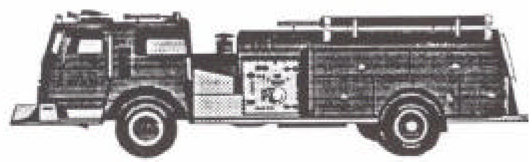
BASIC COMMUNICATIONS THEORY



URBAN SEARCH & RESCUE

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BASIC COMMUNICATIONS THEORY

INTRODUCTION

It is very important for those that are not Technicians or Communications Specialists to become familiar with basic radio theory.

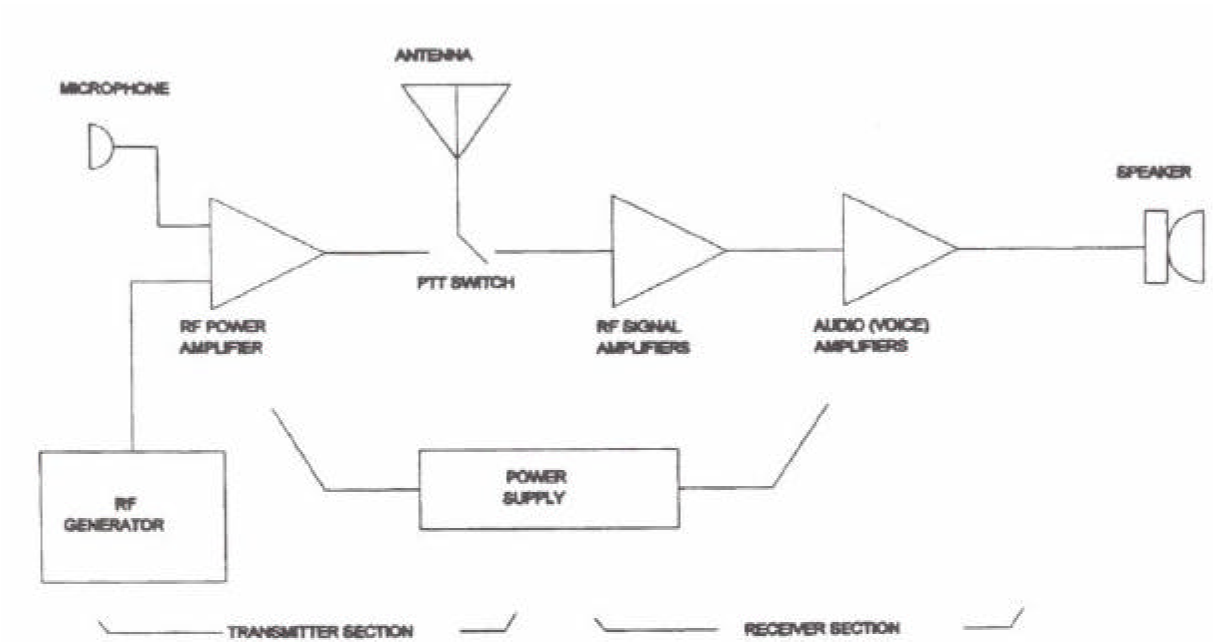
The purpose of this pre-work is to provide that basic radio theory. Remember, Technicians may or may not be present during an incident to assist with technical matters. With this in mind, studying this material will help in dealing with the technical aspects of Task Force Communications.

NOTE: Certain liberties have been taken in dealing with technical subjects to simplify explanations.

2 WAY RADIO

A radio is used to receive **and** transmit messages. It is composed of several components as show in Figure 1 (simplified).

Figure 1



The **transmitter section** contains those components you need to be able to talk (transmit) with your radio.

1. **Mic:** The **microphone** connects your voice (audio) into the circuitry of the transmitter.

2. **RF Generator:** The Radio Frequency Generator is the source of the radio signal for the transmitter. (Details in a later section.)

3. **RF Power Amplifiers:** Increase the level of the audio signals and R.F. generator to usable levels.

4. **PTT:** The **Push-to-Talk** switch connects the antenna to the output of the R.F. power amplifiers when transmitting, and connects the antenna to the receiver when not transmitting.

The **receiver section** contains those components you need to be able to receive messages with your radio.

1. **RF Signal Amplifiers:** Increases the very low received signal level.

2. **Voice (Audio) Amplifier:** Amplifies the voice signal from the RF signal amplifiers, to a level sufficient to drive the speaker.

3. **Speaker:** Takes the voice signal and converts it into sound waves which your ear hears as the message.

There is also a power supply or power source which supplies the necessary voltages and currents for the radio to operate. The power supply could be batteries or commercial 110 volt AC power.

FREQUENCY

There are several basic technical terms that must be defined to be able to understand radio communications. The first of these is “frequency”.

Frequency is the number of repeated happenings per unit of time. A pendulum may swing back and forth, say 600 swings per minute. In the case of radio/electronics/electricity, frequency is usually expressed in “Hertz Per Second” (Hz). For the pendulum, this would be 10 Hz. A very common frequency is the commercial power that supplies our homes. It is usually 110 or 220 volts at 60 Hz. This actually means that the current in the wires changes direction 60 times per second.

As it applies to incident or agency radio communications systems, frequency is most often used to specify the legal channel(s) or frequency(s) on which you are allowed to operate your radios. For instance, the NIRSC-NIFC Radio Cache has permission to use several discreet frequencies. The NIRSD has decided to use 6 of these frequencies for tactical purposes on incidents. Forest Service (FS) Tac-1 frequency is 168,050,000 Hz (cycles or times per second). To shorten this number, and make it easier to talk about, put a decimal point after the “million number” and write it like this: 168.050 **MHz**. The other three are Bureau of Land Management BLM tactical channels and are also available for assignment from NIRSD-NIFC.

The radio has to be very accurate in generating each frequency. EX: To be on Tac-1, the radio would have to be generating very, very close to 168.050 MHz. It could not be generating, say 168.060 MHz. This would be illegal because it could interfere with someone who was authorized to operate on 168.060 MHz. Also, you wouldn’t be able to talk to anyone on Tac-1 because their receivers are “tuned” to pick up **only** 168.050 MHz.

These FS-NIFC frequencies are called “clear channels” because incident emergencies are the only ones allowed to use them. These frequencies are under the control of The National Interagency Fire Center (NIFC) and can be used anywhere in the country west of the Mississippi River without the risk of interfering with another operation or agency.

With most agencies such as a City, County, State, or Federal, their assigned frequencies are also assigned to several other users throughout the country. The assignments are separated geographically by several hundred miles, to minimize the chance of interference. Even with the geographic separation, there still may be occasional interference from another user on "your" assigned frequency.

An example of multi-users having the same frequency is the California Division of Forestry (CDF). The Tulare Ranger Unit is assigned 151.900 MHz. As is the CDF E1 Dorado-Amador Ranger Unit and CDF San Diego Ranger, as well as agencies in Oregon and other parts of the country.

What all this means is that the agency's assigned frequency is only to be used in the geographical area of your unit, unless you have approval to use them elsewhere.

In general, the frequencies of interest to governmental and public service organizations that may be involved with incidents are: VHF-FM (Lo-band) 30-50 MHz, VHF-FM (Hi-band) 150-174 MHz, UHF-FM 406-512 MHz, and VHF-AM (Aviation, Victor or VHF) 118-136 MHz. Their relation to other frequencies is shown in Table 1 (following page).

You now know about frequencies. A radio must generate (transmit a very accurate frequency. In the case of Tac-1, it is 168.050 MHz. However, this is a "pure' frequency, it doesn't yet contain any real information, and it won't until you start talking into the microphone. The radio will then take this voice information and impress it on the frequency 168.050 MHz. This is called modulating the carrier or frequency.

