FIRE DEPARTMENT COMMUNICATIONS MANUAL

A BASIC GUIDE TO SYSTEM CONCEPTS AND EQUIPMENT

FEDERAL EMERGENCY MANAGEMENT AGENCY

UNITED STATES FIRE ADMINISTRATION

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Contents

1. Introduction

Communications is a crucial and rapidly evolving element of fire service operations. Increased sophistication of equipment, incident command systems, and radio frequency congestion are among the forces stimulating change, and making it more essential than ever for fire officers to have a good understanding of communications systems and policies,

Communications and communications systems also are critical to safe and effective fireground performance. Lapses in communications and radio difficulties have been implicated in numerous firefighter deaths across the nation. Limited budgets are forcing fire departments to resort to more frequent mutual aid, which requires communication among agencies that may not operate on the same frequency.[1]

Computer-aided dispatch systems are becoming increasingly popular. Once found only in the largest departments, fire departments serving communities of 100,000 population and below are now adopting these systems. County dispatch centers serving volunteer or combination departments also are installing these systems. Planning for and working with these systems requires fire service communications managers to be familiar with the concepts and technologies behind them.

Other communications technology is changing rapidly too, with portable facsimile machines, automatic vehicle location, computer-aided dispatch, push-button vehicle statusing, more compact and powerful computer hardware, and more sophisticated software available. National standards for communications are changing as well. All of the above changes require the fire service to keep abreast of communications technologies more than ever before.

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[1]Chip Darius. "A Key to Interagency Communication," *9-1-1 Magazine,* January/February 1991, p. 20.

Scope and Target Audience

This manual is written as an introduction to a variety of fire department communications topics. It is intended to provide a wide fire service audience with a minimum level of familiarity with communications basics: hardware issues, policy and procedures issues, and human resource issues. It attempts to provide some background on all major aspects of communications for the fire service, with the exception of call receiving systems (9-1-1, municipal street boxes, etc.).

The manual is designed to be useful for a wide range of purposes, from developing specifications for new equipment to development of a department-wide radio system to familiarizing a novice with the basics of fire department communications.

In addition to the hardware of wires, radios, and computers, the manual addresses the policies and planning processes that must be undertaken to effectively use the hardware to achieve the desired result. Management of communications through standard operating procedures and policies also is discussed.

This manual is not a substitute for the numerous technical references in the field, but rather is intended to provide enough detail to give the reader some understanding of the concepts, and the ability to ask some of the right questions when a system or procedure is being designed or implemented. Examples of fire departments using various communication systems are cited throughout the text. A bibliography provides a range of existing literature to get more detailed information.

This manual is not aimed at the expert. It is written in nontechnical language and is intended primarily for use by those newly responsible for planning, operating, or improving communications systems within their fire department or agency, and others interested in understanding more about fire department communications.

How to Use the Manual

The manual is designed to be used as a reference rather than read cover to cover. Each section can be read separately as the need arises. For design of a new system or a review of your department's operations, an entire chapter or several chapters might be necessary. There is some overlap among chapters to make them more stand-alone, and considerable cross-referencing. Many topics could have been placed in more than one chapter, and it is suggested that readers scan the entire report to find topics of interests.

Methodology

This manual was developed mostly by fire service chief officers who had extensive experience in developing and/or managing fire department communications systems. It is written from their viewpoint rather than that of engineers.

To supplement their personal knowledge, visits were made to five fire departments reported to have excellent communications systems and procedures. (These are cited repeatedly as examples in the text, including photos of their equipment.) The five fire departments were Dallas, Texas; Huntington Beach, California; Montgomery County, Pennsylvania; Palm Beach, Florida; and Phoenix, Arizona.

2. Managing A Communications Center

The communications center, often also called the dispatch center, is the nerve center of fire department operations and usually the first point of contact the public has with its fire/rescue agency. It is also the hub of fire department communications.

For the purposes of this manual, the communications center or CC is defined as the place where calls for service are received from the public and information is transmitted to the appropriate units or stations. These two functions are in two separate locations in some communities. Beyond these basic functions, the communications center records information on times and durations of incidents, and serves as the primary location for management of routine emergencies, including processing calls for additional units or resources.

The communications center must manage and allocate the fire and rescue resources of the fire department or jurisdiction in a way that ensures that the proper resources are dispatched in a quick, efficient, and professional manner to emergency incidents. The CC also provides support to field operations personnel and units in carrying out many routine tasks and responses to nonemergency incidents. Given its important role, it is critical that the CC be managed in a way that gains the confidence of the public and the department served.

The CC usually is run by a local government agency, either the fire department, police department, or public safety agency. The communications center may serve one organization or many, depending on the size of its staff, the number of responses it must dispatch and monitor, and interjurisdictional agreements that have been made. The most common arrangements are for larger career fire departments to dispatch their own units and for smaller departments to share dispatching services, often at the county level. There is a wide variety of sharing arrangements.

Alternative Organizational Forms

The organizational form and types of personnel employed in operation and management of communications centers vary widely throughout the United States. Regardless of which organization manages the communications center or whether its employees are firefighters, civilians, or police officers, the most important factor in the success of a communications center is the reliance on good procedures and management, with an emphasis on serving the public and field units.

Small and Medium Size Communications Centers - Highly technical communications operations are expensive, even in their most basic form. The workload determines whether the small-to-medium size communications center can justify the expense of sophisticated communications equipment.

County-wide or area-wide communications centers allow the pooling of resources from many small departments to provide a higher level of service and access to more sophisticated equipment than is possible for each department working on its own. In addition, the combined workload may more fully use existing personnel or be sufficient to justify hiring more personnel (and thereby provide more backup for each participating department).

Small volunteer fire departments sometimes employ civilian dispatchers by providing living quarters in return for their dispatching services. The living quarters may be in a department-owned house adjacent to the station. A volunteer fire department or small fire district also may pay some compensation to this family-type operation. The drawbacks of this arrangement are obvious. If the person, or family, wants to have a night out, or a vacation, someone must come into the house to take over the dispatching, or at least monitor the calls,

A variation on the family-type arrangement is employment of a “handyman” by the volunteer fire department or the fire district. Often the maintenance person performs routine

repairs to the fire station, station equipment, and fire apparatus, while also answering the telephone and listening for calls for service that might arise from the radio. If there is a call for service, the maintenance person is trained to activate whatever kind of fire department notification systems there might be. Once the firefighters are responding, the maintenance person operates the base station radio, provides information about location and how to get to the scene, and provides whatever support is needed after the units arrive at the scene.

While arrangements such as these are still practiced, they generally are being phased out and replaced with consolidated communications centers that can provide a greater degree of reliability.

In small career or combination departments, a common practice is to assign one of the onduty firefighters to a certain time on what is called the watch desk. The duty of the firefighter is to answer phone calls, route the calls to the chiefs office, if necessary, and to dispatch the stations (typically one or two) to calls for service.

Where firefighters work the dispatch desk in shifts, it is important to make sure that communications-related information is passed on properly. Smaller fire departments often monitor automatic fire alarm systems in the communications room. If a fire protection system goes into test or repair during one person's watch, failure to pass on this kind of information can easily result in an unnecessary response of equipment. A status or announcement board can be used to post this type of information,

Combined Communications Centers - Combined fire/rescue/police communications centers and combined regional communications centers are growing in popularity for many reasons, but mainly because of the high cost of maintaining independent fire/rescue and police CCs. In some small communities a combined center is implemented by using the one or two police dispatchers on duty at the police department to process the small number of fire-department-related emergency calls received daily, say four or five calls a day. (Police calls tend

to greatly outnumber fire calls in most jurisdictions.) A typical organization chart is shown in Exhibit 2-1.

When the police control the dispatch center, the fire chief must make certain that the police communications managers understand the difference between fire dispatches and police dispatches. Emphasis must be given to ensuring that dispatching personnel understand the need for prompt processing of fire and EMS calls. Procedures should be established to assure adequate support for the fire mission, even during police emergencies. Also, it is common for interpersonal difficulties to arise when nonemergency communications are needed by the fire department.

The main drawback to a police-controlled system from the fire/EMS viewpoint is that it is difficult to require desired performance from police personnel not working under the fire chiefs direction. In order for this type of system to work, there must be understanding and cooperation between the police and fire chief and commitment from their supervisor within government.

One way to alleviate concerns about uneven support of police and fire functions is to place communications in a separate agency which services both the police and fire departments. This arrangement requires that the manager of the communications center be responsive to both agencies while reporting to one supervisor.

Another alternative that often works extremely well is to consolidate fire and EMS communications at the county level or with other fire/EMS communications from other jurisdictions. This often allows better coordination of mutual aid and also the use of Emergency Medical Dispatchers (EMDs) -- dispatchers trained to provide emergency medical advice by phone.

Organizational Chart

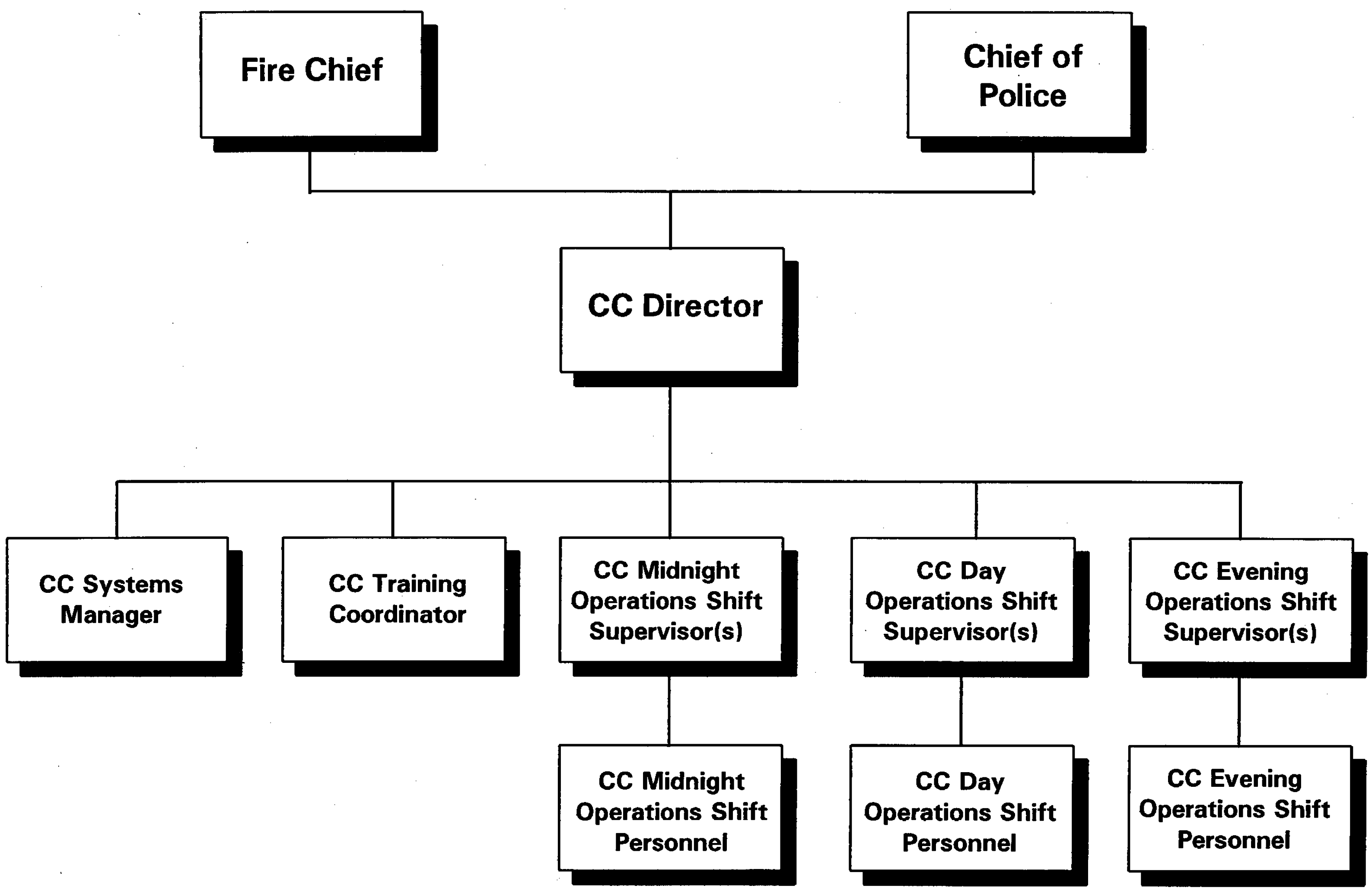

Exhibit 2-1. Combined Communications Center

Manual Versus Computer-Assisted Operations

A communications center may be run entirely manually, or with Computer-Assisted Dispatch (CAD), or a combination of manual and computer-assisted dispatch.

Manual -- Manual operation still remains the most prevalent type of CC operation in the United States, although there is a strong movement toward installing CAD systems in smaller and smaller departments. Even in CCs with manual operations, it is rare that there is not some use of computers, e.g., for displaying "run cards," even if there is no full CAD system.

CAD-equipped CCs must maintain some type of manual backup system for operation when the CAD system is "down." Consequently, manual skills and files must be maintained in all CCs, and CC personnel must periodically be trained on the use of these skills even in a CAD-equipped system.

CAD -- Computer-Assisted Dispatch systems have been a great enhancement to CC operations since their inception in the 1970s. The early apprehensions that the pride CC personnel had in their skills and knowledge as dispatchers would be lost under a CAD system proved to be unfounded. Actually the reverse has occurred, since today's dispatcher is more important than ever before. EMS calls have come to dominate the emergency call workload, and the ability of the dispatcher to determine what is going on at the scene and to give advice is crucial, In addition, as mentioned above, the skills and knowledge of the traditional manual dispatcher still must be maintained as a backup.

One of the early decisions that has to be made by departments making the transition to CAD is whether to develop and maintain their own system or to purchase a tailored or ready-made system from a CAD vendor. In the past, some departments chose to develop and maintain their own system mainly because it was supported by their jurisdiction's mainframe computer, and there were very few CAD vendors.

In the 1980s, with the further acceptance of CAD systems and their increased sophistication, most departments moving to CAD opted to purchase from vendors and have the system maintained by support personnel.

In general, although offering great speed and capacity, many CAD systems are patterned after the manual systems they replace. This allows for an easy transfer from manual to CAD and back to manual when necessary.

The heart of any CAD system is the geo file on which it is based. The geo file is the computer file comprised of the street and address network of the community served. A geo file in a CAD system can be likened to a paper map and the dispatcher's knowledge of the map and the community, as they relate to unit alarm boundaries.

When a decision is made to purchase a CAD system it should be well planned, with input from all agencies involved, especially from the dispatchers who will operate the system. Often the dispatcher is overlooked in this important aspect of system development.

Some of the advantages of a CAD system are

- the speed with which dispatch recommendations are made to the dispatchers;
- more accurate assignment of appropriate units to specific-type incidents at reported locations;
- improved dispatcher access to critical information, hazards, etc., regarding a specific location; and
- enhanced recordkeeping capabilities.

For cities or communications centers serving populations of less than 100,000, there are many personal-computer-based CAD programs that can easily handle the dispatching demands. At the same time, application of these programs in a personal computer requires attention to the database and keeping the database updated. It is recommended that one person be designated to perform that task. That person also should be responsible for its accuracy.

Public Safety Answering Point

The term Public Safety Answering Point (PSAP) is used to define the primary location at which requests for fire/rescue and police are received from 9-1-1 and other services. In some large jurisdictions, there may be more than one PSAP for operational or political reasons. Typical of this approach is an independent city PSAP within a county that has its own PSAP.

The PSAP may or may not be the point at which a dispatch is made. This depends on the organization of the public safety communications dispatch operation. The PSAP may dispatch fire/rescue and police, i.e., be a "combined" dispatch center. Other modes in which a PSAP may operate are as follows:

- Receives the initial request and transfers the person making the request to the appropriate fire/rescue or police agency.

- Receives the initial request, processes the information, and transfers the information (not the calls) to the appropriate tire/rescue or police agency. A drawback to this type operation is that it denies the agency that is responsible for the actual dispatch of units the ability to talk with the reporting person.

- Receives the initial request, processes the information for one agency (fire/rescue or police), dispatches its units and transfers the caller to the other agency to

further process and to dispatch it. This type of operation is referred to as a Secondary PSAP.

The agency responsible for the dispatch should have the opportunity to talk directly to the reporting person so that no important information is "lost."

Because they usually receive the majority of calls for service, the police department or local law enforcement agency serves as the PSAP more frequently than does the fire/rescue department.

Basic 9-1-1 -- The concept of 9-1-1 was born during the late 1930s in Great Britain where the telephone number "999" was used to summon police, fire, and medical services. During World War II, the efficiency of this system was recognized by American military personnel stationed in England. As they returned from the war and entered civilian life as firefighters and police officers, they brought with them the concept of a universal three-digit telephone number to summon help in an emergency.

In 1956, the National Association of Fire Chiefs, now the International Association of Fire Chiefs, formally recommended that a universal telephone number be established in the United States for summoning fire, police, and medical services in an emergency. In 1968, led by AT&T, all telephone companies in the United States provided the number 9-1-1 to any community desiring to establish it.

The database that the local telephone company uses for recording the location of each assigned telephone number is used to direct a 9-1-1 call to the appropriate Public Safety Answering Point in the area. Upon receipt of a basic 9-1-1 call at the CC, the call-taker must obtain from the caller the location of the emergency.

If the location of the emergency is not in the PSAP's jurisdiction, the PSAP is responsible for efficient transfer of that call to the appropriate PSAP.

Enhanced 9-1-1 — As with Basic 9-1-1, an Enhanced 9-1-1 system directs the call to the appropriate PSAP. However, the call-taker is provided with a small screen that shows the telephone number from which the call is being received. (This feature is commonly referred to as Automatic Number Identification or ANI). The call-taker also is provided with the occupant's name, location (address), including apartment number, suite number, business name, and possibly other information. (This feature is referred to as Automatic Location Information or ALI.) The call-taker then must confirm the location of the incident being reported in relation to the caller's location. It is critical that the address given by the Enhanced 9-1-1 be verified. In some cases, the billing address may appear, causing a response to the wrong location. As with basic 9-1-1, if the location reported is not in the jurisdiction for which the PSAP is responsible, procedures should be followed for the efficient transfer of that call to the appropriate PSAP.

Monitoring Unit Status

The knowledge and maintenance of a department's fire and rescue unit status is a vital function of the CC. The status of units, particularly a unit's availability for an assignment, must be known at all times by the dispatcher.

In most cases, information concerning a unit's status has to be provided by the unit to the CC by personnel assigned to or responsible for a unit. The CC then is responsible for unit status keeping. There are two ways that this can be achieved: manually or electronically.

Manual status keeping usually involves the dispatcher flipping a switch, turning a knob, pressing a button, or writing things down to track unit status. This action is based on some type of notification and/or action initiated by a unit or station and received via radio or telephone,

such as a unit advising of its arrival on scene or a unit reporting an incident it has encountered while en route somewhere.

Electronic status keeping usually involves the crew hitting a button in the cab of the fire apparatus, which sends an electronic signal via radio that causes the unit status to change on a map, status board, computer screen, etc. A signal also may be sent electronically when a unit leaves the station, by tripping a pressure-sensitive mat or electronic eye, or again by hitting a button in the cab or station.

CAD systems provide a screen depicting the status of a department‘s resources, often including a computerized map showing the resources in relation to the areas covered. This is a valuable asset to the dispatcher when determining when it is necessary to relocate units to cover vacant stations in time of multiple incidents or a major emergency.

Many CCs use a large status/map board to allow all CC personnel to view unit status. These status or map boards usually identify the status of units by using different colored lights. Other CCs just use a status board showing units in or out of service. The status boards used by the Town of Palm Beach, Florida, and Dallas, Texas, are shown in Exhibits 2-2 and 2-3, respectively.

Many fire departments have established a set of unit status designations to reflect a unit's disposition. For example, they may define status to be "out-of-service" (completely unable to respond), "available in delayed mode" (such as for units engaged in training evolutions), or "available by request only" (such as for units in formal training classes that are available for working fires). Other types of status are "in station, " "en route," and "at scene" (at an incident).

The CC supervisors need to ensure that unit status is kept up to the moment if not handled automatically.

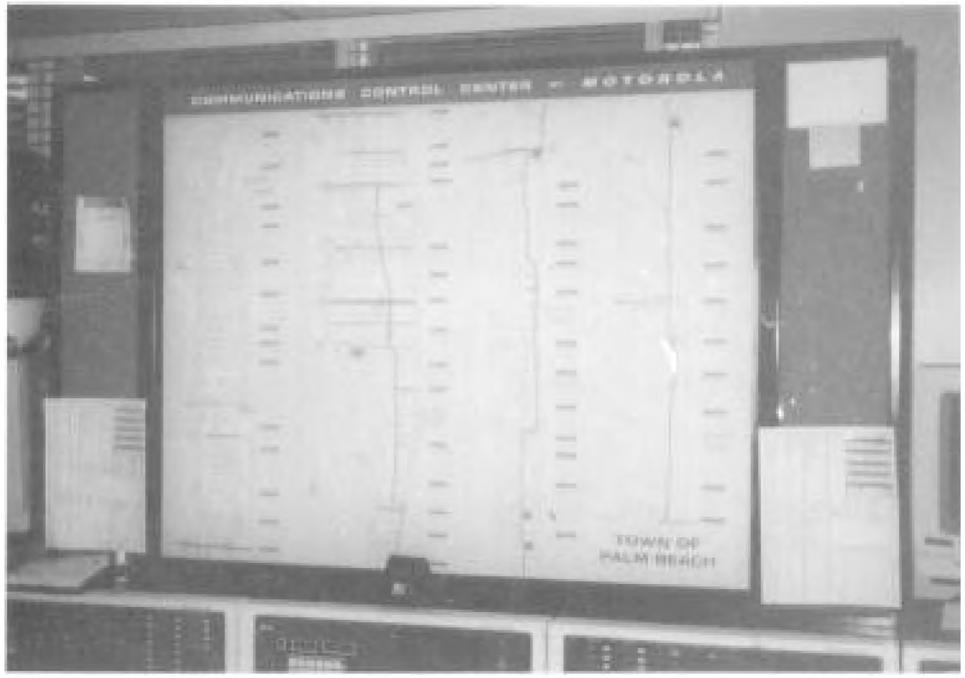

Exhibit 2-2. Palm Beach, Florida Status Board.

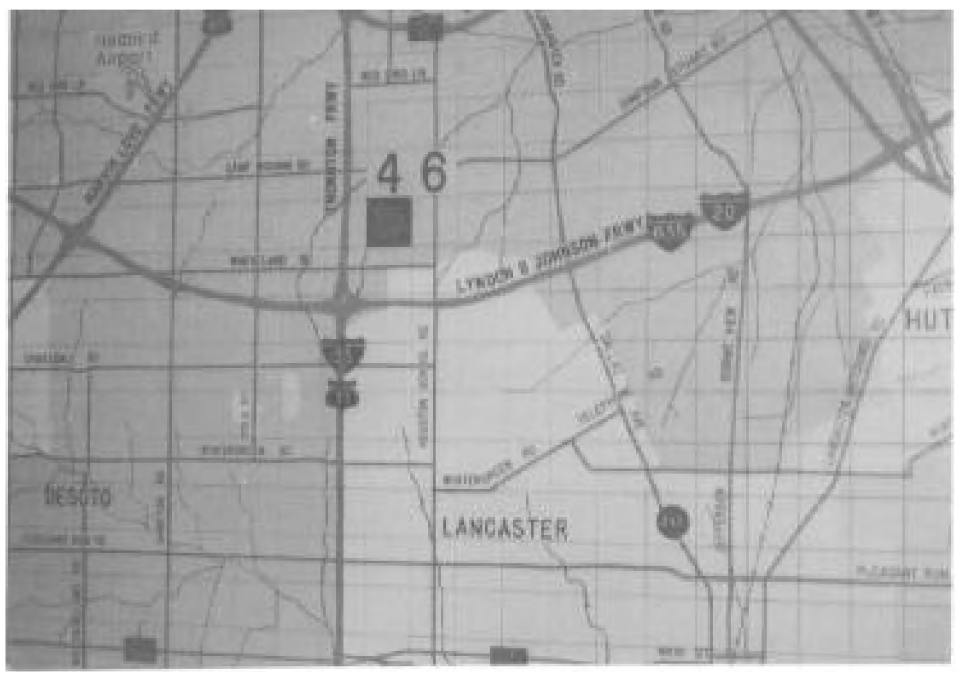

Exhibit 2-3. Details of the Dallas Fire Department Status Board.

Recordkeeping

Every communications center must have a method for documenting its communications activities, including personnel on duty, calls received, alerts, dispatches, pages, acknowledgements, arrivals on the scene, requests for resources, incident status, etc. This information is necessary to comply with various local, state, and federal reporting requirements,

Fire records and communications also have legal significance, and can be called for in legal proceedings regarding fire and arson investigation, service complaints, and civil legal proceedings such as insurance litigation and product liability cases. The security and integrity of dispatch records should be maintained through administrative and hardware/software controls. Steps must be taken to assure that computerized reports cannot be altered or generated after the fact without proper authorization (such as when the probable cause of fire is changed after further investigation).

The CC manager should establish the method of recordkeeping, the information to be maintained, and the method of storage, retrieval, and release of information. This should be done in consultation with the jurisdiction's legal staff and fire department, including the fire marshal, Ideally, this would be done as part of a department-wide data needs assessment, which would identify the data elements needed and the best form for retrieval.

Incident Records -- One of the most basic records kept by every fire department is a log of all incidents. The log may be kept manually or by computer, or using a combination of the two. In some departments the dispatchers jot notes as calls come in and dispatches are made, and then type up incident logs or enter the data in a computer. Much of the incident data are generated automatically when CAD systems are used. Typically, the incident data are provided to the person filling out the incident report, often the company officer from the first-responding unit.

In other departments, the incident information flows the other way. The officer sends data on the incident to the computer or a person who merges that data with the CAD-system-generated data.

Fire departments should attempt to keep their incident reports compatible with their state incident reporting system and the National Fire Incident Reporting System (NFIRS) administered by the US. Fire Administration.

Increasingly, fire departments also are using data generated in the CC as the basis for making decisions on staffing levels, station locations, and in targeting fire prevention activity. It is essential that this information be kept accurately and in retrievable format-preferably in computer retrieval format-for later use.

Records of Verbal Communications -- Accurate records of verbal communications to and from the CC must be maintained. Most fire departments use tape recorders to document all radio traffic on all frequencies normally used by the department and on telephone communications with the dispatch center. Incoming emergency lines and tie lines to other agencies should all be connected to a recording system. Depending on state law, an audible "beep" signal may have to be provided on phone lines used by the public that are recorded.

Multiple-track, time-logging tape recorders are available for simultaneous recording of several channels. These units usually feature backup capability to prevent missed communications during changing of tape or in the event of a mechanical failure of one of the recording units.

There is a wide variance in the amount of time that fire departments store tapes before taping over them. It is recommended that tapes be retained at least 30 days for routine operations. In the case of unusual events such as fatal fires, apparatus accidents, injuries to firefighters, or extra alarm fires, tapes might be retained indefinitely.

Cassette duplicates of radio traffic are an excellent training aid and useful in postincident analysis.

Control of Computer Software and Files -- The use of computers in the CC environment is increasing rapidly and is a valuable resource in the maintenance of records of all types. The security of this resource must be maintained. Attention must be given to whom is provided access to this information. There are many ways in which this can be achieved and the CC manager should work with the vendor of such equipment and other personnel on the jurisdiction's computer staff to establish the level of security desired. This security need extends to the recordkeeping software and software associated with computer-aided dispatch (CAD). Security is especially important for files that list streets and addresses in relation to unit assignment. These files, often called geo files, are particularly sensitive when they are shared with other agencies of the government which may have a legitimate need to change the geo file without having a full appreciation of the effect of the change on the CC's operation.

External Relations

Another important part of managing a communications center is interfacing with many groups external to the fire department.

Interfacing with Alarm Companies -- Alarm companies are the source of many calls received at the CC. In most cases the alarm company serves as a monitoring agency for automatic detection systems. When it receives an alarm, it will call the CC via telephone and provide information as to the location of the alarm received, including building, floor, zone, occupancy, etc., and the type of alarm. The CC then will make the appropriate dispatch based on the information provided and established procedure. Often, unpublished telephone numbers in the CC are dedicated for the sole use of alarm companies.

In an effort to curtail the number of accidental or false alarms received from alarm companies, many jurisdictions have established charges or fines for false alarms above a set number. Many jurisdictions also require certification of installers of alarm systems and testing of installations, such as in Portland, Oregon, where false alarms have been reduced to a minor problem. It is important that CCs maintain a dialogue with the alarm companies that serve the jurisdiction so that problems can be addressed. The CC also should provide reports on problem buildings to fire prevention or operations personnel responsible for such issues.

Some jurisdictions are enacting regulations that require the alarm company to provide a computer link to the CC's CAD system. This allows the alarm company to enter alarms received at its monitoring point directly into the CC's CAD system as an alarm to be dispatched in accordance with an established procedure, and the information that is required to be provided. As more buildings become alarm equipped, it is important that the fire department be proactive and not let problems develop that could have been addressed earlier. This approach will not lessen the number of alarms received from the alarm company but will allow for a more rapid transmittal of the alarm from the alarm company to the CC.

Relations with the News Media and Public -- Notwithstanding the fact that the tire department may have a public information officer, the reality is that the CC often is the first fire department office contacted by the media when inquiring about a specific incident or about the department's fire and rescue activity level in general. Reporters frequently call CCs to find out if anything interesting is going on.

The CC should have a clear and uniform policy as to what type of information is to be released. This policy should be shared with the media so that media representatives will know how to contact the CC (a specific telephone number, who to ask for, and what type of information is to be released). A clear understanding of the policy will reduce the possibility of conflict and allow the media and the CC to understand each other's needs.

A list of the department's public information officers and their telephone and pager numbers should be kept handy for the dispatchers.

Some tire departments have installed a telephone answering machine as a means of providing information to the media. In this type of system, information concerning recent or ongoing incidents is placed on an answering machine. This is a way to provide information without tying up CC personnel. Fire departments equipped with "voice mail" can use it in a similar manner. If done properly, the taped message can be carried by the broadcast media.

Emergency and Nonemergency Telephone Numbers -- The seven-digit or 9-1-1 fire/rescue emergency reporting number for the fire department should be published in local telephone directories and in a variety of other places, such as on department letterhead, telephone stickers, and in department vehicles. A public information program should emphasize the importance of using the emergency number only for genuine emergencies.[2] A nonemergency number also should be provided to the public to reduce unnecessary calls to the emergency number. In addition, the government section of the telephone directory should list the direct numbers for the public to use to reach specific offices of the department, such as administration or fire prevention. Because a station may be vacant at the time of an emergency call, it is not advisable to list individual fire station telephone numbers. The public should be discouraged from calling a specific station to report a fire or request EMS.

Personnel Policies and Organization

Nothing is more important to the effective operation of a fire/rescue CC than the people who staff it, from the manager to the newest employee. Many times an agency CC and its personnel are given "stepchild" status, with the focus going to other segments of a department. A

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[2] The United States Fire Administration provides a public education campaign kit on this subject called *Make the Right Call.*

fire agency should give the same attention to the personnel policies and procedures of the CC that it does to its fire prevention, fire suppression, and other divisions.

The internal organization of the CC should, in many ways, be similar to that of a fire company and, administratively, be equal to that of a fire battalion or division. This type of organization allows for good management practices to be used and for the CC to be viewed and, in fact, be on par with other major elements of the department(s) served.

To attract and retain high-quality personnel is a difficult goal to achieve but well worth the effort. Attention must be paid to recruitment, selection, and work schedules.

Staffing -- There is no recognized standard formula that addresses the number of onduty CC personnel required based on the number of emergency/nonemergency calls received, dispatches made, radio channels used, etc. To make staffing more complex, the normal level of CC activity often is punctuated by major incidents such as thunderstorms, ice storms, large fires, or multiple-traffic accidents, which produce intense periods of activity.

The CC needs to be staffed with sufficient personnel to meet both the demands of the normal level of activity and the level of activity associated with frequently occurring "peak" periods. Unlike fire and rescue incidents where the incident commander can request more units from the CC and have them arrive in minutes, most CCs do not have backup help available fast enough to make a difference, except in long-duration incidents. Consequently, there should be enough personnel on duty at the CC to handle all but the most unusual level of activity.[3]

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[3] The Insurance Services Office (ISO) Fire Suppression Rating Schedule also addresses staffing and equipping of communications centers.

The following functions need to be staffed:

- A Supervisor to oversee the CC's operations and to give direction;
- Call-takers. The number of call-takers depends on the number of emergency reporting lines, the call volume, and whether the CC is a primary or secondary Public Safety Answering Point;
- Primary/Dispatch radio channel dispatcher(s); and
- Incident Command radio channel dispatcher(s).

Depending on the size and complexity of the CC's operation, more than one of the above functions may be handled by the same person.

Recruitment/Selection -- Selecting the right employee is as difficult and important to the operation of the CC as it is to the operation of a major corporation. Before any CC employee is hired, the qualities and attributes being sought must be defined (see the following section for examples). The CC manager should work closely with the jurisdiction's personnel department to develop an appropriate recruitment strategy. A typical position announcement is contained in Exhibit 2-4. A typical CC entry-level position description is included in Appendix B.

Exhibit 2-4. Sample Position Description

City of Hunington Beach
Class Specification
Title: Fire Controller

Duties Summary: To receive calls, analyze and prioritize emergency requests for assistance, and dispatch fire and paramedic according to established policies and procedures.

Example of Duties: Receives emergency calls, analyzes and prioritizes emergency requests for assistance, and dispatches fire and paramedic units according to established polices and procedures; gathers vital information from calling parties and uses a computer-aided dispatch system to determine the best utilization of resources; provides emergency medical dispatch information to calling parties; transmits dispatch information by radio and by voice and data telecommunications circuits/paths; maintains communications with field units and monitors radio and data transmissions; monitors availability status of fire department resources and makes recommendations for temporary/permanent changes to deployment standards; responsible for ensuring the working conditions of communications equipment by means of scheduled tests and procures repair service for malfunctioning equipment; loads, maintains and updates a variety of business and emergency computer and/or manual files; monitors equipment for other city/county agencies as required. Performs other duties as assigned.

Knowledge, Skills, Abilities & Personal Attributes: Knowledge of the principles, practices, and procedures of fire and emergency medical communications; geographic knowledge of the area served by the Net 6 communication center; better than average verbal skills, good english grammer and spelling skills; must be able to quickly analyze situations, make decisions, prioritize actions, and coordinate activities; must be able to project voice over the radio and speak clearly and distinctly; must be able to work under stress and have ability to remain calm in emergency situations.

Minimum Qualifications: One year of public safety (fire police) EMS radio dispatching Experience; must be able to type 30 words per minute; must have some experience working with computers; must be able to work varying shifts, days of the week, holidays, and overtime shifts; Emergency Medical Technician (EMT) certification is desireable at time of employment or ability to obtain within the first year of employment; may be required to pass a background chack and psychological testing; must have eyesight correctable to 20/30 in both eyes and cannot be colorblind.

The placement of the recruitment announcements is very important. For newspaper classified sections, it may prove better to place recruitment ads under "public safety" or "government," than under "dispatcher" or "clerical." If placed under "dispatcher" the ad should elaborate on the emergency public safety nature of the position, The dispatcher's job is largely unknown and/or misunderstood by the public, and every effort should be made to portray the position in the most accurate way.

If the CC is staffed by sworn firefighters, the same attention should be given to their selection as that given to civilian recruits. Being a firefighter does not, in itself, make someone a good dispatcher. The same talents and interest level are necessary in sworn (uniformed) personnel as in nonsworn (civilian) personnel.

Many jurisdictions have asked local television stations or newspapers to run feature articles on the operation of the CC. If the CC is staffed by civilian personnel, this strategy serves to expose the real-life nature of the job and can spark the interest of potential applicants who may never have considered such a position.

The Manager -- The management and leadership style of the CC manager can have a major impact on the CC's efficiency. The CC manager may be a sworn fire department officer or a civilian. Regardless of background, the CC manager should have the authority to establish the policies and procedures that will allow the CC to carry out its responsibilities to the department and the public. The CC manager should have good management skills, knowledge and understanding of the role of the CC, a desire for the position, and a commitment to an extended assignment.

More specifically, the CC manager should possess the following characteristics:

- Knowledge and experience in dispatch operations.
- Understanding of the mission, goals, and objectives of the department.
- Understanding of the present and emerging technologies available to enhance the communications capabilities of the department.
- The ability to identify when changes in procedures and technologies are necessary and to articulate how they can benefit the department.
- The ability to deal with the public and address complaints received in an effective manner.
- Respect for the fire department management team and, in turn, the ability to command their respect.
- The ability to develop clear, comprehensive standard operating procedures.
- Understanding of the pressures and stress experienced by dispatchers.

In addition, the CC manager should have the following types of good management skills:

- Excellent interpersonal skills.
- Good oral and written communications skills.

- An understanding of the needs of CC personnel regarding job satisfaction and recognition,

- Demonstrated integrity and fairness

- An openness toward change and progress.

- Good short- and long-range planning ability, both technical and fiscal.

- An understanding of the department's budget process and the ability to advance the needs of the CC in that process.

Shift Supervisors -- The CC shift supervisors usually are the people with direct oversight of the daily operation of the CC. Consequently, they will have a great deal of responsibility and should be given the authority to match their responsibilities. CC supervisors usually are promoted or assigned from the ranks of the CC's dispatchers. A CC supervisor should possess the following characteristics:

- Extensive knowledge of the policies and procedures of the CC and the fire department.

- The ability to train and to explain the complex and changing nature of fire/rescue communications, so that those supervised have a clear understanding of their duties.

