Survival Communitcations FAQ Version 0.5

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This document was written mainly by a long-time lurker on misc.survivalism. He sent it to me, and I filled in a few blanks, deleted a few things that seemed confusing or spurious, and tried to clean up the formatting somewhat.

Any comments should be sent to me at medintz@ukans.edu, and will be acted on or forwarded to the author as appropriate.

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This document is a work in progress. Suggestions, comments, and recommendations are always welcomed, and will be acted on or forwarded as appropriate.

Further information on radio may be gathered from _The ARRL Handbook_ and the _ARRL Operating Manual_, published by the American Radio Relay League (http://www.arrl.org)

A topic as broad as communications can never been completely covered, especially in what should be a terse and matter-of-fact FAQ. We ll start out with the most general description we can provide, and get more specific deeper in the document.

WHAT COMMUNICATION IS

The first step in understanding survial communications is understanding of the fundamentals of communication itself. Communication is a very complex topic, as difficult to completely define as truth, beauty, or time, but we ll cut to the chase to make our life simple with two definitions:

COMMUNICATION is the successful transfer of information from one person to another person or entity.

COMMUNICATION SYSTEMS are comprised of equipment, methods and techniques of supporting information transfer, enabling communication to take place between two people. (Please note that these definitions are cheap outs, since we haven't defined what we mean by information, but you get it, right? Note that we re also limiting things by requiring at least one person in to loop, to reduce the scope of this document.)

What Happens When We Communicate?

In order for any communication to take place, there s two major requirements that must satisfied.

REQUIREMENT ONE: There must be a sender and a receiver. For most survival purposes, this means a person trying to send a message and a person looking for a message sent to them.

REQUIREMENT TWO: The sender and reciever must understand how the message is to be conveyed, and must understand the message itself. Again, for survival purposes, this means that both people trying to communicate understand how their communication system works (how to operate the radio, that one or two lamps have different meanings, how to look up a word in a dictionary) and that they understand the message (the message in clear and in a common language, that one lamp means by land and two lamps means by sea.)

REQUIREMENT THREE: the communication system must be capable of delivering the message. (There s not so much fog the lamps can t be seen, the radios are within range and working properly.

THE ONE RULE OF COMMUNICATIONS: To communicate, the sender creates a message that both he and the reciever should understand. Then, using a common system that is capable of delivering the message, the sender transmits the message to the receiver, who understands the message sent.

SURVIVAL IMPLICATIONS

Failure to communicate is always the result of a failure to meet the requirements. A few specific examples:

The first requirement--that there s someone trying to send a message, and someone listening--seems obvious, but in practice it s probably the most violated requirement of communications in a survival sense, giving the violator a false sense of security until they need to communicate. For some reason, somebody buys a CB and thinks they can be in the middle of nowhere, call for help on channel 9, and Air Rescue magically appears to come in and save them. Yup, it s a long day in hell when this happens. It s not just CB owners, either: this requirement gets violated by amateur radio operators (I'll just call for help on the repeater...except they left the directory home and their rig doesn t provide the right subaudible tones, or the guy that just answered your CQ or SOS on 40 meters thinks you re a crank).

Nor is this limited to radio: flare guns (It s 2AM, a bear just ate your camp partner, and you re fifty miles from civilization in a valley. Shoot a flare off, and you ve made your camp brighter for a few seconds and pissed off the bear. Feel better?) Air horns (same scenario, maybe the bear leaves if it s loud enough.)

Resolving problems surrounding the first requirement simply means making sure there s a person listening--perhaps someone you know, perhaps not. The 911 system, for example, consists of people continually monitoring a phone for incoming messages from senders. World-wide, satellites and many pilots listen to 121.5 MHz on their radios, looking for distress signals.

If the CBer knew someone in the area who agreed to listen on channel 9 for 15 minutes at 6PM everyday, his chances of being heard then are vastly improved. The ham, who had punched in the frequency to his club's repeater, which has a long-tone-zero emergency alert system that gets friends from the club on would be in better shape too; and if the ham s friend was listening at 6PM everyday on 40 meters, it s doubtful his friend would think he was nuts if he said he needed help urgently. Having a friend look for a flare on a ridge line a hour before sunrise--and climbing to the ridge line to fire the flare--would work wonders, too.

