# Emergency and Disaster Radio Communications

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There have been a number of FAQs and articles written on this subject but most are lacking in some areas while getting far too technical in other areas expecting that the reader already has some training and/or experience in the subject. But that is not always the case.

This article is written as a primer for radio communications for the reader who knows little or nothing of the subject. It provides enough information that the reader can gain enough understanding about radio to make informed decisions but without the confusion that may be caused by too much theory or specific applications. Links are provided so the reader can do further research in specific areas as desired.

When discussing radio communications during an emergency or disaster it is impossible to address each of the vast number of possible scenarios and applications. Therefore, this article is limited to information that may be relevant to those preparing for emergency and disaster situations. It covers some of the most common types of radio communication that are readily available, and addresses their advantages and disadvantages with respect to variables that may be common to more than one scenario.

Ultimately, it is up to the reader to decide which type of Communication will best serve the needs at the time.

Contents

I. Introduction

Radio is one of the most widely used methods of communicating over long distances whether that distance is a few hundred feet or a few thousand miles. Radio communication is so entrenched in our society that it should be considered an integral and necessary part of any emergency or disaster plan. However, it should not be the -only- method of communication but rather one part of a more comprehensive communication plan that includes other means.

Some information in this article may seem very rudimentary to some readers and they may be tempted to skip part of it. I suggest it be read in its entirety anyway to understand and appreciate the scope of the article.

II. Radio fundamentals

A. Radio defined

Radio is a technology that uses electromagnetic waves to convey information. Radio communication requires both a transmitting station (with a transmitter) and a receiving station (with a receiver). Because the nature of radio is electrical a radio station requires electrical power to work.

B. Radio spectrum

Electromagnetic waves vary in frequency from zero to infinity. This is the electromagnetic spectrum and the frequency is measured in Hertz (cycles per second). According to the FCC the range of this spectrum used for radio is from 9 Kilohertz (KHz) to 300 Gigahertz (GHz). However, most of the radio used for emergency communications will be in the Megahertz (MHz) range.

C. Antennas

Both the transmitting station and receiving station must have an antenna; the transmitting antenna converts electrical signals into electromagnetic waves and the receiving antenna converts electromagnetic waves back into electrical signals. In most cases the same antenna can be used for both transmitting and receiving.

The length of an antenna depends on the frequency of the radio and the antenna's configuration (dipole, vertical whip, loop, etc.). But generally the lower the frequency the longer the antenna. For example, a CB radio works at 27 MHz and requires an antenna that is 9 feet tall; today's cell-phones use much higher frequencies and the antennas are sometimes less than an inch tall. For more information on basic antenna types and their applications, as well as instructions on building simple but effective antennas, please consult the Radio Amateur's Handbook, any edition.

Antennas can be directional or Omni-directional (working equally well in all directions). Examples of directional antennas include satellite dishes, roof-top television antennas, loop antennas, and even the rabbit-ears on top of grandma's TV. Directional antennas can be used to easily locate the position of a transmitter using triangulation, a procedure called "direction finding" or "DFing". There are receivers specifically designed for this task and years ago were the primary means of nautical navigation. Omni-directional antennas are as simple as a vertical whip. Examples include most mobile antennas and the towers at AM broadcast stations that can stand several hundred feet tall (low frequency = tall antenna).

D. Range

The range of any radio signal depends on many factors. For both receiving and transmitting stations the most important factors are the frequency of operation, the type and directionality of the antenna and the height of the antenna above the ground. Also, the transmitter can increase its transmitted power and the receiving station can increase the sensitivity of its receiver. But as with everything there are limitations.

Frequencies below about 5 MHz tend to "hug" the ground and can travel along with the curvature of the Earth. This is called 'ground-wave propagation'. Frequencies higher than about 5 MHz have little ground-wave propagation and will travel in a straight line or 'line-of-sight'. Since line-of-sight doesn't follow the curvature of the Earth these higher frequencies would seem to be limited in range regardless of the amount of transmitted power or the type of antenna being used. This is generally the case for frequencies above 50 MHz. But between about 3 and 50 MHz there is an effect called 'skip' that allows much longer communication distances (to be explained in the section on 'skip').