There are two ways to modulate the carrier. First, by varying the carrier frequency a little bit with the voice information, then at the receiver, this varying frequency is turned back into voice information which is sent to your ears by the radio's speaker. This type of modulation and demodulation is called Frequency Modulation or FM, because the carrier frequency actually varies a little. It is the type of modulation that we use on the Land Mobile Bands. It is also what is used by FM broadcast stations.

The second way to modulate the carrier is called Amplitude Modulation or AM. This type of modulation **does not** vary the frequency of the carrier frequency, it varies the amplitude (or how much carrier there is) by the voice. This type of modulation is used with the VHF-AM aircraft frequencies. It is also what AM broadcast stations use. In general, AM two-way systems are not as efficient and do not sound as good as FM systems.

TABLE 1

110 V AC Power	60 Hz (Cycles Per Second)
Voice	100 Hz to 5,000 Hz
Hi-Fi	20 Hz to 20,0000 Hz
AM Broadcast Stations	535 KHz to 1.6 MHz
CB Frequencies	26.965 MHz to 27.305 MHz
LAND MOBILE REQUENCIES (VHF-FM Lo-Band)	30 MHz to 50 MHz
TV Channel 2	56 MHz
3	62 MHz
4	68 MHz
5	78 MHz
6	84 MHz
FM Broadcast Stations	88 MHz to 108 MHz
AIRCRAFT FREQUENCIES	118 MHz to 136 MHz

(VHF-AM "aircraft frequencies" or FAA frequencies) Other terms used are "Victor or VHF frequencies

LAND MOBILE FREQUENCIES (VHF-FM Hi-Band)	150 MHz to 173 MHz
TV Channel 7	176 MHz
8	182 MHz
9	188 MHz
10	194 MHz
11	200 MHz
12	206 MHz
13	212 MHz
LAND MOBILE FREQUENCIES (UHF-FM)	406 MHz to 512 MHz
Radar, Satellites & Microwave	1 GHz to 20 GHz (Giga-Hertz)
Visible Lite	600 THz (Tera-Hertz) (1 THz = 1,000,000 MHz)
X-Rays	10 EHz (Exa-Hertz) (1 EHz – 1,000,000,000,000 MHz)

RF POWER (Radio Frequency Power)

RF power refers to the "quantity" of a frequency that a radio is capable of generating. It is no different than any other power in that it is a measure of "work". A 100 watt radio transmitter could cause a 100 watt light bulb to glow as brightly as if the bulb were plugged into a wall outlet, or it could be made to turn a 1/8 hp motor as fast as if the motor was plugged into a wall outlet.

The reason radio frequency (RF) power may appear different than other types of power is that you really can't see or feel the work it does. The power is used to "send" a message to a receiver some distance away. The greater the transmitter power, the further away the receiver can be. Because the radio waves go in all directions from the transmitter and very little is ever used by a receiving radio, almost all of the RF power is "wasted". But it is necessary to "waste" this power so that no matter where you take your receiver, as long as you don't get too far away from the transmitting unit, you will be able to receive a transmitted message.

Typical RF power out for agency and cache radios are as follows:

1. Personal Portables (Handi-Talkies, 2 to 5 watts (about like a medium size Christmas tree light.
2. Pack set Portables, 5 watts.
3. Mobiles, 25 to 100 watts.
4. Lookout radios, 5 to 20 watts.
5. Table Top AC powered radios (ACUs), 20 to 50 watts.
6. Base stations, 35 to 350 watts.
7. Batter powered repeaters, 3 to 10 watts.
8. AC powered repeaters, 25 to 100 watts.
9. Aircraft radios, 10 watts.

These radios have efficiencies of about 20% to 50%. This means that for every 1 watt of power used by the radio (from batteries or AC power) only 1/5 to ½ watt of RF power comes out of the radio. The rest is wasted as heat in the radio.

It might appear that a 100 watt radio could transmit (talk) 50 times further than a 2 watt radio. However, as a receiving radio gets further and further away from the transmitting radio, the area and volume the RF power must cover rapidly increases. Actually, the range you can talk only increases by about 20% every time the power is doubled. So if a 2 watt transmitter could talk, say 10 miles, a 100 watt transmitter could only talk about 27 miles. In reality, the 100 watt mobile radio or base station transmitters would talk some what further than 2.7 times the 2 watt personal portable transmitter because the mobile or base will have a much more efficient antenna system. The actual difference for a 100 watt mobile to mobile could be up to 4 to 5 times further than a 2 watt personal portable to personal portable with the very inefficient "rubber duck" antenna often used with personal portables.

While RF power out is important, small increases in power are not very noticeable. It is very hard for even an experienced technician to tell much difference between a 100 watt mobile and a 50 watt or eve 25 watt mobile.

RECEIVER SENSITIVITY

This is a measure of how little RF power is required at the receiver input (antenna) to produce an understandable voice message out of the receiver speaker. Most receiver sensitivities are specified between .2 uv to .5 uv (uv is microvolts and is 1 millionth of a volt or, in this case, .0000002 volts to .0000005 volts). Sensitivity is specified in voltage not power (watts) but it is mathematically related to power. The actual power levels needed would be .000,000,000,000,000,000,8 watts to .000,000,000,000,005 watts. These are **extremely** small amounts of power. Remember, the transmitter could be transmitting 2 watts to over 100 watts, however, all that is needed to receive a usable signal are these very small power levels.

The receiver will take these very small power levels and amplify (increase) them, using power form batteries or AC power, to a level loud enough to drive the speaker. The speaker audio output power is about ½ watt for portables and 5 to 10 watts for other radios.

ANTENNAS, RADIO SIGNAL PROPAGATION, AND RANGE

Antennas are the devices that send the radio signal frm the radio to the surrounding space and, when receiving, picks the radio signal from that space and connects the signal to the receiver.

Antennas are very important. Several general statements can be made regarding them.

