

*a Quick Guide to*  
**REACT**  
Radio Systems



by R. K. Leef

**REACT** International, Inc.

5210 Auth Road, Suite 403

Suitland, Maryland 20746

301-316-2900

<[www.reactintl.org](http://www.reactintl.org)>

<[react@reactintl.org](mailto:react@reactintl.org)>

©2002 *REACT* International, Inc.  
All Rights Reserved

This Guide is intended to provide basic information about radio systems used by local *REACT* Teams to provide volunteer communications services to their communities.

It is not a technical or legal reference to Federal Communications Commission policies or regulations.

More detailed information on radio systems may be found in the *REACT* Emergency Communications (ECOMM) Manual, part of the Certification Training Program offered by *REACT* International, Inc.

We wish to acknowledge *REACT* member Tom Currie of Kentucky, chairman of *REACT* International's Training Committee, and communications consultant Gordon West of California for assistance in composing this material.

Publication approved by the Publication Review Committee  
September 2002

# REACT Radio Systems

## Table of Contents

Intro .....	page 2
1 – Purpose of a system .....	page 4
public access or not	
emergency or routine communications	
team monitoring log	
annual REACT International report	
2 – Distance to be covered .....	page 4
power limits	
interference	
3 – Equipment features .....	page 5
handheld	
mobile	
base	
repeater	
4 – Radio types and licenses .....	page 6
Citizens Band (Citizens Radio Service)	
Family Radio Service (FRS)	
Multi-Use Radio Service (MURS)	
Amateur (HAM)	
General Mobile Radio Service (GMRS)	
Business (“IG”)	
VHF Marine	
5 – Special modes .....	page 8
Packet	
Automatic Position Reporting System	
Television	
Cellular phones	
The Internet	

## 1 – Purpose of a system

In establishing the purpose of a *REACT* communications system it is necessary to keep in mind our Mission Statement. It reads: “The mission of *REACT* International, Inc., is to provide public safety communications to individuals, organizations, and government agencies to save lives, prevent injuries, protect property, and give assistance wherever and whenever needed. We will strive to establish a monitoring network of trained volunteer citizen communicators using any and all available means to deliver the message.”

Each Team should discuss and decide what kind of radios will be used in its area to carry out this mission. In arriving at a decision, establish whether your focus will be on monitoring, communications for community events, or both. Do you want CB (Citizens Band), FRS (Family Radio Service), or MURS (Multiple Use Radio Service) radios that are open to the general public for access? Or, do you want a radio system like GMRS (General Mobile Radio Service), Amateur, Business (FCC class IG), or VHF Marine, systems that are somewhat more restricted in access? The characteristics of each of these are explained in Section 4. Because there are important differences among the various radio services, and many Teams have several different needs, most Teams use more than one kind of radio. We encourage this kind of variety.

In determining the type of radio service(s) for your Team, also consider how the radios will be used: whether for emergency or routine communications, and whether internally, within the Team or externally, with outsiders.

For example, CB channel 9 is officially designated by the Federal Communications Commission (FCC) for emergencies and assistance, and routine messages are not allowed. The GMRS frequency of 462.675 MHz. is designated as an assistance channel but it may also be used for routine messages. Other frequencies and radio types are designed for certain specific uses too; it's important to know what they are.

Regardless of the types of radios used, the Team has a responsibility to keep appropriate records. The three basic documents are the FCC license (if applicable), rules and regulations for each service being used, and monitoring logs. Each member should have a copy of any current license used in the performance of *REACT* activities. This could be a license belonging to *REACT* International, Inc., a Council, a Team, a *REACT*-related entity, or a personal license. A copy of the rules and regulations of each radio service that the Team uses should be available, as well as any manual or guidelines established by the licensee.

If one of the Team's activities is monitoring for emergency calls, monitoring logs should be used to record all calls, and summary information should be submitted to *REACT* International as required (presently on a yearly basis). The summary monitoring log provides a means of evaluating the performance of our organization, and also provides an accurate source of statistical information for public relations purposes. Its importance cannot be overstated.

## 2 – Distance to be covered

In selecting a radio system, one of the most important questions is, “How far can I talk and hear?” Because of several varying conditions, this is not easy to answer. The rule of thumb for a handheld radio is that its useful range is one mile per watt, but that's roughly accurate only over flat land or water, not using a repeater, and with little or nothing between two handheld radios.

The range for handheld operation can be increased by

1. Using a mobile or base radio to communicate with handhelds
2. Placing handhelds at a high location
3. Using a repeater (if allowed)
4. Using an external antenna when operating the handheld in a vehicle

The range for handheld operation can be reduced by

1. Obstacles, such as hills or heavy forestation, between two handhelds
2. Metal and concrete structures, if in a building or between a building and outside
3. Heavy rain or other precipitation (depending on frequency band used)
4. Not using an external antenna when operating the handheld in a vehicle.

