Los Angeles Fire Department

COMMUNICATIONS MANUAL

MILLAGE PEAKS, Fire Chief / Chapter No. 1 / Date of Issue: 01/2011

RADIO COMMUNICATIONS OVERVIEW

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Introduction

Radio communications for the fire service has evolved considerably over the last 60 years.

Previously only the company officer was permitted to use a radio. Today, radios are a critical safety tool that must be in the hands of every fire fighter at every emergency scene. Technology advances quickly, as advances in radio communication technology occur, it's important to make sure that radios remain an effective and reliable means of communication.

Specifically, new technology for radio communication systems must meet the unique demands of the job of fire fighting. Fire fighters must be able to communicate in cold and hot temperature extremes, in wet and humid atmospheres full of combustion byproducts and dust, while under or above ground, inside and below buildings and in rubble piles. Other environmental challenges include loud noise from apparatus, warning devices, tools and the fire itself.

Any new radio communication system must take these factors into consideration. When talking about fire department communications systems usually we are talking about what are traditionally called **land mobile radio systems.**

It is important for firefighters as well as fire officers to have a basic knowledge of radio system technologies to help them effectively use the radio system.

Most radio system users do not need a detailed understanding of the technology behind the systems they use. However, such knowledge is important for those involved in developing procedures for the use of the systems, and in training field users to have a more comprehensive understanding of their operation. All technologies have strengths and weaknesses, and understanding those characteristics is important in making decisions related to the technologies.

Radio communications are the lifeline of the Los Angeles Fire Department's emergency operations.

In many instances, the outcome of an emergency is decided by either the success or failure on the part of members to communicate effectively via radio.

Purpose

The purpose of this bulletin is to first, provide a standardized means for communication and second, explain the basic functions of the radio system.

As a general rule, most members have developed their radio communication skills by listening to radio messages.

The results understandably are a composite of abilities, skills, personal differences, and widely varying interpretations of what is correct.

Standardizing communications will eliminate useless messages and bring a sense of professionalism to our daily duties.

Although many basic emergency operations procedures are standardized, the state of the art in electronics is changing constantly. The effect is an ever-increasing change in our emergency communication procedures and equipment. Understanding the radio systems basic functions may help the user troubleshoot a potential problem.

Standard Protocols

The life safety of both firefighters and citizens depends on reliable, functional communication tools that work in the harshest and most hostile of environments. Firefighters operate in extreme environments that are markedly different from those of any other radio users. Firefighters operate lying on the floor; in zero visibility, high heat, high moisture, and wearing self-contained breathing apparatus (SCBA) face pieces that distort the voice. They are challenged further by bulky safety equipment, particularly gloves, which eliminate the manual dexterity required to operate portable radio controls. Firefighters operate inside structures of varying sizes and construction types.

The size and construction type of the building have a direct impact on the ability of a radio wave to penetrate the structure. All of these factors must be considered in order to communicate in a safe and effective manner on the fire ground.

The reasons for standardizing radio communications are numerous. Given the substantial cost, the citizens and their elected officials have a right to expect the highest level of professionalism in radio communications. In addition, the Federal Communications Commission (FCC) issues guidelines and restrictions on the use of radio transmissions. If these guidelines and restrictions are not followed, the Department risks losing its assigned frequencies.

Currently all positions in the field are assigned a radio. Every year the Department becomes busier and more active with more radio messages being transmitted. Given this, the radio time must be conserved much like a natural resource. Radio messages must be planned, concise and to the point. A properly communicated message will also save time by eliminating the need to repeat.

Often, the news media is present at the scene of emergencies. They are there not only to film newsworthy events, but also to collect audio background to support the film. Actual LAFD radio transmissions are often used.

When claims are filed with the City Attorney, the result is usually a lawsuit. Attorneys filing lawsuits against the LAFD routinely request all written and audiotape records immediately before, during and after the incident in litigation.

Remember, all 18, 800 MHz radio channels MDT messages and phone calls into, and from Metro Fire Communications (MFC or "Metro") are recorded on a 24-hour basis. Additionally, all radios are assigned a four-digit identification number that is transmitted and recorded each time a radio is keyed.

Emergency Operations

Metro Fire Communications Channels (4, 7, 8, and 9) shall be used by field units for communications as outlined in the Manual of Operation Section 2/1-00.00. For the most part, this includes the following types of messages:

1. Initial size-up.
2. Request for additional resources.
3. Request for special services and notifications, such as Los Angeles Police Department, Department of Water and Power, etc.
4. Rundown on resources responding.
5. Location of command post, base or staging areas.
6. Incident command designation (I/C Name).
7. Change of command at an emergency.
8. Knockdown of fire.
9. Reporting resources available.

During emergency operations, it is important for members to utilize a standardized format of communicating on the incident tactical channel to the incident commander and/or other resources assigned to the incident.

A sound approach for members to follow for tactical communications would be communications indicating at least the following. The conditions, their actions, and their needs.

1. General situation status (***CONDITIONS***):
    a. Incident conditions (fire location and extent, Hazmat spill or release, number of patients, etc.)
    b. Incident Action Plan (offensive, defensive, etc.)
    c. Status of the tactical priorities.
    d. Safety considerations.

2. Deployment and assignments of operating companies and personnel (***ACTIONS***).

3. Appraisals of need for additional resources (***NEEDS***).

Radio Alarms

Acknowledgement – A brief response to a radio alarm, i.e., “Engine 1” or “Engine 1 is responding” is sufficient acknowledgement to the dispatcher unless the address or other information clarification is required.

Standby For Dispatch – Dispatchers will, time permitting, alert units on the radio, i.e. “Engine 1, Battalion 2, standby for dispatch,” allowing them to prepare for emergency responses.

Size-Up

If an emergency exists, an accurate size-up covering all pertinent information is required. If there is “nothing showing” it is only necessary to report that fact to MFC.

The fact that “people are waving” is of no value to MFC, and information that you are “ holding the assignment, will investigate, will give a report when you get more information” is all verbiage that is unnecessary and wastes radio time.

No size-up is required for a single company response unless help is needed or other situational changes require it.

The needs of MFC to obtain information from the scene of an emergency incident is limited, but of critical importance to the outcome of an incident and to the deployment of uncommitted forces. Operational needs of MFC from field units are as follows:

1. Section 2/1-001.00 of the Manual of Operation states that a size-up shall include, but is not restricted to the following information, as applicable:

    a. Address of location of incident
    b. Type of incident
    c. Life hazard
    d. Assistance needed
    e. Exposure problems
    f. Location of Command Post

2. Initial size-up by the first officer on-scene. Be brief and to the point. Think of what you are going to say before you start talking on the radio. The initial size-up accomplishes the following:
    a. Informs MFC that LAFD resources are on-scene.
    b. Determines response mode for balance of the assignment.
    c. Helps MFC handle additional calls for the same incident.
    d. Alerts MFC to the possible need to make move ups.
    e. Alerts incoming recourses of what to expect.

3. As a general rule, size-ups by Rescue Ambulances or Fire Companies responding with Rescue Ambulances are not needed unless there are extenuating circumstances or a request must be made for assistance.

   If a life threatening situation exists, i.e., CPR in progress, multiple gun shot wounds, etc., a brief size-up to an incoming company, on the EMS Tactical Channel, is appropriate. With non-life threatening vital signs or no usual situation existing, a size-up is not necessary or required.

   Extensive, detailed, or long, drawn out descriptions of the patient's symptoms are best described at the scene by a one-on-one contact.

4. A comprehensive size-up by the Incident Commander shall be made as soon as possible. The size-up includes, but is not limited to, the following:

   a. Correct address
   b. Description of incident
   c. Life hazards
   d. Assistance needed
   e. Special problems, i.e., exposures, weather, access, etc.
   f. Location of Command Post
   g. Approximate duration of incident

   Updates or a continuing size-up should be made occasionally to MFC in order to keep them informed of the progress of the incident and resource requirements.

   This would include information to the PIO for media dissemination. Generally, these updates would be made at the Chief Officer level.

5. Assistance needed from outside agencies. See Manual of Operation Section 2/1-00.00. Use proper terminology, especially when requesting the police. Specify the type of problem or assistance needed, i.e., "Metro from Task Force ___, we need Water and Power for high voltage wires down pole to pole;" "Metro from Engine ___, we need DOT for traffic control;" "Metro from Rescue ___, we need PD." Specify the need so that the urgency can be determined.

   When requesting assistance from outside agencies, allow approximately 30 minutes before requesting ETA's.

6. Availability of resources and Chief Officers. Companies, special units and Chief Officers are made available by the Incident Commander. When made available, the company, unit or chief officer is to return to their own district unless directed otherwise by MFC.

It is neither necessary nor desirable to include such comments as "Returning to quarters," "remaining on the radio" or "remaining on fire prevention." When becoming available from an incident it is not necessary for units to verbally give that information to MFC. Utilizing the MDT is sufficient.

Companies returning to their own quarters shall not direct MFC to "release the move up companies." At no time shall any member specifically cancel a resource of higher authority, i.e., "Metro from Task Force 1, cancel Battalion 1." A more appropriate message would be, "Metro from Task Force 1 we can handle."

7. A press size-up is required, as soon as conditions permit, for those incidents that are newsworthy. A complete operational size-up meets most requirements of a press size up. A press size-up should emphasize those aspects of an incident which are interest to the news media.

   The press size-up shall not be made at the expense of the operational requirements.

   The press size-up should be made on a channel which is not being used at the time.

   It should include the fact that it is a "Code 20 Incident," if appropriate. If an incident escalates to a greater alarm or larger incident, a Code 20 notification is automatic, verbal notification is not required.

Use of Tactical Channels

The purpose of Tactical Channels is to reduce the overall radio traffic on any one channel.

This feature permits all units on a specific incident to communicate between themselves without interference from other field operations or MFC. MFC does not normally monitor tactical channels. Therefore, they are ideally suited to handle any form of communications not affecting MFC.

However, messages should be brief, concise and limited to essential information in order to maintain a manageable level of radio traffic.

Emergency operations shall be handled to the extent possible on the assigned "Tac Channel." Conversations on these channels can be less formal and structured, but are still required to remain businesslike.

Use of Command Channels

1. Channel 11 has been designated as the Department's Command Channel. This channel is used by Chief Officers or members assigned in command positions for emergency and non-emergency operations.

   When a member wishes to contact the Metro Battalion Commander on the Command Channel, they should first contact Metro on the dispatch channel and state: "Metro from Battalion ___, have the B/C meet me on Channel 11."

2. Channel 11 should be used by Chief Officers to communicate expanded messages or comprehensive size-ups to MFC on working emergencies after the initial size-up.

3. During greater/major incidents, Channel 11 shall be monitored by the Incident Commander and OCD until such time as both agree to discontinue its use.

4. Operationally, members other then Chief Officers may be assigned command functions (Division Supervisor, Group Supervisor, etc…) which may require they monitor channel 11 for operational purposes. Members shall do so as required by assignment.

Radio Use Procedures

In addition to the use of radios at emergency incidents, radio communications play a vital role in the day to day routine of the Department. This section will also serve as a guide to non-emergency radio operations of the Department.

The Department's Radio Communication protocol is that radio communications shall be composed of plain commonly used English. With minor exceptions this applies to all Department radio communications. However, certain code words and abbreviations are acceptable for use on the radio, they are listed below:

- "Roger" means that a radio message is received and understood, do not roger a message that should be answered with a yes or a no.

- "Cancelled" means discontinue response, or you don't need the specific resource.

- "On the air" or "On the radio" means a particular resource is monitoring the radio.

- "Covered" means a stronger signal has interfered with and overpowered another signal, making the weaker signal unreadable.

- "Code 20" a widely used code which indicates that an occurrence has potential value to the news media.

- "A-Unit" abbreviation for Arson Unit.

- "Available" means ready for response within 60 seconds. You are either available or you are not.

- "Bravo Tango" used at incidents involving bomb threats.

- "ETA" estimated time of arrival.

- "Alert 2" Over land, an aircraft has, or is suspected to have an operational issue that affects normal flight operations to the extent there is danger of an accident.

- Blue 2" Over water, an aircraft has, or is suspected to have an operational issue that affects normal flight operations to the extent there is danger of an accident.

- "Alert 3" An aircraft accident has occurred on, or in the vicinity of the airport.

- "Blue 3" An aircraft accident has occurred in the water.

In addition, the Department has adopted the standard International Phonetic Alphabet word list to be used when transmitting alphabetical letters to provide consistency and eliminate repeated transmissions.

-Alpha	-Juliett	-Sierra
-Bravo	-Kilo	-Tango
-Charles	-Lima	-Uniform
-Delta	-Mike	-Victor
-Echo	-Nora	-Whiskey
-Foxtrot	-Oscar	-X-Ray
-Golf	-Papa	-Yankee
-Hotel	-Quebec	-Zulu
-India	-Romeo	

Members shall not use LAPD Code number, i.e., 390 down, etc.

Communicating with outside or supporting agencies
Agencies outside the Los Angeles Fire Department (LFD) use somewhat different terms and call signs to identify their respective dispatch centers or field units.