1. The higher the antenna is above the surrounding terrain, the further you can communicate.

2. Mobile or base station antennas are more efficient than handheld radio antennas.

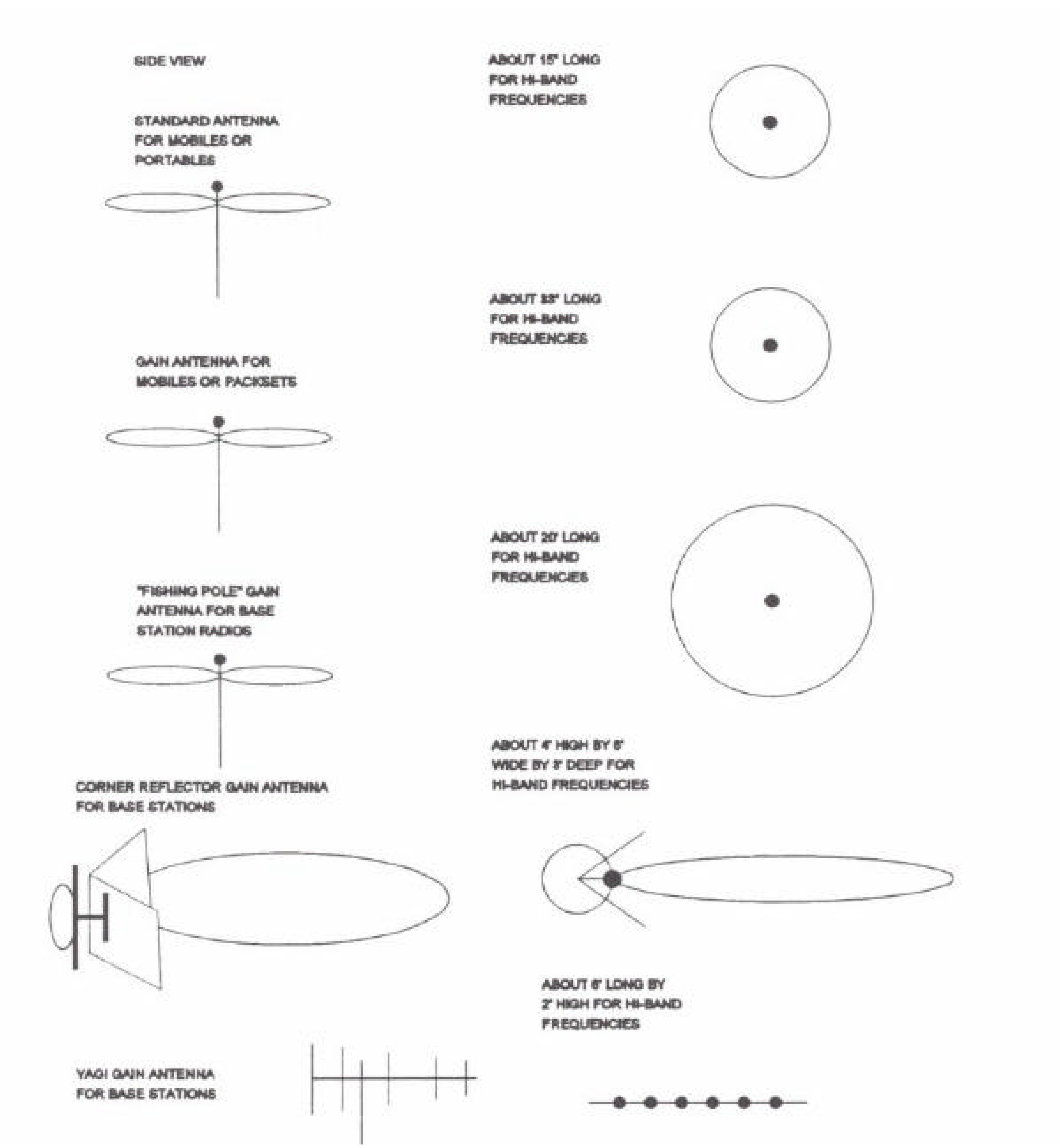
3. a mobile magnetic antenna will work better setting on the hood or roof of a vehicle than on a wood picnic table because the flat metal acts as a “ground plane” which increases the efficiency of the antenna.

4. Personal portable telescopic whips are more efficient than short flexible rubber covered antennas (rubber duck). However, the telescopic antennas are not as durable and break much easier.

5. Portable radios work very poorly when laying on the seat of a vehicle, unless an external antenna such as a magnetic or clamp on antenna is used.

6. Antennas for 151 MHz are usually about 17” for 165 MHz are about 16”, for 172 MHz are about 15”. Antennas for 410 MHz are about 7” and 476 MHz are about 6”. Rubber duck portable antennas are considerably shorter.

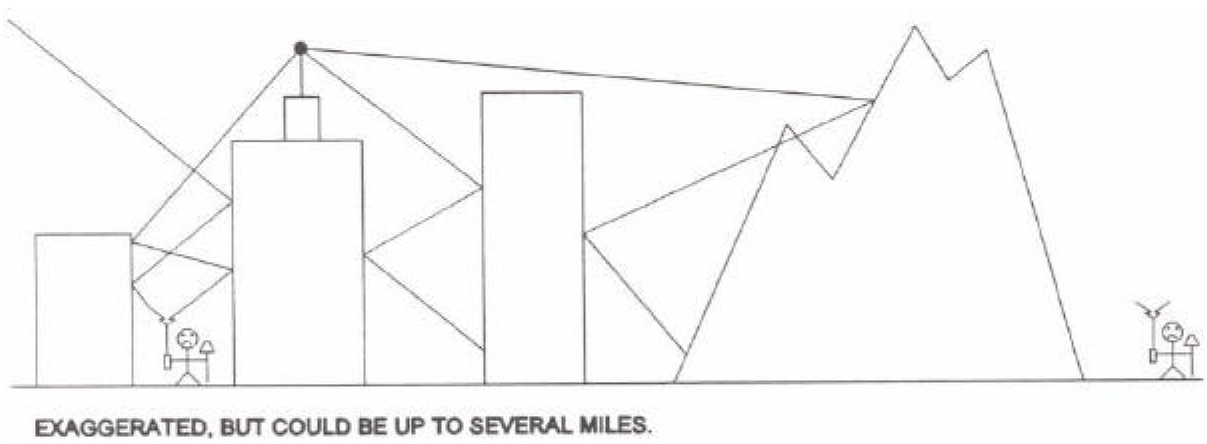
7. It is possible to make antennas that have “gain”. This is possible because they take power from some directions and concentrate it in other directions. Some examples are shown in Figure 2.



NOTE: Corner reflector, yagi and log periodic (this looks a lot like a yagi) antennas all have about the same radiation patterns.

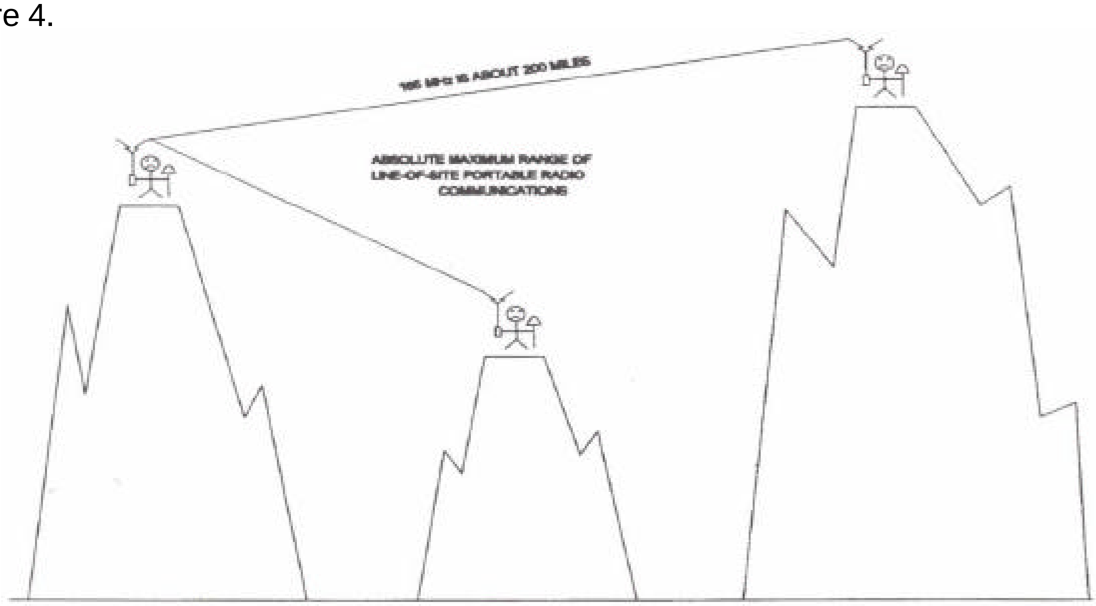
Once the radio signal leaves the antenna, it is subject to a number of influencing factors. What happens to the signal after it leaves the antenna is called propagation. There are several “laws” of propagation to abide by. The most important law of line-of-sight for VHF and UHF-FM systems, which requires that to communicate with someone there has to be a clear unobstructed path, is fortunately not completely true. Actual field experience proves otherwise. Radio signals can be received over long distances when there are obstructions such as buildings or mountains that block clear line-of-sight. This is because the transmitted signal is radiated in all directions and under the right circumstances it will bounce off of (reflected) and/or can be “bent” (refracted) over signal path obstructions. However, the best rule is to always establish line-of-sight between antennas if at all possible. See Figure 3.