However, for frequencies above 50 MHz where skip and ground wave propagation generally do not occur range is usually limited to 'line-of-sight'. When that is the case the communications are subject to radio 'dead zones' which happen when a receiver is 'shaded' from the transmitter by a hill or other large obstacle. Therefore line-of-sight communications are not very reliable in hilly or mountainous terrains.

### E. Skip

The ionosphere is a layer of ionized air that encircles the earth. It is very useful for radio communications because it reflects radio waves back to Earth and well beyond the visible horizon. This is called 'skip' and can allow communications for several hundred miles and more. The range of frequencies where this occurs is generally between 3 to 50 MHz which includes the well-known 'shortwave' bands.

Skip however is highly variable depending on the condition of the ionosphere. The major factors affecting skip are the time of day, the season of the year and the amount of sunspot activity. Regardless conditions can change from moment to moment which is why you hear a shortwave station loud and clear one minute but not at all the next. Skip is most favorably consistent in the 3 to 15 MHz range.

Frequencies higher than about 50 MHz can skip at times but will normally 'punch through' the ionosphere right into space and into the realm of spy satellites, space debris and meteorites.

### F. Modulation

Modulation is how radio waves convey information. If communication is by Morse code the modulation is called CW or 'center wave' modulation. However, voice communication is the method most likely to be used in an emergency. Voice is conveyed using one of several different types of modulation.

The first is 'amplitude modulation', or AM. The broadcast band between 535 and 1705 kHz uses AM so is called the "AM Band". But radios on other frequencies use AM as well such as shortwave stations and CB radio. An AM transmitter is not very efficient and requires more power than any other type of transmitter for a given range. There is a sub-type of AM called 'single sideband' or SSB. It is much more efficient with much greater range per watt of power. It is used in most ham radios and some CB radios.

The next type is 'frequency modulation' or FM. Again there is a broadcast band that uses FM which is between 88 and 108 MHz. And again the use of FM isn't limited to that band. It is used in almost all commercial two-way radio systems as well as the audio portion of broadcast television. FM communications are noted for their lack of noise and static.

Another type is 'digital modulation' and its use for voice is currently limited to cell-phones, cordless phones and some commercial and military two-way radio systems. The voice is first digitized then the data stream is transmitted using a special type of radio modulation meant for data communications. It is used where the voice needs to be encrypted to prevent being received by the general public. But these digital systems are hacked almost as fast as they are developed by the manufacturers. And the radio transmitter can be located or 'DFed' just like any other radio transmitter. So in an emergency or survival situation digital voice may provide nothing more than a false sense of security.

## III. Broadcast radio

### A. AM broadcast band

The AM broadcast band is found between 535 kHz and 1705 kHz in the radio spectrum. It uses amplitude modulation and can be received by the simplest and cheapest of receivers even by a home made crystal radio. The low frequency range allows the transmissions to be carried for hundreds of miles by ground-wave propagation and sometimes thousands of miles at night. If a disaster occurs in a limited area distant AM stations will be heard even when local stations are off the air.

Because of this ground-wave propagation on the band AM radio stations are organized geographically in a certain way. This system was designed under the 1950's mindset of civil defense when nuclear war was a very real possibility. The idea is to have some stations with very high power cover very large areas of the country without interference (called 'Class A' or 'Clear channel' stations). These stations have very specific responsibilities during national emergencies and disasters and are intended to provide important public information when called into service. It is a very good idea to keep a list of these stations and their frequencies close to your emergency AM receiver. (See Appendix for list)

Because the frequencies are so low on this band a very long antenna is required. Most people have noticed however that many AM receivers have no antenna at all. They do but it is really inside the radio in the form of a coil wound around a bar of ferrite. This is usually all that is necessary because AM radio stations transmit with a lot of power.