The most common agencies contacted via voice radio by LAFD members are the Los Angeles Police Department (LAPD), Los Angeles County Fire Department (LAC), Ventura County Fire Department (VNC), Angeles National Forest (ANF) and Verdugo Fire Communications Center (**Figure 1**). Verdugo Fire Communications is a joint dispatch center for the following agencies;

- Alhambra Fire Department
- Arcadia Fire Department
- Burbank Fire Department
- Glendale Fire Department
- Monrovia Fire Department
- Monterey Park Fire Department
- Pasadena Fire Department
- San Gabriel Fire Department
- San Marino Fire Department
- Sierra Madre Fire Department
- South Pasadena Fire Department

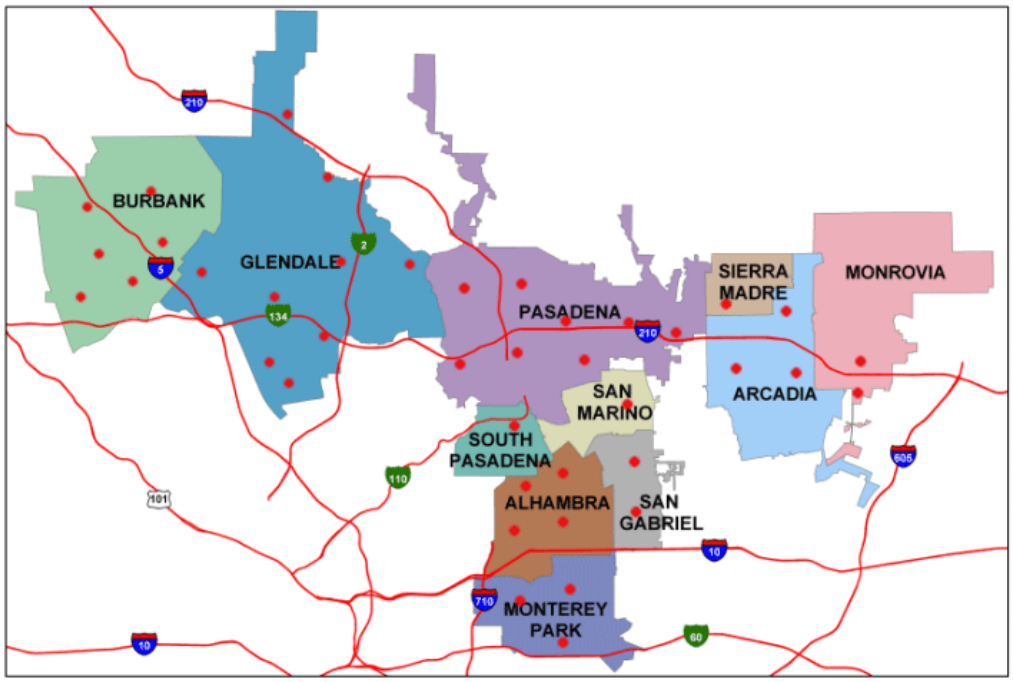

Figure 1

To ensure clear communications with these agencies, the following should be considered when communicating with these respective agencies via radio.

LAPD

LAPD dispatch is called “control”. For example, (control from Fire Rescue 11, has a unit been assigned to the reported assault at 7th and Alvarado?)

LAC
Los Angeles County Fire dispatch is called “LA”. For example, (LA from LAFD Engine 91, do you have units assigned to the reported incident on the south bound 14 freeway at Balboa?)

VNC
Ventura County Fire dispatch is called “Ventura”. For example (Ventura from LAFD Truck 96, what unit is assigned to the traffic accident on the east bound 118 freeway at Rocky Peak?)

ANF

U.S. Forest Service, Angeles National Forest dispatch is called “Angeles”.

VERDUGO
Dispatch Center communications for any of the 11 agencies managed by Verdugo Communications Center would be addressed to “Verdugo”. For example, (Verdugo from LAFD Engine 77, what unit has been assigned to the traffic accident on the north bound 5 freeway at Buena Vista?).

Human Factors

When we talk on the radio, each of us subconsciously performs a process before we speak. Managing this process will provide more effective communications.

- Organization — Before speaking, formulate what information is being communicated and put the information in a standardized reporting template. For instance, a standard situational report might contain Unit ID, location, conditions, actions, and needs. This method forces users to fill in the blanks, answer all the necessary questions, and filter out unneeded information.
- Discipline — Often, ICs are overwhelmed by excess information on the radio. Radio discipline on the fire ground will help to determine if information needs to be transmitted on the radio. If face-to-face communications are possible between members of a crew and the information is not needed by the IC, don’t get on the radio.
- Microphone location — Placing a microphone too close to the mouth or exposing the microphone to other fire ground noise may result in unintelligible communications. When transmitting in a high-noise environment, shield the microphone from the noise source. Hold the microphone a couple of inches from the mouth or, when speaking through a SCBA mask, place the microphone near the voice port on the face piece.
- Voice level — When speaking into a microphone use a loud, clear, and controlled voice. When users are excited, the speech often is louder and faster. These transmissions often are unintelligible and require the IC to ask for a rebroadcast of the information, resulting in more radio traffic on the channel.

Managing these human factors will have a positive impact on fire ground communications. Reporting should be complete, necessary, and in a controlled, clear voice. These actions will reduce the amount of repeat transmissions on the fire ground, reducing air time.

Members are reminded when making radio transmission, there are four considerations:

1. Think about what you are going to say.

2. Ask yourself if the message is necessary.

3. Keep it brief.

4. When you key the mike, be prepared to speak.

Do's and Don'ts

DO:

1. Hold the "press to talk" button down momentarily BEFORE transmitting. This keeps the first word in the message from being "clipped." Likewise, releasing the button prematurely will "clip" the end of the transmission.

2. Keep the microphone CLOSE to your mouth – about one inch.

3. Speak into the microphone.

4. Speak in a normal, firm voice and speak clearly.

5. Give the complete message with the understanding that it will be heard. It is unnecessary and time consuming to call MFC first, wait for a go-head and then give the message.

6. Listen before talking.

7. Listen for acknowledge of radio messages to make certain the message is received and understood. Radio messages not acknowledged are assumed not received.

8. Evaluate the importance of your message compared to others who are using the radio at the same time.

9. Relay for other units when they have repeated their message.

10. Answer for other units at the scene, if someone is trying to reach them and they do not answer. However, ensure the appropriate unit receives the message.

11. Contact other mobile units directly (when possible) instead of relaying through MFC. Monitor your designated MFC Channel while on the radio.

12. Wait for other units that are talking to acknowledge their messages before you begin your radio message.

13. Transmit only necessary messages. Keep messages clear, concise and to the point.

DON'T:

1. Personal messages of a non-business nature are strictly prohibited.

2. Allow the "press to talk" button to be left open, commonly called an "open mike". Inappropriate messages have been accidentally transmitted in this manner.

3. Transmit too closely to another mobile unit or Hand-Held. This causes "feedback" and garbles your message.

4. Use profanity, exchange pleasantries or offer personal greetings.

5. Put injured members names on the radio.

Continuing Dialogue

Once a continuing dialogue is established with the dispatcher or a Field Unit, it is not necessary to continue repeating your unit identification and other obvious information each time you key the transmitter.

Examples of improper or poor radio communications are:

- "Metro from E-29 requesting Public Works to assist in securing the fire buildings."
- "E-29 from Metro will you be needing plywood or barricades?"
- "Metro from E-29 we will need sheets of plywood."
- "E-29 from Metro are you requesting this or is Building and Safety requesting it?
- "Metro from E-29 Building and Safety is requesting it."
- "E-29 from Metro roger."

The proper use of radio time would be:

- "Metro from E-29 Building and Safety is requesting that Public Works deliver to the fire building 20 sheets of plywood to secure the building."
- "Roger."

Messages During High Activity

All members shall be aware that during periods of high activity, careful thought must be given to all necessary messages for clarity and brevity.

The Radio System

The LAFD has two different wireless communications systems. The first is the "voice" radio system and the second is the "data" radio system. The voice radio system is the system commonly recognized because it is the system in which we receive dispatches and talk from unit to unit every day. The voice radio system is an "Analog Conventional Simulcast" system. Conventional Simulcast means that the system is not a trunked system and utilizes more then one repeater, or send and receive sites to receive and transmit radio messages.

The data system carries our Mobile Display Terminal (MDT) communications. It is not recognized as a separate system because the user interface is by pushing a button on the MDT. Because our interaction is limited, it is commonly not thought of as a radio system. However, they are separate and distinctly different systems.

The LAFD voice system operates in the 800 MHz range, and the data system operates in the 500 MHz range.

Each of the Department's radio systems are a combination of several distinct components. The most important of those components, the operator, was discussed in the previous portions of this Training Bulletin. The other components, that act to support the operator, will be discussed here.

In addition to the systems described above, the Department has additional "simplex" or "direct" digital channels in the 700 MHz band programmed in the XTS 5000 portable radios carried by all members, and the XTL 5000 mobile radios installed in late model apparatus. These channels are available for use only in "simplex" or "direct" mode at this time.

There are three 700 MHz digital channels licensed to the LFD located at the end of Zones 7, 8 and 9, accessed via the front panel key pad identified as channels 7TAC19D, 7TAC20D and 7TAC21D. "7" identifies it as a 700 MHz channel, "TAC19" identifies the channel number and the "D" identifies the channel as a digital channel.

There are additional 700 MHz National Emergency Response Interoperability channels in Zone 7, beginning with 7TAC51D available as required

Base Station Transmit/Receive Sites

There are 10 strategically located remote transmit/receive sites serving the LAFD voice radio system (**Figure 2**). While each of these sites appears different to the eye, their basic functions are still the same. These sites include the following;

1. Oat Mountain
2. Beverly Glen
3. Verdugo Peak
4. Mt. Washington
5. KSKQ
6. 100 Wilshire
7. Baldwin Hills
8. San Pedro Hill
9. City Hall East
10. Mt. Lukens (City wide voice back-up system)

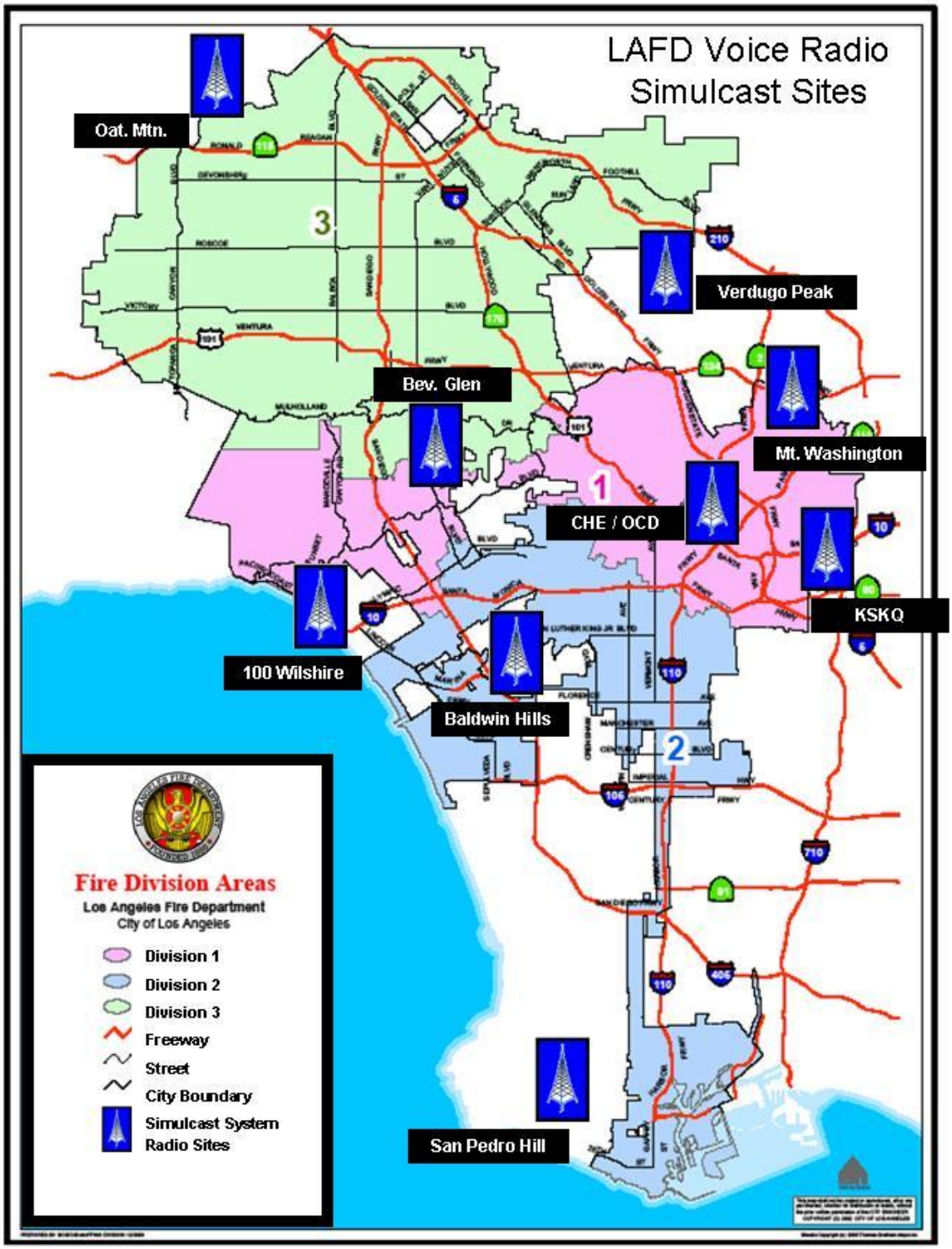
LAFD Voice Radio
Simulcast Sites
Oat. Mtn.
Verdugo Peak
Bev. Glen
Mt. Washington
CHE / OCD
KSKQ
100 Wilshire
Baldwin Hills
San Pedro Hill
1
2
3
Fire Division Areas
Los Angeles Fire Department
City of Los Angeles
Division 1
Division 2
Division 3
Freeway
Street
City Boundary
Simulcast System
Radio Sites