Note that in each of these cases, not only was someone listening, but there was coordination, also, in that the recipient of the messages knew when and where to look or listen.

What we ve learned:

1) Someone has to Send and someone needs to Listen.
2) Both have to use the same system. Both need to understand the message.
3) Coordination between the sender and listener vastly increases the liklihood of successful communications.

A. Types of communications

1.Wired Communications

a)Basic Telephone Service

Current telephone communications, at least in industrialized nations, is the standard of excellence that most comunications systems are compared. Disparaging comments and annoying customer service issues asside, standard phone service is nearly universal, approaches 100 percent reliability, and offers nearly instant connectivity to virtually any person in the industrialized world. Phone service is probably the single most utilized form of survival communications, used whenever 911 is dialed, or a person phones a friend for help.

While basic phone has never been completely secure, it s become very apparent that phone services is on the virge of nearly total security compromise, at least with respect to national agencies. Note that with modern signaling and billing-records systems, every phone call is logged, and the phone number--which is effectly an address to a physical location for wired phones--is present with each call; this is true even of pay phones.

The exposure risk associated with basic phone systems is extreme. Any communications which is intended to remain private probably shouldn t rely on phones. This is of no bearing for most conventional survival scenarios.

Phone service can fail at any time, but due to very good survival engineering, basic phone service often stays operational days after AC power fails. Destruction of plant or equipment--the central office, patch boxes, wiring or the phone poles--will result in failure of service, of course. Note that in floods, hurricanes, and earthquakes phone service often fails in a widespread way, whereas failure in common storms and civil disorder is ususally locaized.

Note that while phone service may continue to be reliable during a disaster, communications may be difficult due to overloading. During the summer of 1996, a power outage in the western united states resulted in a flood of calls to 911 systems in several states from people simply reporting that their power was out; in some areas, 911 failed completely, or had hold times in excess of 30 minutes.

a) Private Point-to-Point (Intercoms and Field Phones )

Outside of PBXs located in buildings, private wired communications aren t very common. Two notable exceptions are intercom systems that are used to communicate within a building, and field phones, which are essentially military versions of intercoms. Intercoms are generally limited in range.

So-called wireless intercoms use the AC power line to convey their signal--and are dependent on AC power themselves. Wired intercoms usually don t cover more than a few hundred feet in a building, due to the wiring dificulties. Such intercoms usually run on batteries.

Field phones are generally used in environments where complete control of the lines of communication exist. The typical military field phone runs on two D cell batteries, and can operate over up to twenty miles of two-conductor wire.

In general, private wired communications is the most secure, . The wires themselves can be followed if not concealed, revealing both points of communications.

1.Radio Signals

There s a huge number of possible options for radio-based survival communications, ranging from getting broadcasts from authorities via a $4 AM radio to portable satellite phones.

a)Broadcast Radio

AM Radio

Let s be blunt. If you can have only one radio, if you have less than ten bucks to buy equipment, forget CB, Ham, and everything else. Get a portable AM radio. The first radio band for survival, news, and government information is the old AM radio band, from 550KHz to 1700KHz.

Equipment can be very small, with typical radios 1 x 3 x 4 in size, light, low-power (two AA batteries can run a radio for weeks at low volume or with earphones), cheap (Radio Shack s FlavorRadio is $7), very reliable (single IC), long range (100s of miles for clear-channel radio stations at night)

In addition to the radios themselves being reliable, AM broadcast radio stations themselves are also fairly reliable with back-up transmitters, emergency generators, and bomb shelters: a few radio stations in every area are part of a extremely reliable network that is a carryover from the civil-defense radio network s heydays of the 1950 s. The two civil defense frequencies are ____ and ____. (insert your area freq's here)

As a result of the defense network carry-over, and the fact that many AM stations offer talk-radio call-in formats, AM radio is ideal for getting news and information during emergencies, probably more so than any other source.

The military and other government agencies also maintain emergency portable radio stations for disaster-stuck areas, that are AM stations. Inexpensive AM radios with ferrite bar antennas have a secondary survival use as navigation instruments. Such radios have sharp, well-defined nulls where the signal goes dead. If one knows the direction of the nulls of the radio and the locations of the AM radio stations in the area, it s possible to triangulate your own location based on the directions your radio indicates each station is in. Accuracy isn't incredible, but it can generally give a position of +/- 5 miles if the radio stations are 50 miles away.

