PART II

TECHNICAL INFORMATION ON RADIO COMMUNICATIONS

The radio-frequency spectrum is a national and international resource in the public domain. Since 1906, international administrative radio conferences have controlled the orderly development of this vital natural resource through carefully planned frequency allocations to various radio services.

The Federal Communications Commission (FCC), established by Act of Congress in 1934, controls frequency allocations in the United States to various non-government radio services and licensed individuals.

Frequency Spectrum

"Radio waves" are confined to that portion of the electromagnetic frequency spectrum extending from 3 kilo Hertz (3,000 Hertz or 3,000 cycles per second) to approximately 3,000 Giga Hertz or three trillion cycles per second. See Table 3. Since a normal voice channel requires a minimum of about 3,000 cycles/second (Hertz) of band width, it would appear that the radio frequency spectrum has about one billion voice channels available for assignment. Such is not the case. Many of the frequency bands are either inappropriate for land mobile use or are already assigned for other purposes.

Table 3: Radio Spectrum Frequency Bands

Band Designations		
Very Low Frequency (VLF)	3-30 kc/sec	(kHz)*
Low Frequency (LF)	30-300 kc/sec	(kHz)
Medium Frequency (MF)	300-3,000 kc/sec	(kHz)
High Frequency (HF)	3-30 Mc/sec	(MHz)
Ultra High Frequency (UHF)	300-3,000 Mc/sec	(MHz)
Super High Frequency (SHF)	3-30 Gc/sec	(GHz)
Extremely High Frequency (EHF)	30-300 Gc/sec	(GHz)
	300-3,000 Gc/sec	(GHz)
	or 3 Tc/sec	(THz)

* Abbreviations generally used are:

Hertz (Hz)	=	cycles/second (C/sec)
Kilo (k)	=	1,000
Mega (M)	=	1,000,000
Giga (G)	=	1,000,000,000
Tera (T)	=	1,000,000,000,000

Frequency Bands

1. *Very Low (VLF), Low (LF), and Medium Frequency Bands (MF)*

These frequencies, located below 3,000 kHz, were the first of the radio portion of the electromagnetic frequency spectrum to be developed and exploited. They are not used extensively for land mobile services because their transmitting antennas require rather large dimensions and were occupied for broadcast, maritime mobile, and radio navigation services long before the land mobile services needed spectrum space.

2. *High Frequency Band (HF)*

The HF portion of the spectrum is not used in the land mobile service because of its great range – sometimes thousands of miles – brought about by the presence of ionization layers in the upper atmosphere which reflect or refract these frequencies and return them to earth.

3. *Very High Frequency Band (VHF)*

The VHF band contains many of the frequencies available to the land mobile radio services which include emergency medical services communications. See Tables 4-A and 4-B. Arbitrarily, this band has been subdivided into what is commonly referred to as Low-Band (30-50 MHz) and High-Band (150-175 MHz) frequencies.

The low-band frequencies are characterized by somewhat greater normal range than high-band frequencies. When ionospheric conditions are favorable, the range may extend to 2,000 miles or more. These bursts of extreme range are unpredictable since ionospheric conditions change with time of day, with the time of year, and with the level of solar activity. These conditions can plague the land mobile service with "skip" interference and provide the amateur radio operator with excellent "DX" or long distance communication capability.

The high-band frequencies are almost totally free of "skip" interference, but achieve less normal range. At these higher frequencies vehicle antennas have smaller dimensions and noise levels are somewhat lower than those experienced in the low-band frequencies.

4. *Ultra-High Frequency Band (UHF)*

The UHF band assignments for land mobile radio service are in the 450-470 MHz range and the FCC has recently allocated seven frequency pairs in this band for use by biomedical telemetry systems. See Table 4-C. At these frequencies communications are completely free of "skip" interference and the noise level is low. Because radio waves are reflected from the earth and solid structures such as buildings, the UHF band exhibits better penetration in dense metropolitan areas. UHF band radio waves can be received quite well inside buildings with large windows. The UHF band has a shorter range than the VHF band; and energy at these higher frequencies is more readily absorbed by trees and foliage.

The radio frequency spectrum above 450-470 MHz and within the UHF band has not yet been used extensively for land mobile service. However, the mounting pressure for more frequencies may result in the opening of this portion of the spectrum to the land mobile service.

5. *Super High (SHF) and Extremely High Frequencies (EHF)*

The difficulty and expense involved in generating these frequencies at the required power levels generally limits their use for mobile communications at this time.

Emergency Radio Frequency Assignments

At the present time, except for two frequencies in the Medium Frequency (MF) band, the FCC has set aside VHF band assignments for general emergency medical radio communications and UHF band assignments for ambulance to hospital telemetry systems. Tables 4-A and 4-B show the VHF frequencies which are available to the Special Emergency Radio Service which includes hospitals, ambulance and rescue organizations, physicians and veterinarians, disaster relief agencies, school buses, beach patrols, establishments in isolated areas, and common carrier standby and repair facilities. The UHF frequencies can be assigned for biomedical telemetry operations to eligible licensees in the Fire, Local Government, and Special Emergency Radio Services (hospital, ambulance operators or rescue squads).