- The means to gain the confidence of the fire department's personnel in areas of judgment, knowledge, and professionalism.

- The ability to deal effectively with the public, government officials, media, and all sections of the fire department, including operations, tire prevention, and support services.

- Understanding of the technical operation of the CC's equipment, so that problems can be identified and corrective actions can be taken.

- The ability to motivate employees and recognize them for commendable performance.

- An even temperament and balanced approach in dealing with citizens, CC personnel, and fire department personnel.

Dispatchers -- The CC dispatchers (or telecommunicators) are the heart of the CC's operation and the people most vital to its operations. Great care must be taken in the recruitment and selection of dispatchers. A CC dispatcher should be highly motivated, emotionally mature, and have a strong desire to serve the public and the fire department. The characteristics of good CC dispatchers are as follows:

- The ability to stay "cool" under pressure and maintain professional decorum. If the dispatcher "loses it," it does not bode well for the incident and for those who depend on the dispatcher.

- Good diction and speech pattern so that they can be effective communicators.

- The ability to hear several conversations or messages at one time, concentrate on one conversation, and process that information effectively.

- Understanding of their role and responsibilities to the citizens, CC, and fire department.

- Appropriate level of empathy with the public in their time of need.

- Positive attitude towards citizens, the CC, and the fire department.

- The desire to feel satisfaction in helping people during a time of need.

- The self-confidence to act appropriately in an emergency, transmit confidence, and have a calming influence on an incident.

- Knowledge of when and how to take charge of a situation and the ability to do so in a firm, professional, and nonoffensive manner.

- The ability to anticipate what may be requested next based on what's being heard and what's happening.

- The ability to adjust to varying levels of activity, from no active incidents to having all units committed and large mutual aid forces assisting during a disaster.

- The ability to hear a message, interpret it, and repeat it without losing any of its meaning.

- The ability to pass a "criminal history check" and a polygraph examination, as permitted by local laws.

- The ability to pass a medical examination that includes a hearing test and sight test (in accordance with applicable laws such as the Americans with Disabilities Act).

Work Schedule -- As in fire suppression, the work schedules for CC personnel vary widely. There is no perfect schedule. Some CC personnel may be governed by provisions of the Fair Labor Standards Act (FLSA), which affects overtime pay. Information concerning the FLSA can be obtained from your jurisdiction's personnel department or the U.S. Department of Labor.

In CCs staffed by nonsworn personnel, the trend has been away from the rotating schedule in which an employee works a week on the day shift, a week on the midnight shift, then a week on the evening shift, or a combination thereof. There are many reasons for this trend, but the most common is the burden of the shift change on the employee. CCs that still use a rotating shift have, in many cases, lengthened the time between rotation to be months, and, in some instances, use a yearly rotation. A schedule that uses fixed shifts with rotating days off is becoming more popular. Under this schedule personnel are assigned to work as part of the same team on a permanent basis.

In CCs staffed by sworn personnel (firefighters), the shift sometimes is the same as for personnel assigned to suppression units. This is often because of contractual agreement or organizational/personal preference. For those jurisdictions opting for this approach, consideration must be given to employee effectiveness on shifts that extend beyond 12 hours. Some departments use 24-hour shifts with nap periods in the evening, but there are still questions about the effectiveness of personnel on such long shifts.[4]

Civilian or Firefighter Personnel

Both civilian and firefighter personnel have been used successfully in dispatch centers. Sometimes the civilian employees wear uniforms, but they are not considered "sworn" or

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[4] Presently, there is no central source of information concerning shift schedules relating to CC operations and considering FLSA requirements. The Association of Public Safety Communications Officials International, Inc. (APCO) was planning, at the time this manual was being written, to undertake a project with the goal of developing a computer software package that will allow for the design of work schedules based on personnel, organizational, and FLSA criteria.

"uniformed" members of the department. The most frequently stated advantage of using civilian personnel is that they (nonsworn personnel) tend to be less expensive (considering salary, benefits, and equipment) to employ. Second, by using civilian personnel, longevity in the communications center may be greater than for uniformed personnel, who may transfer into other units after a few years.

Civilians have been used as dispatchers in departments of all sizes. Where they are used, the following practices should be considered:

- Good hiring and selection processes should be used (the job is demanding and not everyone can fill it).

- The salary of the nonsworn dispatcher should be commensurate with the demanding and important nature of the position.

- A formal and extensive training program should be used.

- Training should be provided to CC personnel on the operation of the department(s) served by the CC.

- A career ladder should be developed to allow CC personnel to view their job as a career and to afford them the ability to advance from dispatcher to higher levels, preferably that of manager.

- Standard Operating Procedures (SOPs) should be developed to provide clear guidance to the dispatcher.

- An employee evaluation program should be used to keep employees apprised of their performance.

The main advantage of using firefighters as opposed to civilians is that they are familiar with fire department operations and tend to have EMT certification, which enables them to use their knowledge in making decisions not covered by the standard guidelines for dispatch. Locations of structures, knowledge of response routes, and firsthand knowledge of operational concerns can give the uniformed firefighter the ability to anticipate requests for assistance from the field. Another advantage is shorter training time; they already have been trained in firefighting operations and have been successfully screened. They require training only in communications equipment and procedures.

The use of uniformed personnel can allow more discretion to be given to the dispatcher, for example, in adding units to a standard response in the event of a suspected major incident. The firefighter/EMT also may handle EMS calls with more awareness of the caller's problem and how to treat it. Yet with proper training and procedures, experienced civilians have shown that they can perform as well as uniformed personnel.

Training

Communications operator training is evolving from the older on-the-job training concept to a more formalized training system. In the past, fire departments paired new dispatchers with more experienced dispatchers to learn the system. The level of training was based solely on what the senior dispatcher thought was important. Often some vital element of the new dispatcher's training was overlooked until a mistake was made.

Today, most fire departments have formalized programs for training new dispatchers. While on-the-job training is still the major portion of these programs, now clear training objectives are delineated within written training courses. Lesson plans are developed for each segment of the course. These plans spell out the desired results and performance levels. Tests are prepared to determine when the student is ready to advance to the next step. This formalized training plan allows the student to logically progress through the training program to the final objective: becoming a competent member of the communications team. Exhibit 2-5 shows the

Dallas, Texas, Fire Department dispatcher training console. Dallas uses sworn firefighters as dispatchers and provides an extensive training program before assignment to a dispatching shift.

Exhibit 2-5. Dallas Fire Department Communications Center Training Console. The console allows realistic training without having to tie up an operational console.

Excellent dispatcher training is available from the Association of Public Safety Communications Officials International, Inc. (APCO)[5] for dispatchers and call-takers for fire, emergency medical services, and law enforcement. Many fire departments develop their own guidelines for training their personnel.

[5] Nasser, Joseph Y., *80-Hour Telecommunicator Training* Course, APCO, 1987, First Ed.

The subjects covered in good dispatcher courses can be placed in four broad categories:

1. Communications skills.
2. Departmental procedures.
3. Equipment use.
4. Interpersonal communications and understanding.

The material covered in these categories is summarized in the table below.

Table 2-1. Elements of Dispatcher Training	
Communications Skills	Includes the ability to listen intently, speak clearly and accurately, not jump to conclusions, and obtain the correct information.
Departmental Procedures	Includes basic types of fire incidents, emergency medical incidents, responses to other emergencies, administrative notifications, and interagency communications.
Equipment Use	Covers the gamut from telephones to sophisticated computer systems. Today's dispatcher must be skilled in the use of the latest communications equipment available to his or her department.
Interpersonal Communications and Understanding	Addresses the need to be aware of the community. Differences in verbal mannerisms can prevent accurate information from being communicated.

***Communications Skills* --** APCO has defined communications as the transmission of an idea from one mind to another, with understanding. Communication skills for dispatchers include the techniques of writing, reading, speaking, and listening.

Key skills for the call-taker/dispatcher include

- identifying yourself and determining to whom you are speaking;
- listening closely to what the caller or speaker is saying;
- asking questions in a logical order so as to receive pertinent information;
- never assuming an answer;
- remembering to be brief during questions and answers since time is of the essence;
- recording the information accurately so that it can be retrieved;
- speaking calmly and with a clear voice, not rushing your words; and
- remembering that the dispatcher/call-taker speaks with the voice of authority for the department.

***Departmental Procedures* --** Departmental communication procedures cover the broad spectrum of what a fire department does and how it accomplishes those tasks. Each department has developed written or implied policies regarding how it conducts business. Each of these policies should have corresponding written communications procedures. An example of a well-developed communication policy and procedure manual is that of the Huntington Beach, California Fire Department. Huntington Beach has divided its policies into six general areas:

- administrative
- communications
- equipment
- operations

- responses
- training

Administrative policy provides written procedures for incident number assignment, chief officer notifications, outside agency notifications, organizational charts, and administrative lines of authority.

Communications policy contains procedures for dispatching units, mutual aid responses, receipt of emergency reports by field companies, 9-1-1 calls, definitions, use of clear text, and general radio protocols.

Equipment deals with equipment out of service, apparatus identification, and standard terminology for equipment.

Operations policy covers fire company coverage, alerting stations and personnel, emergency medical responses, hazardous materials incidents, helicopter operations, and mutual aid responses.

Response policy sets procedures for the number and type of units sent to each type of emergency, including structure fires, requests for ambulance service, animal calls, flooding conditions, and nonemergency service requests. The policy includes everything from ordering tow trucks to requests for public utilities' response.

Training policy specifies interagency training, a master training plan, and continuing education for all members of the department.

The Phoenix, Arizona Fire Department has a similar set of policies regarding operations, dispatching, administrative responsibilities, and training. As in many other major departments, Phoenix has developed an additional procedure for emergency medical dispatching. This

procedure requires the use of Emergency Medical Technician (EMT)-trained personnel to dispatch all medical calls within its dispatch center.

Emergency medical calls dominate the workload in many CCs today. The emergency medical system is composed of several levels of care, ranging from first-responder to Basic Life Support (BLS) to Advanced Life Support (ALS) using paramedics. With the presence of different levels of medical skills, decisions often must be made regarding what level of skill is needed for each call, since many departments are unable to provide the highest level of medical response (ALS) to all EMS incidents. Strict procedures are needed to govern the level of response and coordination with other agencies, such as private ambulance services.

Dispatchers should provide medical self-help instruction to the caller until emergency units arrive. Guidelines for giving self-help instructions must be clear, simple, and succinct enough to be given quickly over the telephone. Each of the guidelines should be developed and reviewed by the authorized medical authority responsible for the overall EMS program. In many departments all dispatchers are firefighters trained as EMTs; these personnel often are referred to as Emergency Medical Dispatchers (EMDs).[6]

The new call-taker/dispatcher must be completely familiar with these operational policies and procedures before becoming a full member of the communications team. The training program should include all of the department's policies and procedures that relate to communications.

Equipment Use -- To the new dispatcher, the modem communications center can seem like the "mission control" for space shuttle flights. The large array of sophisticated electronic equipment can intimidate the new trainee.

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[6] Richard Keller and Jamiel Yameen. "EMD in the Fire Service," *Fire Chief;* May 1992, p. 46.

A well-planned training program will cover each element of the overall equipment system in turn and have training segments that build on one another. The Huntington Beach Fire Department begins with basic telephone call-taker techniques and simple computer commands, then adds telephone operations. Once the trainee has mastered these functions, along with the corresponding procedures, he or she can begin functioning as a call-taker and is ready for the next phase of training.

Exhibit 2-6. Los Angeles County's Command and Control Facility.

The next phase of training deals with more complex computer commands and moves into the use of radio equipment. The final phase covers trouble-shooting and maintenance of computers, recorders, and printers. By separating the complex equipment systems into simpler individual elements, Huntington Beach has developed a successful training program. Many other departments have similar programs.

Interpersonal Communications -- Much of what a call-taker/dispatcher says to the public would be classified as formal communications. If care is not taken, the impression given can be impersonal and somewhat cold, the "voice of authority." Skill in interpersonal communications allows a dispatcher to step beyond that formal level and understand the communication skills, attitudes, values, and experiences of the other person.

APCO's Basic Course presents this view of interpersonal communications:

> *Telecommunicators must be aware of the fact that interpersonal communications is the framework upon which all communication transactions are built... Behavioral scientists tell us that less than ten percent of all communication is done verbally, while most understanding is achieved by means such as facial expression, voice inflection, body gestures and so forth. Given this, the process is made much more difficult for the telecommunicator, who is limited to the use of radio, mobile data transmission, teletype, telephone, etc. Basic comprehension of the principle of interpersonal communication is therefore a prerequisite to effective telecommunications.* (APCO, *Basic Telecommunicator Course,* 2nd Ed., 1992.)

That is, interpersonal communications normally includes more than just verbal exchanges. Tone of voice, body posture, and eye contact all are part of everyday communications. Turn off the sound on a television and watch the actors. The silent body

messages will stand out delivering the story line. Unfortunately, emergency communicators usually don't have the luxury of using all of these elements that make up interpersonal communications. Their communications are limited to what is spoken or heard. A trained emergency communicator knows that listening skills, a clear, calm, authoritative voice, and appropriate questioning skills are critical for successful communications. A raised voice or argumentative posture will quickly exacerbate the emergency situation.

Having limited the emergency communicator to listening and speaking for gathering and distributing information, that person's self-discipline becomes critical to the success of the operation. A dispatcher cannot become lazy or lax in gathering and disseminating information. The operator must ask logical questions, listen carefully while not making assumptions, reach accurate conclusions, and deliver clear instructions. An emergency communications operator's error can cause the loss of human life.

The emergency communications operator, as the coordinating link for the department, also must not let personality differences interfere with the smooth flow of information. Each individual has his or her own personality traits. People react differently to each person's personality. The operator must maintain an unbiased, professional attitude toward all the people with whom he or she communicates.

Further, many fire departments serve a population that is becoming more diverse, with growing numbers of new immigrants who have different cultural or ethnic philosophies and difficulty with the English language. Some of these people may come from regions of the world in which asking for help from authorities is considered unwise. Some fear some kind of punishment. Many are concerned with service charges. Communications centers must deal with these differences and the new trainee needs to be made sensitive to the potential problems and have instructions on how to handle these situations.

In areas with large non-English-speaking populations, translation capability should be established to facilitate accurate reporting of emergencies. Nationwide dial-up translation

services are available from telephone companies. Some cities with large foreign-speaking populations use bilingual dispatchers, or train dispatchers in some basics of the local languages.

Monitoring -- The final element of a training program should be monitoring the service provided. The best-written training program will eventually fail if quality assurance isn't maintained. The development of a quality assurance program to verify that the appropriate level of assistance is sent to each call should be an integral part of any training program.

Many other issues and details of managing communications centers are presented in Chapters 3 and 4.

3. Planning A Communications System

Fire department communications within the United States may well have its roots with the "town crier" of the 1700s. Quite often one of his duties was to watch for fires and sound the alarm calling the citizens to form a bucket brigade to extinguish the blaze.[7] This simple solution is an example of analyzing a communication problem and developing a plan to manage the situation. While the Communications Center, discussed in the previous chapter, is the hub of modern fire department communications, there are many other components and facets to consider.

What is a Communications System?

The passing of information from one person to another, with understanding, is the fundamental purpose of any communications system. A fire department communications system is a series of elements that allows a department to exchange information from different sources and generate timely actions that allow the department to meet its responsibilities. Every element that plays a role in the exchange of information is part of the system.

A fire department communications system has three major tasks or purposes. The first is to establish communications between the public and the department for receiving requests for assistance or information. The second purpose is to determine the level of response and communicate that information to the appropriate resources. The third purpose is to provide effective communications among the individual resources and the communications center so as to facilitate the successful resolution of the incident.

Each of these tasks must be done accurately and within acceptable timeframes. The acceptable timeframe may vary with the working environment. For example, within the vast

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[7] NFPA *Fire Protection Handbook,* 14th Ed.

wilderness areas protected by federal and state fire agencies, the required timeframe for receiving a call and dispatching resources may be hours rather than the seconds or minutes expected for the metropolitan fire department.

Any analysis of fire department communication systems must begin with a basic understanding of its three main purposes. The analysis should develop acceptable criteria for accomplishing each element. Future demands for service should be identified. Current systems should be measured against the current and anticipated workload to see if the criteria can be met. This analysis will identify whether there is a need to change procedures or components.

Hardware Components

The components of a communications system include the people and the hardware. Basic fire communications relies on the audible and the visible, what one hears and sees, and how one speaks. Hardware affects how this communication can be accomplished. Fireground communication can take advantage of other senses, but these must be "translated" into speech in order to be transmitted to others.

This section discusses some of the major hardware elements and options in a modern fire department communications system. The next section briefly discusses the human element (which is discussed at length in Chapter 5). The reader who is not familiar with the basic components of a radio system may wish to read Chapter 6, Communications Hardware, first.

Radio Elements- An analysis of a fire communications plan or system must include an understanding of the available hardware systems that can be used to meet the department's objective of effective communications. One of the major aspects of fire department communications is the use of the radio frequency spectrum to carry messages (both verbal and

digital). Base stations, mobile radios, and portable radios are the essential radio components of virtually all fire department communications systems.

Radio signals and visible light have much in common. They both are electro-magnetic fields which oscillate at very high rates (frequencies). However, they occupy different parts of the electromagnetic spectrum-different frequency ranges. Radio signals oscillate at a rate much lower than that of visible light., The oscillation rate is measured in terms of cycles per second (cps). Radio frequencies oscillate at millions of cycles per second. At one time this rate was called *megacycles.* However, to honor a German physicist, Heinrich Hertz, the scientific community replaced *cycles per second* with the term *Hertz.* Therefore, the units of measurement went from Megacycles (MC) to Megahertz (MHz)-a million cycles per second.

For years, fire department radios made use of the frequencies clustered in the "low band," around 33 to 46 MHz, and the "high band" of 150 to 174 MHz. Both of these bands provide excellent coverage for most fire departments.

However, there is a limited amount of expansion available within a given radio frequency range, and fire service radio is no exception. When a department needs additional frequencies to meet expanding communications requirements, it may find that no frequencies are available in the bandwidth (low, high, or UHF) of its existing equipment. Many departments have had to move their radio communications to the 450 to 500 MHz frequencies to find additional communications channels. These ultra high frequency channels do not have the range of the low or high band frequencies and quite often require higher output transmitters or the use of repeaters to have the same coverage as the low or high band frequencies.

In many areas of the country, particularly in metropolitan areas, even the 450 to 500 Mhz frequencies have all been committed and yet the demand for additional channels continues. As a result, many departments now look to the 800 MHz range for additional frequencies.

The majority of fire communications systems include at least one fixed station base transceiver and some number of mobile and portable radios (transceivers). Most of these systems operate on one frequency, that is, the transmit frequency is the same as the receive frequency.

Exhibit 3-1. Transmitter Sections & Receiver Sections of All Transceivers on Same Frequency, Freq. A.

Repeater Systems -- At the next level of complexity in radio systems are "repeating systems." They have at least one fixed station base transmitter and some number of mobile and portable radios, and use two frequencies as shown in Exhibit 3-2. Base to mobile transmits on Frequency A and is received on Frequency A. Mobile or portable to base transmits on Frequency B and is received on Frequency B; base then retransmits the input from Frequency B on Frequency A, so that all other mobiles and portables can monitor both sides of conversation. An even higher level of sophistication for what is still considered a conventional radio system is the use of many satellite receivers and multiple repeating transmitters, all operating off a single dispatch console or communications center.

Exhibit 3-2. Repeater System.

Trunking Systems -- The age of computer-aided communications gave birth to a relatively new concept in radio communications, *trunking systems.* Trunking may be new to the business of fire communications system management, but as an engineering concept, it is not new. The telephone industry has used the concept of trunking for years, for almost the exact same reason trunking is used in radio communications management: the dwindling availability of hard wire and microwave channels between various geographic parts of the country. The Federal Communications Commission (FCC) opened the 800 MHz band to emergency providers with the stipulation that the use of this band be principally for trunked systems.

The technical details of trunking can be obtained from any reliable, experienced radio communications equipment and systems manufacturer. In layman's terms it is something like this.

An uncluttered, available frequency spectrum is becoming rare. In conventional radio communications system and frequency spectrum management, users with like interests were, and are, clumped together, one next to the other, in small bands of the spectrum. Each agency is assigned its own operating frequency, or set of frequencies. In many situations, because of operational needs, some agencies are assigned more than one frequency, or even pairs of frequencies. This is a clean, clear-cut way of keeping one user out of the way of other users, provided all users keep their radio communications transmitted signals nice and clean.

At the same time, there is a certain amount of inefficiency inherent in the "single channel-single user" method of spectrum resource management. The channel often lies dormant, with no radio transmissions taking place most of the time.

Consider the two following examples. A small rural community in the heartland of the United States serves a population of 20,000. A frequency in the 154 MHz region is assigned to the fire department; another is supplied to the police department; another to the public works department. Three frequencies are assigned to 20,000 people. The fire department makes perhaps one or two emergency responses daily. These responses involve critical transmissions on the fire frequency. Likewise the police department. frequency is quiet much of the time. The public works frequency is moderately busy during the workday. After normal work hours and at night, the frequencies are quiet.

On the other hand, a large metropolitan community, with approximately 1,000,000 people, has the same individual public safety and service agencies. Each can be assigned a single frequency, maybe two each, or perhaps even a repeater pair for each. Nevertheless, the vastly different ratio of population to "used frequency spectrum" and "actual transmission time" on these frequencies becomes obvious when compared to the rural community described above.

Certainly the second case is a more efficient use of radio frequency resources compared to the first case. Yet, efficiency is not as high as it might be. What if any transmitter and receiver could be used by any of the agencies, depending on which channel equipment is available?

Consider another situation, where there are six frequencies available. Six agencies wish to cover a moderately large area. Repeaters are required to perform this technical task, In a conventional system, with a frequency assigned to each of the six agencies, unfortunately 12 frequencies would be necessary, and they aren't available. Certainly all can't have the luxury of repeater pairs in a conventional configuration. Is it possible to provide repeater service to six agencies with the resources of six frequencies, and upgrade system performance?

Insofar as the user is concerned, the frequency being used is not important, only the "communicating." Consider now a computer-managed radio system. Assume one of the frequencies is assigned to constant transmission of data to every receiver in the field, and reception of data from every transmitter in the field. All the field equipment would "know" what the main system controller is "thinking about," and the main system controller would know whether every field unit is available and whether it is transmitting or receiving, just to mention a few critical pieces of information. The data, sent on a "control frequency," are continuously telling all the receivers in the system what frequency they should be listening to and telling all transmitters the frequency on which they should be transmitting.

Assume that the fire department field radios are all assigned one common code and that a different code is assigned for all public works radios. The computer manager monitors all the communications by each agency. It also monitors the traffic on each of the repeater pairs available in the system. If public works makes a transmission and Channel A is available, the public works transmissions go onto Channel A as managed by the computer manager. If police wish to communicate at the same time, they are placed on Channel B. If fire transmits, this agency is sent to Channel C. This now places all the available channels in service. Along comes

a fourth city agency. A transmission is made. It just so happens, at the time, that there is a lull in the transmissions on Channel B. The computer places the fourth agency on Channel B. Communications take place. Later, when trying to make another transmission, the computer senses that Channel C is not in use and places the fourth agency on Channel C. The user is unaware that there has been a change in frequency, because all transmitters and receivers in the field are directed automatically to the proper channel by the computer manager.

Let's carry this one step further. Assume the public works department wishes to work with the fire department for an hour or so. Upon computer command, as requested by the dispatcher or the user, the codes of the public works and fire department are managed by the controller so "conversation" can take place. Suddenly, it is as if they are all one happy family. Individual field radios can be programmed to speak privately with some other individual radio, All these tasks are accomplished by the computer manager.

In many areas, several agencies have cooperated to share in trunking systems that make available a greater number of channels for reuse. The Huntington Beach, California, Fire Department uses the Orange County 800 MHz trunking system for both voice and data transmissions. One of the advantages to this county-wide system is the ability of any department on the system to communicate with any agency on the system. The available channels on this system could not have been obtained with conventional systems.

The examples above are but a sample of the features that are being added constantly to trunking systems. One of the principal reasons these features are in flux is that the system operation is managed principally by computer software. Many of the applications of trunking systems are yet to be discovered. When the opportunity arises or necessity requires that a new radio system be considered, the manager might temporarily mentally cast off current radio system practices and consider how the agency would like to operate a communications system since so much more is now possible with the advent of trunking system technology.

Mobile Data Systems -- The increasing demand for more and better communications while still meeting the basic objective of rapid dispatch has caused many departments to turn to digital communications. A verbal dispatch to multiple units using conventional radio methods may take as much as one minute for broadcast and acknowledgement. That same dispatch can be done digitally in less than five seconds. [8] One digital radio channel can handle roughly ten times as many messages as a conventional voice frequency.[9]

A key element of these digital systems is the mobile data terminal (MDT). These terminals are usually installed in each apparatus and have the capability to transmit and receive text (alphanumeric messages). A typical unit has a keyboard for typing messages, a small video screen for displaying messages, and a series of buttons for indicating unit status.

When a mobile data system is tied to a modern computer-aided dispatch system, the time of dispatch, from receipt of the call to automatic acknowledgement from the responding units, can be less than one minute.

The written message of the MDT also alleviates the problem of the spoken message being misunderstood (such as transposing address numbers). For those departments with heavy voice traffic, the MDT system is an excellent tool for reducing traffic to just the tactical needs of commanding incidents.

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[8] Performance tests, Los Angeles County Fire Department, 1991.

[9] Ibid.

Exhibit 3-3. Mockup of Los Angeles City Fire Department mobile communications equipment. The MDT display and keyboard are at bottom of cabinet; automatic vehicle locator and radio control are at top.

Microwave Links -- Another radio element for many systems is the microwave link. For departments that have to use remote base station sites or require several channels to each fire station, microwave links normally are used.

A microwave link bundles together several radio channels, both voice and/or data, and retransmits them at very high speed from one point to another. The link acts like a "freeway" with multiple lanes that allow the messages to travel faster than on individual "side streets." Once the message reaches the end of the link, it separates and follows its own course. The

microwave link allows for multiple messages to be transported at very high speed between two fixed points.

Cellular Telephones -- Many fire departments have installed cellular telephones to augment their main communications system. An example of how cellular telephones can assist departments was evidenced in the Whittier earthquake of 1988 in Southern California. Regular telephone service was disrupted and emergency radio channels were overtaxed by tactical operations. The Los Angeles County Fire Department had installed cellular telephones in all of its command vehicles. The field commanders were able to use their cellular telephones to reach the department's command center, thus providing timely information that allowed the department to assess the extent of the damage. It may even be worthwhile to keep a cellular line open between the incident and the CC to prevent having the lines tied up by the media or public. It may be wise to also establish cellular phone numbers for outgoing and incoming cellular calls.

Another advantage of cellular telephones is that they can help the fire chief or command officer to be more productive by giving him or her access to the telephone system while in his/her vehicle. The chief can handle administrative duties quickly without having to wait to reach the office.

Hard-fines -- Many departments use what are called "hard-line" systems to communicate with remote sites such as fire stations or other communications centers. The hard-line may be municipal alarm lines or leased telephone lines dedicated to the department, as opposed to radio links. The lines can be used to send messages to a teletype machine or to transmit voice announcements over a speaker system.

Today, much of the fire service still uses some form of a hard-line system to dispatch units from fire stations. Although the teletype machines are quickly fading into history, personal computers and printers are taking their place. The hard-line system can be a very practical method for communications between fixed points.

The Huntington Beach Fire Department has developed a Wide Area Network (WAN) for the exclusive use of the fire department using a hard-line system that links personal computers and printers in each fire station along with "voice-over" capability. Dispatches are transmitted to the fire stations via the hard-line system and printed out using the PC and printer. A short voice dispatch also is given over the same system. Units responding can acknowledge either over the station system or on MDTs in the apparatus.

The WAN offers the additional capability for the fire stations to electronically complete their various reports and transmit them to a central computer. This provides quicker and more accurate fire reports and statistics. The WAN begins the process of uniting the whole department electronically, allowing its members to share information quickly and easily. Fiber optic cable is fast replacing wire as a means for linking computers in a WAN.[10]

Fax -- Fax machines are another frequently used element in fire department communications. Besides their use in routine office work, fax machines are sometimes used to supplement radio and hard-line voice communications. In one department, for example, the fax is used to send the address received from an extended 9-1-1 system at a police-run communications center to the fire dispatch office.

Pagers -- There has been an explosion in the use of pagers in emergency services. These are devices worn on belts or elsewhere and are triggered by radio or telephone systems to alert the wearer that someone wants to speak to him/her or to pass on a message. Pagers vary from transmitting a live radio message to showing a single telephone number to call back, to having a screen with alphanumeric messages. They may alert the wearer by a tone or vibration or by simply turning on and broadcasting. They are enormously useful for tracking down everyone from the chief to volunteers, and getting key messages heard.

[10] Frank Christen. "Fiber for the Fire Service," *Firehouse,* April 1991, p. 70.

Computers -- Twenty-five years ago, nearly every fire department in the country had a manual dispatch system. Calls were received and addresses looked up on some form of manual card system. Resources were identified from chalkboards or paper tickets, and dispatches were made over voice radio frequencies. In the early 1970s, some of the larger departments began to develop computer programs to assist them with an ever-increasing demand for services. These early systems were often clumsy and not very "user friendly," but they did begin to automatically process some of the previous manual functions.

The modern computerized dispatch systems are information processors that use automated data processing to assist personnel in dispatching emergency units to incidents. They include ancillary systems that maintain status information, generate management reports, and supervise communications subsystems. The combination of modern computer dispatch systems with new radio technology can save critical minutes in the dispatch process.

The Huntington Beach, California, Fire Department now has a modern computer-aided dispatch system (CAD). Calls for assistance are received via an enhanced 9-1-1 system which transfers the address automatically to the CAD. The address is displayed on the operator's (call-taker's) monitor; the computer has already verified the address and given the dispatch zone. The system also will notify the operator of any other incidents in the same area. If the caller is reporting an incident that is not directly at his or her address, the operator can display the incident on an electronic map showing nearby streets and landmarks.

Exhibit 3-4. Huntington Beach, California, CAD System installed in the 1970s. The system has since been replaced.

Once the type of incident is identified, the information is automatically transferred to the dispatcher, along with the appropriate available resources recommended to be dispatched. The call-taker can remain on the line with the caller to give prearrival instructions, if necessary. The dispatcher transmits the dispatch to the recommended units by both automatic digital message to the MDTs and with a short verbal voice dispatch. The MDT system digitally tells the CAD that the message has been delivered. An audible/visible signal is received at the MDT indicating a message has been sent to that unit. Status changes are processed digitally between the MDT system and the CAD. All transactions are recorded with time and actions taken.

The CAD, along with the MDT system, is saving valuable minutes on each incident. It also is providing accurate statistics so that the department's management can see response patterns to use for future planning. Another plus is that it reduces radio traffic.

Exhibit 3-5. Los Angeles County CAD System display monitors at a Tactical Radio Operator Console.

Human Elements

The best hardware in the world will not be effective unless there are competent people to operate it. The equation for a successful communications system includes hardware, trained personnel, and standard operating procedures. In addition to selecting and training personnel, as discussed in Chapter 2, the planning for a communications system must consider the types of verbal messages that will be permitted, and the procedures for the style of verbal discourse to be allowed.

Each profession tends to develop its own verbal shortcuts for conversing with fellow professionals. This professional jargon can present a serious handicap in the emergency communications field. Verbal shortcuts can lead to misunderstanding between the parties that are attempting to communicate. A trained dispatcher must understand the importance of clear speech without shortcuts.

The Association of Public Safety Communication Officials International Inc. (APCO) recommends that departments adopt a "clear text" format for emergency communications. A clear text format does not allow jargon or codes but instead requires the communicators to use simple commands and responses that can be easily understood. Such a system helps eliminate the potential for verbal errors and eliminates the need for memorization of numerous codes.[11] (The familiar 10-codes used by police and fire agencies, and other aspects of verbal communications, are discussed further in Chapter 5.)

Analyzing Current Performance

When analyzing communications performance, each fire department must develop criteria that define acceptable performance for each aspect of the communications system. The same criteria need to be specified for planning a future system. The categories of criteria may be as follows.

- Acceptable timeframe from receipt of call to acknowledgement of dispatch by responding units.
- Adequate communication channels for tactical operations.
- The requirement for using communications protocols.
- The communications requirements for multiple incidents.
- A plan for graceful degradation of the overall communications system when component systems fail.

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[11] Codes are used successfully by many departments. For a defense of 10-codes, see W.W. Varedoe, "Standardizing Communications," 9-1-1 *Magazine,* January/February 1991, p. 30.

- A complete tracking of all resources.

Once a department has identified its criteria, it then can measure its current system against them. Does the system meet the department's objectives for current demands and future growth?

Many departments may find that their current system, although not the latest technology, meets the communications needs of the department. Some departments have fallen prey to continually trying to keep up with the latest communications trends. Unfortunately, the latest technology tends to become obsolete soon after it is installed. It is more important for the system to meet the needs of the department than to always try to have the newest technology. Responsible spending requires the fire department to separate its wants from its needs.

Interference with Other Systems -- Departments sometimes forget that they do not operate in a vacuum. Their communications system must coexist with other systems, both internal and external to the department. The possibility of interference with or from other systems must be considered in advance as part of the licensing process and in planning new systems.

As an example, a large West Coast fire department installed a complex new communications system to meet its increasing demands for service. At the same time the corresponding law enforcement agency was installing its own separate communications system. They shared transmitter sites and had worked out interference problems at those locations but had gone their own separate ways on each system. When the systems were brought online it was discovered that mobile units parked next to each other created interference to the other units when transmitting.

The lesson here is that departments planning new systems must analyze the effect of that system on all communications users in their area. As more frequencies are used in a concentrated location, the greater the chance that some frequency interference will occur.

In many areas of the country, fire departments share radio frequencies with other fire agencies and EMS providers. As demand for services has increased, many departments find themselves competing for air time with other system users on the same frequency. These others can be planned users, such as the other departments in a county-wide communication system, or they can be unplanned users, such as agencies in other communities whose transmissions cause interference.

To change a frequency is usually very expensive for an agency, yet the interference may prevent the department from meeting its delivery standards. There must be a coordinated approach to frequency use if all of the users in an area are to meet their communications needs. An area-wide communications plan is highly desirable for reducing interference problems.

Establishing System Requirements

Planning fire service and public safety communications systems is an extremely critical function for several reasons. The most obvious reason is that the communications system is a vital element of a public safety organization because if the communications system fails to operate effectively, the organization may not be able to function and deliver its services. In addition, modern communications systems are very expensive and complex, requiring extended lead times to obtain new equipment or to correct design errors that may occur because of poor planning. Poor planning of communications systems has resulted in multimillion-dollar mistakes and nonfunctional systems, and has led to personal embarrassment and ruined careers among planners. In some cases an error in planning can cost lives.

Effective communications planning requires a thorough knowledge of the functions of the organization as they are today and as they are likely to be in the future. It also requires thinking out the manner in which communications must support the organization, and the rapidly changing technology of public safety communications. One of the challenges is to make some essential decisions on technological options and to decide on a system design and configuration. It is possible, in the changing technological environment, to chase after state-of-the-art systems to the point that a final design cannot be selected and agreed upon. The effective planner will "freeze" the design process at a point where it is feasible to proceed with purchase, installation, and implementation, while keeping a capability to incorporate future advances and opportunities that will improve and extend the effective life cycle for the communications system.

Projecting Future Demand -- Projecting future communications system requirements begins with predicting an overall activity level for the system. This can be projected most directly from consideration of the population to be served and the number of incidents that are generated on a per capita basis, considering present levels and past trends to identify the probable activity level. For example, a population of 1,000,000 might be estimated to generate 100,000 calls per year. If the projected population 10 years in the future is 1.2 million, a first approximation of the activity level in 10 years would be 120,000 incidents. This could be modified by adding an activity level increase of two percent per year, based on past experience over and above population growth. This would increase the projected activity level to 132,400 incidents. Refinement to the projection can be made based on the estimated changing mix in population by age group and income group, and the past or projected call rate for each of these groups.

In projecting a future activity level, it is important to base projections on a "steady state" activity level. A system that has seen a significant change in service delivery often experiences a major growth in activity per capita over a two- to five-year period, then levels out. Projecting trends to continue for 5 to 10 years into the future can cause gross errors. However, an emergency communications system cannot be planned simply on an "average" workload. The

workload will vary with seasons of the year, days of the week, hours of the day, climatic conditions, special events, and other factors. An effective system will have the ability to handle peak predictable workload, without compromising on accuracy or the time to process priority traffic, although some degradation of the processing time for nonpriority traffic is usually acceptable. It is next to impossible to predict or plan for an absolute peak activity level because there are circumstances that present the possibility of overwhelming any system in an absolute worst-case situation.

By studying the relationships between annual activity levels and peak day and hour activity levels, it is possible to project design activity levels for a system for 5, 10 or even 20 years into the future. The accuracy of those projections can have a tremendous impact on the design of a new system.

One of the most important factors in design of a new system is to define acceptable or desirable service levels for some date in the future. The normal projection range for new communications systems is 10 years, based on the rate of change of current communications technologies. For some major components, such as the overall size of a communications center, a 20-year projection may be appropriate. Projecting a service level for a date in the future means that the system will be designed to handle an anticipated workload or activity level with certain performance characteristics at that future date.

The performance level can be described by factors such as the throughput of transactions and time performance specifications. For example, a 9-1-1 center may project a maximum call volume of 600 calls per hour, or 10 calls per minute, with every call being answered by the third ring and not more than one percent of the callers receiving a busy signal. Accuracy of routing and handling calls also may be specified.

