Where There is no Telephone

by
JOHN R.G. CORBETT
C.Eng., M.I.E.E.
Communications Engineer
C.B.F.Z.- E.C.Z.
Republique du Zaire

A handbook on short wave radio and LEO satellite communication for missions and aid agencies in developing countries. The book describes how to plan, select, install, operate and maintain a radio telephone network in these countries. It deals with the peculiar and special considerations necessary for reliable operations and will assist both technical and non-technical personnel.

Handbook Table of Contents:

Chapters: (Revised April 1997)

Note: The www copy does not include the 34 diagrams.

Updated: August 18, 1998

Federal Emergency Management Agency

WHERE THERE IS NO TELEPHONE

Chapter 1. HOW RADIO WAVES TRAVEL

Topics:

Return to Table of Contents

1.1 Basic theory of short-wave radio.

Short-wave bands are to be found on many broadcast radio receivers. There are various broadcast bands and to tune into them you are given the wavelength,for example 25, 31 or 41 metres. In radio communications the tuning information is given in kHz (kiloHertz) or MHz (MegaHertz), formerly Kc/s or Mc/s. Radio waves travel at the speed of light i.e. 300,000 km per second and because wavelength and frequency are related you can easily translate from wavelength to frequency by the relationship:

$$\text{Frequency in MHz} = \frac{300}{\text{Wavelength in metres.}}$$

For example,a wavelength of 25 metres gives:

$$\text{Frequency} = \frac{300}{25} = 12 \text{ MHz}$$

The short-wave band is referred to as the HIGH FREQUENCY (HF) band. The HF band covers frequencies in the range 2 to 30 MHz.To communicate between two different places it is necessary to transmit radio waves to the distant receiver, but radio waves travel in straight lines and the earth is round, so how do we communicate over hundreds and thousands of miles? Such communication is possible because the earth is surrounded by the ionosphere. The ionosphere is made up of several ionised layers which are continually combining and then separating. They occupy a region between 100 and 300 kilometres above the surface of the earth. At certain times the layers will reflect radio waves back to earth, see Wave A in Fig.1. The ability of the ionosphere to reflect radio waves depends upon the electron density of the layer. The higher the electron density the more effective the ionosphere is as a reflector. The sun, shining on the ionosphere, causes the electron density to increase. Hence the density increases from dawn, being a maximum around midday and gradually decreasing towards night. In addition to this daily variation in density, there is also an annual cycle and a 11 year sunspot cycle. It is possible for radio waves to pass straight through the ionosphere without being reflected as shown by Wave B in Fig.1. To be of use for radio communications the radio waves must be reflected back to earth.

Three of the factors which determine whether radio communication is possible are the time, the frequency in use and the distance between the radio stations.

1.1.1. Frequency and Time

The higher the frequency the more likely the wave will pass through the ionosphere and not be reflected back to earth. Therefore the highest frequency that will be reflected and can be used for communication between two places is called the MAXIMUM USABLE FREQUENCY (MUF). The MUF varies throughout each 24 hour period and also throughout the year. An example of the daily change for January and July is shown graphically in Fig 1.2. Because Kinshasa and Kisangani are near the Equator the seasonal change in MUF is not very pronounced. The graphs are drawn for a Sunspot Number of 0 which is its lowest value. The values of MUF will also change with sunspot number, in general the higher the sunspot number the higher the MUF. If possible the time around dawn and dusk should be avoided for radio communications because the ionosphere is in a state of change. The ionosphere is reasonably stable during daylight hours.

1.1.2. Distance

The shorter the distance between two radio stations the lower will be the MUF. In Fig 1.3. this can be seen where the distance from Kinshasa to Tondo is 500 kms and the daytime MUF is 8 MHz whereas the distance from Kinshasa to Kisangani is 1,300 kms and the MUF is 12 MHz. With a sunspot number of 10 the MUF for stations up to 100 kms apart would be 7 to 8 Mhz in July in Equatorial Africa. Therefore at higher frequencies no contact is likely. However there will be a ground wave (see Fig 1.1. Wave C)

which may extend some 20 kms or more depending upon the surface of the earth. Ranges between 50 to 100 kms can be difficult for HF communications unless a suitable frequency is used and for reliable communication up to a few hundred kms frequencies around 2 MHz may be necessary.

1.1.3. Sunspot Cycle

The electron density in the ionosphere varies according to the 11 year sunspot cycle. The ionosphere is most dense when the sunspot number is high. A sunspot maximum occurred in 1979/80 so the next maximum can be expected in 1990/91 with minimum occurring in 1985 and 1996. An example of the effect of the change of sunspot number was seen in Great Britain. The use of Citizen Band (CB) radio for communication became very popular around 1980. The radios operated at 27 Mhz and were illegal at the time. People were able to make CB contacts into Europe and were thrilled with this long distance communication with transmitter power output often of only 4 watts.Gradually over the next few years these contacts became more difficult and few overseas CB stations were heard. The lack of propagation was simply due to the fact that the ionosphere was no longer reflecting the 27 Mhz waves back to earth. This change in propagation would have been expected by anyone aware of the sunspot cycle and its effect on the ionosphere.

1.2. Propagation Prediction

One frequently reads that the prediction for HF communication is as much an art as a science. There are nevertheless patterns which can be predicted and are valid guidelines on which to plan the times for your radio contacts. The ionosphere and its effect on radio wave propagation is a vast subject into which research continues and many books are written. A simple treatment of ionospheric propagation can be found in the amateur radio handbooks such as RADIO COMMUNICATION HANDBOOK from RSGB, Potters Bar, EN6 3JW, England. There are various ways to determine at what time the ionosphere will permit communication.

1.2.1. Computer Prediction

Programs which give the MUF between any two geographical locations are available to run on many different computers. To use such programs it is necessary to give the computer the latitude and longitude of each location, the month of the year and the sunspot number. The computer will then calculate the MUF at hourly intervals for a 24 hour period. It should be noted that with some programs the calculated MUF may be up to 2MHz above or below the actual value. Also some programs are not very accurate at ranges below a few hundred miles, though the accuracy increases at longer ranges. The name of one prediction program is MINIMUF. Enquiries about these programs should be made through the supplier of your radio, also the programs are available through amateur radio sources.

1.2.2. Calculation by hand

It is possible to calculate by hand the frequency that can be used for communication between any two

stations. This method requires information regarding great circle distances and the zenith angle of the sun amongst other factors. However all the necessary information including step by step instructions for calculation is given in a very useful book PLANNING AND ENGINEERING OF SHORTWAVE LINKS by Gerhard Braun from Heyden and Son, London and Philadelphia.

1.2.3. Experience and Experiment

It is always worth listening to the experiences of other people who claim to have done what you intend to do, but enquire in detail what frequency, time and area they operated their radios in and with what success. Then proceed to verify any information by trial transmissions yourself. If you have no such prior information regarding propagation, then arrange a timetable between your stations to attempt to make contact. The contacts could be every 2 hours from 0600 to 1800 hours, trying each frequency you have for say 5 minutes. After several days you would obtain a general pattern of the best time for contacts. During such experiments if no contact is made your frequency may be too high. Also you may never make contact at frequencies of 11 mhz and above when the sunspot number is low, but when the sunspot number rises towards a maximum such contacts would be possible. It is therefore sensible to obtain some theoretical predictions of MUF before the radios are purchased. Here is an example of lack of information regarding propagation:

A group obtained radios with a frequency around 10 MHz and proceeded to try to use them for contacts at ranges of 70 kms at 1800 hours. When they found it was impossible they assumed that their radios were at fault and wanted them to be repaired. They were advised to try for the same contacts at 1300 hours instead of 1800 hours and were successful.

1.2.4. Rule of Thumb

A "Rule of thumb" method is used in East Africa and is also suitable for Central Africa. This method calculates the best frequency for various radio links operating between 6 am and 6 pm.:

For ranges up to 800 kms use 7MHz. For every 160 kms of range above 800 kms add 1 MHz to the frequency. e.g.

Kms	Frequency in MHz
800	7
1120	9
1600	12

Note that frequencies below the best frequency may also be usable. For example, 7.5 MHz is used by a group based in Nairobi for links with the rest of Kenya.

1.2.5. Unpredicted Effects

The general pattern of propagation is further varied by disturbances of the ionosphere caused by solar flares. The result can be very poor or no HF radio communication for a few hours or a few days. Expect such events and do not immediately assume your radio is at fault, though it is wise to perform the checks suggested in para. 7.2.3.

WHERE THERE IS NO TELEPHONE

Chapter 2. AERIALS

Topics:

[Return to Table of Contents](#)

The purpose of an aerial is to launch the power from a radio transmitter into space in the form of radio waves. These waves then proceed, either by reflection from the ionosphere or along the surface of the earth, to the receiving location. Here the waves are captured by another aerial and steered to the receiver. So the aerial is a very important part of your radio system and it is essential that you use an aerial which is suitable for the particular frequency you intend to transmit. You may be told that all you require is a long piece of wire,the longer the better. Whilst such a wire could be suitable for reception an additional unit would be necessary to tune the wire before it was suitable for transmission.

2.1.Standing Wave Ratio

VSWR stands for Voltage Standing Wave Ratio and is often abbreviated to SWR. SWR is a measure of how suitable an aerial is for a particular transmitter at a particular frequency i.e. how well it is matched to the transmitter. The theoretical ideal value for SWR is 1. Some radio manufacturers specify that an aerial with a SWR of 1.5 or less should be used with their radios whilst others permit a maximum SWR of 2. The SWR of an aerial can be measured by connecting a SWR Meter between the transceiver and the aerial. The operating instructions for these meters varies according to the manufacturer. You must make sure you have the instructions and keep them with the meter and always follow them correctly, otherwise you may get inaccurate readings.

Although aerials are normally made to a length suitable for your specified frequency the SWR should be measured after the aerial has been erected. It is desirable to tune the aerial for a minimum SWR but it is essential to do it if the SWR exceeds the manufacturers permitted maximum e.g. 1.5 or 2.0. For instructions on tuning aerials see para. 6.2.4.6.

2.2. Dipole Aerials

The horizontal half-wave dipole aerial (see Fig 2.1) is the most commonly used HF aerial. Of the 188 aerials reported on the Questionaire 91% were dipoles. The dipole is electrically simple, cheap, requires no earth system or additional circuits and it is easy to erect. However it is normally only suitable for use with one frequency.

2.2.1. Dimensions

The total length of a dipole aerial is half a wavelength at the frequency of use. However it is permissible to use the aerial at frequencies up to 2% above and below this frequency. e.g. a 10 MHz dipole could be used for frequencies from 9.8 MHz to 10.2 MHz. The length of the aerial can be calculated from the following formulae:

$$\text{Total length in feet} = \frac{468}{\text{Frequency in MHz}}$$

$$\text{or Total length in metres} = \frac{142.6}{\text{Frequency in MHz}}$$

For example a frequency of 6 MHz would require an aerial of :

$$\frac{468}{6} = 78 \text{ feet} \quad \text{or} \quad \frac{142.6}{6} = 23.77 \text{ metres.}$$

2.2.2. Construction

The dipole consists of 2 pieces of wire each piece a quarter of a wavelength long: i.e. half of the total length. One piece of wire is connected to the centre conductor and the other piece of wire is connected to the outer conductor of a coaxial cable. The other end of each piece of wire is connected to its own insulator see Fig 2.1. Pre-stressed aerial wire is used to prevent streaching of the aerial. The resulting assembly is suspended horizontally at a certain height above the ground. The connections between the coaxial cable and the aerial wires must be both mechanically strong and waterproof. Ready-made small units can be bought for this purpose. These units can include a BALUN which it is claimed improves the aerial performance. However dipoles are usually purchased ready-made and cut for the specified frequency by your radio manufacturer.

2.2.3. Horizontal Directivity

A horizontal dipole transmits and receives most energy in a direction at 90 degrees; i.e. at right angles to the wire itself as shown in Fig 2.2. For example a dipole erected in a north-south line would be suitable for communicating with stations to the east and west but would be less effective for stations to the north and south.

2.2.4. Height

The height of a dipole above the ground will determine the vertical directivity i.e. the direction in which power is both transmitted and received. An indication of the vertical angles at which power is transmitted is shown in Figs 2.3. and 2.4. The height of the aerial is given in units of wavelength of the frequency for which the dipole is designed to operate. For short ranges e.g. up to 150 kms, power needs to be transmitted at a steep angle up to the ionosphere see Fig 2.3. So a dipole suspended 1/4 wavelength above the ground should be used. For distances of 1000 or 1500 kms a height of 1/2 wavelength would be more suitable see Fig 2.4. The ideal condition would be to have two dipoles one for short, one for long ranges but in practise this is not always possible. Take a frequency of 7 MHz : 1/4 wavelength is 10.7 metres and 1/2 wavelength is 21.4 metres. Erecting an aerial 21.4 metres above the ground would demand the construction of special supporting towers which would be a costly exercise even if the materials were available. Therefore in practise aerials are often suspended as high as possible between trees and poles or between a tree and the top of a building. The result is therefore a compromise between the theoretical ideal and that practically achievable but remember that for better communication at long distance your dipole should be as high as possible.

2.3. Inverted Vee Aerial

This is simply a dipole supported in the middle and having each side of the aerial sloping down to some 2 metres above the ground. It thus forms an inverted V, see Fig 2.5. This aerial transmits energy in most directions hence it is suitable for more all round coverage. Some of the transmitted power is vertically polarised and some is horizontally polarised making it suitable for communicating with fixed stations with horizontal dipoles as well as vehicles using vertical aerials.

2.4. Vertical Aerial

Another simple HF aerial is the 1/4 wavelength vertical. The name describes the aerial, a vertical conductor 1/4 wavelength high insulated from the ground at its base and connected to the inner conductor of a coaxial cable see Fig. 2.6.

2.4.1. Earthing of vertical aerials

It is necessary to provide a good earth for this aerial. This can be achieved by connecting 3 or more 1/4 wavelength long pieces of wire to the outer braid of the coaxial cable at the base of the aerial. These wires should be laid out radially and spaced an equal distance apart as in the plan view of Fig.2.7. and then buried some 25 cms underground.

2.4.2. Directivity

A vertical aerial will transmit power equally in all horizontal directions and at low vertical angles (below 45 degrees). It is therefore a good choice for a central station with a network which is spread out at various angles and long distances.

2.5. Mobile Aerials

Practical considerations dictate that most mobile HF aerials are vertical but not physically a full 1/4 wavelength long e.g. 1/4 wavelength at 5 MHz is 15 metres! So you will find vertical mobile aerials some 2 or 3 metres long. These can either be tuned to any frequency with an Aerial Tuning Unit (ATU) see para 2.6.3. or they will have been pre-tuned to a single frequency with a coil. The coil forms part of the aerial and will either be at the base of it or halfway up. The further the coil is away from the base the more efficient is the aerial. The tuning should be checked and adjusted after installation on the vehicle see para.6.4.3. Another form of mobile aerial is the helical whip. Here the aerial wire is twisted around and sealed into a fibreglass rod. If this is tuned to a specific frequency it may

also be used at other frequencies by using a ATU.

2.6. Multi-frequency aerials

It has been stated that an individual dipole is only suitable for one frequency. However most transmitters will be operated at several frequencies hence requiring an aerial system suitable for all the frequencies.

There are several aerial configurations that will satisfy this requirement.

2.6.1. Multi-dipoles

This aerial consists of several individual dipoles, each ones length being appropriate to its particular frequency. They are A-A', B-B' and C-C' and are all connected to one piece of coaxial cable as shown in Fig 2.8. The advantages of this type of aerial is that only one coaxial cable feeder is required and that the aerials can be accommodated in a smaller space than required by several individual ones. However the frequency of each dipole should differ from the others by at least 15%. A maximum of 4 dipoles can be connected to one piece of coaxial cable. The tuning of the dipoles can sometimes be difficult because of interaction between each other.

2.6.2. Broadband aerials

A single broadband aerial can cover all the frequencies in the range stated by its manufacturer for their particular aerial e.g. 3 to 30 MHz. They use special frequency compensating networks and matching circuits therefore need to be bought ready-made. One broadband aerial is some 30 metres long and has a single coaxial cable connecting it to the radio. It can be erected horizontally or in the inverted vee form. Its height above the ground should be at least 5 metres but 10 metres if possible.The SWR of these aerials can be less than 2.0 over a high percentage e.g. 90% to 95%, of their frequency range. However some manufacturers specify that an aerial with a SWR of 1.5 or less should be used with their transceivers. A broadband aerial will receive all transmissions i.e. wanted and unwanted, equally well. Hence strong transmissions, including SW broadcasts, can cause interference when the station you are listening to is weak.

2.6.3. Long wire aerials and Aerial Tuning Units

A long piece of wire e.g. longer than 10 metres, can be used as an aerial but it has to be tuned for each frequency with an Aerial Tuning Unit (ATU). The SWR of a long piece of wire could be high so the purpose of theATU is to match the wire to the transmitter and to give a low SWR. The ATU can be an integral part of the transceiver as in the case of some CODAN models. Here the tuning procedure is to adjust the controls of the ATU for the brightest light from a lamp. Separate ATUs can be purchased, some with meters as tuning indicators. You can buy ATUs which will automatically tune a long piece of wire to any frequency from 1.5 to 30 MHz. The most modern ATUs will reduce the SWR of the long wire aerial to 1.5 and also handle a transmitter output power of up to 1KW. Long wire aerials are often used for temporary or portable situations when it is easy to hang up a piece of wire. However the wire must be insulated from anything that supports it.

2.6.4. Single Dipole for Two Frequencies

It is possible to design a single dipole and its coaxial feeder cable to operate at two frequencies. The main reason for using this design is economy, that is to obtain "two aerials for the price of one". However, to

understand the design you may require the aid of a radio communications engineer. The method is nevertheless a very useful one to use with aerials which do not have a balun transformer. The dipole is designed for use normally at one frequency, but at the second frequency there will be standing waves on the coaxial cable. So the length of cable has to be cut to present a low impedance at the transceiver. This is done by measuring the SWR at the transceiver output socket and by reducing or increasing the length of the coaxial cable until an acceptable SWR is achieved e.g. less than 2.

WHERE THERE IS NO TELEPHONE

Chapter 3.TRANSCEIVERS AND POWER SUPPLIES

Topics:

3.1. Transceivers

The word transceiver is an abbreviation of transmitter-receiver and indicates that these two facilities are combined into one unit. Normally the transceiver can either transmit or receive at any one time. The transceiver will only use one aerial which is switched automatically to the transmitter or receiver portion within the transceiver. Many different types of HF Single Sideband (SSB) transceivers are manufactured. Some sets appear to be rather complex being fully synthesised and capable of being tuned to any frequency e.g. from 2 to 30 MHz, simply by typing in the frequency on a keypad. In fact the front of these sets are often covered with press buttons and indicator lights enabling a wide range of facilities to be selected. Such sets should only be selected for use if competent operators are available who would fully understand the use of all the controls and if an adequate repair facility was available for the sophisticated circuitry. There are more simple HF SSB sets available such as those with only 4 or 10 pre-selected frequencies. The number of front panel controls on these sets is usually less and their circuitry often is more easy to repair.

3.1.1. Transmitter output power

The power output of SSB transceivers is defined by its Peak Envelope Power (PEP) which is about 3 times the average power output. Sets are available which provide PEP in the range 25 to 150 watts. Of the 155 transceivers reported in the Questionaire, 26% had a PEP of 60 watts and below, 52% had 100 watts PEP and 22% were between 100 and 150 watts PEP. Almost all transceivers, with power outputs up to 150 watts PEP, manufactured after 1988 were completely transistorised i.e. not containing any thermionic valves. Also many of these transceivers will operate direct from a 12 volts DC power source e.g. a car battery. It is possible to calculate the theoretical transmitter power necessary to achieve highly reliable radio communications over a specified link. However there are many other incalculable factors which determine whether you will be heard and understood by the distant station. At the present time some developing countries have a very limited telecommunications infrastructure hence Government departments, commercial companies, missions etc. all have their own HF radio communication networks with the resultant crowding of the radio channels. You may experience any of the following situations:

> a) One radio channel may be allocated for the use of several different groups,each group being given a time when they can use the channel e.g. 09.00 - 10.30. In an ordered society this system can work well but you may find that the groups do not adhere to their allocated time and chaos results.

b) Even if you have your own radio channel you can experience interference from stations operating on adjacent channels or on the other sideband e.g. you are using USB (Upper Sideband), they are using LSB (Lower Sideband).

c) In a town the transceivers of several different groups may be located close to each other e.g. within 1Km. Although the groups are using completely different frequencies the transceivers can cause interference with each other simply because of their proximity.

In an ideal interference free situation you might expect to use a 25 watt PEP transmitter for ranges up to 300 kms. with power rising up to 100 watts for 1,000 Kms. What is happening in practice is that many groups are using higher power transmitters in an effort to make themselves heard, even resorting to the illegal use of amplifiers producing 1,000 watts. This produces an increase in the level of interference for other users and the "law of the jungle" results.

The Questionaire showed that 74% of the transceivers were 100 watts and above. The only realistic conclusion that can be drawn is that unless you are sure you can operate satisfactorily with a power less than 100 watts then you should select a transceiver capable of producing this power. You may be able to reduce the power output of your 100 watt transceiver to a lower level if required but you cannot increase the power output of a 40 watt one without buying more equipment.

3.1.2. Transceiver power requirements

A rough guide of the average input power required by a transceiver, during transmission, is 2/3 of the PEP watts. For example, a 150 watt PEP transceiver would require an average power of 2/3 x 150 = 100 watts. The relation between power, voltage and current is:
Power in watts = voltage in volts x current in amps.
or Current = Power/Voltage.

Hence the current required from a 12 volt battery for a 150 watts PEP transmitter:
Current = (150x2/3)watts/12 volts = 8.3 amps average.

The transceiver will in fact be demanding a peak current for short periods and then no current. The value of this peak current can be a little above twice the average current, in this case about 18 to 20 amps. Whilst receiving the transceiver will take very little power. Typical 150 watt PEP HF SSB transceivers require 0.2 to 0.5 amps during reception.

3.1.3. Transceiver controls

The number of controls on the front of a transceiver can vary from some 5 to 25. The more common and essential are described here:

VOLUME or AUDIO.

As found on all radios, cassette players etc. it simply adjusts the loudness of sound from the loudspeaker and earphones.

Combined ON/OFF and AUDIO.
These are frequently found on ordinary radio receivers as well as transceivers. Because the action of switching off requires the knob to be turned down to zero volume each time and also up again to normal level each time you switch on there is excessive wear on this component and it is often the first item to wear out. If a separate ON/OFF switch were available then the volume control could be left in its usual position.

POWER light.
This indicates that power is being supplied to the set. It is usually a red bulb or Light Emitting Diode (LED).

TRANSMIT light.
This may be a red or orange light which flashes when you speak into the microphone of a SSB transceiver and shows that the transmitter is generating power. The light may be labelled TRANSMIT or XMT.

R.F. GAIN and ATTENUATION.
The purpose of these controls is to adjust the amount of amplification of the incoming signal in the receiver portion of the transceiver. The RF GAIN control is operated in a similar fashion to the volume control. Alternatively there may be one or two switches labelled ATTENUATOR, with values of 5, 10 or 20 dB, which enable you to reduce the RF amplification by the number of dB switched in.

CLARIFIER or CLARIFY.
There can be a difference of several hundred cycles in the frequency of the transmitters you are listening to. So when you listen to one person speaking they may appear to have a deep bass voice whilst the next one has a high pitched and perhaps unintelligible voice. The CLARIFIER will enable you to adjust the pitch of the voice coming from the loudspeaker to your particular preference.

SQUELCH.
On some Australian transceivers this is labelled MUTE. The control can either be a variable one like the AUDIO one or an ON/OFF switch. The purpose of the SQUELCH is to prevent any noise coming from the loudspeaker unless speech is being received. Hence you could have your transceiver left switched on receive, on your office desk, without it producing continuous hisses, crackles and bangs. The effectiveness of squelch circuits varies depending on their design. Some manufacturers offer what is called SYLLABIC squelch. This looks for the syllabic rate in speech and so it is able to differentiate between speech and other noises.

CHANNEL selector.
This control selects the particular radio frequency which has been allocated to each channel. A rotary

multi-position switch may be used for fixed frequency sets e.g. crystal controlled ones. Each switch position can have the full radio frequency beside it e.g. A 7305 KHz, B 5782 KHz, or the positions may simply be labelled A, B, C, etc. Synthesised transceivers are more versatile, by selecting a channel and typing in the frequency the transceiver will store this frequency so that whenever that particular channel is selected in the future it will automatically be set up to the stored frequency.

USB/LSB.

A single channel frequency can produce two usable channels. One channel is the UPPER SIDEBAND (USB) which occupies 3 KHz above the channel frequency while the LOWER SIDEBAND (LSB) occupies 3 KHz below the channel.

AM.

This stands for Amplitude Modulation and is used by broadcast transmitters on the short-wave bands. An AM facility is not found on all transceivers. AM is not used or indeed not usually permitted for speech communications as it requires twice the amount of frequency space that USB or LSB does i.e. 3 KHz above and 3 KHz below the channel frequency.

CW.

This stands for Continuous Wave and only the channel frequency is transmitted and is switched on and off to form the Morse Code or any other kind of code.

3.2. Power Supplies

Basically there are two types of power sources. One source which can be considered to be "interruptable" e.g. a 110 or 220 volt AC mains supplied by the local electricity authority. A failure anywhere in the generation or supply system can mean that, often without notice, you will be without power. A similar loss of power can occur when your own generator fails. So you must consider the reliability of the electricity supply which you intend to use for your radio and the effect of not always being able to transmit when you wish. Such shortcomings can be overcome by using a "uninterruptable" supply, that is to store the electricity in your own storage battery which is automatically connected to the transceiver when the mains fail. The battery will require charging and you will have to put into the battery a little more energy than you expect to get out of it.

3.2.1. Mains supplies

The availability of the mains electricity supply in some towns of the developing countries can be unreliable. The supply can disappear for hours or days with no information being available regarding when it will go off or come on. So it is as well to discover as much information about the mains supply which you intend to use before you complete the plans for your network. This information should be obtained from existing users rather than the electricity supply authority. Sometimes the authority will give you an over optimistic picture of the supply, it may well be what they hope to supply you with but not what you actually get. Some towns may have electricity for certain hours only e.g 6 pm to 10 pm.

3.2.1.1.Constant voltage transformers

Apart from interruptions your mains supply may fluctuate considerably about its nominal value e.g. 240 volts. One European standard for national voltage supply is that it shall be within +/- 6% of 240 volts. You may obtain your electricity from a locally generated supply e.g. a plantation or a hospital, which also may be unreliable and unstable. In all such situations a fast-acting constant voltage transformer i.e. one which will respond to changes within 1/50 of a second could be used to advantage. Such a constant voltage transformer may accept input voltages in the range 204 to 276 volts and provide an output in the range 236 to 254 volts.

3.2.1.2. Fail to battery

This facility is as its name describes. When the mains fail the transceiver is automatically connected to a standby battery. A mains operated relay can be used as shown in Fig.3.8. The relay contacts must be capable of carrying the maximum current required by the transceiver. Provision must be made to always keep the standby battery fully charged.

3.2.2. Generators

You may encounter a wide range of generators from 50,000 watt ones driven from 6 cylinder noisy diesel engines to 150 watt ones driven from small quiet petrol engines. If you intend to use power from an existing generator you should check the reliability of supply for both times when power is available and the constancy of the voltage. For example, does the voltage rise by 10 or 20 volts when a load is switched off or does a 230 volt supply fall to 190 on occasion? Is there a reliable fuel supply and is the generator well maintained or are there periods of days or weeks when the generator is not working ? Is there a standby generator available ? You may wish to provide your own generator. This could either provide 110 or 230 volts AC direct to your radio or 12 volt DC for charging your radio battery. Some small generators provide both 110/230 volts AC and 12 volts DC.

3.2.3. Batteries

Batteries can be divided into two groups. Primary batteries are ones which cannot be recharged and which are thrown away after use e.g. some torch batteries. Secondary batteries are ones which can be used and recharged many times. It is only secondary ones we shall deal with here. The value of secondary batteries is that they can be charged when electrical power is available i.e. when a generator is running, the energy is then stored and can be used when required. The classic example in daily use is the sun on the solar panels during the day charging the battery which will provide energy for lighting at night. The importance of battery use can be seen from the Questionaire which showed that 74% of the 176 transceivers at fixed locations n Africa used batteries recharged by various means.

3.2.3.1. Types

There are many different types of secondary or rechargeable batteries. Small capacity nickel cadmium ones are used in torches and in small transistor radios. The battery most commonly used for radio transceivers is the vented lead acid type i.e. the car battery. Now increasing use is being made of sealed lead acid batteries both for cars and radios. The sealed types are sealed for life and require no maintenance whereas the vented ones need checks on their acid level and filling up with distilled water as necessary. Note that it is important to keep the charging voltage within the manufacturers limits especially for sealed types. Care should be taken when purchasing sealed for life batteries because special PHOTOVOLTAIC batteries are now available. These are sealed for life batteries specifically designed for use in solar systems where the charge and discharge currents are usually lower than in a car. Therefore they must not be used in any vehicle for any reason not even to start one. It is suggested that their currents are calculated from the 100 hour rate in paras. 3.2.3.4. and 5. In practice the calculated values can be exceeded during peak solar charge and peak transmitter load. When one cell of a normal 12 volt battery fails the battery is of little use. It is now possible to buy a battery made up of 6 individual 2 volt cells. The advantage is when one cell fails you need only buy one new cell to restore the 12 volt supply. The cost of this arrangement is more than for a normal 12 volt battery.

3.2.3.2. Capacity

The amount of energy that can be stored in a battery is expressed in AMP HOURS (AH or Ah) i.e. Amps x hours. The working of a battery can be understood by considering a typical car battery with a capacity of 60 Ah. A fully charged 60 Ah battery will give 1 amp for 60 hours or 10 amps for 6 hours. This is an over-simplification because the efficiency of a battery decreases with higher discharge current. Efficiency is the Ah obtained from a fully charged battery during discharge compared with the Ah used to fully recharge it. Misunderstandings have occurred concerning the relationship between battery voltage and the state of charge of the battery. It has been assumed that the voltage of a fully charged battery was 12 volts and that this voltage would fall to 6 volts when the battery was half discharged. There is in fact only a small change in battery voltage. When a battery is delivering current its voltage will be about 12.6 volts when it is fully charged. When the voltage has fallen to about 11 volts some 90% of the stored energy will have been used up and the voltage will soon fall to 10.6 volts when it is fully discharged. These figures will vary slightly according to the type of battery and its condition. To calculate the Ah capacity of the battery you require see para 3.2.3.5.

3.2.3.3. Life Expectancy

The most commonly used battery for transceivers in the mid 1980s was the rechargeable lead acid type e.g. the conventional car battery. Only a few sealed types were in use. A conventional type car battery should not be stored in a discharged condition because this can drastically reduce their life expectancy. When you buy a new battery how do you know when it was manufactured and in what condition it has been stored? A good quality British made battery was purchased as new in Mbandaka in Zaire in September 1986. After 8 months in use one cell failed and the battery was no longer usable. Enquiries made to the British manufacturer showed that it was at least 5 years old when it was bought in Mbandaka. The normal storage life for that type of battery without deterioration is considered to be 1

year. You may not be able to obtain any information regarding the true age of batteries which are not manufactured in the country so if you wish to buy locally it would be best to obtain them from large trading establishments e.g. in the capital city, where there may be a rapid turnover of goods. Alternatively you could import a battery yourself preferably by air if you are able to do so. Once you have a good battery its life expectancy will be further determined by how it is used. If a battery is kept fully charged and only a 1/3 or 1/2 of the energy stored in it is used before it is recharged again a reasonably long life can be expected. The following figures indicate how many times a lead acid battery can be charged and discharged. They are for guidance only and details for any particular make of battery must be obtained from the manufacturer:

Percentage of energy used before recharge.	Number of times battery can be charged and discharged.	
	Vented	**Sealed**
30	1,000	850 -1,200
50	700	280 - 450
100	350	100 - 180

These figures suggest that a vented lead acid battery used each day powering a transceiver will last for 3 years if only 30% of its energy is used and it is recharged daily. However if the battery is fully discharged each day it is used then its life expectancy is less than 1 year.