Figure 3.



Another law is that the signal decreases (is attenuated) very rapidly after it leaves the antenna. The higher the frequency used, the shorter the distance you can communicate over, all other things being equal. See Figure 4.

Figure 4.



Trees, other foliage and soft soil will “absorb” RF signals. This is more apparent at 400 MHz than Hi-band.

From all this and experience, there are some general rules fo thumb for portable and mobile communicating distances.

Estimated communication range over flat terrain, such as desert country:

1. Portable to portable, 2 to 4 miles.
2. Portable to mobile, 3 to 6 miles.
3. Mobile to mobile, 10 to 15 mile, perhaps further.

Steep mountain terrain:

1. Portable to portable, ¼ mile to 2 miles.
2. Portable to mobile, 2 miles to 4 miles.
3. Mobile to mobile, 2 miles to 10 miles.

City or urban setting with large buildings:

1. Portable to portable, Hi-band, 2 blocks to 1 mile.
2. Portable to portable, 400 MHz, 1.4 mile to 1 mile.
3. Portable to mobile, Hi-band, 5 blocks to 1-1/2 miles.
4. Portable to mobile, 400 MHz, 1.4 mile to 11/2 miles
5. Mobile to mobile, Hi-band, ½ mile to 5 miles.
6. Mobile to mobile, 400 MHz, ¾ mile to 5 miles.

These short ranges can be overcome by using “repeaters” located on high places. This will be discussed later.

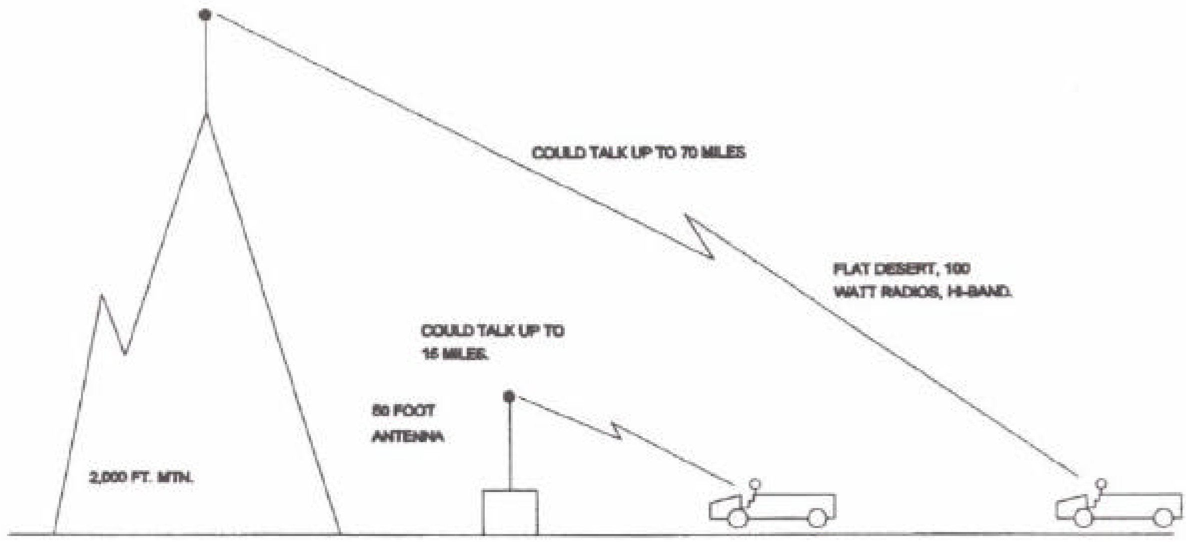
TYPES OF RADIO EQUIPMENT

As a Task Force Communications Specialist, it is necessary for you to understand the various types of equipment used on incidents.

The last section gave some estimated radio ranges for various types of field radios. These distances are quite short and methods had to be found to increase them.

To talk for long distances from a Base of Operations (BoO) to a field radio, the BoO radio is usually located on a tall building or on a site higher than the terrain surrounding the BoO, such as a hill. An example is shown in Figure 5.

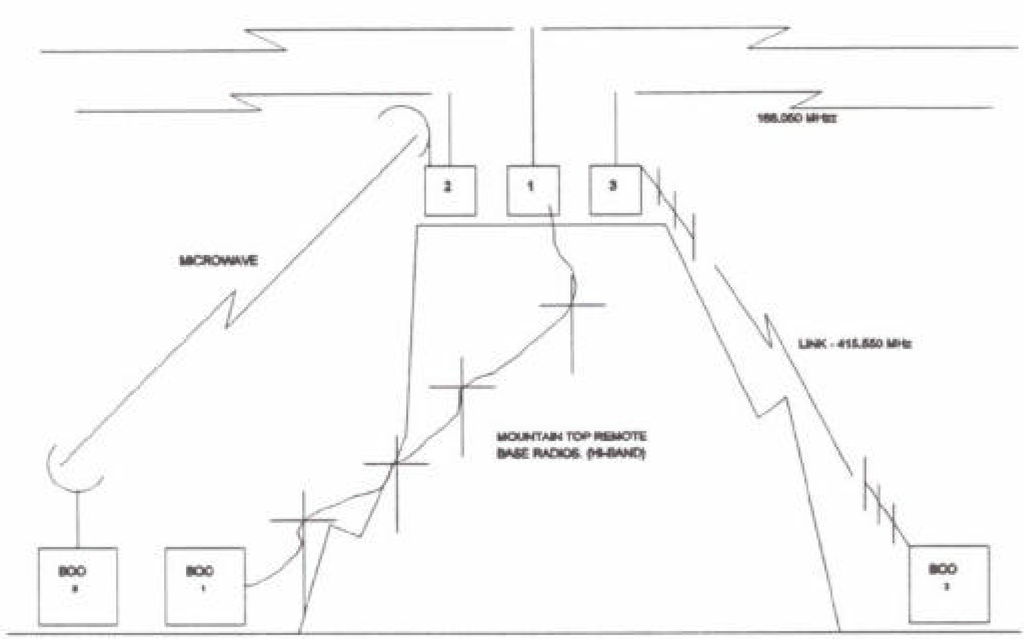
Figure 5.



As can be seen, there is a dramatic increase in range by locating your radio on a high site. Actual terrain conditions would cause numerous obstructions which would affect the actual distance you would be able to talk. In Figure 5, for the 50' antenna to be able to talk 70 miles would take over 10,000 watts.

The type of basic radio shown in Figure 5 is what almost all agencies install for their units to talk from the main offices to the field. It is called a **Remote Operated Base Station**. How is it used if it is located away from the BoO? There are 3 ways. See Figure 6.

Figure 6.