Given all of these inputs, plus the information that each operator spends an average of, say, 52 seconds handling a call, it would be possible to design a system to meet those criteria. It

also would be possible to predict the effects of a system change on the overall design, such as a change in procedures that would allow the operators to handle a call in 30 seconds instead of 52 seconds.

Other components of a system can be planned based on projected service levels and workloads. One function of the radio network may be to track the status of units. Using voice transmissions to advise a dispatcher when units are in or out of quarters, responding to calls, arriving at the scene, and available for another call may add up to a rate of 30 transmissions per minute during a peak period. This could occupy three radio channels and three radio operators. The introduction of digital technology could allow all of these messages to be transmitted and entered into a CAD system with 100 percent accuracy, with no radio operator and reserve capacity on a single radio channel.

Each change in an operating system may result in a significant change in workload, staffing requirements, system accuracy, and overall capacity. A major communications system may have one radio channel and one position dedicated to paging individuals with emergency and nonemergency messages. A plan to install a digital message system could allow outside callers to make nonemergency pages and allow an operator to send a major incident notification to 25 individuals with a single keyboard transaction, using the excess capacity of the radio channel that is set aside for digital transmissions. These changes can be incorporated into a system plan and the improvements in operational efficiency can be projected against future workloads and service levels. One of the major challenges in planning is to keep up with changing technologies and to maintain the ability to upgrade systems to take advantage of the advances.[12]

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[12] One of the most popular planning cycles for public safety agencies is a five-year planning system. This involves a detailed plan for the next five years, which is updated annually to keep five years of current detailed plans in focus, followed by a projection for the 6th through 10th years, which is necessarily less precise. Every five years a major plan revision cycle is conducted.

Planning for Maintenance

The specified communications performance standards will only be as viable as the level to which they are maintained. Planning a communications system therefore needs to address how the various elements of the system-people skills and software as well as procedures and hardware-will be maintained, not just how they will function on day one. Each of these elements of the system must have a maintenance or quality assurance program if the system is to be successful.

Types of Maintenance -- A set of formal, written procedures constitutes the plan by which a department operates its dispatch and communications system. It includes the types of equipment to be dispatched to different types of incidents, how units are controlled, how emergency calls are handled, which frequencies are assigned, how units are to communicate with each other and with the communications center, and how communications and notifications to other agencies are handled. (The procedures are discussed further in Chapter 4.) The manuals that describe these procedures must be updated as practices change.

Many departments incorporate dispatch and communications procedures into software programs that make automatic recommendations and notifications to departmental personnel. For example, the computer may select a candidate complement of equipment to be sent based on the address of the occupancy where a fire is reported. All of these software programs require ongoing review and updating to maintain their integrity and keep them current. The procedures and software need to match existing practices if they are to remain successful.

In addition to maintaining the capability of the software and procedures, it is important to maintain the capability of the personnel. Some form of training and quality assurance is vital if communications personnel are to maintain their professional skills. The Phoenix Fire Department uses one of its communications supervisors as a full-time quality assurance trainer. Each month he/she randomly selects 21 calls by selected type for review. Seven of these calls are then screened for a training session that includes both dispatchers and field personnel.

Discussions are held on both the strengths and weaknesses of each call, and personnel identify new procedures to improve the system. The trainer also reviews all major incidents and prepares reports for incident critiques. This kind of program monitors daily operations and spots trouble areas quickly.

Communications **hardware** can be one of the most expensive purchases a fire department will make, and is the most obvious aspect of communications that requires maintenance. Equipment failure can shut down the communications system, or reduce its capability.

There are four approaches to achieving hardware dependability. The first approach is to use reliable hardware components in the first place. A second approach is to use a system design that provides some form of backup for critical areas that could bring the system down, A hardware system should not have a single source that can take the total system out of service; a failure should leave some part of the system still operable so that some form of communications is still available. A third approach is to use high levels of redundancy at the module and functional levels, similar to the redundancy used with spaceborne computers that must operate for long periods of time with no maintenance. This level of redundancy can be expensive but offers very high reliability. The fourth approach is adequate, ongoing systems maintenance that is both preventive and repair oriented.

Organizing for Maintenance -- The organizational approach to maintaining procedures, software, personnel skills, and hardware generally falls into one of three general categories: 1) Create and maintain an internal staff to provide maintenance; 2) "Contract out" maintenance to private vendors; and 3) Develop a combination of outside vendors and internal staff for overall maintenance of the system.

A large metropolitan department such as Phoenix's quite often will hire and maintain a large maintenance staff. There is enough work to justify programmers, radio repair personnel, electronic technicians, and full-time trainers for system dependability. A suburban department

such as Huntington Beach will selectively decide whether to contract outside or use internal staff. Quite often, personnel can be shared with other local agencies. Some small departments will contract all hardware and software maintenance to private vendors. Nonetheless, a center serving multiple small departments, such as Montgomery County, Pennsylvania, has the resources to operate its own radio shops.

Every department needs to control its own written procedures and personnel quality assurance. There are some excellent sample programs available for those departments that want help in this area.

Exhibit 3-6. Montgomery County, Pennsylvania's radio repair shop.

Planning Facility Space

Communications centers must have appropriate space in which to operate. The environment must be reasonably comfortable and quiet to allow the dispatchers and call-takers to concentrate and hear well. It also must be designed to allow the communicators to have ready physical access to all controls and equipment they need, and to communicate with each other visually, manually, or in other ways as needed.

The space must allow for some growth in functions or activity levels and for storage of records.

Security and safety also must be built in to the facility design-including fire protection.[13]

NFPA 1221, *Standardfor the Installation, Maintenance, and Use of Public Fire Service Communication Systems,* is a good reference on communication facility design and protection.

Planning for Security and Safety

A fire department can build the finest communications system available yet have it fail if its security and safety are not adequate. Security and safety for an emergency communications system mean more than building a fortress. It means protecting the system from all threatening elements, including natural and man-made hazards, and should be a basic consideration in planning a communications system.

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[13] One large city has its fire communications on the fourth floor of an unsprinklered building.

Protection from human intrusion is often based on stopping deliberate attempts at vandalism or sabotage. Yet one of the major distractions for a communications center can be unauthorized, well-meaning departmental personnel intruding on operations. A security system must address both of these situations.

Many security systems handle security for the human element but ignore the threat from nature. Plans must be made to prevent damage from tire, earthquake, tornados, and hurricanes. The community counts on the CC operating in these circumstances.

The Los Angeles County Fire Department's new state-of-the-art communications center exemplifies how security can be considered in planning. This center also demonstrates that a facility need not be a concrete "bunker" to be secure. Because of the distances involved and the complexity of telephone and microwave systems, the building has to stand alone without a major backup facility. Each element that might affect the operation of the building was analyzed and security measures were taken or backup systems developed.

The first consideration was designing the building and its internal systems to withstand a major earthquake and function through and after a seismic event. The building was built on rubber "base isolators" that absorb the seismic shock. All utilities and communication lines had to have flexible connections that would not break during an earthquake. Structurally, the building was built to one and a half times the building code requirements,

Exhibit 3-7. L.A. County Command and Control Facility.

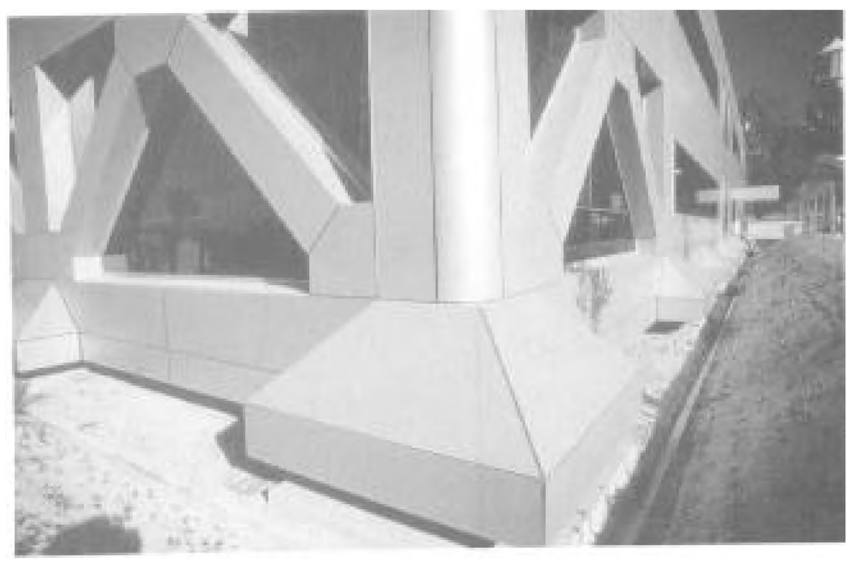

Exhibit 3-8. Detail of corner of L.A. County Command and Control facility. This corner (and the entire facility) is suspended on flexible base isolators.

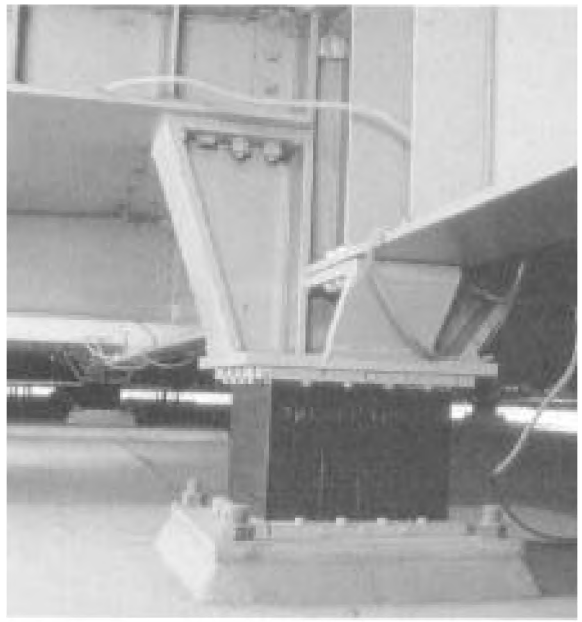

Exhibit 3-9. Base isolator
for the L.A. County CC.

The building is fully sprinklered and has alarm detectors for heat, smoke, and moisture. All major equipment systems have sensors that notify an alarm console at the supervisor's position of any equipment failure. The building has two separate diesel power generators in case the public utility power fails. Telephone lines are routed into three separate feeds to prevent the total loss of telephones by a cable being cut. Separate redundant paths also were developed for radio communications.

To handle the human element of security, the building has electronic locks on all outside doors and on all critical rooms inside the building. This door access system is computer controlled and limits access to those personnel authorized for a particular area. The system records all entries and sets off an alarm at the supervisor's console if unauthorized entry is attempted.

Remote video cameras are mounted in each major equipment room and on the outside of the building. The dispatch supervisor has a 360-degree scan capability of the outside area around the building and full views of all equipment rooms plus the front door of the building. Security fences surround the parking lot and building.

To keep well-intentioned departmental personnel from interfering with emergency operations, large viewing windows were installed looking into the dispatch and emergency operations rooms, thus allowing people to view the process without interrupting operations.

Remote Site Security -- Most communications systems have more than one site within the system. These may include dispatch centers, microwave transmitter/repeater sites, backup communications centers, and command centers. Each site within the system must be analyzed as to its security when developing an overall systems security program.

Remote transmitter/repeater sites offer the most opportunity for vandalism because of their remoteness and because they are unmanned. In addition, they are vulnerable to natural forces.

The construction of a remote site often takes the form of a reverse prison, keeping people out rather than in. High security fences with deep concrete footings, cement block buildings, and steel doors are common. These structures normally are equipped with emergency power generators and alarm systems for smoke, heat, moisture, equipment failure, and unauthorized entry. The antenna tower should be certified by its manufacturer to withstand the highest recorded wind for the area. Lightning protection is a must. These remote sites also usually have some form of intrusion alarm.

Communications Security -- Communications security can be the most difficult part of protecting a communication system, particularly if the department has numerous mobile and handheld radios. Illegal use of emergency radios plagues many major departments. It is difficult to eliminate this practice completely, but strong policies and procedures requiring departmental personnel to secure radio equipment from theft or misuse will help. Many large departments have tracking equipment to help locate missing equipment being used illegally. The best cure is prevention-developing security measures for field equipment.

Developing Specifications

Once a department has completed an analysis of its communications needs, the next step is the preparation of specifications to meet the identified needs. Specifications are the guidelines that allow vendors to understand a department's needs and to meet those needs adequately. If specifications are not clear, the resulting procurement will be difficult and probably unsatisfactory.

There are two levels of specifications to consider: specifications to help design and develop part or all of a communications system, and specifications for individual hardware and software components.

System Specifications -- The system specifications are usually contained within a "statement of work" (SOW). The SOW should have clear statements of the department's expectations, acceptable levels of performance, timeframes for completion, and provisions for training. The specifications should state clearly that prospective vendors must address the requirements; alternatives should be presented as options for the department's consideration.

An example of items that might be included individually or in combination in a SOW are as follows.

- Specify and design a facility to house a communications system.
- Design and implement a computer-aided dispatch system.
- Design and implement a data/voice communications system.
- Design and engineer a combination of existing and new components for support systems.

Provide an analysis of principal interfaces and a matrix for their intra/interoperability issues.

Unless there is some specific need to match existing hardware or software, specifications of particular equipment should not be given so as not to limit the vendor's creativity or the department's choices. Allow the vendors to offer the best available system without unnecessary constraints.

Equipment Specifications -- Whereas system specifications are more general in nature and address functional needs, equipment specifications can often be much more precise. This is particularly true when the equipment must be compatible with existing hardware and systems. In this case the specification should be precise as to all elements necessary for the hardware to work within the system. For example, the specifications for a portable radio might include the following criteria:

- VHF, high band, 148 MHz, 14 channels, 5 watts RF power.
- Built-in microphone and speaker, leather case with swivel belt loop and T-strap, large NiCd battery, time-out timer, helical-wound rubber flex antenna.
- Large connector(s) for external antenna, microphone, and speaker.
- Volume/on-off and channel select knobs large enough to be operated by a person wearing firefighter protective gloves.
- Capable of being operated in mobile chargers.

A clear specification makes for satisfied customers and merchants, Vendors will sell fire departments what they asked for in their specifications, not what the department thought it was getting.

Obtaining Licenses [14]

In addition to having the right personnel with the right training and appropriate hardware, software and facilities, a communications system must obtain the licenses needed to conduct radio operations.

There are several common types of radio station licenses required in the public safety sector. One necessary license is for *fixed station* applications, which applies to the radio equipment that does not move from place to place during its use.[15] Another necessary license is for *mobile equipment* applications, which relates to radio transmitting equipment installed in vehicles or carried from place to place.

Soon after radio technology came into existence and the first radio transmissions occurred, it became evident that control and coordination of radio transmissions and radio transmitters was a necessity. Since radio signals do not respect political boundaries, it likewise became evident that international agreements would be needed to place some kind of control on radio transmissions. Eventually, the Federal Communications Commission (FCC) became the voice of the U.S. government in these matters.

The radio frequency spectrum is a precious natural resource. It is in the interest of the community that the owner of a transmitter be responsible for proper operation of the device. Specifically, it is the responsibility of the transmitter owner to make sure the transmitter signal is "clean" and does not transmit spurious, or "dirty," signals on other people's frequencies. Further, the nature of the use of the radio frequency spectrum becomes critical when the priorities of frequency allocation are reviewed. For example, the use of radio spectrum for public safety

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[14] This section is generally based on *Fire Service Radio Communications,* Chapter 2, Pennwell Publishing Co., 1989.

[15] See Chapter 6 for a further discussion of fixed station equipment.

purposes overshadows the use of spectrum for model aircraft control, or, for that matter, routine governmental functions such as collection of money from parking meters.

In order to obtain a license, a fire department must go through the following steps: technical analysis of proposed system performance; frequency coordination; application for license; approval of license; and implementation of the process, as discussed in the following sections. The technical analysis shows the operating characteristics of the system in terms of frequencies used, frequencies that are spuriously generated, and their strength and spatial distribution.

Some larger municipalities or counties have engineers and technicians on staff who can undertake the technical analysis, but more often, professional communications consultants are used to design the system, provide the analysis, and otherwise assist in obtaining a license. If this is the selected route, require the consultant to demonstrate competency and experience before entering into an agreement.

Frequency Coordination -- The proposed use of the radio system is then examined to see whether it is in accordance with legally designated and agreed-upon "use guidelines," and does not interfere with other users. Voice communications may be used only on certain frequencies. Other frequencies are set aside for handling data. It is rare that voice transmissions and data transmissions are allowed on the same radio frequency.

A new radio system must not interfere with existing users on the same frequency or close-by frequencies. It is the responsibility of the frequency coordination agency to review the proposed coverage (radiation pattern) of the radio signal after it leaves the transmitting antenna to make certain that existing users nearby will not experience interference. Two or more radio transmitters can operate successfully on the same frequency if they are geographically far enough apart. On the other hand, having different transmit frequencies does not preclude interference if users are located too close to one other. The considerations and calculations involved in determining whether interference is likely are very complex.

A review also must be made to determine whether the agency applying for use of a specific frequency may operate on that frequency. Police operations are not allowed on frequencies allocated for fire operations. The converse also is true. At the same time, certain frequencies are designated as *local government frequencies.* These frequencies are set aside to provide a common operating channel for all phases of government, including fire, police, and public works.

The International Association of Fire Chiefs (IAFC) is recognized by the government as the general coordinator of fire service and EMS radio frequency matters. However, it is virtually impossible for the IAFC to determine whether the technical details of each radio system proposal in the nation are appropriate. The IAFC therefore concentrates principally on maintaining the fire service and EMS interest in currently allocated radio spectrum and fighting for the interest of the fire and EMS service in obtaining additional spectrum as it becomes available.

In most states, *the detailed frequency coordination occurs at the state level.* The relevant state agency usually is identified as the State Communications Coordinator, Division of Communications, or a similarly titled agency. The need for a detailed performance analysis is more critical in a large metropolitan area such as New York City, than in rural areas, such as remote parts of Montana, but radio systems in both areas must be coordinated nonetheless.

While a fire department could undertake the coordination with the state agency directly, it is usually preferable to ask a potential communications system contractor if it will perform the frequency coordination and licensing as part of the purchasing effort. Usually the contractor can and will do that. Contractors have advantages over the neophyte license applicant in that they go through the process constantly, all over the country, and have the contacts necessary to expedite license approval. If there is some reservation about using the equipment contractor, contact the IAFC, and ask for the name and address of the frequency coordinating agency in the area. Between the manufacturer and the IAFC, the information is available.

FCC License Application -- The license application is made to, and approved by, the Federal Communications Commission following frequency coordination with the state. Under ordinary conditions, the FCC will not look favorably upon an application for a public safety license that has not been through frequency coordination. Approval from a coordinating agency is one of the first things the FCC reviewers look for.

The information required for a fixed station license application usually includes the following.

1. Location of the transmitter in terms of latitude and longitude.
2. Power output from the transmitter, i.e., the effective radiated power from the transmitter and the antenna system combined.
3. Antenna height.
4. The owner of the transmitting and antenna equipment.
5. Other technical and business-oriented questions.

Approval is predicated on availability of frequencies in the area, relative need of the petitioning agency for the radio frequency compared to other needs in the area, and quality of the application. Attention to completion of forms and correctness of format is highly important. If any information is missing, rejection is virtually guaranteed.

While not commonly considered a step in the license application process, the rapid disappearance of available radio frequency spectrum brought on by increased service demand and new technology has caused an additional step to become very important: use the frequencies or lose the frequencies. The applicant must build and use the radio system to retain approval. The concept of securing frequencies and not using them immediately, but, rather, holding them for future use is no longer acceptable to the FCC.

Renewal of Licenses -- Licenses have expiration dates. It is the responsibility of the licensee to make sure that the licenses are renewed in a timely fashion. One cannot wait until one month before the expiration date. It is necessary to start working on renewal at least six months before the expiration date. The renewal process is much simpler than the initial application. Systems that contain many frequencies, such as trunking systems, may cause the renewal process to be more complicated and time consuming than it is for simpler systems.

The fire agency should be prepared to report the number of radios operating on the system and to justify the number of radio transmitters to be authorized under the licensing provisions. Likewise, one must be prepared to document the number of transmissions made, their approximate length, and the percentage of air-time used. The contractor who provided the system is a good source of advice on how to go about preparing for renewal. A good practice would be to begin preparing for renewal as soon as the license is issued.

4. Operating Procedures

The latest equipment and software, and the finest communications specialists cannot make an emergency communications system work unless a satisfactory set of operating procedures, the "ground rules" for departmental communications, is practiced. All of the "players" must be familiar with and adhere to the departmental communications procedures if the system is to be effective. Some aspects of operating procedures were discussed in the previous two chapters, since they are interwoven with managing a communications center and planning communications. For example, a key aspect of operating procedures is recordkeeping and another is security, both of which were discussed earlier. This chapter continues with other key areas for which operating procedures must be established, after discussing the need for a communications plan.

Communications Plan

Fire Chief Alan Brunacini, in his book *Fire Command,* lists the communications function as one of the three major tireground command elements. This element serves as the link between the incident commander and his/her subordinates and also with the outside world. It can be the incident commander's best friend or worst enemy.

Incident commanders are only as effective as the communications links that allow them to request resources and deploy them to the incident. On major emergencies involving large numbers of individual resources, multiple agencies, and extended time periods, a communications plan is a must.

The two basic communications principles for major incidents are to, first, establish a two-way flow of information between the scene of operations and the communications center and, second, to afford the incident commander access to tactical and support resources.

A communications plan is a prescribed strategy for establishing the required communications for an incident, beginning with the dispatch of that incident and progressing through the operation to its conclusion. A communications plan must address the needs of the incident commander to communicate with subordinate resources and with the communications center. Although technology has created complications -the multitude of available frequencies and equipment used in the fire service -it also has offered solutions such as cellular telephones and multiple-frequency radios.

A plan should address the potential problems before a major incident ever occurs. By anticipating the incident commander's needs during a major emergency, an agency can prepare in advance to meet those needs. Unfortunately, many departments wait until an incident occurs before addressing the communications requirements.

An agency should identify its communications needs for all types of emergencies. It then should review its available communications resources and potential alternatives to meet those needs. A plan should be developed to use the best alternatives and to provide backups and additional alternatives. Finally, the agency needs to train personnel and practice implementation of its communications plan.

Ideally, a basic communications plan should provide for a dispatch channel, a command channel, and least one tactical frequency. At a minimum, the performance of these functions must be planned.

An enhanced communications plan would include a command frequency monitored by the incident commander, division supervisors, and the communications center. This link is for command decisions and life-threatening situations. The tactical operations should be on a separate channel. If mutual aid departments are going to be involved, multi-channel radios for first-line units may be necessary. The use of cellular telephones can alleviate congestion on the command channel and enhance the communications flow between the incident commander,

logistics, staging, and the communications center. The importance of a communications plan is to get prepared before an incident happens.

Since major incidents are rare for most fire departments, case studies such as the USFA Major Fire Report series can be reviewed to identify potential problems and so1utions.[16]

Communications Authority

The judgment of both the dispatch and emergency response personnel is an integral part of the decision process for handling emergencies. They must consider both information received and the potential outcome of the incident. Clear lines of responsibility and authority must be established and enforced as part of a communications policy.

A clear communication policy originates in the fire chiefs office. Ultimately, the fire chief must determine the type of communications system his or her department will have. It will only be as effective as he or she directs it to be. Clear policies followed by reinforcement will result in an effective communications system. The fire chief needs to establish policy for each area of responsibility and for the types of communications plans the department will use.

Communications Management -- The overall responsibility for communications management should be clearly stated in departmental policy. The coordination and control of frequencies should remain with the communications center. Status of resources and assignment to incidents also should remain with the communications center for smoothness of operation. Resources assigned to incidents should remain under the authority of the incident commander. The communications center and the incident commander need to work together in managing the

[16] Order form available from the National Fire Data Center, United States Fire Administration, 16825 South Seton Avenue, Emmitsburg, Maryland 21727.

communications and resources needed. Responsibility for ordering mutual aid or move-up companies should be worked out in advance.

Field Operations -- Communications needs to be the incident commander's best friend, according to Chief Brunacini. The incident commander must have access to both the communications center and his/her assigned resources. All radio traffic between the communications center and the incident should be funneled through the Incident Commander or assigned staff. There must be one reporting and order point.

If frequencies are available, an incident should be given a separate tactical frequency if there are more than a predetermined number of units assigned or if there are multiple simultaneous incidents.[17] Clear fireground communications will help save lives and enhance the overall operation. Departmental policy should direct units to limit transmissions to pertinent information. The incident commander must enforce effective communications discipline as prescribed in department policy. All units should have a clear understanding of the command structure and have clear instructions as to their reporting authority.

Standard Operating Procedures (SOPs)

The effective functioning of tire department units and personnel for emergency operations requires clear, decisive action. Standard Operating Procedures are uniform procedures to be employed to meet various situations. They fix responsibility for each function and list its associated duties for the proper individuals or units. SOPs make it easier for firefighters and officers to blend in smoothly as they are assigned to different units. All personnel are aware of who has the responsibility for an action and how that action will be carried out.

[17] Los Angeles County assigns a tactical frequency when five or more units are assigned to an incident. Other departments routinely assign additional frequencies on working fires or similar incidents.

SOPs usually define what function is required, who is responsible, what equipment is needed, and the steps to be followed. They also may include safety precautions or additional items to consider if the situation changes, and they must address communications.

SOP Manuals -- The Phoenix Fire Department has developed extensive written SOPs for most of its operational functions, including communications. These SOPs address the communications center's general operations, incident call-taker procedures, dispatcher operations, tactical radio and medic operations, supervisor functions and responsibilities, and administrative functions and responsibilities.

The department also issues SOPs to field personnel covering command procedures, standard company responsibilities and procedures, incident communications, tactical communications and responsibilities for major incidents, and guidelines for various special types of incidents. Each SOP has a strong communications element attached.

Computer-Based SOPs -- Huntington Beach, California, has a series of written SOPs but also built some of the communications center's operating procedures into its system's software. Certain actions by the call-taker require specific responses before the transaction can be completed. The software follows a predetermined logical pattern that assists the call-taker with completing the emergency request.

Huntington Beach also computerized its emergency medical dispatch procedures. Each answer to the set questions presented to the call-taker by the software moves the call-taker through a decision tree. The call-taker doesn't have to memorize written procedures. The computer reacts to specific inputs and directs the person through the procedure.

Response Policy

Every fire department needs to develop a matrix that shows the level of resources that are to be sent to various types of incidents, such as shown in Table 4-1. There are a number of

factors involved in choosing what to send, including what there is to burn, life hazard, frequency of a particular type of incident, climatic and geographic conditions, and the community's expectation of what the fire department should do. This matrix of responses to alarms must be readily available to the communications operator and its use should be consistent.

Additional matrices are needed for second, third, and higher-level alarms, and ground rules established for requesting special units or simply more units, and for allowable deviations from the normal response, The terminology used must be understood by all who communicate, so that a request for a second alarm means the same thing to the dispatcher and to the battalion chief. Where multiple departments work together under mutual aid or automatic response agreements, they all must agree on the jargon of responses.

Table 4-1. Sample Response Matrix for Fire Calls (First Alarm)

Reported Type of Incident	*Engines*	*Truck/ Ladders*	*Chiefs*	*Water Tenders * (Tankers)*
Outside Rubbish Fire	1			1
Automatic Alarms				
Residential	1	1	1	1
Commercial/institutional	2	1	1	
Structure Fire				
One- or Two-Family Dwelling	3	1	1	2
Large structure	4	2	2	3

* in nonhydrant areas only

Firefighting Response -- Rural, suburban, and urban fire departments face similar yet very different problems when addressing the level of resources to send to responses. Distance and availability of water affect the type and level of resources required. Rural departments often

require water tenders (tankers) to meet the same extinguishing requirements that an urban department can meet with its municipal water system.

The urban department faces the problem of clustered occupancies that increase exposures and constitute a higher life hazard. A major commercial response for an urban department might include four engine companies and two ladder trucks, along with two chief officers on a first alarm. Yet a small suburban or rural department might not have two ladder truck companies and will have to provide the equipment for truck company operations with other types of resources, or with mutual aid or other arrangements. Each department must evaluate its potential fire hazard and determine the most effective resources it can provide to meet the need.

In contrast to the typical response matrix in Table 4-1, the Los Angeles County Fire Department, which serves a diverse area that includes rural, suburban, and urban areas, all with wildland interfaces, has developed the response assignments shown in Table 4-2. A larger assignment is given to a brush fire than to a home fire. It is not because the brush fire threat is greater, but that it takes more personnel to control. These two examples are part of a matrix that identifies 55 separate levels of response to alarms in Los Angeles County.

Table 4-2. Examples of Los Angeles County's First-Alarm Response Assignments

To A Residential Fire	***To A Brush Fire***
3 engine companies	5 engine companies
1 truck company	1 water tender
1 paramedic squad	4 hand crews
1 battalion chief	2 crew superintendents
	2 helicopters
	1 dozer
	1 battalion chief

Emergency Medical Service -- Originally, fire departments approached the EMS incident like other emergency requests, taking the worst case to determine the resources needed. Using cardiac arrest as an example, many departments determined that five to six people were

required to handle these kinds of incidents: two people for CPR, paramedics for advanced intervention (such as IVs), and support personnel to take and record vital signs and carry equipment.

As the demand for services has increased, many departments faced the decision of adding additional resources or changing their response patterns. Two new approaches have been developed. The first is the use of communications personnel to give prearrival first aid instructions to the caller and to triage the calls. Many fire departments staff one or more of their dispatch positions with EMT-trained people who provide first aid instructions. These instructions are based upon guidelines and predetermined questions that have been reviewed and approved by the appropriate supervising medical authorities. These medically trained dispatchers are referred to as Emergency Medical Dispatchers (EMDs).

A second approach is to use a “tiered” response to EMS calls. Many incidents do not require an Advanced Life Support (ALS) unit and can be handled by Basic Life Support (BLS) trained personnel. A series of questions are asked of the caller to determine the level of response required. The responses to these questions help the call-taker to determine the severity of the emergency. As with the prearrival instructions, this kind of program must be reviewed and approved by the appropriate medical authorities.

Other Services -- Most fire departments handle other types of requests in addition to fires and emergency medical incidents. Flood conditions, hazardous materials spills, and building collapses are examples. Each of these kinds of incidents requires a predetermined level of response or a hierarchy of responses. A department must analyze the potential effort required, and the threat to life or property, then evaluate available resources to determine the appropriate response level. These response levels should be incorporated into the response matrix available to the dispatcher.

Communications Center Operations

The communications center is the hub of fire department communications and also the starting point in the communications associated with each incident (see Chapter 2). Dispatch operations must be characterized by accuracy, timeliness, and thoroughness. An inaccurate address will cause a response to the wrong place, jeopardizing both the victim and the department. Slowdowns in the communications procedure have a critical effect in both life-threatening and property-damaging situations. The lack of thorough instructions to responding units can unnecessarily harm both the victims and the field personnel.

People new to emergency telecommunications may not understand the importance of gaining all pertinent information from the caller, not just the address and general problem. Failure to obtain all the vital information can cause the dispatch of inappropriate resources, or none at all, to the incident.

Sequence of Responsibility -- The communications for an incident usually starts with a call handled by the call-taker. The primary responsibility of an incident call-taker is to determine, without delay, the nature and location of the emergency and the source of the call. A call-taker makes the initial determination of the type of response based on the information from the caller.

Requirements for different types of incidents can be planned, as discussed in the preceding section. The set of units selected for dispatch should meet the established plan unless there are extenuating circumstances. This can be accomplished with a computer-aided dispatch system that maintains status and automatically recommends units for dispatch, or by using a manual system of status and a response matrix.

The dispatcher (person responsible for actual notification of units) is responsible for verifying the suggested unit dispatch from the CAD and modifying the dispatch based upon

additional information or circumstances. The dispatcher transmits the call to all units assigned to the incident and verifies receipt of the alarm from the assigned units.

The tactical radio operator handles all communications among units assigned to an incident and the communications center.

As noted earlier, the three functions of call-taker, dispatcher, and tactical radio operator may be staffed by just one person in small departments and by dozens of people each in major metropolitan departments or combined communications centers.

Communications with Fire Stations

The methods used to notify personnel in fire stations of both emergency incidents and administrative bulletins have changed dramatically over the years.

Dispatches -- Old emergency alarm systems used a central alarm that went to all stations giving a box number or typed message. Each station would have to check to see if the alarm was in its response area. Initially, only the company officer knew what type of response the unit had and then would have to relay that information to the rest of the company.

New alert systems use microwave, radio, telephone, or departmental lines to transmit alarms to the fire stations, These systems provide a voice announcement over loudspeakers, activate lights and doors, and print the response information on printers. Digital systems also can indicate the units dispatched to each responding unit via onboard MDTs or personal laptop computers.

Acknowledgement back from the station is by voice or digital transmission. Current methods are intended to inform all members of the company of the type and location of the response so they can begin to prepare themselves for that particular type of incident. Locations

can be checked quickly as the company officer completes acknowledgement. The whole operation becomes smoother when everyone is informed.

Administrative Communications -- The new alarm channels offer the ability to send administrative messages over the same system, an effective method of sending and receiving administrative messages. There is a drawback, though, to this use. In 1980, Phoenix installed its digital communications system for emergency traffic and status keeping. As the years passed, additional administrative functions were assigned to the system. Unfortunately, this additional nonemergency workload began to slow down the emergency operating system. The lesson to remember is that the primary purpose of the system is emergency communications. If administrative traffic is going to interfere with emergency operations a separate system should be installed for administrative functions or the total capacity of the system must be expanded.

Many departments have solved their administrative message needs by using personal computers and modems that are activated by a dial-up telephone system. Several departments have installed wide area networks tying their fire stations together with the administrative headquarters. The cost of such systems has dropped significantly in recent years.

Communications with Units En Route

While responding, companies should communicate with one another if radio traffic permits. Effective communications during this period can set the stage for effective action. Company officers should review any predetermined tactical information. New digital systems using MDTs have the capability to electronically store such information for immediate retrieval by all responding units. The tactical radio operator of the CC should relay any additional information gained from subsequent calls or from central files maintained within the communications center.

Communications with Units On Scene

Communications discipline for field operations requires a predetermined communications procedure that clearly delineates areas of responsibility. The Phoenix Fire Department has a field communications operating procedure that specifies responsibilities and action steps.

It begins with an "onscene" report, such as "Engine 78 at the 1320 North Eastern Avenue, commercial two-story structure with light smoke showing from rear. Let all units continue." Once the first field unit or the incident commander has made a more complete sizeup, he or she needs to report more details on conditions, structure type, and actions being taken, along with an estimate of how long it will take to contain the situation.

All communications with the communications center should go through the incident commander. A report is made to the CC if most or all of the units are to be committed. This begins a process of notifications and move-ups. For large fires, "command" declares a staging area. All units arriving in staging report their identity to "command" or to the staging officer via a tactical channel or face to face. Sector officers are encouraged to use nonradio methods to communicate with assigned companies to reduce radio traffic. Only "command" can return companies, or declare "under control," or "all clear."

The term "Emergency Traffic" is used by any unit encountering an immediate perilous situation, and it receives the highest priority from dispatch, command, and all operating units.

Phoenix also provides guidelines on "Good Field Radio Procedure." It directs field units to be brief and specific, and to know what they are going to say before keying the radio. The speaker should be task and company oriented: orders received should clearly describe the specific task which is assigned to the company. Assignments should indicate a clear plan of action and the objective to be accomplished. Further guidelines cover use of accurate pronunciation, well-timed, clear speech and steady pace, control of emotions, and prioritizing

messages and pausing between consecutive messages. (Chapter 5 goes into more detail on field communications procedures and policies.)

Move-ups

The communications center supervisor often is responsible for relocating units to maintain the best available coverage for the department. Sometimes this is left to the dispatcher, and sometimes it is done under the direction of fire operations officers. If left to the CC's direction, the CC should begin "move-up" coverage after reviewing the incident commander's report of conditions and receiving an estimate of time that the units will be committed to the incident. To assist the supervisor, management should have predetermined critical coverage stations. For large incidents that drain the total resources of the department, mutual aid move-up programs may need to be implemented with neighboring departments or by call-backs of off-duty personnel. In some departments, e.g., Portland, Oregon, the uniformed fire prevention force or reserves are called to form backup companies, often using pagers to reach them.

Before a move-up plan is implemented, the department should analyze its different types of resources and identify potential move-up companies. This list should be by type and location. There are two methods to approach this task. For small and medium size departments, a predetermined list can be developed by considering coverage and incident patterns, travel distances, high-risk areas, and apparatus type.

For larger departments, an algorithm can be developed using the CAD's status-keeping ability to recommend move-up coverage. The supervisor still must play a vital role in these computerized systems as multiple alarms or unusual circumstances can cause the preprogrammed system to make inappropriate recommendations.

The CC should plan the method by which vacant fire stations will be "filled" by incorporating a "move-up" procedure for mutual aid units. Questions to be answered include

- Can the filling unit gain entrance to the station being filled (are doors locked by key or code system)? Can the filling unit physically tit into the station (are the doors large enough)?; and

- How will the filling unit be dispatched? Do personnel have map books or a local escort to provide them directions to incidents?

Major Disaster Operations

The ability of a CC to handle major disasters is related to its ability to handle routine daily activity. If the CC staff are well trained, there are good operating procedures in place, and proper planning has occurred, disaster operations should be not much more than an extension of what is done on a daily basis. CC personnel should be well trained in their role as an intricate part of the department's Incident Command System. However, communications is consistently identified as a major problem in disaster response. [18] Planning and training are the keys to success.

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[18] Jiri Nehnevajsa. *Emergency Preparedness: Reports and Reflections of Local and County Emergency Managers,* Federal Emergency Management Agency, March 1990 (completed under cooperative agreement #EMW-K-1024).