Some radios have connectors for an external antenna which can be used to increase sensitivity of the receiver. There will be two terminals one marked 'AM' or just 'ANT' and the other marked 'GND' for ground. The antenna can be any piece of long, straight wire strung between two tall objects like trees, houses or poles. At this point length doesn't matter much because you probably won't have enough wire to make a very efficient antenna. Connect the ground to the water pipe of a house. Any grounding rod or pipe stuck in the ground will work but the bigger and deeper the better. Make good connections by sanding the pipe before clamping on the wire. A good ground is just as important as the antenna. When everything is hooked up turn on the radio and tune from one end of the dial to the other. You may find that one end of the dial is more sensitive than the other. If the higher frequencies are more sensitive then your antenna might be too short so you can make your antenna longer. Likewise if the lower frequencies are more sensitive you can make the antenna shorter. You probably won't be able to get very high sensitivity across the entire band so don't try. Instead, try to get the best reception only on the stations you want to hear. Experiment a bit. In any case do whatever works best for your radio. And don't forget to disconnect the antenna during a thunderstorm.

B. FM broadcast band

The FM broadcast band covers between 88 and 108 MHz of the radio spectrum. These are very high frequencies so stations do not have nearly the same range as AM broadcast stations. Thus, they are not required to abide by the same standards in an emergency situation even though they are still part of the Emergency Alert System. In most instances FM stations will not provide emergency information beyond telling you to tune to a Class A AM station for further information.

C. Television

Television broadcast frequencies cover large and scattered chunks of the spectrum from 54 to 890 MHz. The range is limited like the FM broadcast band because of the high frequencies. However, they broadcast video information which can be invaluable. And there is a drawback which is due to the wide variation of frequencies. This means that a separate antenna is required for each station for maximum sensitivity. But this isn't a major problem because a relatively sensitive and efficient television antenna can be made easily from a roll of 'twin-lead' antenna wire (specs to follow at a later time).

Satellite television is a different matter. Range is unlimited as long as your dish can be pointed at the satellite. But because the signal comes from a satellite reception can suffer due to many problems such as atmospheric ionization, interference from dust clouds or volcanic ash, problems in space like meteorites or space debris and malfunctions at the ground station sending the signal to the satellite.

IV. Two-way radio

A. Cellular phone

Cellular phones are everywhere except in my home. They use very high frequencies and so have very short antennas. Cell phones are notoriously unreliable during a widespread emergency or disaster. The reason is because the phones do not connect with other phones directly but through a system of cell towers. The cell towers are connected to a network of microwave links, landlines and satellite services. If any of these fail the load is increased on the rest of the network. If several fail then the network fails by a cascade effect of overloading. For an area-wide emergency they are for all practical purposes useless.

B. PRS (CB/FRS)

The Personal Radio Services include the venerable Citizen's Band (CB) radio service as well as the newer Family Radio Service (FRS).

CB radio has been around since the late 1950's and some form of it exists in almost every country on Earth. Before the cell-phone boom it was the most common two-way radio ever made and its popularity has lasted for decades. It is easy to find, easier to install, and even easier to operate. With plenty of aftermarket antennas and other accessories it is highly flexible in the number of possible applications. It is widely used by truckers, farmers, civil and emergency services and that guy with the truck down the road. CB radio was intended to be replaced by the Family Radio Service but that never happened due to the continuing popularity of CB radio.

CB radio no longer requires a license. It does have rules even though those rules are often ignored and rarely enforced. One of the most important rules is that channel 9 is restricted for emergency communication only. This rule is followed by most and many people monitor the channel on a regular basis. The non-profit organization REACT (www.reactintl.org) plays a significant role in emergency CB communications.

CB radio works on frequencies around 27 MHz. At this frequency the most reliable communication is line-of-sight limiting its range to just a few miles. Using a radio equipped with SSB ranges can be reliable to as much as 20 or 30 miles with a good antenna. When conditions are right for skip such as during a sunspot cycle or inversion layer in the atmosphere intermittent radio contacts of several hundred miles are a regular occurrence.

There have been many handheld CB radios made over the years. The range of these handheld radios is significantly less than mobile radios because there is no way to make an efficient antenna for a handheld at the operating frequency. If such a radio is needed a better option would be an FRS radio. Regardless if you have a CB handheld radio NEVER transmit unless the antenna is FULLY extended or it may and probably will break your radio.

The Family Radio Service is another low-power service. It uses very high frequencies (462/467 MHz) so maximum range is limited to line-of-sight and therefore subject to radio dead-zones. However the radios are very small and light. Unlike CB radios that can be installed in a vehicle or home, FRS radios are required by law to run from batteries only and not an external power source. They are also required to use the built-in antenna with no provisions for an external antenna. There is no designated emergency channel for the FRS service. No license is required for an FRS radio.

