

297

NFPA 297

Guide on

Principles and Practices
for Communications

Systems

1995 Edition



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The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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NFPA 297

Guide on

**Principles and Practices for
Communications Systems**

1995 Edition

This edition of NFPA 297, *Guide on Principles and Practices for Communications Systems*, was prepared by the Technical Committee on Public Fire Service Communications and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 22-25, 1995, in Denver, CO. It was issued by the Standards Council on July 21, 1995, with an effective date of August 11, 1995, and supersedes all previous editions.

This edition of NFPA 297 was approved as an American National Standard on August 11, 1995.

Origin and Development of NFPA 297

The Guide on Telecommunications Systems was originally published by the NFPA in 1975. Its purpose was, and still is, to provide general information relating to communication requirements of agencies involved in wildfire suppression operations. The guide was revised by the Technical Committee on Forest and presented to the Association for adoption at the 1985 Fall Meeting as NFPA 297.

During the 1995 Annual Meeting revision cycle, the title of the document was changed to reflect that communication systems are used in many applications. Communication systems are an integral resource for proper incident management, span of control, accountability, and personnel safety.

Communication systems are changing daily. Today, the ability to track personnel and apparatus is instantaneous. Geographic positioning systems (GPS), automatic vehicle locating systems (AVS), enhanced 911 (E-911), cellular phones, mobile data terminals, and computer-assisted dispatch have enhanced communication capabilities.

The technical committee members will continue to keep current with changing technology and terminology, and incorporate those changes into future editions. These changes will also be reflected in NFPA 1221.

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NOTE: Membership on a Committee shall not in and of itself constitute an endorsement of the Association or any document developed by the Committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents relating to the operation, installation and maintenance of public fire service communication systems.

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Information on referenced publications can be found in Chapter 6 and Appendix D.

Chapter 1 Introduction

1-1 Scope.

1-1.1 This guide deals with systems and their components and operations that involve the transfer of information over a distance utilizing electrical or electronic means. It is intended to provide general information only. More specific technical data should be secured from manufacturers or communication specialists in state, provincial, or local governments.

1-2 Purpose.

1-2.1 The need for reliable communications has long been recognized in the fire service. This guide focuses on four basic elements in the communications requirements of a fire department. Included are communications between the public and the fire department; communications within the fire department under emergency and nonemergency conditions; communications among fire departments; and communications between the fire departments and other agencies.

1-3 General.

1-3.1 Radio, telephone, and other electronic equipment, operating procedures, and personnel training should enable messages to be conveyed as quickly and reliably as the situation requires. Messages should be sent and received correctly with no delay. Effective operating practices should be developed and training should be provided to meet the needs of each department. The measure of adequate service is the ability of the system to handle both emergency situations and the normal daily activities of the department.

1-4 History. In early America, fire companies were brought together by the ringing of bells and gongs, shouting, and word of mouth. In contemporary America, municipal fire department companies are equipped with direct line or radio signaling systems, while suburban or rural companies may alert volunteers with a loud, audible signal produced by siren or horn, or by radios or paging systems at their homes or businesses.

The need for reliable communications has long been recognized in the fire service and is exemplified by the crossed trumpets insignia on the chief officer's badge. The use of the trumpet as a megaphone by chief officers was one of the earliest methods of extending communications beyond the normal range of the human voice. The fire bell in the steeple was an early form of communication used to notify volunteers of the existence of a fire. Hand signals

had their beginning in the early days of the fire service and are still used successfully today. With the inventions of telephone, radio, and computers, the field of fire communications took giant leaps forward.

1-5 Definitions. Unless expressly stated elsewhere, the following terms will, for the purpose of this guide, have the meanings indicated below.

Acknowledgment. The act by which one operator signifies to another that a message has been received.

Added Information Message. A message sent to supplement a previous message and referred thereto.

Air Net. A radio communications network designed to provide air-to-air and air-to-ground communications for agency-owned or contract aircraft. Air nets are often designed on a regional basis.

Amplitude Modulation (AM). Modulation in which the amplitude of the carrier-frequency current is varied above and below its normal value in accordance with the audio, picture, or other intelligence signal to be transmitted. The magnitude of the radio wave is varied in accordance with the information to be transmitted or exchanged.

Antenna. A system of wires or electrical conductors employed for reception or transmission of radio waves. Specifically, a radiator that couples the transmission line or lead-in to space, for transmission or reception of electromagnetic radio waves. (Also known as aerial.) Also, a device used on a vehicle and at a station to radiate the transmitted signal and to receive a signal.