3.2.3.4. Charging

The voltage of a battery will vary whilst it is being charged. The actual voltage will depend upon its type and condition and its state of charge. To ensure that charging current flows into the battery the voltage of the charger should exceed that of the battery by at least 1 volt. Regulators on many vehicles limits the maximum battery charging voltage to 13.6 volts. When solar panels were first used for battery charging the voltage of the panels was often some 14 to 15 volts but this voltage did not really require regulating. Now higher voltage panels are in use and will need regulators see para 3.2.6. When a fully discharged battery is put on charge its actual voltage may be only 11 volts so a high charging current will flow. As the battery voltage gradually rises to its maximum e.g. 14 volts the charging current will reduce.

One recommended maximum charging rate $= \dfrac{\text{Battery capacity in Ah}}{\text{10 hours}}$

For example: $\dfrac{\text{60 Ah battery}}{\text{10 hours.}} = 6 \text{ amps.}$

The approximate state of charge of a battery can be deduced from its voltage.

Battery Voltage when:

Battery state	On charge	In use i.e. Not connected	on load
Fully Charged	Maximum set by charger e.g. 15V	13.2 V.	12.6 V.
Requires Charging	——	——	11.1 V.
Fully Discharged	11 to 12 V.	——	10.6 V.

Another method of determining the state of charge of a battery is with the aid of an inexpensive HYDROMETER. This sucks a small quantity of the acid from the battery into its transparent bulb and a calibrated float gives a reading of the SPECIFIC GRAVITY (S.G.) of the acid. The acid is then returned to the battery. The following table gives the relation between the S.G. and the state of charge of the battery:

Battery state	S.G.
Fully charged	1.28
3/4 charged	1.25
1/2 charged	1.22
1/4 charged	1.19
Fully discharged	1.11

3.2.3.5. Discharging

The current demanded by the transceiver will determine the Ah battery capacity required. There are two figures to consider. First the total energy in Ah required from the battery before it is recharged each day. Take for example a transmitter requiring an average current of 8 amps. For a total transmit time of 1/2 hour Ah = 8 x 1/2 = 4 Ah. Transceiver when operated in the receive mode requires 1/2 amp. For a total receive time of 4 hours Ah = 1/2 x 4 = 2 Ah. Therefore total energy required from battery is 6 Ah. Second figure to consider is the maximum discharge rate in this case 8 amps. For continuous use the recommended rate is :

$$\text{Discharge amps} = \frac{\text{Battery Ah capacity}}{10 \text{ hours}}$$

Or this can be written: Ah capacity = 10 hours x Discharge amps. However for intermittent demands of current, such as speech transmission, the 10 hour rate can be reduced to 5 hours. Thus: Ah capacity = 5 hours x 8 amps = 40 Ah. Of the two figures calculated for Ah, 6 and 40 in this example, the highest Ah is the one required. If the battery cannot be recharged when necessary, perhaps because a solar battery charger is used and the amount of sunshine is irregular in certain seasons or if a generator is not run at regular intervals, then a battery of higher capacity than the calculated value will be necessary. The battery will need to store enough energy to operate the radio until the next charge is available.

3.2.3.6. Low Voltage Disconnect

The information in para. 3.2.3.4. showed that the life expectancy of a battery was increased if it was not fully discharged before recharging. Units are available which automatically disconnect the radio from the battery when its voltage has fallen to a preset value e.g. 11.1 volts. Note that the unit must be capable of switching the maximum current demand of the radio.

3.2.3.7. New Battery for Old

When a battery fails it is frequently only one of its 6 cells that has in fact failed, hence the 12 volt battery becomes a 10 volt battery. From the 12 cells of two old batterys 6 good cells can usually be found. These cells can be connected in series to give 12 volts. One method of finding the good cells is described briefly.

1. Fully charge up the battery, then discharge it through a car headlight bulb.

2. After discharging for 30 minutes measure the voltage of each cell. It may be necessary to make small holes in the top of the plastic battery case to enable contact with each cell.

3. Empty the acid from the battery. Connect the 6 good cells in series i.e. negative of one cell to positive of the next. Make these connections in the old cells adjacent to the good cells being used.

4.Refill only the 6 good cells with acid and then recharge the battery.

3.2.4. Solar Battery Chargers

A solar battery charger is simply a flat panel containing photo voltaic material e.g. slices of silicon. When the sunlight reaches the photovoltaic material a voltage is produced which provides a charging current to the battery. In bright sunlight each silicon slice in a panel will generate just under 0.5 volts.

The number of slices in a panel can vary from 30 which will produce 15 volts to 40 which produces 20 volts. The amount of current which a panel produces is proportional to the surface area of the silicon slice. To estimate the approximate size of solar panel one can assume that 150 square centimetres of total panel surface area is required to generate 1.0 Amps at 0.5 volts. Therefore the size of a solar panel to produce 18 volts at 2 amps can be calculated, assuming 150 sq.cms. required to produce 1 amp at 0.5 volts.

Area in sq.cms.	= (voltage x 2)	x (Current in amps)	x (150)
	= (18 x 2)	x (2)	x (150)
	= 10,800 sq. cms.		

That is a panel area of about 1 sq. metre.

3.2.4.1. Available Solar Energy

The amount of solar energy available can be obtained from ISOHEL maps which show the Average Annual Solar Energy in units of kilowatt hours (kWh). The figure for Western Europe is 1,000 kWh, the Sahara is 2,000 to 2,500 kWh and most of Zaire is 1,700 kWh. Obtain details of the solar radiation for your area of work. An example of how the daily quantity of solar energy varies throughout the year is shown for Kinshasa, which is 4 degrees south of the equator,in Fig.3.1. How the total intensity of solar radiation varies through the day during June is shown for Kinshasa, the capital of Zaire, in Fig.3.2. The total solar intensity comprises both direct sunlight and that diffused by cloud. In Kinshasa the diffused energy reaches its maximum after midday, as the cloud becomes less dense, hence the total intensity peaks at 1300 hours. About 10% of the solar energy which arrives on a silicon solar cell is converted to electrical energy. An example follows showing how to calculate available electrical power. First you must know the following relationships:

Watt hours (Wh) = Watts x hours
Watts = Voltage (V) x Current (A)

Therefore: Wh = Voltage (V) x Current (A) x hours
A solar panel with cells covering 1 square meter will receive 4KWh per day in June in Kinshasa. Of this 10% (0.4 KWh) will become electrical energy.

0.4 KWh = 400 Wh
Charging a 12 volt battery from the solar panel.
Wh = Voltage x Current x hours
400 = 12 x A x h

That is: $\dfrac{400}{12} = $ Ah $ = 33$ Ah

In theory the 400 Wh of energy will put a charge of 33 Ah into the battery. In practice the battery will receive a somewhat less charge because the voltage of the solar panel has to exceed the battery voltage before charging commences. The calculations are based on the actual area of solar cells which can be considerably less than that of the solar panel. However the calculations will give an idea of the necessary area of solar panel required. Solar panels are classified according to their voltage and maximum power output.

3.2.4.2. Electrical Connection

Solar panels can be connected together either "in series" or "in parallel". In series" means that the negative of one is connected to the positive of the next see Fig 3.3. The combined voltage of such panels is the sum of the voltage of each panel. So if you connect two 9 volt panels in series you will have an output of 18 volts. The value of the output current will be set by the panel having the lowest current output so this is normally used for connecting panels that produce similar current levels. "In parallel" means that the positive of each panel is connected to the positive of the next and negative to negative of each. It is usually used for panels of the same voltage and the total voltage for all the panels will be only the same as for one of them but the total current output will be the sum of the current of each panel. So if you connect two 9 volt panels in parallel you will get 9 volts out. It is important to get these connections right as shown in the following example. We found in one place two 9 volts panels installed and connected to a 12 volt battery. The disappointed user was certain solar power was no good because the battery was not being charged by the panels. However we discovered that the panels were connected in parallel so giving only 9 volts to the battery. Now you must have a charger that gives at least one volt more than the battery see para 3.2.3.5. so we connected the panels in series and they produced 18 volts which was more than enough to keep the 12 volt battery fully charged.

3.2.5. Diodes in Solar Chargers

Originally only one diode was used with each solar panel as this has always been necessary in a solar charger circuit to prevent the battery from discharging through the panel. Now you may well find several diodes built into a panel. The manufacturers do not always explain either the presence of the diodes or their purpose. For example: there is a label on the back of your panel saying "By-pass Diodes fitted" but you would still require a Main Diode. There will probably be a small plastic box mounted on the back of your solar panel. If you remove the lid of this box you should find the + and - terminals. There may also be diodes in this box and in the absence of any information from the manufacturer you should attempt to identify the purpose of the diodes. A description of a diode and its several uses in solar panels follows.

3.2.5.1. What is a diode?

A diode is a device which permits electric current to flow through it in one direction only. It is, therefore, very important that the diode is correctly connected. One place you should always find a diode is connected between a solar panel and the battery it is charging. A diode is shown in circuit diagrams by the theoretical symbol of an arrow on a line. -->|-- , see Fig.3.3. The arrow shows the direction in which the current flows. The current flows from the one end which is called the anode to the other which is called the cathode. The anode is positive and the cathode is negative. When current is flowing through a diode there will be a loss of 0.5 to 1 volt across the diode. The cathode of a diode may be identified by one of the several markings found on diodes e.g. by a light coloured ring on the dark body of the diode or by an arrow printed on the diode which points to the cathode. If the marking has come off the diode the cathode can be identified using a multimeter.(see para 8.6.2.3.) This method should also be used to test all diodes, including new ones, before they are connected as it is difficult to test them once they are in a circuit.

3.2.5.2. Main diode

When a solar panel is used for charging a battery it is always necessary for a diode to be connected between the solar panel and the battery. The purpose of this main diode is to permit the solar panel to send charging current into the battery whilst preventing the battery discharging current through the panel during the night or when there is no sunshine. The diode may be connected in the + or the - wire provided the diodes direction is correct, see Fig 3 3. Main diodes are sometimes built into solar regulators, see 3.2.6.

3.2.5.3. Blocking diode

When more than one solar panel is connected in parallel it may happen that one panel becomes shaded. The output voltage of the shaded panel will fall and it will absorb current from the other unshaded panel. This waste of current can be prevented by connecting a "blocking diode " between each panel and the battery as shown in Fig 3.4. The fitting of blocking diodes is optional but if fitted to all panels then a "main diode" is not necessary.

3.2.5.4. By-pass diodes

These are used to minimise loss of voltage across sections of a panel or across individual panels, which are connected in series, when a part of the panels becomes shaded. The diodes limit any reverse voltage which may be produced by shading to 0.6 volts see Fig.3.5. If by-pass diodes are fitted to your new solar panel you can discover if they will in fact be of any use. That is , if a section of the panel is shaded so that a by-pass diode is conducting, will the remaining voltage from the panel be sufficient to charge the battery. For example, when two diodes are fitted to a panel which has an open circuit voltage of 18 volts, i.e. 9 volts plus 9 volts, then with one by-pass diode conducting the output voltage would be 9 volts minus 0.6 volts which is clearly not enough to charge a 12 volt battery. If four diodes were fitted i.e. 4.5 + 4.5 + 4.5 + 4.5 volts and one section was shaded causing one diode to conduct then the output is 4.5 + 4.5 + 4.5 - 0.6 = 12.9 volts which is sufficient to put some charge into a battery. By-pass diodes which

are serving no purpose could be removed because problems may arise if they failed e.g. due to lightening damage. They can be used as blocking diodes or kept as spares.

3.2.5.5. Diodes for multiple loads

Where there is a solar panel which has been installed to charge a battery e.g. to power your radio, the question may soon arise "Can we charge other batteries from the panel as well?" The answer is "perhaps" and "providing priority is given to the radio battery". First it must be established that the existing panel is capable of providing adequate charge to the battery it was intended to charge. Then if there is surplus current the extra load should be so connected that there is priority to the premier battery. Such an arrangement can be achieved by using a somewhat complex and expensive electronic management system which itself will require power. Alternatively a simpler and cheaper system of diodes can be used see Fig 3.6. However this configuration of diodes does not guarantee that the principal battery will get sufficient charge but it will ensure that the additional load receives at slightly lower voltage and that it will not discharge the principal battery.

3.2.6. Solar Regulator

Current practice is to use solar panels producing up to 18 volts to ensure a high battery charging current throughout the period of charge. With such panels it is necessary to use a regulator to reduce the 18 volts supplied by the panels at peak performance times to the maximum permitted at the battery e.g. 14.5 volts, to prevent the battery from being overcharged. Some solar regulators contain the Main diode. Only use a regulator that can handle the maximum power output of your panel. There are several different types of solar regulators. One has a current controlling device between the panel and the battery which controls the amount of current going into the battery. Another type has resistors which "dumps" some of the current from the panel when the battery voltage exceeds the predetermined limit. Both of these types can provide proportional control that is the charging current is gradually reduced as the battery voltage rises. There are also "on-off" regulators where the full charging current flows for a time then is reduced sometimes to zero fora period of time. Proportional types are preferable.

3.2.7. Pedal Generators

Generators pedalled by people have been used to produce electricity for radio communication purposes since the 1930s. Their use was pioneered by Traeger in Australia for the Flying Doctor Service. Pedal generators were still in use in the British Army in the mid 1980s though by this time production had ceased in Australia. A network of several Traeger pedal powered transceiver, giving a power output of 25 watts PEP each, was established around Dodoma in Tanzania in 1980 and this equipment was still serviceable in 1987. These generators produced power directly but only while they were being pedalled and usually did not incorporate a storage battery. When there is no storage battery it is necessary to pedal all the time whilst you are receiving and waiting for your turn to speak, in practice this can be 10 to 20 minutes. Therefore it is helpful to have a timetable with specific times for contacts which is strictly adhered to. Since production of these ceased many individuals and groups have designed their own

generators.

These designs have frequently been based on a bicycle, one incorporated a 3 speed drive, to drive dynamos or alternators from cars. A disadvantage of using a normal car alternator is that it requires a battery to provide current to start it generating and also to stabilise the output voltage. However a battery gives an operational advantage in that it can be used to power the transceiver during what may be long periods of receiving only. Then pedalling commences for transmission and also to charge the battery.

The cost of car batteries in some countries can be very high. Also the life of these batteries can be only 1 or 2 years and they can easily be stolen or borrowed for other purposes. So it is sometimes beyond the financial resources of small groups to provide themselves with a battery. When using a low power transmitter e.g. 25 or 40 watts, these groups could use a new design of pedal power generator which requires no battery although it uses a car alternator. In this design the existing control unit in a LUCAS 17ACR car alternator was replaced by the circuit shown in Fig.3.7. This maintained the output voltage of the alternator between 13.0 and 13.6 volts for a load varying from 0 to 40 watts. The pedal generator has been used to power a 40 watt PEP SSB transceiver.

WHERE THERE IS NO TELEPHONE

Chapter 4. HOW TO PLAN YOUR RADIO NETWORK

Topics:

Return to Table of Contents

When it is decided that your group needs some form of communication and could benefit from a radio communication network you should consider what this implies in some detail. Before you get down to choosing a transceiver from the glossy brochures there are some general aspects to be considered. What are the facilities you would like and what facilities you can actually afford to buy, licence, operate and maintain? What form of radio communication between which places will the Government of the country permit? You may plan several different systems on paper before you arrive at the one which is acceptable in all its aspects. Keep all your various plans because you could find that after going through various planning and costing stages and through government departments etc. you need to go back to an earlier plan!

4.1. Who do you want to talk to?

The first stage of your planning should be to take a good look at the present method of communication

between your locations and to make an assessment of their needs. Look at how long it takes to get urgent and routine information passed on, how much it costs, how far away from good roads each location is and from towns that might possibly have a telephone link or from other groups with a radio link. Then decide which locations have the highest priority for a radio link. You will probably give priority to the most isolated and distant places but there may be others which could be usefully linked by radio even though they are more accessible.

You may think that a place with a good road link does not need a radio even though it has no telephone, that in an emergency a journey by vehicle could be made. However where the costs of running a vehicle are high, where there can be risks of fuel shortages and the availability of vehicles are often in doubt, then a radio link may prove invaluable in an emergency situation as well as cost effective in routine matters. You must think carefully about the advantages and possible disadvantages. For instance, while radio messages will certainly speed up your communications, it is possible that they can also put understaffed headquarters under a lot more pressure as outlying stations may come to expect instant responses to their demands. You do not want the introduction of a radio link to become "more nuisance than it's worth!"

You should decide which location is to be your Headquarters (HQ) station and most likely use this station to control the operation of the radio network. At this stage you should plan for locations to be able to speak directly with each other rather than have messages relayed by intermediate stations as this can be a source of introducing errors into messages. There is a party game where one person whispers a message to the next person and so on until it is relayed round the room to the last person. Invariably the message quoted at the end differs considerably from the original one. This demonstrates the hazards of relaying messages by speech. From Table 4.1. emerges the number of transceivers required, the distances that each station has to communicate over and the cost of the present method of communications.

Table 4.1.Existing methods and cost of communications.

Location	Kms to HQ	Time for message to arrive	Present Method	Present cost per message	Total cost in past year
"A"	350	2 or 3 days	URGENT. Via radio of other group if it is working then by 2 days overland.	no charge + £10.00	—— £70.00
		4 days	URGENT. If radio is not working send person by air and road	£110.00	£330.00
		Variable	ROUTINE. Send with next person to travel there		
		3 months or never	ROUTINE. Letters by local post	£0.05	£2.00
"B"	250	1 day	URGENT. Via radio of other group if it is working	no charge	
		1 day	URGENT. Charter an aircraft	£300.00	
		1 week	SEMI-URGENT. send a person by boat	£20.00	£100.00
		Variable	ROUTINE. send with next person to travel		
		3 to 8 weeks	ROUTINE. letters by local post	£0.05	£2.00

Making a list similar to this for all your stations should help you decide which places really need a radio. When you have reached this decision then draw a geographical map to scale showing the locations of the proposed radio stations with respect to the HQ station. Join together with a straight line the stations which are to speak directly to each other. Write beside each line the number of kilometres it represents, see the example in Fig.4.1. Let this be your basic plan for the future network.

4.2. Licences

Licences for radio communication equipment are usually obtained through the national post and telecommunications office of the country concerned. e.g. in Zaire - Office National des Postes et Telecommunication du Zaire (ONPTZ). Whilst these deal with the technical aspects, approval may also be needed from the state security. So you should have a licence before you use your radio or you may be in trouble!

4.2.1. Applying for a licence

Attempt to discover all the information you can about licensing conditions before you purchase your radio. You may be able to get information from the authorities or from other groups who are already licensed to operate. There may be a central body which is experienced in applying for licences and may handle the applications for you. In Zaire such a body is L'Eglise de Christ du Zaire (ECZ) which is recognised by the Government as representing the Protestant Churches. Obtaining licences can sometimes take a long time and you may have to fill in many forms and supply technical specifications and circuit diagrams of the radios you intend to use together with maps and plans of your network for each proposed station. You should obtain the technical specifications and circuit diagrams from the manufacturer of the radio you hope to use but you should not purchase or import your radios until you have the licences for them, sometimes the condition of importing them is that you must have the licence first. Also it is possible that the authorities might not give you the required permission or might impose limitations on the sort of radios you can use.

Some countries may wish to study a complete technical specification of the particular type of radio in order to give "type approval" before it is imported and used there. Sometimes "type approval" may have been given previously to another group using that particular radio so this is one stage where you may experience little delay. If "type approval" is a necessary stage in your particular country, enquire which types of radio have already been approved in this way as it could be helpful for you to chose one that has been approved. Do ask people who are already licensed for advise on all the things you can, e.g. you might learn, perhaps, that it is better to apply for more licences than you need because it is the practice of the authorities to only grant five out of ten applications.

One question which appears on application forms is often "What is the distance to the nearest public telephone?" It is reasonable that if the national telephone service has provided a telephone system, both private and public, that works then it should be used where possible. The operative words being "that works". The national telephone networks of several countries in East Africa are being extended into the rural areas, some telephones being linked by VHF radio not by telephone wires. One mission with 55 licensed radio stations in its network had the licences of 20 stations withdrawn as telephones became available as an alternative means of communication. Before spending a large sum of money on a radio telephone network it would be as well to enquire if there are plans to extend the national network to any of your areas. The plans and timetable of any proposed extension of the national system should be looked at through the eyes of experience of that particular country. To some authorities success is the provision of marvellous plans and this is an end in itself. The fact that these plans may never be implemented for

years or decades is of no consequence.

4.2.2. Licence Fee

The annual licence fee for a transmitting station varies greatly from country to country. In 1987 the licence fees in some African countries varied from the equivalent of £25 to £75 per station. It is an offence to operate a transmitter without a current licence therefore it must be renewed annually.

4.2.3. Frequency choice

When applying for your radio licence you can mention the time of day you want to speak over the radio link, the distances to be covered and suggest a suitable frequency. You may then be allocated a frequency of the order you require. Alternatively you may be given a frequency and have to schedule your operating times on it for satisfactory ionospheric propagation. See the information on propagation in Chapter 1.

4.2.4. Limitations

You may wish to use a synthesised transceiver capable of operating at any frequency from 2 to 30 MHz. However the ability to transmit on all these frequencies may not be acceptable to the licensing authorities. You may only be permitted to use a transceiver containing the frequencies for which you have been licensed. Your plan may be for a network with twenty stations with whom you wish the HQ station to communicate direct as suggested in 4.1. Such an arrangement may not be agreed by the licensing authority. For instance they could suggest that your twenty stations be divided into four groups of five stations. Each group having a principal station with whom the other four communicated and only these four principal stations permitted to communicate directly with HQ. The reason for this might well be that they do not want too many high-powered stations and they could limit the power of the subsidiary stations in each group to, perhaps, only 25 or 40 watts depending on the local situation.

4.2.5.Import Licence

At the same time as you apply for the licence to operate the radios you should also enquire if a licence is needed to import them. Enquire about customs charges and if any exoneration from duty is available to churches or aid agencies. If the radios are being purchased by a mission or aid agency in another country as a gift to your organisation you may need papers giving proof of this. It is important to make sure that you have all necessary documentation with the equipment when it arrives or it could be stuck in a customs store while you obtain what you need. In such a situation there is always a danger of loss or damage as well as the risk of being charged large sums of money for storage.

4.3. What type of radio communications?

There are many different types of radio communication ranging from local Citizen Band (CB) to the men who talked to earth from the moon! Within each type there are many methods of transferring information,

for example by the spoken word, morse code, teletype, picture and data transmissions. Methods of radio communication normally used by groups who have no access to a telephone are CB, VHF (Very High Frequency) and HF. The subject of CB and VHF are covered briefly but the main concern of this book is with HF radios.

4.3.1. CB

The use of CB radio is authorised by the Governments of many countries. There are no international regulations for standardising the service,though the majority of countries allocate frequencies in the range 26.96 to 27.41 MHz. One country allocates 49 MHz and a further two allocate frequencies between 476 and 479 MHz. The U.K. has made an allocation just above 900 MHz as well as 27.6 to 29.9 MHz. Typical values of maximum transmitter power allowed is 5 watts of FM and AM and 12 watts of SSB, though some countries limit the power to 0.1 watt. The result is that legal CB is meant to be for local use, typically up to 8 kms range. But if one or both stations are on high ground then longer ranges are possible. Also if the transmitter power is increased to 40 or 100 watts or if beam aerials are used ranges up to 30 kms. may be achieved.

The types of modulation used in CB sets can be AM, FM and SSB. Some sets are capable of producing all three types of modulation and have a selector switch. Other sets are only for one type e.g. AM. A FM transmission cannot be understood on a AM receiver or a SSB transmission on a FM receiver. Therefore you should ensure that any CB radios you obtain all have the same modulation system.

For a few years, each time the sunspot number is around its maximum, CB can be used for long distance contacts between countries and continents. Such contacts are often not within the terms of the CB licence. CB radios are readily available and often at low cost so depending on your distance requirements CB may be an economic solution. It is a useful solution for communication within a mission or other establishment e.g. a hospital complex, where the buildings are spread over a wide area and where an internal telephone system would be impossible to install and maintain owing to its high cost and to the possible theft of overhead lines as has happened in some cases. CB has proved to be very useful within towns and cities which have no satisfactory telephone system. For it to provide a good service some form of co-ordination is necessary. In one African city a mission group took the lead and produced a list, updated twice a year, of some eighty CB users. This gave the channel on which each one listened and their individual call-sign. The CB transceivers were left switched on all day, with the squelch control set to prevent noise from the loudspeaker until a signal was received. So by using the correct channel and callsign one could call a required station as easily as using a telephone. Most CB sets have forty channels, others may have eighty.

4.3.2. VHF

VHF can be a reliable form of communication as it is not dependent upon the fluctuations of the ionosphere but its range is limited. For networks using 25 watt transmitters ranges up to 80 kms. may be achieved. However the range is very dependent upon the topography of the area. A rough guide is that if there is a "line of sight" between the two VHF aerials then communication is possible. Range can be extended beyond the horizon and round intervening hills by unattended automatic VHF relay stations.

These can be located on a hill or high building and can greatly increase the area served by VHF transceivers. This is because there can be line of sight from each station to the elevated repeater even though stations are not visible to each other. Therefore it may be possible for all stations within a 80 kms. radius of the repeater to communicate with each other. VHF systems often operate in the 70 and 150 MHz region. The operational requirements for a VHF radio network should be specified with the help of a radio engineer who would then produce a plan and a list of appropriate equipment to satisfy your needs.

4.3.3. Amateur Radio

The facilities provided by the amateur radio service should not be confused with CB or privately licensed networks. Amateur frequencies are allocated on an international basis and range from 1.8 MHz to 10,000 MHz and enables global communication including the use of satellites. All types of communication are possible including normal speech, television, teletype and computer talking to computer. However as the name suggests the facilities are intended for the amateur enthusiast and not for commercial organisations. The restrictions on what communication can be performed by amateur radio varies from country to country. Most countries expect the amateur to pass certain examinations before a licence is issued and some will only permit the licence holder himself to speak on the radio. Others will allow anyone to speak under the supervision of the licence holder. Also others e.g. USA, will allow the amateur to connect his amateur friend from another country into the telephone system via the radio so enabling him to speak to non-amateurs. Unfortunately in UK for example this is never permitted. Amateurs are also expected to co-operate with the International Red Cross and Government departments during disaster and relief operations. The facilities of the amateur service are many and varied and are also continually increasing therefore you should enquire if the amateur service is relevant to your situation and if so encourage some of your personnel to obtain an amateur licence. Many expatriates use amateur radio for a daily or weekly talk with their friends in their home country. However it should be noted that some countries put many restrictions on amateurs, others make it difficult to obtain licences while a few ban amateur radio completely.

WHERE THERE IS NO TELEPHONE

Chapter 5. COSTS AND CHOICES

Topics:

5.1. Costs

First impressions of the cost of a radio network can be deceptive. You may know that a basic transceiver can cost around £1,000 but before that transceiver and its associated equipment is installed and working the total cost can be up to £2,500. The cost of introducing a radio network can be divided into two parts. First there is the capital cost of the equipment together with the shipping, insurance, customs duty and installation which are "once only costs". Secondly there are the "recurring costs" of operating, maintaining and licensing the network.

5.1.1. Capital Costs

The £1,000 mentioned above is the cost of a basic transceiver. There are many additional items necessary as suggested in Table 5.1. which gives an indication of the approximate prices in 1988. Whilst not all the items listed will be necessary, you may require some of the additional facilities described in Chapter 9. The cost of the additions will need to be discovered at the time because they vary considerably with manufactures and time etc. An adequate selection of spare parts should be purchased with the transceivers. The manufacturers may have a recommended list of spares based on experience. Allow about 10% of the basic transceiver price for spares for each set you buy. Technical manuals of the transceivers must be obtained, preferably in the language of the country where they will be operated. The numbers of manuals will depend upon what provision you make for maintenance. If each station is responsible for maintaining their own sets then there should be a manual with each set. The purchase of major items of test equipment such as a signal generator or an oscilloscope will again depend upon your plans for maintenance, see para.5.2.4.

Table 5.1.

Item.	Cost in £
150 watt pep SSB HF transceiver	1,000
Each additional Channel	50
Spare parts	100
AC power supply	40
USB and LSB	80
Hand-held (fist) microphone	25
Desk microphone	80

Earphones	15
Single dipole aerial	150
Broadband aerial	300
Aerial selector switch	25
Your specified modifications(para.5.2.5.)	50
Technical manuals	10
12 volt battery	80
Solar battery charger	250
Mains battery charger	50

The list may have to be extended to cover such items as petrol or diesel generator and aerial masts. The possibility of obtaining a discount price should be investigated especially if you are buying a large quantity of radios. Some manufacturers give concessionary prices to missions and aid groups, indeed some give gifts of equipment. Discounts of 10% to 40% have been obtained. Check if there is a tax on equipment when it is purchased e.g. Value Added Tax (VAT) in Great Britain, which need not be paid or can be reclaimed when you export the equipment. It is the resulting discounted price that must be considered e.g. a £1,000 radio with 40% discount costs £600, a £700 radio with 20% discount costs £560. You will have to make a list of your particular needs. If your set is mains operated and you wish it to switch automatically to battery operation when the mains fail, you will need a "fail to battery unit". If you employ a solar charger then you may not need a generator or a mains battery charger.

5.1.2. Shipping

To ship equipment from the country of manufacture to the country of use could take several days by air or several months by sea. Air freight costs more but the longer equipment is in transit the more likely is it to be damaged or lost so using the cheapest method is not always the most cost-effective in the end. It is usual for radio manufacturers to pack equipment in shock absorbent material in a cardboard box. You should instruct them or the shipping agency to further enclose the cardboard boxes in a strong wooden one. This is to give both added mechanical protection and to reduce the chances of cardboard boxes being opened and items stolen. Insurance may cover the cost of replacing any equipment stolen but the time and effort necessary to recover the cost, reorder and ship the replacements will mean a delay in the installation and availability of your radio network. Therefore any steps you take to prevent loss of equipment at any time is worthwhile. The following example gives some idea of the cost of shipping equipment by air freight from Britain to Zaire in 1986. You must, of course, make sure you have up-to-date information for your own estimates. It shows that there are other things beside the actual freight charges.

	£
To supply wooden box, pack band and mark	35.00
Delivery to the airport	8.00

Air freight charges on 147 kilos at £2.25 per kilo	330.75
Airway bill charges, documentation etc.	20.00
Insurance	10.00
Telex with flight details	6.00
Total	**£409.75**

If you have small amounts of equipment to come out the best and safest way is often for someone to bring it out with their personal luggage even if you have to pay excess baggage costs but you must make sure they have all the necessary documentation with them.

5.1.3. Customs Duty

The custom duty payable varies from country to country and can also depend on the type of organisation you are working with e.g. commercial, foreign government aid programme, church or mission. Some countries allow properly documented gifts of equipment going to non-profit making organisations to come in free of duty, others do not, while again others give this concession only to a few aid agencies. The regulations and duty payable can also be changed without much warning so make sure you get as much up-to-date information as you can. An example of what can happen is that the cost of equipment ordered in U.K. in 1986, as a gift to a church, was doubled by the imposition of customs duty just before its arrival a few months later. Previously all genuine gifts had come in free of duty for many years. In some cases customs duty is charged not only on the value of the equipment but on the total cost of equipment, freight charges and insurance. It is therefore important to obtain full details of all likely charges including any local tax and possible storage and handling costs. In some places it can be difficult to get accurate and reliable information thus making it hard to know whether or not the amount you are asked for is the true amount. If you are not familiar with the system it would be worthwhile using an agent who is known to be reliable by other missions or groups. You would have to pay for this service but it could save you time and money as an experienced importing agent would know what was legally required to be paid.

5.1.4 Installation

After you have imported the equipment into the country there will be further expenditure for transporting it, together with a technician to install it, to its final destination. The cost for this can vary depending on availability of transport and technician and the remoteness of the location. For instance, if there is no other way, it may be necessary to charter a small plane. The cost of a day's charter with Mission Aviation Fellowship (MAF) to a station one and a half hours flying time away was in 1988 in Zaire £300. A commercial charter company would charge double this. In practice however it is often possible to share costs with others or to make use of local transport. As regards the installation work it is very important to get things fixed up correctly. A properly installed station will function better and longer and be more cost effective, even if you have to pay a technician to do it, than one badly installed by someone who knows nothing about it. It is even worse still to use someone who thinks he knows what he is doing when he

really does not. See chapter on Installation. There are several options open to you regarding using a technician:

Option 1. Employ your own technician. This is the best method especially if you will have a big network.

Option 2. Use one of your personnel who has a practical aptitude and an appreciation of things electrical. If he reads and understands the information in this book and can follow instructions sensibly the installation should be successful.

