those are the channels that are available to the fire people. So they are...a fire fighter out of the truck only deals with those. However if you look horizontally I think its number 9.

IQP: The enhanced 911?

WEM: Yes. For the most part that's on everybodys. Also there is an Event A and Event B that goes across on both. So those are the common channels. So if there was an event in Worcester different people can get on that because those appear on all radios in the city.

IQP: ok.

WEM: I'm not sure but if you interview the communication people...I think they are only capable of putting the police and fire on the same event channel. Yep they can patch in on that. They can also patch mutual aid in on high band and low band. And while we are

talking about high band and low band to make sure you know what I'm talking about. Behind me also those are…one of those low band radios that we have and those are those are red cross for example are all here…and we also have a high band also behind me which would have those on it. For example, all the radios for the towns around here are 33.60, 33.62, 64, 33.70 all of those. Those are mutual aids, so when the fire calls the towns in the communications can either patch or what the usually do it's a lot easer is they give the officer on the truck, coming in from Holden lets say, a 800MHz radio and he can talk and one of the command guys does have that low band capability on the fire department…from the fire side. Mutual aid in the police is just starting to develop. So when we use mutual aid you basically don't have contact except for the location you are going to. This is little radio in the middle on to that's the 800MHz, state radio that bill is also talking about. Now do you guys I'm sure know John Ruggiero.

IQP: yes

WEM: Sit down and talk to him.

IQP: we are planning on it

WEM: If you get into the technical aspects he does that at the state. And when we have an event here, we have him come in on our radios. How big does your project have to be.

IQP: Its just covering Worcester

WEM: Because right now the state is going though a survey state wide. They got $800k to do this survey to try and to determine what type of radio system to go with. They already ruled out doing the whole state on one radios. They are going to have to go into regions because a lot of their reason for regions has networks where they dispatch from one regional dispatcher for several communications, and it seams to work well that way. So I don't know where they are going to go with this but the thing is if they keep the regional tact we might by the equipment that's compatible with the joining region so we would have the same capability. But that's up in the air right now. Like I said, Worcester with its 800MHz is someone out of the loop right now. We had a public safety meeting last night and we had discussed the possibility depending on federal or state funding maybe we should look at scrapping that system and being more compatible with the others but we won't know till the survey makes its suggestion. Then we have to find the money. There is money out there but they are not going to allocate money for radios until the survey is completed and we know exactly what we are going to do here. In the next couple of years there are going to be a lot of changes in radios in the state. But the important thing is that the city is basically radioed networked into other cities. It's really not too much of a problem. It's when we start with mutual aid things like that it gets a little big complex. Its called interoperability if you haven't heard of it. That the new key word. It came out of the world trade center. Have you done any reading on what happened there?

IQP: no.

WEM: There are two things that happened there. There is something that's called the incident command system. Are you familiar with that ICS.

IQP: Yes.

WEM: Well they weren't using that system. So when they setup their command post in the tower which they normally do cause no tower has ever burnt down and none have ever collapsed. So they went in on the first floor. I don't know if you saw the movie they made. Anyways, they weren't using unified command so the police weren't really present there although the police had their helicopter there with radio and were surveying the building and was relaying to their troops to get away. No one every told the fire department. If they used the unified command at the incident command post even though they didn't have compatible radios. Some one could have just said, ok we got the word from the helicopter we are going to evacuate and move back 1000 yards Now. But since then, everyone is looking for interoperability. What happened in NYC, not to go off on a tangent, was they knew their radios where pretty lousy anyways...they didn't have a lot of repeaters out there because of the buildings and they where going to go to the new radios system and somebody inside said we don't need those, stay with the old ones, and they stayed with a dysfunctional system. And we all know the end result. So it's called all interoperability. So now the federal government under homeland security says lets take a look at the whole country and see where the problem is. Everywhere in the country had the same problem, there was no interoperability in radios systems. They all had these expensive systems and patch networks. The main problem is in every community...let's get right back to Massachusetts. There are 351 cities and towns. They are all individual independent entities. They all purchase what they think is right for them. They also purchase depending on the low bid items and also a good sales pitch someone gives them. There was no radio agency per say that prier to now was looking at radio communication saying hey look lets combine and will buy radios regionally there a lot cheaper there are more compatible. These things weren't happening. This is the direction we are all taking. So once that study is done the city will somehow be part of that. Maybe they will say, 'well Worcester radios don't have that much problem with it, lets push it out to the towns and once it rings out and we'll beef up there network and create or make the city the central regional dispatch center. Although the facility when you get down there is very small. It would have to be quite expanded. They just rehabbed it recently down there. Actually the contours and things have all been rehabbed. Repositioning the seats and stuff like that. The other problem you have to thing about, is also the turn over in the positions of the dispatcher. It's a very high stress job, Some what dysfunctional work schedule, and the pay isn't the greatest. Its hard to find qualified people first of all and its even harder to retain what you have got down there. And there training is basically train as you go. You are hired and you would sit in there. They use part time people like college kids. That would work for less money and kids looking for money, it would be really nice you know. But they haven't really looked into that effort. They are unionized also.