Exhibit 4-1. Physical equipment for long-term operations does not have to be elaborate. Here, the Central Net Communications Center (Huntington Beach, California) has outfitted one room for use as an operating center for major incidents.

CC representatives should be involved in the disaster planning process, so that they know in advance what may be expected of them and thus react accordingly. Plans should be developed to address outages resulting from a natural disaster. These plans should include local, state, and federal disaster management agencies and should provide for the means of restoring electrical, telephone, and water resources. It also is advisable to conduct routine tests of all disaster procedures to familiarize all personnel with the procedures and their role in the disaster operations.

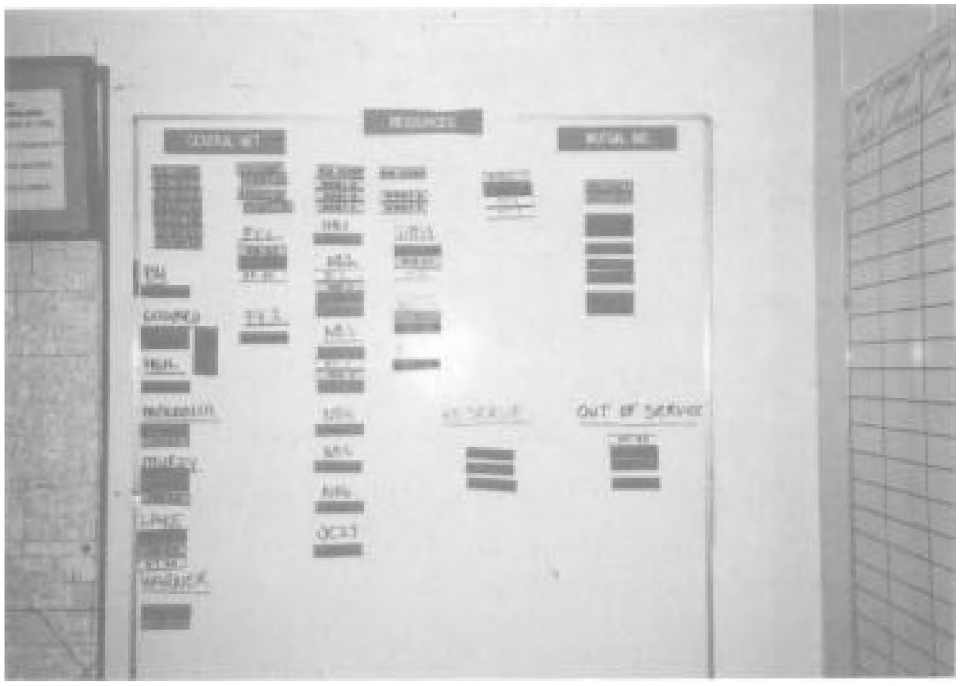

Exhibit 4-2. Separate boards are provided for each jurisdiction to track incidents, resources, and frequencies in use. The board illustrated includes magnetic markers for each piece of equipment controlled through the communications center.

The Federal Emergency Management Agency (FEMA) has initiated the Telephone Service Priority program. This program provides a method and priority for restoration of emergency telephone communications that are disrupted by a major emergency.

A means also should be established to rapidly increase the number of onduty CC personnel in a disaster to ensure adequate staffing. The CC should have a plan that allows the work schedule to be modified to make efficient use of personnel resources and provide adequate time off. This plan also should provide for meals to be available and arrangements should be made in advance to berth personnel. In a disaster operation, however, the need for and value of returning personnel to their families during time off should not be overlooked.

Other important aspects of planning communicationsfor major disaster operations are as follows.

- Maintain an extensive list of agencies, firms, and personnel that may need to be notified regarding the disaster or whose services may be needed. These may include highway or public works departments, state agencies, and private contractors. [19] When necessary, establish contracts in advance with firms whose services may be needed, to expedite the delivery of service if required. Military installations located in the disaster area are an excellent source of personnel and specialized equipment such as that needed for construction, food dispensing, and auxiliary electric power.

- Predetermine the method(s) of communications that will be used by the various assisting agencies to communicate with the fire/rescue CC.

- For jurisdictions that may be affected by weather-related disasters such as hurricanes, tornados, and ice storms, the CC should have a stock of replacement base station transmit/receive antennas. This will allow downed antennas to be restored more quickly, particularly considering that in weather emergencies other radio antennas also may be downed and many different companies and agencies will be seeking replacement antennas that may be difficult to purchase, have delivered, and install. Also, ensure that extra portable radio batteries are available so that field operations are not diminished as the disaster continues and batteries are in need of recharging.

- The fire department and the CC should have a plan for field units to conduct an area-wide survey of a natural disaster area to report to the CC the extent of damages.

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[19] As an example, the acquisition of heavy construction equipment was facilitated in the Kansas City, Missouri, disaster in 1981 when an elevated skywalk in a hotel fell and pinned many people. Onscene and communications center personnel were able to clearly define the type of equipment needed by referring to a reference book that had pictured the types of construction equipment available in the area. The CC obtained the equipment using contact persons and telephone numbers identified in advance.

- Emergency vehicle fuel sources must be determined in advance, including how fuel can be pumped if there is no electricity.

- Critical Incident Stress Debriefings (CISD) should be considered for CC personnel as well as field personnel. Often CC personnel are overlooked in this regard. They have the daily stress of dealing with emergencies and seldom have the benefit of learning the outcome of those incidents or of being recognized for their contribution to incident resolution.

The above list is illustrative of the type of planning that should take place to ensure that major disaster operations are conducted with the same efficiency with which the CC operates on a daily basis.

Mutual Aid and Mutual Response Operations

Mutual aid operations can be defined as one or more fire/rescue departments assisting a jurisdictionin the mitigation of an incident or multiple incidents. Mutual aid operations usually are governed by a previously agreed upon plan contained in a formal written "mutual aid agreement." This agreement may be general or specific. If not covered in the mutual aid agreement itself, there should be a companion document developed jointly by the departments involved, concerning the operational aspects of the agreement, including communications.

The FCC has reserved three frequencies in the 154 MHz spectrum for mutual aid operations: 154.265, 154.280, and 154.295 MHz. Use of these frequencies is coordinated by the International Municipal Signal Association (IMSA),[20] by agreement with the FCC.

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[20] ISMA's mailing address is ISMA Frequency Coordination, P.O. Box 1513, Providence, RI 02901 (401/738-2220).

The FCC also has reserved five frequencies in the 800 MHz spectrum for use by fire and rescue departments. These frequencies are a national calling channel of 866.0125 MHz, and four tactical channels: 821.5125, 822.0125, 822.5125, and 823.0125 MHz. These frequencies (800 Megahertz +) are coordinated by APCO, by agreement with the FCC.

Other concerns in preparing for mutual aid communications include

- The way in which units that are party to the agreement will be physically marked to provide for easy and uniform identification. This includes the size, color, and placement of identification numbers on the unit. (See "Unit Identifiers" below.)

- The jurisdiction that will provide the communications control of the operation. This should include who has the authority to take control, and under what circumstances the responding mutual aid units come under the control of the CC of the jurisdiction requesting the mutual aid.

- The ***pro words*** used to identify the unit and/or CC transmitting, such as "Central Control to Medic 7-1" or "Centerville Engine 3 to Dispatch."[21]

- The uniform terminology that will be used to identify the jurisdiction or department and the type of unit. As an example, a "ladder tower" in one jurisdiction should be identified the same way in all jurisdictions participating in the mutual aid agreement. This lessens confusion and allows all involved to understand what is needed and requested, and what type of apparatus is being referred to.

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[21] ***Pro words*** are the first words used when transmitting a message via radio.

The metropolitan Washington, DC area has developed a Fire Mutual Aid Radio System (FMARS) manual that addresses these issues.[22]

Mutual response operations differ from mutual aid operations in that they are the result of agreements between jurisdictions or departments that allow the closest units, regardless of jurisdiction or department, to be routinely dispatched based only on the type of incident and location, without requests having to be made for assistance. This type of operation can be a highly cost-effective way of providing fire and rescue coverage.

Exhibit 4-3. Members of several departments in a Mutual Response System in Orange County, California, participate in a regular training exercise.

[22] The manual is available from the Metropolitan Washington Council of Governments (Public Safety Section), 777 North Capitol Street, N.E., Suite 300, Washington, DC 20002-4201, (202/962-3200).

Many of the same communications considerations for mutual aid operations are applicable to mutual response operations. The communications operations should be clearly defined in a written agreement. The mutual response operations agreement also should provide for incident record management: how and by whom the incident records are to be maintained.[23]

Unit and Personnel Identification

Every vehicle and every individual needs to have a visible identifier to aid in deployment and safety. Apparatus identifiers also are used often in written and verbal communications.

Identification of Units -- Historically, fire departments identified apparatus according to the time the units were placed into service. The first engine company of a department would be known as Engine Company 1. The same held true for ladder or truck companies. Quite often the same fire station will have truck and engine companies with different identifiers.

Many departments now are developing apparatus numbering systems that identify where a piece of apparatus is located, especially where units from different departments often work together. In Orange County, California, for example, all fire departments have agreed to a uniform unit identification system in which the first letter represents the city or department. The second letter identifies the type of equipment. The first number identifies the battalion and the last number is the individual unit. Huntington Beach Engine 5 in Battalion 4 has an identifier of HE-45 with a call sign of "Huntington Engine Forty-Five." All units have large identifying plaques on the side doors and in front on engines and trucks.

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[23] In the area of northern Virginia the fire and rescue departments of the City of Alexandria, Arlington County, and Fairfax County have jointly participated in a MRO agreement since 1975, to the mutual benefit of all. Information concerning this MRO agreement can be obtained by contacting those departments. MRO agreements also are widely used in California, Maryland, and Florida.

Exhibit 4-4. Identification on the front of an engine. The letters stand for Newport Beach. The system is shared by regular aid partners.

Huntington Beach and the other departments of Orange County have very active mutual aid and initial action plans. Their numbering system allows the fireground incident commander and the communications center to quickly identify pieces of equipment. This is particularly helpful when specialized equipment or apparatus is involved.

Los Angeles County Fire Department uses a slightly different scheme in which letter identifiers are used consistently throughout the county for different types of equipment, as shown in Table 4-3.

Table 4-3. Los Angeles County- Letter Identifiers for Fire/Rescue Equipment	
E	***E*** ngine company
T	***T*** ruck company
S	***S*** paramedic squad
F	***F*** oam unit
D U	***D*** eluge ***U*** nit
B C	***B*** attalion ***C*** hief
A C	***A*** ssistant ***C*** hief
D C	***D*** eputy ***C*** hief
A U	***A*** ir ***U*** nit
L U	***L*** ight ***U*** nit
TF	***T*** ask ***F*** orce
H	***H*** elicopter

Each apparatus or piece of special equipment should have clear large identification markings on all sides (including the rear) and on the top. The characters should be on a background that contrasts with them. At a minimum, markings should appear on the driver and the passenger sides, and be visible from 300 feet. Markings on the roof should be large enough to permit units to be identified by helicopter and be visible from 300 feet. The identification markings should be visible at night (they can be manufactured from reflecting tape). While it often is appropriate and attractive to enhance the apparatus with graphic pictures or other embellishments, they should not detract from a clear and easy recognition of the unit's identity at a fire or emergency operation.

Exhibit 4-5. Identification on the top of a ladder truck in Arlington, Virginia.

Identification of Personnel -- Identifiers for personnel also are important and should be incorporated into the standard operating procedures. Turnout clothing should serve as an identification tool. In areas where many fire departments interact consistently, the name of the department should be clearly indicated on turnout clothing. In addition, where turnout clothing is not shared by firefighters, the name of the wearer should be clearly indicated,

It also is a generally accepted practice to use the fire helmet as a personnel identification tool for fireground tracking and safety. The fire helmet should be clearly labeled with the wearer's assigned unit and rank or position. Colors should be standard throughout the department. Ideally, colors should be standardized for departments that work together frequently,

A system which permits a rapid but secure means of changing the unit identification for an individual should be in place in each department. This flexible identification system will permit members to be properly identified when working temporarily with another unit,

Exhibit 4-6. The Seattle Fire Officer (standing) is wearing a removable, reflective helmet front marked "TRG" indicating his assignment to the Training Division. Removable fronts are used to properly identify personnel on temporary assignment. Extra fronts are kept with each unit.

Establishing and Maintaining Databases

Another major area for which operating procedures are needed is the establishment and maintenance of the databases that the communications center draws upon. The development, and especially the maintenance and security of the databases used in communications, are crucial areas to address.

One form of database deals with response area maps, street names, block numbers, cross streets, common place names, and landmarks. Another database is a response matrix recommending the type and number of resources to be sent to different types of emergencies at different locations. Another database may list other available resources. Some of the key

types of files common to many fire department dispatch operations are discussed below and in the section on response policy.

Response Area Physical Characteristics -- Every fire department's jurisdictional description begins with the physical characteristics of the land it occupies, such as the hills, canyons, and rivers that affect the department's ability to deliver emergency services. For Southern California it may be the canyons and hillsides of the urban interface with wildland areas. New York City begins with the rivers and waterfronts that define its areas. To these characteristics of land are added streets, bridges, and buildings. Streets are named and numbers are given to the buildings so that individual parcels can be identified and located.

To provide a common format for dealing with these geographic features, the U.S. Census Bureau developed, in 1980, the "Dual Independent Map Encoding" (DIME) file that standardized street name spelling, directions, and nonstreet features. It also includes the latitude and longitude for each intersection and landmark.

The sequel to this file is the Census Bureau's "Topologically Integrated Geographic Encoding and Referencing" (TIGER) file. [24] This new file adds shape points that can define topography along with streets, addresses, and latitude and longitude. These files are available for all metropolitan areas of the United States. Many departments have used these files as a basis for developing their own "Geofile." Both files lend themselves to geographic encoding, and the TIGER file can be used for mapping purposes. If a department is considering the use of Automated Vehicle Location (AVL) the use of a map base that contains these features is required.

Street Files -- A typical street file contains an alphabetical listing of streets by name and type, block numbers with corresponding cross streets, landmarks, map coordinates, and an

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[24] A catalog of U.S. Bureau of Census publications is available from the Bureau of Census OPD Publications Unit, 1201 East 10th Street, Jefferson, Indiana 47132, or by calling your regional Census Bureau office.

identifier as to dispatch zone. In larger jurisdictions, the file also may contain political subdivisions, law enforcement responsibility, and ambulance coverage. The file could include nonstreet features such as railroads and waterways.

Building and Hazard Files -- The collection, classification, and storage of information about target hazards has been the subject of considerable attention in the past. Recent experience and technological innovations suggest renewed attention to this topic.[25] Information obtained in preincident planning should include information about the following four elements: (1) environment, (2) occupants, (3) operating features (and hazardous materials stored), and (4) fire protection features.

The description of the environment includes the nature and location of a hazard and its exposures. It includes the height and area of a building, its construction type, its location, street setbacks, proximity to other buildings and wildland interface areas, utility connections, street and site access, and similar features.

The occupant information may include telephone number, location, age, physical and mental capabilities, familiarity with the structure, functions performed, and relationship between the occupants. This information helps assess the nature and magnitude of the life hazards of a given occupancy.

The *operating features* of the occupancy include the quantity of stock, existence of conveyors or material-handling equipment, high-rack storage, automated storage and handling equipment, and similar features. Also, the presence of guard dogs or other dangerous security measures should be noted.

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[25] See W.F. Jenaway, (1986), *Pre-Emergency Planning,* Ashland, MA: International Society of Fire Service Instructors. In July 1990, the NFPA established a subcommittee project on warehouse preincident planning under the supervision of the Fire Service Training Committee. This action followed expressions of concerns by the insurance industry about fire department response to large-loss warehouse fires, in particular the Sherwin Williams Warehouse fire in Dayton, Ohio in May 1987.

Occupational Safety and Health Administration in 1988 established Hazard Communications Standards that require hazard information to be transmitted to affected employers and employees. As part of this standard, Material Safety Data Sheets (MSDSs) must be provided by the manufacturers. Information contained in these MSDSs can be a vital resource to incident commanders on hazardous materials emergencies. Under provisions of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA), the MSDSs must be submitted to a designated government entity. Fire departments are often recipients of these MSDSs.

The size of these MSDS files can be enormous and the department will need to develop a method of highlighting the vital emergency information for the incident commander. This may be as simple as notebooks or as complicated as electronic data sent digitally via MDTs to the emergency responders. Accurate maintenance of the file will be paramount if the information is to be of value.

The *fire protection features* of an occupancy are also of critical concern. Fire protection systems, whether active or passive, are the fire department's first line of defense when combatting a fire. One of the first priorities after assessing the life hazard at an incident should be supporting the installed fire protection. Connecting to automatic sprinkler or standpipe systems, assessing fire door operation, opening roof vents, and similar operations can greatly reduce the spread of fire and perhaps limit the life hazards presented by a fire.

Many building files will contain preplanned firefighting objectives that specify the size and number of lines required, location of standpipes, and access to the building. A drawing of the site is desirable.

The above information should be tied into the dispatch system and should automatically be brought to the dispatcher's attention when an address is entered for dispatch. The communications center should notify the units that additional information is available; it is not necessary that this information be transmitted each time a response is required by location.

Maintenance of Resource Docnments

Each of the procedures listed in this chapter requires some form of documentation. Communications operations can be significantly affected by either the lack of documentation or by poor documentation.

Responsibility **--** The responsibility for maintaining communications resource documents usually is a joint effort by management, field, and dispatch personnel. Management must determine the guidelines and communicate them to all personnel. Management also should be responsible for informing dispatch of recommended response levels and staffing levels. Field operations personnel should continually update the communications center on any short- or long-term special conditions affecting their ability to respond. Communications center personnel should be responsible for recording changes and maintaining the status of all of their resource documents. Usually a supervisor has responsibility for permanent or long-term changes and communication operators handle short-term or temporary changes such as temporary street closures, units on routine move-up, and drills,

Each person must clearly understand his or her role in maintaining resource records. The department should have clear written guidelines and followup procedures that verify that record maintenance is being done.

Timeliness -- Documentation of dispatcher information is of little value if not kept up to date. New streets need to be entered into the system as development starts, not weeks or months after occupancy has taken place. Delayed changes in response levels may send inappropriate resources to incidents. It is critical that responsible personnel understand the urgency of maintaining resource documents.

Accuracy -- Inaccurate documents are worthless and can be very damaging. For example, the northern area of the Los Angeles County Fire Department's jurisdiction has two streets called Avenue 140 West and Avenue 140 East. These are two parallel streets running north and south 28 miles apart. They have many of the same cross streets. An error in dispatch documentation or selection can mean a response that is 28 miles off.

A common error is the inaccurate listing of building numbers for dead-end streets. With the wrong listing, units may respond to the wrong block and not have quick access to the correct location. These kinds of errors will delay responses. The need for accurate records is essential for emergency operations.

5. Onscene Communications

Like other facets of emergency scene operations, successful emergency scene communications are based on planning and preparation before the incident occurs. This includes not only selecting and coordinating the use of hardware and procedures for communications, but also an appreciation of the nature of fire and emergency incident decisionmaking and the role communications plays in it.[26]

Fireground operations are demanding and of necessity must be tightly controlled, Likewise, fireground communication procedures must be tightly controlled. To do this effectively requires that all personnel responding to, operating at, and communicating with fireground personnel know, agree upon, and use only one standard set of rules for communication. The rules must be established prior to the response, must be written down, and must have someone responsible for enforcing them. These rules and procedures describe the priority hierarchy of transmissions, what transmissions are prohibited, the length and substance of transmissions, and any other factors that will enhance or detract from effective communications.

The plans and actions taken prior to fire or emergency operations are critical. For fire departments to communicate effectively, it is necessary that all parties involved understand the content and meaning of the words, gestures, and signals, both visible and audible.

This chapter therefore starts with several sections on issues to be considered in planning for onscene operations and then discusses communications issues pertinent to each phase of an incident. It elaborates on the material of the preceding chapters.

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[26] See the following publications for information about the incident command system: *Command and Control of Fire Department Operations at Catastrophic Disasters: Student Manual.* Emmitsburg, MD: National Fire Academy; Field Operations Guide (1983), (ICS 420-1): Incident Command System Publication, Stillwater, OK: Fire Protection Publications; and, National Interagency Incident Management System (1983), *Incident Command System,* Stillwater, OK: Fire Protection Publications.

For the purpose of this discussion, it will be assumed that the Incident Command System is the principal command and control system in use for emergency incidents.

Elements of Effective Onscene Communications

Ensuring that a message is received and understood by the intended parties is obviously a crucial part of communications. Besides the hardware, it is necessary to consider encoding, noise, feedback, and discipline.

Encoding -- Fireground verbal communications often have been encoded to increase efficiency by reducing the number of words transmitted through the use of an agreed-upon code. Codes also increase privacy by making it harder for eavesdroppers to understand the message. Unfortunately, codes can confuse the intended receivers, too.

The most commonly used codes in fire communications are the " 10 codes." The 10 codes make up a set of numbers that corresponds to predefined messages. Each number is preceded by the number "10." For example "10-4" is used to acknowledge receipt of a message. The number 4 refers to the encrypted message "received and understood," and the number 10 is a prefix which acts as an alert to the message which will immediately follow it.

The 10 codes may be used incorrectly or be misunderstood. Difficulties in using them include the commitment of time required to learn them and the problem of reliably remembering the less-used codes.

Generally, the 10 codes are not appropriate for areas where many different fire departments must interact, where the turnover rate of members of the department is high, or where the response personnel are not clearly defined and known beforehand. As previously discussed, national organizations such as APCO now recommend the use of plain text, although 10 codes and other encryption systems are successfully used in many departments.

Reducing Noise -- Anything which can interfere with a sender's message before it arrives at the person receiving it is considered noise. Noise may be induced by the equipment or environment used to communicate the message. Since emergency scenes are, by definition, uncontrolled environments, sources of potential noise must be anticipated and controlled before an incident if possible. That means identifying equipment which can operate efficiently and effectively in a wide range of environments. Furthermore, it means adopting and using an incident management system which controls the sender's and receiver's environment. Though not noise in a strict sense, limiting the number of persons sending and receiving messages in any communication system is essential to ensuring that each sender and receiver gets an adequate opportunity to be heard and understood. The incident command system also is an ideal vehicle for ensuring this.

Improving Feedback -- For effective tireground communication, not only must the receiver understand the message transmitted by the sender, but the sender has to know that the message was received and understood. Feedback is a way of communicating that understanding from the receiver back to the sender.

Procedures for letting the sender know that a message was received and understood are a part of communications that needs to be planned in advance. Like the message itself, feedback need not be verbal. In fact, the message and the feedback may not be in a common format. As an example, consider an order from the roof sector to cut a vertical ventilation, opening to allow smoke and hot gases to escape a building with a deep-seated, smoky fire. Although the truck company officer directing firefighters on the roof may acknowledge his or her superior's instructions, the true test that the message was understood will come when changes occur in the avenue and character of smoke escaping the building. On the other hand, ordered actions do not always produce expected results, so feedback on the receipt and understanding of orders can be essential.

Fireground Communications Discipline -- Officers and firefighters should be aware of the importance of interpersonal and radio communications discipline. The communications

network is extremely active at times, and a failure to exercise proper communications discipline may affect operations negatively. In critical situations, improper radio procedures could affect the safety of the operating force. Officers and firefighters using the radio must be alert to avoid improper or untimely transmissions which interfere with effective or critical communications.[27] Particular care should be exercised to avoid the following breaches of radio discipline:

- Units with nonemergency transmissions breaking into radio traffic. Units should not transmit routine traffic until the air is clear.

- Units transmitting unnecessarily long and detailed messages. Lengthy messages should be transmitted by telephone or face to face.

- Units calling the dispatcher to determine if they are assigned or should respond. If a unit has kept the dispatchers apprised of its status and availability, it is not necessary to prompt them or encourage them to dispatch the unit. Dispatchers will assign available units, including those which are available by radio.

- Units failing to monitor the radio and acknowledge transmissions as promptly as radio traffic allows. (Chief officers should be alert to radio traffic, improper use, and delayed communications responses. They should assure that unsatisfactory transmissions are investigated and are the subject of appropriate corrective action.)

- Radio users speaking prior to or simultaneously with depressing the microphone button. This practice causes the first part of the message to be clipped. Users should wait a moment after the microphone has been keyed before speaking.

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[27] At the World Trade Center fire and bombing incident in 1993, several hundred firefighters were crowded onto one of three channels used, causing a major problem in on-air discipline.

Fireground Decisionmaking

Understanding the role of communications in incident management requires an awareness of decisionmaking methods and the flow of information on the fireground. Thinking about the nature of fireground decisionmaking is useful as one plans the specifics.

Use of Mental Model **--** Research conducted by Klein and Calderwood (1985) found that the nature of previous personal experience appears to be a critical factor in the decisionmaking process of fire department incident commanders.[28] The basis for their time-critical decisions often is the ability to recognize a situation as a paradigm and match it with a plausible solution based on experience.[29] They call this "recognition-primed decisionmaking." This finding contradicts traditional decisionmaking models which assume that decisions are based on a functional analysis of available alternatives, followed by the selection of a best-fit solution based on its effectiveness or efficiency. Recognition-primed decisionmaking highlights the importance of experience. Rapid communication of the facts of the situation to the incident commander is crucial in forming the "paradigm" and selecting the "solution."

Situational Awareness -- Klein and Calderwood also theorized that the ability to develop a sense of a situation and formulate a paradigm to aid decisionmaking was based on the ability to develop what they referred to as "situational awareness." Such awareness is difficult to establish in the real-time, large-scale, high-pressure world of an emergency, and thus they theorized that incident commanders must develop an ability to filter and focus their attention on the critical details about an incident. Their research led them to believe that the only way to deal with the complexity of an emergency incident effectively was to decentralize

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[28] See G.A. Klein, R. Calderwood, and A. Clinton-Cirocco, (1985), *Rapid Decision Making on the Fireground,* (TR-85-46-12), Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

[29] Klein and Calderwood (1985) use the term paradigm to refer to a situational model or representation of an incident management scenario from past experience. The model may have been formed as an experience at a past incident or developed through training.

control of the details. This is precisely what the ICS does. By maintaining the cohesiveness of the company, task force, and battalion units of the fire department, incident commanders can deal more effectively with a large number of resources by maintaining span of control. The ICS simply gives the incident commander the ability to do this without sacrificing unity of command, and his or her control over the management of the incident.

Fireground Communication Philosophy

The importance of communications to achieve situational awareness and to implement command and control makes it essential that fire service professionals understand what needs to be communicated, who at an emergency scene communicates with whom, and which way information must flow.

What is Communicated? -- The so-called navigation analogy is a particularly apt way of describing what must be communicated to achieve effective incident control. To discover how to get someplace, we first must know where we are, and then where we wish to be. Knowing how to get somewhere, regardless of how elegant and concise the directions may be, is irrelevant without some knowledge of where we begin and where we want to be. All of your knowledge about the streets and buildings of your city and years of experience fighting fires are useless until you find out where the fire is.[30]

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[30] Until the advent of enhanced 9-l-l systems, such information had to be obtained, not simply verified, every time an emergency call was received. Now dispatchers can save valuable seconds, and concentrate on other details such as ensuring that all the occupants have evacuated and determining if any hazardous materials are involved.

Like the navigation example, communication at fires and emergencies is task-oriented. We start with an emergency and we orient all actions toward controlling that incident as quickly as possible, with the least cost to people and property. Therefore, after the initial dispatch, emergency scene communications focus on how to do something-for example, fight a fire or control a hazardous materials release-and the progress made to accomplish that objective. To accomplish this the incident commander must have a clear understanding of what the current situation is (situational awareness) and must have formulated a clear and concise strategy for dealing with it. Establishing control in the midst of the turmoil and confusion of a fire or emergency scene is a primary function of communications.

These types of information then are the focus of most emergency scene communications: (1) *orders* or *instructions* for accomplishing the control or mitigation of the incident, (2) *reports* on progress, and 3) *requests* for resources to achieve control or mitigation of the incident. Orders and instructions in the task-oriented world of fire and emergency scene operations are messages which command or instruct responders to perform tasks or implement tactics consistent with the incident control strategy selected by the incident commander. Effective orders and instructions are clear, concise, and direct.

However, issuing orders and instructions is not enough to ensure effective communication. Orders must be issued to subordinates capable of responding to them. Therefore, to ensure that fire and emergency scene communication is effective, a feedback mechanism must exist. Subordinate commanders must have a means available to report their progress and request resources to accomplish their tasks to ensure effective communication, and in turn, effective incident control. By keeping this communication back-channel open, the incident commander is not only informed about the nature of the incident and the needs of subordinates, but is equipped with the capability to anticipate future developments and adapt the incident control strategy accordingly.

Who Communicates With Whom? -- The principal communicators at any fire or emergency scene are the decisionmakers charged with responsibility for developing strategies

and implementing tactics to control the scene. The proliferation of communication hardware makes communication among all emergency scene personnel more effective, and some fire departments are now issuing communications hardware such as mobile or portable radios or telephones to more members. However, one of the principal means of controlling who communicates verbally with whom at an emergency scene has been to control the assignment of portable radios and other communications devices. The mere presence of radios in the hands of emergency responders encourages increased communication, since these devices enable people to overcome the noise in the communication environment more readily than the unaided human voice. The communications roles of each person on the fireground need to be spelled out and practiced in training to keep communications from turning into noise,

Direction of Communication -- As important as what or who is communicating is their place in the structure of the incident management system and the nature of their communications. Communication between decisionmakers about the tactics and strategies used to control an incident creates an environment where most formal communication about a fire or emergency is vertical, that is, up and down the chain-of-command between commanders and subordinates. However, the larger and more complex an incident becomes, the more horizontal communication becomes. This results in part from the necessity to limit inputs-filter information-coming to the incident commander.

Decisions that do not affect overall incident strategy should be handled at the lowest possible level, and only major elements which require integration among major incident command functions should be channeled back to the incident commander. Ideally, communications among emergency responders at the task implementation level should be primarily horizontal and with their immediate superior.

Incident Command and Control -- The term C^3 I is used to describe the four elements of a military command and control system: command, control, communications, and intelligence. The concept also applies to the fireground incident command system.

Considering the roles of command, control, and intelligence at fires is another useful model to help understand communications requirements at emergency scenes.

Command is the authority to direct the operation. The incident commander (IC) in the Incident Command System is the person responsible for making decisions and issuing orders about how to control the incident. Lines of authority must be understood for communications to be effective, and vice versa. The IC decides what resources are needed and how they will be deployed. He or she determines who will oversee subordinate or support functions, and delegates responsibility for these functions. Nonetheless, the IC remains the individual vested with primary responsibility for the outcome of the incident. Although the Incident Command System makes no assumptions about the rank of the person in charge of the incident, most fire departments see that only experienced officers assume incident command responsibilities.

To effectively *control* the fireground requires that all personnel responding to, operating, at and communicating with fireground personnel know, agree upon, and use only one standard set of rules for communication. The rules must be established prior to the response, be written down, and have someone responsible for enforcing them. These rules and procedures outline what the priority of transmissions is, what transmissions are prohibited, the length and substance of transmission, and any other factors that will enhance, or detract from, effective communications.

Intelligence is the gathering or distribution of information about an incident or that information itself. Prior to the occurrence of an incident, intelligence gathering usually takes the form of prefire plans. However, many fire departments are finding other sources of information helpful in assessing incidents. With the advent of computers, mobile data terminals, mobile facsimile machines, cellular telephones, and sophisticated management information systems, information about a given property or scenario can take many forms. Past event histories, inspection records, the Arson Information Management System (AIMS) data, property tax records, and building permit records are just a few of the data sources available to fire departments. Once an incident is underway, the gathering and distribution of

"intelligence" becomes the critical factor in maintaining the situational awareness of the incident commander.

Incident Operations

Perhaps the best way to illustrate the above concepts of the communications philosophy is to consider emergency scene operations in chronological order from the time an emergency call is dispatched to the time the incident is terminated.

Notification and Initiation of Response -- Earlier chapters dealt extensively with the operation of communications centers and dispatching. This discussion of incident operations starts with the dispatch-the order to emergency forces to respond. It must be received and acknowledged. At a minimum, the dispatch instructions must contain the location of the incident. Beyond that, additional information may provide helpful, even crucial details but still remains subordinate to the location of the incident itself.

Communication En Route -- It has been said that sizeup begins the moment an alarm is received, as a firefighter's or fire officer's mind becomes focused on the incident once the dispatch is received. Preparation for action actually begins even before an incident is dispatched, in the form of preincident or prefire plans.[31]

Prefire incident plans may be kept in the responding vehicles, relayed verbally by the dispatcher, transmitted in hard copy to the vehicle, or communicated by a combination of these

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[31] A good example of how this preparation affects incident management occurred at the Sherwin Williams Paint Warehouse fire in Dayton, Ohio, May 27, 1987, which resulted in a multimillion dollar loss. (See *Sherwin Williams Paint Warehouse* Fire/1087. Report 009 in the Major Fire Investigation Program, United States Fire Administration, Emmitsburg, MD.) The tire chief reported that the principal reason for not aggressively attacking the fire was a concern about contaminating the city's primary supply of drinking water, a large aquifer directly beneath the warehouse. In consultation with the city's water department director, the chief had assessed the environmental exposure from firefighting water runoff at the warehouse long before he received notice that the warehouse was burning. Initial reports of the advanced nature of the fire, and progress reports en route confirming that the fire had fully involved the 180,000-square-foot building, simply reinforced his decision not to apply water to the burning volatile organic compounds inside the facility.

methods. Preincident plans also exist in the minds of the officer and crew, Armed with these plans, incident commanders and responders are better prepared to assess the risks posed by a fire or emergency. For example, firefighters arriving at a shopping mall during the holiday shopping season with smoke showing from the roof of an anchor store should know from a preincident plan whether the building

- o is well isolated from adjacent buildings;
- o is of noncombustible construction;
- o has occupants representing a wide cross-section of the population;
- o may have, at certain times of the year, a larger-than-normal quantity of merchandise on hand, and an increased number of shoppers and staff; and
- o has (or does not have) automatic sprinklers, standpipes, smoke detection, and smoke control systems.

Based on this information, one of the IC's first priorities may be to ensure that the fire alarm system is sounding and that occupants are heeding it. Ordering the support of automatic sprinkler and standpipe systems and assessing the operation of any smoke control system also may be planned as the responding apparatus are en route.

In addition to verbal information relayed from the dispatcher, observation en route may provide important clues about the nature of an incident. For example, traffic congestion en route to an automobile accident call usually indicates that the call is legitimate and may be obstructing the thoroughfare. Likewise, a large smoke plume or "loom-up" on the horizon usually indicates that the fire call you are responding to is the real thing. When the observed conditions en route translate into an action plan, or will significantly affect the decisions of the first-arriving companies, this information must be relayed to all responding units.

Communication Upon Arrival -- Up to this point, nearly all communication has flowed from the dispatch center toward the responding units and the initial incident

commander. From this point on, communications from the incident commander back to the dispatcher and out to the other responders will become the focus. The arrival of the first unit at the emergency scene serves as the benchmark for this communications transition. The dispatcher must be notified by the first unit as it arrives on the scene. From then on, the incident commander is the focal point for communications. All communications from that time forward should be directed through the incident commander, unless he or she delegates otherwise.

After the first company arrives, an assessment of conditions (sizeup) must be made immediately. This assessment integrates the information already in hand with the observed conditions upon arrival, to formulate the initial incident control strategy. The incident commander must quickly take note of the same elements found in the pre-incident plan: the environment, occupants, operating features, and fire protection features. This information then must be relayed to subsequently arriving units and the dispatcher via the initial report.

The initial report is critical because it sets the stage for the actions of each subsequently arriving company, and prepares the dispatcher for requests for additional services or the redeployment of resources. A good initial report raises the situational awareness of all responders and the dispatcher. It should include the following five elements:

1. Fire progress (e.g., nothing showing, smoke showing, fire showing, "working fire").
2. Fire location (e.g., basement, rear of the building, second floor windows, roof, Quadrant D - Side 2).
3. Building information (e.g., six-story brick and steel mercantile building, single-family wood-frame residence, three-story ordinary construction garden apartment).
4. Occupant behavior (e.g., occupants are evacuating, people at the windows).
5. Command post location and officer-in-charge (e.g., front of the building or Side 1, Lt. Gallagher in charge).

Some departments include one additional piece of information in the initial report-the capability assessment--in which the IC informs the responding companies and the dispatcher of his or her confidence that the incident can be controlled with the resources and personnel assigned. If conditions upon arrival indicate that control is unlikely or impossible with the assigned complement of personnel and resources, additional resources should be requested in sufficient quantity and capability to assure operational success.

Establishing a Command Post -- The initial incident commander must establish a command post. The location chosen for the command post may dramatically affect incident command and control by the way it aids or impairs communications. Once established, the command post becomes the hub of the communications network at the emergency scene. A good command post location must facilitate effective communications by giving the incident commander access to the incident environment without overwhelming his or her situational awareness. Generally speaking, the larger and more complex the incident, the further the command post should be from the actual incident site. At a small or routine incident, the IC should have good visual access to the scene to receive feedback on the progress or effectiveness of his or her incident management strategies. A good rule of thumb for ensuring this type of visual contact is for the first-arriving unit to pull past the scene as it approaches. The initial command post is usually established where this first company sets up for initial operations. This approach ensures that the first-arriving officer has seen what is happening on three sides of the incident scene.

Exhibit 5-1. The chief officer and aide operate a command post for a small highrise fire. Note the position of the cellular phone and radio microphone for smooth operation in concert with the work surface.

However, this approach may be imprudent or impractical at some types of emergencies. Sometimes the terrain, street network, weather, or the nature of the incident itself leave the IC with no choice about how to approach the incident, and therefore, little choice about where to set up the initial command post.