Option 3. Obtain the services of a local technician either from another mission or group or from a local company if there is one. Costs may vary but could be £10 to £20 per hour.

Option 4. Use a technician employed by the manufacturer of the equipment. This is an expensive option as it could involve, for example, the cost of flying out the technician from U.K. and paying a daily rate of £300 for each day he is away from U.K. Therefore to get such a person to spend several days at a remote location in Africa could cost some £3,000.

5.1.5. Operating

Who will operate the radio? How long will they spend each day sending and receiving messages and getting answers to messages and passing on requests for help or information? At a small station the extra demand on people's time due to the introduction of the radio may be low so that it can be absorbed with no extra cost. At the HQ station of a large network it will be different. Here it may be necessary for someone to be available all day both to operate when required and to deal with messages. The question of employing and training a radio operator and the responsibility of who should pay his wages ought to be carefully thought out beforehand. There will also be a small cost involved in the provision of "log books" to keep a record of all messages both sent and received. This is usually a legal condition of your radio licence.

5.1.6. Maintenance

You should decide how you are going to maintain your network before you buy your equipment. There are many factors which will determine the annual maintenance costs and therefore this is a difficult figure to estimate.

The need for maintenance will be minimised by certain factors which include good quality control during manufacture, having safeguards built into equipment, by good design of installation at each station and by having good operating procedures. These are dealt with in detail in this book. If your network will have twenty five or more stations you should consider having your own radio technician and workshop unless you are in an area where good reliable repair facilities are available at reasonable cost from other sources. The initial cost of equipping a workshop with the basic test equipment can start at £1,000 depending on

the technician's choice. See para. 5.2.4. for choice of test equipment. To this you may need to add the cost of providing a building and work benches and seats, lights and fans or an air conditioner.

Then there is the annual cost of employing the technician. This is one area of cost in which certainly church missions and to a lesser extent aid agencies have an advantage over commercial concerns. The annual allowance paid to an expatriate missionary radio technician working in an African country was about one quarter of that paid to a similarly qualified person by a commercial organisation. Once you have established a repair facility you will usually find that other groups will come to you requesting you to do repairs on their equipment. If your technician has time available to do this then this could be a source of income to help with your costs.

An alternative to setting up your own workshop may be to arrange for prompt and effective repair work through an existing organisation. Some individual groups have a reliable facility in their own area but a more widespread organisation is MAF who because it has to maintain the equipment in its aircraft have some workshops of their own and sometimes is able to offer repair facilities to others. In Zaire the Catholic church is spread over the whole country and has radios at some five hundred locations. It has its own organisation for the supply and repair of radios and also offers a repair service to other groups. The cost of using a repair service other than your own will consist of the transport costs of getting the equipment to and from the workshop, the cost of the technicians time e.g. £10 to £20 per hour and the cost of replacement parts.

5.2. Choice of equipment

After you have decided the plan for your radio network and obtained the necessary permission you will need to make your shopping list. If you have had to give details of your chosen transceivers in order to get your permission you should have already studied the next section!

5.2.1. Transceivers

There are many glossy brochures advertising radio communications equipment. Pictures show vehicles with aerials sweptback as they speed across the desert or through the forest and the equipment is claimed to be "highly reliable for all conditions". Such claims are meaningless unless data such as the "mean time between failure" (MTBF) is quoted for specific operating conditions and this data is normally not available. Organisations such as MAF make a study of transceivers suitable for use in countries in which they operate and may be able to advise you. You should aim for the simplest transceiver that will satisfy your needs. A leading manufacturer of transceivers recently introduced a new crystal controlled model by claiming: "You do not have to be a computer programmer to operate it or an electrical engineer to repair it!" There now follows a list of some of the things to look for when selecting a transceiver.

5.2.1.1. Supply Voltage

You should discover what voltages are actually available at the site where you intend to install a

transceiver. For example you may be told that a 220 volt AC mains supply is available but in reality this could fall to 185 volts at certain times. The voltage requirement of a transceiver may be given as one fixed voltage e.g. 220 volts or it may be able to be set at any one of several voltages e.g. 210, 220, 230 or 240 volts. Enquire from the manufacturer the AC voltage range over which the transceiver will really operate as this may be greater than that quoted in the specification. One British transceiver was found that would operate satisfactorily when the main voltage had fallen to 190 volts. Battery voltage. There is generally a misunderstanding about the voltage required for a battery operated transceiver. You may find a transceiver which is said to operate from a 12 volt DC supply. However the specification for such equipment is usually based on an input voltage of 13.6 volts because this is the voltage of a vehicle battery on charge i.e. with vehicle engine running. When the transceiver is operated from a battery which is not on charge at the time then the voltage supply may well be just 12 volts and the specification may be different. For example a transceiver which produces 150 watt PEP with a 13.6 volt supply may only produce 100 watt PEP at 12 volts. Be aware of the real voltage which will be available and ensure that you obtain a transceiver that will operate satisfactorily from that voltage.

5.2.1.2. Ease of maintenance and modification

Can the transceiver be easily dismantled for servicing? There are some, e.g. the TWC ones from U.S.A. and AEL from the U.K., which have plug-in circuit boards. This means that the components are built onto a board which can be simply unplugged from the chassis of the set and an identical replacement board can be plugged in, should a component on the circuit board fail. With such a system it is often possible for someone with little radio knowledge to locate and correct a fault by simply taking out and replacing each board in turn with a new board. It is then easier to send a single faulty board to be repaired at your nearest radio workshop than to send the whole transceiver. Please read para.8.6.2. on maintaining your network for further details of this procedure. Can the transceiver be easily modified e.g. to add an additional frequency? In the case of Traeger (Australia) this was done by adding a single circuit board whereas some radios will require several components to be soldered into various parts of the transceiver. Ensure that the Technical Manual for each set contains full circuit diagrams and testing procedures with numerical values. If you require more detailed information ask for this as part of the purchase arrangement, otherwise additional information may be more difficult to obtain at a later date.

5.2.1.3. Ease of use

An explanation of controls etc. was given in para 3.1.3. You do not want the front of the transceiver covered with controls and indicators that the operator may never use. The minimum controls necessary for a SSB transceiver are: ON/OFF, VOLUME, CLARIFIER and a CHANNEL SELECTOR if more than one channel is fitted. A SQUELCH control and a TRANSMIT indicator will also usually be found. The use of earphones has proved successful for hearing weak signals under noisy receiving conditions. Some transceivers have a earphone socket, others can be modified to have one. If you want this facility, check on its availability and order as necessary. see also para. 5.2.5. If you expect to use the transceiver on both the mains and DC battery operation from time to time, find out what is involved in changing from one to the other. Is it by a switch, changing plugs or soldering wires? Will a separate unit for operation on AC mains be required? Some transceivers have their AC power supply unit built into them, others do not.

External power supply units require interconnecting cables, plugs and sockets, all of which can wear out or be damaged and thus be a source of failure.

5.2.1.4. Future availability

It is wise to standardise on one model of transceiver if it has proved satisfactory but unwise to buy a model that is about to go out of production. This may be difficult as manufacturers do not always give advance notice when a model is being withdrawn. After production of a particular model has ceased spare parts are usually available for several years. Before you buy the equipment write to the manufacturer and ask for how many years are they going to supply spare parts. You may get a more realistic answer to a written question whereas an enthusiastic salesman's response to a verbal question may be: "No problem, spares will be available for the next ten years!" Two years later when that particular salesman has left the company there could be difficulty in obtaining spares. You will need to consider how easily and rapidly you will be able to communicate with the manufacturer. Do you have a common language in which to discuss technical questions? How rapidly can you obtain equipment and spares? It may be advantageous to select a manufacturer, or certainly an agent, in the country in which you are working or in your home country. With foreign manufacturers you will be subject to fluctuations in the exchange rate when performing currency transfers. It should be noted that whoever you are dealing with, you will possibly encounter delays in the postal system when enquiring or ordering from overseas.

5.2.1.5. Protection

You should enquire if there are any protective devices built into the transceiver to protect it from damage by lightening. These usually take the form of diodes which give limited protection, in practice the aerial ought always to be disconnected from the set when it is not in use. see para.7.2.2.5. Some transceivers are "reverse polarity protected" i.e. the 12 volt DC supply can be connected to the transceiver the wrong way round without damaging it. See para.5.2.5.

5.2.1.6. Channel Frequencies

Transceivers which are not synthesised only have a limited number of channels see para. 3.1 and 3.1.3. For these you will need to specify the required frequencies for each channel, including whether it is USB and/or LSB, and you will need to choose a transceiver which will provide the necessary number of channels.

First you must list the frequencies which have been authorised for use by your own group.

Secondly you may need the authorised frequency of some other groups. e.g. MAF frequency for a location with an airstrip.

Thirdly there may be certain frequencies on which you want to listen i.e. receive but not transmit. List these as channel frequencies but qualify with RECEIVE ONLY. For example, there may be members of

your organisation in another nearby country with whom you are not permitted to communicate by radio. However you can listen to their transmissions on their particular frequency and similarly they could listen to you. Note if you have for personal use a short-wave broadcast receiver, preferably digital, that has a SSB facility you could use this to listen to any frequency.

Fourthly if the country in which you are operating permits amateur radio and you have or are likely to have radio amateurs in your group then you could allocate one or two channels to amateur frequencies. Such channels have been used in the past with some success in Africa for a missionary net on 14.19 MHz. The merit of this arrangement is that a limited amateur facility is provided at the cost of one or two extra channels rather than the cost of a complete amateur transceiver. The reverse has also been done when amateur transceivers have been successfully modified to provide the authorised mission frequencies.

Lastly you ought to have at least one channel, possibly two, spare for future use as you may well find at a later date that it is necessary to add a further frequency. So now you should know the number of channels you will need and you will be able to select a transceiver that satisfies your demand. There are two frequencies associated with a channel. There is the CHANNEL frequency which is the actual frequency transmitted and there is the CRYSTAL frequency which is often 1650 KHz higher than the CHANNEL frequency. When ordering crystals for a additional channel or for replacement, either definitely state which frequency you are giving or state both the channel and crystal frequency.

5.2.1.7. Microphones

The most expensive transceiver and elaborate aerial system will not permit you to speak to anyone if your microphone fails!. Although the microphone is one of the least expensive items of a radio system many people try to save money and buy cheap ones, often with disastrous results. Prices in 1988 for hand-held or "fist" microphones varied from £12 to £36. When a hand-held microphone is in use there is continual movement, both of it and of its connecting cable. There is also the temptation of passing it from one speaker to another often involving the stretching of its cable to its furthest extent! It is also easy to put it down carelessly or even to drop it on to a table or desk or to let it swing from the end of its cable. All this constant wear and the occasional bump is often the cause of failures which could be avoided if a desk microphone is used which can cost £60 to £85. They are normally left in the same position on the desk or table and apart from pressing the on/off switch at the beginning and end of your message it does not need to be handled.If considered necessary a desk microphone can be securely fastened to the desk. It is recommended that you use a desk microphone and also have a hand-held one as a spare. In any case you should always keep a spare one available as it such an essential part of your equipment. Microphone types are classified as dynamic or ceramic and their impedance as high, medium and low. You will need the microphone to be compatible with the stated needs of the transmitter, in other words the manufacturer will tell you what sort of microphone you must use with a particular transceiver. See also suggested microphone modifications in para.5.2.5.2.

5.2.1.8. Power Requirements

Transceivers are available to operate from either one or more voltages e.g. 12v DC, 110 or 220 to 240v

AC. If the transceiver circuits operate from 12v DC then an additional power unit is necessary for operation from 230v AC. Conversely a transceiver requiring 230v AC will need a power unit for it to operate on 12v DC. These units will either be inside the transceiver case or in a separate case connected by a cable.

5.2.2. Aerials

For a single channel set a single aerial will most likely satisfy your need but it will depend on your directional needs. See para.2.2.3 and 4. A single dipole can be used for all frequencies within +2% or -2% of the centre frequency for which it was cut, see para.2.2.1. Up to four dipoles can be combined with in multipurpose configuration to cover a range of frequencies see para.2.6.1. A broadband aerial, see para.2.6.2. should be considered for more than two frequencies as its cost can be competitive. Check that the all weather power rating of the aerial is sufficient for the power you will be transmitting. This is unlikely to be problem as aerial ratings of 1Kw. PEP. and above are common and your transmitted power may be a maximum of 150w. PEP.

5.2.3. Power Sources

It is the externals to the transceiver that often cause the failure of a radio station e.g. microphone or power supply. Table 5.2. can be used for selecting a reliable and suitable source of electric power. For more detailed information on each source read para. 3.2. on Power Supplies. In particular note that if you choose solar power it is an advantage to have done your own calculations to obtain an estimate of your needs before you buy the panels see Para.3.2.4. One user found that the quantity of solar panels they had purchased on the advice of the supplier were insufficient for the task they had specified. It was later discovered that the supplier had intentionally underestimated the need in order to quote a lower and more competitive price. The result was that they had to buy more panels at a later date after experiencing frustrating delays in setting up their operation.

Table 5.1. Selection of Power Source.

Main electricity supply
available

YES
Is it reliable?

NO

YES
No problem

NO

Voltage fluctuates?
Use a Constant Voltage
Transformer

Supply fails?
Use Standby Battery and
"Fail to Battery" unit

Use Generator

Reliable fuel supply
and maintenance?

YES

NO

Power radio
directly

Charge
battery

Solar for
battery charging

Pedal power
generator

Most reliable source
no fuel problems

Only requires
a person

5.2.4. Test equipment

A simple item of test equipment is the multimeter which measures voltage, current and resistance. The original multimeters consisted of a meter with a moving pointer (analogue type) and a range and function (voltage or current) selector switch. More recent versions have a numerical display (digital type) of three or four digits and automatic range selection, only requiring a function selector switch. Whilst digital displays are more robust than moving pointer types they do require a battery to power them. Examples of multimeter prices are:
Analogue type £20 to £150. Digital type £60 to £140.

Multimeters have proven useful wherever there is a radio because most people are capable of using them to measure mains or battery voltage and testing fuses. If you are equipping a radio workshop you can

spend from £1,000 to £10,000. The choice of equipment should be made by the radio engineer who will have experience and preferences. A modest workshop would contain an oscilloscope (£300 to £600), a signal generator (£100 to £200), multimeter, SWR meters, transmitter dummy load, soldering irons and various tools. The amount of test equipment necessary can be minimised by using a spare transceiver as a transmitter to provide a test signal for a receiver being repaired, then as a receiver for testin a transmitter.

5.2.5. Modifications

If the modifications suggested in this section do not exist in the transceiver you select then they can usefully be added. This may be costly if performed by the radio manufacturers so you should first obtain a quotation for such work. Missions and aid agencies may have a radio engineer amongst their home base supporters who could do the modifications at low cost. However it is important to make sure a volunteer engineer is really competent to do the job before you let him touch your equipment! If you do have a radio engineer able to help you in the country where it is manufactured he could visit the manufacturer for the final testing of the equipment as this would be an excellent opportunity to check that your written specification has been interpreted as you wanted. If such a relationship with your manufacturer can be established it will give you confidence in their equipment and their ability to serve your future needs and it may be useful to them to have feedback from someone using their equipment in your particular area. Such an arrangement with one particular firm in UK as been of great help to the author. Suggested modifications will now be explained.

5.2.5.1. Reverse polarity protection

As everyone should know a 12v.DC battery (e.g. a car battery) has a positive terminal and a negative terminal. The power cable coming from your transceiver will have a positive lead which should be connected to the positive terminal and a negative lead which goes to the negative terminal. Many times these leads have been wrongly connected with disastrous results to transceivers resulting in having to replace expensive transistors. The leads on the cables should be labelled but labels can be removed and replaced incorrectly. They are also often colour-coded e.g. black negative red positive but different colours are used by different countries and by different manufacturers so causing mistakes to be made. The safest thing to do is to provide protection which will prevent the reversed voltage reaching any components should the wrong connection be made. Three methods of providing this reverse polarity protection will now be described.

1. Fuse and diode.
   A diode provides a short circuit to a reverse polarity causing the fuse to blow, see Fig.5.1. In practice this configuration has not always safeguarded a transceiver because a fuse takes a fraction of a second to react and in that short time damage has been done to transistors. Also after a reverse polarity connection had been made to several transceivers the diodes were found to have been destroyed and no longer providing any protection. Without an electrical check of the diode this fact would not have been known to the user. The shortcomings of the quality control of one manufacturer was very evident because the diodes were connected directly across the supply. When a reverse polarity connection was made the diode immediately burnt out and had no effect

on the fuse so giving no protection.

2. Series diode.

    This is connected in series with the power supply where it enters the transceiver and will prevent current flow in the reverse direction, see Fig. 5.2. The voltage lost across a silicon diode will be about 0.6 volt, therefore only 11.4 volts will reach the transceiver from a 12 volt supply. A transceiver using an average of 8 amps on transmit will cause 4.8 watts (0.6 volts x 8 amps) to be generated as heat in the diode. Therefore this method of protection is usually found in low power transceivers e.g. up to 40 watts pep. To reduce the 0.6 volt loss which occurs across the diode some transceivers use a series transistor with base and emitter connected which loses only 0.2 to 0.3 volt.

3. Relay.

    The power supply has to pass through the contacts of a relay before it reaches the transceiver. The relay will only operate through D1, see Fig.5.3, when the supply polarity is correct. D2 is a suppression diode normally found across relay coils. So if you have a relay fitted in this way and you connect the transceiver to the battery the wrong way round nothing should happen as no power will go past the relay! The cost of a diode is low 1988 prices were o0.05 for 1 amp, o1.00 for 13 amps and o1.50 for 40 amps. A relay with contacts to switch 20 to 30 amps costs o7 but this gives good protection. Many transceiver in Zaire have had their HF power transistors wrecked because of reverse polarity and these cost o30 each. SAnother factor that makes some transceivers more venerable to reverse polarity damage is that their +12 volts supply goes direct to the HF power transistors as soon as the battery is connected before you switch on the set at the on/off switch, only the low current circuit goes through this switch. This problem is overcome by ensuring that the supply to all the transceiver goes through the protection diode or relay. When Low Voltage Disconnect (para.3.2.3.6) and Solar Regulator (para.3.2.6) units are used their circuitry should be protected by a series diode. It will be necessary for a radio engineer to consult the circuit diagram and possibly the manufacturer because the introduction of a protection diode will alter the voltage at which the units operate. Hence some circuit adjustment will be necessary.

5.2.5.2. Microphone switches

There may be several switches on your microphone, e.g. high-low impedance and VOX, which can usually be set and left in one position. Therefore it would be safer to fix these in the required position by altering their wiring. Impedance only on the switch shown in Figs. 5.5 and 5.6, it may appear that shorting pin A to C would be sufficient but Low Impedance could still be selected. Therefore it is necessary to remove the wire from Pin C and connect it to Pin A. If a transceiver has a VOX position it means that whenever you speak into the microphone you will automatically transmit without pressing the "press to talk" control providing the microphone is switched to VOX. If you do not have a VOX facility on your transceiver or if you will not be using VOX then the microphone VOX control should be wired to the normal position.

The "press to talk" control normally operates two switches inside the microphone as shown in Fig. 5.5. One switch shorts out or disconnects the microphone during reception. This is a facility not required in most modern transistor transceivers because the power is automatically removed from the microphone

amplifier during reception. This switch causes problems when it does not make good contact and often one can hear transmissions going on and off every few seconds due to an intermittent contact. When the switch is not necessary the wires should be removed from it and the microphone permanently connected as shown in Fig. 5.6. This leaves the switch free for other use. The second (transmit) switch turns the transceiver on to transmit and should be left to operate normally. However the now disconnected microphone switch can be connected in parallel with the transmit switch as shown in Fig. 5.6. to give extra reliability.

5.2.5.3. Earphone socket

When earphones are plugged into their socket it is usual for the loudspeakers to be disconnected automatically. The earphones used should be of similar impedance to the loudspeaker they are replacing e.g. low impedance phones for a low impedance speaker.

5.2.5.4. Squelch

The squelch control, see para. 3.1.3., can present a problem to inexperienced operators. If the squelch control is set for high level signals then weaker ones can be missed altogether. One aid agency in Kinshasa requested the help of a radio engineer because they could no longer hear any of their other stations. On turning the squelch control on the front panel the engineer was able to hear all stations without any problems. There was no fault at all in the transceiver, the operator had actually set the squelch control so high that no stations could be heard. In situations where the squelch facility will not be used the control can be wired so that it is permanently off. This can be done by removing the wire from the "variable" arm of the control and soldering it to the "squelch off" end. To indicate that this has been done the squelch control knob can be removed from the front of the transceiver.

5.2.5.5. Power light

The simple power light, see para.3.1.3., can be replaced by a two state LED (indicator light). The LED can be green when the +12 volt DC supply is in excess of say 11.6 volts and then it changes colour to a flashing red when the voltage falls below that. Supporting circuitry is necessary to operate these LEDs but this indication is particularly useful when the transceiver is operated from a battery and no voltmeter is available. A competent radio engineer should be able to design such a circuit using transistors and zener diodes. A circuit used by the author is given in Fig.5.7. The LED was Radio Spares (RS) 588-112.

5.2.5.6. Internal connections

Maintenance of a transceiver can be carried out rapidly by a technician visiting a remote location if all the main components are on plug-in circuit boards. However some transmitter HF power amplifiers have their connections made via soldered wires e.g. the high current connection to the power supply. This can be modified so that the connections to the power amplifier are routed via plugs and sockets e.g. the power supply can be via high current snap-on car electrical type connectors.

5.2.5.7. Foot switch

This is simply a foot operated version of the microphone "press to talk" switch. Pressing the foot down on it causes the radio to transmit removing the foot returns the radio to receive. The foot switch can be wired in parallel with the existing "press to talk" switch on the microphone so that either can be used.

WHERE THERE IS NO TELEPHONE

Chapter 6. HOW TO INSTALL A RADIO SYSTEM

Topics:

Once you have obtained the radio equipment there will be an instinctive urgency to get it installed and working as soon as possible. However long term benefits should not normally be sacrificed for rapid results! The equipment should be installed by the most competent person available, see para. 5.1.4. for options regarding technician.

If you are using a technician unfamiliar with the various locations make sure you have as much information as possible about each site available for him to study before he visits them, when possible give him the opportunity of discussing a site with someone who is familiar with it. You should make sure you have all the necessary equipment ready for him to take with him and if equipment such as aerial poles need to be got locally you should advise those in charge at each location regarding the size of poles and that they are to have them ready for his arrival. Wherever possible unsuitable temporary arrangements, e.g. wiring, should not be fitted because once the transceiver is working this may never be changed. For example the limitation in performance caused by the loss of voltage in a long thin wire being used as a power lead from battery to transceiver may never be discovered. The resulting poor quality of transmissions may well become accepted as normal for that particular location whereas with more careful and proper installation things could be much improved.

You should allow adequate time for the installation by building in an allowance for delays which you, from experience, have learnt to expect. Bearing in mind the culture and traditions of the area you are in, for example, a long welcoming session before you can proceed with the work. If the equipment arrives at your HQ direct from the manufacturers in large packages it will need re-packing in suitable sizes for transporting by small aircraft, Land Rover or canoe to the various installation sites. You must ensure that any new packing is sufficiently shock-absorbent and waterproof.

Whether or not the equipment needs re-packing you should take every opportunity to check that all the

items are actually there and if possible that they are working before despatching it to the various sites. Although everything is new and apparently working it is wiser for the installer to have spare parts with him to avoid delays and abortive journeys if a fault occurs during transporting or installing the equipment. Another point to consider is whether you may need documentation for the equipment you or your technician will be carrying. The need for this will vary from country to country. When you travel by air within Zaire, for instance, you have to pass through immigration and sometimes customs and you may need to prove to the authorities concerned that you are authorised to carry this equipment and that customs etc. have already been paid when it originally entered the country. So make sure that all the necessary papers are available including customs receipts, radio licences and written authority from your organisation saying who you are, where you are going and what equipment you are carrying. It is better to be prepared than to risk confiscation of the equipment.

6.1. Where to put the equipment

Ideally your technician should have sufficient time at each location to supervise each step of the installation and this ought to include time for inspection of the site and time for deciding the details of where best to locate the equipment. However in practise he may have only a short time to spend on each site or you may have no technician available and so you may need to do these things yourself. Therefore before you start any installation work look around your location and ask yourself where is the best place to put it all? Ideally you should select or build a room to house the radio equipment then clear a large area of ground of trees and any other obstructions then erect aerial poles of the required height. The solar panel would be mounted in an unshaded position and the battery would be adjacent to the transceiver. However in practice the ideal is rarely achieved. Indeed you may have little choice in locating your equipment in an existing building complex and it may not be acceptable to clear fruit trees such as mangoes which are a valuable source of food for the people. The aim should be to locate the transceiver within 25 metres of the aerial and as close as possible to the battery. It is important to locate the battery near to the radio because of the high current e.g. a peak of 20 amps, flowing in the connecting cable. However the solar panel can be further from the battery as the solar charging current may be only 1 or 2 amps.

6.1.1. The Radio Room

Try to find a permanent place for the transceiver and its battery. This place will have to be secure and you may have to fit burglar bars and reliable locks. It is not a good idea to have to carry the transceiver and/or its battery from its place of use during the day to a safe storage place at night. This practice could well result in unnecessary damage being done to the equipment because of constant moving and careless handling as well as causing inconvenience to those responsible for using and moving the equipment. In one situation where only one lady was available to carry a vented battery, her tee-shirts were spoiled from acid burns which could easily have resulted in hurt to the person. There was also the problem of keeping the transceiver dry whilst carrying it through wind and heavy rain to keep a scheduled radio contact. Conversation by radio is not private in as much that anyone with a suitable receiver can listen on your frequency. You may however wish to fit the equipment in a separate room which affords some form

of privacy to the operator and prevents conversations being overheard. If this is desirable but not possible then the operator can wear earphones so preventing the distant end of the conversation being overheard. Rooms in which other people are working and talking, also rooms which echo should be avoided because the sounds in the room will be picked up by the microphone and transmitted as background noise. This will not help the person receiving your transmission as they may already be listening through the crackle of static and interfering transmissions. Any form of sound absorbing screens or the "telephone hoods" as used in airports can be of help. Provision must be made for keeping the equipment dry even if this means covering it and its desk with a plastic sheet. Tropical rain can penetrate roofs, windows and doors!

6.1.1.1 Radio Desk

You should consider the ergonomics of operating the equipment and so prevent any time-wasting exercise. The transceiver should be located on a table or desk of a suitable height for the operator to sit at and where there is sufficient light for reading and writing messages. There should also be adequate space for writing and for using a desk microphone. If this is to be a busy station it is helpful to provide the operator with a foot operated switch in place of the hand operated "press to talk" switch. In Zaire desks have been made specifically to house the radio equipment. These were made of solid hard wood and with a good padlock were safe and secure. The desk was designed so that it was impossible to close it without first disconnecting aerial and power leads thus reminding the operator of the vital necessity of this action. You must not make holes in the desk for these cables to go through, see Fig. 6.1. If an aerial selector switch is used it should be within easy reach of the operator not on a distant wall. If several aerials are used with an aerial selector switch, this switch can be fitted on the outside of the desk so that only the single cable from the switch to the transceiver needs to be disconnected. The fold-back lid of the desk can be used to display information e.g. lists of stations with their call-signs and times of operation, also the phonetic alphabet. The layout of the desk in Fig.6.1 provides for ease of operating and hence reduces operator time. The desk microphone and foot switch give the operator two hands free for writing and refering to any documents.

6.1.1.2 Power supply

Your power supply connections whether from a battery or mains should be a permanent and reliable installation from the beginning, not a temporary and unsafe mix of wires and sockets as so often has happened.
MAINS. A mains supply will come from a socket on the wall or perhaps a socket hanging from a cable on a wall. You should firmly fix a socket near the transceiver because long mains cables on the floor or draped round tables and chairs are a danger to people and equipment. If your transceiver has provision for an earth connection on its power lead make sure that the earth pin on the wall socket you are using is connected and actually goes to an earth point.

BATTERY. The battery should be located as near as possible to the transceiver. Experience has shown that the only battery in a village that is not flat is often the radio battery. Disastrous results have occurred from disconnecting the battery, taking it to a vehicle, flattening it trying to start the engine and then

reconnecting it to the transceiver with the wrong polarity. Therefore the battery should be in a secure enclosure close to the transceiver. One method is to screw the wooden case in which the battery was transported to the floor, then put the battery in and secure wooden bars across the top to hold it in. If it is a vented battery there must be room between the bars for making visual inspection of the acid level and for easy topping up with distilled water.

Where for reasons of security it is impossible to keep the battery permanently in the radio room then you should install a permanently fixed cable from the battery to the radio room rather than be constantly carrying it back and forwards. If this cable is to go between buildings then for safety reasons it should go underground. The voltage drop in this cable should be as low as possible and never more than one volt and this will in fact limit the distance you can have between battery and transceiver. For guidance on this note that the thicker the metal conductor inside the cable the less will be the voltage loss. Also the lower the current flowing in a cable the less will be the voltage loss. For example a conductor with a cross-sectional area of 3.25 sq. mm. will drop one volt over a length of 15 metres when the current is 10 amps or over a length of 60 metres when the current is 2.5 amps. So if your transceiver uses 10 amps on transmit your battery must not be more than 15 metres away. The best solution is to try to have both transceiver and battery located securely in the same room.

PEDAL GENERATOR. A pedal generator is not very noisy and if located in a room shared with other people it will not cause any more interference than a radio operator speaking into a microphone or the sound from a loudspeaker. The generator can have the transceiver mounted on it so that one person sits on it to both pedal and operate or it can be located adjacent to the transceiver's position so that one person pedals while another does the operating. Experience has shown that if one person pedals while a second transmits then the speech transmitted is much clearer and more understandable. The generator should be in a room which is as cool and has as much ventilation as possible.

6.2. Installation

A good initial installation will require much more work than a quick job of just putting the equipment on a table and erecting an aerial. But the resultant good reliability and hence availability of communications has shown that sufficient time spent on installation to be a cost-effective exercise. There can be a conflict of demands for funds in an organisation if each department is trying to keep its expenditure to a minimum. For example one department may have been responsible for funding the purchase of the equipment, another for the installation and a further for the operating. If there is no one person with technical understanding and financial responsibility for the overall project then inefficiency can result. In one radio handbook it is written " the efficiency of communications and the long term reliability of the transceivers are critically dependent upon correct installation and the use of a suitable aerial." Your equipment should have with it both operating and installation instructions, when ordering the transceiver you should have specified a technical manual see para. 5.1.1. Always read and take note of all instructions and try to follow them but you may find that in your particular circumstances this may be a little difficult. One of the aims of this book is to help you solve problems you will not find mentioned in your technical manual.

6.2.1. Transceiver

Ideally the first step in your installation should be to fit the transceiver into its chosen position as this will determine the length and routing of the connecting cables. When you have the transceiver set up with its power source ready and working then you should begin to get the aerial up because you will need the transceiver working to tune the aerial and test its effectiveness. However there are times when you may have to do it differently. For instance, if the time your radio technician can stay at a certain location is very limited it may be a good idea to get the aerial up beforehand as this can be a time-consuming exercise, always depending of course that the aerial can be sent on in advance and that there is someone at the location capable of following correctly the instructions you would need to send for erecting it. It is best to have your technician or some other competent person there to supervise all the details of the installation and this is what you should aim for. So now we will look at points concerning the installation of the transceiver.

6.2.1.1. Cooling

For security reasons the transceiver may be housed in an enclosed space e.g. the radio desk. In mains operated transceivers the regulator transistors can produce a lot of heat and require a fan to keep them cool. You should obtain the quietest fan possible e.g. axial flow type, and fix it on a sound absorbing mount if necessary. To ensure a flow of air around the transceiver it is an advantage to mount it on two pieces of wood about 2 inches square with holes drilled in the wood for any "feet" on the transceiver and the wood attached to the desk see Fig. 6.2.