The range on mobile and base radios is greater because they generally use a bigger and higher antenna, as well as a more powerful transmitter.

Repeaters offer the greatest improvement in range. A repeater receives the signals from handhelds, mobiles, and bases; amplifies the signal; and retransmits it on a different frequency. In most radio services, repeaters are permitted higher transmitting power than handhelds or mobiles (although usually not higher than base radios).

Legally-permitted transmitting power varies in different radio services, and for different radios within a given service, from the 0.5 watts permitted in FRS to services that allow as much as 50 watts or more. In general, the higher the transmitter power, the greater a radio's useful range. However, that is not as great a limitation as it might seem.

The maximum transmit power allowed on FRS is 0.5 watt, which translates to approximately one-half mile for reliable communications, and repeaters are not permitted in this unlicensed service. However, a half-watt FRS handheld has been known to reach another FRS handheld 70 miles away, when the transmitting radio was high up on a mountain, and similar low power transmitters are used all the time from earth satellites thousands of miles away.

Interference also affects the useful range of a radio system. Some interference is man-made, some isn't. Typical sources of interference are other users on the channel, vehicle ignition noise, atmospheric conditions, and equipment malfunction. Ignition noise is typically found in AM (amplitude modulation) radios such as CB. Other radio systems used by *REACT* operate on FM (frequency modulation), which is less vulnerable to most types of interference.

### 3 – Equipment features

Handheld radios are probably used by more *REACT* members than any other type. A typical model will have multi-channel capability, 4 or 5 watts output, antenna, and rechargeable battery with charger. It should have tone capability (except CB or VHF Marine radios. Tone is the common name for CTCSS, Continuous Tone Coded Squelch System. CTCSS is a subaudible sound from 67.0 Hz to 250.3 or 254.1 Hz sent by the radio as you talk. (If you listen carefully you may be able to hear it!) Many extra functions, such as priority channel selection and scanning, may be included in a handheld.

In the radio services where CTCSS is available, having the same tone on all the radios in a system allows communication with little or no interference from other users on the frequency, as long as they use a different tone. These are sometimes wrongly called "privacy codes" or "subchannels" in FRS radios, but keep in mind there is no privacy. You can hear other users and they can hear you by simply disabling the tone, such as by pressing the "monitor" button on some radios.

CTCSS tones also are used to control access to a repeater, and sometimes to control its operation (such as turning it on and off, or enabling or disabling tones).

Mobile radios usually have multi-channel capability and features of a handheld, but typically are larger and transmit with up to 25 watts or more. They require an external antenna. There are few base radios (that is, radios intended for permanent installation at a fixed location) as such being marketed, so members often use a mobile radio and add a power supply and outside antenna.

Repeaters are used on Amateur, GMRS, and Business frequencies.

When the radios in a system communicate directly with one another, is known as “simplex” operation, or just “direct”: Each radio transmits and receives on the same frequency (but each radio can do only one or the other at a given time; no radio can both transmit and receive simultaneously).

In order to extend the distance covered, a repeater can be used. In this case, radio A transmits on one frequency; the repeater receives the signal on that frequency and immediately sends the signal out on a different frequency where radio B hears it. Radio B answers by also transmitting on the repeater’s receiving frequency and the same process takes place in reverse so radio A receives the message on the repeater’s transmitting frequency. As before, each radio can either transmit or receive at a given time, but not both simultaneously. Typically, the repeater’s transmitting frequency is the same as the direct or “simplex” frequency used for a given channel, so that any radios being used in simplex mode will receive the repeater’s output signals as well.

Cellular phones and some very sophisticated radio systems operate on “full-duplex” systems in which any two radios, at any given time, use separate receive and transmit frequencies, which makes it possible for a radio to transmit and receive simultaneously.

## 4 - Radio types and licenses

**CB.** Citizens Band is an unlicensed service, 5 watts is the maximum allowable power; it is useful for short-distance, general public use for personal and commercial communications. At present, CB is used mainly by truckers. For several reasons, CB can be subject to heavy interference at times, making all but very-short-distance communications impractical. There are 40 VHF channels on AM and SSB, with channel 9 designated by the FCC for emergencies and assistance to travelers. Handheld, mobile, and base models are currently available in the range from \$50 to \$200. Repeaters are not permitted.



**FRS.** Family Radio Service is an unlicensed service, 0.5 watts maximum power, limited to very short-range communications, used mainly for family communications at home and for recreational activities. It can be subject to moderate interference. There are 14 UHF channels on FM; channel 1 is unofficially used as a common “call” channel. Many handheld radios are available and a mobile/base is currently available from one manufacturer; some handhelds are as low as \$20. Channels 1 through 7 are shared with GMRS.



**MURS.** Multiple Use Radio Service is an unlicensed service, 2 watts maximum, short distance, personal and commercial use, moderate interference; there are 5 VHF channels (FM). There are handheld models only, but external antennas are allowed. Radios cost \$150-\$250.