Within the US, there was originally a set of stations set up with what is known as clear channels that made sure a single, high power station had no others within hundreds of miles on the same frequency. Nowdays, these are known as Class A stations. These stations can be heard for hundreds of miles at night, allowing listeners in disaster-striken ares to hear stations that are in surviving areas. (for example: At night, one can hear WMAQ-Chicago on the eastern edge of the Colorado Rockies without too much difficulty.)

| FREQ | CALL | CITY | STATE |
|---|---|---|---|
| 640 | KYUK | BETHEL | AK |
| 650 | KYAK | ANCHORAGE | AK |
| 660 | KFAR | FAIRBANKS | AK |
| 670 | KDLG | DILLINGHAM | AK |
| 680 | KBRW | BARROW | AK |
| 700 | KBYR | ANCHORAGE | AK |
| 720 | KOTZ | KOTZEBUE | AK |
| 750 | KFQD | ANCHORAGE | AK |
| 770 | KCHU | VALDEZ | AK |
| 780 | KNOM | NOME | AK |
| 820 | KCBF | FAIRBANKS | AK |
| 840 | KABN | LONG ISLAND | AK |
| 850 | KICY | NOME | AK |
| 890 | KBBI | HOMER | AK |
| 1020 | KFFR | EAGLE RIVER | AK |
| 1080 | KASH | ANCHORAGE | AK |
| 1170 | KJNP | NORTH POLE | AK |
| 1090 | KAAY | LITTLE ROCK | AR |
| 580 | CMJP | CIEGO DE AVILA, CAM. | CA |
| 640 | KFI | LOS ANGELES | CA |
| 680 | KNBR | SAN FRANCISCO | CA |
| 810 | KGO | SAN FRANCISCO | CA |
| 900 | CMJV | CIEGO DE AVILA | CA |
| 1070 | KNX | LOS ANGELES | CA |
| 850 | KOA | DENVER | CO |
| 1080 | WTIC | HARTFORD | CT |
| 750 | WSB | ATLANTA | GA |

1040 WHO DES MOINES IA

670 WMAQ CHICAGO IL
720 WGN CHICAGO IL
780 WBBM CHICAGO IL
890 WLS CHICAGO IL
1000 WMVP CHICAGO IL

1190 WOWO FORT WAYNE IN

840 WHAS LOUISVILLE KY

870 WWL NEW ORLEANS LA
1130 KWKH SHREVEPORT LA

1030 WBZ BOSTON MA

1090 WBAL BALTIMORE MD

760 WJR DETROIT MI

830 WCCO MINNEAPOLIS MN

1120 KMOX ST. LOUIS MO

1110 WBT CHARLOTTE NC

1110 KFAB OMAHA NE

660 WFAN NEW YORK NY
710 WOR NEW YORK NY
770 WABC NEW YORK NY
810 WGY SCHENECTADY NY
880 WCBS NEW YORK NY
1130 WBBR NEW YORK NY
1180 WHAM ROCHESTER NY

700 WLW CINCINNATI OH
1100 WTAM CLEVELAND OH

1170 KVOO TULSA OK

1190 KEX PORTLAND OR

1020 KDKA PITTSBURGH PA
1060 KYW PHILADELPHIA PA
1210 WPHT PHILADELPHIA PA

550 CMAA PINAR DEL RIO PR
740 CMAC PINAR DEL RIO PR
740 CMAB PINAR DEL RIO PR

650 WSM NASHVILLE TN

820 WBAP FORT WORTH TX
1080 KRLD DALLAS TX
1200 WOAI SAN ANTONIO TX

1160 KSL SALT LAKE CITY UT

1140 WRVA RICHMOND VA

710 KIRO SEATTLE WA
1000 KOMO SEATTLE WA

1170 WWVA WHEELING WV

a)Two-Way Radio

1)Unlicensed Services

All radio services are regulated in some form, even if it s a law that states that the service is unregulated. However, there are several license-free services in the U.S. Note that other locations aren t quite as progressive in terms of unregulated services. The U.K., for example, requires CB radios to be licensed, and doesn t offer a free 1750 meter band. YMMV!