Approved. Acceptable to the authority having jurisdiction.

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Attenuation. The decrease in amplitude of a signal during its transmission from one point to another. It can be expressed as a ratio or, by extension of the term, in decibels.

Audio. The voice component of the transmitted signal. The normal ear responds to audio frequencies.

Authority Having Jurisdiction. The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or

others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

Band. A range of frequencies between two definite limits. By international agreement, the radio spectrum is divided into nine bands. Also, a term applied to a group of frequencies.

Bandwidth. The width of a band of frequencies used for a particular purpose. Also, the range of frequencies within which a performance characteristic of a device is above specified limits. For filters, attenuators, and amplifiers, these limits are generally three decibels below the average level. Half power points are also used as limits.

Base. Short for "base station."

Base Station. A land station in the land mobile service carrying on a service with land mobile stations. Also, the two-way radio transmitting location.

Battery Drain. The amount of electrical power taken from the battery through use of the two-way radio equipment. Usually measured in amps.

Broadcast. Radio or television transmission intended for general reception.

Broadcasts.

(a) *Broadcast.* The transmission of a message to the coded area concerned.

(b) *Direct Message.* A message addressed to a specific point or points on a system.

(c) *All Points Bulletin (APB).* A message direction indicating that the message is to be sent to all points.

Cable. One or more insulated or noninsulated wires used to conduct electrical current or impulses. Grouped insulated wires are called a multi-conductor cable.

Cancellation. A message that cancels another, without delay.

Capture Ratio. The ability of an FM radio receiver to reject unwanted signals and interference on the same frequency as a desired signal, measured in decibels. The lower the figure, the better the receiver performance.

Carrier. Radio wave radiated without modulation by a transmitter. Also, an electromagnetic wave at a specific frequency.

Carrier Frequency. The frequency of an unmodulated electromagnetic wave.

Channel. Sometimes used synonymously with "frequency." It is the electronic signal path through which radio frequency flows.

Channel Bandwidth. The difference between the upper and lower frequency limits of a channel, expressed in hertz.

Channel, Point-to-Point. A radio channel used for radio communication between two definite, fixed stations.

Channel, Radio. An assigned frequency of sufficient width to permit its use for radio communication. The necessary width of a channel depends on the type of transmission and the tolerance for the frequency of emission.

Chassis. The part of the two-way radio that contains the transmitter and receiver assemblies.

Coaxial Cable. A transmission line in which one conductor completely surrounds the other, the two being coaxial and separated by a continuous solid dielectric or by dielectric spacers. (Also called a coaxial line or concentric line.)

Co-Channel Interference. Interference caused by other parties using the same transmitting frequency already being used.

Communication Center. A building or portion of a building specifically configured for the primary purpose of providing emergency communication services to one or more public safety agencies under the authority(ies) having jurisdiction. This facility should apply to all areas necessary for operation, domicile, and the installation of necessary equipment.

Communications Channel. Similar to a radio frequency, but more general. It is a medium over which communications are established and carried out.

Communications Link. Established communications between two parties.

Communications Network. A combination of links that are complete as to some specific function (e.g., a network to serve command personnel; a network to serve air-to-air control).

Communications System. A combination of links or networks that serve a general function (e.g., a ground attack communications system made up of command, tactical, service, and intracamp networks).

Continuous Duty. A rating applied to receivers and transmitters to indicate their capability for use in a continuous duty cycle (as opposed to the term "intermittent duty").

Control Console. A panel that contains controls to operate communications equipment.

Couple. To connect two circuits so that signals are transferred from one to the other.

Crystal. A device that controls the exact operating frequency of the transmitter or receiver.

Crystal Controlled. Radios in which each operating frequency is determined and controlled by a vibrating quartz crystal. This limits the number of channels available because of the physical size of the crystals required.

Crystal-Controlled Oscillator. An oscillator in which the frequency of oscillation is controlled by a piezoelectric crystal.

Crystal-Controlled Transmitter or Receiver. A radio transmitter or receiver in which the carrier frequency is controlled directly by a crystal oscillator.

Directional Antenna. An antenna possessing the ability to strongly radiate signals in a specific direction.

Directivity. The value of the directive gain of an antenna in the direction of its maximum value. The higher the directivity value, the narrower the beam in which the radiated energy is concentrated.

Dispatcher. Common name applied to the station operator who relays message traffic in the system. (*See Operator.*)

Distortion. Unfaithful reproduction of audio or video signals due to changes occurring in the waveform of the original signal somewhere in the course it takes through the transmitting and receiving system. Classified as linear, frequency, and phase distortion.