Subsequently arriving officers may elect or be required to assume command of the incident. Upon their arrival, the command post may be relocated to a site which remains accessible to the scene but ensures adequate insulation from it. The new command post should be clearly established and identified. Signs, flags, lights, and special vehicles are a few of the ways a command post can be distinguished at the incident scene. (Design criteria for command vehicles are discussed in Appendix C.)

The new location of the command post must be clearly announced to all companies operating at or assigned to the incident. This ensures that nonverbal communication remains effective. Furthermore, this ensures that those who must conduct face-to-face communication with the IC can locate him or her without delay.

Tactical Communications -- As stated earlier, much of the communication at emergency scenes is task oriented. Directing a fire attack will primarily involve communication between the incident commander and subordinate officers, and the companies and crews fighting the fire. Most messages will consist of

- orders and instructions to perform tasks for controlling the fire;
- reports about the conditions and progress encountered; and
- requests for additional resources to fulfill assigned tasks.

These communications must be clear, concise, and timely to ensure that communications fully support the incident command and control function. Much of the communications will involve intelligence about the nature of the incident, which increases the situational awareness of the IC and the firefighters alike. The IC's situational awareness is critical to effective management of the incident. The firefighters' situational awareness, keeping abreast of conditions beyond their immediate environment, is critical to their safety.

Even when an incident becomes a defensive operation, a significant degree of communication is required to ensure effective coordination. Defensive operations ordinarily require a significant commitment of personnel and resources. The more people that are involved in an operation, the more difficult communication becomes. For instance, when an advanced fire threatens to produce a structural collapse and firefighters are ordered out of a building, efforts must be made to quickly account for all personnel who were in, on, or around the involved structure. Once assembled and accounted for, these personnel will require new instructions for their effective deployment. The incident commander must recognize that the functions performed by all personnel prior to the evacuation will be substantially affected by changes in

the overall incident control strategy and prepare to communicate new instructions during the time it takes to regroup the forces,

In addition to tactical communications, there often are many other types of communications needed during an incident.

Locating, rescuing, and protecting endangered people are usually among the first priorities at any fire or emergency. Often the victims of fires and other emergencies are extremely agitated, anxious, or excited. The stress of the emergency may make civilians behave irrationally, or they may be unresponsive, combative, or uncooperative. The emergency responders need to calm and reassure the victims(s) to gain their confidence and cooperation to complete their rescue or secure their protection. Such communications must be authoritative, confident, and direct but should avoid melodrama, hyperbole, or vulgarity. Telling people what is really happening in the most concise and straightforward fashion usually works best, whether you are trying to effect an evacuation or reassure an accident victim. Incident analysis has demonstrated that people usually respond best when confronted with the facts about a dangerous situation. The more complete and accurate the information they receive, the better their response can be.

Managing exposures during an incident often involves some degree of communication with people other than the emergency responders themselves. The location of vital business records or people requiring evacuation assistance, for example, may be identified in pre-incident plans, or by contact with the person reporting the incident, or from people at the emergency scene.

Salvage operations often involve establishing a sense of the relative value of exposed property and the degree of danger confronting it. This requires communicating with property owners or occupants as to what is of highest priority to save, or if any areas need special protection. For example, the value of paper records themselves may be negligible, but when

those records are the accounts receivable or inventory records of a firm, their protection may be considered priceless in the eyes of the owner.

Emergency Traffic -- The fire service is trained to accept emergency scene operations as "part of the job." In fact, keeping a cool head in hot situations is what firefighting is all about. However, some situations represent emergencies even to seasoned firefighters and emergency responders. These include missing or injured firefighters, deteriorating or extremely hazardous structural conditions, weather changes that will exacerbate the fire situation or further endanger lives, and dramatic changes in smoke conditions. All of these situations require prompt and coordinated action to avert an operational disaster. Effective communications is the key to assuring that appropriate action is implemented quickly. Therefore, procedures for distinguishing and conveying such emergency messages must be adopted.

The use of signal words, such as "May Day, " "emergency traffic," or "urgent," or the broadcast of a predefined signal like a radio alert tone, apparatus siren, or air horn blast must indicate to everyone operating at the incident that important, indeed vital, information follows. To maintain their effectiveness, these signals must be coordinated before an incident occurs and reserved for exclusive use in life-threatening or extremely hazardous situations.

Once broadcast, emergency signals should cause the interruption of all other communications until the message is received and acknowledged. Procedures for dealing with such emergencies should be defined before an incident, and implemented immediately. For instance, if an alert tone is received from a Personal Alert Safety System (PASS) device in a trapped firefighter's radio, the IC should immediately begin efforts to identify, locate, and rescue the missing firefighter. (Radio equipment which integrates the features of PASS devices also may give an immediate identification of the radio assigned to the firefighter in need of assistance If radio assignment data are accurate, the identity of the radio operator and his or her assignment can then be readily determined.) Similarly, if sector reports indicate that a structural collapse is imminent and defensive operations should be implemented, a signal should be sounded both outside on the fireground (e.g., three long blasts on an airhorn) and on the radio (e.g., three long

alert tones activated by the dispatcher or field communications personnel) to direct firefighters to evacuate the building, secure defensive tactical positions, and await further instructions.

***Status Reports* --** Within a fixed time interval following the preliminary or onscene initial report, the IC should give a progress report to the CC. A progress report is a verbal picture of what is occurring at the scene and should include (1) a description of the fire building or emergency zone, (2) location of the fire, (3) description of the exposures, (4) description of the strategy, tactics, and resources being employed to control the situation, (5) an appraisal of the expected outcome of the current actions, and (6) any other facts which will be important to superior officers or surrounding companies listening to the report.

Some departments feel that progress reports should be transmitted at the discretion of the IC and should only be transmitted when there is a change in operations or when the operation is complete (such as an escalation or de-escalation). Another option is to require the IC to formulate and transmit progress reports at regular time intervals. Those who favor nonprogrammed progress reports want to give the IC an opportunity to manage the operation without higher levels of command interceding and to limit the radio traffic to essential dispatch traffic. Those who practice programmed progress reports believe the practice of regularly communicating a verbal picture of onscene conditions helps the IC to better understand and appreciate the problems; keeps the higher level of command better informed, thus allowing them to make judgments on the effectiveness of operations and the need to respond; creates a permanent record of the actions and reported conditions at regular intervals, and helps communications center personnel to have a clearer understanding of the incident and its development.

A suggested time interval for programmed progress reports is to give the first progress report approximately 10 minutes after the preliminary report, and, for the next hour of the operation, to give one every 10 to 15 minutes and whenever a significant escalation of operations

occurs. The transmission of additional alarms would be defined as escalation and would require the IC to inform the communications center of the reasons for this additional response.

Where fire departments use multiple radio channels, such as a primary dispatch or operations channel and a command or tactical channel, the operations channel is the routine communications link from the incident to the communications center. The dispatcher should rebroadcast all progress reports of major operations on both the primary channel and the command or tactical channel. The procedure for rebroadcasting reports should be predetermined and based upon the number of units working at the scene. Preliminary reports and progress reports for fires or emergencies smaller than the predetermined size need not be rebroadcast.

Status reports help personnel maintain their situational awareness and prepare them for operational changes and new tasks. The reports help ensure safety by keeping personnel abreast of changing conditions. And the reports prepare the dispatcher and other potential responders for the deployment of additional resources or redeployment of those still uncommitted.

Requests for Additional Resources -- Requests for additional resources during an incident should include the nature and number of the required resources. Most departments group their companies in alarm assignments based on the task force concept. With this concept, companies are grouped by capability. Typically, each task force consists of one truck, aerial, ladder or service company assigned with two engine or pumper companies. For each group of two task forces, an officer of battalion or district chief rank is assigned to command. (While these groups of companies often are referred to as alarm assignments, an alarm assignment also may refer to all of the companies from a particular station or fire district.) Occasionally, special service companies like breathing apparatus supply units, canteen trucks, light towers or utility trucks, manpower squads, or medical units are assigned to round out the complement of capabilities of an assignment.

When additional companies or alarms are requested to control an incident, instructions also must be given to ensure their orderly integration into the incident. Units needed at the scene should be directed to their assignment and instructed as to whom they are to report. Units not immediately required at the scene, but whose assistance is needed for tools, equipment, or personnel, should be assigned to a staging area. The staging area should be established at a location with good access to the incident but far enough away to prevent uncommitted resources from interfering with emergency scene operations. Once established, the staging area represents a resource pool for the IC. At protracted incidents, a relief area and logistics sector may be established adjacent to the staging area. This way, as personnel and resources become available for reassignment, they can easily be attached to the staging sector.

Requestsfor Special Services -- Often at large incidents the assistance of other agencies is required to mitigate a situation. This assistance may include Red Cross disaster relief teams, social welfare agencies, environmental protection officials, utility companies, emergency management officials, or National Guard personnel. Ordinarily, these services remain under the direction and supervision of their own agency supervisors or commanders when assigned. To ensure effective communication with these outside agencies, someone from each agency should be included in the incident command hierarchy according to the agency's role in the incident. For example, organizations furnishing relief supplies like cots, bedding, food, water, or shelter should be assigned to the logistics division. [32] Communicating with outside agencies will probably remain difficult even if integrated into the incident command system. Hardware and operating procedures often vary considerably between fire service and non-fire service agencies. Outside agencies with radios often cannot communicate with the fire service on a common frequency. One way to overcome such difficulties is to request each outside agency to supply the incident commander or division commander with one of its radios and an identifier. However, even with a radio, the fire service IC or division commander may have communication difficulties with the outside agencies, because they often have less formal communication

[32] The term "logistics division" refers to the ICS branch concerned with supplies, reinforcements, public information, and other support services. The division commander is one of five (or fewer) officers who report directly to the incident commander.

protocols and standard operating procedures than the fire or EMS department. Face-to-face communications may be the most reliable method in some cases. Once again, planning and practicing integrated emergency management operations can help overcome many of these difficulties.

Avoiding Unnecessary Traffic -- Most communications at the scene of a tire or emergency will be verbal. Radios have become the primary means of communicating information among emergency responders. However, some communication, particularly at the operational or attack level, is most effective when conducted face to face. Bogging down radio communications with traffic about where to direct a nozzle or how bad smoke conditions are can choke a communications network.

Some departments have been issuing radios to each firefighter on duty to improve firefighter safety, the rationale being that each member should be able to immediately report extremely hazardous conditions or emergencies such as a missing or injured firefighter or a structural collapse. Procedures and controls must be adopted to ensure that all radio operators are maintaining radio discipline, and sending and receiving the right information to the right people at the right time. It does no good for everyone at an incident to have a radio if only half of them are listening to the right channel for instructions, or if many are speaking at the same time.

Terminating an Incident

As an incident is brought under control, the need for personnel and resources diminishes. However, incident commands must be terminated in an orderly fashion so that control of the incident does not end prematurely and so that resources are only placed back in service when fully prepared to engage in new assignments, The life cycle of any incident readily facilitates scaling back in an orderly fashion.

All Clear -- The first significant benchmark in the control of an incident is usually the completion of a primary search or the removal of all trapped or injured victims from danger. Announcing the *all clear* indicates to all personnel operating at the incident that all known or immediately apparent victims have been removed, and the danger to civilians has been mitigated within reasonable certainty. In other words, there may still be some chance that lives are in jeopardy, but their status could not be determined and must wait for the secondary search, which will be conducted when the incident is controlled or conditions improve. This incident management priority holds for automobile accidents with trapped victims and hazardous materials incidents with contaminated or exposed victims as well as wildland and structural fires. The actions of firefighters and other emergency service personnel usually are dominated by actions to save lives during the early stages of any incident. Announcing the *all clear* tells all assigned personnel that the focus has shifted to fire control or property protection.

Under Control (Situation Contained) -- Once an incident is no longer growing in magnitude or severity, or is at least doing so in a predictable, controlled fashion, an incident may be referred to as *contained* or *under control.* By announcing that the incident is contained or controlled, the incident commander is declaring that the incident can be managed with the resources assigned. Furthermore, this declaration prepares the dispatcher and assigned companies for an orderly return to normal operations. If companies are still responding to the incident scene or staging area, they should be considered assigned and continue their response, since they may be required for relief or other duties, unless released by the incident commander.

Available/In Service/Ready for Service -- As companies are released by the incident commander through their sector officers, they should report their status to the dispatcher or communications center. Companies which are fully staffed, equipped, and prepared for another assignment should report themselves as “available” or “in service,” or “ready” for service (depending on local jargon). Companies with reduced capabilities which do not impair their

readiness or response status should indicate their capabilities in their message to the dispatcher. For example, a four-person engine company which sends a firefighter/EMT with a medic unit to the hospital might radio the dispatcher, "Engine 23 in service with three. One member assisting Medic 12." Occasionally, a company must return to quarters but still be out of service. Although the unit is unavailable for reassignment, the dispatcher still must be notified that the company is no longer assigned to the incident. When the last company clears an incident the command should be formally terminated. This indicates that no further resources are committed to the incident and that the scene is no longer under the control of the fire service. This is a particularly important distinction if the incident is a suspicious fire or is associated with other criminal activity. When an incident scene is left under the control or supervision of another agency, the responsible agency should be reported to the dispatcher as a matter of record.

Postincident Operations

After an incident is over there may be an investigation, critique, and a variety of dealings with the media.

Investigations -- Every tire and emergency incident should be investigated to determine its origin and causes as well as the contributing and mitigating factors. The actions and assessments of emergency responders aid immeasurably in the reconstruction of emergency scenes. Communication between emergency responders and investigators is vital to reconstructing the events surrounding most fires and emergencies. Therefore, emergency response personnel should become skilled in observing, recording, and recollecting details about the incidents to which they respond. This information will aid them as well as the investigators.

Critiques, Post-Mortems, and After-Action Assessments -- Even the best-trained and equipped fire departments and emergency response organizations can learn from their experiences, Every incident is an opportunity to test responders' knowledge while gaining new insights through experience. Postincident critiques, post-mortems, and after-action assessments are an opportunity to share these insights among peers. Sharing the lessons learned from every

fire and emergency operation from those with diverse perspectives helps iron out operational deficiencies, build teamwork, establish mutual respect among team members, and build a common core of experience which will serve the responders well at other incidents. Postincident critiques should be critical to the extent that they examine every detail that contributes to or detracts from effective incident management.

Press Releases -- One of the most difficult and challenging aspects of communications for any significant incident is dealing with the media. Often it is vital that communication begin with the media while an incident is in progress. In fact, the sooner the demand for information about an incident can be met the better, provided the information is accurate. After an incident, all the loose ends about an incident should be cleared up. A complete press release should be issued following every major incident. Many departments also issue daily press releases or briefings through the communications center. A good press release should answer the five Ws of journalism: who, what, when, where, and why (how). Keep press releases clear, complete, and to the point, and the media usually will be satisfied. And, when details are sketchy or incomplete, remember that accuracy is more important than timeliness.

6. Communications Hardware

This chapter is a brief introduction to communications systems hardware and terminology. The basic elements of a communications system include transmitters, antennas, receivers, and their power supplies. There is also various ancillary equipment.

Before discussing hardware details, we will discuss the characteristics of radio signals and their intended operating environment, and some key ideas on modulation and frequency ranges, all of which have a major bearing on the hardware required.

Characteristics of Radio Signals

To begin understanding radio systems basics, it is helpful to pause and consider that all radio receivers and transmitters are not compatible. The compatibility of receivers and transmitters is determined in part by the type of *modulation* (AM or FM) the transmitters use to place information on radio signals, and whether the receivers have an internal circuit design that can remove the modulated information from the transmitted radio signal. Compatibility also depends on the receiver and transmitter both being tuned or tunable to the same frequency.

The type of modulation used and the part of the radio frequency spectrum used are two of the most important criteria in designing a system.

Modulation -- “Modulation” is the process of encoding messages to be transmitted on a radio signal. A radio signal without any modulation applied is called a *carrier* signal. It is a constant frequency and sounds like a steady tone before any modulation is applied to it. After modulation takes place, the result is called a *modulated carrier signal. Demodulation* is what occurs on the receiving end of a radio path. It is performed inside the receiver box. The modulation of the transmitter must be compatible with the demodulation process in the receiver.

The three major types of modulation are Amplitude Modulation (AM), Frequency Modulation (FM), and Phase Modulation (PM). "AM" Radio is a radio using Amplitude Modulation. "FM" radio uses Frequency Modulation.

In amplitude modulation, the information desired to be transmitted is placed on the carrier wave by varying the amplitude (or power) of the carrier. In frequency modulation, the information to be transmitted is placed on the carrier wave by varying its frequency slightly (by several thousand cycles per second out of tens of millions cycles per second on the carrier). Phase modulation is similar to, but not exactly the same as, frequency modulation, and involves varying the phase of the signal to encode the information to be transmitted.

Frequency modulation and phase modulation are the principal methods used by fire service communications to place information on the carrier wave. These methods are not the most efficient modulation methods from the point of view of power consumption and radio frequency spectrum use. This is unfortunate since the relatively high power demand of FM and PM requires heavy, bulky battery packs, and their somewhat inefficient use of radio spectrum wastes this precious resource. The main reason FM and PM continue to be used is the tremendous existing financial investment in hundreds of thousands of pieces of radio equipment. It is difficult to consider a wholesale discard of all this equipment already in service in the field.

The ramifications of one department changing its modulation method are not limited to that department alone. Mutual aid procedures depend on the ability of one department to communicate with another. There would be a logistic and communications nightmare involved in attempting to change fire service communications modulation methods to more powerful and frequency-efficient methods if all departments in a metropolitan area did not change simultaneously.

Frequency Ranges -- The radio frequencies used in the fire service are in the following ranges:

VHF-Low Band:	33 MHz - 46 MHz
VHF-High Band:	150MHz-174MHz
UHF:	450 MHz - 460 MHz
--	800 - 900 MHz

Each frequency range uses a different antenna and has different propagation characteristics.

VHF stands for *very high frequency.* There are two sections, or bands, identified for public safety use in the VHF radio spectrum. The VHF-Low Band is the radio frequency spectrum found in the 33 MHz to 46 MHz region. The other band is the VHF-High Band from 150 MHz to 174 MHz.

Antennas used in the VHF-Low Band are typically between one and one-half feet to several feet long, the length being inversely proportional to the radio frequency selected. VHF-Low Band frequencies have the ability to hug the earth and travel relatively long distances over the horizon. This has advantages for agencies which have very large service areas that extend beyond the "line of sight."

A disadvantage of this frequency spectrum is the tendency of the radio signals to travel off into the portion of the atmosphere called the *ionosphere,* where the signals bounce back and forth between layers of atmosphere like a ball on a racquetball court. This bouncing carries the signals over great distances, sometimes thousands of miles. This provides no advantage to the principal user, but causes a disturbance to receivers on the far end as a phenomenon called *skip.* This transmission path is very unreliable. It is not used for communications circuits that need predictability. And it is very troublesome to distant stations in the form of sporadic interference to local line-of-sight transmissions.

VHF-High Band, in contrast to VHF-Low Band, requires antennas that are about 15 to 20 inches in length. The specific length is determined by many factors. Propagation is for the most part line of sight. However, there is a slight tendency of these waves to bend over the visible horizon, so the "radio horizon" is slightly beyond the visible horizon. This explains the observation that radio signals which supposedly have "line of sight" characteristics perform consistently beyond the visible horizon.

The tendency to travel off into the ionosphere and bounce between layers of atmosphere until the signal arrives at a distant point is less apparent for High-Band VHF than for Low-Band VHF; nevertheless, the tendency is there. But the skip signals are usually fleeting and do not present as much of a problem as Low Band does at distant receiving points, in the form of sporadic interference to local radio transmissions.

UHF means *Ultra High Frequency.* Generally speaking, the UHF spectrum starts at about 400 MHz, but fire and EMS radio operations in the UHF spectrum are in the 450 MHz to 460 MHz region. UHF antennas are about six inches or so in length. The exact length is dependent on several design factors.

Propagation of a radio signal is almost entirely line of sight. Propagation over the visible horizon is common, but less than with VHF. There also is less of a tendency for the radio signal to bounce back and forth in the ionospheric layers than in either of the VHF bands, and when it bounces it dissipates energy quickly. The signal tends to head out into space on a straight line rather than become trapped in the ionosphere.

Going even higher in frequency, the 800 to 900 MHz range is today's practical upper frequency frontier for fire and EMS service communications. It is technically possible to increase the operating frequencies of mobile and portable radio equipment beyond 900 MHz, but certain practical matters such as maintenance and electronic component design need to be worked out by the communications industry.

The 800 to 900 MHz antennas typically range in length from one or two inches to six inches. Again, the length of the antenna is dependent on many design factors. Propagation characteristics at these frequencies are principally line of sight; the radio horizon is closer to the visible horizon in this frequency spectrum. Trunking radio communication systems typically use this frequency spectrum; they require frequency pairs grouped together closely.

Microwave Systems Transmission -- Microwave systems are high frequency (two Gigahertz) FM radio communication systems. They are not found in the majority of fire department communications systems but are common in large fire departments covering relatively large geographic areas. This is not to say that it is not technically feasible to apply microwave systems to small areas. The use of a microwave system is predicated on economic considerations and operational reliability considerations. Another factor is distance over which control of remote sites must be effected.

Microwave systems provide an alternative to heavy use of many telephone lines. Reliability of communications during periods of natural disaster can be compromised if too much dependence is placed on the commercial telephone system. It can become overloaded or be subject to mechanical and electrical failures. Each fire department communications system needs a close evaluation to determine whether it is overly dependent on the commercial telephone system. (In fact, each communications system should be evaluated to discover whether it is overly dependent on any one path.) Then a management decision is required to determine whether the risk is acceptable or not. Microwave systems can provide a flexible backup.

The beauty of microwave is its ability to carry many simultaneous channels of audio, data, video, and combinations of the three on one microwave frequency. The principle of multiplexing is used to accomplish this task. Multiplexing provides a method of processing more than one communications event over a single wire or single radio frequency.

Microwave systems as used in fire communications often are configured in a "loop." The loop provides redundancy so that if any one leg or one station in the system fails, the remainder of the loop provides a secondary path for communications.

While all of the microwave functions listed below can be provided by other communications services, the microwave system enhances reliability in two ways. First, the system and its performance are completely under the control of the fire department or public safety managers, The priority of repair and maintenance are determined from a public safety point of view, not a commercial, economic point of view. Second, since the system is completely dedicated to public safety, there are no questions regarding priority of communications paths. The system manager knows precisely what communications should be given priority should there be a partial failure of the system. Some of the applications of a public safety microwave system are as follows.

- Transmit audio and digital signals from the dispatch center to remote fixed station transmitter sites.

- Provide intercom and telephone circuits from various sites served directly by microwave, or located near microwave sites.

- Provide control of mechanical and electrical operations such as transmitter key line functions, satellite receiver monitoring, monitoring of battery voltage levels and charging systems, gas pressure in high frequency and high power transmission lines, condition of temperature control devices in radio shacks, fire and burglar alarm circuits, and control of security devices such as television video and security lighting and safety marking lights.

In larger fire departments, where fire stations and other facilities are spread over great areas, a feature called teleconferencing often is used to pass information along from supervisors

to their subordinates, to allow the fire chief to discuss issues with employees, or to perform any number of communications tasks.

Teleconferencing involves a central telephone processing unit into which all fire stations or facilities involved dial as they would a normal telephone system. Microphones and speakers in each facility allow the participants to speak to each other as if the conversation were taking place with all the participants in one large room. Obviously this process involves many telephone lines. A microwave system can replace the hardwire telephone lines with a radio frequency signal. The microwave signal has the unique ability to carry many voice conversations on one radio frequency. This characteristic makes the task of setting up teleconferencing sessions much easier and more reliable than the use of commercial telephone lines.

Microwave, while an expensive initial investment, is very reliable and efficient over long periods of time from a technical and economic point of view.

Differences Among FM Uses -- Many entertainment radios which have the ability to receive commercial FM also claim they are multi-band receivers and offer the purchaser the opportunity to "tune into the excitement of the public safety fire and police bands." While these radio receivers do a relatively good job of detecting and demodulating the entertainment transmissions, they generally do a very poor job of detecting and demodulating fire and police transmissions. Although both the entertainment transmitter and public safety transmitter are FM transmitters, they use two different kinds of FM, which points up the need to consider more than just the stated modulation type. The FM entertainment radio cannot effectively receive the public safety FM transmissions. And an FM police or fire receiver, if tuned to the FM entertainment transmitter frequency, cannot demodulate the entertainment transmitter. The differences lies in the magnitude of the frequency variations of the carrier wave. In the case of the entertainment transmitter, the swing is in hundreds of thousands of cycles; in the case of the public safety transmitter, the swing is measured in only thousands of cycles. Both are FM transmissions, yet are not really compatible.

Mobility of Senders and Receivers

Communications equipment is characterized according to its mobility and intended application as fixed station, mobile, or portable equipment, as well as by its modulation and frequency band.

Licensing is different depending on whether the hardware and system are fixed or not. The environmental conditions in which the equipment is expected to operate also differ according to mobility. The mechanical shock, mechanical vibration, and temperature extremes to which the equipment is subjected are important in designing or purchasing equipment. They must be clearly stated in the specifications. Mobility also affects the type of power that can be used; the distinguishing characteristic of fixed station equipment is that it can use commercial power sources, such as 110 VAC or 220 VAC.

Fixed Station Equipment -- Fixed station equipment is defined to be communications equipment that does not move around from place to place during use. Equipment installed in a truck, van, trailer, bus, or similar vehicle can be considered fixed station equipment if the vehicle is not moved during use ***and*** the location of the vehicle can be precisely identified at the same spot all the time. For example, radio equipment installed in a 40-foot trailer, parked at some specific location, is not mobile equipment.

A fixed station transmitter can have any power output level authorized by the licensing process. The power output needed depends on the coverage area. A fire dispatch transmitter usually has a power output of anywhere from 5 watts to 250 watts, rarely higher. The more typical range is 50 watts to 150 watts.

Special control transmitters, while not exactly fixed station transmitters, are not portable or mobile pieces of radio equipment either. They usually operate with very low power output, and are used for point-to-point control or communications. Highly sophisticated antenna assemblies make the most of the low power and direct it from the transmitter to some distant

receiver in such a fashion that only a receiver directly in the path of the transmitter can hear the transmission. Control transmitters often are situated in a municipal water supply pump house or well. The transmitter sends data on the operating status of the pump house and other critical data to a remote monitoring receiver. These data are accumulated and reports filed. Some systems trigger an alarm if the data fall out of limits, or are not present, or if the transmitter carrier disappears altogether. Another example of a control transmitter is the street corner radio emergency call box. Upon activation, information is transmitted to the dispatch office indicating police, fire, or EMS assistance is needed.

Mobile Equipment -- Mobile radio equipment is expected to perform communications functions while in motion. It is used on automobiles, trucks, boats, and the like. The communications may take place with other mobile radio equipment, portable radio equipment, or fixed station radio equipment.

The definition of the expected mobile application "duty" is very important for equipment specifications. If the operating environment is not defined there is no guarantee that the equipment will survive mechanically. Often the obvious requirements for survivability are overlooked by the user when a purchase is being contemplated.

It is necessary to consider a mobile radio as part of a system. It is not simply a transceiver placed under a dashboard, an antenna here, and a "mike" holder here. For effective communications, the entire system, from microphone, data terminal, transceiver, through and to the antenna itself, must be planned carefully.

The transceiver configuration is the most popular arrangement in mobile operations. Transceivers are nothing more than a marriage of a transmitter and receiver into a "box" along

with a common power supply. As a system component, radio transmitters are seldom used alone in mobile applications.[33]

The power output level of a mobile transmitter is limited by its ultimate power source. In the case of an automobile, it is the vehicle's battery. Theoretically, power levels up to 200 watts are possible, but practical system configurations limit mobile radio transmitter power outputs to 50 watts or even 25 watts. In most radio systems, mobile transceivers operate in concert with portable radio transceivers elsewhere in the field. The system design usually is such that the mobile transmitter power output need not be too different from the portable transmitter power levels. If the system can effectively pick out low power handheld radio signals, it should be able to receive at some satellite receiver the much more efficiently radiated signal from a mobile unit. If the handheld power output is approximately 3 watts, there usually is no need to specify a mobile radio transmitter with power outputs greater than 25 watts.

Access and operator convenience are very important in specifying, selecting, and installing mobile radio equipment. Cellular telephone installations are a newly recognized contributor to motor vehicle accidents. Considerable care in placement of controls is needed to reduce the likelihood of an accident when emergency vehicle drivers attempt to select a channel, change a mobile unit from repeat to direct, or even just raise or lower the volume. The same care is needed in selecting equipment features.

One of the most dangerous mobile radio ancillary devices from the viewpoint of diverting a driver's concentration is the Mobile Data Terminal (MDT). Most MDTs have many message buttons from which the driver must select. Add in the video display or hard printout, and the temptation exists for the driver to divert his/her attention from the road. Given prevailing

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[33] That is not to say that some unique system configuration would not allow a transmitter to operate alone. An example could be some kind of telemetry operation where data are transmitted in one direction from the mobile unit to the fixed base station,

staffing levels, MDTs often must be operated by one person who also functions as the driver of the vehicle.

Exhibit 6-1. Well-placed controls are critical, especially when vehicles are operated with one person, such as this command vehicle.

Portable Equipment -- Portable equipment is sometimes called Personal Radio Communications Equipment. Portable radios used to communicate in both directions are transceivers. The battery is the common power supply. The antenna is common to both the transmitter and the receiver.

Some communications systems are completely configured around performance of personal radio equipment. The fixed base station or several fixed base stations and the associated system of receivers and antennas are designed to communicate with portable radio equipment only. No mobile equipment is included in the design, procurement, or installation, despite the fact that field personnel are in motor vehicles. When field personnel are in the vehicle, communications are to be performed using a portable radio attached to the user. This creates a very challenging system design. Nevertheless, it accomplishes the ultimate in communications with field personnel.

Modern portable radio equipment provides the fire service with a wider range of operating features than did earlier radios. These features came into existence because of fire service desires or because of technology cross-over from other user groups, such as industry, transportation, or law enforcement. From a technical and flexibility point of view these features may be good, but they also must be assessed in terms of whether they increase or decrease risk to field personnel.

For example, many portable radios now provide features that are controlled by accessing a key pad on the side of the radio. One must consider the ability of field personnel to use these key pads, and to access channel change knobs, volume controls, built-in LED lighting controls, and similar features under the high-risk, low visibility environmental conditions of fire operations. The choices of features must be tempered with the safety of the user. Can the user really access channels, change from direct to repeat, and adjust volume using finger touch only? In some areas, the ability to survive harsh environments and simplicity of tactile operation take precedence over having multiple features.

Before any purchase is made, it is usually a good idea to do a "needs" analysis of what the field fire service personnel really need. An "ideal" performance specification for a portable radio might be "... can be changed from channel to channel, direct to repeat, in a pocket, at the end of a speaker-mike, at 2 a.m. on a cold winter morning, in a burning warehouse, with smoke banked down to the floor, by a fully bunkered-out, glove-wearing, blinded firefighter on his/her

hands and knees, wearing self-contained breathing apparatus." Consider this end user specification against many of the portable radios now on the market. Consider it against what is now in service. It certainly provides a challenge to the design community.

The basic hardware elements of communications systems are transmitters, receivers, transceivers, and antennas. Command consoles might be added. The sections below treat each of these elements in turn.

Receivers

Receivers are the "ears" of the communications system. They are tuned to listen to either a single frequency or to a "band" of frequencies. Receivers in fire communications systems perform the same function as entertainment radio or TV receivers. They look at the world through a kind of electromagnetic "window" to see if a radio signal of the right frequency is coming through the window. If it is, the receiver will attempt to understand what the signal is "saying." This is possible only if the modulation method of the transmitter signal and the receiver are compatible.

Receivers are made up of what are called *stages,* or sections. Simply put, the receiver is made up of

- the front *end,* or the radio frequency amplifier section, also called the *rf amplifier;*
- the *intermediate frequency amplifier stage,* also labeled the if stage; and
- the *audio amplifier stage.*

Each receiver has circuitry that performs the above three tasks; the difference from one receiver to another is the quality of design demonstrated by how reliably it removes the information from the carrier. The quality of each stage's design and performance dictates the price of the receiver.

As a stand-alone component, receivers find frequent application as scanners or monitors of fire service agencies other than the agency the user is associated with. From time to time it is of interest for a fire officer to listen to activity in adjacent jurisdictions. A "monitor receiver" is perfect to fill this need. Commercially available scanners usually perform adequately if there is no need to transmit on the monitored frequencies.

Rural and suburban areas do not usually present a hostile operating environment for inexpensive, off-the-shelf monitor and scanner radio receivers. The most common shortfall in rural areas is a lack of ability to pick up the desired signal because the radio frequency(rf)-amplifier is not as sensitive as higher quality public safety radio receivers.

Urban settings present a different challenge to inexpensive receivers. Here there are often concentrations of entertainment FM radio transmitters, paging systems, and other radio services which wreak havoc with lower-quality radio designs. Only good quality design and good-quality components can overcome the tendency of urban radio congestion to overload inexpensive receivers' rf-amplifiers.

The difference between a $50 monitor or scanning receiver and a $500 monitor or scanning receiver usually is not apparent by viewing the outside of the case or by listening to the audio output. The test of the quality of a receiver is its ability to operate successfully in an urban area where there are many transmitters of all kinds, at all frequencies. Only quality design and quality components can overcome the tendency of urban radio frequency congestion to overload the "front end" of the receiver and cause the circuitry near the antenna end to go into distortion because of too many signals or signals that are too strong. This undesirable performance exhibits

itself by annoying squawking and squealing from the receiver speaker while driving through heavy urban areas.

Most of the communications receivers in the fire service world are used for voice transmission or data transmission. All receivers that are tuned to or listening on the same frequency as the transmitted signal will understand the transmitted information if the transmitter modulation technique and the receiver demodulation technique match. When encoding is used, the receiver continually evaluates the received signal to determine whether there are any encoded messages in the signal, and, if so, decodes them.

Monitoring Receivers -- "Monitoring radio receivers" are radio receivers that listen all the time for some signal of interest. Something is usually triggered when the information is received. Receivers do not require licenses from the Federal Communications Commission or other government agencies.

The distinguishing characteristic of monitoring receivers is that they operate alone, not in conjunction with a transmitter. In a way, monitoring receivers can be likened to an "eavesdropper," whereas a radio receiver operating with a transmitter is involved in a "conversation."

Monitoring receivers may be used to monitor the state of sprinkler control valves, fire alarm devices, hot and cold water tanks, or the temperature in a building. Monitoring receivers may listen for a transmitted signal from a street corner radio fire alarm box, a roadside motorist's help alarm box, or even a garage door opener.

Many volunteer fire departments and civil emergency management agencies have large alerting sirens located at or near their stations. These sirens can be activated manually with a push-button switch or they can be activated by broadcasting a radio signal that is "heard" by a monitoring receiver at or near the siren. If the signal code is acceptable to the receiver, i.e., it is

something the receiver circuitry understands, a small switch inside the receiver is thrown, causing the siren to be activated.

Monitor radios often are used in the homes and automobiles of volunteers or on-call personnel to notify them of an emergency. Pagers are another device commonly used to alert firefighters of an alarm. Pagers are simply small monitor receivers.

Monitor radios can be classified as either *Continuous Monitoring (Open)* or *Alerting.* The difference is whether the monitoring receiver allows everything it hears to pass on to a loudspeaker or some other circuitry, or whether it is selective about what it allows to pass on. In some areas radio traffic is so heavy that the listener of the radio cannot tolerate the continuous noise and activity. This is an application for an alerting type of monitor radio. The alerting type monitor receiver needs some kind of encoding process at the beginning of a transmitted signal so the receiver can evaluate the code and decide whether it wants to "open up" and let the message through.

Voting Receivers -- Voting receivers, sometimes called satellite receivers, are simply remote receivers used in a system to pick up signals from portable or mobile equipment that is too weak for the fixed base station antenna to detect. Voting receivers are connected to a "black box," called a *comparator,* which will be explained shortly. From a receiver point of view, voting receivers have all the characteristics of any other receiver.

The need for voting receivers arises from the fact that mobile or portable radio transceivers are less powerful than fixed base station transmitters. A one-watt transmitter in a portable radio cannot transmit with the same authority as a 150-watt fixed base station over the same distance. While the portable may be able to hear the fixed station, the dispatcher at the fixed station may not be able to hear the portable over the same antenna-to-antenna path.

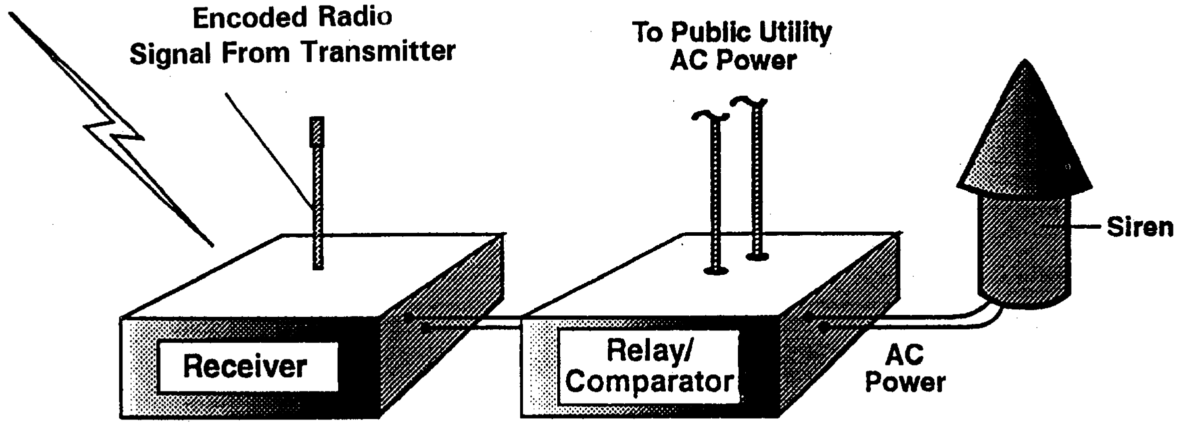


Exhibit 6-2. Radio receiver used to control siren.