Figure 2

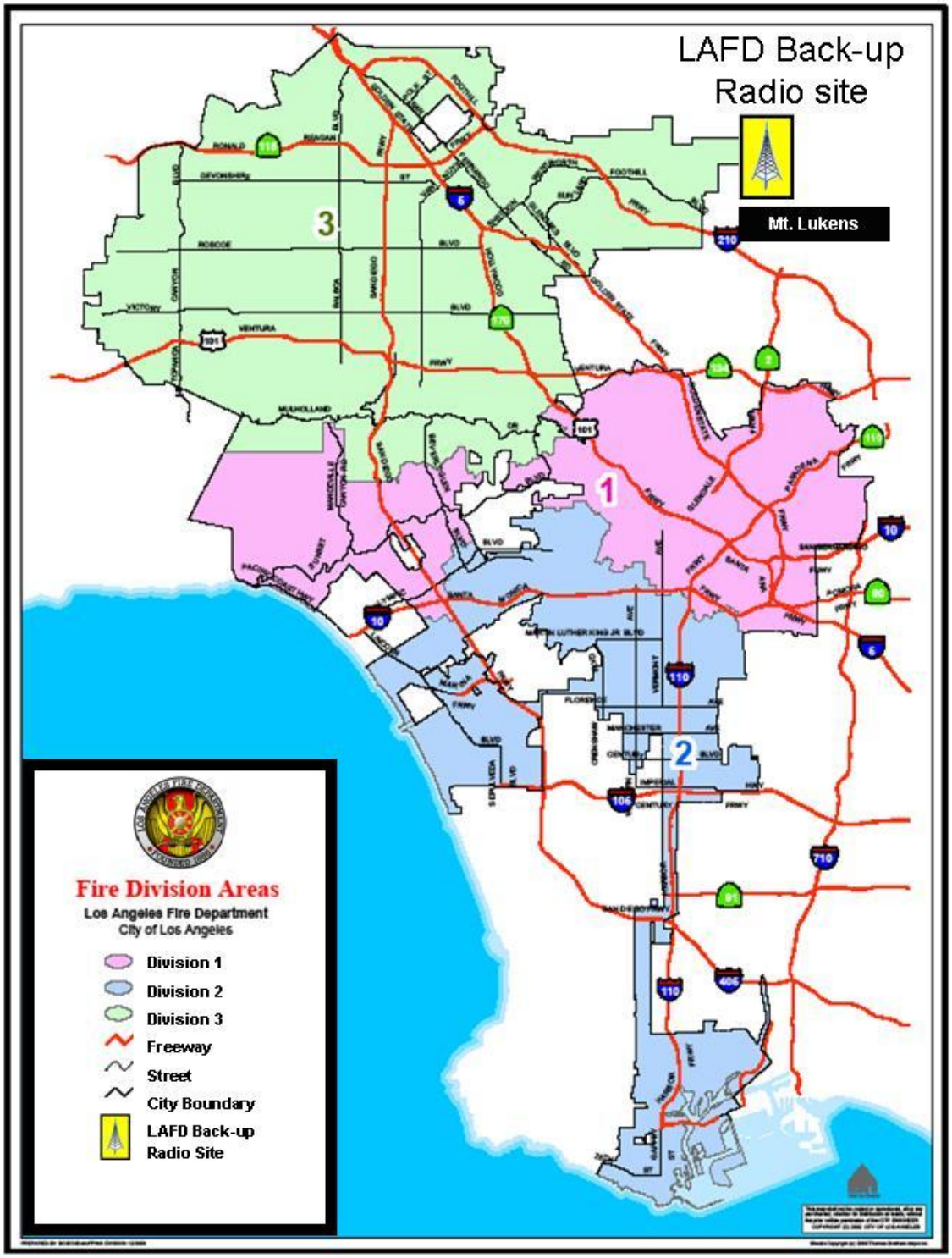
LAFD Back-up
Radio site
Mt. Lukens
3
1
2
Fire Division Areas
Los Angeles Fire Department
City of Los Angeles
Division 1
Division 2
Division 3
Freeway
Street
City Boundary
LAFD Back-up
Radio Site

Figure 3

MFC, OCD or the backup signal office located at Fire Station 108 (Coldwater) can send signals to the transmitter either by wire, microwave or by a combination of both. The transmitter could also receive a signal through a repeater. Once the repeater receives a signal it then amplifies that signal to a predetermined level as it is broadcast out over a geographic area.

The fixed site transmit/receive site located at Mt. Lukens is the Departments "back-up" radio system. It offers full 18 channel capability to repeat radio transmissions, but it does NOT offer full coverage or access to the simulcast system which will be covered later in this bulletin. Mt. Lukens location is depicted in (**Figure 3**).

Even though Mt. Lukens is considered a back-up radio system; there are important points to bear in mind.

1. The Mt. Lukens system is truly independent of the simulcast system. It is not connected to the nine site simulcast system for transmit purposes until it is turned on. When it is turned on, the simulcast system for the selected channels must be disabled.

2. The Mt. Lukens site is located on a very prominent point overlooking the area around Battalion 12. It provides highly expanded system capability in the city and surroundings areas of the valley, especially in the area of Battalion 12 (For example; Vogel Flats).

3. Even though Mt. Lukens is not transmitting with the simulcast system; it is listening in "base station" mode at all times. For example, if a member were working for in a shadowed deep canyon or drainage in the hills above Battalion 12, it is very likely that Metro or OCD would hear radio transmission as if they were coming over the simulcast sites. However, the dispatcher has no way of knowing which site is receiving radio traffic. Responses from the dispatcher to the field unit may be extremely poor, or nonexistent, but the dispatcher will hear the field unit fine. This is because of the full time listening mode and its geographic location looking down into the valley.

   If this were the case, the Incident Commander might ask the dispatcher to "change over" to the Mt. Lukens system on the selected channel. In this instance, Metro would turn off the selected channel on the simulcast system and turn on the channel at Mt. Lukens, thus providing Metro the capability to talk back to the field unit.

4. Mt. Lukens is a repeater site. Field units can only connect to it in repeat mode. When Mt. Lukens receives a voice radio message on the “up” leg, frequency; it repeats it on the “down” leg frequency. This provides the capability for field units to communicate even though they may be on different sides of a ridge line that defy normal communications. See (**Figure 4**).

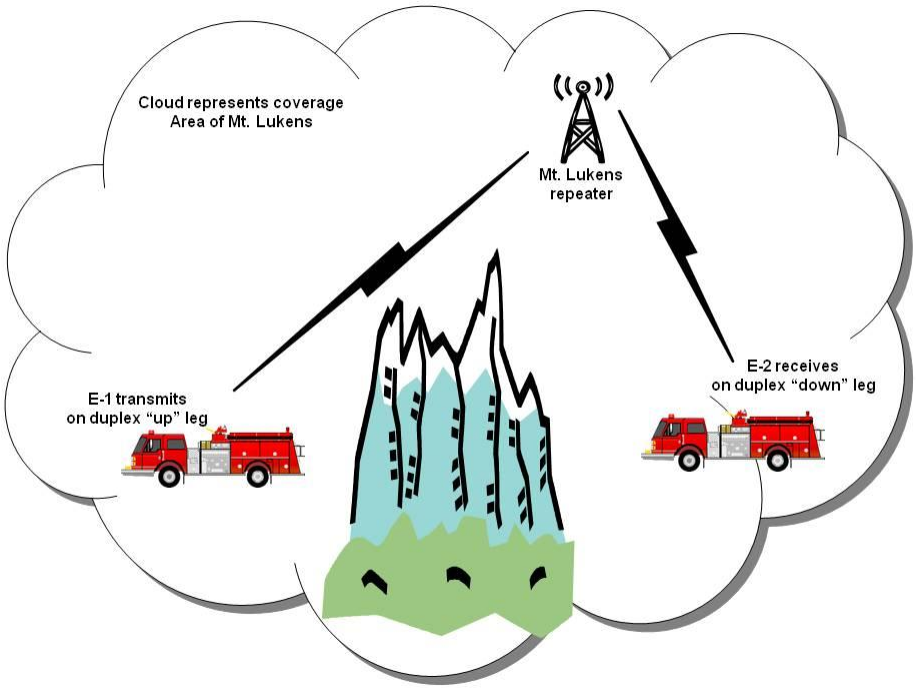

Figure 4

Data Radio Network

Data radio network (MDT) coverage is provide through 6 fixed sites located as depicted in (**Figure 5**)

1. Oat Mountain
2. Verdugo Peak
3. Mt. Lee
4. Elysian Park
5. 100 Wilshire
6. San Pedro Hill

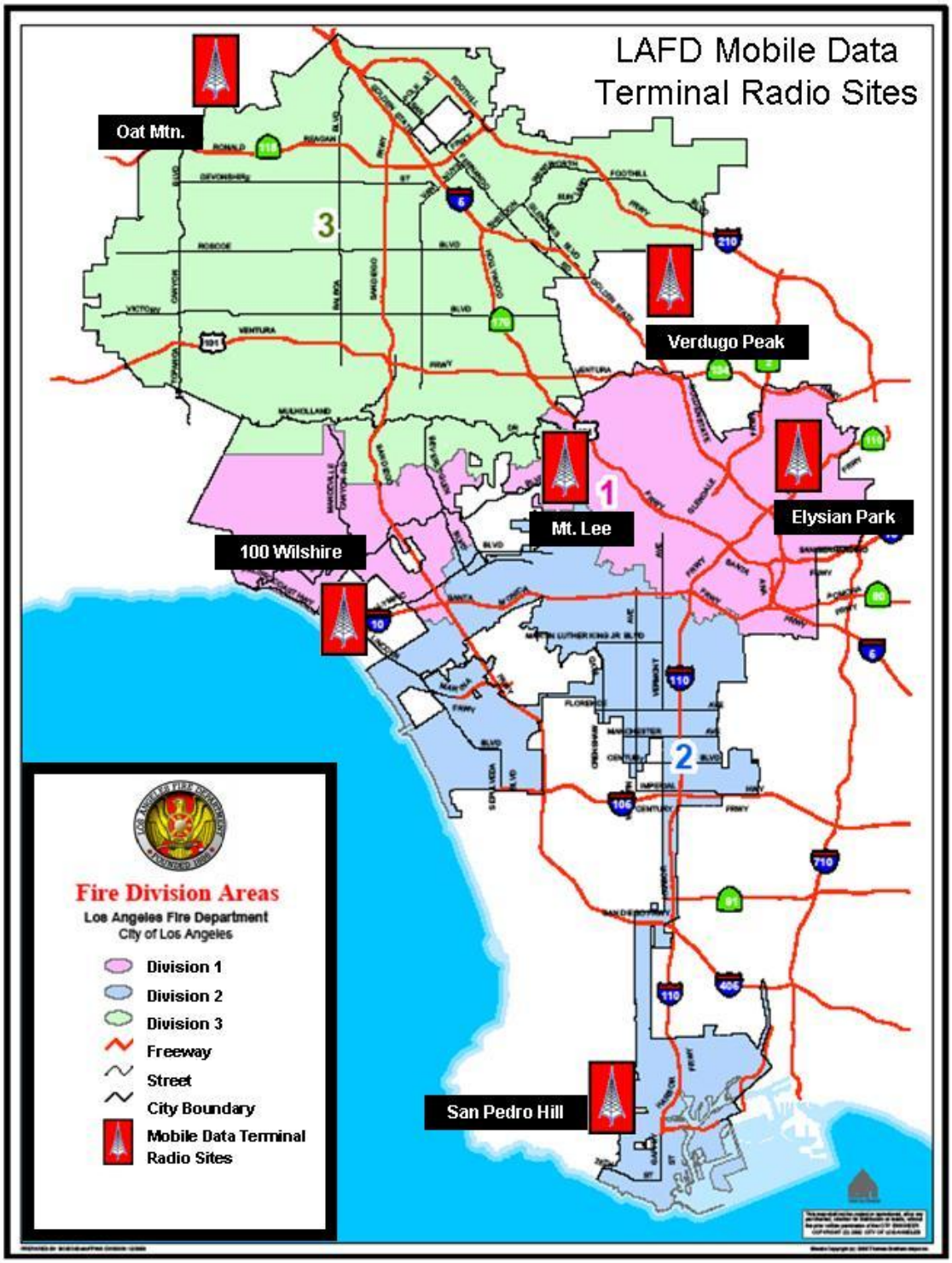
LAFD Mobile Data Terminal Radio Sites
Oat Mtn.
Verdugo Peak
Mt. Lee
Elysian Park
100 Wilshire
San Pedro Hill
1
2
3
Fire Division Areas
Los Angeles Fire Department
City of Los Angeles
Division 1
Division 2
Division 3
Freeway
Street
City Boundary
Mobile Data Terminal Radio Sites

Figure 5

There are several fixed microwave links to relay MDT messages to fixed radio send and receive sites located at strategic points in the City. These relay points are located at.

1. Van Nuys City Hall
2. Baldwin Hills
3. South East Los Angeles
4. San Pedro City Hall

Their location has no direct impact on the end user, the firefighter. These sites serve to link or "connect" the various send and receive sites into an integrated system.

There are several reasons multiple transmit/receive repeater sites are located throughout the City of Los Angeles.

1. Signal Strength

   The FCC limits transmitter power to a level that would not adequately cover the entire city even if is was flat. LAFD radio transmitters amplify signals to a maximum of 155 watts. Contrast that to KMPC-AM, for example, which transmits with 50,000 watts of broadcast power. Yet, even with this powerful broadcast there are areas up canyons, behind building/mountains, etc. that do not receive a signal. Therefore in order to cover the city as well as reasonably possible, the LAFD radio system is built around multiple transmit/receive sites.

2. Geographic and Topographic

   Mountains, valleys, and distances limit the effectiveness of radio wave behavior. They effectively are physical barriers.

3. Radio Wave Behavior

   The 800 MHz frequency band used by the LAFD is a more compact and powerful wave when compared to VHF (100 MHz) or UHF (500 MHz) bands. VHF signals tend to "crawl" over hills and up canyons. While the 800 MHz signal tends to be more limited to line of site. However, the 800 MHz wave tends to be more penetrating, working better inside buildings and underground.