The Federal Communications Commission* has provided seven base-mobile frequency pairs in the 460 MHz band for these operations. See Table 4-C. In summarizing the rule changes adopted March 23, 1972 to establish ambulance to hospital biomedical telemetry systems the Commission stated:

> *All of these frequencies are available in the Special Emergency Radio Service. The mobile frequencies are primarily assignable for telemetry transmissions, but supplemental voice operations related to the telemetry activity may also be conducted on mobile frequencies. The five base-designated frequencies 463.000 through 463.100 MHz are assignable for hospital to vehicle voice communications regarding the telemetry activity. They may also be used to accommodate the need for portable telemetering from patients before they can be placed into ambulances to telemeter from the patients through ambulance radios to a hospital (portable to mobile/mobile-relay). The two base-designated frequencies 460.525 and 460.550 MHz are assignable only for central dispatching of ambulance telemetry systems under an area-wide communication plan for coordinated use of telemetry frequencies. They may be assigned in the*

*Federal Communications Commission, Report and Order, Docket No. 19261, released March 29, 1972.

Special Emergency and Local Government Radio Services, in addition to the Fire Radio Service, for this purpose. (No other 460 MHz frequency is available for dispatching ambulance telemetry systems.) The two mobile-only frequencies, 465.525 and 465.550 MHz, also are availble under an area-wide communication plan for central dispatching which will permit their use of telemetry when they are needed for the latter purpose. These communications plans may incorporate a single licensee dispatching multiple telemetry systems, or a group of licensees operating independent or shared telemetry systems, or both. The object is to encourage and maximize the most effective use of the limited number of frequencies available for these purposes in a given area.

Permissible Communications

FCC regulations permit the following uses of the frequencies allocated to the special emergency radio service:

Hospitals – Except for test transmissions stations licensed to hospitals may be used only for the transmission of messages necessary for the rendition of an efficient hospital service.

Ambulance Operators and Rescue Organizations – Except for test transmissions stations licensed to ambulance operators or rescue squads may be used only for the transmission of messages pertaining to the safety of life or property and urgent messages necessary for the rendition of an efficient ambulance or emergency rescue service.

Test Transmissions

Tests may be conducted by any licensed station as required for proper station and system maintenance, but such tests shall be kept to a minimum and precautions shall be taken to avoid interference to other stations.

Table 4A
LOW BAND VHF RADIO FREQUENCIES
FCC Allocations – Type Radio Service by Frequency
Limited to those frequencies assigned to the
SPECIAL EMERGENCY RADIO SERVICE (SER)
and adjacent frequencies

FREQUENCY (MHz)	SER with limitations*	OTHER ALLOCATIONS	FREQUENCY (MHz)	SER with limitations*	OTHER ALLOCATIONS
33.00		GOV	46.00	x (3)	
33.02	x (2)	HMR	46.02		PRS
33.04	x		46.04	x (3)	
33.06	x (2)	HMR	46.06		FRS
33.08	x		47.40		HMR
33.10	x (2)	HMR	47.42	x (4)	
33.12		SIR	47.44		SIR
37.88		PwrR	47.46	x	
37.90	x (2)	HMR	47.48		SIR
37.92		HMR	47.50	x	
37.94	x (2)	HMR	47.52		SIR
37.96		HMR	47.54	x	
37.98	x (2)	HMR	47.56		SIR
38.00		GOV	47.58	x	
45.90		PRS	47.60		SIR
45.92	x (3)		47.62	x	
45.94		PRS	47.64		SIR
45.96	x (3)		47.66	x	
45.98		PRS	47.68		SIR

Abbreviations Used:

SER - Special Emergency Radio Service
FRS - Fire Radio Service
GOV - U.S. Government
HMR - Highway Maintenance Radio Service
LGR - Local Government Radio Service
PRS - Police Radio Service
PwrR - Power Radio Service
SIR - Special Industrial Radio Service

Table 4A (Continued)

*Limitations (numbers in parentheses <u>on preceding page</u> are explained)

1. Those frequencies which are not assigned to the Special Emergency Radio Service (SER) are listed because they are possible assignments in neighboring areas which may affect licensing.
2. This frequency is shared with the Highway Maintenance Radio Service.
3. Available for assignment: Provided that until further order of the Federal Communications Commission, application is accompanied by a written and signed statement that licensees of all stations—*excluding Special Emergency stations*—located within the radius of 75 miles of the proposed location, and authorized to operate on a frequency 30 kHz or less removed, have concurred with such assignment, or is accompanied by an acceptable engineering report indicating that harmful interference to the operation of such existing stations will not be caused.
4. This frequency is reserved for assignment only to national organizations established for disaster relief purposes.