To solve this problem, receive sites are situated in remote parts of the radio system's coverage area. A receiver is required for each frequency of interest in that part of the service area. Receive antennas are placed on towers or on buildings in which these receivers are located. The receivers are placed in a special secure room in the building or in a small outbuilding sometimes called a "radio shack." Since there is now more than one receiver monitoring the channel, the probability increases that one of the receivers spread out over the service area will hear the signal better than another. Each receiver sends what it hears back to the base station on telephone lines, or by means of a microwave channel. At the dispatch office or base station, a piece of system equipment called a *comparator* evaluates the quality of each receiver's output, and "votes" for the best signal, which it then routes to the dispatcher.

Most often, more than two voting receivers, other than the base station receiver, will be used in a radio system requiring this feature. There is no reason why the fixed base station receiver itself could not be configured as a voting receiver and operate in concert with another receiver remote from the base station. Because of their relatively low power requirement and use in remote geographic locations, they are prime candidates for which to consider use of a solar power supply.

Transmitters

If receivers are the "ears" of radio communications, then transmitters are the "voice" of radio communications. Transmitters are the originating end of the radio transmission path. A transmitter works in cooperation with an antenna to send out a radio frequency electrical signal that anyone can listen to. All the listener needs is an antenna and a receiver tuned to the same frequency as the transmitted signal. The receiver must be able to understand the language, or modulation, of the transmitter.

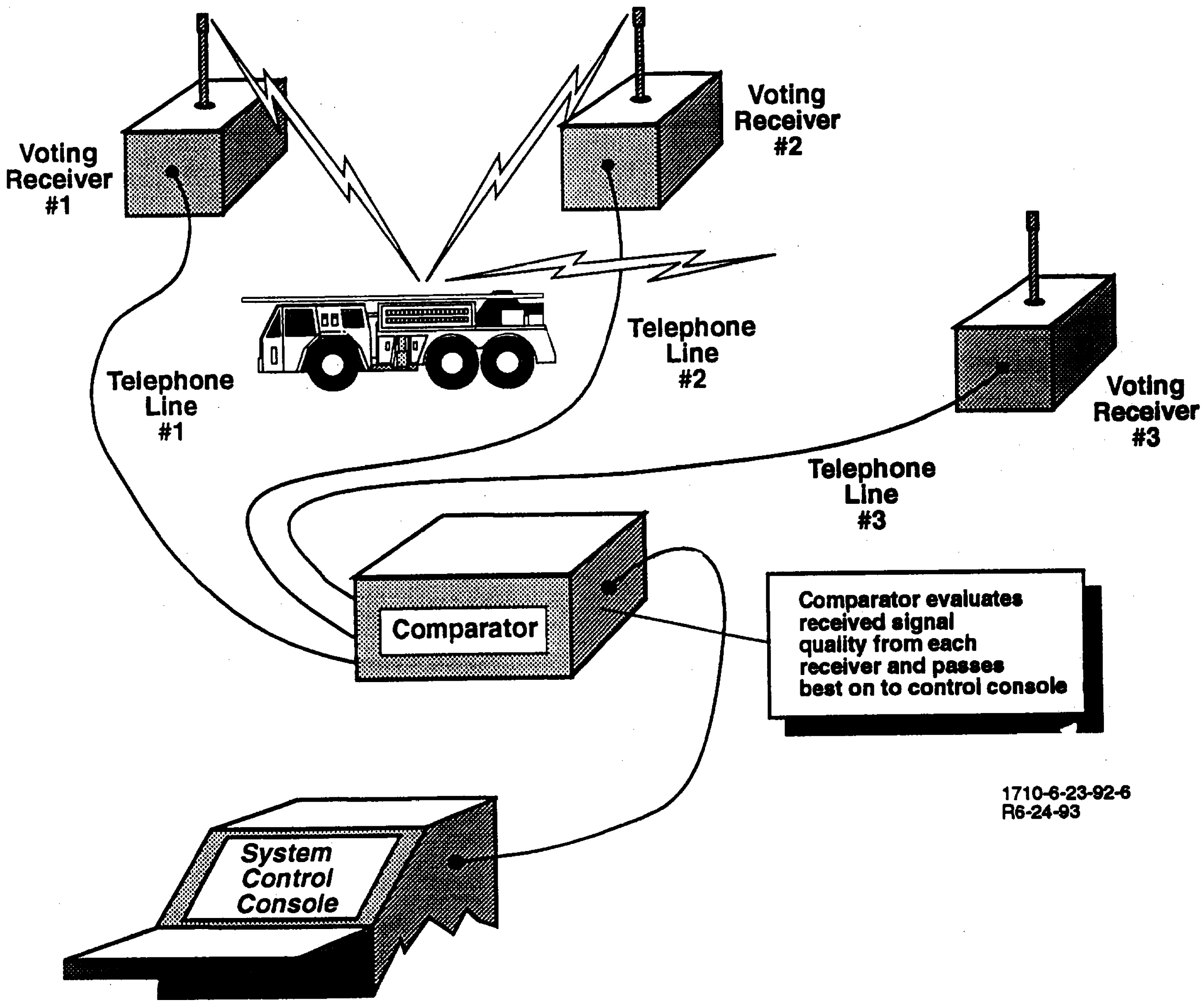


Exhibit 6-3. Voting Receivers.

The essential parts of a transmitter are

- the sections which determine the frequency at which the transmitter operates;
- the section which makes certain that no undesired frequencies leak out of the transmitter and that the frequency of the generator stage is properly multiplied if needed; and
- the section that determines how much power the transmitter will output to an antenna.

The first stage, frequency generation, can be achieved by either what is called *crystal oscillator* generation or by a *synthesizer.* The synthesizer is the most modern type of frequency generator. It provides a fast and easy way for the user to change the frequency of the receiver or transmitter, but requires additional design and manufacturing expense for the increased circuitry and filtering needed to minimize the generation of false or spurious signals.

In certain systems there is no choice about whether or not a synthesizer should be used: modern trunking radio systems require synthesized frequency generation for both transmitters and receivers. Computer-based master controllers in trunking systems send encoded commands to all the system transmitters and receivers telling them the frequency on which they should operate. This is done without any action on the part of the equipment user.

The second major stage of a transmitter is called the frequency *multiplication stage(s).* These stages not only increase the frequency of the oscillator or synthesizer, but also possess circuitry that works to keep the output signal of the transmitter "clean," or in other words, to limit the output signal to only the desired signal.

Finally, a transmitter is provided with what is called an *amplifier stage.* This stage raises the power output to the antenna to whatever power the designer desires. The power output of a transmitter significantly affects its price.

***Repeating Transmitters* --** A *repeating transmitter* simultaneously rebroadcasts to all receivers in a radio system the message a user of the system is transmitting from a mobile or portable transceiver. The mobile or portable must be configured so that its transmit frequency is the same as the base station receive frequency, and its receive frequency is the same as the base station transmit and repeating transmitter frequency. The advantage of this arrangement is that the field mobile or portable units transmit to all other units in the system with the same "power output authority" and signal coverage as the fixed base station transmitter. Conversely, system receivers receive all system transmitters, regardless of their transmit power output, as if they were transmitting at the full power output of the base station transmitter.

While this may seem a good idea, there is a price to be paid: the feature requires at least two separate, properly spaced radio frequencies dedicated to this operation. The frequencies are called *repeater pairs* and are selected to accommodate the receiver in the system. Ideally, radio receivers listen to one frequency only. But in real life, the ability of the radio receiver to discriminate between the desired frequency and transmissions made one or two channels away is dependent on the quality of the receiver. If a high power transmitter sends out a signal on a channel too close to the one to which the receiver is tuned, the receiver is "aware" of the transmissions and becomes *desensitized.* This occurs even when the user is unaware that his/her receiver is overloaded and essentially useless. Put another way, the rf-amplifier of the receiver goes into an overloaded condition. Therefore, the repeater pairs must be selected so the transmit frequency is far enough from a receive frequency to eliminate this overload condition. This frequency spread must be determined by the equipment manufacturer.

In the VHF-Low Band and VHF-High Band spectrums, there are few, if any, repeater pairs available. If the fire department operates at 154 MHz, and if frequencies are not currently "owned" by the fire department, it is highly improbable that the frequencies will become available for a repeater system in most parts of the country, because the frequencies needed for one or the other part of the repeater pair are usually already assigned to other agencies. If the operating frequency is at 450 MHz, or even 800 MHz, the probability is higher that repeater pair frequencies will be available. But even there, it is difficult to obtain licensing for repeater frequency pairs because the regulating agencies have adopted a policy of promoting *radio trunking systems.* These systems, addressed elsewhere in this manual, require extensive assignment of repeater pair frequencies to a multichannel radio system.

Transceivers

Transceivers are a combination of transmitter, receiver, and power supply. The word transceiver is a contraction formed from the words "transmitter" and "receiver." Every receiver or transmitter must have some kind of power supply. In the transceiver, the power supply provides power to either the transmitter section or the receiver section, but only one at a time. Most common references to portable or base station "radios" actually mean transceivers.

A distinguishing characteristic of transceivers is their antenna connection and switchover. It is not desirable to have one antenna for receive and another for transmit. The transceiver employs circuitry to carefully and quickly switch the antenna back and forth between the transmitter and the receiver. This circuitry is controlled by what is called the *Push-to-Talk-Switch,* frequently labeled the *PTT Switch.* A design flaw or failure in this circuitry could "dump" the high power output of the transmitter into the sensitive and delicate receiver "front-end" rf-amplifier with disastrous results. Since the receiver is listening to, or is near, the same frequency as the transmitter, it is necessary to turn the receiver off while the transmitter is operating so "feedback" does not occur.

Base station radio equipment is almost always configured as a transceiver. Transmitters have higher power supply requirements than receivers. Therefore, the power supply section of a transceiver, while supplying both receiver and transmitter, is sized for the transmitter.

Exhibit 6-4. Fixed station radio in use at a fire station. Also note the printer, MDT, and external alarm used for redundant means of communication.

Antennas

The antenna can make or break a system. In terms of cost per component, allocating money to antenna design provides more benefit in system performance than any other system component. Two key antenna characteristics are the *angle of radiation* and the *directionality.*

The angle of radiation is important in that it determines the ability of the antenna to direct most of its radiated radio frequency energy toward the horizon. After all, in most fire department applications, there is not much value to allowing much of the radio energy to be radiated straight upwards toward outer space. The location of the receiver is almost always in the direction of the horizon. The more basic antenna designs unfortunately allow this waste of energy by radiating upward at many angles. Simple antennas also allow radio energy to be radiated in all horizontal directions from the antenna. This is called the omni-directional characteristic. But if 80 percent of the energy could be directed in one given direction instead of in all directions, the energy put into the antenna by the transmitter would be used in a highly efficient manner. This is not to say that all antennas should be directional. But it is generally helpful for antennas used in the majority of fire department systems to have narrow angles of radiation.

As noted earlier, the higher the operating frequency, the shorter the physical length needed for the antenna. (The length of the antenna is related to the wavelength of the frequency, which is inversely proportional to frequency.) Most antennas used in the fire service are vertically polarized. This means the antenna rod points up or down, not side to side. The expanse of the conducting surface on which the antenna is mounted should have a radius at least one and a half times the length of the antenna. This expanse of conducting surface is called a *ground plane.* A trunk lid or a rooftop are examples of mounting surfaces that serve as ground planes. Therefore, it is more difficult to find a suitable mounting location for a 33 MHz (long wavelength) antenna than it is to find one for an 820 MHz (short wavelength) antenna. The ability to find the horizontal ground plane for the higher frequency antenna is easier.

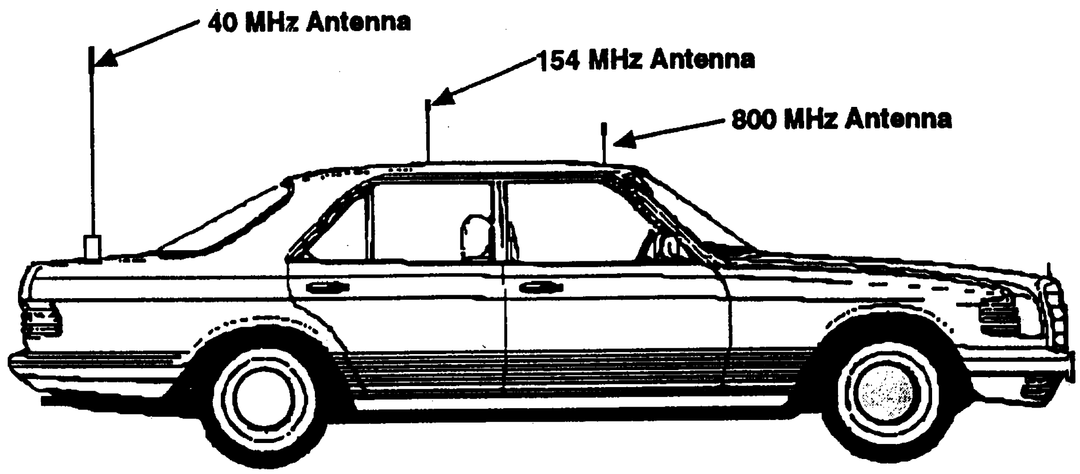


Exhibit 6-5. Relative Length of Antennas at Typical Fire Department Operating Frequencies.

Certain specialized antennas do not require a ground plane for proper performance. They are usually used in situations where it is impossible to provide a ground plane. However, performance is inferior to that of a simple antenna with an adequate ground plane.

Antenna directional characteristics are measured in terms of decibels. Decibels are simply a ratio or comparison. A decibel has no units of dimensions. It is simply a number. For a given antenna, plus decibels indicate higher performance in the direction indicated; negative decibels indicate lower performance in the direction indicated, relative to a quarter-wave whip antenna. A glance at an antenna specification sheet will help you to understand the principles.

Fixed Station Antennas -- Fixed station antennas provide designers and users the widest range of opportunities to decide the direction in which to project the radio signal. This is because fixed station antennas allow a greater selection of design options with respect to vertical and horizontal signal patterns, The base station directional characteristics not only enhance the propagation of the base station signal but also enhance the ability to receive

mobile or portable transmissions from the field. Whatever advantage the antenna offers to the transmitted signal, it also offers to the received signal.

Gain antennas, those antennas which are designed to propagate radio energy toward the horizon, or in one direction more than another, may be used to favor a certain direction of transmission and/or to minimize interference from distant stations. *Antenna arrays,* a form of gain antenna, can be rotated, raised, or lowered to maximize communications reliability inside the radio service area.

Intuitively it may seem that system performance is enhanced by raising an antenna to a new height. While often true, that is not always the case. Even though the antenna is highly reliable and a relatively inexpensive systems component, antenna theory and antenna applications are highly specialized technologies. It is practical to focus on the antenna system as a solution to coverage and interference problems. However, this should be done by people experienced in the field.

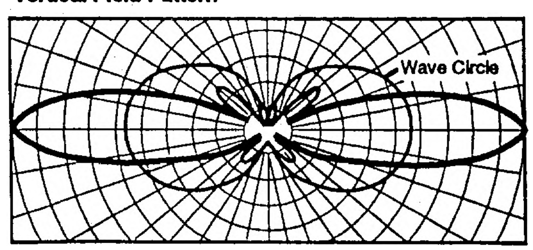
Mobile Station Antennas -- Placement of antennas on motor vehicles is an art as well as a science. There is at least one basic principle to apply: Place the antenna in the middle of the largest horizontal expanse of metal available in most cases. The metal should extend from the base of the antenna at least the length of the antenna itself, and preferably one and a half times the length of the antenna in all directions. It is not always possible to identify a location meeting the above criteria; in these cases, an antenna is used that does not require a ground expanse at all. These antennas may be found by consulting a reliable commercial antenna manufacturer. If the above options are not feasible, then the installer must do the best possible job of selecting an antenna location. This task should be performed by a knowledgeable person.

- **Optimum Gain** – Collinear design delivers 4.5dB omnidirectional gain across each band segment, with 5 dB peak gain at center
- **Fiber glass** – Lightweight white ARMORWEAVE radome protects radiating elements and simplifies installation
- **Rugged** – Wind rated at 128 mi/h (206 km/h) with a 1.65 safety factor
- **Reliable** – Power rated at 350 watts to assure continuous service for years
- **Protected** – Do grounded for maximum equipment protection

Specifications

Electrical	
Power	350 watts maximum
Gain	4.5dB minimum (RS-328) 5.0 dB maximum at center frequency
Frequency Range	137-l44 MHz (ASPD682); 146-l54 MHz (ASPD682); 152-l58 MHz (ASPD682); 156-l62 MHz (ASPC682); 160-l66 MHz (ASPD682); 164-170 MHz (ASPE682); 166-174 MHz (ASPF882)
Bandwidth	Specified frequency range
VSWR	Less than 1.5:1
Impedance	50 ohms nominal
Vertical Beamwidth	22 degrees
Termination	RG-213U, 24 inches (61 cm) flexible extension with male N connector
Mechanical	
Rated Wind Velocity	128 mi/h (206 km/h)
Lateral Thrust	50.37 lbs (22.9 kg) @ 100 mi/h (161 km/h)
Bending Moment	298 ft-lb (41.2 kg-m) @ 100 mi/h (161 km/h)
Equivalent Flat	
Plate Area	1.26 ft2 (0.12 m^2)
Antenna Length	16.2 ft (4.9 m)
Weight	9.5 lb (4.3 kg)
Radiating Elements	3/18 inch (4.8 mm) brass tube
Antenna Housing	ARMORWEAVE fiber glass dome
support	17/8 inch (47.6 mm) O, D, heavy duty heat treated aluminum pipe
Mounting	Two (2) heavy duty mast clamps recommended (furnished)
Shipping Information	
Weight	28 lb (12.7 kg)
Dimensions	3 1/2 inch (8.9 cm) 0, D, tube x 209 inches (531 cm)

Vertical Field Pattern



Gain Bandwidth Curve

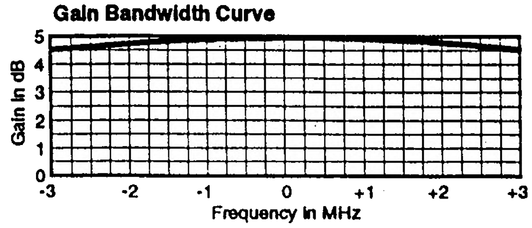


Exhibit 6-6. Sample Antenna Specification From a Manufacturer

While the quarter-wave whip antenna is very simple, it is recommended that "gain antennas" be used in mobile applications, for several reasons. First, the gain antenna provides an inexpensive way to obtain an apparent increase in power. The radiation pattern of this type of antenna directs most of the radiated energy toward the horizon in all directions. Ordinary antennas also direct a good part of the energy vertically, toward the sky. This energy is lost. Second, the gain antenna minimizes the power required to supply the transmitter because the "gain" of the antenna allows the power supply to the transmitter to be downsized. This is very desirable in mobile and portable applications. For instance, if 10 watts of transmitter power output is needed for reliable communications with a standard whip antenna, approximately 5 watts is required for the same reliability using what is called a standard *3db Gain Antenna.* Third, since gain antennas have neither moving parts nor require any power supply, they are very reliable and quickly replaced by a user if they fail. They are not significantly larger than a standard whip antenna.

Portable Equipment Antennas -- There are few ways, if any, to compensate for the poor antenna radiation conditions that surround portable radio applications. The absence of a ground plane or metal-like sheet extending in all directions results in an inefficient radiation pattern for transmission.

At VHF-Low Band, there is little one can do to attain efficient antenna configurations because it is difficult to provide an effective ground plane. At VHF-High Band, antenna systems begin to become manageable. At 450 MHz and above, the antenna system becomes very predictable because it is relatively easy to provide the antenna system with an effective ground plane.

The place on the human body that a radio transceiver is carried when transmitting or receiving is very important. Almost every radio manufacturer equips portable radios so they can be worn on the user's belt. Or, the radio can be placed inside a turnout coat in a radio pocket so it will not be affected by water. In both cases a speaker-microphone is almost always used to

activate the transmit and receive function. When the portable radio is worn on the belt the transmit efficiency is greatly reduced. Much of the radiated energy is absorbed by the body. Likewise, the ability of the portable radio to efficiently receive while on the belt is greatly reduced because the body shields the antenna from the radiated signal. Much of the time the user is unaware of this reduced operating efficiency. The user often assumes that if the manufacturer made a speaker-mike available, then the radio must work properly when it is connected. It is necessary to educate the users of portable radios about the need for the antenna on the portable to be positioned as high as possible, kept vertical, and away from obstructions when the radio unit is used.

Control Consoles -- Control consoles are another type of fixed station equipment, usually located in dispatch offices. A control console is a component in a radio system with knobs, buttons, switches, and displays that allow the dispatcher to control the system. The console effectively becomes an extension of the dispatcher's eyes, ears, hands, and feet. Some consoles are very basic. They might contain only a transmit/receive button or switch, a volume control, a red "transmit" light, and a green "receive" light. Medium to large radio systems employ more complex control consoles that provide channel selection features, cross-patching or connection between channels, clocks, muting, recording, telephone answering and patching ability, and even voice privacy features.

The layout of console controls needs to be planned carefully so that the controls interface appropriately with the dispatcher's hands and eyes, and help make dispatching efficient and reliable. Even foot controls may be used to assist the dispatcher in commanding the radio system, telephone system, and intercom system.

Exhibit 6-7. A commercially available radio control console installed in Huntington Beach, California.

The placement of controls may be as important, if not more important in the long run, than minor variations in technical specifications from one manufacturer to another.

In most cases, radio system consoles are designed by radio equipment manufacturers. Specialists in the field of ergonomics, the science and art of human engineering, carefully plan the location of controls. Engineers plan the layout of the electronics. If departments elect to design and build their own consoles and console panels, they must be aware that the layout and electronic component selection of a console and the ergonomics are critical. Control consoles process relatively low-level electrical signals. Many things can go wrong in the routing of these signals that can result in undesirable levels of hum and other kinds of interference in the radio system.

Exhibit 6-8. The consoles in the Montgomery County, Pennsylvania communications center were custom designed.

Users can expect to see more changes in the characteristics of control consoles over the next 5 to 10 years than they have seen over the past 40 years. The increased use of trunking systems, computer-aided dispatch, and the availability and cost effectiveness of personal computer technology are bringing console technology from the electromechanical era of mechanical push-button switches to video displays. A console formerly five feet wide and five feet high may be collapsed into a package the size of a personal computer complete with a high-resolution color screen. It is not beyond today's technology to expect to see a 14-inch CRT with an entire dispatch console displayed on the screen. How can many functions such as equipment status, typed notes for future reference, phone directory, response patterns, incident report format, and alarms-in-progress information all fit into this small area? The answer lies in computer screen *windowing.*

The term windowing refers to computer programming where information may be called up on a computer screen in the form of overlaying displays resembling windows into the topics listed on the displays. This feature, or type of display, is a distinct advantage for dispatchers

in that they do not need to move their eyes, hands, or body from a single point of view to perform a desired function.

Dispatchers can activate the various functions in a video display by any of several design options. The familiar "mouse" is one. Another is to touch the screen with a finger or an electronic wand. In the future, nothing precludes the application of technology that would allow the dispatcher to wear a head-mounted infrared or other type of "pointer." By simply "looking" at a spot on the CRT and then depressing a key button held in the hand or using a voice command, the operation could be completed.

Other Radio System Components

Transmitters, receivers, and transceivers form the nucleus of a functional communications system. They, in turn, have critical subcomponents such as amplifiers and mixers. There are also other common electronic components such as comparators that are useful to know something about.

Comparators -- Comparators are devices used in radio communications systems that have *voting receivers,* also called *satellite receivers.* The comparator acts as a "judge" of radio signal quality.

Consider two or more receivers in a radio system that are located in remote locations of the coverage area. A portable radio somewhere in the field transmits a signal. This signal might be heard by one or both receivers. The goal of the system is to pass on to the listener the best of all signals received. The task of the comparator is to listen to the signal quality from each of the remote receivers, inspect various characteristics of the signals, and decide which receiver is "hearing" the best. That signal is passed on to the listener.

If the user of the portable radio walks around during the transmission, one receiver may "hear" the portable better at one moment, and another receiver may "hear" it better the next, But so far as the listener is concerned there is a barely noticeable transition "click" or change in the overall quality of the received signal, as the system selects a different receiver's output to pass on.

Satellite receivers most often send their received information to the comparator over telephone wire lines. Unfortunately all telephone wire lines do not have the same quality. Therefore, some installations may be plagued by a certain amount of fidelity loss as the comparator first selects one receiver, then another, and passes the information onto the listener.

The comparator also is charged with the task of keeping tabs on the operating condition of the satellite receivers. Most receivers have a backup battery supply which keeps the receivers operating if there is a commercial power failure. The comparator monitors the battery charge condition. Also, the comparator can be manually controlled by the dispatch supervisor. From time to time, undesired *(spurious)* frequencies can "lock up" or capture a satellite receiver. The manual control feature allows the dispatcher to turn any of the remote receivers off or on and do away with problems until repairs or adjustments can be made. This control is usually performed by digital command or by a single tone or combination of tones slightly below the audible frequency range *(subaudible tones).*

Mixers -- Mixers serve to combine several input signals into one signal, or output. There are audio mixers and radio frequency mixers. Many people are familiar with the concept from the entertainment industry where signals from several microphones or playback devices are blended together into one "signal" to be played or recorded. Mixers are very often found in radio control consoles. They are always found in radio transmitters and receivers. The topic is raised here simply to alert the general user to the purpose of the device when the term is observed in a user's manual, a schematic diagram, or block diagram of a system or piece of equipment.

Amplifiers -- "Amplification" means to make something bigger. In electronics, an amplifier produces an electronic signal at its output that has a higher power level than the signal coming in. Most people are familiar with audio amplifiers used in high-fidelity systems. In contrast, most amplifiers in the radio communications field are radio frequency amplifiers. While the principle is the same, "little signal in; big signal out," the user can't directly experience the results of this amplification. These amplifiers are buried deep in the circuits of transmitters and receivers and can't be seen or heard. Nevertheless, they are necessary for the success of the system.

Some amplifiers are classified as *voltage amplifiers;* some are classified as *current amplifiers.* The design engineer determines what kind of amplifier is needed. These terms often appear in block diagrams and schematic diagrams.

Electronic amplifiers are not often interchangeable. There is a difference between an amplifier used to "drive" audio speakers and an amplifier used to "drive" an antenna. Conceptually they are alike, but there is little physical similarity. This difference is brought on by the frequency spectrum in which each is called upon to operate.

Multiplexers -- A multiplexer is a piece of electronic equipment that allows more than one electronic signal to travel on one path at the same time. The principle of multiplexing has been used for years in the telephone industry as well as in radio communications. The ability to build an efficient and effective multiplexer at radio frequencies depends heavily on the availability of high quality electronic parts. Research is now supplying these parts and the designs are improving.

A common application of a multiplexer in a fire service radio communications system is between the antenna high up on a tower and a transmitter/receiver combination in a repeating transmitter configuration (as previously shown in Exhibit 6-2). In a repeater, the repeating transmitter broadcasts or "repeats" what is being heard at another frequency by a receiver. A

receiver antenna picks up the desired signal, which then goes down a coaxial cable to the input of the receiver, through the receiver, and then to the audio input of the transmitter. The transmitter processes the signal through the transmitter circuits, out the transmitter output terminal, into a coaxial cable, and then into an antenna which rebroadcasts the message.

Two antennas and two sets of coaxial cable would be required unless multiplexing is used, in which case only one coaxial cable and one antenna are required.

Multiplexing also is used in computer operations. For example, if several terminals and several printers were located at some remote spot and the central processing unit (CPU) is located some distance, up to miles away, a multiplexer on each end of a single communications line could allow all of the terminals and all of the printers to operate on one line and not interfere with each other.

Encoder&Decoders -- Encoders arrange information in such a fashion that only specified receivers equipped with decoders find it intelligible. Decoding is the process of receiving the encoded signal, examining it, and deciding whether it is meant for the party that received it.[34]

There are several traditional uses of encoding in the fire service as well as a few more modern uses. The volunteer tire service has had a long-standing need to notify members that an emergency incident has occurred to which they should respond. In the late 50s and early 60s the establishment of central dispatches or answering points serving several fire departments created a need to selectively trigger high-powered volunteer fire department sirens. The expense of wire lines to each fire department from the dispatch center could be replaced by a radio transmitter

[34] Note that the term "encoding" can be used in four senses: The encoding of a signal onto a carrier, which is called modulation; the encoding of speech using lo-codes; the encoding of information prior to modulation, which requires not only demodulation but also decryption to get the information back; and the encoding of a signal to tell receivers whether to open up and accept a particular message.

emitting selected audio tones. These tones were evaluated by many individual siren control receivers associated with the fire companies spread out in a geographic area. If the tones were correct, the siren was activated, telling the volunteer department or company members that they were to go to the station and find out the nature of the call. Even today, this remains a common method of notification.

Manufacturers then provided the fire service with radio receivers that could be placed in the home and provide the same alerting function on the individual level without the need for sirens. These first receivers used vacuum tubes, were quite large, and were hardly portable. Many are still in service today. But today's technology has provided solid state equipment which performs exactly the same function after "looking" at the same tones, but in significantly smaller packages. Automobile battery voltages are perfect for powering solid state circuits. Monitor and alert receivers are now very common in motor vehicles.

Pagers, which at one time cost $400 to $500, now are more reasonably priced and provide adequate signal sensitivity to be a useful and reliable notification method. While the radio frequency amplifier part of the pager "watches and listens" to everything happening on the frequency to which it is tuned, the decoder stands watch over the signals, evaluating each. It waits until the desired combination comes along and then "tells" the output part of the pager it is time to "open up." The message follows.

Many pagers operate on what is called *tone encoding.* Tone encoding involves transmission of a series of two tones, or even four tones. The tone sequence and tone combination determine the "code." The disadvantage of tone encoding is the limitation on the number of possible combinations of codes.

More modern encoding and decoding systems use what is called *digital encoding.* This method involves the transmission of a series of "0s" and " 1s." The series of signals often is made by shifting back and forth between two tones. In this method, the two tones provide an almost

infinite number of encoding combinations. Also, the system is not as sensitive to the absolute frequency of the two tones as is the tone encoding system. Yet higher levels of reliability are achieved in digital encoding by transmitting the same code several times during the transmit process to give the decoders in the receivers multiple opportunities to "interpret" the encoded message.

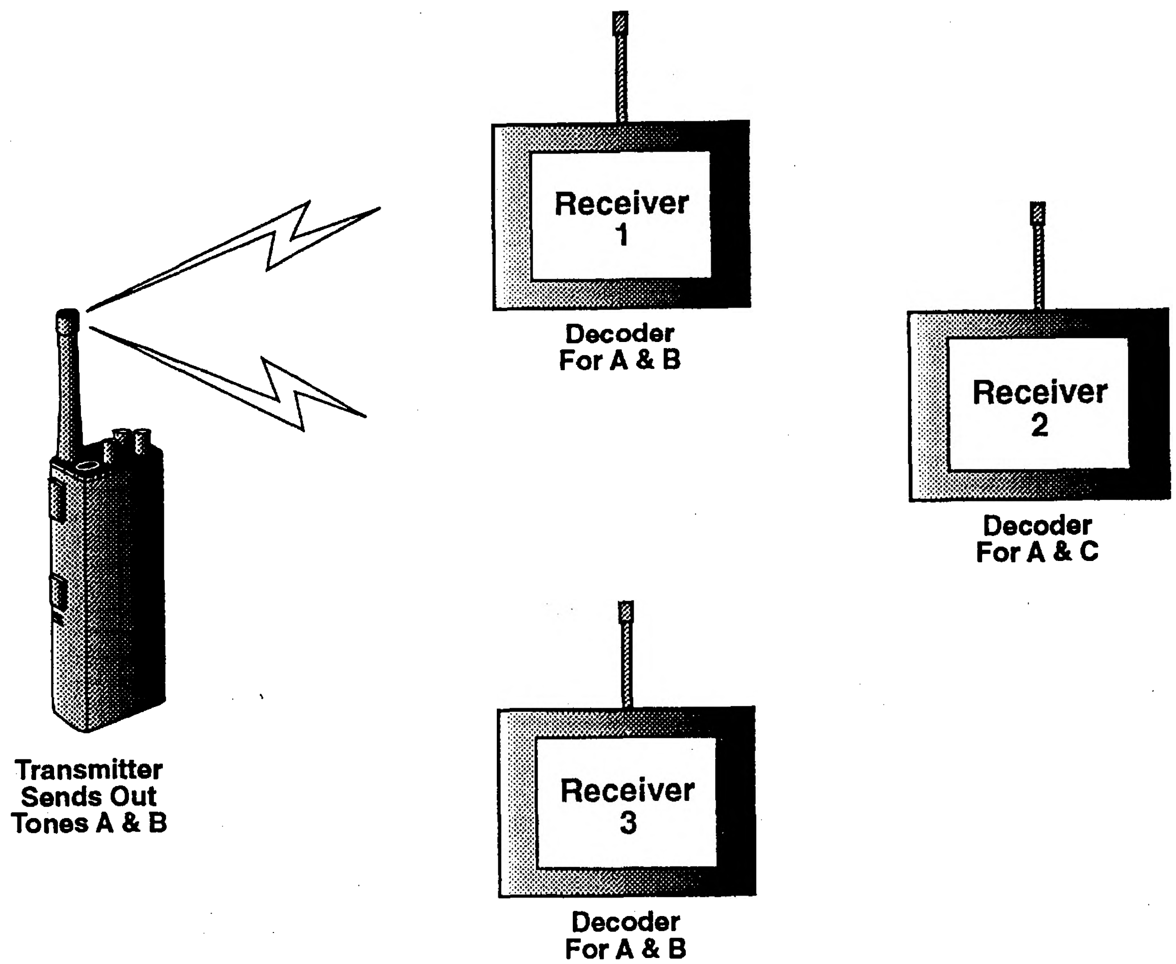


Exhibit 6-9. Tone Encoding -- Only Receivers 1 & 3 Respond to Transmitter

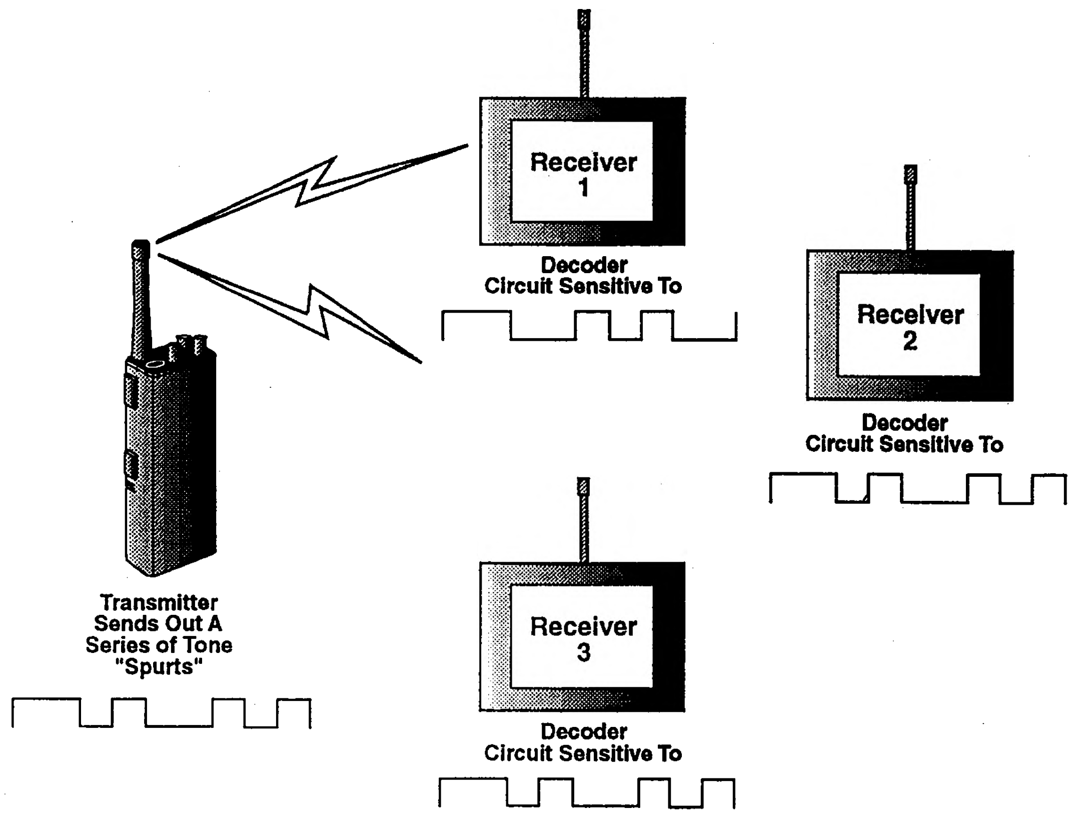


Exhibit 6-10. Digital Encoding -- Only Receivers 2 & 3 Respond to Transmitter

More recent advancements in pagers allow these receivers to be "voiceless." The receivers, large and small, receive a message, emit a notification audio sound, and then display the message on a Liquid Crystal Display (LCD) prominently located on the receiver itself. In many models, these messages are stored in memory for future reference by the user should the need arise. Many receivers and pager type receivers store in excess of 10 messages of approximately 10 to 15 words in length for days. The messages are sent by digital communications. The casual listener to the audio being transmitted has no idea what is being said, unless the decoder is available to him/her. For all practical purposes, tone encoding, while still available and still used, is finding fewer and fewer applications because of the advantages of digital encoding.