WEM: The evolution of the radio problem goes back many years when radios first started. The low bands came in and you have police and fire around the whole state that were either on 33Mcycles or 45, 44 in that range. Then we get into the high bands the 150s, 155s and what happened then is some communities said well since we are getting rid of the old one lets replace it with that. So now we've got that. So lets go to our community with the low band and then 800 came in and 800 came in two ways. As Bill said the Erickson, GE Erickson, is what we have and the rest of the world has Motorola. So this how it all evolved and once you commit that funding whether its Worcester or the smallest community in the state there is no money to go back and do it all over again. And no body was sitting there looking at the big interoperability picture until now. The reason they want the Erickson was that they felt that our services was better then Motorola's. And having bad service records with Motorola they decided it was time to make a change, not looking at the big picture. But at that time, the big picture was never outside your boundaries. But since 9/11 the big picture is everywhere. Its almost a unified nation now. Those are some of the things. So historically we were buying low bid stuff and we were also buying used equipment for the radios. Anther community would dump the system and they [communication companies] would pick it up. So he [communication companies] will help his [community] head ache. And that's why they [Worcester] wanted to use GE Erickson because it was brand new at the time. Id don't know how they code there…who there service person is now. Somebody bought that contract out from Erickson.

IQP: M/A comm.?

WEM: It might be, yea, you can verify all that stuff down there. When you go down there the director has been out for a few months and you're going to talk to a person name Cathy Hennery, she's filling in for her. Not only do you want to talk to Cathy about the radio network but you also want to talk to someone from the fire department Henderson. Also down there is another knowledgeable individual is Bob Harkens, in communications. You will have to clear that though Cathy first. But he has the technical background. Chief Joe Henderson is the fire department. For the police it's Captain Needham. One thing that unique about that system is that they have a hired technician to keep it up, instead of relying on service contracts. Private Mark Caden from the police department.

WEM: The other thing is the ham radio stuff is relativity new, about a year now. We have Mark Rubin who is the city of Worcester radio operator who is coordinating all of the systems. You ever met him?

IQP: yes we did.

WEM: Ok. They use a simplex net every Monday night and we are trying to get a 2 meter repeater up here and if we can, with the students at WPI, after we get a memorandum of understanding done we can get it up here on the hill, set up….

IQP: Its in your hands right now.

WEM: Yes, I know. It will benefit everyone as well as you [WPI]. Then also we have a PSAP, it's a backup for the radio. And that's going to be installed at the Mclearn fire station. Up by Holy Cross College. You know as you go by the football field up the hill, the fire station up there. It's suppose to be in there. That's there backup. You know what PSAP is?

IQP: No.

WEM: PSAP stands for Public Service Answering Point. That's how all the 911 calls come in. Do you know how the 911 calls come in?

IQP: no

WEM: First of all it's called enhanced-911. Which means ones the call comes in; we get information on the location of the caller, the phone number, and the address. Say someone calls and hangs up the phone; they can send a curser to the house and find out why. When all the lines are full, it will kick out, trunk out to the state police in Framingham. They will pick the line and say state police. The person will give them their story and they will call back to Worcester. That sounds stupid because if all the lines are tied up how are they going to call back?

IQP: yea

WEM: Every PSAP has two there lines. That are not the 911 lines. So if they call 911 in Worcester and the 911 lines are tied up and it went to Framingham, they would use one of the "tie" lines, like a tube, they are separate phone lines with separate numbers. So they can call back on one of the two other lines, so there are two extra ones. The problem is this; the operators that answer 911 also answer the convention non-emergency numbers and the other phone coming in. So if they are on calls....it still doesn't matter because there are only a certain number of people answering the calls.