6.2.1.2 Microphone clip

A hand-held or fist microphone is supplied with a clip for holding the microphone when it is not in use. The clips are intended to be fitted in a place convenient for resting the microphone e.g. dashboard of a car or the side of a desk. No provision in the form of holes, screws etc. is usually made for these clips to go on the transceiver but in practice they frequently end up attached to it. One clip was found attached by a single existing screw so that it had swivelled round and broken an indicator light on the front of the transceiver. Another example is of two holes drilled into the side of the transceiver case and self-tapping screws being used to secure the clip. Whilst this provided a firm fitting for the clip the screws protruded inside and made it very difficult to remove the case. More seriously if the screws had been put in a different place they could well have made contact with the components inside the transceiver thus causing damage to the circuits they were touching. So some thought should be given to the where and how of the apparently simple exercise of fitting a clip. When the transceiver has to be carried about it is an advantage to have the microphone clip on it because it means you do not have the microphone swinging around on the end of its cable but otherwise this should not be necessary. If you do need to fix it on the case first all remove the case from the transceiver and ensure that the screws will not touch any internal parts and that it will not make it difficult to fit the case back on. Note also the stiffness of the spring in these clips vary with the result that it is almost impossible to put some microphones in and out while it has difficulty retaining others. The spring usually takes the form of a piece of metal the angle of

which can be bent to give the required tension.

6.2.2. Power Supplies

Your power supply is a most vital link in your equipment e.g. with no mains and a flat battery your transceiver is useless! So it is well worth while taking time and trouble to get it right at the beginning. Experience has shown that seemingly small things like misunderstanding the colour coding of a cable for instance can have quite an effect on vital equipment. A power supply depends both on its source of power and on its connecting cables for it to work well.

6.2.2.1. Connections

The power and aerial connections are usually found on the rear of the transceiver. These should be made as accessible as possible for disconnecting the cables or you can fit another plug and socket in the cables in a more convenient place. Transceivers have been and still are suffering severe and costly damage because incorrect power connections are made. Some have been destroyed because 230 volts AC mains have been connected to models designed to operate on 12 volt DC only. Some of the things you will need to check are as follows:

1. Are there internal connections or switches which change the transceiver to work from 12 volt DC, 110 volt or 220 volt AC? You should be able to make the appropriate connections by carefully following your manufacturers instructions. Some models may have switches on the rear of the transceiver which require adjustment by a screwdriver.

2. Are there two power leads provided which plug into the same power socket on the transceiver? One will be for 12 volt DC and when plugged into the transceiver will be connected to the 12 volt DC input pins in the socket. The other will be for your AC mains volts and when plugged in will be connected to the AC input pins.

For AC mains operation check that the transceiver is set to operate at the required voltage e.g. 110, 220 or 240 volts and fit a suitable mains plug i.e. of the type normally used in your area. This will avoid any confusion in the future. For DC operation there will be a positive and a negative wire which should be terminated in different connectors which are not interchangeable and which can be easily identified as positive or negative. If you are not using such connectors and have to remove the insulation from the wires to attach them to the battery terminal make sure that they are clearly labelled as positive and negative. A common fault in 12 volt DC supplies is the wrong polarity connection being made but transceivers can be safeguarded as explained in para.5.2.5.1.

6.2.2.2. Colour Coding

One reason for mistakes being made is due to the colour coding of the cables because no world-wide standard exists. As a result the colours of the cables in your equipment will depend on what each

individual manufacturer decides or on what is demanded in the country of manufacture. Some combinations of cable colours which have been seen in use are listed below.

Table 6.1   Examples of Colour Codes Seen.

AC Mains.

Example.	Phase or Line.	Neutral.	Earth.
1.	Black	White	Green
2.	Brown	Blue	Grey/Yellow
3.	Brown	Blue	Green/Yellow

Cables on 12 volt DC transceivers.

Example.	Positive.	Negative.
1.	White	Black
2.	Brown	Green
3.	Red	Black

Cables on Solar Panels.

Example.	Positive.	Negative.
1.	Brown	Blue
2.	Black	Blue
3.	Red	Black

This lack of standardisation has lead to mistakes being made. An example of this was when a person making a connection on a 12 volt transceiver which had black as negative and white as positive was himself familiar with the AC mains system which has black as line and white as neutral with the result that he mistakenly assumed that on this transceiver black was positive and white was negative. If different coloured wire is going to be used for the same voltage connections then the cables should be labelled to show what voltage and polarity they carry and a wiring diagram should be provided. However in practice labels can come off and diagrams be lost especially if there are changes in staff. One can always tie a knot in the positive cable to identify it. It is recommended that you decide on a colour code for your wiring which will be used for all the equipment in your network, for example the traditional colours in UK for DC wiring was red for positive and black for negative. These should be used throughout the wiring from solar panel and regulator to the battery and the transceiver. Where necessary you should change the existing cable. Whilst this will involve additional cost it could well be repaid in saving future catastrophes such as the inability of a different person to reconnect any wires which have become disconnected.

6.2.2.3. Plugs and sockets

Plugs and sockets which will only fit together in one orientation will have a locating lug and key-way to ensure a correct fit. If the plugs are often pulled out e.g. for the power supply, it is worth painting matching halves of the plug and socket in the same colour, but one that contrasts with the rest of the radio. This will assist the person to fit the plug correctly and should reduce attempts at forcing the plug in the wrong way.

6.2.2.4. Solar Panel

POSITION.

In Equatorial regions the solar panel can be mounted nearly horizontal. Rain will clean the surface of the panel but there must be sufficient slope for it to run off. e.g. 15 degrees from the horizontal. Panels installed north of the equator should slope towards the south, those south of it should slope northwards. An approximate guide is to make the angle of slope equal to the number of degrees of latitude of the geographical location. The panel should have an uninterrupted view of the sun especially from 9 a.m. to 3 p.m.

FIXING.

When a panel is mounted on a metal roof note the following;

(a) it should be spaced at least 2 inches off the roof on pieces of wood to allow for cooling.

(b) the metal roof should be electrically connected to earth.

(c) the panel should be mounted below the highest point of the roof unless it is protected by lightening arrestors.

Solar panels have been installed on thatched roofs, this presents no problems provided the panels are mounted on a wooden frame which rests on the thatch. Wires can then be easily passed through the roof and secured inside either to the existing roof frame or to extra lengths of wood attached below the roof frame. In fact panels can be mounted on any suitable structure e.g. a wooden frame at ground level if this can be safe and secure. The extent to which it is mechanically screwed to its mounting will be determined by both the local type of storms and to the probability of it being stolen. Always use rust-proofed screws, do not use nails to secure the panel.

DIODES.

A blocking diode may have been fitted to the solar panel during manufacture, see para. 3.2.5.1. to para. 3.2.5.5. for description of various diodes. It is recommended that the blocking diode be removed or if this

is not practical then shorted out and one should be fitted instead near the battery. The reason for this is that these diodes have been destroyed by lightening and so needed replacing. It is so much easier to test and replace a diode in the radio room than when lying on your back on a hot tin roof trying to work on connections underneath a solar panel. The diode connections should be made to rigid points e.g. soldered lugs rather than just connected to flexible cables as the movement of such cables could break the diode leads.

REGULATORS.

Where a solar regulator is used it may have a blocking diode within it. If the regulator is the "dump" type see para.3.2.6. you should mount the resistors so that they have a free circulation of air because they become very hot and should not be touched.

6.2.2.5. Battery

TRAVEL.

New batteries are available "dry-charged" i.e. there is no acid in the battery but it is partly charged. If you are travelling by air you may not be permitted to take a battery filled with acid so either a "dry-charged" one or a sealed one would be necessary. Do not forget to have sufficient battery acid available to fill the "dry-charged" one when you reach your location. The acid required will have a S G in the region of 1.240. Note that the battery will get very hot when it is filled with acid and the metal connections may be too hot to hold.

SECURITY.

Where there is need to prevent misuse of the battery as mentioned in para. 6.1.1.2. you can further safeguard it by sawing off the battery lugs along the dotted line in Fig, 6.3. Spade terminations of the type used on vehicles can then be attached by self-tapping screws or soldered to the lug. If available use a wider spade for the positive than for the negative. You can also paint the positive red and negative black or blue and scratch + and - on the battery as a further means of identifying polarity. If a vented battery is used and it is not housed in a wooden crate then stand it on a solid piece of wood larger than its base or in a plastic tray. This will prevent on overflow of acid from reaching the floor.

CONNECTIONS.

The cables connected to the battery should be via proper battery connectors. Crocodile or other types of clips are not suitable for permament use. Not only do they make poor electrical connection, especially as their teeth wear away, but they also wear away the battery lugs so preventing future use of proper connectors. The position of the positive and negative lugs are not the same on all batteries. Usually the lugs are both on one side of the battery so that if you turn the battery round the position of the positive and negative terminals are reversed. So if it has had to be moved do not automatically assume that the

positive is still on your right ,for instance, as it was before, but always carefully check that you are reconnecting to the correct lug. When you install the power leads for the battery make them sufficiently long for connection to a different size and shape of battery for sooner or later you will need to replace it. Whatever method of connection is used on the battery all the metal parts must be covered with a good layer of an anti-corrosion grease.

6.2.2.6. Fail to battery

At least one make of transceiver has a 6 pin input power socket which accepts a cable and plug either from the AC mains or from a 12 volt battery. However the mains plug serves a second purpose by completing another electrical circuit because two of its pins are shorted. Therefore if you are installing your own "fail to battery" relay and circuit first check in detail what is connected to each pin of the transceiver power socket. A simple "fail to battery" circuit was described in para.3.2.1.2.

6.2.3. Protection against lightening

Another point to consider before commencing installation which many people are not aware of is lightening protection. When broadcast receivers first came into use in the early days of radio they used a long piece of wire for an aerial. This aerial had always to be disconnected from the receiver during storms to protect it from lightening strikes. So most people who used radios were aware of the problem. Today people are used to having portable transistor sets which have their aerials built in to the set so that the question of disconnecting aerials during thunderstorms never arises. When it comes to short wave transceivers the users must be made aware of the damage that can be caused by lightening and must be instructed in the necessary precautions. This is particularly important in countries such as Zaire where thunder and lightening are very frequent occurrences. For instance Kenya has a National Lightening Protection Committee which arranges the installation of lightening arrestors within that country. Where there is no such official advice and help available it is absolutely necessary to alert the radio communications users to the possible dangers and how to cope with them. Lightening can cause the failure of costly transistors and other components within a transceiver and can even destroy it altogether. It can also cause injury to the operator who attempts to use it during thunder or even to someone who happens to be by a radio at the moment of a lightening strike. The lightening reaches your transceiver by way of the aerial cable and in some cases by the power supply cable. We will now look at some of the ways lightening protection can be provided.

6.2.3.1. Arrestors

If you are not familiar with lightening arrestors take a look at the highest point of any building in your area. You may see lightening arrestors with several spikes pointing upwards and connected to earth by a thick metal conductor. The expectation is that lightening will take the easiest path to earth via the arrestor thus safeguarding the building etc. on which it is mounted. Arrestors can be mounted near to but higher than solar panels to give them protection. The conductor to earth should be capable of carrying 50 amps. A good earth can be made by burying a 6 foot water pipe or metal rod and keeping the ground damp.

6.2.3.2. Aerials

There are several methods of stopping lightening passing through the aerial and reaching the transceiver. The safest method and the most simple which has not been known to fail is to always disconnect the transceiver from the aerial after it has been used and never to use it during a thunderstorm. You must ensure that the radio operator has been given these instructions and understands their importance. Also these instructions should be displayed in a prominent position and in as many languages as may be necessary so that if someone other than the normal operator is using the transceiver they will know what to do. After disconnecting the aerial it can either be connected to earth or just left "floating" i.e. not connected to anything, but it should not be left within 30 cms. of the transceiver. Other methods of protection include gas discharge lightening arrestors which can be screwed into the coaxial cable between the aerial and its transceiver.

6.2.3.3. Transceiver

A limited form of protection is often found in transceivers in the form of "back to back " diodes connected across the receiver input. Both normal rectifying diodes and zener diodes have been used in this role. Transceivers powered from solar charged batteries should be disconnected from the battery when not in use because lightening striking the solar panel could be conducted to the battery and hence to the transceiver.

6.2.3.4. Static

Users of transceivers in dry desert areas across Africa have complained of getting an electrical shock when they touch the aerial or the transceiver to which the aerial is connected. The reason was because of a build up of static electricity on the aerial. In such situations it is necessary to have an aerial switch or other arrangement which earths the aerial either all the time that the transceiver is not in use or at least just before the aerial is connected to the transceiver to discharge the static. Its case should also be earthed to avoid the build-up of static.

6.2.4 Aerials

An aerial properly installed can stay up and operate correctly for many years. Therefore it is worth allowing sufficient time, for example several hours, for aerial erection. Attempts at forward planning are not always successful in some cultures. The sending of messages to one village to cut two straight 12 metre poles from the forest and have them ready for a certain day resulted in no poles being available that day! However , as soon as the technician arrived in the village the men departed to the forest, returning with the necessary poles four hours later. Whenever it is possible a competent person should install the aerial. Whilst it is time consuming for a technician to spend days away from his workshop, it is nevertheless a worthwhile exercise. There are many examples of incorrectly installed aerials. For example, in Zaire an aerial has been found erected at 90 degrees to the required direction and one where the coaxial cable was tied to the top of one of the poles while the one end of the aerial was almost on the

ground! In Tanzania an aerial was supplied of the correct length but during installation pieces of the aerial had been cut off to make it fit between two posts.

6.2.4.1 Aerial Supports

Survey the site and decide the best location for the aerial and what sort of support you are going to use e.g. existing buildings and trees or poles.

1. Anchor points on buildings. Make sure that they are strong and secure enough to hold the weight of the aerial. Facia boards are not normally satisfactory. If metal hooks are fitted to wooden beams be aware of the fact that some woods rot rapidly in the tropics. Ensure that the aerial or its associated wire or rope will not rub against adjacent walls or overhanging roofs whilst swinging about in strong winds.

2. Trees. Palm trees can frequently be found in convenient positions to support aerials but the fronds need to be kept cut so that they do not foul the aerial. It should be allowed to hang a little slack because of the movement of the palm tree in storms could break a tight aerial. The same considerations apply to other trees used as supports. Fix the aerial to a rigid part of the tree, not on thin branches which wave about in storms.

3. Metal masts. Where no suitably located buildings or trees are available then aerial masts can be erected. Masts can be made from metal tubing e.g. galvanised steel, aluminium etc. depending on what is available. They will require guy wires about every 4 metres, depending on the strength of the pole material used. At least 3 guy wires are necessary at each point to give all round support. Barbed wire has been successfully used for aerial guys. If it is thought that the aerial will remain in the same place for many years then the mast and the anchor points for the guy wires can be set in concrete.

4. Wooden poles. In Zaire 12 metre wooden poles set into 2 metre holes in the ground have been used as aerial supports. Although the poles were painted with used engine oil some rotted after 3 to 5 years and had to be replaced. If set firmly into the ground these should be self-supporting and not need guys.

5. Movable bases. A mission in Zaire has found that they have had to relocate aerials because the radio room has had to be changed to different buildings. Hence they are trying out a movable aerial base made from pieces of steel e.g. two 1 metre steel bars in a cross and also old vehicle wheel hubs as anchor points for guys. These bases are all buried several feet underground but can be dug up when necessary.

6. Guidelines. The following should be aimed for but may not be achieved. Do not put the aerial parallel to electric power lines or other long pieces of metal wire. Do not suspend the aerial above a tin roof. Have some 20 metres of clear ground in front of the aerial, that is in the direction the

power in it is to be transmitted. A horizontal dipole can be supported at each end. If thick co-axial cable is used then an extra pole can be used to support the centre of the aerial. Do not let either of the aerial wires touch this pole, it should be attached to the central insulator. A central support is necessary for inverted-vee aerials, see Fig. 2.5.

6.2.4.2. Aerial adjustment

The aerial will have been cut either to the correct length or if you have so specified to some 10 cms. too long to allow for tuning after erection. Ideally it should be possible to raise and lower the aerial by means of halyards of nylon rope and pulleys. One disadvantage of nylon rope was that after several years of exposure to the sun in equatorial Africa the rope broke easily. Also in some places a rope halyard is an attractive item and could well be stolen. Hard-drawn wire has been used instead as it is more durable and less noticeable than white rope. An alternative is to use an aerial clamp of the type shown in Fig, 6.4. This was developed by apprentices in Britain to serve the special requirements of being able to raise and lower for initial tuning then to leave the aerial erected whilst being able to recover the ropes. The aerial can be pulled up and lowered by he rope loop A. When adjustments are complete the aerial is pulled up and the eyelet will automatically be above the hole in the base. The rope loop B is now pulled down causing the metal rod to come down through the eyelet and to lock into the hole in the base. The ropes A and B are no longer needed and the knots in them can be untied enabling both of them to be pulled down to earth.

6.2.4.3. Erection

Do not attempt to erect an aerial if lightening can be seen or thunder heard. The length of the aerial together with its required direction and height will be determined from Chapter 2. Now comes the task of putting these theoretical ideals into practice. If the aerial is not going to be lowered for tuning then it should be the calculated theoretical length before erection. See para.2.2.1.

Having decided how and where the aerial will be erected uncoil it and its coaxial cable ensuring that there are no twists or kinks in it. If possible lay it out on the ground below where it is to be raised. This will confirm that the aerial supports are sufficiently far apart. Measure the length of each piece of aerial wire as a final confirmation that the aerial length is correct. These checks are necessary as shown by the following experience. While looking at two dipole aerials which had been in use for some years in Zaire one did not "look right ". Its SWR was checked and found to be 4 which was much too high. It was lowered to the ground and measured. One wire was the correct length of 12.3 metres but the other wire was 10.1 metres which happened to be the correct length of the two wires on the other aerial. A possible explanation is that there was a mix up of wires during manufacture of the two aerials.

Check the length of coaxial cable on the aerial although you know how long it should be, 25 to 30 metres are typical lengths fitted by manufacturers unless you specify a special length. Also ensure that the coaxial cable is secured to the centre insulator and not left to hang only from its coaxial plug. Wire or nylon rope can be used between the aerial insulators and the tree, pole or building on which it is

suspended. See Fig. 2.1. If wire is used check that it does not touch the aerial wire. Also do not use pieces of wire whose lengths are the same as or within 1 metre of the length of any one piece of aerial wire or any multiple of aerial wire length. For example, a dipole for 7.305 Mhz will comprise two pieces of wire each 9.76 metres long. Therefore the supporting wire should not be between 8.76 to 10,76 metres, 18.52 to 20.52 metres etc.This is because such wires can be resonant parasitic elements and can have a detrimental effect on the aerial.

Having taken these necessary precautions and having securely fastened the aerial insulators to their supporting wire or rope you are ready to raise it into position. Note that your supporting wire or rope at this stage should be considerably longer than the amount you will finally need otherwise you will be unable to lift it into position especially if someone has to climb up a tree or ladder to fix it. The excess should not be cut until it is firmly and finally attached to its support. First raise and secure one end firmly to its point of suspension whilst taking care to remove any twists or kinks in wire and cable. If a pole is to be used to support the centre insulator, then erect this next, checking the aerial wires do not touch anything. Then the other end of the aerial can be raised and secured by its wire or rope to its support being careful all the time not to twist or make kinks in the wires and removing any that appear.

For aerials supported between solid buildings or rigid metal poles pull the supporting wire or rope until the aerial is reasonably straight. For aerials supported by trees let the aerial sag in the middle by up to 1 metre. If an aerial is 20 metres long and allowed to sag by 1 metre this will only permit an outward movement of 5 cms in both trees before the aerial is horizontal and tight. However it can be argued that the wind will be blowing both the trees in the same direction hence reducing any strain on the aerial. If thin wooden poles are used without guy ropes it is wiser to allow a little sag as a too tight aerial could cause the poles to break in a strong wind. Once the aerial is in position the coaxial cable can be routed to the radio room. The cable can be afforded some form of protection against damage by suspending it on poles some 3 or 4 metres above the ground. Do not use thin wire to attach the coaxial to the poles as this will cut into the cable. Either put some solid material between the wire and the cable or use cord or other broader material that has not any sharp edges.

6.2.4.4. In the Radio Room

When routing the coaxial cable to the radio room ensure that it does not rub on any rough surface or sharp edge e.g. the edge of a tin roof. Do not put too much pressure on the cable when making a bend rather let it be in a gentle curve. If there are several metres of aerial cable spare when it reaches the transceiver do not cut off the cable as it may be required if the radio is moved in the future. Do not coil up the excess cable but try to lay it out straight, in the roof space for example. Where the installation involves more than one coaxial cable label each one immediately you bring it into the room to avoid future confusion. SRoute the cables to the radio desk and then either to the aerial switch or to the transceiver. Aerial switch positions should be numbered e.g. 1 to 4. and the aerials connected so that they correspond with the channel number which they serve on the transceiver i.e. Aerial position 3 serves Channel 3.

6.2.4.5. Fitting a plug to a coaxial cable

The cable from your aerial will normally be a coaxial cable of which there are 2 common sizes. A thick one which is approximately 10 mm diameter and includes types RG 8/U, RG 213/U and URM 67. A thin one which is approximately 5 mm diameter and includes types RG 58/U and URM 43. The plug in common use is a PL-259, an additional adapter being required for fitting thin cable. If you have never soldered a plug to coaxial cable before it is recommended that you practice preparing the cable end using an extra piece of cable. Do not actually solder the plug on the practice cable. Step by step instructions for large size coaxial cable i.e. 10mm. Refer to Fig. 6.5.

1. Cut the coaxial cable (coax) to the required length.
2. Unscrew the coupling ring from the plug and put it onto the coax with the threaded end nearest to the cut end of the cable. Note. The coupling ring must be put on the cable first as it cannot be fitted after the plug has been soldered to the cable.
3. Remove 28 mm. of the outer sheath which is likely to be made of black plastic. This can be done by cutting round the sheath with a knife.
4. Using a small tip soldering iron and small diameter solder, apply solder to the braid from the point where the sheath finishes for some 15 mm along the braid.
5. Now cut the soldered braid , but not the inner insulation, with a fine saw or small tube or pipe cutter at 11 mm from the end of the sheath.
6. At a point 2 mm. from the cut in the braid now cut through the inner insulator but not the central conductor. Remove the cut piece.
7. Check that the coupling ring is still on the cable as instructed in step 2.
8. The cable is ready for fitting the plug. Gently screw the plug on to the cable ensuring that all the central conductor is inside the hollow central pin of the plug. Continue to screw the plug on to the cable, the thread on the plug will grip the black outer sheath and then the soldered braid should be seen through the solder holes of the plug.
9. With a small soldering iron with a small bit apply solder in the holes and solder the braid to the plug. Be careful not to overheat the cable in the plug.
10. Solder the central conductor where it protudes from the central pin. Now cut off any wire protuding from the pin and remove any excess solder.
11. Screw the coupling ring on to the plug and check that the assembled plug will screw into a socket.
12. If the far end of the cable is disconnected i.e. not yet connected to an aerial balun or a transceiver etc. then electrical tests can be performed on the cable.
13. If practical check there is contact, i.e. a resistance of only a few ohms, between the central pin of the plug and the distant centre of the coax. Also between the outer coupling ring and the braid at the distant end of the cable.
14. Provided there is nothing connected to the distant end of the coax check that there is a high resistance between the inner and outer connections to the cable. A resistance of 1M ohms or more can be expected. Note that if you are touching both the inner and outer conductors or both the metal parts of the meter probes, then you will be measuring your body resistance which could be only 200K ohms.

Fitting a plug to thin coaxial cable i.e. 5mm. e.g. RG-58A/V or URM43 or URM76. You will require the same plug PL-259 but also an adapter (Type UG-175/V) or reducer to enable the smaller diameter cable to be secured into the plug. Step by step instructions. Refer to Fig. 6.6.

1. Cut the coaxial cable (coax) to the required length.
2. Push the cable through the centre of the adapter such that the narrow end of the adapter is nearest to the cable.
3. Unscrew the coupling ring from the plug and put it onto the coax with the threaded end nearest to the cut end of the cable. Note. The coupling ring must be put on the cable first as it cannot be fitted after the plug has been soldered to the cable.
4. Remove 18 mm. of the outer sheath which is likely to be made of black plastic. This can be done by cutting round the sheath with a knife.
5. Ensure that the end of the adapter is level with the outer sheath.
6. Now cut the outer braid, but not the inner insulation, with a pair of small scissors at 10 mm from the end sheath. Remove the cut braid and fold the remaining braid back over the adapter. If necessary further trim the braid so that there is only 10mm folded over the adapter and it does not reach the tread.
7. At a point 2 mm. from the braid now cut through the inner insulator but not the central conductor. Remove the cut piece of insulation.
8. Apply solder to the central conductor.
9. Check that the coupling ring is still on the cable as instructed in step 3. and ensure that the braid is folded back over the adapter.
10. The cable is ready for fitting the plug. Gently screw the plug on to the adapter ensuring that all the central conductor is inside the hollow central pin of the plug. Continue to screw the plug on to the adapter, then the braid should be seen through the solder holes of the plug.
11. With a small soldering iron with a small bit apply solder in the holes and solder the braid to the plug. Be careful not to overheat the cable in the plug.
12. Solder the central conductor where it protudes from the central pin. Now cut off any wire protuding from the pin and remove any excess solder.
13. Screw the coupling ring on to the plug and check that the assembled plug will screw into a socket.
14. If the far end of the cable is disconnected i.e. not yet connected to an aerial balun or a transceiver etc. then electrical tests can be performed on the cable.
15. If practical check there is contact, i.e. a resistance of only a few ohms, between the central pin of the plug and the distant centre of the coax cable. Also between the outer coupling ring and the braid at the distant end of the cable.
16. Check that there is a high resistance between the inner and outer connections to the cable. A resistance of 1M ohms or more can be expected. Note that if you are touching both the inner and outer conductors or both the metal parts of the meter probes, then you will be measuring your body resistance which could be only 200K ohms.

6.2.4.6. SWR measurement and aerial tuning

The meaning of SWR has been explained in para 2.1 To measure SWR first familiarise yourself with the

particular SWR meter by reading the instructions. However in many instances these are not available having been lost or mislaid. Examples of such instructions are: For single meter units there will be a switch labelled REF/VSWR or SET/READ or similar. Put the switch in REF or SET position and connect the meter between the transmitter and the aerial taking note of the labels on the sockets of the meter e.g. "Transmit" and "Antenna". With the transmitter giving a continuous output adjust the meter's variable control for the meter pointer to be at the REF or SET level on the dial. Methods of obtaining a continuous output can be obtained from the transmitter by:

(a) connecting a 2 tone oscillator into microphone socket
(b) unbalance the carrier null control.
(c) whistle or sing a continuous steady note into the microphone.

Now switch to VSWR or READ and note the meter reading which is the SWR. For two meter units: One meter reads power output to the aerial and the other the SWR. A variable control will need to be adjusted so that the power meter needle reads either full scale or at the SET position. The other meter now indicates the SWR. SPrecaution : never disconnect the aerial from the SWR meter when the radio is transmitting. The higher the SWR the less effective is the aerial. An indication of the percentage of power wasted i.e. reflected back from the aerial is given in Table 6.1.

Table 6.1.

SWR	% reflected power.
1.1	0.23
1.3	1.7
1.5	4.0
2.0	11.0
3.0	25.0

The SWR can be measured once the aerial has been erected. For aerials that are difficult to take down and alter their length a SWR of 1.5 or less is acceptable and the aerial can remain as erected. For aerials that can be taken down easily the SWR should be adjusted to the minimum possible. To tune a dipole aerial first note its reading when erected e.g. 1.8. Lower the aerial and reduce the length of BOTH pieces of aerial wire by 3 cms. Do not cut the wire but twist it around the wire as shown in Fig. 6.7. Re-erect the aerial and measure its SWR, this could be for example 1.5. If at one stage the SWR rises after you have shortened the aerial increase the length again using some of the extra wire you have twisted around the aerial. Do not cut off the extra wire until the aerial tuning is complete.

6.3. Final Checks

All the preparations and the good installation should be rewarded by a good radio contact when you test the completed system. Arrangements should be made for a test contact at a specific time so that someone

is listening specially for you but a final series of checks should be performed before the test transmission.

6.3.1. Power

1. Connect an ammeter in series with the solar battery charger. Record the value of charging current noting whether bright sunshine or dull and also the battery voltage.
2. Record the battery voltage with the transceiver:
   (a) switched off (b) on receive. (c) transmitting with a whistle
   or singing a continuous and steady note into the microphone. These measured voltages will depend on many factors, you could expect the voltage to fall by up to 0.5 volts when transceiver is switched on and by a further 1 volt during continuous transmission.
3. Connect a SWR meter in the aerial circuit next to the transmitter. Set the meter calibration control so that it reads power output at the particular frequency of transmission. Transmit by using a 2 tone Test Generator or by making a continuous loud note into the microphone. The meter should indicate a power output some 40 to 60 watts for a 100 to 150 watt pep transceiver providing the SWR is below 1.5. Higher SWR will result in a lower power output. Measure and record the SWR and power output for each channel with the transceiver connected to its appropriate aerial.

6.3.2. Netting

You will have specified the frequency of each channel in your transceivers when you ordered them. However the crystals in each set, although made to the same frequency, can differ by several hundreds of cycles. This difference sometimes can be heard when listening to a network of several stations. With the clarifier control set to give clear speech from one station when the next station speaks it can be necessary to adjust the clarifier and to readjust it when the original station is on again. This problem can be overcome by adjusting the frequency of all the transceivers to exactly the same frequency, a process called
NETTING

Ideally this will have been done already if:

- you have an accurate frequency counter i.e. one which reads to 1 or 10 cycles, and have set the crystal trimmer to give the exact frequency.
- you have brought the transceiver from your HQ station where you have netted the crystal to the frequency of that station.

If it has come direct from the manufacturer or has been used on another network, then check that it is netted onto your HQ station. The method of netting of each different make should be explained in the technical manual of the transceiver and some manufacturers e.g. AEL, make provision for this to be done in the field after the transceiver has been installed. You must consider how and when you are going to net your transceiver before leaving for your installation visit. However, if you do not have the technical knowledge or ability to net the transceivers it is not a major problem but simply means that all the

stations will have to make greater use of their clarifier controls. As the crystals age so their frequencies change hence further netting can be performed. In an ideal situation this would be done after 3 months and 6 months and then annually. In reality many networks function without this being done.

6.3.3. Operating

Remove all your test equipment and go through the procedure of switching-on connecting any cables as described in the instructions. Let the operator perform all the operations and make a radio contact with another station at a prearranged contact time. At the same time you may check the operators method of sending and receiving and recording messages. Then let the operator switch off and disconnect any cables necessary. This sounds like an organised and controlled exercise however it can become chaotic as has been our experience of installing transceivers in remote African villages where these are to be controlled and operated by local people. You may have many interested villagers surrounding the building and blocking the light through the windows. For them to hear the voice of a known person hundreds of miles away causes great excitement and everyone in any position of authority wants to speak. So it is a good idea to try to instruct the operator in advance of the initial formal contact in as quiet a situation as possible.

6.3.4. Look around

Take a final look around and check to see if all is well with the equipment and that nothing has been moved or disturbed by all who had crowded into the room to see it working. Check that the cables on the outside have not be disturbed as well. Collect up all your tools and test equipment and make any final notes regarding the particular installation, especially the non-standard features as these are important for your central records and for future maintenance plans. Make sure that operating instructions and all other necessary information is left with the operator or person in charge in a secure and available position. Make sure they know how to top up the acid level in the battery and how long they can use the radio for each day whilst keeping the battery fully charged. After completing the installation of a system with a solar-powered supply designed for the needs of that particular station one usually gets asked questions such as: "Can we run a light off the radio battery in the evenings?" or "Can we charge another battery off the solar panel?" The answer must normally be "No, because then you will not have sufficient power for your radio and your equipment may be damaged by careless and incorrect connecting and disconnecting of the battery". Many faults have arisen from incorrect connections and radio batterys have been flattened and their lives shortened by extra or unauthorised loads. Impress on all concerned that the reliability of their radio link depends very much on how they use it and how they take care of their power source. Expatriate personnel are often very guilty of mis-use of batterys provided for radio use only. Where the radio battery may be the only fully charged one around there is a great temptation to use it for personal reasons but it must be understood that this must not happen.

6.4. Mobile Installations

Many HF SSB transceivers with power outputs up to 150 watts PEP are designed so that they can be

used equally as well in vehicles or as a base station. Care must be taken in the mobile installation so as to make best use of this facility.

6.4.1. Transceiver

The mobile transceiver should come with its manufacturers special mobile mount. A common place to put it is below the dashboard in front of the passengers seat. This is a good location in as much as it provides some shading of the transceiver from direct sunlight and it can be operated by the passenger. Enough legroom should be left for the passenger if long duration journeys are undertaken. The mounting should allow the transceiver to be easily fitted and removed by authorised persons but some form of lock may be necessary for security reasons. A fist or hand microphone must be used and a clip for securing it fitted on or near the transceiver.