4. Technical Limitations
   Along with power limitations, the FCC limits the LAFD to certain frequencies. It is under these confines of the FCC the LAFD system must operate.

5. System Redundancy

   Multiple repeater sites with overlapping area of coverage allow the system to provide complete, or near complete coverage even if one repeater site were to become non-operational. It is this same overlapping coverage that enhances the coverage in the canyons, valleys and in-building coverage.

Each transmitter site has a companion receiver site. In some cases, such as Mt Lee, the two are closely located. At other locations, such as Oat Mt, the transmitter and receiver sites are some distance apart. For technical reasons, transmitters and receivers must be separated as a means of reducing interference between the two. There are two basic means of achieving the required separation; vertical, as at Mt Lee and horizontal, as at Oat Mt.

Dispatch and Control Centers

The Department currently has two dispatch and control centers. In our Department, these are recognized as “OCD” and “Coldwater”. The new “Metro Fire Communications” (radio identification “Metro”) dispatch center is currently under construction and is scheduled to be completed in mid 2011. On completion, MFC will be the primary dispatch and control center and the existing OCD facility will assume a “back-up” role.

OCD is currently the primary dispatch and resource accountability location for Department resources. Coldwater, located at Fire Station 108, is the “back-up” dispatch and resource accountability center.

The Coldwater Center can carry out all of the functions of the primary center (OCD), but at a somewhat reduced capacity. Physically, it is not nearly as large as OCD, there are limited dispatch consoles, but the 911 call answering, emergency trigger function and all other dispatch functions remain in place.

Mobile Unit Radios

Figure 6

Mobile Radios (**Figure 6**) installed in department vehicles have the same basic features and requirements of a base station but are much more limited in ability. The 800 MHz mobile units transmit at 35 Watts. In a mobile application, there is minimal opportunity to separate transmitters from receivers.

To achieve separation, the receiver is automatically turned off when the transmit unit is keyed. Because antenna locations are limited to the vehicle; buildings, trees, hills, overpasses, other apparatus, etc., interfere with performance quality of the mobile radios. Members need to recognize the impact and take this into considerations when spotting apparatus, especially when ensuring communications is essential, such as when assigned as "Medical Communications" on a multi-casualty incident.

Parking apparatus with consideration for radio communications at emergency incidents generally receives low priority, but it is a consideration that must be addressed.

In extreme circumstances, to provide maximum coverage for selected geographic areas, it may be necessary for commanders to locate in an area which provides maximum coverage for select areas. In such circumstances, commanders should consider locating at the following locations.

Battalion 1	Dodger Stadium South East Parking lot
Battalion 2	Mt. Washington Glenalbyn
Battalion 3	Baldwin Hills
Battalion 4	Baldwin Hills
Battalion 5	Mt. Lee
Battalion 6	San Pedro Hill
Battalion 7	KSKQ RFS47
Battalion 9	Roof of 100 Wilshire/SP as B/U
Battalion 10	Beverly Glen / FS99
Battalion 11	Mt. Lee
Battalion 12	Verdugo Peak
Battalion 13	Baldwin Hills
Battalion 14	Verdugo Peak
Battalion 15	Oat Mountain (east end of ridge)
Battalion 17	Oat Mountain (west end of ridge)
Battalion 18	Baldwin Hills

Portable Radios or "Handi-Talkies"

Portable radios (**Figure 7**) have the same basic features as the mobile units and base stations but are even more limited in ability, especially in the transmit phase. LAFD portable radios transmit 2 or 4 Watts of power (depending on model) and have a transmit range of up to about 2-3 miles in "simplex" or direct mode under the best of conditions. Portability rather than transmit power is the primary value of portable radios.

LAFD Portable radios are provided to the field in 3 different bands. 700/800 MHz, UHF and VHF. Though these radios appear the same, they are in fact quite different. The best way to differentiate between the radios is as follows;

- The 700/800 MHz radio has a red “band” on the antenna and red lettering.
- The UHF Radio has a blue “band” on the antenna and has a blue face and blue lettering.
- The VHF radio has a white “band” on the antenna, has a white face and has white lettering.
- Additional special purpose radios are provided for specific applications such as marine and aviation communications.

800 = Red UHF = Blue VHF = White

Figure 7

BASIC RADIO COMMUNICATION TECHNOLOGY

Radio Frequencies

Radio communications are possible because of electromagnetic waves. There are many types of electromagnetic waves, such as heat, light, and radio energy waves. The difference between these types of waves is their frequency and their wavelength.

The frequency of the wave is its rate of oscillation. One oscillation cycle per second is called one hertz (Hz). The types of electromagnetic energy can be described by a diagram showing the types as the frequency of the waves increase. (**Figure 8**)

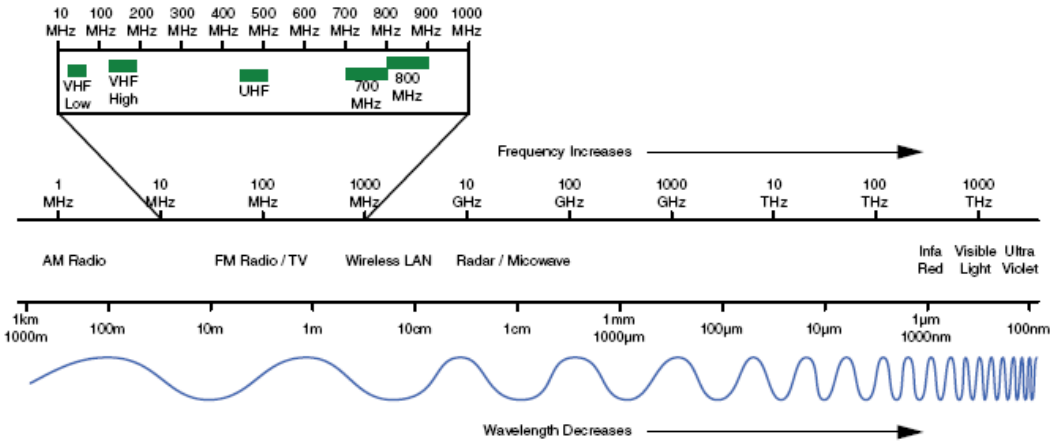

Figure 8

When describing the frequencies used by common radio systems, the metric system is used to quantify the magnitude of the frequency. A typical frequency used in fire department radio systems is 154,280,000,000 Hz. This is a frequency designated by the FCC as a mutual-aid radio channel**.** Dividing the frequency by the metric system prefix mega, equal to 1,000,000, this becomes 154.280 megahertz or MHz.

Land mobile radio systems are allowed to operate in portions of the radio spectrum under rules prescribed by the FCC. These portions of the spectrum are called bands, and land mobile radio systems typically operate with frequencies in the 30 MHz (VHF low), 150 MHz (VHF high), 450 MHz (UHF), 700 MHz, and 800 MHz bands.

The wavelength is the distance between two crests of the wave. The frequency and wavelength are inversely related so that, as the frequency of the wave increases, the wavelength decreases.

The length of a radio antenna is related to the wavelength with which the antenna is designed to operate. In general, the higher the frequency of the waves used by the radio, the shorter the antenna on the radio. (**Figure 9**)

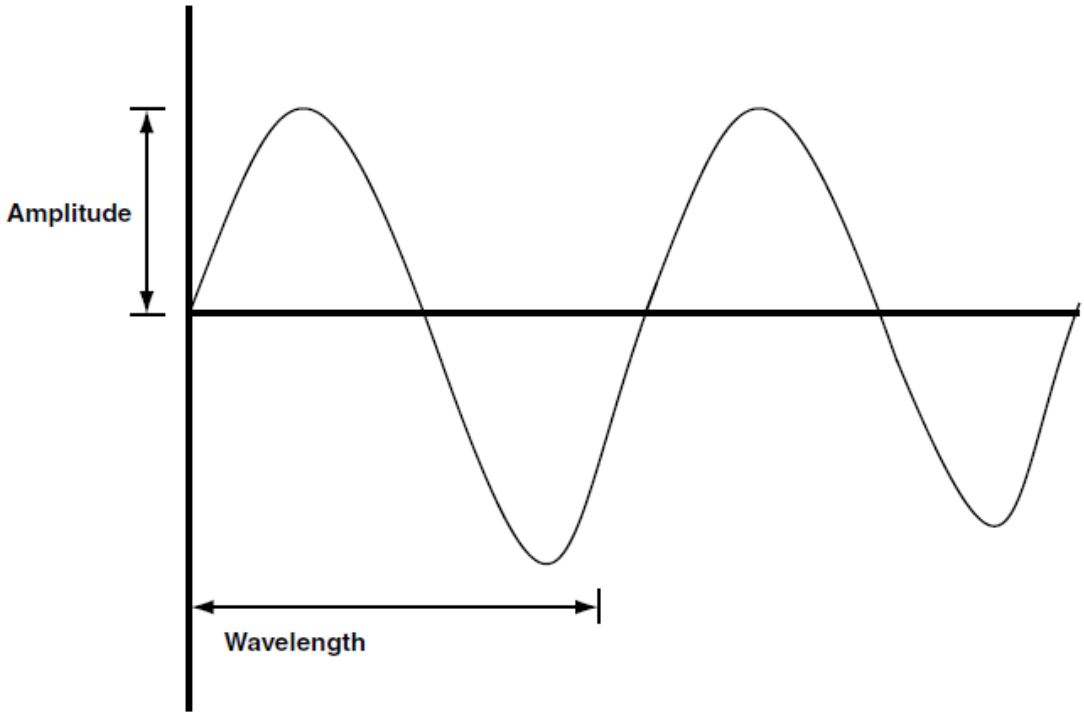

Figure 9

Currently the LAFD uses four different frequency bands. The bands are defined as follows:

1. 800 MHz – The primary radio used for LAFD operations. Portable radios are indicated with red engravings and a red antenna band.

2. 700 MHz – Digital simplex channels which can be used for drills and for emergency operations for non-critical messaging. The 700 MHz band is programmed into the "red" 700/800 MHz band radios.

3. Ultra High Frequency (UHF / 500 MHz) – Used for mutual aid incidents with surrounding fire and police agencies. Also used for Hospital Base Station contact. UHF Portable radios are indicated with blue engravings and a blue antenna band.

4. Very High Frequency (VHF / 100MHz) – Used by surrounding fire agencies for tactical and routine operations. Also used as the Hospital Emergency Administrative Radio (HEAR). VHF Portable radios are indicated with white engravings and a white antenna band.

The LAFD is only licensed to use the 700 MHZ and 800 MHz bands. The Los Angeles City repeaters for the LAFD system operate only in 800 MHz. Use of the UHF or VHF radio is prohibited unless used in a mutual aid scenario. Furthermore, the repeaters used when operating the UHF and VHF radios are not property of LAFD.

There are mutual aid channels in the 800 MHz band that are identified as state wide fire and law enforcement mutual aid channels which the LAFD does support, these channels include.

1. Firemars (Fire Mutual Aid Radio System)
2. Clemars (California Law Enforcement Mutual Aid Radio System)

Radio Wave Propagation

To send a radio signal from a transmitter to a receiver, the transmitter generates electromagnetic energy and sends that energy through a transmission line to an antenna. The antenna converts the energy into electromagnetic radio waves that travel at the speed of light outward from the antenna. If another antenna is located in the path of the waves, it can convert the waves back into energy and send that energy through a transmission line to a receiver. (**Figure 10**)

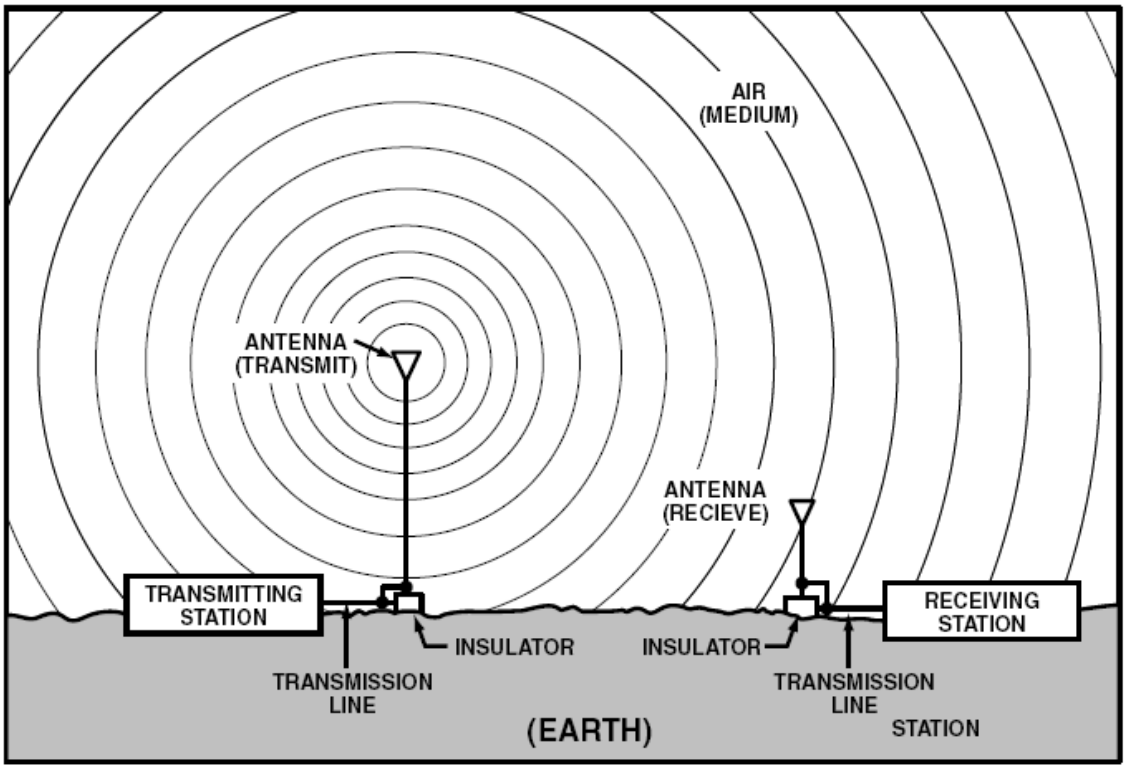

Figure 10

Radio signals emitted from an antenna travel both a direct path to the receiving antenna, and a path reflected from the ground or other obstacles. This reflection causes the wave to travel a longer distance than the direct wave, as shown in (**Figure 11**).