So that's were we are with communications. I don't know if you came up here last September when we had the big drill. The RACES' group was doing their thing, and we have the Airport drill coming up.

WEM: The other thing you have to at to is...ill give you the answer to the first have, is there a back up generator in case of a power outage. At the police building there is but I don't know if there is one at the fire station. They are still working on that. They might have plans to have a back up over there. That's a new station so they should have gotten one when they put it up. But not necessarily.

WEM: What we do up here, we have our own trucking telephone system and their own number. Usually where there is some type of incident, the next room is used called the EOC, the emergency operation center, we open that up and we open up over here, the ECC emergency communication center. We bring up volunteers to answer the phones,

usually augmented by a dispatcher. We do our own training, on what type of questions incase they have a problem and if we have to dispatch emergency vehicles above and beyond what they are doing down there, we do it up here. For example, when we have blizzards sometimes and its going to be a real intense blizzard, we will bring a crew of police cursers up here and some people who have 4 wheeled drive at the airport and bring people up here. The city is divided into 4 sectors and we will take the calls and we get the calls together by sector and we will dispatch these cars by sectors to go pick these people up. We usually pick up essential people, mainly medical people or public safety people that have to go to work and we dispatch that all out of here. If we get a big event we try to get the National Guard in to help us out it takes about 12 hours before they first arrive and it takes a declaration of emergency before they come in. so we do have the capability of dispatching cursers or fire trucks out of here, if it were a real big emergency. With the races group, we are working on starting on a black out plan. Put the RACES' people in when the power went out. It kind of a complex thing. So far so good. Any other questions?

IQP: So you receive information over a LAN line, right? Like the 911 dispatch....

WEM: With these phones here?

IQP: yes

WEM: We give this number out. People that call 911 will get referred to call up here direct. 911 we try to keep free for the everyday calls. The calls up here [EOC] are not emergency calls. They are trees down across the road and things of that nature. They are non emergency because we are basically working in a winter storm. If we ever get a tornado or hurricane, the over flow from down there [911] will have to come up here [EOC]. So they will become emergency [calls] and then it will get a little complex. Because we are going to have to bang them back down there to dispatch cause the smaller staff we will have working here. Depending on the size of your disaster, you have to map your disaster. Say if we had 40 to 90 mph winds though here. You have to commit all your city resources immediately. Then you have to go into call downs and stuff like that, mutual aid, declaration of emergency. Its going to take time for everyone to get in here. Everyone is going to be calling 911 and they will be really backed up. And even if they called here, we would be backed up too. Because to only get so many field people in the field to give service. Like BDW or the parks people we could dispatch those people here [EOC] for down trees and things of that nature. That would take a load off [911]. The fire and medical calls go though 911. Unless they happen to come in here [EOC].

IQP: Will you be able to dispatch them on the trucking system from up here [EOC] if you had to?

WEM: We could dispatch them up here. But we would have one of there representatives up here. See the EOC, when we opening that depending on the event, we staff it with people from the different departments. Its their responsibility, based on the information that come in there. They [ECC phone answers] write out a slip and it goes into that room

[EOC] and they give it to BDW Park, hospital, what ever it is and they handle that problem.

IQP: So it's their job [to dispatch], not yours?

WEM: It's their job not ours. Our job is to organize and coordinate these people. The parks department for example has a forest division. If we had a parks department supervisor next door, he would put on this radio and call the forestry. When the slips come in they are brought over there....they will have radios with them. If we just wanted to just communicate with someone to inform them we would just call them direct and it would be quick (say call this number...).