C. ARS (Amateur, Ham)

The Amateur Radio Service (aka 'ham radio') has made significant contributions to emergency radio communications since it began. An amateur radio operator is permitted to use various parts of the radio spectrum from 1.8 MHz all the way up to and including microwaves. The premier organization the American Radio Relay League (ARRL) has even launched its own orbiting communication satellites for use by amateurs. This service is a significant public resource that should not be overlooked or underestimated. A license is required. For more information go to (www.arrl.org).

### D. GMRS

The General Mobile Radio Service is for both commercial and private use. Upon approval of a license the FCC will assign a frequency within a specified band usually above 30 MHz. Communication range depends on frequency and equipment but there are limitations. Use of the assigned frequency is not exclusive and may be assigned to other licensed users.

### E. Sat-comm.

The satellite phone is the only method of communication that is not limited by location. The frequency of operation is very high but line-of-sight needs to be with a satellite not with another ground station. So you can use a satellite phone anywhere on Earth except at the poles. Both the phones and the service are very expensive.

### F. Part 15

Part 15 refers to the part of FCC regulations that permit the use of very low power transmitters without a license. Under certain guidelines a person can transmit up to 100 mW on the AM broadcast band and 1 watt on a part of the spectrum between 160 and 190 kHz (sometimes called the 'LOWFER' band). The behavior of radio waves at these low frequencies is unique. Long distance communication can be achieved with a very small amount of transmitted power and the range is even better with snow on the ground. There are very few Part 15 devices available commercially that have any practical value in an emergency so the use of these devices should be limited to those with electronics knowledge and experience. For more information go to (www.lwca.org).

## V. Radio communication practices

### A. Normal speech

When using a radio that uses voice communication it is necessary for the person receiving the transmission to understand what you are saying. You must therefore speak as clearly as possible. Hold the microphone away from your mouth at a constant distance (a thumb's length at minimum) and speak clearly with a steady volume. Don't scream into the mic or move it close to your mouth because it makes the received transmission sound garbled and distorted. If certain words are not understood despite good speech practices it may be necessary to spell the word. This is done using a 'phonetic alphabet'. There are two common variations of this one for military and one for civilian use. Use whichever is understood best by the receiver. (See Appendix for both phonetic alphabets)

### B. Coded or encrypted information

By law it is illegal to convey a message using code or encryption. This takes valuable time away from the NSA which is already too busy eavesdropping on the rest of US communications. Instead they may hand the message over to Homeland Security and lock you up as a terrorist - no trial, no lawyer, no right to habeus corpus and no protection from self-incrimination. I don't know if this has happened yet but I don't want to be the first. Until all the domestic US spy programs are dismantled it would be best to avoid encryption and codes.

### C. Secrecy

In general DO NOT convey important information over the radio. Not even bits and pieces of information that can be reassembled by those that may be eavesdropping.

Use just enough range to make contact with the other station and no more. This can be done using radios with less power, smaller antennas, directional antennas and even using geographical features to your advantage. If you do not want the signal to travel several hundred miles use the higher frequencies that will not skip. If you do not want to be heard by spy satellites use lower frequencies that will not penetrate the ionosphere.

Limit transmissions as much as possible to avoid detection. To avoid the transmitter being located by direction finders do not transmit for more than a few seconds at a time waiting a few seconds between each transmission. Do this even if it means breaking up a complete message into several separate transmissions. This is common practice for the military.

D. Relay communication

This has been done for as long as radio has existed. One station receives a message and passes it along to another station that passes it to another station..... Until it finally reaches the destination. Hopefully the message won't be distorted by the time it reaches the intended receiver.