CB Radio (AM and SSB)

CB, also known as Citizen's Band (or Children's Band to its detractors) uses an amplitude-modulated signal on forty channels centered around 27 MHz. These radios are limited by FCC regulation to four watts of output power going up the antenna. Typically, from a vehicle with an average antenna on flat terrain this results in a range of ten to twenty miles.

With a better antenna, considerably longer ranges are possible. However, another FCC regulation requires CB operators to take steps to prevent their signal from being detectable beyond 150 miles. CB frequencies are plagued with a number of problems, such as overcrowding on certain frequencies and considerable rudeness. Typically, Channel eleven is considered a general calling channel, and Channel nineteen is used by truckers. In addition, Channel nine is reserved by law for emergency use only.

Part 15 Radio Bands

So-called part 15 bands owe their name to the United State s Federal Communications Commission, which has a rule (Part 15) which allows certain types of unlicensed radio transmitters. There are three main part 15 bands that are commonly used for two-way voice communications (other bands exist under part 15 for a plethora of other devices.) The only band that s really significant is the 49 MHz band; the other two are interesting, but probably impractical.

# 49 MHz Radios

The 49 MHz band is a widely-used consumer radio band, primarily for cordless phones. There are 10 narrow-band FM channels between 49.67 and 50.00 MHz assigned to the band. The band is relatively noise-free in non-industrial areas, though the millions of cordless phones means plenty of interference in highly urban settings. Power output is specified by field strength -- 10,000 uVolts/meter at 3 meters, and translates to a few milliwats. The band is most useful for short-range communications.

The recievers of good radios are such that this low power gives a 1/4 mile range, though field tests show ranges of 1/8 to 1/2 mile, depending on terrain. The radios perform amazingly well in difficult, hilly terrain at short range. In very controlled tests using a lab-grade reciever/antenna, a detection range of three miles was obtained. Equipment is small and light, often only 1 x 3 x 7 or smaller; it's offered by many manufacturers that also make CB radio equipment. Power requirements are miniscule, with RX requirements of less then 20 milliwatts and TX requirements of 100 milliwats. (In one test with a radio using three AA lithium batteries, run time in RX mode was two WEEKS continuous.)

Though very reliable electrically, durability is a concern, as most equipment is built with light plastic cases and no waterproofing. Cost is generally $25-$40 per unit with features of single-v.-5 channel and voice-operated switching accounting for the difference. Note that kiddie walkie-talkies also operate on this band but the recievers of such radios are worthless.

Due to the proliferation of small, inexpensive 2-way radios for this band, there is no realistic hope of private communications-indeed, it's entirely possible that this band will become so crowded as to be useless in the event of an emergency.

There are no standard frequency uses or nets on this band. Considering the limited range, the primary use will likely be for tactical communications among a small group, such as coordinating camp activities. One group sends a scout ahead in diffcult terrain while the rest of the backpacking party waits, with the scout calling back if the path taken is viable; this saves hours of useless backtracking.

A secondary use is to place a radio with volume set on maximum on a pack that is cached in a well-camoflaged environment. The squelch keeps the radio quiet, but another radio can transmit sounds allowing the user to home-in on the hidden pack.

The 49 MHz band is smack-dab in the middle of the VHF-low band (30-88 MHz, 25 KHz channel spacing) that armies world-wide use for primary tactical communications. It should be no surprise then that there's quite a variety of ground-based, airborne, and satellite-based radio equipment dedicated to intercepting, direction-finding, and jamming these frequencies, which include the 49 MHz band.

Theoretically, consumer 49 MHz radios and military VHF-low radios should interoperate. However, the reality is that only some military radios operate with narrowband FM, and the tuning steps of the radios are 25 KHz at best, frequently placing them off-channel. Newer tactical radios, such as the US Army SINGARS, are usually operated in frequency hopping mode, in which there is no hope of interoperability (such radios can tune to single channels, however.)

Although highly susceptible to interception and direction-finding, in practice the range of consumer radios on this band is so limited that this highly unlikely to occur unless a party is expressly seaching for the signal in the immediate area; the short range also makes these one of the few radios immune to satellite-based DF. In urban evironments there are litterally hundreds of competing signals on the same frequency, making interception and DF difficult. Note that in scenarios involving military conflict, operational jammers could make these radios unusable at tens of miles away, and these radios are likely to be unintended victims--jammed simply because they re in the middle of a military band, and not due to overt intent.