Table 4B
HIGH BAND VHF RADIO FREQUENCIES
FCC Allocations – Type Radio Service by Frequency
Limited to those frequencies assigned to the
SPECIAL EMERGENCY RADIO SERVICE (SER)
and adjacent frequencies

FREQUENCY (MHz)	SER with limitations*	OTHER ALLOCATIONS	FREQUENCY (MHz)	SER with limitations*	OTHER ALLOCATIONS
155.130		PRS	155.295	x (3)	
155.145		LGR	155.310		PRS
155.160	x (2)		155.325	x (3), (4)	
155.175	x (3)		155.340	x (2), (4)	
155.190		PRS	155.355	x (3), (4)	
155.205	x (3)		155.370		PRS
155.220	x (2)		155.385	x (3), (4)	
155.235	x (3)		155.400	x (2), (4)	
155.250		PRS	155.415		PRS
155.265	x (3)		155.430		PRS
155.280	x (2)				

Table 4B (Continued)

Abbreviations Used:

SER	- Special Emergency Radio Service	LGR	- Local Government Radio Service
FRS	- Fire Radio Service	PRS	- Police Radio Service
GOV	- U.S. Government	PwrR	- Power Radio Service
HMR	- Highway Maintenance Radio Service	SIR	- Special Industrial Radio Service

*Limitations (numbers in parentheses above are explained)

1. Those frequencies which are not assigned to the Special Emergency Radio Service (SER) are listed because they are possible assignments in neighboring areas which may affect licensing.
2. Applications for assignment (a) should be accompanied by a written and signed statement that licensees of all stations, authorized to operate on a frequency 30 kHz or less removed (except Special Emergency stations) within 75 miles of the proposed location, have concurred with such assignment; or (b) is accompanied by an acceptable engineering report that harmful interference to the operation of existing stations will not be caused.
3. Available for developmental operation if (a) the proposed station is located at least 40 miles from all other stations except authorized Special Emergency licensees on frequencies 30 kHz or less removed; (b) includes with the application a written and signed statement that the licensees of all stations except Special Emergency stations within 75 miles of the proposed location authorized to operate on a frequency 30 kHz or less removed, have concurred with such assignment; or (c) includes an acceptable engineering report that harmful interference will not affect the operation of existing stations (except Special Emergency stations) within the 75 mile radius; and (d) provides a written statement that licensees of all stations described in (c) have been notified of the applicant's request for the frequency assignment.
4. Available for assignment only to hospitals (institutions or establishments offering services, facilities, and beds for use beyond 24 hours in rendering medical treatment) and to those ambulances which submit a showing that they render coordination and cooperation with a hospital authorized on this frequency.

Table 4C
UHF BAND RADIO FREQUENCIES
FCC Allocations – Type Radio Service by Frequency
Limited to those frequencies assigned to the
SPECIAL EMERGENCY RADIO SERVICE (SER)
for Bio-Medical Telemetry

FREQUENCY (MHz)	Class of Station(s) with Limitations*	FREQUENCY (MHz)	Class of Station(s) with Limitations
460.525	Base & Mobile (1), (2)	465.525	Mobile only (1), (5)
460.550	Base & Mobile (1), (2)	465.550	Mobile only (1), (5)
463.000	Base & Mobile (1), (3)	468.000	Mobile only (1), (4), (6)
463.025	Base & Mobile (1), (3)	468.025	Mobile only (1), (4), (6)
463.050	Base & Mobile (1), (3)	468.050	Mobile only (1), (4), (6)
463.075	Base & Mobile (1), (3)	468.075	Mobile only (1), (4), (6)
463.100	Base & Mobile (1), (3)	468.100	Mobile only (1), (4), (6)

*Limitations (numbers in parentheses above are explained)

1. For two frequency systems, separation between base and mobile transmission frequencies is 5 MHz.
2. The frequency may be assigned (a) to dispatch ambulances and personnel operating bio-medical telemetry units under an area-wide radio communications plan; and (b) is available also for this purpose in the Fire and Local Government Radio Services.
3. This frequency is available for assignment to hospitals (institutions or establishments offering services, facilities, and beds for use beyond 24 hours in rendering medical treatment) for communication with medical care vehicles and personnel equipped with bio-medical telemetry capability. Use of this frequency is further authorized for telemetry or voice transmissions from a portable telemetering unit to an ambulance for automatic retransmission (mobile/relay) from a patient to a hospital or other medical care facility. When using telemetry emission, the continuous carrier mode of operation is authorized for this frequency.
4. This frequency is available for assignment to operate mobile bio-medical telemetry units in ambulances and other medical care vehicles, or when hand-carried by medical personnel. Telemetry transmission may be authorized. Voice transmission may also be authorized on a secondary basis when required for the telemetering activity. When using telemetry emission, the continuous carrier mode of operation is authorized for this frequency.

Table 4C (Continued)

5. This frequency may be assigned primarily for mobile dispatch response by ambulance and personnel operating bio-medical telemetry units in this service under an area-wide radio communications plan involving central dispatching on the associated base-mobile frequency 460.525 or 460.550 MHz. When authorized for this dispatch response purpose, this frequency may be used on a secondary basis for the purposes and in the manner set forth in limitations (1), (4), and (6).
6. Mobile stations authorized to operate on this frequency may be used to extend the range of transmission between portable telemetering units and hospitals or other medical care facilities. Each mobile station used for this purpose shall be so designed and installed that it will be activated only by means of a continuous tone device, the absence of which will deactivate the mobile transmitter. The continuous tone device is not required when the mobile station is equipped with a switch that must be activated to change the mobile unit to the automatic mode.

Available Equipment

Manufacturers offer communications components for land mobile radio service which have common characteristics: virtually all use frequency modulation (FM) and all are almost completely solid state. (Transistors and Integrated Circuits (IC) are used wherever possible).