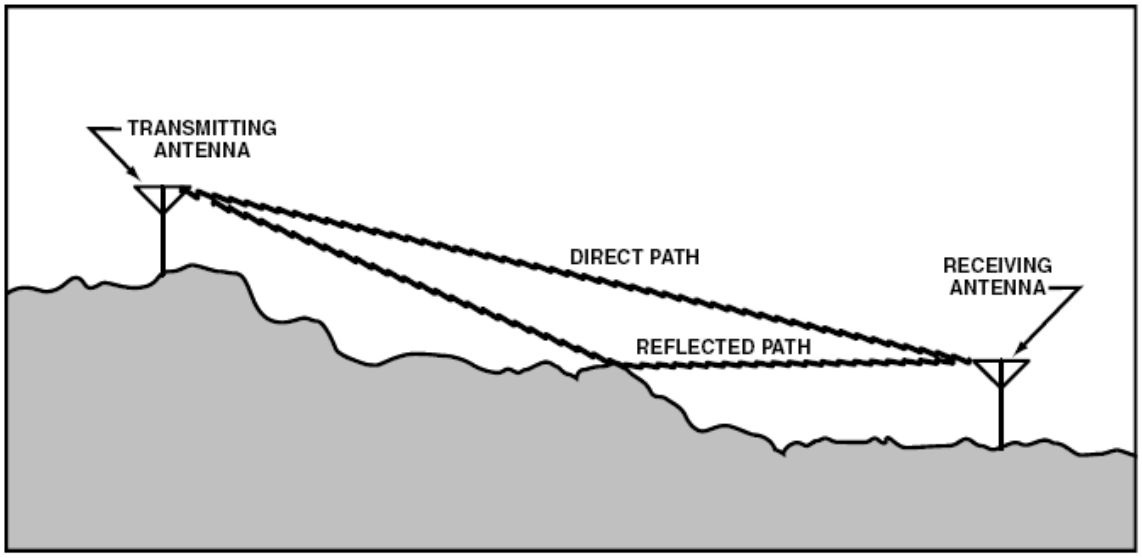

Figure 11

The waves traveling over the reflected path then interfere with the direct waves, causing an effect know as multipath interference. Multipath interference causes a variation in the signal level at the receiver. The signal may be higher or lower than the direct signal depending on the position of the receiver's antenna. As the antenna is moved around, the signal varies, and the user hears a signal that goes from strong and clear to weak and noisy.

Radio waves can travel through some materials, such as glass or thin wood, but the strength is reduced due to absorption as they travel through. Materials such as metal and earth completely block the waves due to their composition and density. In addition, some materials will reflect radio waves, effectively blocking the signal to the other side. In part, this is why the 800 MHz band is more effective for building penetration. The radio waves are small enough to go between the steel frame and metal reinforcing bars.

Because buildings are built from many types of materials, the radio waves can be passed through some, be reflected by some, and be absorbed by others. This, along with the complex interior design of a building, creates a very complex environment for radio communications inside a building.

What Affects System Coverage?

The coverage of a radio communications system generally is described as the useful area where the system can be used reliably. Many factors affect coverage, including the radio power output, antenna height and type, and transmission line losses. However, the factor that most influences coverage is the height of the antenna above the surrounding ground and structures (**Figure 12**).

By locating the antenna on a tower or mountain top, the system provides a more direct path from the transmitter to the receiver. In the case of one radio user transmitting directly to another radio user, having the radio antenna as high as feasible (hand held at shoulder height) significantly improves coverage.

In land mobile radio systems like those used by the Department the antennas are **vertically polarized**. You can see evidence of this with the wire antennas mounted on the roofs of vehicles. Like car antennas designed for frequency modulation (FM) broadcast radio, they stick up vertically from the surface of the vehicle.

The **radiation pattern** of the antenna is the shape of the relative strength of the electromagnetic signal emitted by the antenna, and this depends on the shape of the antenna. The radiation pattern can be adjusted through antenna selection to provide coverage where desired and to minimize coverage (and, in turn, interference) in undesired directions.

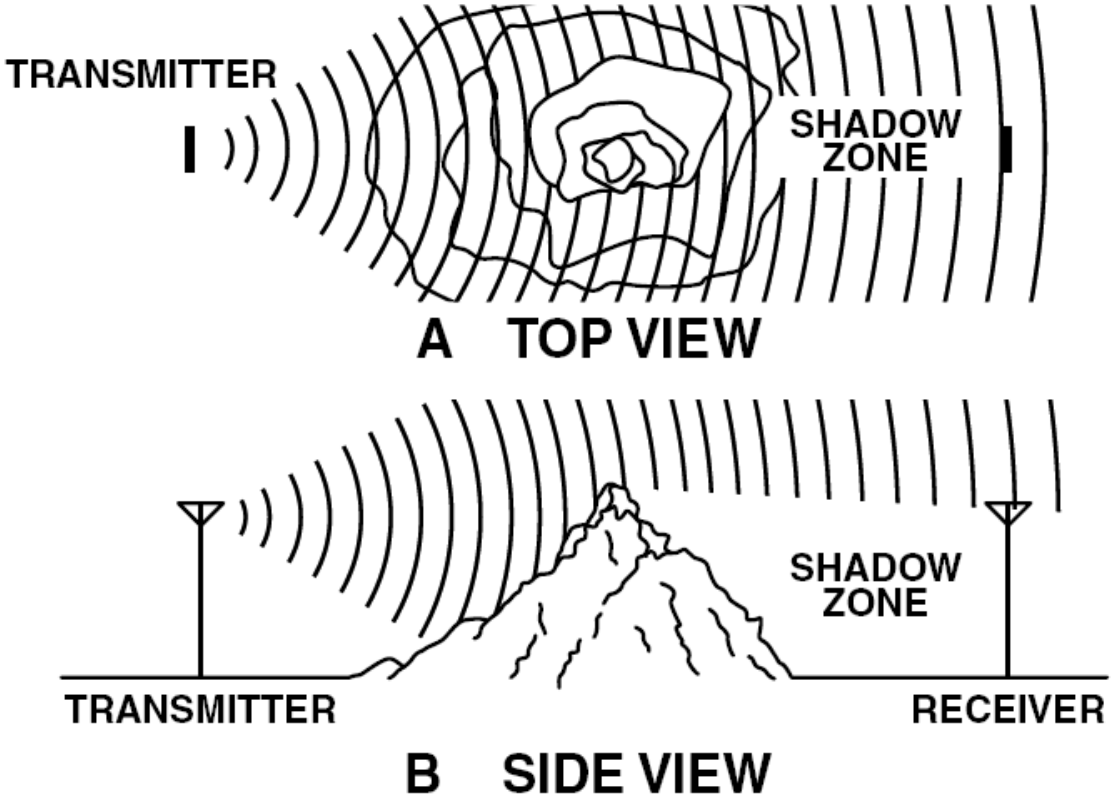

Figure 12

Fixed-Site Antennas

Fixed-site antennas are mounted on towers or buildings to provide the dispatch or repeater coverage throughout the city. The antennas used are designed to operate in the system's frequency band and, for best power coupling, have a center frequency as close as possible to the actual operating frequency.

The radiation pattern for the antenna is selected to provide a signal in the desired sections of the coverage area, and have minimal coverage outside the desired coverage area. This will help ensure that the system is not interfering with other systems unnecessarily. The most basic practical antennas are omni-directional, and have approximately equal coverage for 360 degrees around the antenna.

Mobile and Portable Antennas

In general, all mobile and portable radio antennas are omni-directional to provide coverage 360 degrees around the radio user. Vehicle antennas are mounted so that they are not obstructed by equipment mounted on the top of the vehicle.

Light bars, air conditioning units, and master-stream appliances are some typical obstructions found on fire vehicles. Some obstructions cannot be avoided, and the designer must select the best compromise location.

Vehicle antennas mounted on the roof of fire apparatus can be damaged by overhead doors, trees, and other obstructions such as members walking on the roof for maintenance. Ruggedized low-profile antennas often are a better choice and are utilized on Department apparatus whenever possible even if they have a lower gain than a normal whip antenna. A properly mounted intact antenna with a lower gain is much better than a damaged antenna of any type.

Portable antennas usually are provided by the portable radio manufacturer and are matched to the radio. In some cases alternative antennas can be selected for the radio to overcome specific user conditions. However, in the applications for the LAFD, antennas are not interchangeable and antennas from radios of a different band shall not be used on other radios. Always match an 800 MHz (red) antenna to an 800 MHz radio, a UHF antenna (blue) to a UHF radio and a VHF (white) antenna to a VHF radio. Radio performance will be seriously degraded by swapping out for an incorrect antenna.

When a portable radio is worn at waist level, such as with a belt clip or holster, the user's body absorbs some of the signal transmitted or received by the radio. In addition, the antenna is at a much lower level than if the user were holding the radio to his or her face for transmitting. If a user is in a situation where they need to enhance radio performance, if safe to do so, raise the radio up above head level then attempt communications again.

Interference

Radio frequency interference can be either natural or manmade. Interference from internal noise occurs naturally in all electronic equipment due to the nature of the electronic circuit itself. Manufacturers take this into account during equipment design, and obtaining a low-noise design is not particularly difficult. In addition, natural noise is produced by sunspot activity, cosmic activity, and lightning storms. This noise usually is of small magnitude and not significant for most land mobile radio communications. However, the VHF low band is affected significantly by severe sunspot activity, sometimes to the point of completely prohibiting communications.

More significant to radio communications systems is the interference produced by manmade sources. Vehicle ignitions, alternators, electric motors, high-voltage transmission lines, computers, and other equipment with microprocessors also emit radio signals that can interfere with Department radios.

In general, manmade interference decreases with an increase in frequency. The UHF band and, initially, the 800 MHz band are much less susceptible to manmade interference than the VHF low and high bands. When systems are not subject to significant interference, they are said to be "noise limited," in contrast to "interference limited."

The increase in the number of transmitters used by cellular telephone companies in the 800 MHz band has created increasing interference in the 800 MHz band.

Radio communication takes place using electromagnetic waves that travel from the transmitter to the receiver. These waves can be reflected or absorbed by materials such as buildings, the earth, or trees, reducing the strength of the wave when it reaches the receiving antenna. Elevating the transmitting or receiving antenna will reduce the likelihood of the wave being affected by buildings or trees, because the path to the receiver will be more direct.

LAFD DIRECT AND REPEATED RADIO SYSTEMS

Modes of Operation

There are three basic modes of operation for a radio system; “Simplex”, “Duplex” and “Simulcast”.

In “Simplex”, one frequency is used, the transmitting radio is in direct mode, all receivers and transmitters are tuned to the same transmit and receive frequency. When one unit is transmitting, all other units in the area are able to receive. Units are able to communicate affectively as long as they are within range. (**Figure 13**)

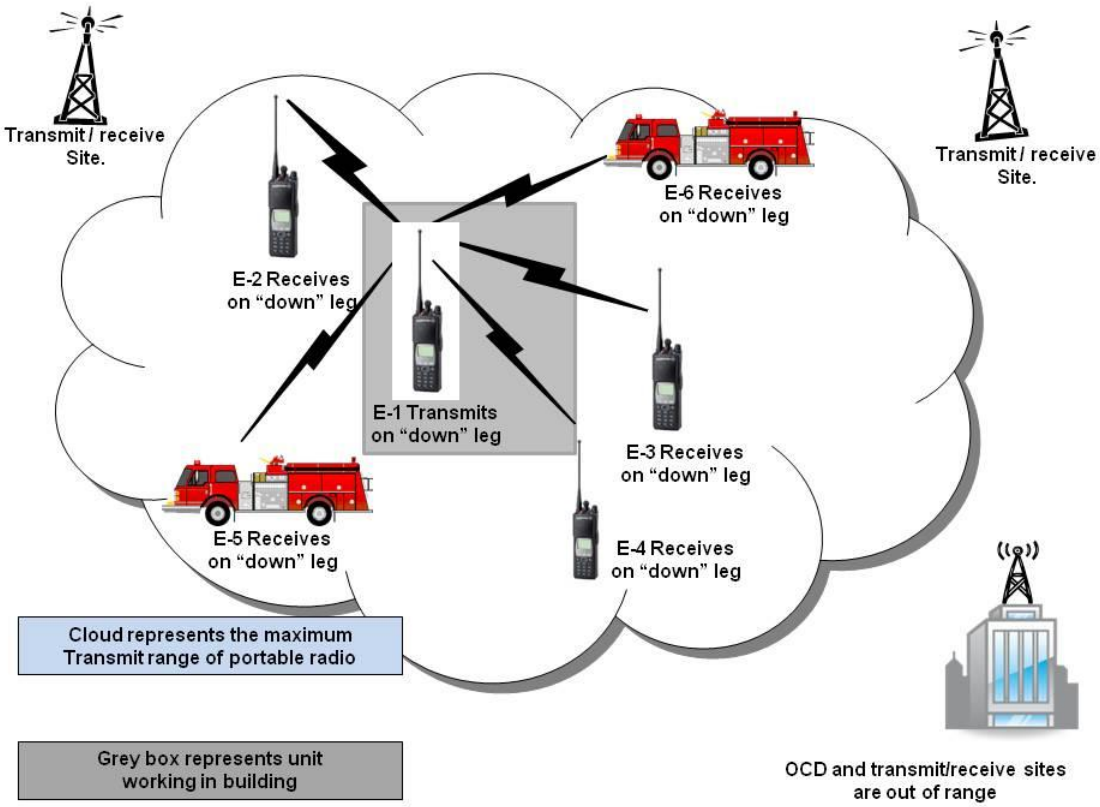

Figure 13

The receiving radios will receive the transmitting unit message regardless if they are simplex or duplex mode. However, to transmit back to the originating unit, the receiving unit must also be in the simplex mode.