One group known to us has primary communications based on 49 MHz radios. The limited range and extremely low power consumption were keys, along with the fact that the group stays close together 100% of the time were factors that lead to the decision.

1750 Meter Lowfer Band

In the US, the 1750-meter band allows radios to operate with 1 Watt of power into a 50 long transmission line/antenna system at frequencies in the 170 Khz (that s 0.170 MHz) range with no license. This is a *really* low frequency.

Equipment for 1750 meters is generally as small as one wants to build it--there are only a few commercially built radios for this band, generally the same size and weight as a larger mobile CB radio. Power consumption is quite low, with about 3 watts peak for TX and hundreds of milliwatts at most for RX. Cost is generally no more than $200 for a top-end commercial built radio.

Antennas are inefficient--and large, since the 50  limit really needs to be exploited for the radio to work--and communication is not very reliable at  long ranges, but at short ranges (a few miles) at night, when the noise level is low, 1750 meters is reliable; at night during the winter, it provides the greatest range, with semi-reliable contacts at 100s of miles. During the summer this band is plagued with static and isn t very reliable. The 1750 Meter band is a (barely) plausible survival radio band only if it's used for a network among users that are located near each other.

There are a few experimenters on this band that perform low-rate data communications using exotic modulation methods, but most prefer morse code or SSB. There are no regularly monitored channels or survival networks in operation, though some radio enthusiasts in California do have a regular net.

It is, however, worth noting, that some caving and spelunking enthusiasts also sometimes use this band , as low frequencies have some limited ability to penetrate obstacles such as the ground.

There's one survivalist of note that does use this band: the U.S. Government. A special high-survivability data network known as the ground-wave emergency network, or GWEN, can be heard between 150 and 170 KHz with a repetitive noise that sounds like a cross between a hiss and a crunching sound. This network is intended to survive a massive nuclear strike and provide low-data-rate post apocalyptic communications.

Low frequencies are so easy to direction find that they are the basis of the first radio-navigation system used for aircraft and ships. Starting at about  200 KHz, there are thousands of low-power non-directional beacons (NDBs). Automatic-direction-finding (ADF) radios tuned to an NDB indicate their direction with high accuracy, and many ADF recievers are capable of tuning the 1750 meter band.

On the plus side, although direction-finders work really well here, the low power and low frequency of the 1750 Meter band make it effective for covert communications; few recievers tune this low, and even fewer people even bother to listen. Due to the inefficiencies of the antenna system jamming is difficult, and there is no known deployed jamming equipment capable of disrupting this band.

Micropower AM and FM

Also permitted under part 15 is low-power (100 milliwatts) AM transmitters with a 10  antenna restriction on the same band as broadcast  AM radio. The AM band shares many characteristics and difficulties of the 1750-meter band.

Equipment is generally always hand-made, usually from AM broadcast kits. Receivers can be cheap AM recievers, but a viable communication system will likely use a sensitive mediumwave/shortwave radio reciever. Cost of the transmitter can be as low as $20, the reciever $5 to $5000.

Transmitter size is generally the size of a small mobile CB, about 2 x 6 x 6 . Power consumption is minimal, under 1/2 watt. Reliable reception ranges of a 1/4 mile or so are common, though with good receivers and quiet band conditions (at night, during the wintertime) on an unoccupied AM channel (rare in its own right) ranges of 100s of miles have been obtained.

Signals are easy to direction find (indeed, many aircraft ADF systems also tune the AM radio band) and it s trivial to jam weak-signal reception in the AM band when mother nature isn t doing it herself with thunderstorms.

No nets are known to use micro-power AM, though some pirate-radio broadcasts violate the FCC s power specification and some of these transmit vaguely survival-related gloom-and-doom conspiracy radio programming. This (with legal power, and probably better, community-related programming, of course) is probably the only viable use for this band in a survival context (weak as though that may be.)

Micropower FM stations are also permitted, but the large bandwidth and low power allowed makes micropower FM even more useless than AM.