Duplex Channel. A communications channel providing simultaneous transmission in both directions. (*For comparison, see Simplex Channel.*)

Duplex Operation. A method of operation in which communication between stations takes place in two directions simultaneously. A separate channel is necessary for each direction of transmission. (*For comparison, see Simplex Operation.*)

Electromagnetic Energy. The type of energy contained in any electromagnetic wave such as radio waves, visible light, x-rays, gamma rays, or cosmic rays. The frequencies of radio waves go up to about 300,000 MHz.

Electromagnetic Radiation. Radiation associated with a periodically varying electric and magnetic field that is traveling at the speed of light, including radio waves, light waves, x-rays, and gamma radiation.

Energy, Radio Frequency. See Electromagnetic Energy.

Facsimile (Fax). Facsimile is the process whereby images (either print or picture) are translated into an electric signal, transmitted over a communications link, and reconstituted at the receiving end into the original image.

Fade. The variation of radio field strength caused by a gradual change in the transmission medium.

Fade Margin. The number of decibels of attenuation that can be added to a specified radio frequency propagation path before the signal-to-noise ratio of the channel falls below a specified minimum.

Fire Department. An organization providing rescue, fire suppression, and related activities. The term "fire department" shall include any public, governmental, private, industrial, or military organization engaging in this type of activity.

Frequency. The number of cycles per second; the reciprocal of the period. Usually refers to the assigned channel. Literally means the time taken by a signal to complete one cycle.

Frequency Deviation. Frequency deviation of an FM signal is the change in the carrier frequency produced by the modulating signal. The frequency deviation is proportional to the instantaneous amplitude of the modulating signal.

Frequency Modulated (FM). The frequency of the radio wave is varied in accordance with the information to be transmitted or exchanged.

Frequency Modulation (FM). A method of modulating a carrier-frequency signal by causing the frequency to vary

above and below the unmodulated value in accordance with the intelligence signal to be transmitted. The amount of deviation in frequency above and below the resting frequency is at each instant proportional to the amplitude of the intelligence signal being transmitted. The number of complete deviations per second above and below the resting frequency corresponds at each instant to the frequency of the intelligence signal being transmitted.

Frequency Stability. The ability of the transmitter to keep the transmitted signal within predetermined limits. (All signals radiate energy outside of their intended paths.)

Generator. A device that develops either direct or alternating electrical voltage at any frequency.

Global Positioning System (GPS). A precise radio positioning system utilizing satellites.

Guard Band. A narrow band of frequencies provided between adjacent channels in certain portions of the radio spectrum to prevent interference between stations.

Half-Duplex Channel. A communications channel providing duplex operation at one end of the channel, but not the other. Typically, the base station is operated in the duplex mode. (*For comparison, see Simplex Channel and Duplex Channel.*)

Handset. A telephone-type combination microphone/speaker that allows privacy of sending and receiving messages.

Hertz (Hz). A unit of frequency expressed in cycles per second. One Hz equals one cycle per second.

High Band VHF. Radio frequencies from 132 MHz to 174 MHz.

Incident Management System. An organized system of roles, responsibilities, and standard operating procedures used to manage emergency operations. Such systems are often referred to as Incident Command Systems (ICS).

Interference. See Radio Interference.

Jurisdiction. Any government unit, such as a federal agency, state, county, city, town, or fire-protection district.

Keying. Activating the transmitter. When the push-to-talk button is pressed, the transmitter is keyed.

Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Link. A transmitter-receiver system and transmission medium forming a two-way path for the transmission of information.

Listed. Equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the

equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

Local Control. Term applied to a locally (rather than remotely) operated station.

Low Band VHF. Radio frequencies from 30 MHz to 50 MHz.

Megahertz (MHz). A common technical term that refers to the frequency of the radio. One MHz equals 1,000,000 cycles, or hertz, per second.

Microwave. A term applied to radio waves in the frequency range of 890 MHz and above.

Mobile Unit. A two-way radio-equipped vehicle or person. Also, sometimes the two-way radio itself, when associated with a vehicle or person.

Modulation. The process of modifying some characteristic of an electromagnetic wave (called a carrier) so that it varies in step with the instantaneous value of another wave (called a modulating wave or signal). The carrier can be a direct current, an alternating current (provided its frequency is above the highest frequency component in the modulating wave), or a series of regularly repeating, uniform pulses called a pulse chain (provided their repetition rate is at least twice that of the highest frequency to be transmitted). Also, the strength of a voice applied to the microphone.