The specifications are very similar. Practically all of this equipment exceeds the standards established by the Electronic Industries Association (EIA). Representative comparisons between the standards and manufacturers' specifications are shown in Table 5.

TABLE 5

EIA Standards And Manufacturers' Specifications
Mobile Receiver

	EIA Standards			Typical Manufacturers' Specifications		
Quantity Measured or Specified	25-54 Mc/sec	144-174 Mc/sec	400-470 Mc/sec	25-54 Mc/sec	144-174 Mc/sec	400-470 Mc/sec
Sensitivity (in Microvolts)	1.0	1.5	2.5	0.3	0.5	1.0
Selectivity (dB)	70	70	70	80	80	80
Spurious attenuation (dB)	85	85	80	100	100	90
IM spurious attenuation (dB)	50	50	50	60	60	60
Audio power output (watts)	1	1	1	2	2	2

Mobile Transmitter

Power output	N/A	N/A	N/A	80 watts	80 watts	60 watts
Frequency stability (%)	±.002	±.0005	±.0005	±.0005	±.0005	±.0005
Spurious radiation (dB)	43 + 10 log (power output)			53 + 10 log (power output)		

Following are brief discussions of the terms used in Table 5.

Frequency Modulation (FM)

Commercial radio equipment used in the VHF and UHF bands for land mobile radio service is not standardized on FM which more easily eliminates random noise, interference, and fading than amplitude modulation (AM) systems.

In FM, the carrier or radio frequency wave, shifts its assigned frequency at the same rate as the voice being transmitted. If the "ah-h-h" of a verbal pause in speech has a frequency, or tone, corresponding to 600 cycles per second, the carrier frequency (155.340 MHz for example) will shift both above and below this frequency at a 600 cycle per second rate. The amount or number of cycles (hertz) that the carrier shifts depends upon the loudness of the transmitted voice.

Narrow band FM has several advantages over the AM broadcast band:

1. The FM receiver is able to suppress the noises caused by vehicle ignition systems and electrical storms.
2. Two FM stations transmitting simultaneously do not block each other. (Tuning across the broadcast band at night will demonstrate how a comparatively weak AM signal can destroy the intelligibility of a much more powerful station with squeals and whistles.) When two FM stations are received simultaneously, the stronger signal takes over and communications capability is not destroyed for both. The stronger signal take-over is known as the "capture effect."

Amplitude Modulation (AM)

In AM, the amplitude of the carrier is made to vary according to the frequency of the intelligence signal. The amount of amplitude change varies with the loudness of the modulating signal.

Sensitivity

Sensitivity in an FM system is a measure of the signal level in microvolts (1 microvolt is one-millionth of a volt) required at the receiver antenna input terminal to produce a stated output. The universally quoted sensitivity measurement is the 12 dB (decibel) SINAD method.

DECIBEL – It is useful to evaluate signal strength in terms of relative loudness as perceived by the human ear. A decibel is a unit of such measurement, being approximately the smallest degree of difference in loudness ordinarily detectable by the human ear. (Ordinary speech is about 60 decibels louder than a sound just audible to the human ear. The total range of human hearing is about 130 decibels.)

SINAD – is an abbreviation for the ratio (SIGNAL + NOISE + DISTORTION) to (NOISE + DISTORTION) expressed in dB. A sensitivity of 0.25 microvolts for 12 dB SINAD means that a 0.25 microvolt signal will produce an output signal consisting of SIGNAL + NOISE + DISTORTION 12 dB louder than the NOISE + DISTORTION, heard when no signal is present at the receiver antenna input terminals.

Selectivity

The selectivity of a receiver determines the extent to which the receiver can differentiate between the desired signal and undesired signals at other frequencies. For example, consider a receiver with a channel spacing stated as 30 kHz and selectivity specified as 80 dB. An undesired signal 30 kHz above or below this receiver's assigned frequency would need a power level one hundred million times greater to produce the same level of output as a signal at the desired frequency. If these figures are converted to a voltage ratio, the undesired signal would have to be 10,000 times greater to produce the same output level as the desired signal.

Spurious Response Attenuation

Reduction of spurious response in receivers and spurious radiation in transmitters has increased with improved design and components. Prior to 1948, spurious responses and radiation were responsible for a large percentage of interference. Now, except in locations where several transmitters and receivers operate simultaneously, interference from spurious response is virtually eliminated.

Intermodulation (IM) spurious responses are a more serious interference problem. This type of interference is generated in a non-linear curcuit (all transmitters and receivers have them) by the mixture of two or more signals which fall in, or near, the affected frequency. For example, a 455 MHz signal and a 300 MHz signal mix to produce intermodulation frequencies of 755 MHz and 155 MHz. The latter frequency, if created at the input of a receiver tuned to receive 155 MHz, could cause considerable interference, depending upon its power level.

Eliminating Noise and Unwanted Signals

The radio frequency channel assignment of 155.340 MHz is not a private communications link within its particular service area. This channel is shared by all stations assigned that particular frequency. For example, if five ambulances, a dispatching center, and three hospitals all share the same frequency, and each receiver responds to every transmission, Continual chatter on this channel could be annoying to those not directly concerned. This unwanted reception is termed "botherance" – the effect of undesired signals when no desired signal is being received.