Another method of encoding and decoding commonly used in fire service radio communications is *subaudible tone encoding/decoding*. The human ear is primarily sensitive to audio frequencies between 100 and 20,000 Hz. The bulk of information contained in human

speech is found in the frequency spectrum 300 Hz to 3,000 Hz. To conserve frequency spectrum, and to allow for control circuits such as the ones under discussion here, fire service radio circuits contain "shapers" which throw away frequencies below 300 Hz and above 3,000 Hz. This leaves room for low frequency transmissions, below 300 Hz. These subaudible tones can be switched on and off in most systems. Sometimes they are referred to as "guards."

The operation of guards is relatively straightforward. If a receiver is set up to activate or "open up" when it hears the proper subaudible tone, the radio transmission on the frequency is heard by the user. If it is not the proper tone, then the user does not hear the transmission. This affords some level of privacy. However, a receiver set up to disregard all tones hears everything that is transmitted.

Power Supplies

Electronic communications systems obviously need electrical power to work. Most commercial power companies are very reliable and are the primary power source used in fire communications systems. However, these power systems may fail during natural or man-made disasters, the times when emergency communications are needed the most. Therefore, fire communications systems need backup power supplies.

One of the principal ways to provide backup power is for the communications center to have its own emergency generating equipment. Virtually all emergency power supply sources *are* of the *rotating machinery,* or *rotating equipment* type. The power supply devices provide single-phase, two-phase, or three-phase power from some kind of alternator device. Some call them generators. They are called rotating equipment because a prime mover, most often a diesel or gasoline engine, powers a shaft, which, in turn, turns a shaft on an electrical generating device. These devices come in all sizes. Some can be carried by two people. The majority of the generating situations under review here require a prime mover, diesel or gasoline, with about 125 to 180 horsepower. These are large internal combustion engines.

When commercial power fails, the absence of power causes a relay or contact to activate the start cycle for the internal combustion prime mover for the AC rotating equipment. When the

engine-generator is up to speed and ready to take on a "load," a *transfer switch* operates. The transfer switch removes the structure from the commercial power lines and "transfers" the building over to the output of the engine-generator. When the commercial power returns and is confirmed to be present for a predetermined amount of time, the transfer switch operates again. At this time the structure is removed from the output of the engine-generator and placed back on the commercial power supply, that is, the public utility. It is common for an engine-generator to run at least 30 minutes before switching back to the commercial power source. This time delay prevents unnecessary "jogging" of the power system because of continuous starting and stopping of electrical equipment during the generator shutdown and startup.

The time required for an engine-generator to sense the absence of commercial power, start, and then pick up the building electric load is typically 10 seconds for dispatch center backup power.

Two useful documents for planning an emergency backup power supply are NFPA 110, *Standardfor Emergency and Standby Power Systems,* which provides details on how to classify and specify this kind of equipment, and NFPA 70, *National Electrical Code,* which is of assistance in determining what one of these systems should look like.

From time to time, solid state inverters have been considered as a possible replacement for rotating machinery. Solid state inverters can indeed convert other forms of energy, such as battery power, into 60 Hz 110 VAC. There are no rotating parts to suffer mechanical damage. However, these power supply units require large battery supplies for the levels of power needed. To power structures of any significant size, mechanical rotating machinery driven by internal combustion engines, and deriving their energy from liquid or gas fuel sources, is by far the most common method.

Uninterruptable Power Supplies -- There are some components of communications systems, such as computers, which cannot tolerate loss of electrical power for even a fraction of a second, There are at least two types of uninterruptable power supplies available for such equipment.

One type of backup supply follows the commercial power supply, cycle by cycle. In a way, it "rides the coattails" of the commercial supply. If there is any tendency for the commercial supply to fail, the local supply, which is "mirroring" the commercial supply, quickly removes the commercial supply from the scene, and the local supply takes over. The switchover is performed by solid state switches; mechanical switches are not fast enough.

Another kind of uninterruptable power supply provides power to the protected equipment at all times. The uninterruptable power supply derives its power from a battery bank which is constantly being charged by a conventional battery charger. The battery charger operates off commercial power. If the commercial power fails, the batteries simply continue to supply the electronics which change the battery DC into 110 VAC or 220 VAC on the output of the uninterruptable supply.

In higher quality and more costly uninterruptable supplies, circuits inside the electronics convert the battery DC into 110 VAC, 60 Hz, or 220 VAC, 60 Hz, and continually check component and smaller critical circuits inside to make certain that unexpected failures have not occurred in the uninterruptable power supply. Some supplies have a feature called "self-diagnostics and repair." If a failure of a critical component or circuit occurs, the apparatus repairs itself by switching in redundant circuits or components. Then the system notifies the user that something has gone wrong.

Ancillary Communications Equipment

There are other types of communications equipment not directly related to radio frequency generation, propagation, and reception, yet part of the communications path. Radio frequency equipment is, from time to time, connected to the devices discussed below. Alternatively, these devices can be connected to wire lines in a radio communication system.

Computers -- Computers are natural components of radio communications systems. They are frequently used in what are called *computer-aided dispatch (CAD) systems.* In one role they perform as sophisticated clerks by providing to dispatchers instant information regarding street address locations and preselected recommendations of equipment to send, keeping track of

equipment, providing automatic assignment of incident numbers, and storing information on each incident for later analysis and report writing.

In a more advanced CAD system the computer actually dispatches the appropriate emergency apparatus. After receiving information from a dispatcher or call-taker regarding the nature of the call and the address, the computer selects the equipment and actually electronically dispatches the apparatus. It keeps track of the equipment status while apparatus is turning out, en route, and at the scene, and notes when the equipment is back in the station. The dispatchers monitor the activity and can intervene at any time if the need arises.

Perhaps the most advanced use of computers in communications systems today is their application in trunking radio systems. A computer in the trunking radio system master control automatically manages the radio traffic on several frequencies. The objective is to optimize the communications traffic on each channel. A given communication between two parties may be moved from channel to channel without the user knowing this shifting is happening. Should traffic become so heavy that all channels are in use, the computer has the ability and the programmed authority to interrupt communications of lower levels of priority and allow only communications at higher levels of priority to proceed. When channel loading diminishes, lower-level priorities are allowed to resume.

Cellular radio systems are examples of high intensity use of computers in system management. Mobile radiotelephone conversations are handed off from cell to cell by computer management as a portable or mobile radiotelephone user passes from one geographic location to another. The computer manages which cell receives and which cell transmits. It also keeps track of how long the transmissions last and keeps detailed records of who places and receives calls.

Fax Equipment -- While considered by many to be an innovation, the radio world has had the equipment of "fax" functions for decades. The modem fax operates similarly, yet differently from what historically has been called "RTTY." RTTY stands for *radio teletype* in contrast to the teletype that operates over hard wire-lines.

Most people are familiar with the office fax machine. This same fax machine technology is applicable to mobile and other field work so long as the transmission path is of adequate quality. In other words, it is technically possible for a base station to fax a document to a mobile unit somewhere in the field using available fax technology and a cellular telephone, or an equivalent radio frequency circuit.

Fax offers the convenience of transmitting maps, building information and layout, hazardous material documents, and similar information from a dispatch office to a field unit. Sending a fax from the field back to the dispatch office is also possible.

The significant difference in and advantage of fax over RTTY is the ability of FAX to transmit images, graphics, and other alphabetic or numeric forms. The teletype input device used to be a keyboard that possessed only alphanumeric characters. On the other hand, a Fax machine "optically scans" what it sees on the original paper, transforms that image into a series of digital (zero and one) electronic impulses, and sends them over either a wire line or radio circuit at some rate.

A facsimile may be sent over wire lines or over radio circuits. However, transmission speed is affected by transmission path bandwidth. The quality of the path is measured in terms of bandwidth and noise. If the bandwidth of the path is not sufficiently wide, the rate of transmission must be slowed until the rate meets the bandwidth limitations. If the noise is too significant, then either the signal level of the desired Fax must be increased or the transmission must be repeated and verified to guarantee the information was accurately received.

Fax is not a video process. It is a data transmission process that transmits small computer graphics symbols which ultimately are placed on paper. The assembled graphic symbols present a picture, a printed page, or even a signature.

Video -- The word *video* refers to a type, or class, of electronic signal. In layman's terms, a video display is like a television picture. It contains many independent component signals necessary to display a picture on what is called a *video display.* It is not accurate anymore to represent a video display as a Cathode Ray Tube (CRT) because modern technology

has provided many other media to accomplish this task. The Liquid Crystal Display (LCD) of a laptop computer is an example of a video display. Even inexpensive watches have crude video LCD displays available.

Transmission of live, real-time video signals requires a *wide bandwidth.* The term wide bandwidth implies a grouping of many continuously adjacent radio frequencies somewhere in the radio frequency spectrum. As a frame of reference, a common public safety FM channel allows operation of a voice circuit every 10,000 cycles. An FM entertainment channel requires hundreds of thousands of cycles to operate. A microwave circuit often requires a million cycles to perform its assigned task. Since video signals require bandwidth not available on VHF and UHF voice channels, there is no technical way to transmit live video signals on these assigned frequencies. Radio equipment, transceivers, receivers, and transmitters commonly found in public safety applications are not able to process video signals.

It is not permissible to transmit video on frequencies commonly assigned to the fire service for dispatch and dispatch use. There is insufficient spectrum available in these bands. On the other hand, microwave channels, if used by the fire department for transmission of system control, telephone conversations, and transmit/receive audio signals, can be used to transmit video signals from one part of the microwave system to some distant part.

Video transmission by radio is seldom attempted by fire departments. Frequencies available to the fire service for this purpose are difficult to obtain. Further, the equipment required to transmit the video signal is not found in the fire service radio transmission equipment inventory because of bandwidth limitations.

Printer/Teletype Machines -- Printers are the devices most often found connected to computer-related equipment. The commonly perceived vision of a printer is a device sitting next to a Personal Computer (PC). The electromechanical device included in a Mobile Data Terminal (MDT) is another example of a printer. The electromechanical device included in the design of field heart monitoring equipment is also an example of a printer.

Teletype machines represent relatively obsolete printer technology. It is not to be implied that the technology does not operate properly. However, the speed at which the machines operate is much less than that of the nominal dot matrix printer.

Modern printers may be classified under three general categories:

- *Dot Matrix Printers (DMP)* normally have 9 to 24 pins and strike a sheet of paper through an inked ribbon assembly.

- *Ink Jet Printers* have ink stored in a very small bladder that sprays upon the paper as commanded by digital electronic elements.

- *Laser Printers* use technology similar to that in most copy machines. An element in the machine responds to electronic information with the result that an electric charge is imposed upon the blank paper where the letter or graphics should be. Minute particles resembling black "pencil lead" affix themselves to the paper where the charge exists. The particles are fused to the paper, with the result being print on paper.

Audio Equipment -- One of the key links in fire department communications is the audio equipment that translates electrical signals into the sounds that humans can understand, While not as exotic as many other component parts of a radio communications system, inefficiencies, unreliability, or improper selection of system audio components can immediately negate thousands of dollars spent elsewhere in the system to get the signal to the speakers.

Voice information must be audible in many fire dispatch office, fire station, and fire apparatus applications. Very often the audio (or voice) signal levels coming from radio receivers or consoles are not high enough to drive the loudspeakers (or *speakers).* Audiophiles are familiar with numbers like "200 watts per channel," but the criteria for the power measurements are not the same in most fire department applications; 200 watts would be overkill in one or two speakers in the living quarters of a fire station.

The total power output capability of any audio amplifier application is determined by adding the power levels at which the user wants to "drive" all the speakers. Typical power levels needed for audio signals are, for a typical fire station room, 2 to 3 watts; for a large meeting room, 5 to 10 watts; and for a truck room, 20 to 50 watts. A mobile application in a sedan finds 5 watts of audio typically adequate. A mobile application on a fire pumper may call for 20 to 25 watts at the pump panel, or in a high-noise situation. These estimations serve only to give a rough idea of the power levels required in speakers; the details must be worked out for the particular space, communications equipment, and environment.

Speakers and similar audio equipment are *passive elements.* They do not generate or create power, but rather use power up or dissipate energy. If a speaker is specified to be a three-watt speaker, it means that it will operate reliably up to a three-watt power input level. The specified power level for a speaker gives the user an idea of how much power the speaker will take before it becomes unintelligible, or is in danger of mechanical damage. The degree of intelligibility of a speaker is defined in terms of *percent distortion.* Any distortion level in a speaker or any other place in an audio system that is in excess of five percent is cause for concern.

Receiver power output ratings can be as confusing in public safety radio specifications as they are in high-fidelity entertainment equipment. When comparing the power output of one receiver to another, make certain that both receivers are using the same percentage of distortion as the measurement point. There can be "lots of power output," but the message may be unintelligible because the distortion is so high.

A relatively recent application of audio equipment is the headsets worn by members of a fire company while in the apparatus. The headsets perform two tasks. First, they attenuate, or cut down, external noise from apparatus engines and other noise sources to minimize the probability of damage to the employees' ears. Second, the headsets provide an opportunity for fire company members to efficiently "tune in" to radio traffic en route to an emergency situation. In some cases, the vehicle audio system not only distributes radio audio, but also acts as an

acts as an intercom between personnel riding on the apparatus. A microphone can be included as part of the headset. The microphone allows each user to talk into the intercom system.

Environmental Considerations

Radio equipment must be purchased with consideration given to the environment in which it will reside. Will it be subjected to heat, cold, vibration, shock, moisture, and other physical characteristics? Sales and engineering departments of large radio communications equipment manufacturers are sensitive to the user's environment because their warranties and reputations depend on proper application.

When the user (fire department) does not elect to enlist the assistance of a manufacturer's representative or engineering department in assessing the usage environment, it is the responsibility of the user to make certain that the following elements are considered.

Temperature -- Temperature extremes are the enemy of electronic equipment. One must pay particular attention to the temperature range over which the manufacturer says the equipment will perform within specifications when purchasing equipment. If the equipment has moving parts, heat and cold are obviously a danger. However, solid state communications components also are vulnerable to heat and cold. Excessively hot temperatures can cause a significant decrease in the life of electronic components. Also, semiconductor devices tend to become unstable above their rated temperatures. Wherever communications equipment is used, it is important to provide proper ventilation, and not obstruct ventilation holes in the equipment. At low temperatures, electronic components can change values quickly, and can become unpredictable and sluggish.

Moisture -- Moisture is another enemy of electronic equipment. A salt atmosphere is especially damaging. Much of the circuitry in electronic equipment contains copper elements and components, and must be protected from corrosion. Corrosion can be combatted in electronic equipment by applying gold plating to critical parts and connections. Moisture can be a particular problem with *plug-in printed circuit boards.* The "fingers" on these printed

boards and the connectors they plug into are gold-plated in quality equipment. Be sure to exercise due care in selecting equipment-mounting locations.

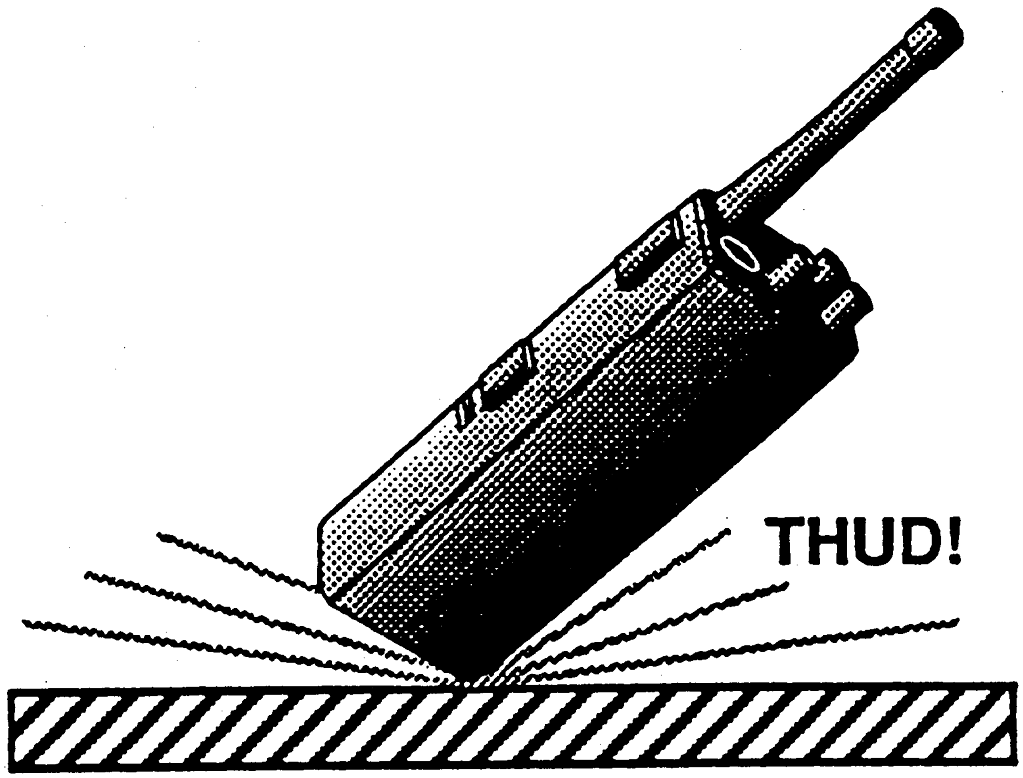


Exhibit 6-11. Shock resistance needs to be considered.

Shock and Vibration -- The potential effects of shock and vibration on sensitive electronic equipment also must be considered in the design and use of communications equipment. Obviously, fixed station applications call for a different mechanical design than do mobile or portable applications. Fire pumpers call for different shock and vibration specifications than do sedans. Manufacturers can be of great assistance when choosing a level of mechanical sturdiness.

Electrical Fields -- Exposure to electrical fields is a particularly insidious problem. They can't be seen, they usually are not well understood, and it is uncommon that anyone knows where to look for them. Solenoids and relays, driven by direct current (DC), and transformers, driven by alternating current (AC), can be generators of interfering fields. These fields can introduce what is called *hum* and other interference into audio circuits. Intense fields can even cause semiconductors to fail. It is good practice to make certain that radio receivers and low-power audio or computer equipment are not placed near large transformers or near medium-to-large solenoids or relays.

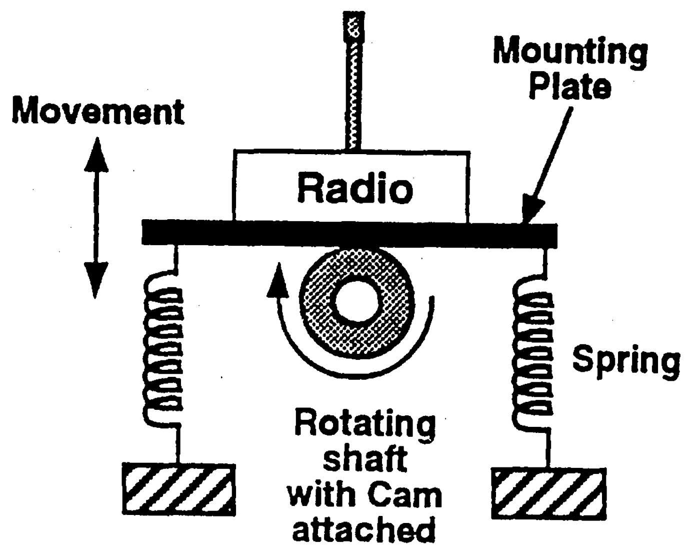


Exhibit 6-12. Vibration resistance must be tested for radios mounted in vehicles. Vibrations can be countered with appropriate mounting.

Also, computers and television sets, including video displays, should not be placed near low-power radio frequency equipment. Computers and video displays can cause interference in radio receivers.

Lightning -- There are few, if any, places free from the unpredictable and often uncontrollable forces of lightning. Lightning need only strike nearby to damage equipment. The intense electric field generated by a strike is strong enough to induce damaging high voltages in wires and power lines in the vicinity of the strike. The field can be so intense as to damage sensitive semiconductor devices.

While there is no way to eliminate entirely the possibility of damage caused by lightning, there are many reliable ways to minimize the probability of damage. Two of the most common approaches involve grounding to prevent an installation from becoming a target for lightning, and using shielding to protect equipment from a lightning strike.

An adequate ground for communications equipment requires considerably more than driving a copper ground rod into the earth. Establishing the ground can be troublesome, especially in dry soil. Specialists in grounding and bonding are usually the best bets to ensure the job is performed adequately. Once a proper ground is established, attention is given to the second defense-how the facility might be "shielded" from a lightning strike. Conceptually, an electrically connected grid is constructed over the entire facility. The grid offers itself as a sacrifice if lightning strikes. The grid is connected to *lightning rods.*

Another, less expensive method of minimizing the probability that lightning strikes on or near power lines could damage sensitive electronic equipment is to install lightning suppression devices on telephone, control, and power lines serving electronic communications equipment. These devices are principally voltage spike suppressors. Each has the ability to absorb a certain amount of energy. Some devices sacrifice themselves in the suppression process. Others, like gas discharge suppression devices, operate with extreme speed and do not sacrifice themselves in the process, but can absorb only a limited amount of energy. A qualified lightning control specialist can discuss several of these methods with the manager of the communications agency. Qualified lightning protection specialists are uncommon and often expensive to retain. Nevertheless, in lightning-prone areas, they are worth considering. Unfortunately, understanding the technology of lightning protection is almost as much an art as it is a science.

The above sections introduced the reader to the principal hardware components of fire communications systems. The bibliography contains references for those readers who wish to have a more detailed understanding of specific communication systems topics.

7. Future Technology

Communications technology available to fire departments is continually improving. The state of the art in military applications is well beyond that used in fire departments, where budgets don't allow the true state of the art to be used. Nevertheless, as costs come down for the existing technology, and as new, more cost-effective technology is developed, there are major improvements likely to be feasible for fire department communications in the next decade. This chapter gives a few examples, starting with some simple advances and moving toward more revolutionary changes.

Portable Radio Features -- Current technology permits the transmission of coded signals to the communications center by using the "Emergency" button which is provided on portable radios. The configuration of this button was designed primarily for law enforcemen and is not readily used by a firefighter wearing gloves. Several companies are developing improved radio systems designed specifically for the fire service which will advance this basic concept. The technical capability exists for many state-of-the-art features to be incorporated into the "typical" firefighter's portable radio, such as a PASS device or more advanced features such as monitoring of vital signs or transmission of temperature or environmental data in real-time back to a fireground control unit or the dispatch center.

Portable radios with built-in PASS devices that send a coded signal to a central location are currently in use in the petrochemical industry. The radios themselves, however, are not designed for fireground use. It is likely that added safety features will be incorporated into portable radio equipment in the coming years. At least one company is planning to have a total fireground electronic accountability system in test stages in 1995.

The electronics already exist today for many of these new applications. The challenge is to develop configurations that will be capable of withstanding the harsh treatment and

conditions encountered in fireground operations, and be affordable. Also, new features must be added without reducing the reliability of the unit.

Two other important recent technological developments likely to influence future fire department communications are the development of digital technology for two-way radio communications and the development of extensive satellite communications systems. These two developments open the door for major technological change in how fire departments communicate.

Digital Radio -- High-quality digital voice systems have better audio quality over a wider range than do analog systems, and also have the capability to transmit data along with voice on the same channel, using less spectrum than analog uses just for voice.[35]

This advanced technology will allow the user to receive and transmit text messages while still receiving voice messages. Embedded signaling can display the calling unit's ID to the receiving unit's mobile radio, eliminating confusion about who sent a message. Using this same embedded digital ID, messages can be prioritized as to which field units will receive the traffic.

Digital technology will allow field units to interface fax machines, laptop computers, and mobile data terminals into their existing voice communications system without interference from voice traffic. Many departments in the past have faced the problem of finding separate radio frequencies for data transmission. Digital radio technology now meets that need and uses half the bandwidth of an analog system.

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[35] A study of advanced technology for land mobile radio is being made by a consortium of federal, state, and local government, and private industry who are to investigate and decide upon basic requirements for digital radio's technical ability to meet the needs of public safety organizations. The study, called Project 25, is co-chaired by the Association of Public Safety Communications Officials International, Inc. (APCO) and the National Association of State Telecommunications Directors (NASTD).

The new digital technology will quickly bring new communication features to the fire service. The power and capability of personal computers will become a standard part of a fire department communications system. Tied to a digital radio, computers can quickly provide important text or images to field units. Central computers can query data banks and transmit vital information to incident commanders to inform them about inventories, building plans, hazardous operations, or types of surrounding occupancies. Through the use of digital radio technology any record in the data banks would be available to the emergency responders.

Several vendors have begun to develop digital programs and products aimed at serving the needs of the fire service. Many of these products use a multimedia approach which incorporates video, digital, and voice synthesis to illustrate a subject. For example, one vendor videotaped a large office building both inside and out. The videotape then was converted to a digital format and placed on a compact optical disk that could be used in a portable computer. Using a multimedia environment, statistical data, building drawings, and synthesized voice were added. The incident commander could bring up the image of the building and, by using computer commands, change the view of the building and/or have graphic overlays along with text or voice to describe the building and construction or contents. The incident commander could "walk the building" without ever leaving his/her command post. All of the information is stored in digital form and will eventually be available for digital transmission to field units from the communications center.

Digital Mapping -- Another example of using multimedia is the digital mapping of terrain and buildings. The information is displayed in a three-dimensional format on a personal computer. Field units would have the ability to visualize the terrain, including buildings from all angles. These maps are produced by digitizing mapbases that have longitude, latitude, and altitude in their base. Photographs or drawings of structures are overlaid and digitized so that a synthetic three-dimensional picture is provided. This technology was developed for the military and is now becoming available for nonmilitary use.

Using this digitized mapping technology and current weather information, field commanders will have the ability to accurately plot the movement of hazardous material incident clouds or determine the speed, direction, and spread of a moving wildland fire. (These abilities already exist today, but the information will be more readily available in the field in the future, and be more graphic.) The key will be the ability of the field unit to obtain real-time information through the digital communications system and to process the data in its mobile computer.

Commercial Satellites -- The advent of commercial satellite systems also will affect the future communication systems of the fire service. Satellites will allow fire departments to access information from central data banks or to contact experts quickly while in the field. They also will provide a backup communications system should the department's regular system fail. In the past natural disasters have created communications system failures just when the need for the system was the greatest.

New navigational satellites introduced to assist shipping and air flights will benefit the fire service by providing a reliable fix for automatic vehicle locator (AVL) systems, Used with new computer programs, this information will allow departments to dispatch the closest units based on their actual location rather than their station location,

AVL systems require a digital communications system to transport the satellite location information to the host computers. Mobile data terminals and digital radios with locator mechanisms can receive the satellite signal and relay the information to a host computer for processing to determine closest units.

In-Building Networks -- Fire departments have had a continuing problem of maintaining effective communications when operating in large concrete and steel buildings. A wireless in-building communications network can be created in such buildings to replace

the current hard-wired telephone and data communication systems.[36] This networked cellular communications system within large buildings could access satellite communication systems for transmissions outside of the building and use digital radio technology for efficient spectrum usage within the building. The building's own communication system then could be tied to the fire department communications system, thus allowing units working in the interior to have clear access to units outside, and also to satellite communications.

The new digital radio technology and satellite communication systems will provide many applications that could change how fire departments receive and send information. Portable computers and distributed software, coupled with digital communications, will open new avenues of assistance to emergency providers. Fifty years ago, most fire department communications systems consisted of a nickel in the captain's pocket to call the dispatch center. Tomorrow will bring personal computers and high-tech digital communication systems connected to data bank networks, and other, as yet unforeseen, developments.

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[36] See "Wireless In-Building Network Technology" by Cheryl Beck et al, Motorola Inc., Arlington Heights, Illinois, February 1991.

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National Standards

National Fire Protection Association (NFPA) 1201, *Recommendations for Developing Fire Protection Services for the Public,* 1989 Edition.

National Fire Protection Association (NFPA) 1221, *Standard for the Installation, Maintenance, and Use of Public Fire Service Communications Systems,* 1991 Edition.

National Fire Protection Association (NFPA) 1561, *Standard for Fire Department Incident Management System,* 1991 Edition.

Communications Standards and Practices Organizations

Associated Public Safety Communications Officers (APCO)
2040 S. Ridgewood Ave.
South Daytona, FL 32119-2257

Insurance Services Office (ISO)
160 Water Street
New York, New York 10038

International Association of Fire Chiefs (IAFC)
4025 Fair Ridge Drive
Fairfax, Virginia 22033

International Municipal Signal Association (IMSA)
1115 N. Main St.
Newark, NY 14513

National Fire Protection Association (NFPA)
One Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9101

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Steve Souder is Administrator of the Arlington County, Virginia, Emergency Communications Center, a joint Police/Fire/EMS center. He is currently overseeing installation of an 800 MHz trunked radio system and new facility. Previously, he spent 25 years in the District of Columbia Fire Department, where he was Chief Dispatcher.

Edwin Spahn, P. E. is a consultant and former Deputy Chief of the Orange County, Florida Fire/Rescue Division, where he supervised Engineering, Financial, Planning and Legal aspects of the Division. He is author of the book *Fire Service Radio Communications* and assisted in the development of a County-wide Public Safety Communications System. He also served as the Chief of the Joliet, Illinois and Hastings, Nebraska fire departments.

The project staff wishes to thank the many fire departments cited in this report for sharing information on their communications systems and procedures. Special thanks go to the fire departments of Dallas, Texas; Huntington Beach, California; Montgomery County, Pennsylvania; Palm Beach, Florida; and Phoenix, Arizona.

APPENDIX A

Sample Policies and Procedures

Example of
9-1-1 Call Policy
Orange County, California

NET 6 POLICY

No. B-9

Date: June 2, 1988
Original (X) Revision [ ]

9-1-1 CALLS

I. PURPOSE

To establish a standard procedure for the handling of 9-1-1 calls

II. RESPONSIBILITY

The Fire Con trollers shall ‘be responsible for operating within these guidelines

III. POLICY

A. The Police Department in each city is the Public Safety Answering Point (PSAP) and initially receives all 9-1-1 calls. Any calls for fire or paramedic services will be transferred to Net 6 Fire Dispatch Center (FDC).

B. Fire Controllers will answer 9-1-1 calls, obtain the needed information and dispatch the call. On every call, confirm that the ANI and ALI displayed information (the telephone number and location) are correct.

C. Any discrepancies in the ALI or ANI information shall be noted on the 9-1-1 Correction Form and forwarded to one (1) of the Leadworkers or the Dispatcher Supervisor.

D. Any incomplete transfers from PD will be followed up by the Fire Con trollers. If the ANI information is available, a call back to the telephone number is required. If no AN1 or AL1 information comes across, but the 9-l-l line rings and there is no one on the line when answered, the Fire Controllers will contact the PSAP’s to see if a 9-1-1 call was transferred.

E. Any problems with 9-l-l phone circuits or equipment should be immediately reported to the Leadworkers or the Dispatch Supervisor.

APPROVED:

Richard Jorgensen
Fountain Valley

Raymond C. Picard
Huntington Beach

James M. Reed
Newport Beach

Larry Holms
Orange County

D'Wayne Scott
Westminster

Example of
Fire Company Coverage Policy
Orange County, California

CENTRAL NET FIRE COMPANY COVERAGE

I. PURPOSE

To coordinate all fire company activities and coverage for the purpose of maintaining a strong fire defense posture.

II. RESPONSIBILITY

A. It is the responsibility of the Fire Controllers to monitor the status of all units to ensure adequate Net coverage and to maintain that coverage by means of "move ups" and mutual aid.

B. It is the responsibility of all Company Officers to notify the Fire Controllers anytime companies are out of service or unavailable for response.

C. It is the responsibility of the Fire Controllers to notify the Net Coordinator (on-duty Huntington Beach Battalion Chief) of any apparatus exceptions:

1. Every morning at the start of status check

2. Anytime during the day or night when an exception occurs.

III. POLICY

A. MOVE UPS

Whenever an area of the Net is uncovered for any reason (working incidents, training, etc.) the Fire Controllers shall initiate move ups to ensure adequate coverage of Central Net.

Anytime there is a working structure fire in the Net, Fire Controllers shall make move ups as soon as possible.

B. MINIMUM TRUCK COMPANY COVERAGE

1. The minimum number of truck companies available for deployment in the Net shall never be less than five (5). Mutual aid shall be used to maintain at least five (5) trucks available and the FDC shall consider the authorization for mutual aid request automatic by this policy.

2. Mutual aid may be utilized for any assignment within the Net when it is known that a mutual aid truck company can obviously deploy more expeditiously than a Net truck company.

3. Key Station Truck Company Coverage

   a. Move ups should always be used to provide the best possible equal truck company distribution anytime a significant reduction in available truck companies occurs and is expected to last for thirty (30) minutes or more.

   b. Anytime the number of truck companies available in the Net is reduced to eight (8) or less the following stations shall be manned with truck companies, or its equivalency available in the field, as a minimum deployment pattern: CM-2, FV-1, HB-MU, N B-2, SA-5.

C. <u>MINIMUM ENGINE COMPANY COVERAGE</u>

1. The absolute minimum of engine companies available for deployment in the Net shall never be less than twelve (12). Mutual aid should be utilized to maintain this minimum requirement and the request authorization for this need should be considered as automatic.

2. Mutual aid may be utilized for any assignment within the Net when it is known that a mutual aid engine company, from outside the Net, can obviously deploy more expeditiously than a Central Net company.

3. Key Station Engine Company Coverage

   a. Move ups should always be used to provide the best possible equal engine company distribution anytime a significant reduction in available engine companies occurs and is expected to last for thirty (30) minutes or more.

   b. Anytime the number of engine companies available in the Net is reduced to fifteen (15) or less the following stations shall be manned with engine companies, or its equivalency available in the field, as a minimum deployment pattern: CM-2, CM-3, FV-I, HB-Heil, HB-Lake, NB-2, NB-3, SA-I, SA-4, SA-5, SA-6, WM-I.

D. <u>MINIMUM PARAMEDIC UNIT COVERAGE</u>

1. The minimum number of paramedic units available for deployment is five (5). Anytime the number of available paramedics drops below five (5) and is expected to continue. for thirty (30) minutes or more, mutual aid shall be used to provide at least five (5) paramedic units available. The FDC shall consider the authorization for mutual aid request automatic by this policy.

2 Key Station Paramedic Unit Coverage

   a. Move ups should always be used to provide the best possible equal paramedic unit distribution anytime a significant reduction

in available paramedic units occurs and is expected to last for thirty (30) minutes or more.

b. Anytime the number of paramedic units available in the Net is reduced to eight (8) or less and the condition is expected to last for thirty (30) minutes or more the following stations shall be manned with paramedic units, or its equivalency available in the field, as a minimum deployment pattern: CM-5, FV-I, HB-MU, NB-2, SA-3.

E. <u>RESOURCE COORDlNATION</u>

Anytime resources within the Net become significantly reduced it is imperative that the Net Coordinator assess coverage and make necessary adjustments.

Within each dispatch center, anytime a major incident occurs, including a second or greater alarm, a multi-victim medical incident, or a multi-team hazardous materials response, or anytime resources fall below minimum levels for engine companies, truck companies, or paramedic units, the Net Coordinator and other dispatch centers within the Net must be notified. Minimum resources requiring notification are:

Central Net:	6 Engine Companies	3 Truck Companies
	2 Paramedic Units	
Costa Mesa:	2 Engine Companies	1 Truck Companies
	0 Paramedic Units	
Santa Ana:	4 Engine Companies	I Truck Companies
	1 Paramedic Units	

F. <u>TEMPORARY SUSPENSION OF AUTOMATIC AID AGREEMENT</u>

Certain circumstances such as an area wide disaster could require the cancellation of this Automatic Aid Agreement by one (I) or more of the agencies involved. It is understood by all parties to this Agreement that any agency may temporarily suspend this Agreement by decree of the Fire Chief.

Mobile Unit Communications Policy
Montgomery County, Pennsylvania

6.0 COMMUNICATIONS WITH MOBILE UNITS

6.1 Under normal conditions it is not necessary for mobile units to call and await acknowledgement before transmitting routine messages such as responding or on location. However, in advance of sending a lengthy message, it is preferable to make a preliminary call and await acknowledgement before proceeding. In such cases, the identifying words "Montgomery County" should be used when calling the Communications Center. The message should start with "Montgomery County" followed by your unit number. For example: "Montgomery County from 82-5."

6.2 When responding to alarms, each and every chief and apparatus should advise that they are responding and on location. This message can be given straight out without waiting for an acknowledgement from the Communications Center. However, only the first chief and apparatus of each station will be acknowledged by the Communications Center. The exception to this rule would be the acknowledgement of a chief that is higher in rank than the first out and on location chief. Even though each unit will not be acknowledged, their status will be kept by the Communications Center.

6.3 Fire Police units should advise that they are responding on F-3. They will not be acknowledged, but it will be noted that they are enroute to the call. The only exception to this, will be when the fire police are specially called, at which time the first out unit will be acknowledged.

6.4 The first chief or apparatus to arrive on location shall advise the Communications Center of their arrival and report information of value to other incoming units (see Section 9.1 for further details).

6.5 When apparatus is relaying information to the Communications Center from an officer, it should be stated such in their message. For example: "Montgomery County from 82-21, by orders of 82-5, dispatch the second alarm." Also, if the Communications Center is calling an officer and the apparatus is answering for him, they should make that fact clear. "Montgomery County from 82-21 proceed with your message for 82-5."

6.6 There is no need to advise the Communications Center that units are "available by radio" for driver-training, fuel, parades, etc., either by phone or radio. The only time that the Communications Center is to be made aware of this fact, is when it would change the dispatch procedure of the station or necessitate a special procedure, at which time the O.I.C. should advise the Communications Center by phone. (See Section 11.0 for further details on special procedures.)