6.4.2. Power supply

A 150 watt pep transceiver operating from a 13.6 volts vehicle supply requires an average current of some 12 amps with a peak demand of 18 amps. Because of this relatively high current demand the transceivers power cable must be connected to the vehicles electrical system at a point where sufficient current is available. The current for the transceiver must not flow through any of the existing fuses because the fuse rating will only be sufficient for its present circuit. The cigarette lighter socket is not suitable for high powered sets though it could be used for 4 watts CB sets. The above constraints demand that the power cable for the transceiver must start from the vehicle battery and that you should install a 20 amp fuse in the cable. The nuts on the battery lugs on many vehicles were found to be worn round hence a grip rather than a spanner was necessary to release the nut. Also lugs were found loose on battery terminals as the terminals had worn thin hence some packing was necessary to ensure a reliable contact to the battery.

6.4.3. Aerial

You may have observed many vehicle aerials mounted on or near the rear "bumper" or "fender". This is not a good position because of the proximity of the vehicle body effects both the tuning of the aerial and the horizontal directions in which power is transmitted. Whilst mounting on a front wing is an improvement the centre of the roof is the most suitable location. The aerial will require tuning after installation Follow any instructions which you have concerning the tuning up of your particular aerial. For example a single frequency aerial can have a coil in the middle and a top section of stainless steel rod some 2 mm diameter. This aerial will have been designed so that 2 to 5 cms of the rod can slide into a housing and be locked by a screw. This enables the length of the aerial to be adjusted by several centimetres for tuning. If the rod is too long then cut off a centimetre at a time to achieve the lowest SWR. If you intend to use the vehicle for journeys with the complete aerial mounted then ensure that the aerial base is secure on a strong part of the vehicle body. The thin metal of a wing or a roof can become distorted by the force of the aerial when travelling so the body may need reinforcing. It is recommended that the aerial be completely removed from its base and carried inside the vehicle for journeys through

the jungle. Otherwise overhanging foliage, bamboo etc. could soon damage it.

Chapter 7. HOW TO OPERATE A RADIO NETWORK

Topics:

Return to Table of Contents

There are two main requirements that have to be satisfied if you are to have a radio network which is useful, effective and efficient. The first is that the radio equipment satisfies the operational need, i.e. you can talk reasonably clearly with all the stations you want to. Ways of satisfying this requirement are covered in the previous chapters. The second requirement is equally important, it is that the network is so operated that it satisfactorily serves the needs of all its users. It is not just a case of finding someone to speak on the radio but serious consideration must be given to the choice of operator, the method of controlling the network of stations and the handling of outgoing and incoming messages. For instance, the advantage of having a well organised and clear speaking operator is that he will require far less time operating the radio. This not only means that he will occupy less time himself on the radio but also all the people he speaks to will >also require to spend less time on their radios. Less time operating means less power discharged from the battery where this is the power source. This will give a longer life to the battery, and a better performance from the transceiver, particularly where a solar charger is in use.

7.1. Choice of Operator

Your aim should be to use a person whose ability is best suited to the demands of the operating but in

reality your choice may well be limited. Despite all the properties you are looking for in an operator there may only be one person available. Did you consider making provision for an additional person to be paid as an operator, see para. 5.1.5.? If operating the radio is an extra job given to an already busy person then the result may not be good. One missionary in Zaire said " I would not want to be without the radio but the time you spend operating it detracts from your other principal work." However your system will work only as well as your operators play their parts.

7.1.1. A Good Operator

The qualities to look for in a good operator should include:

1. A clear speaking voice without a too strong regional accent.
2. A good hearing ability.
3. An ability to remain calm and controlled when under pressure.
4. Enthusiasm for the job.
5. Good time-keeping. i.e. being there at the radio and prepared for the contact before it starts, also waiting until its over before switching off.
6. Patience and perseverance i.e. for repeating and confirming messages when reception is difficult.
7. Fluency in language .
8. An ability to understand the controls of the equipment.
9. A good memory. i.e. for callsigns.
10. Ability to keep accurate records.
11. A sympathetic and friendly approach to other operators while keeping the messages as concise and businesslike as possible.
12. Have good handwriting ability.

7.1.2. Control or HQ Station

This is the vitally important station. A careless operator at HQ who overlooks sending messages or does not pass them on correctly will cause more frustration than if you did not have a radio network. Here there are two options open in the choice of operator. Either the person responsible for the administration and organisation of your group does the operating himself or herself, or he or she decides to employ or delegate it to someone else to act simply as a relayer of messages.

There are advantages if your admin person becomes the operator for he may be able to answer many queries and perhaps sort out any problems immediately so that the outlying station gets its answers straight away. On the other hand it may be an extra job in an already busy schedule and through lack of time it will not be done as it should. It is not only the operating time to be considered but also the proper keeping of message records and the time spent contacting the right person and passing on the message. If the operating is delegated to someone else that person must be allowed sufficient time to do the job properly. They must be able to read accurately over the air the messages for each individual station and to take down accurately the messages coming in. Therefore they must be fluent in the language used for

transmission. They must not be expected to answer questions immediately but rather relied on to pass them on correctly to the right person. Do not under estimate the time they will need to do all this properly.

The actual time taken for an operating session in Zaire between the HQ station and 4 outlying stations was typically over 1 hour. The time was occupied thus:
5 minutes to obtain the keys, go to the room, unlock room and radio desk, connect cables and set the controls ready for the contact.
20 minutes to send and receive messages.
10 minutes to ensure log book was completed correctly and to make the written copies of any messages necessary for distribution.
5 minutes to switch off, disconnect cables and lock up securely.
20 minutes to contact people for whom there were messages or questions.

7.1.3 Outlying stations

The observations about the qualities of a good operator apply equally here although there will obviously be less volume of messages to deal with. It may well be necessary to have several of your people acquainted with the operation of the radio so that in an emergency they could all cope but it is better to stick to one regular operator whose daily work schedule includes the radio operating. The operator here must learn to take his turn on the air with other stations and must be prepared to obey the instructions of the controlling station.

7.1.4. Stand-by operators

Whilst it is wise to keep to one experienced and reliable operator it is also necessary to have a stand-by who has been trained to take over when necessary. The stand-by should keep familiar with the operating procedure and the controls by operating at least once a month.

7.1.5. Training an operator

Each station should have a set of operating instructions applicable to its individual needs and its particular equipment. These instructions must be read and understood before someone is allowed to operate. Training may involve instructing an operator or teaching yourself. There is often sound technical reasons why an operator is told to use a specific piece of equipment although the reason may not be known to him. For instance the use made of one radio network was far in excess of that originally expected and as a result the cables and connections on the hand held microphones developed faults. These microphones were replaced with a desk type so it and its cable remained in one place and was rarely moved. The hand held microphones were then kept as spares at each station. However it was later discovered that an operator had changed back to the hand held against instructions because he preferred that type. To prevent the moving of desk mikes some have been fixed to the radio desk. The operator should also be told never to smoke or use a candle or naked light near a battery. The reason for this is

that hydrogen gas is released from a vented battery, i.e. a car type battery, when it is being charged and if connected to a solar panel the battery will be continually charged throughout the day. The operator should be shown the equipment and the instructions and each switch or knob should be explained to him, see details in para 3.1.3. It will help if he can understand why he should or should not do certain things.

1. He should be told never to operate when lightening can be seen and thunder heard and always to disconnect the aerial and power cables after use because of danger from lightening. If he understands that lightening can come through the cables to the radio and damage it or strike the operator he will take more notice of the instructions.
2. The radio should not be operated from a battery while the battery is being charged by any other means than by a solar charger. This is because excess voltage e.g. from a vehicle alternator with a faulty regulator, can damage the transceiver.
3. No books or papers should be put on top of the transceiver while it is in use. The reason for this is that most transceivers require a free air circulation to assist cooling especially in warm climates. Black cooling fins are often found on the rear of the transceiver.
4. If the radio installation has a "fail to battery" facility, see para.3.2.1.2. then the importance of switching the transceiver off as well as disconnecting the mains must be stressed. With a "fail to battery" facility when the mains plug is removed without switching off at the transceiver controls the transceiver will automatically be connected to the battery and so remain on.

Go through with him the routine of connecting up, switching on, selecting channels, adjusting gain and tone, speaking into the microphone, taking down messages and switching off again before actually trying to transmit. Continue with this practise until it can be done without hesitation then, if possible, let him watch an experienced person going through the routine and let him listen while some are contacts are being made. Explain to him the operating procedure used at the station and let him become familiar with callsigns and expressions used. His first actual contact is best done with an experienced person at hand to help. The first experience of speaking into the microphone and knowing your voice is being heard many miles away can be quite a nerve testing experience for some people although others may find it easy. A nervous operator who is not sure what he is supposed to do will be prone to make mistakes so good instruction and training is very important. The operating instructions should be provided in a simple step by step form and kept close to the transceiver for easy reference. There should be available to the operator such things as a pen and a spare pen, sufficient paper and a clock or watch that keeps correct time. Note that simple things like these are not always instantly obtainable if the station is an isolated one. The operator must know what he is expected to do to take care of the equipment, see para 7.2.2., and what his responsibilities in recording and passing on messages are, see paras 7.3 and 7.4. The operating instructions should include a check list of things he must and must not do, including what to do if there appears to be a problem with the equipment, see para 7.2.3.

7.2. Operating the Equipment

There are many different controls and facilities on transceivers and these vary according to the model. Always be aware of any facility which is peculiar to your particular station whether it was put in by the manufacturers or modified by your networks engineer. However there are certain basic rules that will

apply to all equipment.

7.2.1. Transceiver Controls

The most common and essential controls are listed in the chapter on transceivers see para. 3.1.3. Read again the descriptions given there and then note the following operational points. The handbook for your particular transceiver may give special operating instructions e.g. if the transceiver contains thermionic valves or crystal ovens it should be switched on 5 to 10 minutes before use.

7.2.1.1. Clarifier

The operator may need to alter this control for each station he listens to so as to get the best pitch or sound for his particular hearing. The pitch that sounds clear to one person may not be so clear to another.

7.2.1.2. Squelch

This has often caused problems where its function is not understood. When the transceiver is switched on the Squelch should be OFF. That is either switched OFF if the control is a ON/OFF switch or if it is a variable control it should be fully rotated so that noises come from the loudspeaker. Then after all the other controls have been set e.g. channel selected, audio gain adjusted the Squelch can be set to inhibit the loudspeaker background noise if required. However in many instances operators have set the Squelch threshold too high and stations have not been heard. The author found that it was rarely correctly used in his network and to avoid problems removed it from most sets, see para. 5.2.5.4. on modifications.

7.2.1.3. RF Gain

This should be set for maximum to start with then gradually reduced for the best sound. If the RF gain is set too high then the signal received from a nearby or strong station can sound distorted or even appear to be going off and on. Operators listening to such strong signals have told the station transmitting to them that there is a fault in their transmitter whereas the problem was their own RF Gain control was set too high. Be careful with this control because if someone with a weak signal calls in when the RF Gain is turned down they may not be heard. The operator should get to know all the stations on his network and by experience learn which ones will need the RF turned up and which will need it turned down. Make it the rule always to commence with it at maximum and adjust as necessary.

7.2.1.4. Interference

This can be caused by nearby transmitters although they are not operating on the same frequency. In this case best reception conditions can be obtained by reducing the RF Gain as far as possible whilst still enabling the operator to hear the station with whom he is in communication, any loss of volume can be compensated by using the Audio Gain or Volume control.

7.2.1.5. USB/LSB

If the stations are equipped and permitted to operate on both upper (USB) and lower (LSB) sideband then if there is interference on one sideband it may be possible to use the other. First check the other sideband to see if it is free from interference and is not in use by someone else. Then inform the other stations and suggest they move on to it. After the contact is over return the USB/LSB switch to its normal position for the next contact.

7.2.1.6. Earphones

At stations where some of the other stations are difficult to hear then earphones may be provided. If you have more than one operator you will have to decide whether each operator should have his own earphones on grounds of hygiene. The cable on the earphones can easily become twisted and in knots so be careful and prevent this from happening.

7.2.1.7. Transmit

It is good operating practice to press the transmit button before beginning to speak in to the microphone and also to cease speaking before the button is released. The operator must always speak clearly and reasonably slowly into the microphone but must never shout. Shouting will only distort the signal especially if done close to the mike. If there is a "transmit" light which flashes as the operator speaks he should watch this light as it ought to go out during the slight pauses in his speech. It will be necessary to adjust either the loudness of the voice or the closeness to the mike to ensure that the light goes on and off in sympathy with the voice. When the distant station says they are not receiving the transmission the instinctive reaction is to speak louder. However shouting into the microphone may cause the Automatic Level Control circuits to operate in the transmitter and so make the transmission less intelligible to the distant receiver. Some improvement in communication can be made on a "trial and error " basis. For example one operator can ask the other operator "do I sound better on this first transmission or on the second transmission after I have changed my position?" The success of such tests will depend on the organising ability of the operators.

7.2.2. Care of the Equipment

Operators must be made aware that the equipment they are using needs to be handled carefully. It is often expensive and sensitive but used properly most modern communication equipment should stand up to daily use for a long time. In addition the operator may be asked to do some routine maintenance, see para. 8.6.

7.2.2.1. Controls

Controls and knobs should only be adjusted when necessary, it often happens that operators waiting their turn to transmit will fiddle with the controls turning them first one way then another. Knobs and indicator

lights have worked loose and been broken because of this kind of treatment. So the rule must be to touch the controls only when necessary, e.g. to hear more clearly or to change channels.

7.2.2.2. Microphones

Microphones are delicate instruments and have often been treated badly, sometimes being pulled to reach across a room for someone else to speak resulting in broken connections. So the rule must be that only the operator or the person sitting in his chair does the speaking and in the case of a desk mike it must be left on the desk or the table close to the transceiver. It may be wisest to have it fixed in position on the desk or table and it should always be left connected to the transceiver. Hand held mikes are very often passed from hand to hand or left swinging loose on the end of their cables. The cable can become worn and broken just by the continual handling. They are best kept for use with mobile equipment or as a spare microphone.

7.2.2.3. Cables and Aerials

Cables and leads such as those coming from the power source and from the aerial should not be allowed to become tangled up or twisted into knots. They should be handled with care the same as the rest of the equipment. In particular watch the plugs or connections on the ends. When disconnecting an aerial cable , for instance, make sure that the coupling ring see Fig.6.5. has been fully unscrewed before pulling it from the socket. Never remove a cable by pulling it but hold on to the connector on its end while removing it. Be careful not to cross thread the connectors. If there is more than one aerial, label each aerial cable with the frequency and channel number it is used with. If there is an aerial switch in use leave the aerials connected to the switch all the time, disconnect the transceiver from the aerials by using the connecting cable between the transceiver and the switch. This cable is best connected and disconnected at the aerial switch rather than from the transceiver socket. The actual aerial should be checked visually regularly but particularly after storms and high winds. No tree branches should be allowed to obstruct it.

7.2.2.4. Battery

Never switch on a transceiver when it is only connected to a solar charger i.e. when the battery has been disconnected. The acid level of a vented battery must be checked regularly at least once a week. If the level is down it must be filled up with distilled water or other substitute e.g. rain-water collected in a plastic sheet. The battery voltage should be measured regularly if there is a voltmeter available to do this. If voltage is too low the transceiver must not be used until the battery is fully charged again. It has been known for an operator whose battery was flat to get a second battery and connect it in series with the radio battery with the result that 20 volts was applied to the 12 volt transceiver causing serious damage. When transmitting, the battery voltage is low if it goes down below 11 volts. Receiving does not require so much power so if the voltage is too low to transmit it may be possible to listen and receive messages.

7.2.2.5. Lightening Danger

In areas where thunder storms occur frequently it is a good practice to disconnect the aerial when the transceiver is not in use. Where thunderstorms only occur in certain seasons some operators will only remove the aerial during these seasons but this is not an entirely reliable scheme as the start and finish of a season is not always well defined. Therefore the practice of always removing the aerial at the end of every contact is the recommended practice. The HQ station of one radio network in Kenya periodically reminds the operators of the other stations to disconnect their aerials after using their radios. It is also good practice to disconnect power cables especially mains cables and battery cables where the battery is being charged by solar panels on the roof.

7.2.2.6. Aerial Tuning Units

The operator should be warned that high voltages occur at the aerial terminal of transceivers which incorporate an aerial tuning unit (ATU). RF burns can be received if the terminal is touched during transmission. With these units when the frequency in use is changed the ATU will need retuning as per instructions for that particular unit.

7.2.2.7. Check List

This is an example of instructions given to stations on "Looking after your radio." Always follow the operating instructions.

- Never forget to remove power and aerial cables at end of contact.
- Look after your battery. Keep acid level topped up with water as required. Check it once a week.
- Keep battery lugs free from corrosion and covered with grease.
- Keep the cabinet, desk or table clean and free of dust and pieces of unnecessary paper etc.
- Make sure nothing blocks the ventilation around the radio when it is in use.
- If the radio is covered with a dust sheet when not in use always remove it completely before commencing contact.
- Keep the radio room clean and secure.
- Do not handle the controls more than necessary, especially do not twist knobs etc. round and round when waiting by the radio.
- Do not allow unauthorised people to use the radio.
- Keep an eye on aerials and cables especially after storms.
- Keep an eye on your solar panel e.g. make sure it stays clean and trees do not grow up to shade it.
- Keep to the one operator but have someone trained as a standby.
- Keep operating instructions accessible.
- In case of breakdown of the radio get message by some means to HQ giving as much information as possible.

7.2.3. Fault Finding

An alert radio operator can often give advance warning of the onset of a fault in the radio system by

reporting anything that is unusual. This can cover such symptoms as a station becoming persistently weak, apparently distorted or of gaps occurring in the transmission. These observations should be reported back to the station with the problem and to the person responsible for radio maintenance. However a operator should not be over enthusiastic in telling another station that they have a problem until he has ensured that the apparent problem is not being caused by his own equipment. For example, is it only one station that sounds distorted ? If all the others sound distorted as well then the problem well may be in the operators own equipment. Again if it is a strong station that sounds distorted then is the RF Gain set too high at the receiving station? see para.7.2.1.3. If an operator is told that his own transmission sounds weak or distorted then there are certain checks he can do himself. The following simple tests are given so that the operator can render "First Aid " or advise the radio maintenance person of the possible cause of the fault. Note that in the event of a possible fault in the radio network the radio technician responsible may wish to limit the operators actions to observation and certain permitted actions only. When there is a fault which the operator thinks is within the transceiver he should be told never to remove the cover to inspect the interior unless he has been given precise instructions by the technician to do so. If a component inside the transceiver is at fault there is little an unqualified person can do either to trace the fault or to fix it. Indeed such a person has been known to cause further damage to the transceiver in his desire to help.

7.2.3.1. Transmitting and receiving difficulties

1. If the operator is having difficulty hearing and making himself heard:

> Check (1) That the power light or indicator comes on at its usual brightness. If it is dull then the battery voltage is low and it needs to be charged up again before using the transceiver .
> Check (2) That the power light remains bright when the operator is transmitting. If it goes dull the battery voltage is too low for transmission although it may be all right on receive.
> Check (3) That the TRANSMIT light or indicator flashes as the operator speaks. If it does not try using the spare microphone. If the TRANSMIT light then works the fault is in the first microphone. If it still does not work there is a fault inside the transceiver.
> Check (4) Repeat Check (3) on all the channels on the transceiver. Note if the fault appears on all channels or one particular one.
> Check (5) That the aerial appears to be in good order i.e. no parts are broken or hanging down and no tree branches obstructing it. If the aerial is down try to reinstate it to the original state or ask HQ for any new pieces needed.
> Check (6) That the aerial cables and connections are not damaged. If there is a visible broken connection the operator may be able to do a temporary repair then inform the person responsible for maintenance and wait for his instructions.

7.2.3.2. Battery voltage problems

If battery is charged by solar panels.

Check (1) That the surface of the panel is clean.
Check (2) Observe any charging indicator light or meter where fitted .
Check (3) That the duration of daily use has not exceeded the recommended time.
Check (4) Suspect lightening damage possibly to diode.
Check (5) Allow battery time to recharge see para.3.2.3.4. If battery does not recover inform maintenance person. If battery is charged by other means.
Check (1) That the generator or mains battery charger is giving the necessary charging current.
Check (2) Allow battery sufficient time on charge to recover, if it does not suspect battery is too old or damaged in some way, see para 3.2.3.3 on battery life etc.

7.2.3.3. Unusual Noises

For any unusual noises coming from the loudspeaker, first of all try:

Check (1) Disconnect the aerial from the transceiver itself to see if the noise stops. If it does these are strong external signals and there is nothing wrong with the transceiver.
Check (2) If there is still a whistle or warbling tones etc. even with no aerial connected then reconnect it and try reducing RF and AF Gain controls to stop the whistle etc. so that you can receive, then inform radio maintenance of the problem.
Check (3) If there is a loud hum during receive:
  (a) where radio battery is charged off the mains, ensure that the mains battery charger is switched off while operating.
  (b) where there is a hum on a mains operated transceiver there is a possible fault in the transceivers own mains power unit.

7.2.3.4. Power failure

There is no power at all in transceiver after it is connected and switched on. This is shown by the power light being off and no sound coming from the loudspeaker on receive.

Check (1) For a battery operated set that battery leads have not become disconnected and that the battery is still there! For a mains operated one that there is actually power in the radio room.
Check (2) That the fuse has not gone. Replace it if necessary with a good one , if this then goes there is a fault inside the transceiver so do not replace again but inform HQ by some other means that there is something wrong with the transceiver.
Check (3) That plugs and cables have no visual damage. If a faulty cable is suspected inform maintenance and ask for replacement.
Check (4) If there is a simple explanation. For example where the power lead is normally plugged and unplugged from the wall socket and the other end is permanently connected to the transceiver. It has been known for someone to disconnect it both ends and for the next person to come in and plug into the wall socket without realising the other end is not connected to the transceiver.

Note that things like this can easily happen so always check the ordinary and the obvious when there appears to be a problem!

7.2.3.5. Receiver failure

If there is power in the transceiver i.e. the power light is on at its normal brightness, but there is no sound coming from the loudspeaker.

> Check (1) That all the controls have been set to correct position as in the operating instructions. If RF gain or Squelch is incorrectly set or the Channel switch is wrong for instance.
> Check (2) That the aerial is correctly connected and if using an aerial switch that it is switched correctly.
> Check (3) That the aerial or its cables are in good order.
> Check (4) If the above are all correct and there is still nothing coming from the receiver try transmitting and see if the transmit light flashes. If it does there may be a fault in the receive side only. Try sending a message to say what has happened to your HQ station.

7.2.3.6. Transmit Failure

If the receiver is working all right i.e. the power light is at its normal brightness and other stations can be heard at their normal level but it is obvious that that they are not able to hear your transmission.

> Check (1) That the microphone is correctly plugged in and that the transmit light flashes when speaking. If light does not flash try spare microphone. If the light still does not flash there is a fault in the transceiver or the battery voltage is too low for transmitting so:
> Check (2) That the battery voltage is good. Note if it is low i.e. below 11 volts, it may be possible to receive but not to transmit.
> Check (3) If the voltage and transmit light are correct check that aerial has not been damaged, one half hanging down or broken off for instance. Note that it is possible to receive on a long piece of wire but to transmit needs an aerial properly tuned and the right length for the particular frequency.

7.2.3.7. Physical Tests

Faults often take the form of disconnected or broken wires. These can either occur at the point where the wire is soldered or screwed into a plug or further along a piece of cable. Providing the action is gentle the operator can move the cables about, one at a time, especially where they enter a plug or socket to see if the transceiver will start working again. If the transceiver can be made to work by holding or twisting the faulty cable then a message can be sent to request a replacement cable or the help of a technician. Instructions will have been given to ensure the acid level of a vented battery. This is so often overlooked that it cannot be said too often. Again and again it is not till the voltage falls sufficiently to cause a problem with the radio that the battery is checked. Also the wires from the transceiver can corrode away

and break the circuit where they are connected to the battery. A movement of these wires will show if there is a problem.

7.2.3.8. Breakdown Procedure

All stations should have instructions as what to do in case of breakdown. This will depend on the particular situation of each network and sometimes of each station. Where there are reliable repair facilities nearby arrangements should be set up by your group or organisation when the equipment is installed and the operators should be aware of them and have available a technical manual for the technician. Where there are no such facilities operators must await instructions from HQ. HQ operators must take note of any stations who do not answer when called in and report this to the person responsible for maintenance in the network. A few contacts may be missed for reasons such as sickness or flat batterys but if a station remains off the air for longer than normal it must be assumed that it has broken down and steps must be taken to find out what has happened. The HQ operator should note that it may be possible for the missing station to receive even though it cannot transmit so the operator should continue to call them in and should send any messages or instructions required. However bearing in mind the possibility of a complete breakdown instructions should also be sent by whatever other means are available.

7.3. Operating the Network

It is possible to treat a radio contact in the same way as a telephone conversation with the addition of the word OVER at the end of each portion of speech. If there are only two stations talking to each other this is no problem. However the problems arise when there are three or six or maybe twelve stations waiting their turn to speak. In these cases there must be an orderly procedure to follow and everyone must understand it and keep to it. The following notes are drawn from practical experience and work well if carried out correctly. The important thing is to have a recognised pattern to your radio contacts that all your operators can respond to and cope with.

7.3.1. Callsigns and Control

Each station should have its own official call-sign e.g. 9SD67 or 9SD47, although in practice only the last part is used e.g. 67 and 47. These callsigns will be allocated by the licensing authorities of individual countries. A list of the callsigns belonging to the network should be kept at each station and all operators should know and use them rather than the place names. One station, which is normally the HQ station, should be in control of the network and all others should obey his instructions. When calling a particular station the operator should say this number first followed by his own e.g. 67 from 47.

7.3.2. Starting a contact

The situation exists in one African country where the same radio frequency channel has to be shared by several different organisations. In such situations there should be a timetable which gives you the channel

at specific times and days. Even if this is the case it is not always adhered to by all users. When more than one pair of stations are trying to speak at the same time the result is often that nobody can really understand what the others are saying. This "law of the jungle" usually resolves itself into some informal agreement between users so before the operator starts transmitting he should first listen on the channel. If it is in use he can remind the users that it is his time and unless they have very urgent messages, when some immediate arrangement can be made, then he should be given the use of the channel. Assuming the channel is clear the controlling station should begin by calling in each station in turn by their callsign, asking them if they have any messages and telling them to standby to receive any messages. One station may have a message for one of the others as well as the HQ station in which case it should clearly say so then that particular one will know to wait for it.

If there are no messages incoming or outgoing for a particular station it could leave the net after all stations have been called in. In practice most stations remain to listen to all the others as this is a source of news, especially in remote locations. When all stations have responded to HQs call they should be asked by callsign one after another to pass their messages to HQ and to be ready to take down incoming messages. This should be done in an orderly fashion with each station taking its turn under the control of HQ. They must wait for their number to be called and never try to jump in on top of someone else. Never forget that only one person at a time can transmit and expect to be understood. Two stations talking at once makes for confusion! The HQ or the controlling station should make a note of any stations who do not reply to his call and inform the necessary person.

7.3.3. Sending and Receiving messages

Each message should be as clear and concise as possible. It should be read clearly and not too fast into the microphone. Never shout as this can cause distortion. The operator should begin by saying the callsign of the station he wants to talk to followed by his own. Finish a message distinctly by saying the callsigns again followed by the word " Over" or "Over to you". Confusion can be caused if the operator does not finish clearly but lapses into silence so that the other is not sure that he has finished. Also long pauses and hesitions during transmission can give the impression he has finished or that there is something wrong with the transceiver. Keep all messages to essential matters. Remember others are waiting their turn. Take care that the messages have been clearly understood on both sides. If in doubt the receiver should read back the message to the sender to check for errors in reception. Where reception is difficult and noisy it is essential to do this. If there is difficulty in understanding certain words e.g. names of peoples and places or medical terms, ask the operator to spell them using a phonetic alphabet. see para.7.3.5.

7.3.4. End of Contact

When each station has given and received all its messages it may want to finish and switch off. It should make this clear by using the expression "47 signing off" or "47 going clear". If the operator is finished but he wants the others to know he is still listening he can say "47 standing by". If the operator wants another station to wait for him he should say "can 46 stand by for 47". These phrases may sound like

operators jargon but if used and understood by all they can be an aid to communication. See para.7.3.6. for list of words often used by radio operators. When all messages have been transmitted and received HQ, the controlling station, should pause and check for any stations that were missing at the beginning. He should allow enough time for any delayed station to call him when the others have finished and should give missing ones one more call. If these stations still do not reply then the operator should transmit the messages to them because they may be able to receive. There have been many cases of transmitter failure whilst the receiver has remained serviceable. Also when a battery is discharged there is often sufficient power to operate the receiver but not enough to transmit. Finally the controlling operator should indicate clearly that he has finished by saying "67 going clear" or "67 signing off" before switching off his equipment.

7.3.5. Phonetic Alphabet

To spell out words using this alphabet use a well-known and easily recognised word beginning with the letter that you are sending. e.g. CORBETT spelt out in this manner becomes Charlie, Oscar, Romeo, Bravo, Echo, Tango, Tango. It is possible of course to use any suitable words familiar to the operators but there are some phonetic alphabets which are well known and international and can be heard on channels used by aircraft.

Here is one alphabet in common use:

A ALPHA	BRAVO	C CHARLIE	D DELTA	E ECHO	F FOXTROT
G GOLF	H HOTEL	I INDIA	J JULIET	K KILO	L LIMA
M MIKE	N NOVEMBER	O OSCAR	P PAPA	Q QUEBEC	R ROMEO
S SIERRA	T TANGO	U UNIFORM	V VICTOR	W WHISKEY	X X-RAY
Y YANKEE	Z ZULU				

7.3.6. Radio Jargon

It is possible , of course, to talk on the radio as in normal conversation but it sometimes helps in communication to use certain set phrases or words. These must be understood by everyone using them and not thrown in because it is thought it sounds good. Words like "negative " for "no" help because a little word like no is easy to lose amongst the noise in poor reception conditions. "Negative copy " makes it clear that the message has not been understood and most people recognise the term " Roger" as meaning message received and understood. Here is a list of radio expressions commonly heard.

"Over"Short for "over to you"meaning the operator has finished speaking for the moment and is

waiting for a reply. Always use it to indicate that the message is finished to avoid any doubt.
In French "A vous"also has the same meaning and in Lingala "na yo".
"Go ahead"or "47 to 67 Go ahead"is also used with the same meaning.
"Roger"message received and understood.
"I copy"or "I read"has the same meaning. Also the French "capte"or "bien capte".
"Negative copy"Message not received or understood.
"Negative "No, that is not correct.
"Affirmative "Yes, that is correct.
"Stand by"Please wait for further messages.

7.4. Message Handling

The technical side of the radio network can be working well but the purpose of the network is to pass messages. Therefore the handling of messages before and after transmission over the radio is just as important as the transmission. Messages received on the radio must be passed on accurately and quickly to the person they are intended for and requests received for information or for supplies must be dealt with accurately and efficiently otherwise the network is not satisfying its purpose. In practice it is often found that once a network starts operating the type of message and requests far exceeds the original agreement.

7.4.1. Type of Messages

The Government of the country may place certain restrictions on the use which can be made of the radio network. In addition every effort should be made to define what types of messages your organisation will permit to be sent over the radio network and what services can be requested. Unless there is general agreement on these subjects the advantage of a radio communications network can become a source of discontent because messages are not being passed on and requests for goods etc. are not being met. Messages could be classified as URGENT or ROUTINE. However in practice some originators of messages tend to classify all their messages as URGENT. This becomes obvious to the person receiving the messages who will then handle them as routine so defeating the aim of the classification. An analysis of the messages passed by expatriate personnel over a mission network during a three months period in 1987 is given in Table 7.1. Of these 679 messages 388 were to HQ and 291 from HQ. The network consisted of 9 stations spread along 1700 kms of the River Zaire. It was used to a much greater extent by the national church for which no figures are available.

Table 7.1.