What is necessary to understand is that in simplex or "direct mode, the signal transmitted by the broadcasting unit is transmitted on the "down" leg frequency of the duplex or "repeat" channel.

In "Duplex" mode, two frequencies are used. The "up" leg frequency is defined as mobile to base. The "down" leg frequency is defined as base to mobile. (**Figure 14**)

This system is used when communicating with OCD or access the simulcast system by having the radio in repeat mode. In repeat mode, the transmitting unit is broadcasting on one frequency (the "up" leg), it is received by the repeater site and rebroadcast on the "down" leg on a second frequency, where it received by receiving units.

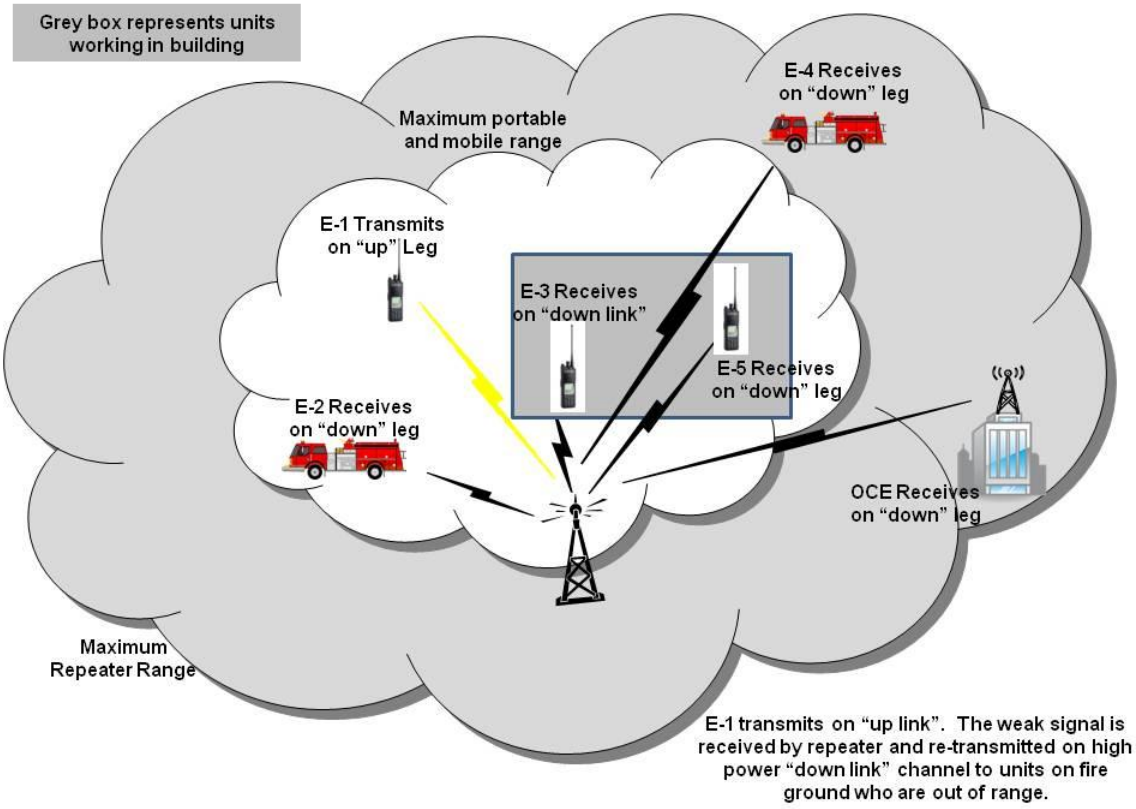

Figure 14

When a radio system must cover a large area, but the number of available frequencies is limited, a simulcast transmitter system may be the solution. With this system, multiple transmitters simultaneously transmit on the same frequency.

The transmitters must be precisely synchronized so that the signals they transmit do not interfere with each other. In addition, the audio source sent to the transmitters must be synchronized so that the radio user hears the same signal from each transmitter. The system consists of a simulcast controller and two or more simulcast transmitters. In the case of the LAFD, nine sites are synchronized. The advantages of a simulcast system are the coverage of a large area, with high signal levels throughout the area, while using only a single frequency.

The "Simulcast" mode is used when transmitting mobile to mobile in the repeat mode. With this system a mobile or portable radio, or OCD can be heard throughout the city. In the "Simulcast" mode the "up" and "down" leg frequencies are used. The "up" leg is known as the transmitting frequency the "down" leg is known as the receiving frequency.

In the simulcast system, a radio message transmitted in repeat mode is sent out on the "up" leg frequency, the weaker signal is received by the transmit/receive site and then is rebroadcast at a much higher output power on the "down" leg frequency. (**Figure 15**)

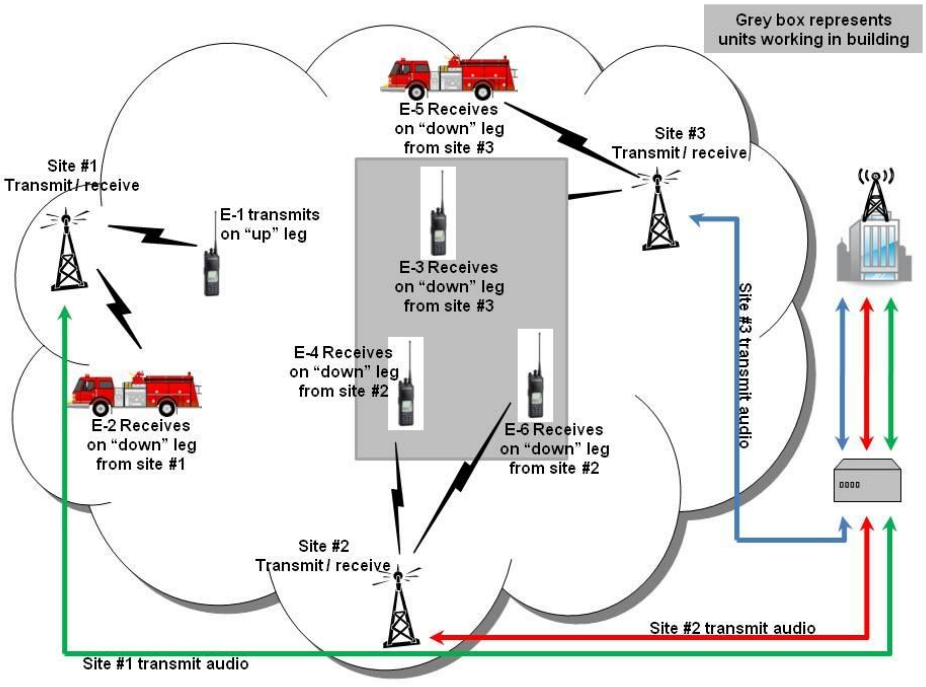

Figure 15

The difference in duplex and simulcast systems is that the simulcast system sends out the “down” leg at all transmit sites, thereby maximizing coverage to units in the field.

When OCD broadcasts a voice message over the radio, it is going out on the simulcast system, thus ensuring the maximum coverage is possible at all times.

It is important for members to understand the concept of simplex and duplex radio operations. There are distinctive applications for each mode. For example, if a member were working inside on a structure fire and was unable to establish communications with other units on the scene in duplex mode, a switch to simplex mode would be appropriate and may well resolve the communications problem. It is possible that the radios waves are blocked from reaching a repeater site. Bear in mind, with the switch to simplex mode, the member is transmitting on the “down” leg frequency and will be heard by other units on scene.

Receiver Voters — Improve Field Unit to Dispatcher Communications

OCD is connected to nine high-powered transmitters to provide the dispatch center with a high level of talk-out capability. The transmitters are elevated to achieve better line-of-sight communications with the service area. High-powered transmitters ensure that OCD’s transmissions are heard throughout the city and provide some level of in-building coverage.

Portable radios have limited power and cannot always transmit a signal strong enough to reach all the transmitter sites. To provide a more balanced system, receivers are networked together throughout the city in a receiver voter system (RVS). When a voice radio signal is received, a comparison of the received audio signal takes place in a receiver voter. The receiver voter and its network of receivers are referred to as the RVS. The RVS usually is located at tech control at OCD. The receiver voter compares the audio from all receivers and routes the audio from the receiver with the best audio quality to the dispatcher. This type of system provides very reliable fire ground communications.

Voice Loggers / MDT Messaging

It is of interest to all members to understand that all 18 LAFD 800 MHZ channels are recorded 24 hours a day, seven days a week. This recording however is only done when the radios are operated in the “duplex” mode. That is, voice radio recording only occurs on messages that are transmitted on the “up” leg frequency and recorded as they are received at the repeater site selected by the receiver/voter system.

In addition to voice radio logging, all MDT transmissions are logged, time stamped and retained on file for future reference. Members are reminded to keep this in mind and keep messages pertinent to Department operations.

Digital Radios
Because the LAFD has incorporated digital communications technology into our operational radios, it is important for members to understand the difference in the technology from analog.

To improve audio quality and spectrum efficiency, radio manufacturers introduced digital radios. This was a necessary move based on the FCC requirements to continue narrow banding or reducing the band width of a radio signal into a narrower band range.

In the digital world when a user speaks into the microphone the radio samples the speech and assigns the sample a digital value. A vocoder (voice coder) or codec (coder/decoder) in the radio performs the function of converting analog voice to a digital data packet.

The digital data packet can vary in the number of bits. The higher number of bits in the data packet, the higher the level of precision. Numerous samples are taken each second to reproduce the source audio. The higher sample rate per second and number of bits per sample result in increased audio quality. For example, compact disc (CD)-quality audio samples 44,100 times per second and the number of graduations in the sample is 65,536. The use of digital audio was expected to reduce static and increase the range of radios in weak signal conditions.

Digital Audio Processing
A vocoder in a digital radio converts analog voice to a digital interpretation from an audio sample. Digital radios, unlike CD or DVD audio, have very limited data rates. Even cell phones have higher data rates than a digital radio. Because of limited data rates, digital radio audio is sampled at a much lower rate with less precision. Designers of the portable radio vocoders felt the radios did not need the same level of precision as CD-quality audio, since reproduction of human speech was the goal.

This is a basic explanation of how analog voice is processed by the radio.

Transmitting radio:

1. The user keys the transmit key and speaks into microphone.
2. The audio is sampled and converted to a digital interpretation by an analog to digital converter (A/D converter).
3. The vocoder converts the digitized speech into digital data.
4. The modulator modulates the radio frequency (RF) with the digital data.

5. The modulated RF signal is boosted in power by transmitter amplifier.
6. The signal is transmitted from the radio antenna.

Receiving radio:

1. The modulated RF is received by antenna.
2. The received RF signal is boosted to a useable level by the receive amplifier.
3. The signal is demodulated by a demodulator. This removes the RF component of the signal leaving the digital data component.
4. Digital data is decoded by the vocoder into digitized speech.
5. Speech data is converted to an analog signal by a digital to analog converter (D/A converter).
6. Analog is sent to the speaker (**Figure 16**).

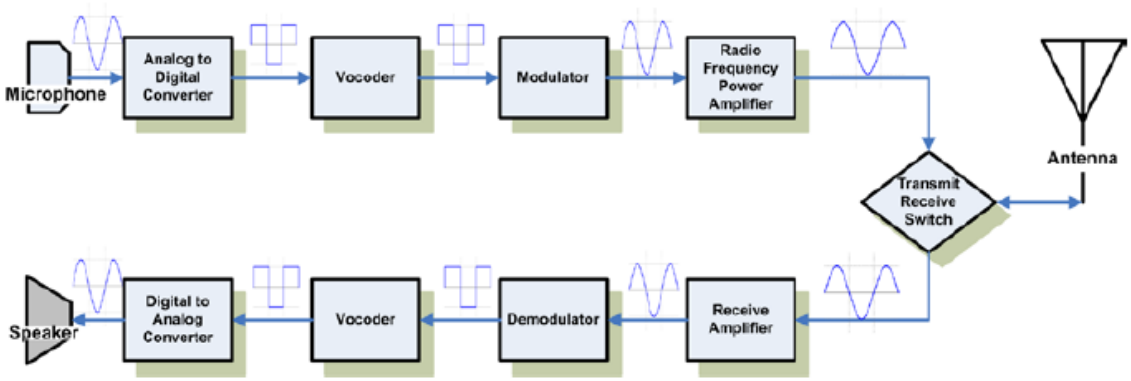

Figure 16

Analog versus Digital Signal Variations with Signal Strength

As the radio user travels further from the transmitting radio, the signal strength decreases. The signal strength directly affects the ability of the radio to reproduce intelligible audio.

In an analog system, the clarity and intelligibility of the transmission, as received by the user, decrease directly as the signal level decreases. The noise (static) in the signal progressively increases in strength, while the desired signal decreases, until the transmitting user cannot be heard over the noise. When a digital user transmits to a receiver, the transmitted signal decreases just as the analog signal does. However, the error correction in the digital transmission contains extra information that allows the audio information to be heard even with a large decrease in signal level.