The *audio squelch circuit* was devised to eliminate the continual background noise heard when no signal is being received. This circuit uses the background noise itself to turn off the receiver audio circuits when the noise level is high. Since a received signal has a quieting effect upon background noise, this effect is used to turn the audio circuit on. The audio squelch circuit eliminates background noise, but does nothing to reduce the "botherance"of unwanted signals. In addition, adjacent channel transmissions

(15 or 30 kHz either side of the desired frequency) can sometimes quiet a receiver sufficiently to activate its squelch circuit and turn on the audio circuit. This action is known as "falsing."

The *tone-coded squelch circuit* was developed to eliminate unwanted signals. The *tone-coded squelch circuit* is activated by a low frequency audio tone incorporated in the transmitted signal. If the received signal includes the correct tone frequency, the squelch circuit is actuated and the receiver's audio circuits are turned on permitting the transmission to be heard. These circuits have several trade names such as "Channel Guard" and "Private Line." It must be noted, however, that they do not provide a private line nor do they guard any channel. These circuits eliminate unwanted signals but their improper use can create co-channel interference. Undesired signals received simultaneously with desired signals constitute co-channel interference. If one station of two or more co-channel systems assumes it has a "clear channel" and proceeds to transmit without first listening to determine that the channel *is* clear, it can be guilty of creating co-channel interference. Tone frequencies (60-250 c/s) which are below the audio frequency passband (300-3000 c/s) are used to operate tone-coded squelch systems.

Another means of turning on the FM receiver audio circuit uses pulsed tones. This digital tone system is controlled by a digital encoder which resembles a standard telephone dial. Dialing it causes the pulsed tones to be sent out over the air, the number of pulses corresponding to the number dialed. These pulses, when received by the radio receiver and decoded by the receiver's digital decoder, turn on the audio system. If the number of pulses of the correct frequency (two or three numbers are usually dialed) corresponds to the code address of a particular receiver, its audio circuits are activated. If a hospital's code address is 525 and the ambulance driver dials 525, that hospital's receiver is turned on. It does not prevent other users from listening in, but it does not bother them with messages of no concern to them.

Antenna Systems

The term "antenna gain" is often used in descriptions of radio communications systems and equipment. This term is derived from the methods used to measure antenna performance and can be explained by an analogy using light.

Let us assume that a source of light is placed at the center of a hollow sphere having an inside surface area of 100 square meters. This light will evenly illuminate the entire inner surface of the sphere and is known as an isotropic light radiator. If a perfect reflector of the correct shape and dimensions is placed at the proper distance from the source of light, the total illumination from the light will be concentrated into one area, just as a flashlight reflector concentrates its light into a narrow beam. Assume that this light is now concentrated in an area of one square meter on the sphere's inner surface. Since all of the illumination, previously evenly distributed over the 100 square meters, is now concentrated on one square meter of surface, the intensity of illumination on this area is 100 times greater than the intensity previously existing. The gain in illumination over this one square meter area is 100. Expressed in dB, it would be ten times the logarithm of 100 (which equals 2) or 20 dB of gain. In like manner, if an antenna radiation pattern concentrates the radiated energy in a desired direction as compared to an isotropic radio frequency radiator, it is said to have gain and the amount of gain is normally expressed in dB.

The antenna system plays an extremely important part in the transmission and reception efficiency of any radio communications system. Transmission power levels are limited by FCC rules and the reception minimum usable signal level is limited by local man-made noise. The antenna system can, to some extent, compensate for these limitations. Careful antenna selection, base station antenna site selection, and antenna height all can be used to adjust the coverage area needed by the communications system. Antenna configuration also can be used to fit the radiation pattern to the shape of the service area.

PART III

BIOMEDICAL TELEMETRY

Biomedical telemetry is the technique of measuring and transmitting certain vital life signs to a distant terminal. Vital life signs are assessed by monitoring the heart, lungs, brain, and temperature. Currently when the term "telemetry" is used in medical care it usually refers to the graphic presentation of heart action as expressed by an electrocardiogram. The method used to transmit electrocardiographic information to a distant point employs a reference audio tone, for example 1000 Hz, which is made to vary with the voltage generated by the action of the heart. This varying 1000 Hz tone is used to frequency modulate the radio transmitter. The signal received at the distant terminal is amplified and demodulated to produce a voltage which is an exact replica of the original. This voltage is converted to the graphic plot of the heart action.

An effective biomedical telemetry system cannot be limited to the transmission of telemetered data only. It must include channels for voice data interchange between the fixed and mobile terminals. The telemetry system may take one of several configurations depending upon the decisions made by the planning authority. If continuous telemetry data (ECG) is required by the planned system, then the ambulance must be equipped with one of the following configurations:

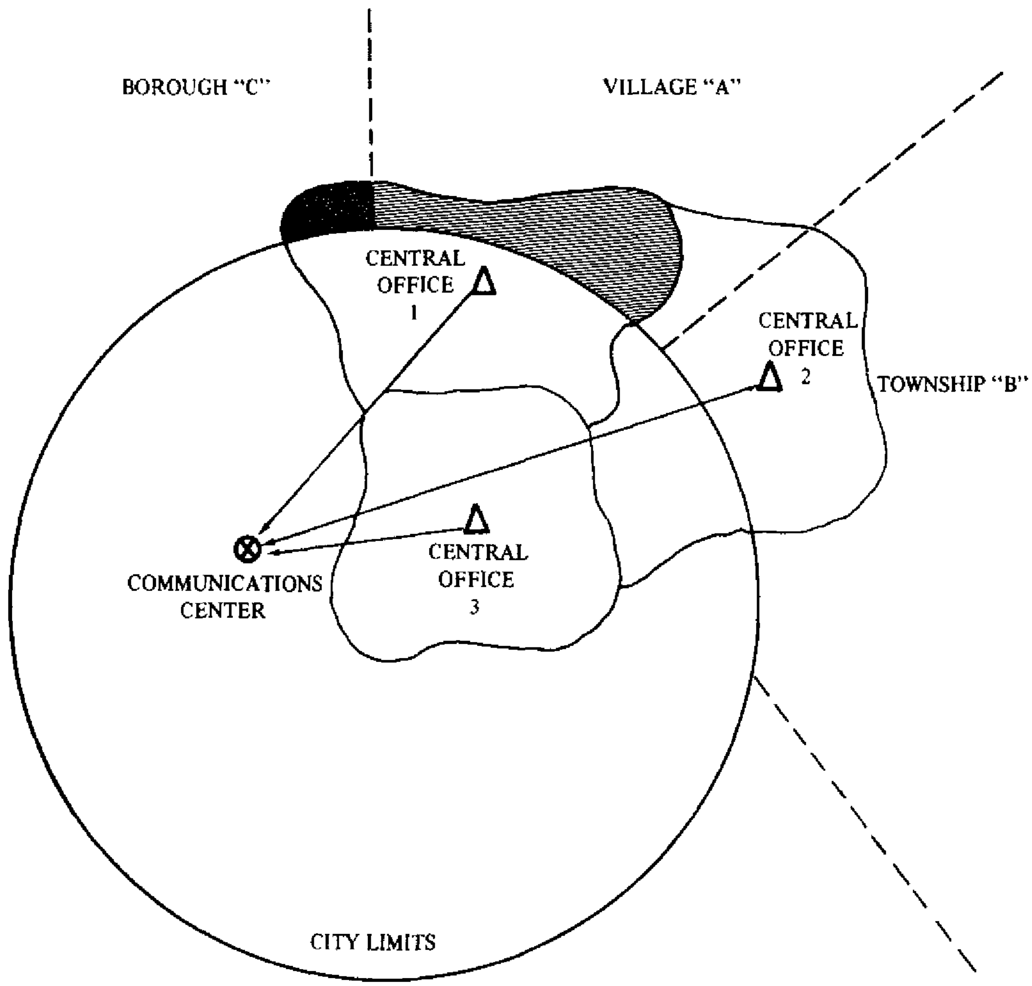
1. To transmit on both frequencies of a frequency pair allocated for telemetry, e.g., 463.000 and 468.000 MHz. This would require that the ambulance be equipped with two UHF transmitters and one UHF receiver. Telemetry would be transmitted to the fixed terminal on the mobile only frequency, 468.000 MHz, and voice data interchange between the fixed terminal and the ambulance would be transmitted on the base and mobile frequency, 463.000 MHz.

2. To multiplex (combine) both telemetry and voice data on the mobile only frequency of the telemetry frequency pair (468.000 MHz.) and receive voice data from the fixed terminal on the base and mobile frequency of the pair (463.000 MHz.). In addition, the fixed terminal must be equipped with demultiplexing equipment for each available channel to separate voice and telemetered data.

3. To transmit telemetry data on the mobile frequency of the telemetry frequency pair, and transmit ambulance voice data on one of the VHF frequencies, 155.340 MHz for example. (Remember that the VHF frequencies are shared with other eligible licensees.)

If the planned system does not require continuous telemetry, then the ambulance equippage will require a UHF transceiver configured to receive on the base station frequency of the frequency pair and transmit on the mobile frequency. The telemetered data can be transmitted in short bursts of data, say thirty seconds, interspersed with voice data interchanges between the ambulance and the fixed terminal. A refinement of this mode of operation would give the fixed terminal control of the telemetry transmission by providing the fixed station with a method of turning the telemetry transmission "on" or "off."

The Federal Communications Commission has allocated five frequency pairs in the 460 MHz region for exclusive use of biomedical telemetry systems, as shown in Table 4C.



Source: National Science Foundation

Figure 1: 911 Regional Concept

PART IV

THE 911 SYSTEM

In January of 1968, the American Telephone and Telegraph Company announced the establishment of Nine-One-One (911) as the single emergency telephone number for use in the United States. The single emergency number concept is not new. It has been used in England for more than thirty years.

The *911-system* can be described as an easy-to-remember, three-digit telephone number used to provide the general public with an immediate and direct access to emergency service resources. The system eliminates the need for the caller under stress to make decisions for which he may be ill-prepared, particularly when outside his home community.

About 230 of the *911-systems* exist today in jurisdictions which range in population from several thousand to several million. Although public acceptance generally has been favorable, Public Safety Agencies have sometimes been reluctant to adopt this system. Following is a discussion of the *911-system* which in part explains the problems which must be faced and solved by public officials and the public safety agencies.