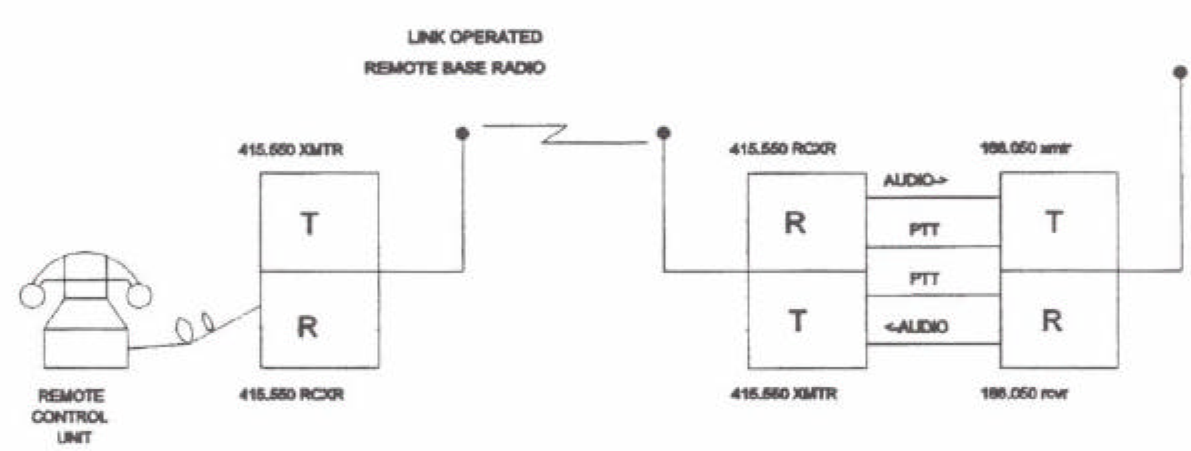
BoO #1 is connected to its remote radio by a telephone line. They use what is called a **remote unit** which is a unit that sets on desk and may look like a telephone. When you depress Push-To-Talk button (PTT), current goes up the line and keys the radio. When you talk, audio from your voice also goes up the line to the radio, just like the line was the microphone. When done talking, you release the PTT and the base radio receives the answer and sends it down the line, just like the line was the speaker. The receive audio is amplified in the remote unit and fed to a speaker. This telephone line can be 10 or more miles in length.

BoO #2 uses two additional radios to connect its remote to its remote radio. See Figure 7. This second radio system is called a **link** because it links the remote to the radio. Of course, it must operate on a different frequency than the remote base. In most cases the link will operate in a different frequency band all together i.e., UHF.

In this example, the remote base is on 168.050 MHz and the link is on 415.550 MHz. When you depress button PTT and start talking into your remote, the office 415.550 MHz receiver starts receiving your message and turns on the 168.050 MHz transmitter and connects the audio to the 168.050 MHz for transmission. When you are done talking and release the PTT, the office 415.550 MHz transmitter quits transmitting and the 415.550 MHz receiver on the mountains quits receiving so it turns the 168.050 MHz transmitter off.

When the filed answers, the 168.050 MHz receiver picks up the answer and turns the mountain to 415.550 MHz transmitter on and connects the received audio to the 425.550 MHz transmitter. At the office, the 415.550 MHz receiver picks up the signal and connects the received audio to the remote. See Figure 7.

Figure 7.



BoO #3 operates the same except it uses micro-wave to control its remote base radio instead of the 400 MHz link. Microwave is simply another type of radio that operates at higher frequencies, such as 2,00 MHz, 6,000 MHz and higher.

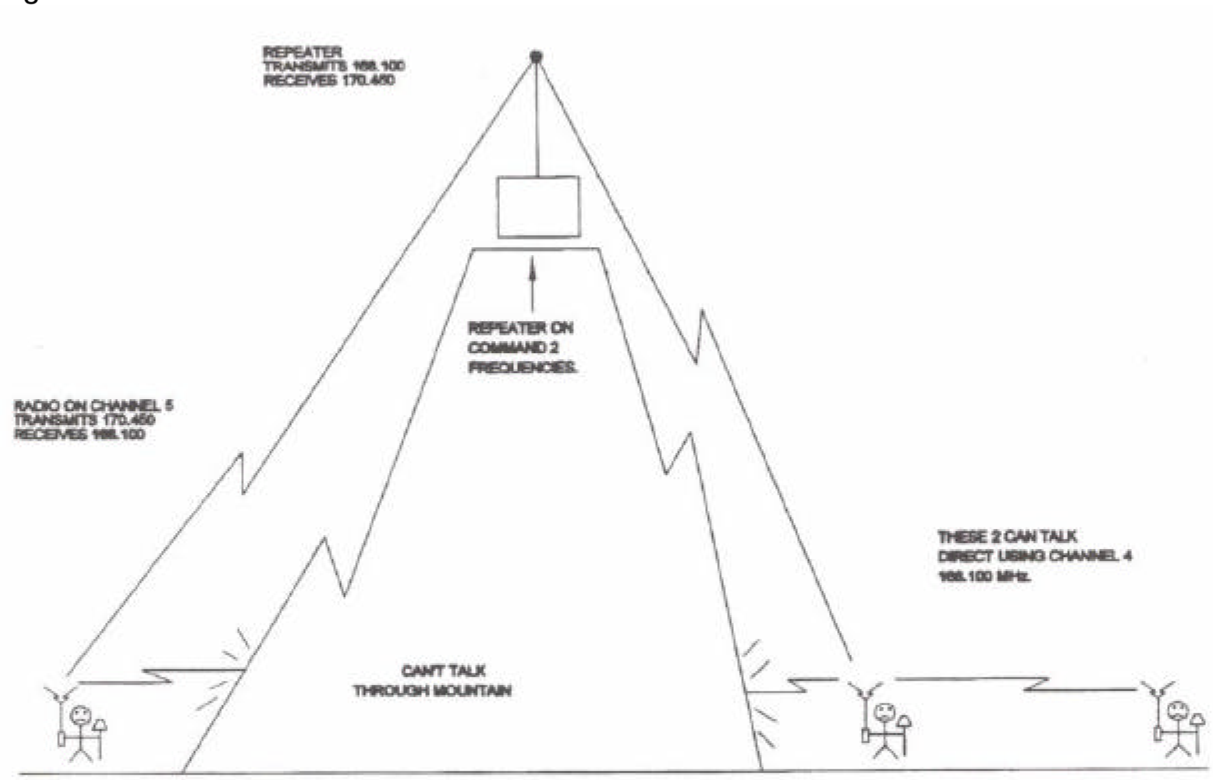
The only real difference between it and the link is that it is capable of controlling a lot of base radios at the same time because it has a lot of "channels". Some of the channels could be used for telephone, telemetry or whatever you need.

I the case of the three examples, several remotes could be used in each Base of Operations to control the remote radios. The remotes could be part of a large console, such as you have at dispatch centers, which can control many remote radios.

Temporary remote base radios are used on incidents, especially in the rural areas. They are available from various agencies, primarily NIRSC-NIFC, and FS-R5. The NIRSC-NIFC remote radios consist of a portable radio adapter with antennas, wire, a remote unit and everything you need to set up the remote base radio. In effect, it is just like example #1, except it is portable. The FS-R5 remote base system is a link controlled remote base unit, much like example #2.