Message type as percentage of total messages.		
Type of message.	**To HQ.**	**From HQ.**
Travel Information(passengers)	16.5	21.6
General Administration	14.4	13.2

Missionary Aviation Fellowship (flight information)	7.4	11.7
Messages-		
Medical	8.5	8.9
Personal	7.2	11.7
For other organisations	4.4	2.4
Technical Information	3.1	3.4 S
Medical Emergency	0.5	1.4
Supplies-		
General Medical	6.0	3.8
Technical and Construction	3.9	2.7
Books and stationary	3.1	1.0
Urgent Medical	2.6	1.0
Finance-		
Personal	6.4	5.2
For others	6.2	3.4
Official	4.4	1.7
Shipping-		
Freight by Air	2.6	3.8
Freight by Boat	1.5	1.4
Personal Items	1.3	1.7

When a lone expatriate is working in a remote location it is helpful for them to have some time on the air for general conversation in addition to the normal message time. This has to be when the channel is not busy, usually a Sunday afternoon. It is often people in similar situations i.e. living alone in remote places, who arrange to talk together.

7.4.2. Timetable

The existence or otherwise of a timetable for different organisations to use the same channel has been discussed in para.7.3.2. Your organisation may wish to further subdivide its own time between different departments. For example one mission allocated 0900 to 1000 Education, 1000 to 1100 Medical and at

1200 General Rendezvous for all other matters. If your network covers a very large area it may be necessary to subdivide it on a regional basis. For example each region could be allocated a certain time to deal with its own regional business and a certain time when it could contact the central HQ control for other matters. Never change an existing timetable that works until you are sure that the channel will be free for you to use at the new time. This can be done by simply listening on the channel for several days to see at what time it is in use.

7.4.3. Message Recording

A log book is necessary at each station as a written record of all messages sent and received. This may be a legal requirement by the Government of the country who may prohibit the use of a loose leaf type of book. Duplicate pads are available which provide one page to be left in the book as a record and a second carbon copy on a tear out page for passing on to the person to whom the message is addressed. Even if there is no such legal requirement the written record is essential to ensure the smooth running of the network. A verbal message is easily forgotten or mistaken! Before the contact begins the operator should write his name the date and time across the page and then the outgoing messages. There should be columns to show if the message is to or from a station, the message itself and then the action taken in response to the message. The HQ operator can give each individual outgoing and incoming message a serial number which he informs the other stations of and this can be used as a quick reference for any future associated information. The log could take the following form:

Operator John Smith 30 June 1988 0615.

To/From	Message	Action
From 45	Please send us 6 drums of diesel fuel.	Replied 8 Julythat 6 drums left on boat MAKASI on 7 July.
From 43	Tell Olive Brown that the box of Lingala books have arrived.	Received message 30 June signed O. Brown.
To 87	Mr and Mrs James need dental treatment. Please arrange appointment and accommodation and advise us of dates.	Reply received 3 July. Go on 10 July and return 14 July must make own travel arrangements

There should be a person on each station who is responsible for seeing that all messages are passed on. The person need not necessarily be the operator. Where practical a person should take the log book

around the personnel of the station after each contact so that recipients of messages can sign to acknowledge receipt. Also they can enter messages they wish to send in the book in their own words. Many errors occur because the operator sends his own interpretation of the message and does not faithfully read it as written. An alternative arrangement is for the log book to be available to everyone to see at a certain time and place each day. When receiving messages some operators write them down rapidly on scrap paper and then copy them into the log book afterwards. When this happens the log should be written up as soon as possible after the contact while the messages are fresh in the operators memory.

WHERE THERE IS NO TELEPHONE

Chapter 8. HOW TO MAINTAIN A RADIO NETWORK

Topics:

There are several aspects of a radio network which have to be satisfied if it is to give a continuous satisfactory service. These aspects are dealt with in each chapter, the importance of each has been

stressed e.g. choice, installation and operating of the equipment. However you are unlikely to end up with a perfect system. There will be failures in the radio equipment, some of which may be due to design or manufacturing faults, others to poor installation or bad operating practices. Wherever possible the author analysed the faults which occurred in the radio systems in Zaire. This frequently showed that either the fault was not in the transceiver itself or if it was it had been caused by something external to the transceiver. The various ways to safeguard the transceivers and prevent some faults occurring are in the chapters of this book, for example see para. 5.2.5. After you have taken all reasonable precautions, there will still be the failures. It may be due to a fault within a semiconductor which is beyond your control or it may be due to somebody in a hurry forgetting to disconnect the aerial and thus allowing lightening to damage the transceiver.

Therefore you must make some provision for the maintenance of the whole network. Within a few hours of the author arriving in many towns and villages in Zaire the fact was known that a radio engineer had arrived and requests were made to look at transceivers that were not working. Enquiries revealed every time that no spare parts were kept, no manual or circuit diagrams were available and no provision had been made for maintenance. Hence the resulting situation of unserviceable transceivers which were unlikely to work until someone got round to taking them to a repair facility within the country or often in another country. A maintenance philosophy which relies on all faulty equipment being sent to a central workshop for repair and then being returned to their stations is not always appropriate for developing countries where there are very few such workshops and transport arrangements are difficult. If the equipment was not originally installed by a competent radio technician then when one becomes available he should make an inspection and upgrade as necessary all the installations.

8.1. Staff

There are often very few qualified full-time radio engineers or technicians working for missions and aid agencies in the developing countries of Central Africa. In July 1988 the author knew of no other radio technician working with any Protestant mission in the northern half of Zaire an area of about 500,000 square miles where there are many radio networks. The need for short-wave communications is decreasing in the developed countries as satellite systems take over therefore there are now not so many communication engineers available who have had experience with short-wave communication. So in countries where short-wave communications are important, nationals need to be trained in this aspect of radio engineering. This, however, is a long term solution. An interim solution could be for several co-operating organisations to provide a technician in turn, e.g. for 2 years who will service the equipment for all the organisations. Another person could also run a programme to train nationals as technicians. It will be necessary to be aware of the visa and work permit regulations of each particular country before you plan to send in expatriate personnel.

8.2. Cost and Payment

The maintenance facility may be allowed an annual sum of money to perform a service to an organisation or it may have to be self-supporting financially. The financial arrangements should be well

defined and estimates of the various costs made at an early stage see para. 5.1.6. It should be decided who will pay for:

1. Repair of transceivers in the workshop including time and parts.
2. Travel and accommodation costs of a technician visiting a distant station.
3. Recurring replacements e.g. batterys.

Also how the payment will be made especially in countries where bank cheques are not in common use and where bank transfers of money can take a long time. In these circumstances money is usually physically moved around the country with the attendant hazards. Examples of costs in 1987 were $15 an hour for a missionary radio technicians time when working on equipment of other churches and missions. One commercial firm would send out a technician from Britain to work in Africa for the cost of his travel, accommodation plus o300 per day. The costs of either providing a radio maintenance facility for your own use or using someone elses facility are considerable and must not be underestimated.

8.3. Spare Parts

If you are providing your own maintenance facility or even if you have arranged for a visiting technician to repair your equipment you should hold a range of spare parts. Providing you hold a good stock of spares your transceiver can be repaired rapidly and returned to service. The cost of spare parts was mentioned in para. 5.1.1. It is recommended that the spares should be kept at the central maintenance facility rather than having a full set at each station. This reduces the capital cost, e.g. 1 spare item for every 10 transceivers rather than 1 item with each transceiver. Originally the author put some spares with each transceiver in Zaire, however over a period of several years many of these spares were lost. This mainly occurred when there were changes of staff and when staff were absent for long periods. There are sometimes advantages in having the spares with the transceiver, for example when you are able to call upon the services of a nearby radio technician. If there is no recommended list of spares from the manufacturers or you do not wish to use the list then a guide to the selection of spares is given in order of priority.

1. Plug-in circuit boards or modules.
2. Mechanical parts which are liable to wear out e.g. switches, press buttons, relays and variable resistors such as volume controls.
3. Hot filament devices e.g. thermionic valves and indicator lights, not LEDs.
4. Plugs and sockets which are unplugged daily, e.g. aerial and power connections.
5. High power transistors used in the transmitter.
6. Loudspeaker and microphone.
7. Non standard components which are special to the particular transceiver.
8. A selection of transistors, resistors and capacitors if possible chosen by the person responsible for maintenance.

Keep an up to date list of all the spare parts you hold. Where the parts have an identifying number always

use this to aid the identification of the correct part. An additional completely spare transceiver can be worth keeping at the central workshop so that this can be used as an immediate replacement for a faulty transceiver. In real life it has been found best to await the arrival into the workshop of the faulty one before dispatching the replacement. Otherwise once the replacement transceiver has arrived at the distant station the need to send back the faulty one seems less urgent. Indeed the known existence of a spare serviceable transceiver in the workshop can present a problem in some cultures. When there is a long waiting list of places requiring radio equipment the head of the organisation may not fully appreciate the need to have a little used spare transceiver. However if it is pointed out that it will be necessary to purchase a new aerial, battery, solar charger, microphone etc. to go with the spare transceiver to make a complete station then the idea may not appear so attractive.

8.3.1. Fuses

Most modern radio equipment requires replacement fuses of the non-repairable type, that is where the fuse wire is enclosed in a glass or ceramic tube. On opening many fuse holders it has been found hat the fuse has blown and a piece of wire had been twisted around the fuse to keep the equipment going. The fusing value of the added wire was usually in excess of the fuse rating. Information on the fuse rating and fusing current of copper wire varies from different sources. In general one can say that a current which is twice the "fuse rating " will blow the fuse. If you have no proper fuses an indication of the size of wire to use instead is given in Table 8.1.

Table 8.1. Fuse Rating of Copper Wire.

SWG	Diameter in mm.	Fuse rating in amps.
38	.152	3
35	.213	5
29	.345	10
25	.508	15
23	.610	20
21	.813	30

8.4 Tools

The decision of what tools to provide for the places which have a transceiver should be based on what you expect the people to do. It may be that you do not wish anyone to attempt to do anything to the transceiver if it fails. It has been proved necessary in some places to paint in white paint the instruction "Do not open" in three languages on the cover of the transceivers and to also seal the screws which secure the cover with white paint. This instruction applied to all personnel, expatriate as well as local. No tools were supplied to these places.

8.4.1. Basic Tools

Providing you are confidant that the provision of tools to the people will not cause damage to the equipment, that the tools will not be lost or broken through misuse and that the people are competent to use all the tools i.e. including the multimeter then the following list is recommended.

1. A selection of screwdrivers to fit the necessary screws of the particular installation only.
2. Spanners if necessary. The modification of battery terminals see para. 6.2.2.5. means spanners for battery lugs are unnecessary.
3. A multimeter to cover the voltages and current in use and to measure resistances from 0 to 10M. A digital meter with an accuracy of only 3 digits e.g. to read 12.6 volts, is suitable. An analogue meter i.e. one with a pointer moving on a scale, should have suitable ranges. For example to measure a 12 volt solar supply system which may be between 10 to 18 volts, a meter scale of 0-20 volt DC will give a much more accurate reading than a scale of 0 to 50 volt DC. A 250 volt AC range is necessary for measuring mains voltage. Also check the manufacturers quoted accuracy for the meter which should be less than plus or minus 3%.
4. Where a multimeter is not supplied then a 230 volt mains bulb of 40 watts to 100 watts, fitted in a bulb-holder with two insulated cables, can be used carefully for checking the presence of mains voltage. Similarly for 12 volt systems a 12 volt car bulb can be used. If the bulb is to be used for testing a solar panel then the current consumption of the bulb should be less than half the current producing capacity of the solar panel e.g. a 12 volt 0.3 amp bulb to test a 12 volt 1 amp solar panel.
5. One or more of the following types of soldering irons should be made available.
    (a) Mains soldering iron to suit available voltage e.g. 110 volt or 230 volt. A small iron of about 20 watts for printed circuits and one of about 40 to 60 watts for coaxial cables.
    (b) 12 volt DC iron for use from either a vehicle or a radio battery are available at 30 watts.
    (c) Fire iron. These irons have no heating element and require heating by a flame e.g. charcoal fire or blow lamp.

8.4.2. Workshop Tools

The requirements for the workshop should be decided by the chief radio engineer of your organisation or this may be delegated to the technician who will be working in the shop. The choice of equipment should be made by a person who is knowledgeable about current electronic equipment and maintenance philosophy. The tools can consist of the basic ones mentioned in para.8.4.1. together with the more major items of para. 5.2.4. For transceivers which comprise mainly plug-in circuit boards a spare transceiver can save many items of test equipment.

8.5. Routine Maintenance

In the history of radio engineering there was an era when "preventative maintenance" was in vogue. A time was given for the expected service life of various components in the radio and these components

were then changed well before they were expected to fail. Hence the radios were taken out of service for maintenance at arranged times and few unexpected breakdowns occurred. However this was an expensive method of maintenance and is now more usually found in areas of activity where the reliability and availability of equipment is important at any cost.

The situation likely to be found in a developing country is one in which it is often difficult to ensure that even the essential basic routine maintenance is performed. When questioning a driver if he had checked the oil level in the vehicle engine he said that it was alright because whenever the light flashed on the dashboard he put oil in the engine. The light was the oil pressure failure warning light!

In countries where the main object of the people is the need to survive and eat today, there is little thought for the needs of tomorrow so this attitude affects their ideas of maintenance. If the radio or the vehicle works today then all is well. If it does not work then it needs maintenance. An understanding of this attitude and the reason for it is necessary when instructing your staff about routine maintenance. The routine actions necessary should be included in the operating instructions given to all stations. An example of this is given in para. 7.2.2.7. and will depend to a large extent on the particular equipment at each station and on the capability of the operators. The most important points are listed below.

1. Check the acid level in a vented battery each week and refill with distilled or rain water.
2. Prevent the growth of corrosion on the battery terminals. Clean and cover with petroleum grease as necessary.
3. Clean the solar panel especially during any dry season when it should be checked every two weeks. In dry, dusty and desert areas it may be necessary to clean it more frequently.
4. Prevent the build-up of dust on the transceiver and microphone. Keep covered inside desk or with a dust cover when not in use.
5. Trees and vegetation grow rapidly in the tropics. Cut down branches before they have grown over or are touching the aerial and its cable. Stop creepers growing up aerial masts and cables.
6. If there is any means of measuring the state of charge of the battery e.g. voltage indicator or hydrometer, then record the state each day before using the transceiver. This record will give advance warning before a battery becomes too discharged due to (a) over use (b) under charging or (c) end of battery life.

8.6. Fault Finding

When a fault occurs some preliminary investigation should be made by the radio operator as discussed in para.7.2.3. Sometimes what the operator thinks is a possible fault can simply be that he has not followed operating instructions e.g. the RF Gain or Squelch control is in the wrong position. In any case the checks mentioned in para.7.2.3. should be done by the operator before contacting the maintenance person. Also the tests mentioned in para.8.6.2.1. could be done by the operator if the person responsible for maintenance considered this suitable. This can be done even if you have the option of calling in a radio technician and should be done before sending the transceiver off for repair. The amount of testing you want an operator to do should be specified when the equipment is installed and the relevant tools and

written instructions left.

8.6.1. False Indications

Indicator lights are provided on transceivers to give confirmation that certain parts of the transceiver are working. Unless the indicators actual position in the circuit is known or its operation fully understood these lights can sometimes give a false indication.

8.6.1.1. Power Light

The DC power protection circuit of one make of 150 Watts PEP HF SSB transceiver is shown in Fig. 8.1. When the transceiver is connected to the 12 volt DC supply the 12 volts will go immediately to the power amplifier circuit via a 15 amp fuse. No voltage will be connected to the rest of the circuits until the transceiver is switched on when the Power light will be lit. If the 5 amp fuse blows this will be indicated by the Power light being out. However if only the 15 amp fuse blows the Power light will remain on so giving a false indication that the power is being supplied to all parts of the transceiver. Once the situation is understood the presence of 12 volts on the power amplifier can be verified by speaking into the microphone thus causing the Transmit light to flash provided the rest of the transmitter is working.

8.6.1.2. Transmit Light

This light indicates that RF voltage is present. The point at which the light is connected to the circuit depends on the particular design, see Fig. 8.3. If the light is connected to Point A it only means that transmitter power i.e., RF voltage, is available at that point. A fault in the filter could prevent any power reaching the aerial. A light connected to Point B simply shows that power is available at the RF filter output but it may have to pass through an aerial change-over relay before it reaches the transceiver output socket. Even if the power is reaching the output socket the aerial could be disconnected or have a fault and the Transmit light would still flash. Therefore you should be aware of the difference between what the light is labelled and what the lights actually indicate.

8.6.2. Do It Yourself

In such areas as house repair and car maintenance the idea of "Do it Yourself " (DIY) has become very popular in recent years. Various guide books and aids have been produced to help the "man in the street" do the job that was previously done by a skilled craftsman. Some jobs have turned into disasters whilst others have been successful often depending upon the aptitude and ability of the person doing the work and the standard of the DIY instructions. There exists a shortage of skilled technicians in many developing countries and so DIY can have an important place. Much care must be taken when introducing DIY into the field of radio communications engineering and notice must be taken of the sayings such as "a little knowledge is a dangerous thing" and "it can do more harm than good". However providing the DIY instructions are sufficiently well defined and also rigidly adhered to then this method of maintenance can give useful results. Before reaching this stage of repair the operator should have

performed the Fault Finding procedure given in the sections of 7.2.3.

8.6.2.1. Trial and Error

It is possible for a person with little or no technical knowledge to perform tests on the parts of a radio system and in some cases effect a repair. The following tests are examples and further tests could be devised to suit your particular system. It should be noted that the results of these tests are not always conclusive.

1. Symptom. Transmit light flashes but no stations heard although noise from the receiver.
Test: Where an aerial switch is in use remove the coax aerial cable from the switch and connect it direct to the radio.
Result:

    (a) Stations are now heard and normal contact is possible means a fault in either aerial switch or cable between switch and transceiver.
    (b) no different then do next test.

2. Symptom: Noise from the transceiver loudspeaker but no stations are received on any channel.
Test: Disconnect the aerial. Turn RF Gain to maximum. Adjust AF Gain or Volume to give a reasonably loud noise (or hiss) from the loudspeaker. Touch the central pin only of the coax plug of the aerial cable to the centre of the transceivers aerial socket, being careful not to let the outer ring of the plug touch the transceiver.
Result:

    (a) Noise from loudspeaker increases and possibly some stations heard. This means the receiver is working.
    (b) Noise from loudspeaker remains the same.

Possible fault in transceiver or break in central conductor of coax cable. Now remove the aerial cable and instead connect about 2 metres of wire into the centre of the transceivers aerial socket. If noise level still does not increase most likely cause is fault in receiver. If the noise does now increase then faulty aerial cable is likely.

3. Symptom: No noise from loudspeaker at maximum volume.
Test: Reduce volume control from maximum and plug in earphones.
Result:

    (a) no noise in earphones when volume at maximum means a fault in the transceiver, probably in audio amplifier circuit.
    (b) noise in earphones means either a failure of the loudspeaker or the circuit to it which may be via contacts in the earphone socket.

4. Symptom: The transmit light is on all the time that the transmit button is pressed although nobody is speaking into the microphone.
Test: Unplug the microphone from the transceiver and connect together the "press to transmit" contacts in the microphone socket.
Result:

(a) no difference. Fault in transceiver e.g. gain of microphone amplifier too high, amplifier oscillating or carrier balance needs adjusting.
(b) light is out means either wire open circuit on microphone or gain was too high in microphone amplifier.

If your transceiver is designed on the plug-in module or printed circuit board system then you have the opportunity of attempting to repair it by changing modules. Whilst this is an advantage, the contacts on the plugs of the modules can themselves cause problems. They can become tarnished, oxidised or corroded so the first thing to do is to unplug one module at a time. Clean the contacts with glass fibre or a piece of course material to remove any layer on their surface. Do not use sand-paper, glass-paper or anything too abrasive. Replace the module and check if the radio works before removing the next module. If after cleaning all the modules the radio does not work then replace each module in turn with a serviceable one leaving each new module in the transceiver until it works. Then leaving the last new module in its place in the transceiver try restoring the old modules in turn to see if it continues to work. For example if the transceiver works after the third module has been replaced then restore the original module 2 and if it continues to work then restore the original module 1. If it then continues to work the fault will have been put right by the replacement of module 3 but if it does not then you will need to use the replacement module 1 or 2 as well.

There are disadvantages in this method of "trial and error" replacement. For example if there was a fault on the main part of the transceiver which had in turn caused the fault on the module then the replacement module would suffer the same fault. Therefore this method of repair should only be used when no better system is available.

8.6.2.2. Diagnostic Aids

One method used to test transceivers is to have a purpose designed test unit with a keyboard which is plugged into the transceiver. This unit then performs certain tests and measurements on the transceiver semi-automatically and displays the results on a screen. Such units have not been encountered amongst the missions and aid agencies in Central Africa.

A simplified and manual version of such test facilities exists in the form of three diagnostic boards designed by the author for the AEL 3030 transceiver which is produced by AEL Communications of Gatwick, UK. Whilst these particular boards can be only used in this model of transceiver, the principles of testing and indeed the circuits are suitable for other makes of transceivers, especially those from Trans

World Communications Inc of the USA. The diagnostic boards are fitted, only one at a time, into the place of existing boards in the transceiver. An example of the tests which Test Board 101 can perform on the AEL 3030 is given in the following instructions which accompany the board. The circuit of Test Board 101 is shown in Fig. 8.3. This board has a row of LED lights along its top edge, numbered 1 to 7.

Test Board 101.
Switch off transceiver. Remove any mains power lead. Remove printed circuit board PC 101 and plug Test Board 101 into the same socket. Ensure aerial and microphone are connected and mains if used. Switch on the transceiver.

OBSERVE LIGHT NUMBER	YOU OPERATE	CONDITION OF LIGHT	THIS INDICATES	YOUR ACTION
1.	Press transmit	Light flashes	Correct	No action.
To	button			
Test	and	Off	No input	Check connections to
the	speak		from	microphone. Repair as
micro-	into		microphone	necessary. Otherwise
phone.	microphone.			try spare microphone.
2.	Transceiver	Off	Correct	No action.
Tests	on			
that	receive	On	Relay	Short in microphone
12v			locked	leads to transmit
is being			on	button. Repair or
switched			Transmit	use spare microphone
to the				
Transmit	Press and	On	Correct	No action.
circuits	hold on			
	transmit	Off	Relay not operating.	Break in microphone leads to transmit button. Try spare microphone. If fault remains change relay.

3. Tests the 12volt supply	When transceiver is on transmit and also on receive.	On	Correct	No action.
		Off	No 12 volts on PC 101.	If 12 volts present in Tests 2 or 4 then fault in the transceiver.
4. Tests that 12volts is being switched to the Receive circuits	Set on Receive	On	Correct	No action
		Off	Relay locked on transmit	Check for short in transmit button. Try spare microphone. Change relay.
	Press and hold on Transmit	On	Relay not operating.	Break in wires to the transmit button. Change relay.
		Off	Correct.	No action.
5. Tests if the Squelch control is worn.	Rotate Squelch fully anti-clockwise	On	Correct.	No action.
		Off	Squelch control worn.	Replace Squelch control.
	Rotate Squelch slowly clockwise.	Slowly goes off.	Correct.	No action.
		Goes	Squelch	Replace Squelch

			out instantly.	control worn.	control.
6. **Tests** **Loud-** **speaker.**	No operations	On	Correct	No action.
		Off	No circuit through loudspeaker.	Check connections to loud speaker and earphone socket.
7. **Tests** **if** **Audio** **control** **is** **worn.**	Rotate Audio fully clockwise.	On	Correct.	No action.
		Off	Audio control is worn.	Replace audio control.
	Rotate Audio slowly anti-clockwise	Slowly goes off.	Correct	No action.
		Goes out instantly.	Audio control is worn.	Replace Audio control.

8.6.2.3. Testing Diodes

Select the OHMS range on a multimeter and connect the diode between the leads. Measure its resistance and then reverse the leads and measure its resistance in the reverse direction. In one direction the resistance should be low e.g. 10 to 300 ohms, and in the other direction it should be high e.g. 1 Megohm = 1,000,000 ohms or more. If the diodes resistance is similar to these values then it is serviceable.

8.7. Workshop Repair

The aim of all users of radio communications equipment should be either for their own organisation to have a radio workshop, providing they have sufficient equipment to justify this, or to have definite arrangements with other workshops to repair the equipment. Workshop repairs is a subject on its own

and no attempt is made to explain the methodology of repair. The cost of maintenance was mentioned in para.5.1.6. and of equipping a workshop in 5.2.4. The other aspects of staff, payments and spare parts have been mentioned in paras.8.1 to 8.3.

8.7.1. Requirements

To perform satisfactory repairs in a workshop it is necessary to have:

- A qualified and capable radio technician.
- Adequate test equipment, tools and working space.
- A reliable source of sufficient electrical power.
- A secure and dust free room with adequate lighting and ventilation.
- A store of sufficient spare components and parts.
- Technical manuals for each type or model of transceiver to be repaired.

8.7.2. Instructions

Radio operators should be instructed and encouraged to perform the test specified at their station before sending the equipment to the workshop. They should be instructed to send the microphone with the transceiver and any separate mains or other power unit used. Also the power cable and plug, aerial switch and its connecting cable if used. It must all be packed in a way suitable for the mode of transport.

8.8. Contract Maintenance

Contract maintenance should be considered where there exists a reliable commercial radio repair facility which will usually be in a large city e.g. as in Nairobi. Also where there exists means of transporting equipment to and from this facility at reasonably frequent intervals. The actual economics of each organisation will be different and you will need to compare all the advantages and disadvantages involved.

The questions and costs to ask of a proposed provider of contract maintenance include: Retaining fee, labour cost per hour, overheads involved in obtaining and handling spares, equipment transportation arrangements, technicians travel and accommodation, and the maximum time from reporting fault to completion of repairs if this is definable.

WHERE THERE IS NO TELEPHONE

Chapter 9. ADDITIONAL FACILITIES

Topics:

[Return to Table of Contents](#)

In addition to the basic facility of transmitting and receiving speech a radio network of HF SSB transceivers can be used as the medium for transferring other forms of information. These can include teletyped messages which are typed out on a teleprinter by the operator for transmission and which are received and printed out automatically. Computers can be linked by radio and enabled to "talk to each other" and pictures can be sent over radio links. All these facilities are usually provided by additional "add on" equipment which simply plugs in to the basic transceiver. Note that SSB transmitter power rating is in watts pep, the equivalent continuous power output will be less than half that figure. So when continuous tones are being transmitted e.g. using a modem, the transmitter output must be kept within the specified limit.

9.1. Selective Calling

Selective calling systems in various forms have been in use on radio networks for many years. The facility provided can be likened to that of a telephone in as much as you are able to cause a bell or buzzer

to ring at a selected station by transmitting its individual calling code. For your HQ station to be able to call each station in the network individually you will require a selective calling unit with a different calling code for each station. This unit will also be capable of receiving the code and activating its own bell. All the other stations will require a unit to receive only their particular code and also to be able to transmit the code. The extent of the calling facility can be varied according to your needs e.g. the HQ station could call all stations at one time or each station could have the same ability as the HQ station etc.

Units are available which can be plugged into an auxiliary socket on the transceiver through which all the connections are made. Other units are battery powered, give an audible output and have to be held in front of the microphone whilst the transmit button is pressed. To be able to receive a call the transceiver must of necessity be witched on and have the aerial connected. The transceiver can be left switched on all day with the loudspeaker off to await a call. Care must be taken to disconnect the aerial etc. when lightening is near. Calling units which use a series of tones are best suited to AM and FM transceivers but can be used on SSB provided that the transceiver is tuned within the limits stated e.g. + or - 500 Hz. Other units transmit a tone which is pulse width modulated and suitable for AM, FM, and SSB transceivers. The calling signal is transmitted for some 5 to 10 seconds and the units give very few false alarms.

9.2. Modems

The word MODEM is derived from MOdulator/DEModulator. It will produce the necessary modulation, usually 2 tones to enable data to be sent over an audio channel i.e. a telephone line or a radio channel. The unit also demodulates incoming tones and converts them into a data format. There are various pairs of tones and different durations of tones used in the many signalling systems. Therefore it is necessary to ensure that the modem at each end of the link and the transceivers are capable of handling the particular signalling system. Where a modem is used with a SSB transceiver link a tuning aid is necessary to enable the clarifier to be adjusted to set the tones at the correct pitch.

9.3. Facsimile

A facsimile or fax machine converts a static black and white picture into electrical signals which can be transmitted over the audio channel of a radio link. The machine can also receive fax signals and convert them into a picture. The picture is transmitted by frequency modulating an audio sub-carrier e.g. a nominal 1900 Hz which transmits white when at 2300 Hz and varying scales of grey through to black at 1500 Hz.

9.4. Electrocardiographs

Low frequency wave forms such as those from some medical sensors e.g. electrocardiographs (ECG), electronic stethoscopes etc. can also be transmitted over audio channels. The same method is used as in facsimile transmissions see para.9.3. ECG waveforms have been transmitted from Africa to America on frequencies allocated to amateur radio operators. This transmission method also enables you to have "a

stethoscope a 1,000 miles long".

9.5. Morse Code

The international morse code covers all the letters of the alphabet and all numbers. This code was well used in the early days of wireless communication. Today its use has greatly diminished. When a signal is weak or when there is a lot of interference you can hear and distinguish the dots and dashes of the morse code when you are unable to understand the speech. The operators at both ends of the link will have to be able to send and receive the morse code at a sensible speed. The minimum speed for a useful link would be some 8 words per minute. A morse key and possibly a tone oscillator will be necessary.

9.6. Linear Amplifier

The transceivers mentioned so far have produced power outputs up to 150 watts pep. A linear amplifier can be connected between your transceiver aerial socket and the aerial itself to amplify the 150 watts pep to some 500 to 1,000 watts pep of transmitted power. A linear amplifier producing 1,000 watts pep will require from its mains or battery supply an average input power of some 500 watts. However if this power is obtained from a 12 volt source e.g. battery, then an average of 40 amps, peaking to over 100 amps would be necessary. Therefore it is best to only use such amplifiers from a 230 volts or 110 volts supply.

A linear amplifier enables you to transmit more power and to be heard more clearly by the distant station. However you could also cause interference to other users of the same or adjacent channels as well as other receivers within a few hundred metres of your aerial. Linear amplifiers can be left permanently connected in the aerial circuit and only switched on when another station is having difficulty receiving you. When the linear amplifier is switched off the transceiver output is automatically connected straight to the aerial therefore it will still be necessary to disconnect the aerial after using the equipment.

9.7. Aerial Tuning Units

The use of these units have been described in para. 2.6.3. for tuning long wire aerials to a transceiver. They can also be used to tune a dipole or other aerial for use at a frequency for which it was not designed.

9.8. Remotely Controlled Coaxial Switches

Where a transceiver needs to use more than one aerial either a manual or a remotely controlled selector switch can be used. A remote switch will be connected to the transceiver by a multicore cable so that when a channel is selected the appropriate aerial is automatically selected by the remote switch.

9.9. Telephone Handset

A handset which looks similar to those in use on a normal telephone can be connected to the transceiver. The handset will have an additional button or lever switch to provide a "press to transmit " facility.

9.10. Boom Microphones

If it is necessary for the person speaking on the radio to look around whilst speaking e.g. whilst driving a vehicle, then a boom microphone which can be fitted to a pair of earphones should be positioned in front of his mouth.

WHERE THERE IS NO TELEPHONE

Chapter 10. Packet Radio

Topics:

Return to Table of Contents

Packet radio is a form of data communication which has several forms e.g. X25 is in professional use, AX25 is used by amateurs and there are other formats. The text message to be transmitted is broken up into packets which may contain up to 256 characters. AX25 packets take the following form:
They start and end with synchronising signal thus making the data within the packet a synchronous format.
The second part of the packet is an address area which contains the destination, origin and any station through which the originator may wish the packet to be relayed.

The relay stations are called digipeaters. They simply receive a packet and automatically transmit it to the next address on the packet. In addition to the text, each packet also contains control codes and error checking information. Until the receiving station confirms to the transmitting station that it has received the packet correctly, the same packet will be transmitted again. This procedure of re-tries will continue until the maximum number of re-tries e.g. 1O, is reached after which a failure will be indicated.

The packet radio operating system, packet format and other information is stored either in the Terminal Node Controller (TNC) or a computer program which interfaces between the keyboardand the radio. The TNC switches the transmitter on and off automatically. Initially the operator has to establish contact with the distant station using the keyboard. A connection will be indicated either by text on the VDU or printer, or by illumination of the appropriate LED, after which the operator sends the message using the keyboard. A further command is necessary from the operator to disconnect the link otherwise automatic disconnection may occur if no messages have been passed for a given time e.g. 1 minute.