WEM: The information you get when some on calls in has to be somewhat analyzed. Like a tree down call, there is a lot to ask from that. Is the tree itself on private or public property? Theoretically if it is on private property you own it. Is the Whole tree down or just one limb down? Can you just more that one limb yourself. Some people see it and just pull it out to the side of the road. Is it laying on to of any wires? Did it break any wires? Otherwise if they [wires] are down, are they sparking? There are a lot of questions to ask that's why you want the right people to be asking those questions. Instead of some volunteer call taker. Just as one example. But sometime they slide though. One time we got this call and there house was on fire and it happen to come in on our line and we just referred it down to them [fire rep] and they sent down a fire truck. What we do when we open here is we sometimes broadcast over the government channel that the operation center is open and if you have to call for transportation or sheltering then call this number. We've had calls from Webster. We actually sent buses out there to evacuate hospitals in Westborough. We slow down here a little. We have busses with chains. We've utilized them a bit but we don't do it normally. Our transportation, we will go out to a police station, pick someone out and bring them into the city and if we have to take them to the town, only one town out, will take them to the police station. Because we don't know where the streets are, we don't have time to search for you. You have to get to that police station at a minimum which most people could do. They could even have the local police pick them up and bring them there [person's destination].

WEM: We encourage all the medical facilities to get there people in early before they are in the middle of the storm and tell those that are working they could be held over. Also when you call in for a ride, you have to be ready an hour early and looking out the window because we have so many calls, we have to give ourselves a little leeway. But that is how we operate. You have to go down there and interview these people and find out what they think of the system.

IQP: if the telephone line (LAN line) when down, how would you be able to communicate with hospitals, shelters, schools, etc?

WEM: We won't. the only way we could, say if we had the RACES's net and we brought the RACES's people in, we would assign them out to those locations. We would determine what the vulnerable assets are, depending on how many operators had, we

could actually plug them in there. Actually we have been thinking about that lately. We have John [Ruggiero] working with the three hospitals trying to get them to buy a 2meter rig and an antenna so that it would be in the hospital and all we would have to do is send an operator down there. Then we would have a means to communicate with the hospital. If we open up any of the shelters in the schools then we will send a radio operator over there to provide the communications. We are going to have these regardless of whether the telephone system is down or not. Carry that one step further, if the fire department radios went down, then that would create a problem. We then would be looking at the hams to go to the fire station and try to work out something like that. But actually what we would probably have to do is have an operator at the police building at the communications building and they can dispatch using the ham radios to different locations. You would have to write out the slips out by hand like they use to do in the old days.

WEM: One thing you are not looking at when it comes to communications is that the communications operators are civilians and are unionized. What happens if they go on strike?

IQP: You mean like police or fire?

WEM: No, a the dispatchers are civilians.

IQP: They aren't government employees?

WEM: No, city employees but they are unionized.

IQP: I though government employees can't strike?

WEM: They can. Only police and fire [can't].

IQP: We are planning to ask the communication's department why they are buying new radios over a period of time.

WEM: Are you talking about the portables or the conceals?

IQP: Both

WEM: ok, well the original radios that came out were big and heavy and when they reached their limit they are going to replace them with the newer smaller portables. Also the police and fire carry different radios.

IQP: why?

WEM: Because of the switches. The police radio is flat faced, you press on the button. On fire, you twice the button because they wear gloves all the time. They've had trouble with microphones on the shoulder, water getting in them.

IQP: Is any of the trucking radios encrypted?

WEM: Some are encrypted. You encrypted the radios for some department like vice squad because a lot of people scan it. I don't know if there are any scanners out there that pick up the whole transmission but you get parts of the transmission and you put it together and it makes sense. Also when you buy a scanner, they have a secret code down there that have to be incorporated into that scanner before you can get it to activate and they don't give it out.

IQP: Where are the trucking towers located?

WEM: One is located here and the other is located in Paxton at Asnebumskit hill. Those are the two towers. They have the microwave dishes at the police station in a triangle and it doubles, it lets you talk to both places at the same time.

WEM: One time, when they were putting an addition on the memorial hospital, a crane was doing construction and it blocked the signal.

IQP: What happens if one of the towers goes down what happens, are their radios useless after that point? Do they work on line of sight?

WEM: Yes, its called convention talk-around. It's very limited. The problem in the city is that not all places can reach the repeater like the basement of UMass. When they go into trouble areas, they go into convention talk around which acts like walkie-talkie portable so one has to be back in communications with the repeater. Where as the chief, for example in a fire, would be talking to everyone fight the fire, but his aid or somebody would have his radio and position them selves so they can talk back to the repeater.

IQP: is it true that the trucking system won't work on outside systems, like if I took a Worcester radio and went to Boston with it, would it work?