Boundaries

Technically, it is possible to design a *911-system* to serve all of the continental United States from one central dispatch center. Operationally, however, it would neither be practicable nor economically feasible. Such a dispatch center could only have computer stored knowledge of the available emergency resources. Dispatch center personnel, however, must have a personal knowledge of the resources and must keep up with changes in them. The area, therefore, comprising a *911-system,* to be efficient, does have some size limitation; but the area does not have to conform to any geographic or jurisdictional boundaries. It will, however, normally coincide with jurisdictional boundaries. A system may be comprised of any or all of the following (see Figure 1) elements:

1. Telephone Central Office Area – in larger urban areas, political jurisdictions and boundaries of telephone central office areas rarely coincide.
2. Various jurisdictional areas – a city and miscellaneous surrounding townships, boroughs, villages, etc.
3. A *911-Communications-Center* for the entire region.
4. Various public safety organization locations. (Not shown on figure 1).

Operation

Regardless of the organization of a *911-system* the operation is the same. Every system works through the following five steps:

1. A citizen, reporting an emergency, dials 911.
2. The call is automatically routed through the central office to the communications center which is not necessarily a separate public safety agency. By mutual agreement, an existing service – fire, police, or other – could operate the communications center as a service to all agencies.
3. The call is received at the communications center switchboard by the 911-operator. This incoming call can be handled in one of several ways depending on the preference of the director of the communications center. Four examples are as follows:
   a. One operator handles all calls regardless of the degree of emergency.
   b. A primary operator ascertains the true emergencies and turns them over to a secondary operator who handles the call. The primary operator retains and disposes of non-emergency calls.
   c. A primary operator handles the true emergency calls and routes the non-emergencies to a secondary operator for disposition.
   d. A primary operator refers calls immediately to the proper agency.
4. The 911-operator determines the extent and nature of the emergency and obtains information about the identity and location of the caller. It is important that the operator determine the political entity from which the call is placed. Problems are seldom encountered on calls originating from homes or businesses, as most people know the address and thus the jurisdiction in which they live or work. However, a caller from a pay phone may not know his location. This difficulty can be overcome by providing the 911-operator with a list of pay telephone numbers by political subdivision or by affixing identification plaques to pay telephones. The plaque might say: "you are calling from telephone 21 in the Village of Woodside." With this information and an appropriate listing, the 911 operator can identify the location and select the appropriate response agency. In the future, an automatic number identification (ANI) system, operating in conjunction with a computer, will be able to provide this information.
5. The 911-operator notifies the appropriate response organization in the proper jurisdiction of the nature and location of the problem. This procedure requires minimal time and ensures that the caller promptly receives aid.

To date most 911 systems are within a single jurisdictional area. When more than one political jurisdiction is included, it is more difficult to establish the system – not because of the technical problems, but because of the problems of obtaining agreement among different agencies and jurisdictions on the working arrangement. To overcome these problems, public officials must understand that 911 can provide better emergency service to the public; public safety organizations must understand that the system allows them to retain control over their own dispatch functions; and the public must understand how to use the system.

Public Officials

Although government officials have shown no direct opposition to the *911-concept,* they are sometimes apathetic, and apathy is one of the surest ways to kill the idea. The National Service to Regional Councils reports that "in every area where 911 has been adopted, a prominent frequently-elected local official has had to push the concept as an issue, sometimes publicly." And the Franklin Institute Research Laboratories, Philadelphia, Pa., in its report entitled *911 – A Study of the Single Emergency Telephone Number,* states that *"It is significant that in most areas in which 911 has been installed, the decision to implement the system has been political. 911 has not been installed at the request of public safety organizations nor through the initiative of telephone companies, but rather because it was a politically wise decision."*

Public Safety Organizations

Public safety organizations must understand that the 911-system will, in fact, improve their operations. It will not weaken or downgrade their operations nor will it take away any of their responsibilities. In the 911-system, a public safety organization can retain control over its own dispatch functions.

Emergency service agencies often argue that implementation of the 911-system will increase their response time. This argument will not stand up under analysis. The most glaring flaw in the argument is their definition of *response time* as the "time interval between the receipt of an emergency call by the 911-operator and dispatch of the appropriate emergency resource." It completely disregards the time lapse between detection and notification. Under a single number system, summoning assistance is virtually automatic. Without a single number system, the sequence of events from detection to notification is further interrupted by the requirement to seek the proper number in a telephone book. Dialing the operator will not necessarily alleviate this problem. The operator very often is located at some distance from the caller and may have even less information about the emergency medical resources available in the area. The length of this interruption is frequently compounded by the excited, highly emotional, or confused state of the summoner. The single number system can even relieve him of the need to have a dime because the local telephone company can configure the 911-system to function from any telephone merely by dialing the number.

The time between notification and dispatch, is principally controlled by the internal communications systems configuration. It is determined by the manner in which the request for aid is turned over to the dispatcher. Perhaps the most efficient method for handling this turnover is to have the 911-operator also function as the emergency resource dispatcher. This method, however, requires versatile and well-trained operators. It is also a system which may not be readily acceptable to public service organizations. The more frequently-used method is to have the 911-operator either collect the required information and pass it on to the appropriate response agency dispatcher or to switch the call over to the appropriate response agency dispatcher. Thus, the public safety agency can retain control of its own dispatch operation.