6.7 Individual apparatus returning to station or available from a scene need not advise the Communications Center of such, unless it will cancel a special procedure or release a stand-by company, at which time the Communications Center should be advised of this fact.

6.8 Individual officers returning to station or available from a scene need not advise the Communications Center.

6.9 When multiple officers are responding on one apparatus, only the highest ranking officer should be announced as responding with that apparatus.

APPENDIX B

Sample Job Descriptions

Sample Position Description
Communications Technician Trainee
Arlington County, Virginia

ARLINGTON COUNTY VIRGINIA

EMPLOYMENT OPPORTUNITY

Position: EMERGENCY COMMUNICATIONS TECHNICIAN TRAINEE (Public Safety Dispatcher) POLICE DEPARTMENT

FILING: Applications must be submitted no later than 5:00 p.m. on the closing date to: Department of Personnel
#1 Courthouse Plaza, Suite 511
2100 Clarendon Boulevard
Arlington, Virginia 22201

FURTHER INFORMATION: Weekdays 8-5: (703) 358-3500
24-HOUR JOB LINE: (703) 538-3363
Hearing impaired ONLY: (703) 358-4613

Announcement No: 5034-2B-POL

Salary $24,864*

Closing Date: FEBRUARY 20, 1992

KIND OF WORK: This is Trainee-level technical communications work in the Arlington County Police/Fire Emergency Communications Center. Employee works primarily with telephone requests for public safety services including police, fire, and emergency medical services and/or dispatching administrative/emergency messages by 2-way radio. The employee receives and records oral complaints and reports from the public and must respond in a time critical manner; operates teletype console, 9-l-l emergency and non-emergency telephone console, various recording devices, computer keyboard/terminal for on-line computer systems, and other related equipment; determines emergency nature and criticality of calls and refers appropriately. Work is carried out under well-defined policies and procedures. Limited independent judgement is exercised under close supervision in a stressful environment. Upon completion of required training and demonstrated proficiency, an employee must qualify for advancement to Emergency Communications Technician (Grade 6) within 18 months.

SCHEDULE: Work is done on a shift basis and an employee will be required to work one of three fixed shifts: day shift is from 6:45 a.m. to 3:00 p.m.; evening shift is from 2:45 p.m. to 11;00 p.m.; midnight shift from l0:45 p.m. to 7:00 a.m. in addition to base pay as indicated, then is a shift differential of $.35 per hour for the evening shift and $.85 per hour to the midnight shift. Shift assignment is made at the discretion of the Emergency Communications Center Administrator. The work of an Emergency Communications Technician Trainee involves a five day work week with rotating days off.

QUALIFICATION REQUIREMENTS:
MINIMUM: Graduation from high school, vocational school, or equivalent. One year of experience in telecommunications, public contact or high volume administrative support work. Ability to type 20 words per minute; ability to satisfactorily complete the training course in communications, police and firefighting operations; abiIity to make independent decisions in a quick and decise manner and operate effectively under pressure; ability to communicate clearly and effectively both verbally and in writing; ability to follow complex oral and written instructions quickly; ability to establish and maintain effective working relationships with employees and the general public; ability to search manual and automated records and files quickly and accurately in order to obtain requested information.

SUBSTITUTION: Additional qualifying experience may be substituted for the educational requirement or any combination of education and experiende that provides the required skills, knowledge and abilities.

EXAMINATION MAY INCLUDE ONE OR MORE OF THE FOLLOWING: (1) Evaluation of training and Experience: (2) Written and/or Oral Examination: (3) Performance Test: (4) Personal Interview: (5) Physical Examination: (6) Group Discussion Exam.

"An Equal Opportunity Employer"

Exhibition Of Discrimination: Discrimination against any person in any practice or procedure in advertising, recruitment, referral, testing, hiring, transfer, promotion or any other term, condition, or privlege of employment which limits or adversley affects employment opportunities, because of political or religous options or affiliation, or because of race, color, sex, national origin, marital status, pregnancy, parenthood, age, sexual orientation, status as a Vietnam Era Veteran or handicap which is unrelated to the person's occupational qualifications or any other non-merit factor which is not a bona fide occupational qualification, is prohibited; provided that nothing in this section is intended to prohibit the County from taking reasonable affirmative action to eliminate the effect of dicrimination."
See back of announcement for expanlation of employment Discrimination Appeal Procedures.

January 23, 1992 gml

DESIRABLE: Preference may be given to candidates with one or more of the following: 1) telecommunications experience; b) experience dealing with a high volume of calls of an emergency or stressful nature; and/or c) experience in a public safety environment.

SPECIAL REQUIREMENTS: Availibility for shift work. Availability and willingness for call back and to work after normal duty hours. Because of the nature of this work, there may be times when shifts may be extended to accommodate emergency situations (the county compensates for overtime).

EXAMINATION WILL INCLUDE THE FOLLOWING:

1) Evaluation of training and experience
2) Typing Test (qualifying)
3) written performance test involving work sample simulation
4) Oral examination involving work sample situation
5) Pane1 interview (qualifying)
6) Personal interview
7) Polygraph examination by Police Department (qualifying)
8) Character/background investigation by Police Department (persons who have engaged in an activity that would support a felony conviction are unlikely to receive favorable consideration)
9) Medical examination
10) Drug abuse and/or alcohol testing

The salary scale for this position is from $24,864 (normal entrance in grade 5-3) to $35,644 (maximum in grade 6). With satisfactory performence, employees are considered for periodic (step) increases up to the maximum of the range. Employees may qualify for additional increases with superior performance.

ADDITIONAL INFORMATION FOR APPLICANTS: (Permanent Appointments)

APPLICATION FORMS: All applications for employment in the Arlington County government must be submitted on official application forms provided by the Personnel Department. Application forms must be received at the Personnel Department (2100 Clarendon Boulevard, Suite #511, Arlington, Virginia 22201) before the closing date shown on the front of this announcement. Postmarks will not be accepted in place of actual receipt of the application. An application may be rejected if incomplete or received after the closing date. The application will be used as part of the examination.

ELIGIBILITY FOR EMPLOYMENT: All persons hired by the County after Nov. 6, 1986, are required to prove identity and eligibility to work in the U.S. The County will employ only U.S. citizens or aliens authorized to work in the U.S.

PRE-EMPLOYMENT MEDICAL EXAMINATION Before being employed, a selected applicant must successfully pass a County medical examination given by County designated medical staff. An applicant with a medical history of significant illness or disability or an applicant receiving a disability pension (which could affect job performance) may be required to (1) submit a statement from the attending physician for the illness or disability and/or (2) be seen by a County-designated medical specialist or diagnostic specialist (the applicant pays the cost of the visit in the limited number of situations where this is required) and/or (3) sign a waiver for benefits under the County's service connected disability retirement provision and the long term disability plan.

VACATION, SICK LEAVE AND HOLIDAYS: Employees in full time permanent positions earn 13 vacation leave days a year. This increases gradually with added service, so that an employee with 12+ years of service earns 26 days a year. Sick leave accumulates at the rate of 1/2 day every 2 weeks (13 days a year). An employee also gets 10 paid holidays per year and Inauguration Day.

SOCIAL SECURITY, RETIREMENT, INSURANCE AND OTHER BENEFITS: All employees are covered under the Old Age and Survivors section of the Social Security Act and under the State Workers' Compensation Act. Full-time and part-time permanent employees who have met all the required medical standards are included in the Arlington County Supplemental Retirement System and the County's group life insurance plan. Three group health insurance plans (Blue Cross/Blue Shield and two health maintenance organizations) are offered as an option to all permanent employees. The County contributes significantly in the cost of insurance. The employees pay a share of that cost through payroll deductions according to the options chosen. Other benefits include a Deferred Compensation Plan (optional for all employees), a credit union, discounted METRO (bus/subway) flash passes, and identification cards. Child care is available on a first-come-first-served fee basis.

SMOKING POLICY: The County has a smoking policy that supports employees' efforts to stop smoking and indicates where and under what circumstances smoking is permitted.

MERIT SYSTEM ORDINANCE: Employee in departments under the administrative control and direction of the County Manager are in the Competitive Service and work under a Merit System Ordinance which is a plan for appointment, promotion, and separation of employees on the basis of merit.

EMPLOYMENT DISCRIMINATION APPEAL PROCEDURES: Any applicant who is not a current County employee and who believes that he/she has been discriminated against in the employment process may contact the County EEO Investigator in the County Manager's Office at (703) 358-3929 and/or may appeal in writing to the Civil Service Commission. An applicant who currently is employed by the County and who believes that he/she has been discriminated against in the employment process may contact the EEO Investigator in the County Manager% Office and/or may file a grievance in accord with Administrative Regulation 2.7, Rule XIII which covers the County's Grievance Procedure. Employees who have questions about their rights under the Arlington County Grievance Procedure or have questions about Arlington County Personnel Policies and Procedures may contact the Employee Advisor at (703) 358-3399. Employment discrimination appeals to the Civil Service Commission or initiation of County Grievance Procedures must be made within 30 calendar days of the occurrence of the event giving rise to the appeal. Individuals filing an appeal with the Commission are requested to provide a phone number where they can be reached to assist the Commission, in responding to the appeal. The address of the Civil Service Commission is 2100 Clarendon Boulevard, Suite 317, Arlington, Virginia 22201 or telephone (703) 338-3966.

Sample Position Description
Communications Technician 2

IV. DESCRIPTION

A. General Summary:

Performs communications duties in the Communications Section of the Police Department, which takes emergency and non-emergency calls from the public and dispatches police and fire units. Exchanges information with the public and police and fire units; receives emergency/non-emergency calls; determines priorities of calls; dispatches police and fire units; relays information on callers; reviews manuals, maps, and standard operating procedures; and may act as supervisor in supervisor's absence.

Major duties:

- Answers calls for emergency and non-emergency services.
- Coordinates and monitors emergency and non-emergency response of police/fire/EMS units.
- Operates and maintains duty-related equipment.
- Updates job knowledge and trains new personnel.

B. Major Duties/Specific Tasks:

- Answers calls for emergency and non-emergency services.
  - Answers and reviews calls over emergency (911) telephones and non-emergency telephones.
  - Determines priorities of incoming calls after obtaining accurate information from callers.
  - Obtains accurate information from callers and records requests.
  - Determines the location of a call and which emergency unit is closest.
  - Relays information to dispatcher,
  - Traces calls if complete information is not obtained.
  - Provides information to callers.
  - Attempts to calm hysterical or irate callers and to understand non-English-speaking citizens.
  - Performs supervisory duties in supervisor's absense.

- Coordinates and monitors emergency and non-emergency response of police/fire/EMS units.
  - Dispatches and displays police, fire/rescue, and emergency medical units.
  - Determines type and amount of emergency aid needed.
  - Maintains contact with field personnel and dispatches additional emergency personnel as necessary.
  - Maintains list of current location of units.
  - References standard operating procedures, maps, telephone books, cross-directories, and codebooks.
  - Maintains records and reports.
- Operates and maintains duty-related equipment.
  - Receives updated information over teletype concerning wanted persons, burglaries, etc.
  - Operates tape recorder to record incoming calls.
  - Types information from caller into computer.
  - Sends messages using teletype.
  - Performs routine maintenance and checks on equipment.
- Updates job knowledge and trains new personnel.
  - Learns new materials and procedures.
  - Reviews manuals and standard operating procedures.
  - Reviews County maps.
  - Trains new personnel.
  - Briefs the next shift on current status of events and units.
- Performs other related duties as required or as directed by Supervisor.

C. Supervision:

- Received: General supervision --work assignments are reviewed by immediate supervisor, but individual is expected to work independently according to standard procedures and/or instructions,

- Given: When appointed as Acting Supervisor, coordinates the activities of the work unit.

D. Minimum Qualifications:

Knowledge, Skills, and Abilities/Examples of Specific Tasks

- Reading comprehension to read standard business English.

  - Reviews manuals and standard operating procedures.

- Writing skills to prepare routine correspondence.

  - Maintains records and reports.

- Interpersonal skills to persuade or manage others.

  - Attempts to calm hysterical or irate callers and to understand non-English-speaking citizens.

- Problem-solving skill to apply standard procedures to problems which may not be clearly defined.

  - Determines priorities of calls.

- Typing/data entry skill.

  - Types information from caller into computer.

Considerable knowledge of emergency communication procedures.

  - Dispatches and displays police, fire/rescue, and emergency medical units.

  - Trains new personnel.

Education and Experience

- Education: Completion of the requirements for graduation from a standard senior high school or vocational school, a GED certificate, or the equivalent.

- Experience: One year's experience in the emergency communication

PAQ JOB DIMENSION PROFILE
and
JOB EVALUATION SCORE

1156

ECT TECH

	WEIGHT	SCORE	POINTS
PRIMARY COMPENSABLE FACTORS			
Having Decision, Communications, and General Responsibility	108.73	17.612	1914.953
Interpreting What Is Sensed	26.19	19.596	513.219
Making Decisions	24.57	19.408	476.855
Having Public/Customer/Related Contacts	24.51	16.256	398.435
Using Machines/Tools/Equipment	20.28	20.520	416.146
Performing Supervisory/Coordination/ Related Activities	17.55	17.984	315.619
Performing Controlled Manual/Related Activities	14.41	17.508	252.290
Working Other Schedules vs Working Regular Day Schedules	13.55	19.648	266.230
Being in a Non-Hazardous Job Situation	11.90	22.844	271.844
Engaging in Non-Personally Demanding Situations	11.10	22.336	247.930
Being in a Non-Stressful/Pleasant Environment	9.59	21.976	210.750
Being Aware of the Work Environment	9.56	18.600	177.816
Watching Devices/Materials for Information	8.76	18.176	159.222
Working in an Unpleasant/Hazardous/ Demanding Environment	8.74	18.452	161.270
SECONDARY COMPENSABLE FACTORS			
Working Day vs Non-Typical Schedules	7.75	18.076	140.089
Working in Businesslike Situations	7.66	21.860	167.448
Performing Regular vs Irregular Work	6.74	21.760	146.662
Using Various Senses	6.51	19.132	124.549
Engaging in Physical Activities	6.09	17.324	105.503
Being Aware of Environmental Conditions	4.82	16.892	81.419
Using Miscellaneous Equipment/Devices	2.95	20.628	60.853
Performing Skilled/Technical Activities	2.94	15.500	45.570
Evaluating/Judging What Is Sensed	2.58	16.216	41.837
Being Paid on a Variable vs Salary Basis	1.98	21.596	42.760
Working Under Job Demanding Circumstances	1.64	17.084	28.018
Engaging in General Personal Contacts	1.17	20.640	24.149
Being Alert to Changing Conditions	.81	19.848	16.077
Working on a Regular vs Irregular Schedule	.23	19.152	4.405

INVERTED DIMENSIONS	WEIGHT	SCORE	POINTS
Operating Machines/Equipment	42.67	17.808	759.867
Having Public/Related Personal Contacts	20.21	19.572	395.550
Exchanging Job-Related Information	15.40	21.984	338.554
Processing Information	5.42	19.396	105.126
Performing Service/Related Activities	4.26	20.952	89.256
Using Various Sources of Information	4.06	21.424	86.981
Performing Handling/Related Manual Activities	3.53	16.260	57.398
Using General Physical Coordination	3.12	25.532	79.660
Communicating Judgments/Related Information	2.64	16.556	43.-708
Controlling Machines/Processes	1.25	16.548	20.685
TOTAL POINTS			**823.883**

To obtain your total points, you should **add** the points from the Primary Compensable Factors and the points from the Secondary Compensable Factors. Then **subtract** the points from the Inverted Dimensions and **subtract** a constant value of 4011.25.

Appendix C

Fireground Command Communications Vehicle

Fireground Command Communications Vehicle

Emergency service personnel respond to emergencies in vehicles of various shapes, sizes, and types. Usually these emergency vehicles are equipped with many or all of the tools required to manage the incident; this includes the C^3I functions. The larger and more complex the incident, however, the greater the demand for a dedicated command and control vehicle to service the command post.

Choice of Vehicle -- In most incidents, from automobile accidents to commercial building fires, the incident commander will probably require little beyond a radio, tactical control guides, preincident plans, some degree of shelter, and a good view of the scene to effectively control the incident. The first-arriving engine or truck company often will suffice as an incident command post for anything requiring only one or two companies. At incidents involving three or more companies on a single alarm, a chief's car or an engine or truck with a so-called command cab should provide sufficient dedicated space to give the incident commander a comfortable and protected work area.

Incidents involving multiple alarms, companies from different jurisdictions or agencies, or large areas or time spans may require support from dedicated command vehicles. These vehicles range in size and complexity from panel vans outfitted for one or two operators up to buses and semi-trailers. The size and complexity of the vehicle often will parallel that of the incident at which it is used.

Command Post Equipment and Features -- Dedicated command vehicles ordinarily will be equipped with a much wider array of communications and support equipment than chiefs' cars or other emergency vehicles. At a minimum, this equipment should consist of the following items.

- Fixed radio transceivers for all channels and frequencies used by agencies and personnel assigned to the incident.
- Portable radios for all incident command line and staff officers.
- Spare portable radios and batteries.
- Public address system or loudspeaker.
- Cellular telephone(s).
- Voice recording equipment.
- Command post identification equipment, such as vests, signs, lights, barricade tape, etc.
- Portable electric generator of adequate size to support all installed equipment.
- Reference materials, e.g., preincident plans, hazardous materials guides, telephone lists or directories, resource lists, maps, etc.
- Tactical control guides.
- Writing materials, including pens, pencils, paper, forms, logbook, etc.
- Personnel protective equipment.

In addition, the following are desirable:

- Television and videocassette recording and playback equipment,
- Cellular facsimile machine.
- Photocopier.
- Relief facilities, e.g., restroom, refrigerator, microwave oven, water cooler, etc.
- Conference facilities, such as conference table and chairs, writing board or easelpad and easel, etc.

Exhibit C-1. Huntington Beach Command Unit.

Exhibit C-2. Rear of Huntington Beach Command Unit showing layout of command and communications equipment.

Lighting and HVAC -- The command vehicle requires good lighting and climate control equipment to maintain a comfortable working environment. Specifications should anticipate the extremes of local weather. Indirect or red interior lighting may help improve contrast or reduce eyestrain during nighttime operations. Electrical power generation equipment must be sized to provide adequate power to operate all equipment assigned to or installed in the vehicle. The vehicle and generator fuel supplies should be of adequate capacity to permit extended operations without fueling.

Staffing -- The complexity of emergency scene operations will dictate how many personnel need to be assigned to the mobile command post. Those personnel assigned to the mobile command post usually will perform logistics and planning duties in support of the incident commander. Some experienced ICs recommend a minimum of two personnel. One of the duties of the command and communications staff should be to constantly monitor the radio traffic for signals of an emergency nature and to promptly notify the IC of these transmissions. The IC cannot do this task by him/herself nor can a single command and communications person.

Exhibit C-3. Multiagency Command Vehicle operated in Tulsa, Oklahoma.

Appendix D
Related National Fire Protection Association (NFPA) Standards

APPENDIX D - RELATED NFPA STANDARDS (cont'd)

NFPA Standard	Description of Pertinent Information	Related Manual Section
NFPA 1001, Standard for Fire Fighter Professional Qualifications (1992 Edition)	This standard identifies the performance requirements necessary to perform the duties of a firefighter. It specifically identifies the minimum requirements for firefighter candidates and two levels of performance. Both firefighter I and firefighter II levels require a knowledge in the areas of fire alarms and communications, sections 3-4 and 4-4, respectively.	Required knowledge pertains to information provided in Chapter 4, Operating Procedures, pp. 4-10 to 4-25
NFPA 1021, Standard for Fire Officer Professional Qualifications (1992 Edition)	This standard identifies the performance requirements necessary to perform the duties of a fire officer and specifically identifies four levels of progression. Fire officer levels I, II, III, and IV are required to demonstrate increasing proficiency in communications skills relevant to providing a detailed account of an incident (Section 2-8); report preparation, dealing with the public, and identification of hazards (Section 3-8). No additional communication skill requirements exist for Fire Officer III and IV.	Required knowledge pertains to information provided in Chapter 5, Onscene Communications, pp. 5-1 to 5-10
NFPA 1201, Recommendations for Developing Fire Protection Services for the Public (1989 Edition)	This standard provides recommendations on the structure and operation of organizations providing public fire protection. Chapter 16 addresses communications with sections on general requirements, the communications center, public reporting of fires/emergencies, dispatch systems, radio communication, fireground communication, nonemergency communications, and private alarm systems.	Related information is provided in Chapter 3 (Planning a Communications System), Chapter 4 (Operating Procedures), and Chapter 5 (Onscene Communications).

APPENDIX D - RELATED NFPA STANDARDS

NFPA Standard	Description of Pertinent Information	Related Manual Section
NFPA 471, Recommended Practice for Responding to Hazardous Materials Incidents (1992 Edition)	This standard recommends practices for hazardous materials response, detailing incident response planning, response levels, site safety, personnel protective equipment, incident mitigation, and decontamination. Section 4-4 covers communications at the response site recommending use of radios, dedicated frequencies, and backup communications via hand signals. In section 5-5, two-way radios are recommended for hazardous chemical protective ensembles for Levels A, B, and C.	Does not cover haz mat operations specifically, but related material provided in Chapter 5, Incident Operations, pp. 5-10 to 5-22
NFPA 472, Standard for Professional Competence of Responders to Hazardous Materials Incidents (1992 Edition)	This standard identifies the levels of competence required of responders to hazardous material incidents. Levels of competence include first responder, hazardous materials technician, incident commander, and off-site specialist employees. Competence includes effective communications of site information to appropriate authorities.	Chapter 5, Elements of Effective Onscene Communications, pp. 5-1 to 5-10
NFPA 473, Standard for Professional Competence for EMS Personnel Responding to Hazardous Materials Incidents (1992 Edition)	This standard identifies the levels of competence required of emergency medical service (EMS) personnel to hazardous material incidents. Levels of competence include EMS/HM Level I and Level II responders. Appendix C provides a description of recommended hardware for communications with hospital personnel and information resources.	Various parts of Chapter 6, Communications Hardware, apply pp. 6-1 to 6-38; 6-40 to 6-47

APPENDIX D - RELATED NFPA STANDARDS (cont'd)

NFPA Standard	Description of Pertinent Information	Related Manual Section
NFPA 1221, Standard for the Installation, Maintenance, and Use of Public Fire Service Communications Systems (1991 Edition)	This standard covers the installation, maintenance, and use of public fire service communications systems and facilities. While it is not a specification it addresses several details related to communications centers, dispatching systems, and public reporting systems.	Entire manual, particularly Chapters 2, 3, 4 and 6.
NFPA 1500, Standard on Fire Department Occupational Safety and Health Program (1992 Edition)	This standard primarily covers health and safety program, vehicle safety, protective clothing and equipment, and emergency operations, facility safety, medical/physical requirements, and member assistance programs for fire departments. Under Chapter 6, Emergency Operations, the standard requires the incident commander to "initiate, maintain, and control incident communications." It also requires fire departments to establish and maintain a fire dispatch and incident communications system that meets NFPA 1561.	Chapter 5, Incident Operations, pp. 5-10 to 5-22
NFPA 1561, Standard for Fire Department Incident Management System (1990 Edition)	This standard contains the minimum requirements for an incident management system used by fire departments to manage emergency incidents. Section 3-6 addresses communications as part of the incident management system, prescribing standard operating procedures for radio communications, use of standard terminology, and standard transmission methods.	Chapter 4 (Operating Procedures), pp. 4-4 to 4-6 and Chapter 5 (Onscene Communications), pp. 5-10 to 5-25.

Appendix E
Related National Fire Academy (NFA) Student Manuals to Content in This Manual

***APPENDIX E - RELATED NATIONAL FIRE ACADEMY STUDENT MANUALS**

NFA Student Manual	Description of Related Information	Related Manual Section
Code Management: A Systems Approach (NFA-SM-CODES), April 1, 1989	Communications as part of the incident command system (p. ix to x).	Chapter 5, Fireground Communications, Philosophy, p. 5-6
	Effective communications at meetings with the public.	Chapter 21 External Relations, p. 2-15
*Command and Control of Fire Department Major Operations (NFA-PM-CCFDMO), February 1, 1988	Communications as part of the incident command system, example of incident command system (p. viii to x, p. 2-9 to 2-33).	Chapter 5, Fireground Communications, Philosophy, p. 5-6
	Proper communications in preparing preincident plan, including status report, use of radio frequencies, common communications problems, and establishing standard operating procedures and quick action plans (p. 3-1 to 3-19).	Majority of Chapter 5, On-scene Communications, p. 5-1; Incident Operations, 5-10
	Communications during incident sizeup; with public, other units, outside resources (p. 4- 14 to 4- 19).	Chapter 5, Incident Operations, p. 5-10; Chapter 2, External Relations, p. 2-l5
	Communications for establishing command (p. 6-2 to 6-4,6-18).	Chapter 5, Fireground Decisionmaking, p. 5-5
	Establishing a command post and related communications capabilities (p. 6-19 to 6-26); Communications as part of the action plan (p. 7-9 to 7-12).	Chapter 5, Incident Operations, p. 5-10

**The information in this appendix was current at the time of publication.*

APPENDIX E - RELATED NATIONAL FIRE ACADEMY STUDENT MANUALS (contld)

NFA Student Manual	Description of Related Information	Related Manual Section
Command and Control of Fire Department Operations at Catastrophic Disasters (NFAI SM/CCFDOCD), April 1992	Emergency communications as part of the emergency operating plan involving vulnerability of primary systems, backup methods, alerting/warning methods, emergency public information, and evacuation (p. 2-30 to 2-32, D-17); Evaluation criteria for communications during emergency operations (p. 3-16).	Chapter 4, Major Disaster Operations, p. 4-14; Mutual Aid and Mutual Response Operations, p. 4-18
	Role of effective communications during emergency operations (p. 4-9).	Chapter 5, Elements of Effective Onscene Communications, p. 5-2
	Communications as consideration for establishing a command post and emergency operations center (p. 4-18).	Chapter 5, Fireground Communications, Philosophy, p. 5-13
	Communications in coordination and management of emergency response (p. 4-33 to 4-35); Methods of implementing emergency communications procedures and using resources from other agencies (p. 4-36 to 4-37).	Chapter 5, Incident Operations, p. 5-20
	Communications as part of pre- and postearthquake safety assessments (p. 6-31, 6-34 to 6-36).	Chapter 4, Major Disaster Operations, p. 4-14
Developing Fire and Life Safety Strategies (NFA-DLSS-SM), October 17, 1991	Communicating with the public (p. SM 6-8).	Chapter 2, External Relations, p. 2-15
Executive Development (NFA-ED-SM), May 1992	Effective communications with the public, other agencies, and employees (Sections 4 and 5).	Chapter 5, Postincident Operations, p. 5-25

APPENDIX E - RELATED NATIONAL FIRE ACADEMY STUDENT MANUALS (cont'd)

NFA Student Manual	Description of Related Information	Related Manual Section
Executive Leadership Course (NFA-EL-SM), May 1992	Effective communications with employees (SM 9- 15).	No specific cross reference
Fire/Arson Investigation (NFA/NETC)	Communications as part of the incident command system (p. iv to viii).	Chapter 5, Fireground Communications, Philosophy, p. 5-6
Fire Command Operations (USFA/NFA-FCO-SM), February 1993	Communications for responding units to a mutual-aid incident (p. 3-8).	Chapter 4, Mutual Aid and Response Operations, p. 4-18
	Communicating the action plan (p. 4-17).	Chapter 4, Communications Plan. p. 4-1
	Incident scene communications (p. 7-23 to 7-24).	Chapter 5, Incident Operations, p. 5-10
	Communications in effective incident management (p. 10-6).	
	Consideration of communications resources in establishing a command post (p. 10-17).	
	Dispatch response patterns (p. 11-13).	Chapter 4, Communications with Fire Stations, p. 4-12
Fire Inspection Principles (NFA-FIP-SM). August 1992	Effective communications with public (Activity 1.3).	Chapter 2, External Relations, p. 2-15
Firefighter Safety and Survival: The Company Officer's Role (NFA-SM-FSCO-TtT), July 13, 1988	Obligation of emergency vehicle operator to clarify with Dispatcher type of response (Appendix I-B).	Chapter 2, Training, p. 2-34; Chapter 5, Incident Operations, p 5-10

APPENDIX E - RELATED NATIONAL FIRE ACADEMY STUDENT MANUALS (cont'd)

NFA Student Manual	Description of Related Information	Related Manual Section
Fire Service Communication (NFA-FSC-SM), October 1992	Fire service writing, correspondence, incident reports, speeches, listening, presentations, and meetings (entire manual).	Parts of Chapter 5, Elements of Effective On-Scene Communications
Hazardous Materials Incident Analysis (NFA-SM-HMIA/TtT), February 1, 1985	Integrated communications as part of the incident command system, p. xii to xiii.	Chapter 5, Incident Operations, p. 5-10
	List of resources and organizations to contact in event of hazardous materials incident (Appendix D).	Chapter 4, Major Disaster Operations, p. 4-14; Establishing/Maintaining Databases, p. 4-28
Hazardous Materials Operating Site Practices, July 1993	Communications during dispatch and initial response stage (SM 2-1-6 to 2-1-7).	Chapter 5, Incident Operations, p. 5-10
	Communications between the onscene commander and the entry team (p. SM 5-2-4).	Chapter 5, Fireground Communications Philosophy, p. 5-6
Hazardous Materials: The Pesticide Challenge (NFA-SM-HMPU/TtT), February 1, 1985	List of resources and organizations to contact in event of hazardous materials incident involving pesticides (Unit IV).	Chapter 4, Major Disaster Operations, p. 4-14; Establishing/Maintaining Data Bases, p. 4-28
	Incident command post communications with other agencies; other communications responsibilities (p. VI-4).	Chapter 5, Incident Operations, p. 5-13

APPENDIX E - RELATED NATIONAL FIRE ACADEMY STUDENT MANUALS (cont'd)

NFA Student Manual	Description of Related Information	Related Manual Section
Incident Safety (NFA-SM-FSCO [MS]-TtT), July 13, 1988	Dispatcher communication of best routes to emergency vehicle (p. SM 5-2).	Chapter 5, Incident Operations, p. 5-11; Establishing/Maintaining Databases, p. 4-28
	Onsite communications at incident and chain of command in passing communications; exercising radio discipline; incident commander communications with interior firefighters (p. SM 5-4, 5-7, 5-17).	Chapter 5, Fireground Communication Philosophy, p. 5-6
Infection Control for Emergency Response Personnel (FEMA/USFA/NFA-ICERP), September 1992	List of resources and organizations to contact for assistance in emergency medical operations infection control (Appendix C) .	Chapter 4, Response Policy, p. 4-7
Initial Response to Hazardous Materials Incidents: Basic Concepts (NFA-IRHMI: BC-SM), August 1992	List of resources and organizations to contact in event of hazardous materials incident (p. SM 9-23 to 9-31).	Chapter 4, Major Disaster Operations, p. 4-14; Establishing/Maintaining Databases, p. 4-28
Initial Response to Hazardous Materials Incidents: Concept Implementation (NFA-IRHMI: CI-SM), August 1992	Communications during dispatch and initial response phase information; incident information management (p. SM 2-4 to 2-5).	Chapter 5, Incident Operations, p. 5-10
	Goals in notification of hazardous materials incidents; methods of notification and communication (p. SM 4-6, 5-10 to 5-12).	Chapter 5, Incident Operations, p. 5-10
	Hazard communication requirements of OSHA regulations for employees and site safety plan p. SM 5-46, 6-7 to 6-8).	No specific cross-reference

APPENDIX E - RELATED NATIONAL FIRE ACADEMY STUDENT MANUALS (cont'd)

NFA Student Manual	Description of Related Information	Related Manual Section
Initial Response to Hazardous Materials Incidents: Concept Implementation (NFA-lRHMl: CI-SM), August 1992	List of resources and organizations to contact in event of hazardous materials incident (Appendix E).	Chapter 4, Major Disaster Operations, p. 4-14
	Communications-related responsibilities of haz mat officers and personnel (Appendix F).	No specific cross-reference
Interpersonal Dynamics in Fire Service Organizations (NFA-IDFSO-SM), January 1982	Techniques and training activities for effective communications with employees and supervisors (Unit 6).	Chapter 5, Elements of Effective Onscene Communications, p. 5-2
Management of Emergency Medical Services (NFA-SM-MEMS), December 19, 1986	Department chief or assistant chief responsibilities for comnnmicating with various county, state, national, or federal organizations (p. 245).	Chapter 4, Move-Ups and Major Disaster Operations, p. 4-13
Management of Fire Prevention Programs (NFA-SM-MFPP), December 16, 1985	Negotiations and communication with the public (p. VI-6 to VI-25).	Chapter 2, External Relations, p. 2-15
Managing Company Tactical Operations : Decisionmaking (NFA-MCTO-D-SM), July 15, 1991	Communicating the initial report as sizing up an incident (p. SM 2-20).	Chapter 5, Incident Operations, p. 5-12
	Use of communications in implementing the action plan (p. SM 4-7 to 4-11).	Chapter 5, Fireground Decisionmaking, p. 5-5
	Communications in incident command system (p. SM 5-11 to 5-14).	Chapter 5, Fireground Communications Philosophy, p. 5-9
Managing Company Tactical Operations: Preparation (NFA-MCTO-P-SM), July 1991	Skills and requirements necessary for effective communications (p. SM 3-11 to 3-16).	Chapter 5, Elements of Effective Onscene Communications, p. 5-2

APPENDIX E - RELATED NATIONAL FIRE ACADEMY STUDENT MANUALS (cont'd)

NFA Student Manual	Description of Related Information	Related Manual Section
Managing Company Tactical Operations: Preparation (NFA-MCTO-P-SM)) July 1991	Need for a communications model (establishing communications procedures and communications hardware); Common communications problems (p. SM 3-16 to 3-26).	Chapters 3, 5, and 6 throughout
	Tactical communications responsibilities (p. SM 3-26 to 3-28).	Chapter 5, Incident Operations, p. 5-15
Managing Company Tactical Operations: Tactics (NFA-MCTO-T-SM), April 1993	Need for communications, prefire, and tactical models, establishing communications procedures and communications hardware (p. SM 1-15 to 1-23).	Chapters 3, 5, and 6 throughout
	Coordination of resources using communications in rescue operations (p. SM 2-19 to 1-21).	Chapter 5, Incident Operations, p. 5-15
	Simulated communications during private dwelling fires (p. SM 6-15 to 6-60).	No specific cross-reference
Recognizing and Identifying Hazardous Materials, 2nd Edition, September 1992	Notification procedures using local Emergency Response Plan, implementation of incident command system, including communications structure, p. 19 to 20.	Chapter 5, Incident Operations, p. 5-10
Strategic Analysis of Fire Department Operations (NFA-SM-SAFDO), November 1990	Specific strategies for several incident case studies, including role of communications (entire manual).	Chapter 5, Incident Operations, p. 5-10
Strategic Analysis of Fire Prevention Programs (NFA-PG-SAFPP), March 1, 1990	Comrnunity relations and effective communications.	Chapter 2, External Relations, p. 2-15

Appendix F
Deviations in NFA Student Manuals From Content in This Manual

APPENDIX F - DEVIATIONS IN NFA STUDENT MANUALS TO CONTENT IN THIS MANUAL

NFA Student Manual	Related Section in this Manual	Description of Deviation
Command and Control of Fire Department Major Operations (NFA-PM-CCFDMO), February 1, 1988	Chapter 5, Incident Command and Control, pp. 5-9 to 5-10	Most NFA manuals describe the incident command system (ICS) has having five components: command, operations, planning, logistics, and finance (pp. 2-12 to 2-20). This manual describes ICS in terms of command, control, communications, and intelligence.
	Chapter 5, Incident Operations, p. 5-10	This manual lists incident operations as (1) notification and initiation of response, (2) communication en route, (3) communication upon arrival, (4) establishing a command post, (5) tactical operations, and (6) incident termination on pp 2-24 to 2-28. The NFA manual describes the incident command sequence as (1) incident priorities, (2) sizeup, (3) goals & objectives, and (4) tactical operations.
	Chapter 5, Status Reports, pp. 5- 18 to 5-19	The NFA manual calls incident progress reports "periodic" reports (p. 3-12). This manual does not specify a final incident report.
Command and Control of Fire Department Operations at Catastrophic Disasters (NFA-PM-CCFDOCD), April 1992	Chapter 4, Major Disaster Operations, pp. 4-16 to 4-18	The NFA manual specifies the major considerations of preparedness for emergency communications to consist of special communications procedures, new communications links, and backup/auxiliary systems (p. 2-47). This manual provides two other considerations--having emergency vehicle fuel sources in reserve and conducting critical incident stress debriefings on communications center personnel.

APPENDIX F - DEVIATIONS IN NFA STUDENT MANUALS TO CONTENT IN THIS MANUAL (cont'd)

NFA Student Manual	Related Section in this Manual	Description of Deviation
Managing Company Tactical Operations: Preparation (NFA-MCTO-P-SM), July 1991	Chapter 5, Fireground Decisionmaking, PP. 5-5 to 5-6	The NFA manual describes the use of a communications model consisting of six steps for formulating the message, sending the message, transfer of the message through the medium, receipt of the message, interpretation of the message, and confirmation for understanding the message (pp. 3-21 to 3-23) . This manual uses a navigation analogy to describe how messages should be prepared, sent, and understood.
	Chapter 5, Terminating an Incident, pp. 5-22 to 5-23	The NFA manual uses the terms "all clear," "under control," and "loss stopped" to indicate different situation status at the end of the incident (p. 3-27). This manual recommends using "available, in-service, or ready for service" as another message for incident termination.
Managing Company Tactical Operations: Tactics (NFA-MCTO-T-SM), April 1993	Chapter 5, Fireground Decisionmaking, PP. 5-5 to 5-6	The WA manual uses the six-step communication module described above.

Appendix G
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