WEM: No because Boston has a different type of computer system.

IQP: if the emergency went beyond the boundaries of Worcester, would you rely on LAN lines to communicate outside of Worcester?

WEM: Well like Bill said at that point we would be going to the state police for 800 MHz radios. John [Ruggiero] would be able to you a good background on that. The state will just turn on the repeaters that are not usually active. So when they active those repeaters, then it allows communications over a greater distance.
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IQP/MQP SCANNING PROJECT

George C. Gordon Library
WORCESTER POLYTECHNIC INSTITUTE

It would be more cost-effective to add a third site in downtown. I don't know the cost-effectiveness..

Depending on the options of making the system works outside the building

there is another place downtown that will allow them to put in building repeater they don't ..... because they don't repool.. worcester downtown.. holding frequencies, in my BDA the BDA does 800-900 Mhz, its has 2 antenna inputs in it, you put an anenna outside the building, usually a directional pointing at the trunk side, cause thats what were looking at.
and then the second antenna can be a... it can what they call a leaky coax, a long coax, with holes in it, all you can do it put it in various places in the building, and it can act as a radiating antenna, radiax... umm.. bi-directional amplifier, what's inside gets amplified outside, and vice-versa, but the problem is you have the whole frequency, you're gonna get, cellphone, pagers anything else in that range.. and sometimes if you have a paging transmiter thats in that range that's so close to the highrise, usually on the roof on the highrises, that can endup overloading what's going on in there, and you end up with all kind of intermodulation, its very tricky to implement properly, if you engineer it correctly, and install it correctly it works. I know of a situation, Airborne express shrewsbury, they utilised Nextel for all their little computers that they walk around with, that all works over Nextel, but they couldnt get Nextel coverage in their warehouse, in shrewsbury,..... well, a couple of state police trunk system went down... and when the state police radio tech. went there found out when they installed the thing, they saw the BDA with 2 coax going out of the roof, with the antennas next to each other. So whatever contracter installed it, said "here you go install it yourself", or didnt know anything about it.

@12minutes

Same thing in the cell phone companies, they have technicians who know nothing about radios, propagation and cell phones.

Boston fire has an elaborate in building system, it covers all of their area, and they also operate in UHF... no trunk only in UHF.. they have an elaborate in building repeater system, also has a.... has one power transmitter in the roof.. real powerful transmit site an what they do is into that they hook like a one dozen receivers around the city and all the recievers are noded...when the signal is recieved from a site they look for the best signal and use that to talk through. And the system automatically, its a dynamic thing so,... another system where most of the time a computer is listening .....(13.30-13.51)

a repeater system in new york..... thats another system, though its a little harder to implement... you need to test it.

Have you ever used any of the trunk radios in worcester. [the actual radios not the trunk system]
Yes

There are a couple of portables at the EOC, and state station..

Can you comment on them on the quality?
..... the concept of the antenna,.... the controls, how the radio works... its like an analog repeater... that an the fact it has 16 channels, it works? yes it does, having a radio as a commecrcial radio its not programmable..

That and the fact when using a commercial u have to be license, to point at a certain frequency.. {if you want more power out of it}... i dont think, i can't say that, it has a high power, low power button.. i dont know if it has any effect...on the radios, but i have to say if fire and police, dont know what to do, they always keep it on High power all the time..

If the trunk system went down?

trunk systems in general, depends on what part of the system goes down; repeater has transmitter, and reciever, antenna, the radio end, the repeater end of it, or did the controller system fail. The controller meaning, channel assigning, find channel.. which component fail, is defnately different from what if the generator failed..

if the controller end of it the trunk fail, most trunk system has a Fail-Soft mode in it, which starts something, which tells the repeater go into repeater mode, and becomes like a normal repeater, and tells the radios that there is no trunk channel, so i'm gonna put my radio stuff mode into repeater mode..

so will they all end up being in one frequency

i dont know.. i can tell you when the radio looses the control channel because it was driven out of range.. it says no service on the radio like a cell phone.. but i dont know what the radio is really doing, i dont know if the radio is dead, or switches to listen mode... what was the software's name? FailSoft

I've never seen it happen in my experience.

What happens if you loose green hill? does it run from paxton? i dont know where it [the control] resides?

the city has also license for IPAC and I-Call channel... they are not for public safety..