If, in using the consumer's definition of response time, the 911-system results in an increase in response time, a further analysis of the overall emergency service organization is indicated. An objective review of the system's organization and procedures undoubtedly will reveal means of expediting overall response time.

When contemplating the implementation of the 911-concept, the telephone company should be one of the first organizations consulted. Telephone companies are obligated to provide 911-capability within their current dial station facilities when requested just as they provide "411" for directory assistance, and "611" for repair service. They also should provide immediate dial tone response on all pay phones. This allows all 411–611–or–911 calls to be placed without payment, but blocks all other calls until proper payment has been made.

The Public

The public, as the user of the 911-system, has a major role in its successful operation. The term "emergency" is highly subjective; it defies precise definition. The public, however, must be educated to use the 911-system correctly and intelligently. The number must not by used as an information service or as a means of airing grievances. Even an understanding and intelligent public will generate some nuisance calls. However, methods for handling them will be similar to those currently used by public safety agencies.

When the public is properly educated, the 911-system can be used effectively by the young, the old, the handicapped, the illiterate, and by those with limited knowledge of English to report an emergency. The system allows almost every citizen to reach help quickly and correctly.

PART V

SOURCES OF ASSISTANCE FOR EMERGENCY MEDICAL COMMUNICATIONS

For technical advice or information about possible financial support in the development and implementation of emergency medical communications, the following organizations may be contacted nationwide as shown hereafter. Potential assistance available from the various groups is described briefly.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

- Information and guidance is available on emergency medical communications matters. Provides technical assistance to States and their communities on designing communications systems to meet area emergency medical services plans.

  Contact points: Division of Emergency Health Services, HSMHA* Regional Health Directors at ten DHEW Regional Offices (See back cover for addresses).

- Hill-Burton funds available to eligible hospitals to procure communications equipment.

  Source: Health Care Facilities Services, HSMHA*

  For information, contact: Hill-Burton Program Director in State Departments of Health.

- Assistance in community comprehensive health planning.

  Source: Comprehensive Health Planning Service, HSMHA*

  For information, contact: Comprehensive Health Planning Agency offices in the several States.

- Funds to support various types of emergency medical services programs that might include communications.

  Source: Regional Medical Programs Service, HSMHA*

  For information, contact: State and/or Areawide Regional Medical Program offices in the several States; or DHEW Regional Health Directors (See back cover); or State Departments of Health.

*Health Services and Mental Health Administration, U.S. Department of Health, Education, and Welfare, 5600 Fishers Lane, Rockville, Md. 20852.

U.S. DEPARTMENT OF TRANSPORTATION (DOT), National Highway Traffic Safety Administration

- Funds for certain communications equipment available under provisions of Standards 11 et al. of the Highway Safety Act of 1966.

  For information, contact: At State Capitols in the several States, the Governor's Representative to the National Highway Traffic Safety Administration.

U.S. DEFENSE CIVIL PREPAREDNESS AGENCY (DCPA)

- Provides assistance in coordinating civil defense *emergency operating center* facilities with a community's emergency medical communications system.

  For information, contact: State and Local Civil Defense Directors.

APPALACHIAN REGIONAL COMMISSION

- Funds available for demonstration health projects covering the total area of emergency medical services, including emergency medical communications.

  For information, contact: The Governor's Office in each State.

U.S. DEPARTMENT OF JUSTICE, Law Enforcement Assistance Administration

- Funds are avilable under the *Crime Control and Safe Streets Act* to strengthen police communications capabilities.

  For information, contact: State Planning Agencies, Office of the Governor in the several States.

BELL TELEPHONE and other telephone companies

- Assist political jurisdictions to study community requirements, costs of installation, and operation of the "911" system.

  For information contact: Local offices of telephone companies.

CERTAIN PHILANTHROPIC AND OTHER FOUNDATIONS

- Provide financial support for emergency medical services, including biomedical communications. A useful reference to locate these functions is the *Foundation Director,* published by the Russell Sage Foundation, New York, N.Y. 10017 (copy available at most libraries).

U.S. DEPARTMENT
OF HEALTH, EDUCATION, AND WELFARE

Constituent States within the Ten DHEW Regions*

Region No. I (Boston)–Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.

Region No. II (New York City)–New York, New Jersey, Puerto Rico, and the Virgin Islands.

Region No. III (Philadelphia)–Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia.

Region No. IV (Atlanta)–Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee.

Region No. V (Chicago)–Illinois, Indiana, Minnesota, Michigan, Ohio, and Wisconsin.

Region No. VI (Dallas-Forth Worth)–Arkansas, Louisiana, New Mexico, Oklahoma, and Texas.

Region No. VII (Kansas City)–Iowa, Kansas, Missouri, and Nebraska.

Region No. VIII (Denver)–Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming.

Region No. IX (San Francisco)–American Samoa, Arizona, Guam, California, Hawaii, Nevada, and the Trust Territories of the Pacific Islands.

Region No. X (Seattle)–Alaska, Idaho, Oregon, and Washington.

*Please refer to the back cover for the addresses of the 10 DHEW Regional Offices.