In addition to a direct contact between two stations, packet radio is extensively used with mailboxes and bulletin boards. These facilities are similar to those which are available using modems over telephone

lines. Mailboxes, as the name suggests, provide the facility for leaving mail at a distant station when the operator is not present. The mailbox may be at the distant station or some other station from where the mail can be collected, over the radio link. Bulletin Boards are again self explanatory. Messages are displayed on a bulletin board (BBS) at a station which has the necessary computer and software. These stations can be connected to and the list of bulletins observed. The full text of the required bulletin can then be down-loaded as indeed can any files or computer programs listed as being available at that particular BBS.

In addition to PACKET there are other systems for passing data such as AMTOR and PACTOR, the latter being a combination of PACket and amTOR.

10.1. HF, VHF and UHF Links

Problems can be encountered when transmitting data over HF links. Signal fading can be more serious when data is transmitted than with voice transmissions. Whereas a human operator can decide whether a missed word needs repeating, a data system cannot so decide and is required to produce an error free message. On the other hand data transmissions require a lower signal to noise ratio than speech. A voice radio link can also be used to carry packet radio. However the highest baud rate that can be used will be dependant upon the quality of the radio link. This is the case when data is passed over the telephone network where the quality of various lines vary. A baud is the number of pulses transmitted per second.

On VHF and UHF circuits baud rates of 1200 to 9600 bauds are common. Because of effects such as multipath reception on HF the baud rate is lower, 300 bauds being common. An example of incorporating packet radio into a radio network can be seen in a unit developed by Dr S.A.G. Chandler of Warwick University, U.K. The unit can be used in developing counties which have limited telecommunications infrastructure, one network was established in the Bonthe area of Sierra Leone. The AFRICOM RADIO NETWORK CONTROLLER can be used to provide many very useful facilities on a radio network which would otherwise only have conventional voice capability. In its packet mode the unit enables the exchange of text messages between any two similarly equipped stations. If the stations are too far apart for direct contact then the messages can be automatically relayed via several intermediate stations. If the distant station is switched on, even though no operator is present, the text message can be received and stored.

Amongst other parameters the unit measures the stations battery voltage and solar charging current every 15 minutes and stores this data for the previous and current day. This data can be requested by a distant station and will be automatically transmitted to that station. The unit can measure the transmitter power output and VSWR of the aerial system. Again this information can be requested by a distant station.It appears that this unit is most useful, not only in the management of the station itself, but also for remote measurements of all the stations in a network from the maintenance headquarters.

An extension of the facilities envisaged by the author is that one station will collect daily, over the radio network, the 24 hour record of each stations parameters including transmitter power, VSWR etc. This

data can then be transmitted via a store and forward packet satellite (see para 10.2) to another country, which may have the overall maintenance responsibility.

10.2. Satellite Links

When communication facilities were first provided by satellites in the 1960's it was anticipated that this would result in the demise of short wave radio communication systems. Despite the vast number of satellites in orbit, providing many thousands of telephone and data channels, short wave radio is still in common use and is the only means of communication that many organisations can afford.

Much of the international telecommunications traffic is carried by geostationary satellites in orbit at some 33,700 kilometres above the earth. Using one or two of these satellites gives virtually instantaneous communications between any two locations on the earth, except in the polar regions. Such satellites can cost $400,000,000. When instantaneous communications is not vital then a less costly satellite system is available using satellites in low earth orbit (LEO). These satellites can be in orbit some 800 kilometres above the earth and cost some $1,000,000. Such satellites are only visible to an earth station for up to 15 minutes at a time and take about one and a half hours to go around the earth. Hence messages are transmitted up to the satellite, stored and then transmitted down when the required ground station is in view. The satellite is a flying mailbox and the technique used is called STORE and FORWARD.

LEO's are a suitable and affordable solution to the problem of transferring information between two places on the earth without dependence upon the telephone systems of the countries concerned. Telecommunications to, from and within some developing countries can be difficult and in some cases impossible. By 1992 two groups, Volunteers in Technical Assistance (VITA) and SatelLife, had provided a satellite. This had a store and forward facility and enabled text messages to be sent by various groups involved in helping in developing countries. LEO's were described by some people as "the poor mans satellite", but in this application they can be described more correctly as the "appropriate satellite".

The opportunities offered by LEOs are limited, e.g. a satellite can only be contacted from a particular point on earth whilst it is passing over that particular region i.e. within a range of some 3,000 km from the ground station. Then the satellite is usable for 1 to 15 minutes during each pass and there are 2 or 3 consecutive usable passes, occurring at 100 minute intervals, every 12 hours. The method of handling the text messages is by packet radio. It may seem that a usable time of 10 minutes is rather short, but with a baud rate of 9,600 and a duplex system, the packet radio system used can in theory send and receive 700,000 characters in 10 minutes. In practice some 500,000 characters have been down-loaded in one pass.

A ground station for the VITA system consisted of a computer e.g. laptop, a packet radio terminal node controller (TNC), a transmitter for 148 to 149.9 MHz with a power output of some 30 to 40 watts, a receiver for the 420 to 430 MHz band and a modest aerial array made of thin metal tubing. The whole system could be solar powered with the aid of a storage battery. The cost of a ground station was some $4,500 to $6,000 in 1997. Such a VITA ground station, provided the the UK based Baptist Missionary

Society, was rapidly deployed at Vanga Hospital, Zaire at the time of the ebola outbreak in May 1995. This facility provided a data link from this remote area to the international community, via satellite UO_14. Similar additional equipment was later provided from USA for a link to the SatelLife satellite HS_2.

At the beginning of 1997 the addresses of the organisations were:

Volunteers in Technical Assistance	Tel: 703 276 1800
Director of Informatice	Fax: 703 243 1865
1600 Wilson Boulevard. Suite 500	E-mail: vita@vit.org
ARLINGTON	
Virginia 22209	
USA	

SatelLife	Tel: 617 789 5455
Director of Operations	Fax: 617 789 4771
1360 Soldiers Field Road	E-mail: hnet@usa.healthnet.org
BOSTON	URL: http://www.healthnet.org/
Mass. 02135	
USA	

The World Administrative Radio Conference (WARC92) allocated 148 to 149.9 MHz on a primary basis, for use with small LEO satellites e.g. the VITA satellite. In the UK the radio regulatory body is the Radiocommunications Agency of the Department of Trade and Industry. This agency will not permit the use of 148 to 149.9 MHz by ground stations to communicate with LEOs. This is because they allocate the frequencies to the private mobile radio systems of the gas and electricity industries, for public safety and emergency situation communications. This was the situation in September 1992 but it may change with time. Current regulations can be obtained from:

Radio Communications Agency
Waterloo Bridge House
Waterloo Road
LONDON SE1 8UA

UK users are overcoming this restriction by sending their messages by e-mail to other countries e.g. Eire and USA, where there are ground stations in operation.

WHERE THERE IS NO TELEPHONE

Chapter 11. DISASTER AND RELIEF COMMUNICATIONS

Topics:

[Return to Table of Contents](#)

11.1. Need

If the urgency for a task determines the prioity given to it, the communication facilities for disaster and relief come high on the agenda.The rapid progress in, and availability of, smaller and less costly portable global communication facilities means that this is a continuously changing scene. However it is necessary to stop, consolidate a requirement and provision for that need. But, wherever possible, designing in the ability for the system to be updated rather than replaced when this a cost+effective exercise for the user. Many specifications have been written for such communication facilities.

11.2. History

In 1979 the World Administrative Radio Conference updated its recommendations of 1971, relating to the use of satellite telecommunications for disaster situations. The belief was that "the rapid availability of reliable communications immediately following a natural disaster would prove helpful in saving lives". Mention was made of the CCIR study of 1974+78 for a "transportable earth station" which could be shipped by air and not exceed some 7 to 10 tons.

By 1984 equipment size had been reduced and an experiment was performed in Swaziland, using a land

mobile facility. This consisted of a 'ship earth station' mounted in a Land Rover, with an extended roof area at the rear. A portable generator provided the electrical power and the system could be operational 5 minutes after the vehicle had been parked.The cost of ground stations is an important consideration for relief agencies. At the Disaster Communication conference, held at Tampere, Finland in 1991, the US$ 35,000 cost of an INMARSAT+ portable earth station was considered too high.

11.3. Today

The situation in 1997 is that portable earth stations exist in the form of SATPHONES, costing from US$4,500 to US$9,000. The whole system is contained in a small case with the lid housing the antennae, having an area of approximately 0.05 square metre. The weight, including the rechargeable batteries can be some 2.5 kgs. Additional charges can be incurred for import into, and for use within, some countries.

11.4. Tomorrow

By the year 2000 there should be several satellite communication systems operational which can be accessed with handsets, which resemble the mobile phones of today. The satellites will be in either low earth orbit (LEO) at a height of some 1,000 kms or medium earth orbit (MEO) at some 10,000 kms.

11.5. Information

A book has recently been published, in June 1996, which deals with the whole subject of communications for disaster and relief. The book is DISASTER COMMUNICATIONS by Mark Wood of "The Disaster Relief Communications Foundation". Ordering details can be obtained on Web page: http://ourworld.compuserve.com/homepages/mark_a_wood

The book is obtained from:
ASSOCIATION OF PUBLIC SAFETY COMMUNICATION OFFICIALS (APCO) with USA telephone: 904.322.2500 or fax: 904.322.9766 the cost is US$ 40 plus shipping.
Because this book covers the subject in detail, no attempt is being made in this chapter to duplicate the subject. Instead the Index of the book is given in the following Appendix so that the extent of the contents can be seen.

WHERE THERE IS NO TELEPHONE

by
JOHN R.G. CORBETT
C.Eng., M.I.E.E.
Communications Engineer
C.B.F.Z.- E.C.Z.
Republique du Zaire

A handbook on short wave radio and LEO satellite communication for missions and aid agencies in developing countries. The book describes how to plan, select, install, operate and maintain a radio telephone network in these countries. It deals with the peculiar and special considerations necessary for reliable operations and will assist both technical and non-technical personnel.

Revised April 1997
This www copy does not include the 34 diagrams.
ISBN 0 901733 15 6

Table of Contents

ACKNOWLEDGEMENTS

The author wishes to express his gratitude to the many unnamed individuals and organisations who have provided information concerning their experiences of radio communication in central Africa and to the following,

African Inland Mission - Kenya and Zaire
Church Missionary Society - Tanzania and Zaire
Disciples of Christ Church - USA and Zaire
Elim Church - UK and Zaire
Medical Missionary News - UK and Zambia
Mission Aviation Fellowship (MAF) - Tanzania and Zaire
OXFAM - UK and Zaire
Peace Corp (USA) - Zaire
Regions Beyond Missionary Union - UK and Zaire
Salvation Army - Ghana
Seventh Day Adventist Church - Nigeria
Worldwide Evangelist Crusade - UK and Zaire
Wycliffe Bible Translators - Sudan

To my wife Margaret who translated into a readable form the often rather technical handwritten manuscript and for preparing the text on a wordprocessor.

To the British Embassy, Kinshasa, Zaire for providing the word processor for a period of nine months so enabling this book to be written.

To the Communaute Baptiste du Fleuve Zaire (CBFZ) for the opportunity to wok with them for two years.

To the Baptist Missionary Society for sponsoring this book.
Copies of this book available from:
Baptist Missionary Society (Publications Dept)
PO Box 49, DIDCOT, OX11 8XA, United Kingdom.
Tel: +44 1235 517700
Fax: +44 1235 517600
E-mail: mail@bms.org.uk

FOREWORD

It is often difficult for the uninitiated to imagine life in the jungles of Zaire, Africa. Oh, certainly the imagination soars to think of the great rain forests, pygmy natives, river boats etc. But it is easy to take many things for granted concerning the many conveniences most of us have experienced in the developed countries of the western world. The one aspect I believe we take for granted the most is good, or at least adequate communications. Six years of living in Zaire, where virtually no telephone link exists outside the capital city of Kinshasa, has made me appreciate what a precious commodity this is. The HF radio fills the crucial gap left by no telephone availability. This HF radio is no recent marvel of the modern electronics revolution, having been in use since before World War II. Yet its sophisication can not be taken lightly. In order for one to enjoy the benefits of good communication via HF radio in Zaire, or in any other tropical environment, for that matter, careful attention must be paid to its installation and operation. For most of us without formal electronics education, the successful of an HF unit seems mor e shrouded in mystery...something more akin to art than science. Fortunately, John Corbett has come to our rescue with this excellent guide book to HF radio operation. Everything is here that is necessary to knowing how to install and operate this type of equipment. The book is written so that readers from many levels of electronic can benefit from it. Those who want merely to install a new unit can read those applicable sections. Whereas someone wanting more technical information to maximise their units efficiency will find that as well. Although it is written from the perspective of operations in Zaire, it is basically applicable to operations in any underdeveloped, third world country. John is uniquely qualified to author this manual. His formal electronics background coupled with his handson experience of radio maintenance here in Zaire has given him the knowledge and insight necessary to the task. Those of us in MAF, where our flight operations depend so heavily on radio, have deeply appreciated his aid and assistance. And now, we will benefit even more from his final contribution of his worthwhile ministry here in Zaire.

Jon Lewis
Area Director, Central Africa
MISSION AVIATION FELLOWSHIP
Kinshasa, Zaire
24 August 1988

INTRODUCTION

Where is your nearest telephone? If you are in a rural area of central Africa this could reasonably be 300 kms away and involve a journey of 20 to 30 hours by four wheel drive vehicle on tracks through the

forest. Having reached the telephone the next question will be "Is the telephone working?"

Churches, missions, aid agencies and commercial organisations have overcome the lack of communications by installing their own private radio telephone networks. There are many reasons for having radio contact with people in remote locations. Some reasons are financial and can be shown to be cost-effective, for example it can result in a reduction in the number of times people have to undertake long and difficult journeys not knowing whether or not the person they wish to meet will be there to greet them or if the boat or plane they wish to travel on goes next day or next week!

Another important reason is that of human well-being. The ability to talk with your fellow workers and friends some distance away makes you feel part of the whole community and reduces the feeling of isolation. It is also invaluable in times of urgent medical need, providing both a means of obtaining expert advice and of requesting supplies. In addition should a need for evacuation arise, either for medical or other reasons, instructions can be quickly passed on the radio.

The aim of this book is to help present users of radio networks to make the best use of their existing facilities by improving their effectiveness and reducing the probability of failure as well as to give advice to future users before they plan and purchase a radio system.

The book covers basic theory of short wave radio communication very briefly. For further study there are many books available on this subject, a good general description can be found in amateur radio handbooks. It is the information not generally contained in textbooks that form the majority of this book. The special needs, safeguards and peculiar conditions that arise when a radio network is operated in a developing country are dealt with. An indication of these conditions is given by the following extract, freely translated from a magazine article in French:

"There is, in general, in the population no conception of maintenance of equipment. What is broken and no longer works is repaired moreover often repaired with ingenuity but it is rare that they take care of equipment and so avoid breakdown. In these conditions the length of life of equipment is seriously reduced."

In writing this book the author wishes to share the knowledge and experience that he has gained after twenty years association with a missionary society's network from the home base in Britain. After two short visits in 1980 and in 1983 he has spent two years from October 1986 working on the network in Zaire. He has been looking at ways of increasing reliability of equipment and improving operating efficiency as well as studying the reasons for failure. These investigations have been carried out while doing the routine maintenance and repair work and while installing new equipment so that the observations are based on Sactual experience. He has also gathered information from the experiences of others visiting both Tanzania and Kenya to learn from users there as well as obtaining information from a questionaire sent to seventeen different groups in six African countries operating between them over two hundred radio transmitters.

The person scrutinising the book from the technical standpoint may consider some aspects of radio communications have been over-simplified whilst in other cases he may think that the obvious has been stated. However experience has shown that it is very necessary to establish a few simple facts on the subject into peoples minds. It is hoped that this book will be of help to a radio technician trying to work in a situation very different from the well-equipped workshop he has been used to and also that it will be of help to those who have no prior knowledge of radio so that they can efficiently plan and maintain their network. It is not a sophisticated textbook, it is simply a means of communicating lessons learnt here in Africa. Had it not been produced now in this form it is unlikely that it would ever have been produced.

[Table of Contents](#)

DISASTER COMMUNICATIONS

PART 1 GLOBAL

First Edition, June 1996

Mark Wood, G4HLZ

Disaster Relief Communications Foundation

Table of Contents

1 Global

5 Legal Issues

_____

CHAPTER 1

1.1 INTRODUCTION

The fact is, without communications, you don't have an organisation, you have a disorganisation.

Everyone involved in disaster, aid and allied voluntary services is aware of the huge waste and nuisance caused by poor communications in the field. Time is wasted driving around looking for staff and equipment. The rapid deployment of the right equipment in the right place at the right time is impossible. Managers can have no idea what is happening once people leave their sight. Without eyes, ears and a voice, they are just by-passed by the staff at the front end of the job. The staff in the field know there is no back up, no help coming from outside, and would rather valiantly improvise than spend days in a possibly fruitless search for help.

The ease of communication in a developed city is seductive, so much do we take it for granted that it becomes like the wallpaper in the office (no cheating, do you remember the pattern?). It is a serious but

common mistake to underestimate the complexity and importance of communications, that is why The Disaster Relief Communications Foundation **(DRCF)** continuously researches and reviews the whole matter, calling on expert opinion to keep their advice up to date.
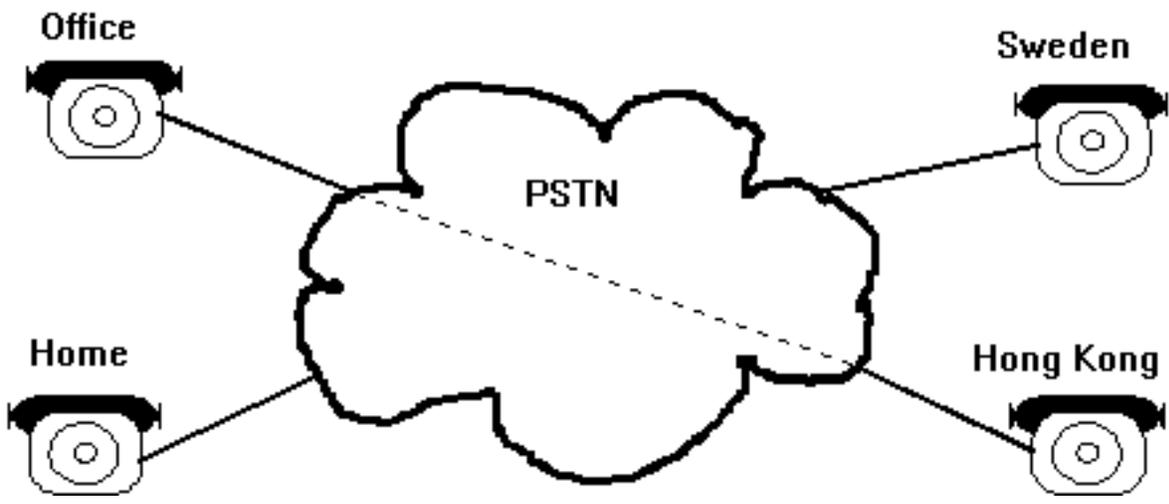
Fig 1 The Public Switched Telephone Network (PSTN) is the largest single structure ever made by man.

Communications may seem like only a third world problem but, even urban areas will find their normal (Landline) phones via the Public Switched Telephone Network (PSTN),[1] Mobile Phones[2] and Telex systems out of action in the case of most types of disaster because the cables may be damaged or there may be no mains to power the telephone exchanges.[3] A perfectly working PSTN system is usually designed so that no more than 5% of the phones connected to it, can be talking at the same time. During a crisis, there may to too much traffic for it to handle, and so it will become overloaded, so you will keep getting unhappy sounding tones when you try to dial. It is not even safe to take 'landline' services for granted in some locations of operation as they may be rather poor or even non-existent.
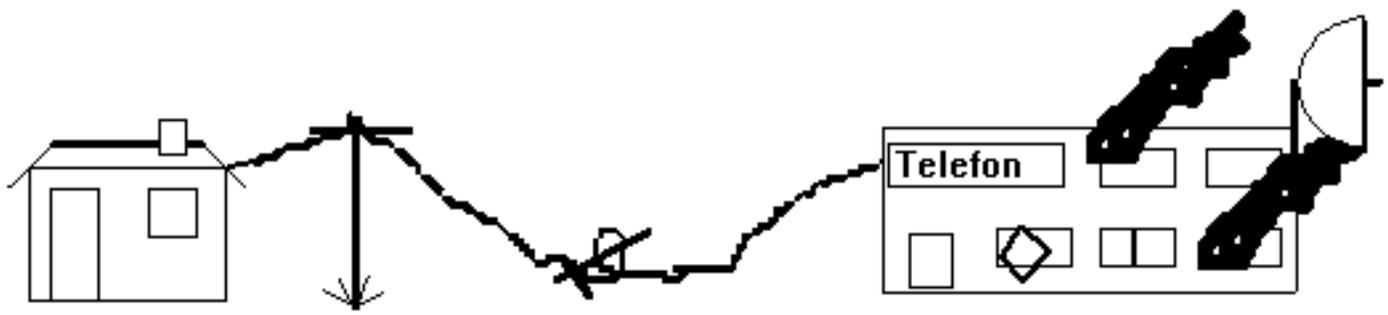
FIG 2 The PSTN actually depends on telephone exchanges and lines on the ground which are vulnerable in times of crisis.[4]

=REPORT=REPORT=

Cyclone "Hollanda", Mauritius, February 1994. To prevent wind damage, the satellite dishes at the earth station had to be parked in a horizontal position, they could not then point at the satellite and thus all international

```
communications to or from the island state was cut off. Despite these precautions,
it took three days to repair the damage, in the mean time, it would not have been
possible to summon help from outside. Technological and commercial pressures are
causing more centralisation of critical network elements, leading to their
vulnerability in times of crisis.
```

So we must take our own communications that don't depend on any lines or power from the area. We also need something that can be set up in a few hours, anywhere in the world, with no previous notice or time to plan elaborate engineering. The solution must also be portable enough to be quickly moved into position by a small number of people, who will be too busy to spend hours with complex technology.

Most important, it must be **affordable** to the organizations sponsoring the relief effort .

The subject of **Local** or Tactical communication, short range communications between the team members or a local cluster of camps for example, is a separate one. This has been given consideration in part 2 'Disaster Communications- Local'

I will try to mention just about every practical system we at DRCF have ever heard of. Just because we mention (or don't mention) a system, **this is not an endorsement of the idea**. We merely acquaint you with the facts and leave you to decide what you think is best for you. Reading this won't make you an expert, but it will help you and your experts to come to a better understanding

The Disaster Relief Communications Foundation (**DRCF**) is a Non Governmental Organisation (NGO), a small registered charity, and we admit that our resources are limited. However we do try most conscientiously to make sure that what we say is generally agreed to be true, or at least valid opinion, by experts in the relevant fields. However if you know of something better that we do, we most sincerely welcome input, for future revisions of the book.

The powerful image of Captain Kirk nonchalantly pulling his communicator from his belt and effortlessly contacting anyone anywhere is not just a dream. By the turn of the century, systems like IRIDIUM, GLOBALSTAR, ICO, Teledesic, Ellipso, Odyssey,Constellation and many more, will bring just that and give hand held mobile phones that really work anywhere in the world. Then, there may be less need for books like this as there may be one obvious way to communicate with anyone anywhere, but as this service will not be available until 1998 at the earliest, and it's effectiveness is as yet unclear, we will consider those services available for our purposes at the time of writing.[5]

There are two methods.

- SATELLITE SYSTEMS, (we will talk mostly about the INMARSAT system)
- H.F. RADIO, (we will consider Private radio, Marine radio, Gateway and Amateur radio)

1.1.2 What Is 'Disaster Communications'?

The needs of disaster communications and aid communications are in some respects similar, but the operational needs of the two distinct types of organisation are quite different. This document is about disaster communications, but the information is applicable to aid users also, provided the differences are understood.

It is the target of disaster communications units to be on the scene of the callout not later than 24 hrs after the first alert. This sounds like plenty of time, until we remember that the personnel involved are Volunteers [6], who first need to be contacted by various means, usually by phoning around by their group leader. Then their employer may need to be contacted to get permission to be absent for the next two or three weeks and family business re-organised, grand parents found to look after the children, clothing and equipment packed etc, all with the phone ringing like mad as the team is assembled.

> *Author's note:-* *These definitions for disaster, aid and Emergency communications are my own invention, for use only in this document. Official definitions vary, but the UNDHA prefer the term "communications in the Acute Phase of an emergency" where I mean disaster communications. and "Long term Emergencies" where I use "aid". Normally there is no separate definition of "Emergency Services" made in legislation. By this I will mean state run and funded organisations. The word "communications" can mean forms such as Broadcasting and other media. For point-to-point communications, the term* *"**Telecommunications**" is preferred.*

Meanwhile, a deadline emerges, a transport plane must take off with the men [7] and supplies, and with only about four hours to spare, the equipment must be found from its storage place and brought to the mustering point. There is no time to test, no time to plan and certainly no time to train on complex technology.

This can be done only if the specialised teams have already got everything organised well in advance. The team members must be sufficiently familiar with the equipment, that once in the field, they can repair anything not working, or more usually, improvise things that somehow didn't make the deadline. They won't know how busy they will be, who and how many teams of what nationality they will serve, or for how long.[8] Networks will have to be created as they go.

A successful operation can only be achieved if the hardware taken to the field will certainly work without prior planning or engineering and if the staff are professional and self reliant.[9] Planning is impossible because the team would have no way of knowing where they are going in advance, or what existing systems may be still working on the site, or if anything is available at all, even electricity.

On the plus side, the operation can be expected to take about 1-4 weeks, so a temporary or makeshift installation is quite satisfactory and elaborate permanent systems designed to be in place for months or

years are not needed. Also, some governments waive or shorten the licensing and Import duty requirements for the equipment, (if you remember to ask nicely).

Finance is a tricky question, from where and when the expenses will be met is often unknown.

```
=REPORT=REPORT=


In one case, a small British NGO found their Inmarsat-A sat phone to be the only
working communications at the site of a disaster. This soon attracted attention
from desperate officials from other organisations to borrow it for 'one quick
call'. On return to Britain, the bill was beyond their resources to pay, and it
was very difficult to prove who should pay what, the result being very
unfavourable for the NGO. The resulting severe financial strain nearly destroyed
the whole organisation. Fortunately they survived wiser but much sorrier. If
people borrow your communications facilities then make sure you know who they are,
how much they owe you and how and when they will pay. This goes for your own
people too, Satcomms is highly intoxicating, you must tell your client when he has
had enough and close the bar!-IRC
```

1.1.3 Differences to 'Aid' Communications

By contrast, aid organisations usually have weeks or months to plan their operations and have a good knowledge of where they are going and what to expect when they get there. They even have staff in place to carry out the operations needed, and also budgets in hand to finance expenses arising.

This means that proper planning and even surveying can be carried out before installation so that a well engineered installation can be done. Networks can be devised, and the recent history of the operation will guide as to with whom and how to communicate.

It makes no sense to have permanent Radio Officers [10] dedicated to communications in a refugee camp (unless traffic levels are high), so after installation, training of the staff who will use the equipment and become Radio Operators [11] or just casual users is most important.

The installations will be likely in place for some years, so a durably engineered solution is needed. Also the correct permits and licences from the host government will be needed by such an installation.

1.1.4 Emergency Services communications

In this book, I will not mention 'Emergency services' communication much at all. By Emergency services I mean such as the local Police, Ambulance Service, Fire Brigade, Civil Defence, Army etc. These organisations have their own existing communications system and networks. It is most likely that they will be working in their usual territory, so their normal VHF or HF radio system will be in range. These will however be supplemented by additional mobile control rooms, reporting centres etc, but again they

will be using their own equipment kept in reserve for emergencies. Statutory emergency services will also have many full time technicians on call to set up and run their networks, so they are unlikely to have very big communications problems.

Experiences show that statutory services are highly self contained. Sometimes however, this has the down side that they may not be trained to see the need to help you by providing equipment or air time on their network. Also their networks will be configured to funnel information to their own control centre rather than the PSTN, so even if they do let you use their radios, you will only be able to send messages to their HQ. Maybe they will be happy to pass messages on for you but maybe not. This will depend on the attitude of the government of the state you are operating in and if a UN OSOCC is operating.

You may find it difficult to communicate with their networks and may find them hostile to anyone trying to do so as they are trained to ignore any call sign that is not on their briefing list. The best policy is to depend on your own network and let your organiser speak to theirs on a peer-to-peer basis to organise a means of communication with them.

A further problem may be language. If you are working with teams speaking another language than yours, protocol may require that you work through an interpreter at high level in their organisation.

1.2 WHAT DO WE WANT?

Knowing the type and amount of messages you will want to send and to whom is the key to deciding which of the many systems to use, so let's briefly look at some of the factors in choosing the message types.

1.2.1 FOR PHONE

Most NGO workers I have asked (who were not communications experts) have expressed a preference for voice communications and by that they mean phone calls via the PSTN. The phone has much to commend it. Giving two way, 'live-as-it-happens' conversation [12], means that problems can be discussed and many alternative ideas brain-stormed in one conversation. It also has the advantage that the caller has the psychological reassurance that the person he[13] wanted has heard and understood the meaning of the message and besides, hearing the voice of a person you know is very warming.

Furthermore there are phones everywhere in the world and it is highly likely that the person you are calling has one at home should he be there. It is also the best way of reassuring relatives at home that you are well and happy in your work, and putting their anxieties to rest.

```
=REPORT=REPORT=
```

Do regularly call your sponsors and family. Just 3 Min. every week or two is enough to hear your voice and won't cost much.[14] Don't make a date or 'sked' you

can't keep, as not hearing from you when expected will make your family literally
sick with worry. If overdue, get a message via someone somehow so that they don't
worry. If you are asked to pass on an 'I'm OK mum' message from someone you meet,
make sure that you do.

1.2.2 AGAINST PHONE

On average, phone calls are a very inefficient way of communicating specific technical information,
facts, tables of abstract figures and numbers etc. We must realize that a phone can ring just one other
phone in the world. You the caller must know the number to dial, taking the risk that there is a person to
answer that phone and that the person you need is near to the phone that you have just dialed. Sometimes
the voice from the mobile station, whether by SSB radio or satellite may sound very strange to the new
listener. Things may be awkward if the called person is not used to the simplex procedures or digitised
voices with long echo and delay.

We are expecting the person at the other phone to drop what he is doing now and rush over to the phone,
hopefully with pen and notebook in hand, and be able to answer your questions 'off the top of his head'.
One problem is that the person you are calling is sure to be very busy, but you have no way of knowing if
your call is more urgent than what he is doing right now. If he cannot answer questions now, we are
relying on him to make notes detailed enough and accurate enough to contain all the information he
needs to find the answer, then rush back to the phone with the reply.

Time is very important here as a satellite phone call may cost up to USD 8.00 per min. you can see that
only 5 min. of wasted time costs USD 40! Even if the person is not there at the time and someone else
takes notes for you to pass them on, we are relying on someone being in the office at the time, and
making notes in handwriting clear enough for someone else to read, then finding the time to remember to
pass the message on.

Another big problem is that of working across time zones. If you are wishing to call a person from their
office number, they may have a 24 Hr watch, or they may be available only during office hours in their
country. It may be that you are much too busy at this time, on the move and out of communication, or
only have a small window of time to be available for communication yourself. The solution is to call the
person at home, but first you must have the number and the person's permission.

1.2.3 For Text

By a text message I mean a written message containing only letters of the alphabet and numbers. An
example of a text message is a telegram or a Telex but also includes Electronic Mailing. The advantages
of communicating by text are many. For example, the sender[15] does not have to worry about the
availability of the person to whom the message is to be sent (the addressee), because the message can be
passed on later.

Time zone and office hours problems are no longer a concern as the message can be sent at a time convenient to the sender. This is important as the sender will have his work set by the demands of the field, or probably be traveling much of the time and only be able to set up and use communications equipment when an opportunity presents itself.

By sending a text message, the sender can go through the ordeal of setting up his system when he feels he is ready to do so. The information can be compiled off line in a personal computer[16] in advance and 'beamed up' when ready. The sender is forced into the discipline of compiling his message in a logical order and presenting it in a meaningful way. The sender also has the opportunity to edit and review the message before it is sent. Just as important is the need to formulate accurately. This prevents the quite serous problem of inundating the addressee with lots of details and incoherent 'odds-and-ends'. As my grandfather, who was a craftsman, used to say, measure it twice, cut it once.

The sender can have the fullest confidence that the addressee or addressees have an accurate 'hard copy' (on paper) of the full text sent rather than a few scribblings of what someone else gleaned from a phone call and that as the message is copied and circulated, it will not be distorted as it is passed round.