(1)Licensed/Regulated Services

(a)Amateur ( Ham ) Radio

6-Meter Band

The six-meter band (50-54 Mhz ham band) is considered sort of a "schizophrenic" band, that can't make up its mind whether to be a worldwide/distant contact band or a local VHF band. It generally has been known to be used as both of these. The use of this band is primarily a local phenomenon-extremely popular in some areas and completely silent in others.

2-Meter Band

2 Meters (144-148 Mhz.) is one of the most commonly used bands in the United States. Frequently these days, when a ham buys his first radio, it's a mobile or handheld 2-meter FM transceiver. SSB and CW are rarely, but occasionally used on this band. However, 2M is a favorite for amateur radio satellite and amateur Earth-Moon-Earth communications, and for technical reasons these methods require the use of SSB or CW rather than FM.

MF/HF Bam Bands:

In the United States, ham radio bands exist at 1.8MHz, 3.5MHz, 7MHz, 10.1MHz, 14MHz, 21 MHz, 24MHz, and 28 MHz. These bands are all capable of long-distance communications, depending on atmostpheric and sunspot conditions, and have all been used for worldwide/international communication. The most common emissions modes are CW (Morse Code) and Single Sideband, but certain data communications are also used. Equipment for these bands is all over the range in terms of price and complexity -> low-power CW-only single frequency transmitters can be built for $20, and high end all-band all-mode transceivers can be bought for several thousand dollars.

(1)Commercial Carrier and Emergency Services

Cellular Phones

A Cellular phone is essentially a low-power UHF transceiver. When a call is made, the phone signals a fixed station called a 'cell.' The cell transfers the signals between the radio waves and thephone exchange. (A gross oversimplification, but detail is not required here.)

Cell phone conversations are not private, any more than any other radio conversation. Technically, the law says that they may not be monitored, but this law is unbelievably easy to violate-scanners able to pick up cell frequencies are not sold to civilians any more, but they can be built.

Cell phones also depend upon a working cell. A power outage for an extended period could result in shutdown. Also, cells can be overloaded. In the event of a disaster, a cell can handle a given number of calls-that number plus one risks overloading the cell and causing it to shut down completely.

Paging

Paging is essentially a method of one-way radio communication. An individual makes a telephone call to a given phone number, and is prompted to enter a message. This message is then sent out over VHF or UHF radio to a specific pager. Some paging service allows the display of phone numbers.

Others actually permit one to email a message to a pager.
This service has an advantage, in that it can discreetly summon one to check in or go somewhere as needed, but is dependent upon a network of transmitter towers and phone lines, and therefore might not be fully functional in a disaster.

a)Radio Operation and Procedures

A radio-based communication systems depend on two main elements to work: operational radio hardware, and proceedures that allow the sender and reciever to communicate.

(1)Radio Equipment, Antennas, and Propagation

Introduce the decibel. The decibel--or dB--is a comparative measurement, that is, there s something measured against a reference. The decibel allows a very wide range of signal power to be represented with small, manageable numbers:

| Power Change | Decibels |
|---|---|
| 2X | 3dB |
| 100X | 20dB |
| 1,000,000X | 60dB |
| 0.5 X | -3dB |
| 0.000001X | -60dB |

Things that increase a signal are usually called gains and things that decrease a signal s strength are calles losses, and both are usually measured in dB, with gains being positive and losses negative. Note that if we compare power to a fixed reference, such as a 1 Watt or one milliwat, the dB can also be a measurement of actual power; a transmitter with a 20dBW output, for example, has 100 Watts of power.

There two major factors that determine total radio performance, known as station gain (what the equipment does) and path loss (what the environment does to the signal between the stations.)

It may seem confusing, but it s as simple as this: If station gain is greater than path loss, you can communicate, otherwise, you can t. If you can t communicate, you need to fix one or more parts of the radio system until you have enough station gain--use more power, a more sensitive reciever, better or higher antennas.

| Station Gain Factors | Good Base SSB CB |
|---|---|
| Transmit power | +10dbW (12 Watts) |
| Transmitting antenna height gain | +3db |
| Transmitting antenna gain | 0dB |
| Recieving antenna height gain | +3dB |
| Recieving antenna gain | 0dB |
| Reciever sensitivity | +149dB (-149dBW) |
| Total Station gain | 165dB |

The ultimate goal of the radio system is to get a signal to the reciever that s stronger than the background noise, so the signal can be heard. This is known as signal-to-noise ratio, and reciever sensitivity is usually stated as the lowest power level that will result in a given signal-to-noise ratio, typically 10dB. Note that the reciever sensitivity is actually how much a signal can be reduced before it can t be heard (-149dB) but it counts as a positive, as we have 149dB in our station gain account that we can lose before we can t hear a signal anymore.