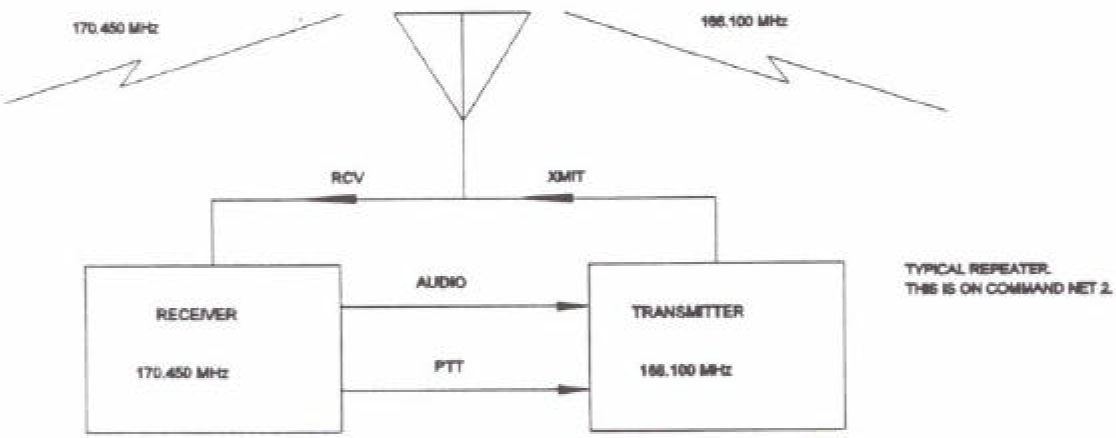
While remote base radios do help Base of Operations communications centers to talk long distances, they do not help personal portables talk long distances to other personal portables. To help in this situation, use a device called a **repeater**. See Figure 8

Figure 8



A repeater does just what it says it does. It repeats messages. The radio, whether base, mobile, or a personal portable will be set up to operate either direct (simplex, or car to car), say on channel 4 or on channel 5 through the repeater in a duplex mode. In simplex mode, the radio transmitter **and** receiver would operate on the same frequency. In this example, 168.100 MHz. However, in duplex mode on channel 5 the transmitter is on a different frequency i.e., 170.450 MHz. The repeater on the mountain top will be just the opposite. See Figure 9.

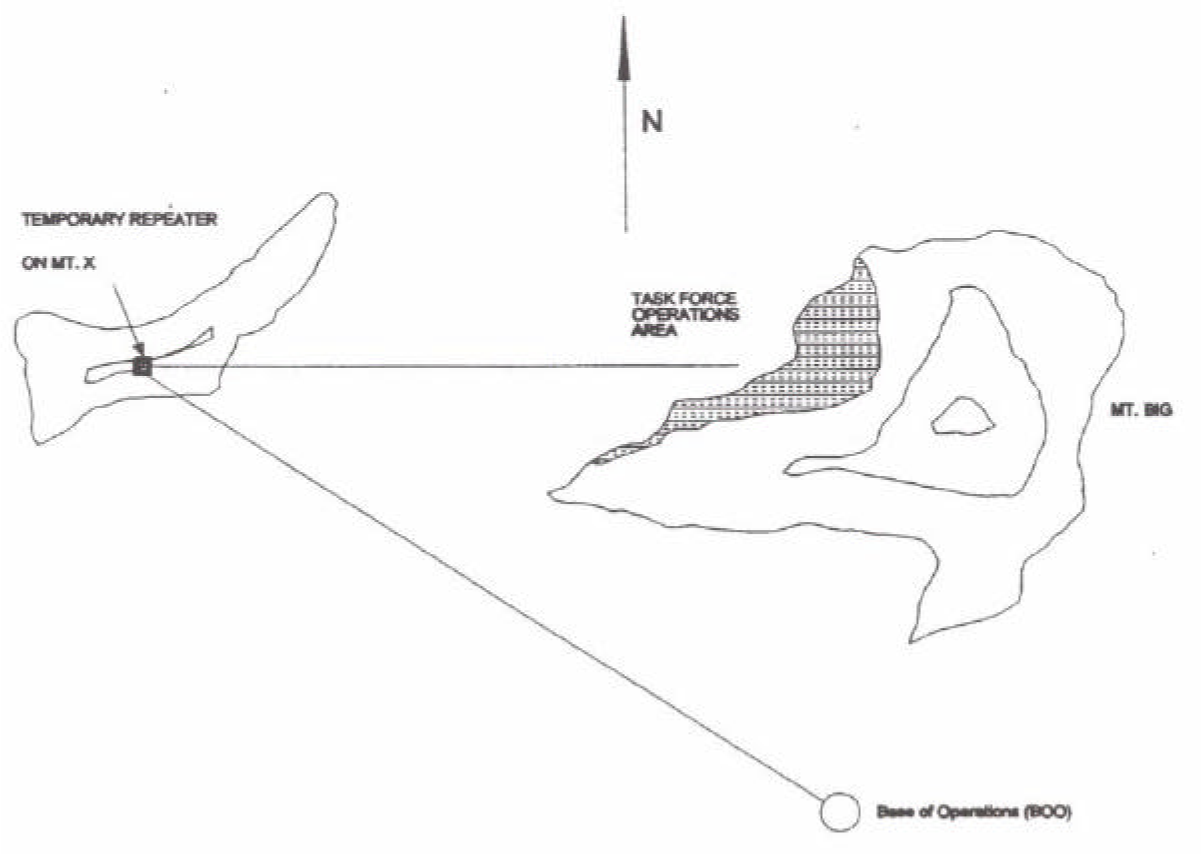
Figure 9.



The repeater is the most useful tool to have for Task Force communications. It needs to be located at a spot that covers most of the task force operations area and can still be reached from the Base of Operations.

Remember, the repeater acts just like any other radio in relation to how far it can talk. The portable repeaters operate off batteries and transmit form 2 to 5 watts. But, because repeaters can be located on high vantage points, their range can be significant if “line of site” is actually maintained, and as short as 2 to 5 or 6 miles when there are obstructions like there are at many locations. A good installation site can be below the operations area is some cases. An example is where a repeater is installed that “looks up? A drainage in mountainous terrain. See Figure 10.

Figure 10.



Of course, if the operations area increases in size to include the east side of Mt. Big, you would have to relocate the repeater to the top of Mt. Big. Maintaining the most coverage of the operations area and still providing contact to the BoO is a high priority. For those areas that the repeater may not do as good a job at covering, personnel working in the operations area will be required to adjust to the change in coverage to maintain safe operations.

Agency radio systems also use repeaters. They can be either low power battery operated, often powered by small solar-electric panels, or higher power AC operated units. There are other radios you will use. ACU;s are table top AC powered radios. These are similar to mobiles except they operate off AC power. They are available in the VHF and UHF-FM land mobile bands **and** the VHF-AM aircraft frequencies.

The last type of radio is the personal portable or handheld radio. These are battery operated radios that use special batteries. A battery will last 1 to 4 shifts depending on the type of battery and the radio's use. The radio TX out is 1.5 watts to 5 watts. These are the most common radios used on incidents, because of their small size.

INTERFERENCE

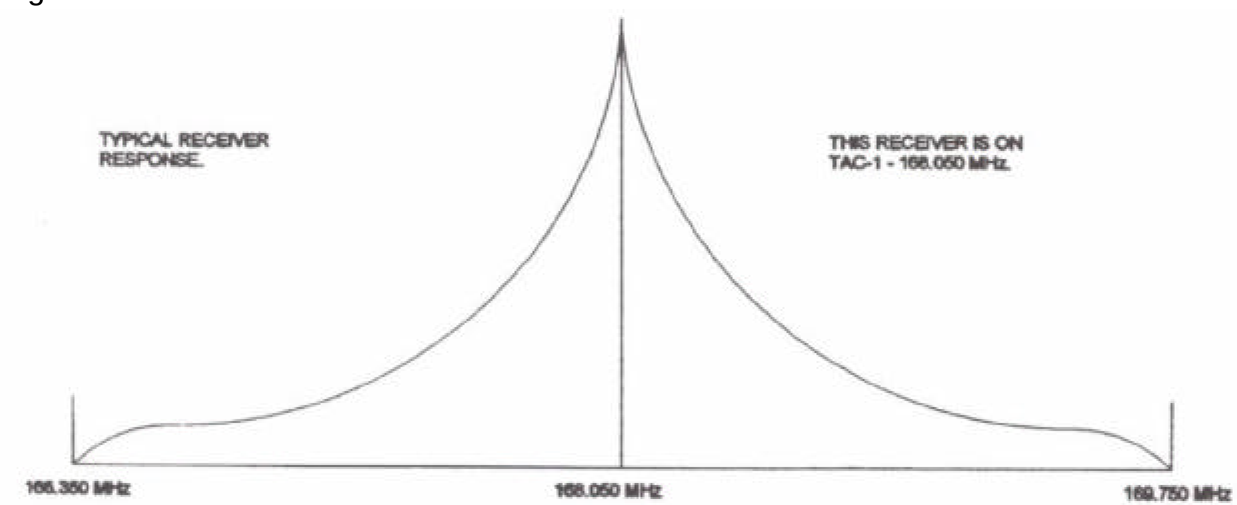
Interference between radio systems is a mjor problem. The first type of interference has already been mentioned which is the unauthorized use of frequencies. Remember, do not use your unit's radio outside of your area because you might interfere with another user who has been assigned the same frequency. A second type is co-channel interference and happens when a radio is not exactly on frequency. The frequencies adjacent either above or below the frequency the radio is on gets interfered with. This depends on which way the radio drifts off frequency.