As the receiver travels further from the transmitter, the signal level decreases to the point where the error correction cannot correct all errors in the signal.

When this point is reached, the receiving users will hear some distortion in the signal and may hear some strange non-speech noises.

These strange non-speech noises are sometimes called "**Ewoking**" after the language spoken by the Ewok characters in the movie "Star Wars".

Once this point is reached, a small reduction in signal level will cause the number of errors to exceed the ability of the system to compensate, and all audio will be lost.

The problem this causes is that the radio signal goes from usable to unusable with little or no indication that this is about to occur. With an analog radio system, the signal slowly gets noisier, giving the user hints that the signal is getting weaker. This behavior adds to the situational awareness of the user and allows him/her to make decisions about the environment. Although digital radios provide a larger range of usable signal levels, the lack of advance indication of signal level decrease allows users to get closer to complete loss of communication without any advance warning.

Bidirectional Amplifiers

Another solution to improving communication between field units inside buildings or tunnels and dispatch and other on-scene units is the bidirectional amplifier (BDA). BDAs can be used with duplex and simulcast radio systems to extend coverage from inside the structure to the outside of the structure and vice-versa, but BDAs do not operate with simplex radio systems.

To overcome radio system in-building coverage difficulties, BDAs often are used to rebroadcast the system in buildings. There are many types of BDAs; all require electrical power and some type of antenna system. Often the antenna systems are installed in the plenum spaces of commercial structures. These antenna systems are generally nothing more then plastic coated coax cable which runs to the amplifier. The amplifier is generally located in a communications or alarm system room.

Most BDA systems include battery backup power to keep it operational if a loss of commercial power occurs.

BDAs work well for incidents such as EMS calls and law enforcement incidents where there is no fire involvement in the building or building systems. In a structure with active fire, the building and building systems are affected directly.

The building environment changes with the introduction of fire: Temperatures rise and particulate matter is suspended in the atmosphere. Firefighter actions to eliminate the fire can also have a detrimental effect. As water is applied to the fire, steam is generated and may have an effect on electronic equipment.

The moisture mixes with the suspended materials, and acids are formed. These acids can cause intermittent failure of exposed electrical contacts over time.

As with all electronics, BDAs are subject to failure when exposed to high heat and moisture. Other actions taken during firefighting operations also could destroy the BDA system. Firefighters checking for extension using pike poles may inadvertently tear the BDA antenna system down, rendering the BDA useless and causing loss of communications inside the building. (**Figure 17**)

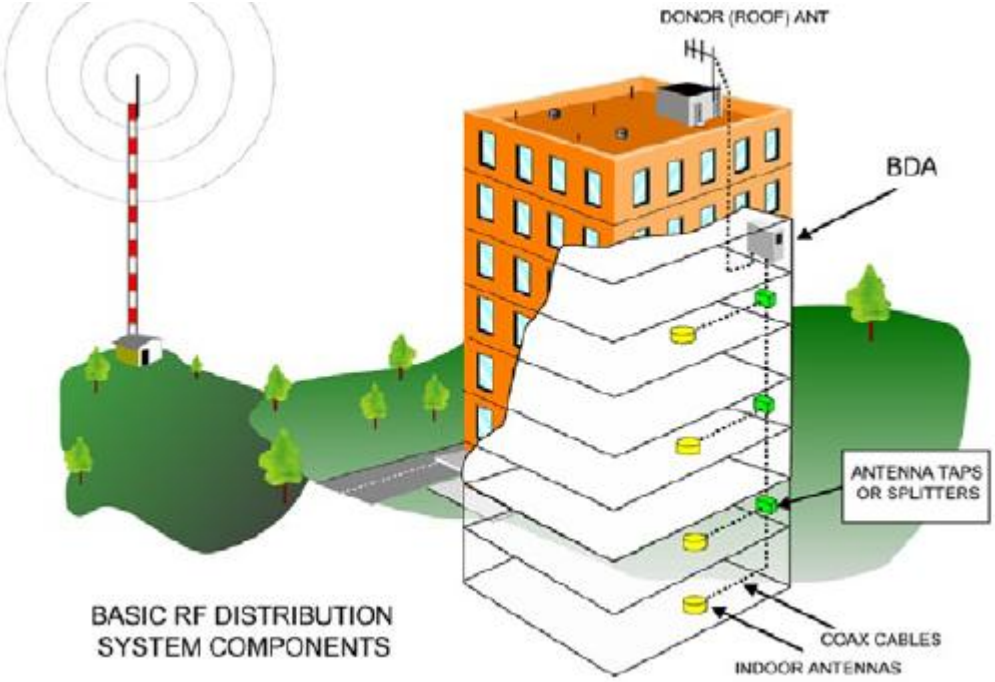

Figure 17

A list of building in Los Angles with BDA's to enhance LAFD communication includes the following.

1. Nokia Theatre
2. Getty Center
3. City Hall East
4. Staples Center
5. MTA Tunnels

As Fire and Building Codes are updated and modernized, this list can be expected to grow.

TRUNKED RADIO SYSTEMS

Currently, the LAFD has Verdugo dispatch programmed into the UHF (blue) portable and mobile radios carried by personnel and installed on late model apparatus. Therefore, it is important for members to have a basic understanding of trunked radio systems.

Trunked radio systems are complex radio systems that were developed to improve the efficiency of the use of available radio spectrum.

In conventional (non-trunked) radio systems, such as the LAFD simulcast system, a radio frequency is dedicated to a single function. When the radio frequency is not in use, it cannot be used by another function. Trunking borrows technologic concepts from telephone systems to assign radio frequencies to active calls, improving the efficiency of frequency use.

Like a conventional repeated radio system, trunked radios communicate with each other through two or more repeaters.

In a trunked system, the radios often are known as subscriber units and a voice communications exchange is known as a call. A basic trunked radio system has a system controller that controls the assignment of the repeaters, called voice traffic repeaters, to individual calls.

For example, the radios communicate with the system controller to request the use of a voice traffic repeater, by sending data messages to the system controller on a special dedicated channel called the control channel. The system controller acknowledges these communications and sends information to the radios using the control channel as well. The radios also can communicate some information using the voice traffic channels after a call has been terminated.

The voice traffic repeaters are shared among all users of the system; they also are known as **resources**.

The radio industry uses the term **talkgroup** to distinguish among physical frequencies or channels used in conventional radio systems. This terminology often is confusing, since from the actual radio user's point of view a talk group and a conventional channel are the same; they are both communications paths. The distinction is made by the technologists to differentiate a physical channel or frequency from the logical channel or talk group.

The system controller and other parts of the trunked radio system maintain a log of all activity that occurs in the system, as well as statistical information on the operation of the system. These system logs can be used in the event of a suspected anomaly in the operation of the system to help determine the cause.

GENERAL TRUNKED RADIO OPERATION

Radio On/Off — Registration/Deregistration/Talk group Affiliation

When a trunked radio is powered on initially, it begins operation by telling the system controller that it is active, along with the talk group currently selected on the radio, using the control channel. If the registration is successful, the radio is registered on the system and now can receive and transmit; if the registration is not successful, the radio will not operate on the system.

Any time that the radio is powered on and the user changes talk groups the radio will tell the system the new talk group selection, and the system will confirm the selection. In this way, the system tracks the currently selected talk group for all radios registered on the system.

When the radio is switched off by the user, the radio transmits a message to the system controller telling the system to deregister the radio. The radio then will wait for an acknowledgment from the system before actually powering off.

Talk group Call

When a radio user wishes to transmit on a talk group, he/she presses the PTT switch, just as with a conventional radio. The radio then sends the trunking system a data burst request to transmit, using the control channel.

The trunking system checks to see if the requested talk group is free and if there are available voice traffic repeaters. If these are true, then the system assigns a voice traffic repeater to the call and instructs all radios with the talk group selected to change frequencies to the voice traffic repeater frequency.

The system also sends a message to the requesting radio telling it that it may proceed with its transmission. This causes the user's radio to play a tone sequence (typically three short beeps) to tell the radio user that he/she may proceed with the transmission. The radio's transmission is received by the voice traffic repeater and retransmitted to the other radios on the frequency.

If the there are no voice traffic repeaters available for the call, the system will place the request in a busy queue in order of priority, send a busy message to the requesting radio and wait a short time for resources to become available. If the resources become available, the transmission proceeds. If the resources do not become available before the wait time expires, the system transmits a message to the requesting radio telling it that the request failed. The radio will play a tone (commonly called a "bonk") to the user indicating the failure. When a radio on a trunked system moves out of range of the system, it will emit a long tone indicating it is not available on the system. It is important for the user to recognize communications is compromised and know to take action to re-establish communications.

Call Disconnection
When the transmitting user is finished with the transmission he/she will release the PTT switch. This causes the radio to send a message on the control channel telling the system that it can release the resources assigned to the transmission.

Depending on the configuration of the talk group, the system either waits a few seconds for additional transmission requests before releasing the resources, or it releases the resources immediately. Once the timeout is reached, the system tells all radios on the talk group to change channels to the control channel and releases the voice traffic repeater for use for other requests.

If another request is received before the resources are released, then the system immediately grants the requesting radio's transmission request and does not need to tell the other radios to switch frequencies.

INCIDENT COMMUNICATIONS SUPPORT

Department Capabilities

Separate from our standard radio equipment, the Fire Communications and Dispatch Support Section and OCD have access to tools and apparatus that will aide in the advent of a large scale incident to assist with and resolve communications shortfalls. This ancillary equipment includes the following.

1. Portable 800 MHz repeater systems.
2. Portable cross band link system.
3. Interoperability vehicles.
4. Broadband (Internet) connectivity.
5. Cellular phone amplifiers and repeater systems.
6. Radio, battery and charger caches (VHF, UHF, 700/800 MHz)
7. Mobile repeater vehicles with cross band capability.

Portable Repeaters
The Department has a supply of portable 800 MHz repeaters which can be placed by trained and qualified members to resolve radio coverage in areas which may have compromised coverage. A classis problem area for the LAFD is the Kirkwood Bowl area in Battalion 5. Fire Communications personnel have preplanned sites for known problem areas in the city (**Figure 18**).

Figure 18

Portable Cross Bank Links

Portable cross bank links enable the "linking" of different radio bands into a common system. For example; a voice radio message transmitted on 800 MHz can be received by the cross bank link and then retransmitted on UHF or VHF as desired. This would also occur vice versa, a UHF or VHF voice radio message would be linked and retransmit on 800 MHz to provide for a common communication link with outside agencies. Portable links look exactly like a portable repeater; it is the internal workings that vary.

Interoperability Vehicles

The Department has two radio interoperability vehicles. Radio Interoperability vehicle 100 "RI-100" and Radio Interoperability vehicle 200 "RI-200" (**Figure 19**). Essentially, the radio interoperability vehicles are a grand version of the portable repeaters with much more capability. Thus, they are much more complicated and require more experience and extensive training to operate.

RI-100 and RI-200 have the ability to link channels in different frequency bands. For example, in a large-scale incident where LAFD members were working with an outside agency such as LACoFD, communication could prove to be difficult.

Figure 19

LAFD's tactical channels are in the 800 MHz range while LACoFD's tactical channels are in the VHF range. The interoperability vehicles have the ability to link a LAFD TAC channel with a LACoFD TAC Channel.

When a signal is transmitted by a LAFD radio the RI vehicle will convert the 800 MHz signal to a VHF signal that can be received by the LACoFD's radio. This will allow the two agencies to communicate using their own familiar radios.

OCD also has special radio capabilities for mutual aid purposes. This includes radios on the fire mutual aid "white" channel and the three primary LACoFD UHF "Blue" dispatch channels. OCD can also access channels on the State Fire Net, which has repeaters throughout the state for interdepartmental coordination, and for communications with the State Office of Emergency Services (OES).

Other channels available at OCD are HEAR 1 and HEAR 2 (Hospital Emergency Administrative Radio) for coordination with hospitals.

The City Civil Defense channel available at OCD is used in disaster operations to contact the Mayor, City Council and their staffs as well as other persons with key positions in disaster operations and for coordination with dispatch centers maintained by other City departments.

Additionally, OCD has the capability to activate the Mt. Lukens back up radio system as well as link our 800 MHz radio system to the City Wide Trunked Radio System or EDACS system as well.

Broadband Connectivity.
The Department has the ability to provide Internet connectivity to assist in incident management and information. This connectivity can be established via broadband (wireless card) or through satellite connection. Additionally, secure local wireless networks can be established to enable a larger number of users (**Figure 20**).

Figure 20

Interoperability
This definition of interoperability is taken from the DHS SAFECOM project:

In general, interoperability refers to the ability of emergency responders to work seamlessly with other systems or products without any special effort. Wireless communications interoperability specifically refers to the ability of emergency response officials to share information via voice and data signals on demand, in real time, when needed, and as authorized.

Day-to-Day
Interoperability efforts are generally driven by the need to meet day-to-day operational requirements. Since September 11, 2001, there has been significant attention to expand interoperability past the day-to-day needs of a public safety agency to address extraordinary events and incidents.

Interoperability is required and necessary in today's world. Where and how it happens is based on a logical analysis of operational practices and requirements.

Almost all fire departments have interoperability with other fire departments in California. Interoperability between agencies in the same discipline is intra-discipline interoperability. Inter-discipline interoperability is between different disciplines.

Intra-discipline interoperability is the easiest to achieve, since there is a common language, terminology, and tactical objectives. Inter-discipline interoperability may not share common terminology or have the same tactical objectives.

A prime example is when the LAPD responds to a brush fire to assist with evacuation, when the LAFD responds on a reported shooting. Each discipline (LAFD/LAPD) has very different tactical objectives. As the fire responders fight the fire using the "common language" of the fire service, this terminology may not be understood by the law enforcement component. Knowing when to talk and when not to talk becomes a safety issue. In these situations interoperability may require face-to-face coordination with the Command element.