The path loss is how of the signal is reduced by the environment--distance, air, mountains, water vapor. Distance alone reduces the signal at a rate of the square of the distance--a signal two miles away is one-quarter the strength of a signal one mile away, just because of the distance. Path loss varies (just a little bit) with the frequency used until one gets to microwaves, where path loss jumps quite a bit. Under ordinary conditions between two stations on average terrain, path loss goes this way:

| Frequency | 10 Miles | 25 Miles | 50Miles |
|---|---|---|---|
| 27 MHz (CB) | -135dB | -152dB | -174dB |
| 144 Mhz (2M) | -134dB | -157dB | -175dB |

For a good SSB CB radio, we have 165dB of station gain, and we can communicate as long as path losses are less than this; on average terrain, this is somewhere between 25 and 50 miles. Note that if the antennas used are poor and low to the ground, this will change things considerably, as we ll see in a few paragraphs.

In situations where the signal is bouncing around--such as shortwave radio signals--the both loss includes both distance and the efficiency that the signal is reflected; when conditions are good, this reflection efficiency can be 100%, and only the distance matters. Likewise, if a satellite is used, the path loss is pretty much a result of just the distances between the ground stations and the satellite involved. Distance-only path losses run about -110 dB for 100 miles, or a typical low-earth orbit, and -151 dB for 22,500 miles, or geosyncronous orbits. No place on earth is more than 12,500 from any other location, so the path loss for a perfectly reflected shortwave signal is somewhere in-between.

Not that it s done, but our 165dB of station gain is quite a bit more than the 151dB path loss of a geosynchronous satellite, so it s trivial for the satellite to hear a SSB CB or a 2-Meter Amateur radio. Indeed, several emergency systems depend on this: simple 1/2 watt emergency-radio beacons are detected with low-earth orbit satellites, and the newer 5-watt beacons are detected by geosyncronous weather satellites.

(1)Basic Radio Antennas

Antenna Effectiveness

Antennas can be measured by listening to a standard transmitter on the frequency of interest, and changing the antenna and noting the changes in the signal. Higher-end radios have meters that show relative signal strength, using numbers of 1 to 9 (S1...S5...S9) and then dB over S9; each S--unit is typically 6dB. Using a calibrated reciever, we did measurements of a local weather station (near the amateur 2-meter band) to illustrate several antennas. We used the best antenna (which isn't very good at all, actually) as a reference, and then compared several portable antennas:

| Antenna | Sig. Strength | dB | % Signal |
|---|---|---|---|
| Discone @ 20 feet | S9 | 0db | 100% |
| 1/2 Wave Rod @ 6 feet | S5 | -24db | 40% |
| Rubber duck @ 6 feet | S3 | -36db | 2.5% |

Doing the same thing at CB frequencies:

| Antenna | Sig. Strength | dB | % Signal |
|---|---|---|---|
| Dipole @ 20 feet | S9 | 0db | 100% |
| Rubber duck @ 6feet | S0 | -54db | .0004% |

Poor antennas will reduce station gain; indeed is we use the SSB CB example where we had 165 dB of station gain, and change the antennas used to rubber duck antennas, the station gain plunges to just 51dB, not even enough to cover five miles! What these measurements show is that antennas can compromise perfectly good equipment, and that it takes a good antenna for a radio to work well.

There are several types of antennas that are easily built with wire or stiff metal rods that are suitable for survival use and are also good antennas. As a general rule, if you want maximum range and station gain, use a good antenna and place it as high as possible, including climbing up mountains or hills.

(a)1/4 Vertical

This is perhaps the simplest antenna. Basically, it's a vertical rod or stiff wire fed by a feed line at the bottom and cut to about one quarter of the desired wavelength. It radiates uniformly in all directions, and is the most common type for handheld and vehicle-mounted radios.