A third type of interference is just plain noise. As an example vehicles in poor operating condition can generate a lot of noise that can get into nearby Lo-band or Hi-band radio receivers. Radios in the 400 MHz band are not as susceptible to this type of noise. This type of interference can be heard when listening to a car's AM broadcast radio on a weak station. It sounds like very rapid clicks or pops. Other sources for this type of interference are: fluorescent lights, power company transformers and power lines, and incident camp generators. This is why it is a good practice to locate radios away from these potential sources of interference. Even 50 to 100 feet away can help.

The previously mentioned types of interference are quite apparent and are easy to correct. However, there are other forms of interference of a highly technical nature, the full explanation of which is beyond the scope of this pre-work. They will be discussed in a simplified manner and as well as recommendations to alleviate the problems.

The most important form of interference that applies to temporary incident communications is called close frequency interference or receiver desensitization. This is caused because it is impossible to build a receiver that passes only its frequency. All receivers "let" in frequencies above and below their frequency. The response to all these frequencies gets less and less as the interfering frequencies gets further and further away from the desired frequency. Eventually a point is reached where the interfering frequency will be undetectable. See Figure 11.

Figure 11.



Transmitters do not transmit only the desired frequency. Most of the output power is concentrated on the assigned frequency, but there is always a small amount of output power that is wasted and utilized to transmit on frequencies above and below the desired or center frequency. See Figure 12.

Figure 12.

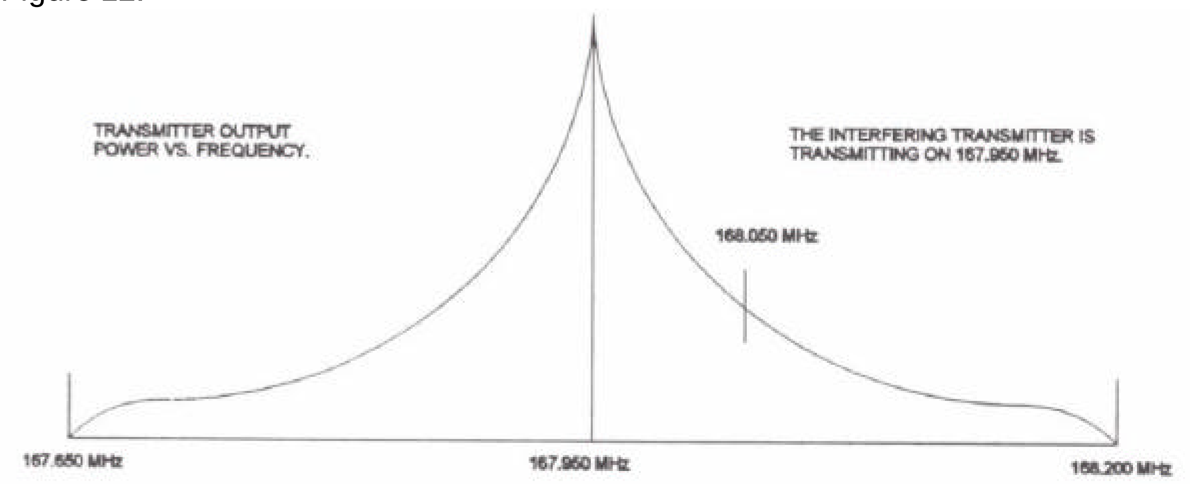


Figure 12 shows that by far the most power out is on 167.950 MHz. There is also a very little bit of power out all the way up to 168.200 MHz and down to 167.650 MHz. A little bit is on 168.050 MHz. There is no way the 168.050 MHz receiver can tell if it is a desired signal or an interfering signal. Further more, the desired signal would have to be somewhat stronger than the interfering signal to be understandable. In effect, the interfering signal has reduced the unable sensitivity of the 168.050 MHz receiver. It is possible to reduce the affect of this "receiver desensitization" by the use of large and expensive filters. However, on most incidents this won't be practical. The most useable solution will be physical separation of the interfering radios.

Receivers are very sensitive and an understandable message can be received if it is only about .3 uv in strength. Desensitization interference is exactly that. It reduces the sensitivity of the receiver. The reduction could be just a little, about down to 1 uv, in which case you probably could still use the radio. Or the reduction could be a lot, down to 100 uv or, in extreme cases, even more.

In most cases, reduction will not be that bad, but even so, it can be a real problem. For example, the normal sensitivity of our receiver is .3 uv, but it has been desensitized to 3 uv by a nearby "close frequency transmitter". This means that instead of being able to receive some one 10 miles away, you can now only receive them from about 3-1/2 miles, when the "close frequency transmitter" is transmitting.

The solution is not to put the radio close to other radios. It is best to put repeaters or base radios on a site several hundred yards away from any other radios, including any of the incident's repeaters or base radios. You can usually put a VHF-FM Hi-band repeater and an UHF repeater on the same site, however, separate them by at least 100 feet. If you have to put your repeater or base close to the other radios, try to shield them by topography and/or use a directional antenna if possible. See Figure 13.

Figure 13.