Large Incidents
As incidents grow, interoperability is planned for in the Incident Command structure. When developing interoperable Command structures, many interoperability tools may be employed. Technical staff plays a pivotal role in providing technology tools to meet the operational requirements.

The use of a Communications Officer at major incidents and a Communications Unit Leader is part of the National Incident Management System (NIMS) Command structure.

Communications Unit Leaders in the NIMS Command structure provide a central point of contact to develop a communications plan (**ICS 205**) to meet the interoperability needs on a large incident.

When developing interoperable communications systems, determining the number of channels needed to support the incident must be a consideration. It is always important to account for the amount of radio traffic on a channel.

Shared or patched channels can be used when there are common tactical objectives. Before patching channels or using gateways that essentially tie channels together, the amount of traffic on each channel must be a considered. If both of the channels are near saturation, the patch or gateway will make communications nearly impossible.

Many technologies are available to achieve interoperability, and often the simplest solutions are overlooked in favor of complex technological solutions. The simple solutions usually are the quickest to implement and easiest to understand. In some instances, face-to-face communications may provide the desired level of interoperability, while in other cases other methods may be necessary.

Strike Team Operations

It is important for all members to understand that the LAFD is licensed to use our FCC assigned frequencies specifically within the geographic boundaries of the City of Los Angeles and the immediate vicinity. Use outside the City limits is authorized, and it can in fact be dangerous.

The frequencies assigned to the LAFD by the FCC are used by other public safety agencies throughout the state as well as through out the country, and their specific use may not be limited to voice communications. These frequencies may also be utilized for other purposes such as controlling electrical grids, water systems and other radio networks.

The use of our assigned frequencies outside the City of Los Angeles may have catastrophic results. There is real potential (especially as you venture further from Los Angeles) that use of our radios on our frequencies could inadvertently activate, or deactivate systems that would normally be isolated from our system by distance. There is no practical method to know in the field what or where these conflicts exist, therefore it is incumbent on members to adhere to incident communications plans or use national or statewide interoperability channels when traveling or working outside the immediate area of Los Angeles.

The following state or national interoperability channels are recommended for travel, or tactical operations use outside the immediate area of Los Angeles.

1. INTL FIREMARS (Fire Mutual Aid Radio System) in the 800 MHz band (red) radio. Use in “simplex” or direct mode of operation.

2. CESRS (California Emergency Services Radio System) in the VHF-100 MHz band (white) radio.

Radio, battery and charger caches (VHF, UHF, 700/800 MHz)

Figure 21

The Department currently uses the Motorola “IMPRES” batteries and charger systems for its portable radios. This smart energy system automatically reconditions IMPRES batteries based on actual usage, keeping them in peak condition. Talk-time and cycle life are optimized and the need for manual maintenance programs is eliminated. IMPRES batteries, when used with an IMPRES charger, provide automatic, adaptive reconditioning, end-of-life display and other advanced features. Data is stored in the battery and communicated to the charger via a unique IMPRES communication protocol which is designed to maximize talk-time and optimize battery cycle life – all automatically. In addition, batteries left in the charger are kept fully charged so they are always ready when needed. This rapid-rate, tri-chemistry charging system will also charge compatible non-IMPRES batteries (**Figure 21**).

Most conventional chargers transition to a maintenance charge mode at the completion of a charge cycle. Maintenance charge is constant power applied to a battery in an effort to keep it charged over time. This results in long-term heating that can damage a battery, resulting in lost capacity. IMPRES chargers automatically turn off at the end of a charge cycle yet continue to electronically monitor IMPRES batteries every 5 minutes to determine when more energy should be applied to the battery. This process assures that the battery maintains a very high state of charge without sustaining heat damage due to the charger.

IMPRES chargers have additional LED indication capability to supply you with even more information during a charge cycle.

The alternating red/green LED indicates batteries have fallen below a certain capacity threshold (typically less than 60% of rated minimum capacity). An IMPRES battery exhibiting a red/green indication is not defective – it has simply reached a capacity level that may limit its usage.

Portable Batteries and Battery Maintenance

IMPRES technology provides a communication interface between radios, batteries and chargers, which automates battery maintenance and enhances the capabilities of two-way radio systems. Batteries that are charged and maintained at their optimal levels benefit from longer life, ensuring the reliability of the radio and meet the safety requirements of the mission.

Optimizing battery performance requires an intelligent approach to battery maintenance. Inadequate maintenance and overcharging are two of the leading reasons for premature battery failure. Most apparent in Nickel-Cadmium (NiCd) batteries, but also relevant to Nickel-Metal Hydride (NiMH) batteries, "memory effect" occurs when batteries are repeatedly charged without allowing the battery to fully discharge prior to subsequent charge cycles. Memory effect manifests itself as a condition wherein the battery loses its ability to accept a full charge. This results in shorter usage time and the need to recharge more frequently. To minimize this problem, NiCd and NiMH batteries require periodic reconditioning for optimal performance. Users of conventional batteries, chargers, and reconditioners must guess at the correct reconditioning intervals, which vary due to usage patterns and may be unknown. Reconditioning too frequently wastes battery cycles, while reconditioning not often enough results in diminished battery performance and shorter lifespan—driving up equipment costs.

Each IMPRES battery contains memory to store battery historical charge and recondition/recalibration data. IMPRES chargers contain a microcontroller that manages communication between the battery and charger. Placing an IMPRES battery into an IMPRES charger triggers the charger to write data into the battery's memory listing the charge event details.

IMPRES charging, periodic automatic reconditioning and recalibration serve three purposes:

- Recalibrates the battery
- Helps to minimize the memory effect
- Utilizes battery data to optimally charge the battery

IMPRES chargers evaluate the actual usage pattern of each IMPRES battery. This allows the charger to adapt to that individual battery's usage pattern and establish the optimal reconditioning and recalibration interval for that battery. IMPRES uses an adaptive algorithm, which relies on several factors to evaluate the need for reconditioning/recalibration.

The system then automatically reconditions/recalibrates the battery as required. The intelligence within the IMPRES system automates the process, removing guesswork from determining the optimal reconditioning/recalibration interval.

At time of manufacture, every battery contains a fixed amount of energy, all of which remains available for use when the battery is fully charged. Fully charging a battery generally means that the battery has completed both the Rapid Charge and Trickle charge phases of the charge process and now contains all of the energy that the battery is capable of producing. As a battery cycles through repeated charge and discharge phases, the amount of available energy decreases. The battery remains fully charged, but will ultimately contain less energy over time. For example, a new battery when fully charged contains 100% of its initial available capacity, whereas an old battery when fully charged contains only 60% of the original capacity.

Motorola chargers used by the Department report the following information in a two-line display:

- Battery serial number, kit number, and chemistry
- Battery charge capacity in milliamp hours (mAh)
- Battery charge capacity as a percentage of rated capacity
- Battery voltage
- Estimated battery capacity at end of charge in mAh
- Time remaining to complete rapid charge cycle (NiCd and NiMH only)
- Notification when a battery is approaching reconditioning

Battery charger systems and batteries are available at each work location and a cache of chargers and batteries is available through the Fire Communications Section to support large scale or extended incidents.

In-vehicle IMPRES pocket chargers (**Figure 22**) are provided on apparatus to provide charging capability of portable radio batteries during extended duration incidents or deployments. The apparatus pocket chargers will not condition the batteries as the Multi-charger will. It is essential that all radio batteries are routinely cycled through the multi-charger to provide for proper battery maintenance to ensure maximum service life and dependable reliability.

Figure 22

The IMPRES compatible vehicular charger has full IMPRES charger to battery communication capability. This ensures continuity of IMPRES battery charge data logging in a vehicular environment, so the IMPRES battery will receive adaptive, automatic reconditioning.

NOTE: Again, the IMPRES compatible vehicular charger will not recondition IMPRES batteries while in a vehicle, but it will provide an indication when reconditioning is required in an IMPRES desktop charger.

"IMPRES" Battery Charger Operation

Charge Indicator	Description
Steady Red	Battery is in rapid charge mode.
Flashing Green	Battery is in trickle charge.
Steady Green	Battery is fully charged.
Flashing Yellow	Charger is waiting to charge (temperature of battery too hot or too low).
Flashing Red	Battery not making proper contact.
Steady Yellow	Battery is in recondition mode.
Flashing Red/Green	Battery is fully charged but is nearing the end of its rated service life.

Outside Agency or "Non-IMPRES" Batteries

Members are advised that other City Departments such as LAPD use the same brand and model radio as the LAFD (Motorola XTS5000), but the radios are not intrinsically rated, nor do they use the intrinsically rated IMPRES battery. IMPRES batteries can be identified by the "IMPRES" marking and the intrinsically rated "green dot" as depicted in (**Figure 23-A & B**).

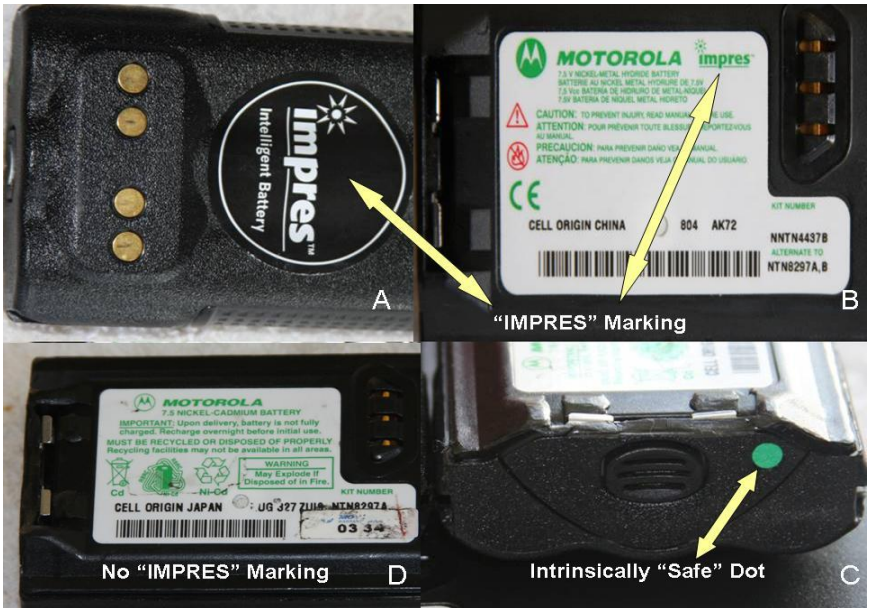

Figure 23-A-B-C-D

Portable radio batteries that do not bear the IMPRES marking and the green intrinsically rated green dot (**Figure 23-C**), shall not be used with LAFD portable radios. Note, it is possible for a battery to have the "IMPRES" marking and NOT have the intrinsically safe "green dot".

In the event non IMPRES batteries (**Figure 23-D**), or batteries without the intrinsic safe green dot are identified in the field, the Fire Communications Section shall be contacted telephonically to arrange an exchange for the sub-standard batteries to remove them from the field to eliminate the possibility of using them in an environment that creates an unsafe situation for LAFD members..

Portable Radio Replacement Procedures

Portable radios are "inventory" items. Procedures for lost or stolen portable radios are delineated in the Departments Manual of Operations, 8/5-42.60. In the event of a lost or stolen portable radio, members shall adhere to established policy.

For suspected defective or non-operational portable radios (or for temporary replacement of lost or stolen portable radios), members shall adhere to the following procedure.

Field Assignments

1. When field platoon duty personnel identify a suspect portable radio they shall immediately notify their officer in charge.

2. The officer in charge will contact the respective administrative battalion office to coordinate a "loaner" radio from the battalion radio cache.

3. All portable radios will be exchanged on a "one for one" basis. At the time of exchange of the suspect radio for a Battalion cache radio, the Battalion Commander shall ensure that OCD is notified of the exchange and that the replacement radio identification number and suspect radio identification number is provided so the radio inventory data base can be updated.

4. After OCD has updated the data base, the Battalion Commander shall ensure that a "emergency trigger" activation test is completed with the replacement radio to ensure proper operation and accurate assignment information.

5. An F-2 entry shall be made documenting the above procedures.

6. After replacement, the Battalion office shall notify the Fire Communications Section telephonically of the need to have a radio repaired. Information required would include, radio type, identification number, assignment (position specific) and suspect problem with the device. The Fire Communications Section will coordinate the pick up and return of the radio. A receipt will be issued at time of pick up, but a loaner radio WILL NOT be provided.

7. The radio shall be tagged indicating assignment and information as to what the specific issue is regarding its functionality (i.e. “does not transmit”, “volume control does not function” etc…).

8. After servicing, the Fire Communications Section will return the unit to the respective Battalion office. After which, steps #3, #4 and #5 above shall be followed to swap the radio back to its original assignment.

Special Duty or Administrative Assignments

Suspect radios within administrative bureaus should follow notification procedures to their immediate supervisor for documentation. The Fire Communication and Dispatch Support Section shall be notified and a replacement (loaner) radio will be issued while the suspect radio is being repaired. Following repair, the Fire Communications Section will contact the member for return of the original assigned radio.

Conclusion

Communications systems for public safety use the same basic communication technologies as other industries, but the needs of the fire service often are unique. These unique requirements, primarily the frequent use in IDLH environments, require different solutions than those of other radio system users.

It is important that fire service members understand the systems they have in service and use their knowledge to ensure effective communications.

The fire service has unique communications needs related to operating in hazardous atmospheres with protective equipment. Although the general communications needs of the fire service often are represented, it is important that these needs are presented clearly to the manufacturers, standards-making bodies, and regulatory agencies. The only way to achieve a favorable outcome is to participate and inform.