Monitor. To listen to radio messages without transmitting.

Multi-Channel System. A radio system that uses more than one radio channel. Also known as multi-frequency system.

Multiplexer. A device that simultaneously transmits two or more signals over a common carrier wave.

Noise. Interference characterized by undesirable random voltages caused by an internal circuit defect or by some external source.

Noise Cancelling. This term is applied to microphones that blank out bothersome background noises and permit communication in high-noise areas.

Omni-Directional Antenna. An antenna that radiates signals with equal strength in all directions.

Operator. A person or persons certified to receive or retransmit an alarm in the communication center.

Output. The energy resulting from the work the radio performs. Power output is the strength of the signal as it leaves the transmitter. Audio output is the strength of the voice wave as it leaves the speaker. Both are usually measured in watts.

Pager. A compact radio receiver used for providing one-way communications.

Portable Radio. A completely self-contained radio that can be moved from one position to another.

Power Source. The power obtained from the utility distribution system, an engine-driven generator, or a battery.

Power Supply. A device that receives its input power from a power source and converts the input power to the alternating current or direct current voltage(s) required to operate the system.

Propagation Characteristics. Descriptions of how effectively a radio wave is transmitted from one place to another.

Propagation (Electromagnetic). The travel of electromagnetic waves through a medium.

Public Safety Answering Points (PSAP). An identified location for the receipt and routing of emergency calls.

Radio-Frequency Power. The power associated with any signal consisting of electromagnetic radiation that is used for communications.

Radio Interference. Undesired disturbance of radio reception.

Radio Network. A number of radio stations, fixed and mobile, in a given geographical area that are jointly administered or that communicate with each other by sharing the same radio channel or channels.

Radio Receiver. An instrument that amplifies radio-frequency (RF) signals, separates the intelligence signal from the RF carrier, amplifies the intelligence signal in most cases, then converts the intelligence signal back into its original form.

Radio Station. A fixed or mobile installation that is equipped to transmit and receive radio signals.

Radio Transmitter. A radio-frequency power source that generates radio waves for transmission through space.

Relay Station. See Repeater Station.

Repeater Channel. A two-frequency channel that utilizes an intermediate repeater to extend the range of the channel. The repeater unit simultaneously receives on one frequency and transmits on another.

Repeater Station. An operational station established for the automatic retransmission of communications.

Selective Call. A system for communicating individually with selected vehicles, stations, or personnel.

Sensitivity (of a Radio Receiver). The minimum input signal needed by a radio receiver to produce a specified output.

Shadow Area. A dead spot in a communicating area where radio communication is difficult or impossible.

Should. Indicates a recommendation or that which is advised but not required.

Side Band. A frequency band above and below the carrier frequency, produced as a result of modulation.

Simplex Channel. A communications channel providing transmission in one direction only at any given time. (For comparison, see *Duplex Channel*.)

Simplex Operation. A method of operation in which communication between two stations takes place in only one direction at a time. (For comparison, see *Duplex Operation*.)

Single-Frequency Channel. A channel that is direct from transmitter to receiver. Transmitter and receiver frequencies are identical.

Spectrum. Any series of radiant energies arranged in order of frequency.

Squelch. A system for removing objectionable background noise by desensitizing the receiver.

Station Identifier. The radio call sign assigned by the Federal Communications Commission.

Telephone Patch. An instrument that allows a radio to be used as an entrance and exit point from the commercial telephone system.

Text. The body of a message.

Traffic. A message, or communication, between stations.

Transceiver. Combined transmitter and receiver unit.

Transmission Line. A communication medium used to transfer energy from one location to another.

Trunk Line. A telephone line or channel between telephone central officers or switching devices, including lines to the fire alarm telephone switchboard.

Two-Way Radio. A radio that is able to both transmit and receive.

Ultra High Frequency (UHF). Radio frequencies from 300 MHz to 3000 MHz.

Unit Identifier. An identifier assigned by the licensee to a mobile unit for exact identification.

Very High Frequency (VHF). Radio frequencies from 30 MHz to 300 MHz.

Chapter 2 Basic Concepts

2-1 System Elements. There are four basic elements in the communications requirements of a fire-protection agency. Each plays an essential part in enabling the fire department to meet its protection responsibility. The particular method used should provide for each element in order to be effective. (See Figure 2-1.)