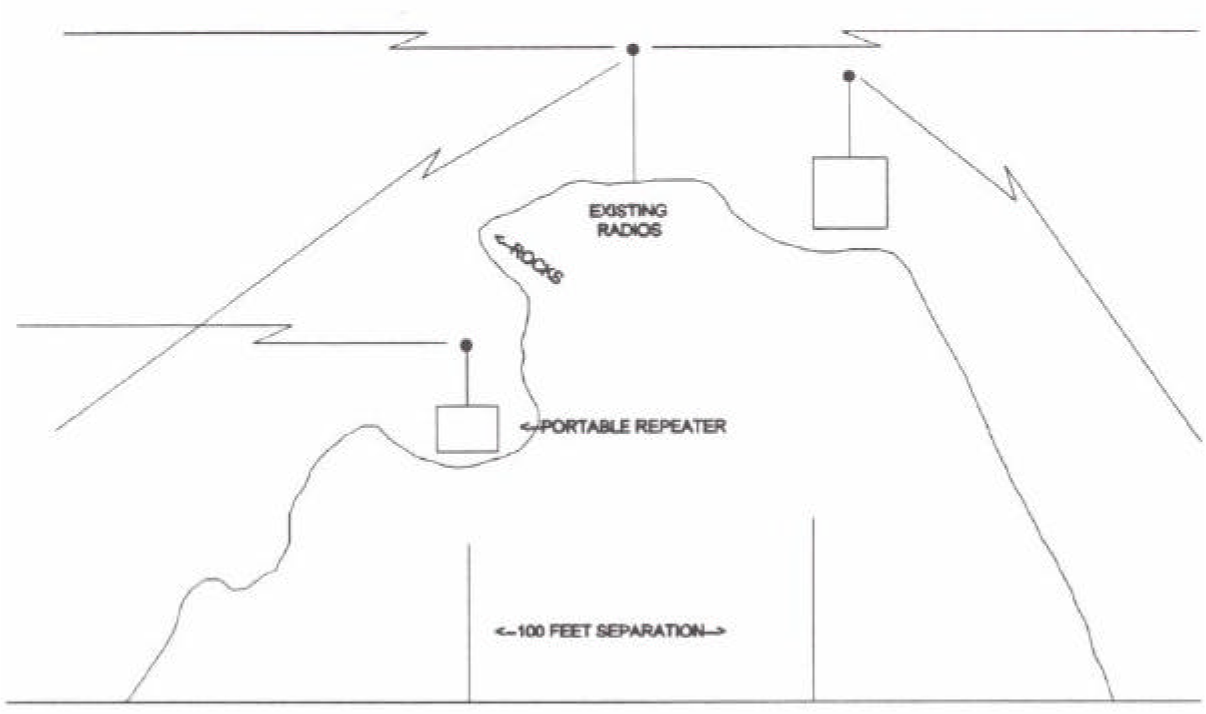
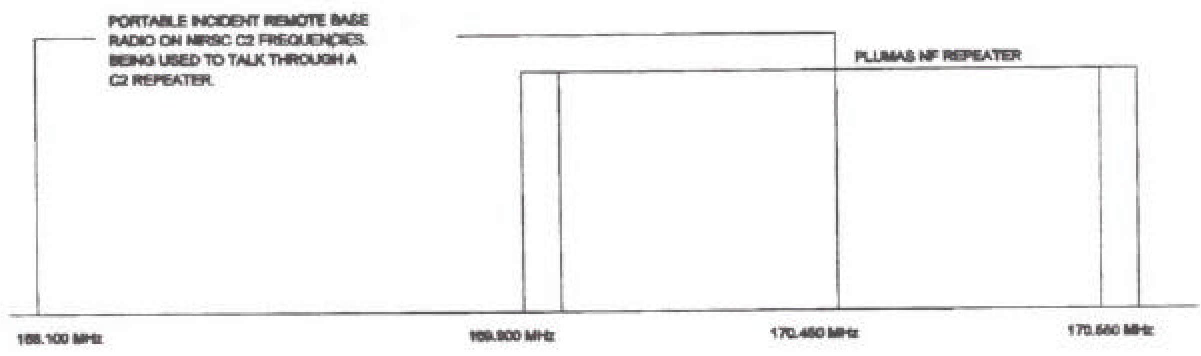


Figure 13 shows partial shielding from rocks. Use of a gain antenna (Yagi) which does not "pick up" signal from the rear as well as it does from the front is another way to reduce interference. It is also important to have some horizontal (100 feet) and vertical separation (5 foot minimum) between antennas. All these things will help reduce interference. All other things being equal, vertical separation is significantly more effective than horizontal separation in reducing interference by a ratio of 10 to 1. (5 feet of vertical equals 50 feet of horizontal).

It is important to remember that while the temporary repeater or base radio may not be getting desensed, the transmitter could be desensing the existing radios at the site. For an example, see Figure 14.

Figure 14.



There is 1.8 MHz between the Plumas transmitter and your receiver. These transmitters may not interfere. However, there is only **.1 MHz** between your transmitter and the Plumas receiver. This would certainly interfere with the Plumas if the radios were located close to each other, probably within a ¼ mile of each other.

Another form of interference that causes problems is called “wide spectrum noise”. It is caused when the transmitted RF signal “hits” metal to metal contacts that are not making good contact, such as dirty, corroded or loose bolts, fencing, antenna towers, lookout grounding systems, antennas themselves, vehicles, etc.

This “wide spectrum noise” only happens when a transmitter, such as the repeater transmitter, is transmitting. At those times it can cause real disruption of receivers, including other repeater receivers, by desensing them, usually at a random rate (sometimes you can hear, sometimes you can’t) caused by wind or vibration.

“Wide spectrum noise” can cover a very wide frequency range and, therefore, interfere with a large number of receivers. Fortunately, the solution is simple. Again, location is the important factor. Try to locate your repeater or base radios 50’ to 100’ from metal of any kind.

The last two interference problems to discuss are heterodyning and transmitter intermodulation. There are usually many agencies with their radios at the incident. People are carrying radios around the Base of Operations, the Task Force Command Staff may have radios on, the Communications Center may have several radios operating, and there may be mobile or cellular telephones in the area. If several of these transmit at the same time on the same frequency, receivers on this frequency will squeal. This squeal is called heterodyning and is caused by two or more signals hitting the receiver at the same time. Intermodulation however is caused by the fact that two different frequencies add or subtract from one another and create a third frequency which may be on frequency with another receiver. If the new frequency is a strong enough signal it can be detected by receivers on this new frequency and cause interference. This is a common interference problem in areas with lots of transmitters in close proximity to one another.

The solution to both of these problems is to keep the radios at the incident base to a minimum. Brief the users not to use their incident radios unless they are out of camp. Also, discuss the problem with the cooperating agencies at the incident that have radio communications present. The best solution, as stated earlier in the pre-work, is for the communications center radios is to be remoted from the camp as far away as possible.

CONCLUSION

It is hoped that this pre-work booklet on radio theory has helped you to gain a better understanding of two way radio communications. You should now be able to discuss communications with a little more knowledge; and, after completing the remainder of the pre-work package and the Communications Specialist Course, you should be able to effectively function as a Task Force Communications Specialist.

GLOSSARY OF TERMS AND ABBREVIATIONS

AM Radio — Normally used for aircraft communications

Backbone — A term which applies to a system of repeaters and repeater/links that allow communications to take place over a very long distance (i.e., across 2 or more mountains).

CMD — Command, usually refers to network(s) used for command and control of incident operations.

CMD/TAC — Command/Tactical refers to VHF-FM or in the case of Urban Search and Rescue, UHF-FM radio networks used on an incident. It can also refer to capability of radios in a particular kit. (CMD/TAC radio Kit as an example).

Communications Specialist — A Specialist trained in the design, installation, operation and maintenance of communications systems. This individual isn't necessarily trained or equipped to perform electronic repair.

FM Radio — Frequency Modulated radios that are within the land mobile frequency spectrum. Radios used by Task Force personnel for operations and logistics two-way communications.

Land Line — Any copper or fiber wire system. Commercial telphone lines are land lines.

Link — A unit which is used to interface two different communications components together (i.e. two repeaters VHF to VHF or VHF to UHF). Links can also be used to interface VHF-AM to UHF or VHF-FM.

Line-of-sight — Refers to a direct path between two points such as Task Force operations area and the Base of Operations with **no** obstruction in between.

LOG — Logistics

NIRSC — National Incident Radio Support Cache

PTT — Push-to-talk. Button which activates radio transmitter.

Repeater — Used with FM radios to provide communications between areas that are not line-of-sight or that are separated by long distance.

RPT — Repeater

RTI Radio Telephone Interconnect

Simplex Talking radio to radio without the use of a repeater. Same frequency used for transmit and receive functions.

Tactical Usually refers to communications network(s) used for directing tactical operations at an incident.

Tone Control A feature of the UHF link used to turn it on and off from a remote location by sending DTMF tones through either a radio or a remote base that have touch tone capability.