(b)Dipole

Another simple antenna. Basically, it consists of two wires pointed in opposite directions, and either horizontal or sloped. This antenna is most commonly used for Medium- and High-Frequency ham radio and shortwave listening (1.8-30 Mhz). It radiates most strongly in a direction perpendicular to the long axis of the wires.

Quads and Yagis

Quads and Yagis are two types of directional antennas. A Yagi has a center element, called a driven element, which is connected to the feed line from the transmitter. This element is cut to roughly one- quarter of the desired wavelength, and mounted on a horizontal boom. Then, slightly shorter elements, called "director elements" are cut and mounted on the boom on one side of the driven element. Slightly longer elements, called "reflector elements" are cut and mounted on the other side, and the whole antenna is generally mounted on a rotateable mount. These types of antennae tend to be highly directional, favoring the direction towards the director elements, and are frequently used for HF, VHF, and UHF ham radio stations.

(1)Signal Operating Instructions and Radio Nets

Signal Operating Instructions (SOI) is the military name given to a whole host of methods and proceedures to communicate; essentially, SOI is a protocol of behavior for people and equipment to communicate successfully.

The single most imporant thing to remember is that that it takes someone listening for communications to work, and the best radios in the world are useless if no one hears you call for help. Establishing or connecting to a radio net of listeners--making sure that someone is out there listening for you--is the single most important step to take in radio communications. Period.

Schedules

It s impractical for most people to listen to radios continuously, so having a schedule for stations on your net to listen makes radio communication practical. Either use a published schedule, or a regular interval (every day at 7pm, for example) for the net to come on-line.

## Guard Channels

All radio users need to be on the same frequency to communicate. A special listening frequency makes monitoring easy; for example, on CB radios, channel 9 is used only for emergency traffic, so you can listen to this channel and know if you hear something, it s important. In many areas, there are amatuer radio repeaters with a feature known as LiTZ (Long-tone-zero) which is used to turn on recievers of regular listeners, for when help is needed. Your radio net should have a guard channel to listen to when the net isn t active, and a one or more net channels for when it is. (Depending on other factors, these channels may be changed regularly or not.)

## Codes

In general, the use of codes, ciphers, and other encryption on most radios is illegal in the United States if the intent of the code is to obscure the meaning of a message. There are legal uses for codes in CB and ham radios-see below under "Brevity and Message Coding"

## Authentication

Authentication is the art of verifying that all people in a given net are people who have legitimate access, for example through the use of unannounced questions. For example, during World War Two, it was a popular perception that no German soldier would know anything about baseball. As a result, American GI's would frequently quiz each other about baseball trivia to be sure that everyone present was in fact an American.

## Brevity and Message Coding

Radio communication takes time and bandwidth. Certain codes have become agreed-upon conventions to compress a relatively large amount of information into a relatively small amount of space. For example, almost everyone who listens to a CB or to police radio has heard the "Ten codes" in which a sender may say "Ten-four" and be understood by everyone listening as having said "Your message is acknowledged"

## SOI Spares

Having extra copies of your Signal Operating Instructions can be a double-edged sword. On one hand, if your SOI is at all complex or elaborate, losing your only copy could be crippling. However, if your net's integrity depends upon not having your procedures widely known,an extra SOI is a copy of the SOI waiting to fall into the wrong hands.

1. Visual Signals

Morse code by light

Ships carry a set of blinker lights for communication by morse code. These lights are essentially searchlights fitted with shrouds or shutters that can be quickly opened or closed.

Semaphore

In the days before wired telegraphy, a code was used to send messages over long distances called semaphore. Basically, the sender stood atop a hill holding a brightly colored flag in each hand. He would face the receiving station and raise his arms up out to his sides, and the angle at which he held his arms would signify a given numeral or letter.

three-in-a-row rule (whistles, gunshots...)

In general, three of any signal repeated at a regular interval signifies distress. For example, a hunter who is lost can fire three shots in the air a few seconds apart. Theoretically, anybody in the vicinity will hear the three shots and realize that the hunter is in some sort of distress, and will be able to figure out the direction to search from the sound of the shots.

1. Postal Modes

OK, it s here for completeness, but it s worth mentioning hiding messages in ordinary communications. Messages which aren't particularly time-sensitive can be sent inexpensively, and with some relative degree of anonymity.