Radio, telephone, and other electronic equipment, operating procedures, and personnel training should enable messages to be conveyed as quickly and reliably as the situation requires. Messages should be sent and received correctly with no delay. Time delay and the number of messages to be handled are strongly interrelated with service. Systems and equipment should be provided so that the public can notify the fire department of fires or other emergencies. Attention should be given to message types, the number and length of messages, the equipment capabilities, radio frequencies, and system organization. Effective operating practices should be developed and training should be provided to meet the needs of each agency. The measure of adequate service is the ability of the system to handle emergency situations as well as the normal daily activities of the agency. A major conflagration, or multiple fires, generates a much greater need for communications than do normal daily activities.

2-1.1 Communications Between the Public and the Fire Agency. Communications between the public and the fire department revolve around several areas:

(a) Calls from the public for emergency assistance or for reporting fires;

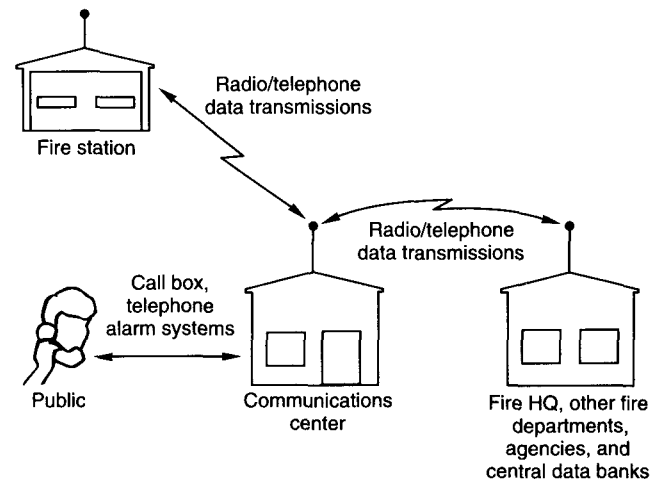


Figure 2-1 Fire communications.

- (b) Calls from the public giving information to, or requesting information from, the fire department; and
- (c) Calls from the fire department to the public.

Calls from the public, usually received through the telephone system, giving or requesting information, can be of an emergency nature. Whether or not such a call is an emergency is decided by the individual answering the telephone. Many fire departments maintain different administrative and emergency telephone numbers to keep the two types of communications separate. Calls from the fire department to the public usually are of an administrative nature. 9-1-1 (universal emergency number) reporting has become common. (See Figure 2-1.1.)

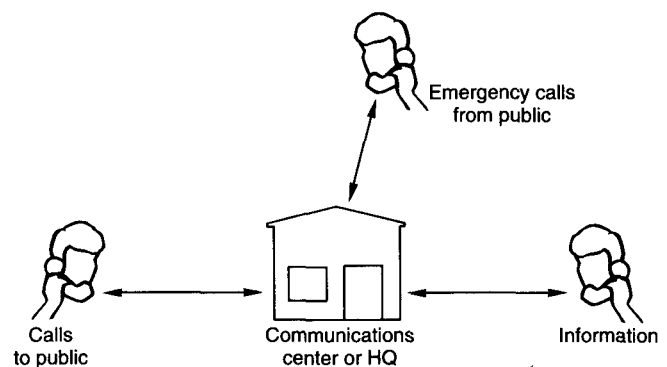


Figure 2-1.1 Typical fire department communications with the public.

2-1.2 Communications within the Fire Department. Communications between members of the fire department include emergency and nonemergency messages. Communications can be accomplished by radio, telephone, or other transmission methods and might involve the dispatcher, radio-equipped vehicles (land, water, or air), personnel equipped with two-way radios, or personnel at outlying stations in a variety of situations. (See Figure 2-1.2.) Examples of such communications are as follows:

- (a) The dispatcher gives information to the fire stations and mobile equipment.
- (b) Personnel report location and work status to the dispatcher for emergency assignment.

(c) The dispatcher gives coordination information and status to personnel and equipment responding to an emergency.

(d) Incident commanders give instructions to personnel under their command.

(e) Tactical communications at a fire or other emergency scene.

(f) The information on status of personnel and equipment, fire danger rating, weather forecasts, and outdoor burning.

2-1.3 Communications Among Fire Departments. Many fire departments supply neighboring departments with requested information. Such communications are necessary because many small agencies depend on mutual aid agreements. In addition, many fire departments have common information needs.