VI. Appendix

A. Class A (Clear Channel) AM broadcast stations as of 08/06/07:

CALL FREQ CITY STATE

KYUK 640 kHz BETHEL AK
KFI 640 kHz LOS ANGELES CA
WSM 650 kHz NASHVILLE TN
KENI 650 kHz ANCHORAGE AK
WFAN 660 kHz NEW YORK NY
KFAR 660 kHz FAIRBANKS AK
KDLG 670 kHz DILLINGHAM AK
WSCR 670 kHz CHICAGO IL
KBRW 680 kHz BARROW AK
KNBR 680 kHz SAN FRANCISCO CA
KBYR 700 kHz ANCHORAGE AK
WLW 700 kHz CINCINNATI OH
WOR 710 kHz NEW YORK NY
KIRO 710 kHz SEATTLE WA
WOR 710 kHz NEW YORK NY
KOTZ 720 kHz KOTZEBUE AK
WGN 720 kHz CHICAGO IL
WSB 750 kHz ATLANTA GA
KFQD 750 kHz ANCHORAGE AK
WJR 760 kHz DETROIT MI
KCHU 770 kHz VALDEZ AK
WABC 770 kHz NEW YORK NY
KNOM 780 kHz NOME AK
WBBM 780 kHz CHICAGO IL
KGO 810 kHz SAN FRANCISCO CA
WGY 810 kHz SCHENECTADY NY
KCBF 820 kHz FAIRBANKS AK
WBAP 820 kHz FORT WORTH TX
WCCO 830 kHz MINNEAPOLIS MN
WHAS 840 kHz LOUISVILLE KY
KOA 850 kHz DENVER CO
KICY 850 kHz NOME AK
WWL 870 kHz NEW ORLEANS LA
WCBS 880 kHz NEW YORK NY
KBBI 890 kHz HOMER AK
WLS 890 kHz CHICAGO IL
KOMO 1000 kHz SEATTLE WA
WMVP 1000 kHz CHICAGO IL
KAXX 1020 kHz EAGLE RIVER AK
KDKA 1020 kHz PITTSBURGH PA
WBZ 1030 kHz BOSTON MA
IT’S 1040 kHz DES MOINES IA
KYW 1060 kHz PHILADELPHIA PA
KNX 1070 kHz LOS ANGELES CA
KUDO 1080 kHz ANCHORAGE AK
WTIC 1080 kHz HARTFORD CT
KRLD 1080 kHz DALLAS TX
KAAY 1090 kHz LITTLE ROCK AR
WBAL 1090 kHz BALTIMORE MD
WTAM 1100 kHz CLEVELAND OH

KFAB 1110 kHz OMAHA NE
WBT 1110 kHz CHARLOTTE NC
KMOX 1120 kHz ST. LOUIS MO
WBBR 1130 kHz NEW YORK NY
KWKH 1130 kHz SHREVEPORT LA
WRVA 1140 kHz RICHMOND VA
KSL 1160 kHz SALT LAKE CITY UT
KFAQ 1170 kHz TULSA OK
WWVA 1170 kHz WHEELING WV
KJNP 1170 kHz NORTH POLE AK
WHAM 1180 kHz ROCHESTER NY
KEX 1190 kHz PORTLAND OR
WOAI 1200 kHz SAN ANTONIO TX
WPHT 1210 kHz PHILADELPHIA PA
WTWP 1500 kHz WASHINGTON DC
KSTP 1500 kHz ST. PAUL MN
WLAC 1510 kHz NASHVILLE TN
KGA 1510 kHz SPOKANE WA
WLAC 1510 kHz NASHVILLE TN
WWKB 1520 kHz BUFFALO NY
KOKC 1520 kHz OKLAHOMA CITY OK
KFBK 1530 kHz SACRAMENTO CA
WCKY 1530 kHz CINCINNATI OH
KXEL 1540 kHz WATERLOO IA
KNZR 1560 kHz BAKERSFIELD CA
WQEW 1560 kHz NEW YORK NY

B. Phonetic alphabets

Letter / Military / Civilian

A Alpha Adam
B Bravo Boy
C Charlie Charles
D Delta David
E Echo Edward
F Foxtrot Frank
G Golf George
H Hotel Henry
I India Ida
J Juliet John
K Kilo King
L Lima Lincoln
M Mike Mary
N November Nora
O Oscar Ocean
P Papa Paul
Q Quebec Queen
R Romeo Robert
S Sierra Sam
T Tango Tom
U Uniform Unicorn
V Victor
W Whiskey William
X X-ray

Y  Yankee Young
Z  Zulu Zebra