**AMATEUR.** Each user is licensed by the FCC for ten years after passing a free test (although there is usually a small charge for test materials). Many different power limits, modes, and frequency bands are



included in the amateur service. Two meters (144-148 MHz) and 440 MHz (also referred to as 70 centimeters) are the amateur frequency bands most commonly used by *REACT* Teams. Long-range communication is possible through repeaters. Handheld, mobile, and base radios, and repeaters, are available from \$100 up. Amateur radio communications are strictly limited to personal (non-commercial) use. Interference from other users is relatively infrequent and unintentional. Check for current license requirements.

**GMRS.** A General Mobile Radio Service license is issued by the FCC to an adult but covers everyone in the family. Currently a five-year license costs \$75; no test is required.. Maximum power is 50 watts on 16 UHF channels (FM) plus 7 channels that are shared with FRS. 462.675 MHz. is the unofficial "assistance" frequency. Long-range communication is possible through repeaters. This service is limited to personal and commercial use; interference is infrequent. There are many handheld and mobile radios and repeaters, from about \$150. (Some models are not designed for use with a repeater.) Under present FCC rules, only individuals may hold a GMRS license, but some Teams have a "grandfathered" license that can be used by members for Team activities.



**BUSINESS.** A license for FCC category "IG" is not supposed to be used for personal messages; it is intended for internal communications of a company or organization. There is no test, but the cost of a license is about \$100 and can vary according to the complexity of the system applied for. If "itinerant" frequencies are not applied for, frequency coordination will be necessary and will add approximately \$150 to the cost. Various frequencies and power levels are available for FM, mostly on UHF. Long-range communication is available through repeaters; interference is infrequent except in highly congested areas such as major metropolitan areas. Handheld, mobile, and base radios, and repeaters, are available from \$150. *REACT* International has a business band license that can be used by Teams for appropriate activities, but authorization must be obtained in advance from International headquarters.

**VHF MARINE.** Quite a few Teams use VHF Marine radio frequencies, mostly monitoring channel 16 (156.8 MHz) to assist callers on rivers, lakes, and along coasts. Communications on the band are limited to ship's business, weather, and Marine safety information; no personal messages. If on-board

communications equipment is limited to VHF Marine two-way, radar, and EPIRB, and all cruising is local (U.S.), no license is required. Identification is done with the vessel name plus bow numbers.

Marine land monitoring stations, called Private Coast Stations, require a FCC license that currently costs \$150 and is good for ten years. This covers base, mobile, and handheld radios. Cost of the radios is approximately the same as commercial and amateur models.

## 5– Special modes

The following are not types of two-way radio as in Section 4 but they can enhance communications for monitoring, and community events.

**PACKET** is a type of e-mail by radio and computer. Text messages are formatted, by the computer's software, into digital strings called "packets," which then can be transmitted by radio; when received by another radio, the packets can be converted back into text by a computer. There are a number of different packet software systems available, and they are not mutually compatible. More info available from <[www.tapr.org](http://www.tapr.org)> web site.

**APRS** (Automatic Position Reporting System) uses a Global Positioning System (GPS) receiver connected to a radio to send a digital message containing the radio's location by latitude and longitude. APRS uses a specific application of the Packet radio protocol to send location, call sign, and short text message to a computer. More info available from <[www.tapr.org](http://www.tapr.org)> web site.

**TELEVISION**. Fast-scan TV (FSTV). also referred to as amateur television (ATV), uses a transmission system that is fully compatible with video equipment designed for the home consumer market. Most activity is between 420 and 440 MHz. Slow-scan TV (SSTV) uses a special format to send TV-like images one frame at a time. The effect is a still picture or a slide show rather than a moving picture. Civil Air Patrol units also have SSTV equipment that is intended to relay pictures from an aerial observer back to a base station such as an EOC.

**CELLULAR PHONES**. In any activity where lots of information needs to be passed quickly among a limited number of people, or where it is important to contact someone who can be reached by the public telephone system, *REACT* members will find the cell phone may be a good method; it is much less useful for the kinds of communications that ordinarily accompany community events or disaster scenes.

**THE INTERNET**. Internet e-mail is most useful when a large number of people need to be contacted, and an accurate record of communications must be maintained. Anyone with a computer, proper software, and access to the Internet can send messages without further cost, and additional information (such as documents) can be attached to an e-mail message. *REACT* International strongly encourages all of its members to obtain a valid e-mail address and to register that address with their Team, Council and *REACT* International.

More detailed information on radio systems may be found in the *REACT* Emergency Communications (ECOMM) Manual, part of the Certification Training Program offered by *REACT* International, Inc.

We wish to acknowledge *REACT* member Tom Currie of Kentucky, chairman of *REACT* International's Training Committee, and communications consultant Gordon West of California for assistance in composing this material.