Incidental or nondirected communication among agencies occurs whenever one agency monitors the transmissions of another, although the information is not specifically intended for interagency distribution. Most of this kind of communication is by radio, especially among agencies that share a radio channel. (When agencies have a choice of channels on which to operate, they must weigh the advantages of mutual monitoring by all system users against the disadvantages of greater message traffic and the resulting problems of channel loading.) This kind of communication is no less important than directed communication, for it allows one agency to be aware of situations in another community or area that may spill over or involve it directly in a short time.

Monitoring of nearby fire departments or fire department transmissions helps the listener to anticipate the need for mutual aid and to be aware of the level of emergency activity in an area larger than the department's or agency's own boundaries. If two fire departments anticipate a need for mutual aid or cooperation, they frequently monitor each other's calls even when not on the same radio channel. Monitor receivers at the dispatcher positions are generally used.

Special mutual aid radio frequencies or channels for mobile use only have been licensed so that fire departments from adjacent jurisdictions can communicate directly with each other. Such a channel can assist normal day-to-day interagency communication needs and emergency communication during widespread disasters. The

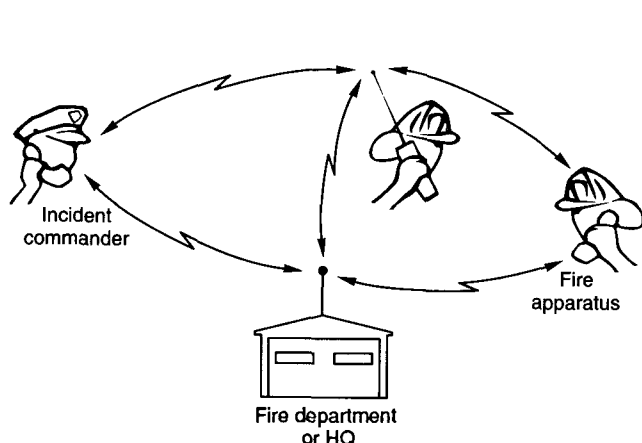


Figure 2-1.2 Fire department radio communications.

channels can serve as command channels for interagency communication. Although these are helpful, there are also problems with them. The frequencies can become overloaded very quickly. The multi-channel mobile radio allows all radio traffic to be conducted on the "Agency in Charge" radio system, from initial attack through large fire operations. (See Figure 2-1.3.)

2-1.4 Communications Between the Fire Department and Other Agencies. Another function of a communications system is to pass messages between the fire department and public safety oriented agencies, such as public works, highway maintenance departments and utilities, hospitals and ambulance services, towing and wrecker services, law enforcement agencies, civil defense units, industries, media, and weather forecasters.

Fire departments exchange a large variety of information with nonfire agencies. Since many of these agencies are radio equipped, they can be of assistance during large fires or other major incidents.

One of the greatest demands for communications with other agencies can occur during major emergencies. The ability to meet this problem necessitates planning for message volumes and for possible language barriers. Communications for a fire department or fire agency should include contingency plans for emergency situations. During an emergency there is little time to set up new communications links. The volume of messages to be handled is likely to exceed most estimates, so plans should include means for handling the volume of message traffic to prevent system breakdown due to overloading. Concerned public and media can rapidly overload a telephone system. Nonfire agencies might not understand the standard language of fire radio. Therefore, liaison personnel familiar with the radio language of the fire service and the assisting organizations are needed to maintain effective communications. Any incident management system should include two important communications concepts, that should improve communications effectiveness during major emergencies. These are:

- (a) Common terminology — using clear text or plain language and established standard terms and phrases, and
- (b) Integrated incident communications — intending the best possible use of all participating agency radio systems including frequency-sharing agreements. (See Figure 2-1.4.)

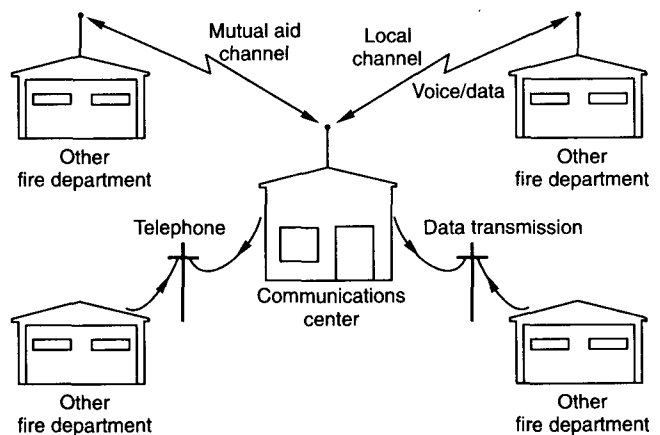


Figure 2-1.3 Interdepartmental communications.