If the people in the field have the luxury of a fixed location. then they can leave their communications equipment switched on and leave it unattended[17], freeing them to concentrate on their primary mission. They can be secure in the knowledge that if a message should come for them, it will be ready for them to look at and digest at their convenience, rather than having to assign someone to 'baby-sit 'the phone.

Text message systems are not generally 'real time' systems (though you can have this if you have a Telex, which also offers full duplex links). This has the advantage that having received a question, there is not the pressure for an immediate answer that the phone produces. The addressee has plenty of time (off line) to make a considered and full reply rather answering in haste and repenting at leisure.
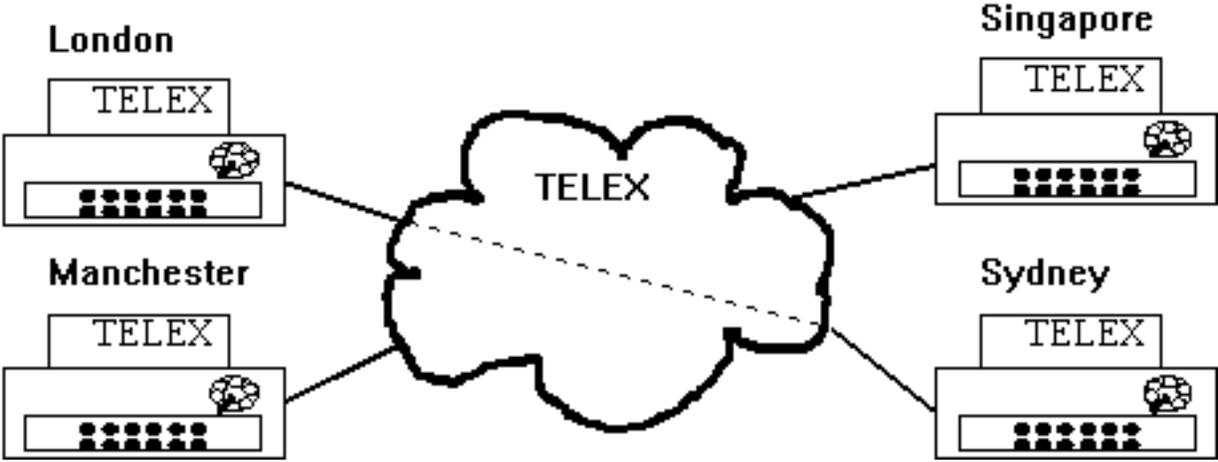
FIG 3 *The international TELEXTELEX system is the text version of the PSTN. Any TELEX can 'dial' any other telex and leave a message even if the receiving machine is unattended.*

It is MUCH cheaper in terms of call charges to send a text message. For example, by satellite the average short message cost USD 6-8 whereas the average short phone call will be USD 20-60. Text is the system supported by INMARSAT-C, which is the cheapest satellite system. A text message can be sent to any TELEX machine, Electronic Mailing system or computer with a MODEM, or text can be sent from a mobile unit in the field to a FAX machine on an ordinary PSTN landline back at the office, (called SEMI-FAX)

Language problems are very seriously difficult to overcome by phone with misunderstanding being the usual outcome. A text message may be handed to someone more competent for translation, giving the addressee more confidence in his understanding of the meaning.

1.2.4 AGAINST TEXT

The lack of human contact means that it is less reassuring than the phone. For those who are computer literate and used to keyboards, screens and commands etc. it is a natural way to communicate but for others it can seem rather daunting to learn.

Text messages need some kind of hardware to receive them back at the office, a TELEX machine, FAX machine or a MODEM attached to a computer or Electronic mailing system. There are obviously fewer TELEX or E-MAIL terminals than FAXes or Telephones at the time of writing, so this has to be taken into consideration when deciding who the addressee is.

While most types of communications gear are very tough, the Lap Top[18] usually providing the terminals are not. Ask anyone who depends on Lap Tops and they will tell you what I mean. Computers also need regular charging, and a programme of backing up the hard disk to floppy disk. Remember that if your PC fails, nothing will work at all. The wisest thing is to carry at least two, both loaded with identical software and compatible hardware. You will have to test out both computers with the communications gear as small glitches are easier to fix at base than in the field.

```
=REPORT=REPORT=
```

```
Three times during the writing of this document the whole document was nearly lost
due to computer problems; this despite using only licensed software. In one case a
virus prevented the operating system on the PC from booting up and the hard disk
had to be reformatted. The document was saved because of a regime of back up to
floppy disc. BEWARE, computers can just CRASH (refuse to work) and it is the job
of an expert to fix them when this happens. In the field, where there is seldom a
Local Area Network (LAN), exchange of discs is frequent. Check each disc for virus
before running it. Sometimes exchange of files is impossible because of
incompatible formats. As far as you can, prepare files in the plain text ASCII
format, or convert them to plain text (*.TXT) before exchanging them. Other
formats look prettier and more professional, but plain text is the format least
likely to cause problems. (Sending unreadable or corrupt files won't make you look
```

```
more 'professional').
```

Any FAX machine back at the office can be used to receive a text message automatically (by Semi-Fax), but to send a text message from the office to a field team with a text terminal by fax, the message has to be faxed to BT MARINE's Portishead Radio station and then TELEXed from there. Alternatively faxed to a bureau or friendly Telex operator. There are plans to automate the sending of text only faxes in future. Text messages can not support graphical information such as maps, photos, diagrams etc.

A less obvious problem is that the field team will need to carry a printer. This is needed in order to print out the message on paper so that it can be passed to the addressee, if he is not able to come to the computer screen. Printers will need interface cables and Printer Driver programmes, some kind of power supply system, and plenty of the special paper and ink cartridges that the model needs, all adding to cost, bulk and weight. Take care to purchase only a model recommended for portable operation as many models, especially laser printers, will fail if moved roughly.

This fact also limits the usefulness of large data volumes, such as detailed maps and diagrams, in the field. A small portable printer can not do much with such documents. To printout anything worthwhile may need very large, heavy and expensive mains driven colour printers.

1.2.5 FOR FAX

FAX is not a separate system of its own like TELEX , but uses ordinary PSTN Phone lines. The FAX machine (Facsimile or Telecopier) scans the picture and sends it as data by a built in MODEM, taking usually less than 1 min per page depending on how much detail there is on the paper.
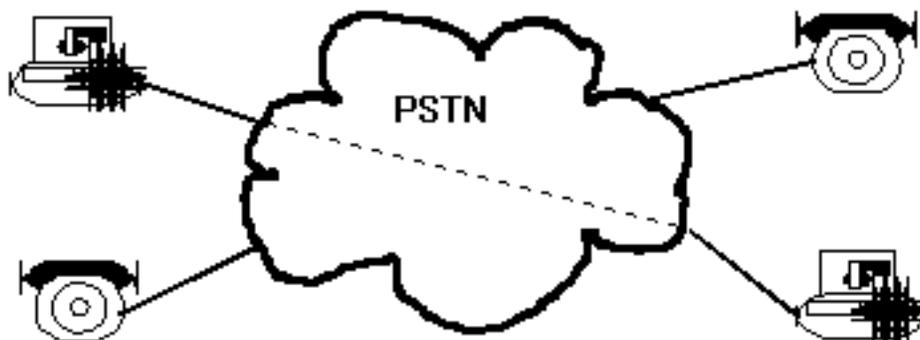
FIG 4 *FAXes use the ordinary PSTN network.*

It is the only system capable of sending graphical information such as pictures, maps, diagrams etc., and the only one sending handwriting in script. An important attraction is its ability to send messages in, for example, Chinese or Arabic text.

```
=REPORT=REPORT=
```

The CICR (International Red Cross) prefers text messaging as a rule, but has found one advantage of FAX. Sometimes a convoy needs to pass a checkpoint or border and the local official is reluctant to allow this without the properly accredited certificate or form. By using fax a copy of the form complete with the stamps, seals and signatures may be shown to the official and this may sway him.

There are now a large number of FAX machines in existence, most small companies have them as do many people working from home. Many FAX machines also automatically stamp the FAX with the originating FAX number and date/time. A journal also keeps account of how many messages are sent or received from the FAX.

From the point of view of convenience, as operators are not required to receive faxes, all the same advantages apply as for text. The field team can leave it switched on, unattended and check for messages periodically.

FAX can be supported by INMARSAT-A, INMARSAT-B, and now INMARSAT-M though a special port has to be provided in the terminal for this. HF radio does not offer a public two way FAX system via PSTN at the moment, though there are projects working on this.

As an added bonus, most FAX machines offer a facility called Local Copy, meaning that it can also be used as a photocopier and some models can also function as a computer printer and image scanner.

If you do not wish to carry a Fax machine, any PC can be programmed to generate and receive FAXes. However this usually means that you can't use it for something else while it is waiting for an incoming call. The problem is that you would still need a printer to hard copy the FAX , to show it to someone who cannot come to the computer.

1.2.6 AGAINST FAX

You will need to carry a FAX machine around with you, and plenty of the special paper that some models need, as ordinary paper won't do for some models, and the correct paper can be hard to find out in the field (it even varies from model to model). You must take care to buy a portable model as some plain paper FAXes are sensitive to bumps and will just turn out grey rubbish once moved. The machine must be sited somewhere well-lit, dry and not windy (or incoming paper sheets blow away before being read).

=REPORT=REPORT=

The Camel Trophy communications team reports that in very hot and humid conditions the fax paper tends to become sticky and won't pass through the machine. The solution is to pass two sheets through at once.-Transat.

Technical people tend to be less enthusiastic about FAX than, for example, electronic mail, because FAX

is not very efficient in its use of bandwidth or data. For example it can be very slow over a Standard-M terminal. A big problem is, when you have received a FAX, there is nothing you can do with it but read it and store it as paper. You are not well advised to pass it on to someone else by FAX as FAXes become unreadable after only about 4 re-generations. It is better to ask the sender to send a copy of the original to the intended recipient. Even if you scan the FAX into a computer, it can't read the message, which it treats like graphics.[19] This means it can't be inputted into a word processor unless the whole thing is re-typed. Another problem is power, FAX machines need mains power, or regular charging if they have batteries.

1.2.7 SEMI-FAX

This is an automatic service provided by BT. It takes TEXT messages from its INMARSAT-C terminals, or from HF Radio Telex terminals,(which are in TELEX format), automatically converts them into a FAX image and sends the FAX to the number you specify. The problem is that it can send only text, no pictures and only works one way (from mobile to FAX machine).[20]

1.2.8 ISDN

This stands for Integrated Services Digital Network.(ISDN)[21] It is one part of this new Data super highway that everyone is talking about. President Clinton of the USA thought it so important that he assigned his vice president, Alan Gore to supervise its implementation. It will bring remote control libraries, video phones, and more besides in the future.

A big problem is that in field conditions you may not have the hardware to process the information. Also there may not be the time for anyone to generate or really digest the information.

ISDN is of use mainly to industrial / scientific and journalistic users at the moment and is supported only by INMARSAT-A, INMARSAT-B and INMARSAT-M . I have not included it for further consideration at this time. However if a need should arise for ISDN in a disaster or aid role, as it surely will in the future, the technology is there and I will be watching with great interest.

1.2.9 Internet Electronic Mail

'The Internet' is a network of computers connected together, mostly by ISDN circuits. I could write a fat book about this, but to simplify, it is a sort of super TELEX. There are however, some important differences to mention. You would use your personal computer to contact a 'Host', (an ordinary computer which is running a special mailing software and is connected to the Internet), either by Local Area Network (LAN) wiring in your building, or over a dial up PSTN phone line via a modem. You would then send you message to the host. The start of the message must be the Internet address of the addressee. This is not a number, as in TELEX but something like 'eus.eusmwoo@memo.ericsson.se', which is my address. (You are welcome to contact me this way if you wish). When you have finished your message,

it is passed from host to host until it reaches the host which is the mailbox for the addressee.

It then remains there until the addressee next connects his computer to his host, when the message is then read on his computer screen, or printed out. The problem is that there is not always a bell or bleeper to alert the user to log on (connect up) and retrieve his mail, so he may be unaware if there is an urgent message pending. Although the message takes a few seconds to go to the mailbox, it could be hours or even days before the user logs in next, so it is best to alert the user in some other way if you have sent an urgent E-Mail message via Internet.
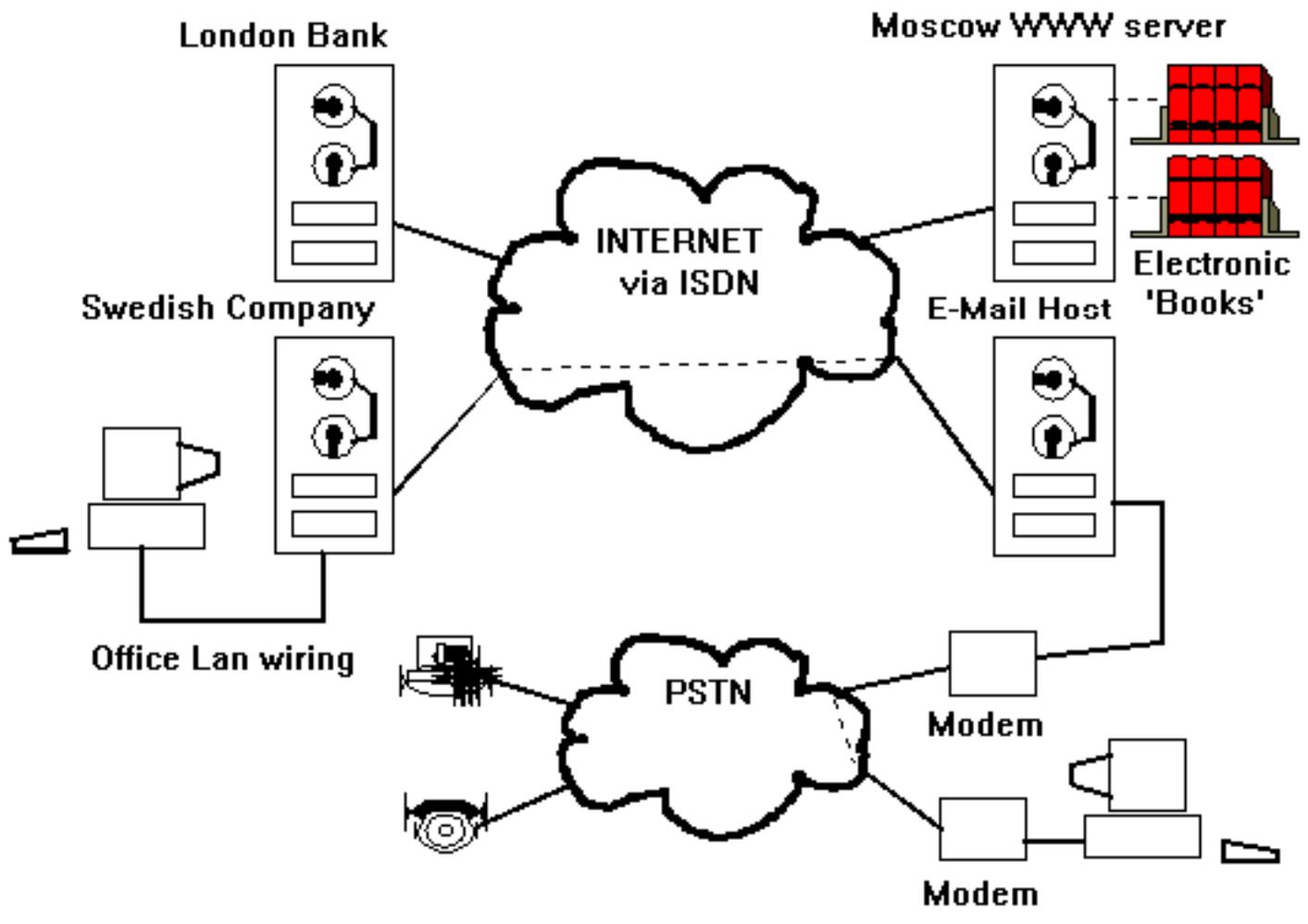
Fig 5 ISDN is like a 'phone system' for computers enabling them contact each other. This is how services like Internet and World Wide Web are supported.

1.2.10 World Wide Web (WWW)

Another use for Internet is to download computer data files from disc drives in machines far away from your own, by so called 'File Transfer Protocol' (FTP). There are many ways of doing this but I will not elaborate on them here because they are not strictly communications related functions. The World Wide Web (WWW) uses a special form of Internet signaling, called Hyper Text Transfer Protocol (HTTP),

designed for remotely reading 'Electronic Books'. Special 'WWW Servers' have electronic books, including pictures and diagrams, available for browsing at the click of a mouse.

This book, and others by the DRCF will be readable on the web. disaster users could read maps and information about the area where they are working, for example. The WWW system is still quite new (in 1996) so the information is quite patchy at the moment. My prediction is that once money starts to be made on it, it will balloon to stupendous size and become one more of those thing we can't live without.

When you are browsing through WWW in your office, over your LAN that is one thing, but trying this over a satellite link or HF radio link is quite another. WWW files often contain detailed colour pictures or graphics such as logos at the top of each page. These use much, much more data than the whole of the rest of the document! Wether you pay by the kilobyte or by the minute, you pay very dearly for every byte you download to the field. You must resist the temptation to browse aimlessly with WWW in the field. The solution is to let someone at HQ browse for the information for you, then edit and send a digested version to the field. Or you can programme your client application (Mosaic or Netscape) not to download images unless you say so. Don't be tempted to download something that 'looks interesting' unless you are sure that someone will have the time to digest the information.

The best book on this is 'Internet for Dummies', see Bibliography.

1.3 Networks

An important subject that you ignore at your peril is Networks. Both HF radios and Satellite terminals can 'plug in' to the international phone system, but the problems don't end there.

The chances are that the people you need to speak to are on the move themselves, like you are. Do you know what phone number they can be reached on? Are they using radio, or satellite terminal, phone or Telex? Who is their assistant and who is their manager?

Who has the equipment you need, where is it, when can you expect to have it ? Who needs the equipment that you seem to have and can't find a use for? Why are you twiddling your thumbs when you know you are desperately needed elsewhere? Do your sponsors know where you are or are they desperately trying to contact you?

To compound the problem greatly, virtually none of the established systems allow communications while on the move in a car. Most types of gear have to be unpacked and set up before use.[22] Because of power budgeting, things can't be left on indefinitely when not in use and security aspects go against leaving things un attended. Anyway, there is no point in setting up your very expensive satellite phone if you can't be in ear shot of the bell![23]

In fact, communications gear may be only switched on for a few hours a day, once or twice a day or when convenient. Do you know when the station you want to talk to is 'on watch'?

To save money, HF radio can be used directly from point to point in the Simplex mode. Do you know what frequencies and at what time your colleagues monitor? There are usually daily 'round table' 'chat shows' where local teams can chat about the problems of the day and help each other. Do you know when and at what frequency they occur?

If you tried to address all these problems when out in the field, you could waste hours of each day and a lot of money on the necessary calls. Obviously someone back at base, usually called a traffic dispatcher needs to track all of this information and funnel it back to you. That person should be the sort of person who is not shy of making a nuisance of himself, being a real nosey parker, minding everyone else's business and hoarding every scrap of information and gossip he hears.
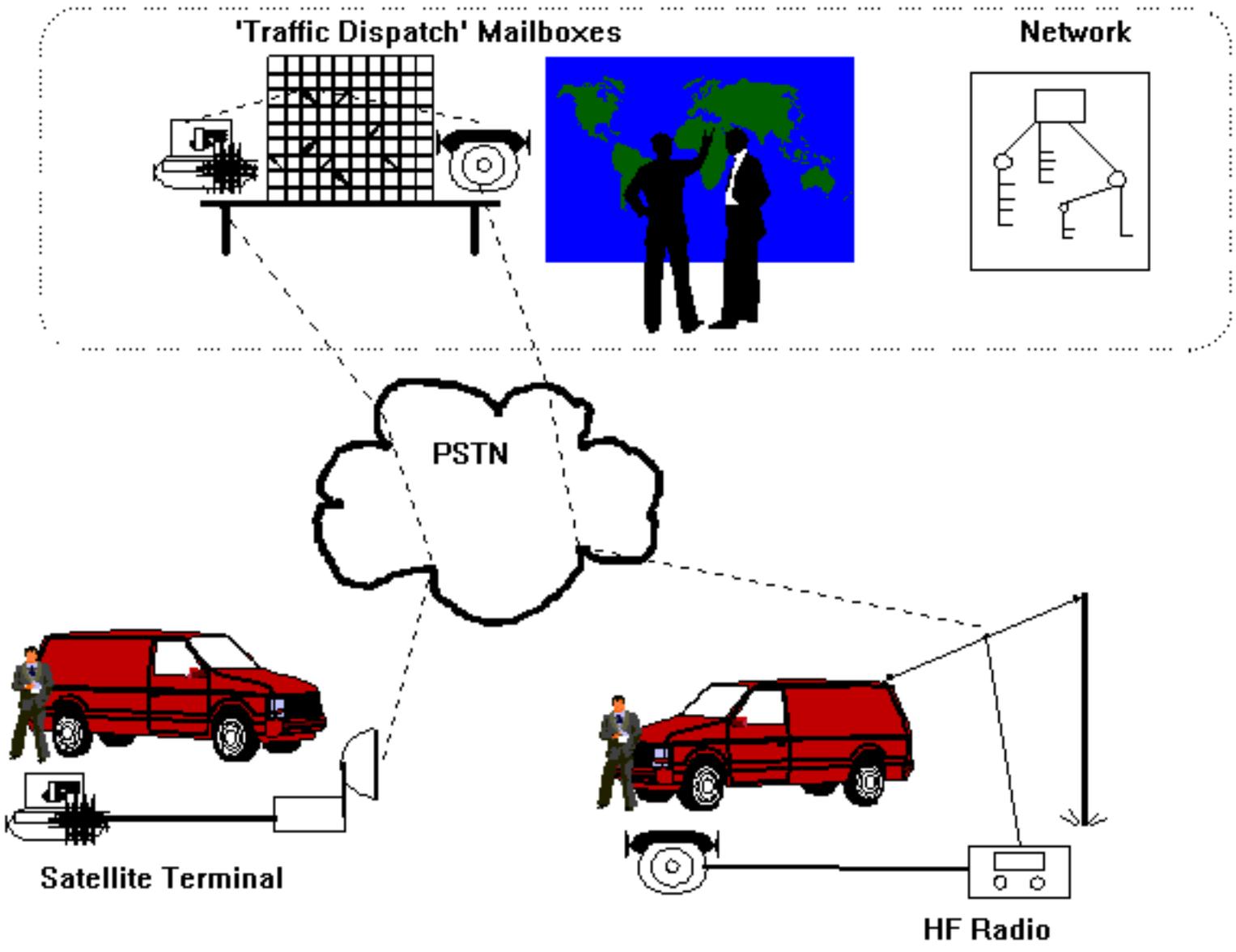
FIG 6 *Having a Traffic Dispatch function maximises the value of any system.*

```
=Report=Report=
```

This is the method favoured by the BBC and most News organisations. Journalists call in to a phone number called 'Traffic'. First they are passed any messages for them from elsewhere in the BBC, which have been sent to the traffic dispatcher. They then dictate their report over the line which is either tape recorded for transmission or typed out. This is what has happened when you see a Photo of the journalist and hear a scratchy voice on the TV news.

Everyone must report their position and status, and agree to (and keep) scheduled reporting times (called 'Skeds'), this includes you. You should also report who is with you and from what organisation they work so that messages to them can be expedited. Another advantage of such an approach is that if you go out without an exhaustive phone directory, you have only one number to remember to retrieve the rest. Your coast radio station can help you to find who you need if you are really stuck, provided they have been warned in advance.

1.3.1 Trafficking messages

One reason for the reluctance of some people to send particularly important messages by text is lack of confidence in the system. When you make a phone call, you can hear a voice you know saying "Yes, I see" or "got all that, I'll have it done by your next sked". If you send a text message, he will have a much better idea of what you really want and won't forget the important details, that is, **if** he gets the message. You may need to know **when** he got the message for logistical reasons.

Do you remember the old fashioned Telegram with a sigh of nostalgia? Well there is no reason to dismiss it as a relic from the past. Over a hundred years of experience has made trafficking telegrams a thoroughly mature art, and there are many features of them that we do well to learn from. You may scoff now at the unreadable gobbledygook in the first line of a telegram, but this was the 'Preamble' and its function is very important.

The first thing it tells is a unique message number and where it came from. From then on and forever this message will be identifiable amongst all the others. this will make it possible to refer to this message later and in this way track its progress. The number may be something like 'Aidcamp4' meaning the fourth message aidcamp base sent that day.

Obviously we also need to add at least the date and time when the message was sent, to avoid confusion, this should be in GMT (UTC). The preamble must say unambiguously who or what department the message is going to (The addressee). Other information such as how urgent the message is, is optional but these are the minimum. Other options are to say how many words there were in the message so that we can have confidence that we got all of it. It is a very good idea to end the message with a + sign meaning 'end of message', or the word "`more..`" , if there is more to come.

```
=AIDCAMP4 941005 1058
=TO BLOGGS AIDBASELONDON
=RECEIVED YOUR AIDBASELONDON 3,4 AND 7.
=DR SMITH AND NURSE JONES ARRIVED 0900 TODAY. WHERE IS THEIR EQUIPMENT?
=BILLBROWN+
```

Fig7 a well formatted text message. need not be so formal as this but should contain information uniquely identifying it. Notice confirmation of arrival of his messages number 3, 4 and 7. He can now 'check them off' in his log.

```
=AIDCAMP5 941005 1400
=TO BLOGGS AIDBASELONDON
=SORRY JOE I LOST YOUR AIDBASELONDON 9 PLEASE RESEND IT.
=BILLBROWN+
```

Fig 8 A 'service message' is about messages. it is only possible to track lost messages properly if they can be identified.

1.3.2 Keeping a Log

Whenever a message is sent or received, a note about this should be kept in a special book, called a Log book.[24] There should be columns in the book for details about the message such as who sent it, when, and when it was passed on from our station to the next one in the chain.[25] Another important feature should be a confirmation of when the message was received by the addressee. This will help us to know how long it really takes to send a message to someone, for future reference. Even the destination and duration of phone calls must be so entered so that charging can be tracked. Someone must check the log books at least each day to make sure that messages did get passed on and were not forgotten. This also applies to messages written on paper by hand and sent in person by truck. Check that they were acknowledged by the place to which they were sent for onward transmission, and that they were acknowledged by the addressee in due time. With some systems, this is automatic.[26]

Message number	Handed in/sender	Adressee	Sent/received via	Acknowleged
Aidcamp 1	941005 0900 By Brown	Aidbaselondon Bloggs	Portishead by 1000	HF00lex 1400 BJB
Aidcamp 2	941005 1000 Dr Smith	Aidbaselondon Bloggs	Portishead by 1000	HF00lex 1400 BJB
Aidbaselondon 941005 1400 Bloggs		Aidcamp smith 1500	Telex Inmarsat 1700	1700 BJB
Aidcamp 3	091005 1600 Jones	Helpgroup Sanchez	Purchased with Dr Smith in turck	

FIG 9 A log book helps keep track of messages and makes sure none get lost.

1.3.3 Echo Tests

Periodically it may be useful to use Echo Tests. These are messages to the other stations below you on the network hierarchy. They should ask the person receiving the message to send a message saying at what time he **read** the message. This will give you a realistic idea how long it takes to send a message to someone. If you think it is taking too long, you can revise your procedures to speed things up. If you get no reply at all, you can suspect a technical fault and get it fixed before an emergency call is lost. On the other hand they do cost money and are only needed if there is not enough regular flow of traffic to a particular destination to promote confidence in the link.

1.3.4 Summary

Every solution brings its own problems, so someone in your organisation should set their mind to the networking problems that communications solutions will present. You don't have to have an elaborate control room set up, rather someone trained and resourced for this responsible task. If you don't, you will be wasting a lot of your money on expensive technology that is not being used efficiently.

At least two British organisations[27] are now looking into the problem, with the aim of establishing a central 'clearing house' (not central control) for such information which would be manned round the clock with communications experts.

The United Nations Department of Humanitarian Affairs also has such a scheme called the On site

Operations Co-ordination centre (OSOCC), a field communications centre with expert operators in the field at the site of the disaster. They are equipped with Satellite, HF and VHF equipment and link to a control room in Geneva. Information about how to work with them is available from the UNDHA telecommunications centre at the Palais des Nations in Geneva.

Only when we have thought out these basic factors about our communications needs, can we now approach the systems technologies that will act as carrier to our communications. However it may also be that we need to modify our organisation's culture to accommodate what is possible within the budget that we have set ourselves. Anything is possible with technology but at a price. Only when we have considered both things can we engage in intelligent discussion about this, so lets start looking at what is on offer.

---

[1]Americans call it the 'Plain Old Telephone System' (POTS), 'Ma Bell' or 'the twisted pair'.

[2]In this document the PSTN will also mean the Public Land Mobile Network (PLMN), also known as Cellular Mobile Telephones. The PLMN depends on transmission from the bearer network and terrestrial Base Stations within 50Km of the disaster zone. Therefore it may be nearly as vulnerable to disaster as the PSTN is.

[3]In fact the different services are usually switched by separate systems but sent down the same line transmission network (for reasons of economy). This is known as the Bearer Network. It uses the local telephone exchanges in the area. If it fails you will lose everything depending on it.

[4]This is also true of Telex and ISDN services which depend on the bearer network.

[5]It is intended to update the document annually, please contact DRCF for an update.

[6]Disaster volunteers are usually professional or qualified people who agree to make themselves available on a callout basis. They are either sponsored by their company or take annual leave during the call. This is the reason for the short availability window of such teams.

[7]In this book men shall also mean women.

[8]Because volunteers are seconded from their full time professions at short notice, a term of duty for one person will normally be 10-15 working days. After this, new persons will probably be needed to continue the operation if required.

[9]Qualified Radio Officers are well suited to Disaster Communications duties.

[10]A Radio Officer is a highly trained (to 3 year HND level) professional person who is not only technically trained but also trained in normal and Emergency message handling. They must hold an international permit to operate such as a Marine Radio General Certificate. They typically have a background from ships, expeditions or the military.

[11]A Radio Operator is trained only in operation of the equipment and normal message handling. Training typically last a few days.

[12]When both ends at once can talk, it is called 'Full Duplex'. If they have to take it in turns and say 'over', It is called 'Simplex'.

[13]In this document, He or Him shall mean She or Her.

[14]You can tell your coast radio station to interrupt you when a certain time or a certain charge is up.

[15]In text messages, the sender is the person whom message is from, the addressee is the person to whom the message is sent. This distinction is made because a message arriving at one telex may be sent on to another to reach the person or persons who are the addressee(s).

[16]In this document the term Personal Computer will mean in the generic sense.

[17]Provided there is reliable power and security.

[18]In this document 'Lap top' is used in its generic sense.

[19]There are 'text bridge' programs which recognise text and will re-generate the text as an ASCII file, but they are laborious and unreliable.

[20]Very often used by the UN and others.

[21]In this document ISDN will include Public Packet Switched Data Network X25.(PPSDN) and Public Circuit Switched Data Network (PCSDN) and TCP/IP INTERNET networks. Although separate logical networks, they all share the same vulnerability to the bearer network.

[22]Only INMARSAT-C and HF radio (in good conditions) can be used in a moving vehicle.

[23]Cordless phones can be directly connected to some models of INMARSAT terminal

[24]This is a legal requirement in most countries.

[25]There may be good reasons for passing messages to another place with better contacts for greater economy or reliability. If so you must check that they did remember to pass the message on.

[26]Many systems carry out this operation automatically, but confirmation is sometimes only provided when you remember to request it. As it costs about 16P per message it is well worth it. It is still worth keeping a paper log book separately in any case.

[27]The Path-finders, of the 'World Memorial Fund for Disaster Relief' and The Cranfield Trust.

CHAPTER 6

6.1 Introduction

In Part 1, "Disaster Comunications-Global" (required reading) we have discussed the problems facing a disaster or aid team wishing to communicate with their office back in their home country. In this part we will turn to the problems of communications with and between members of the same team or group of teams in an area of about 100KM or so around a given point. So how complicated can that be? Well, it can be very simple if you wish, but also there are some cases where a more complicated set-up is justified.

I will try to mention just about every practical system we at DRCF have ever heard of. Just because we mention (or don't mention) a system, **this is not an endorsement of the idea**. We merely acquaint you with the facts and leave you to decide what you think is best for you. Reading this won't make you an expert, but it will help you and your experts to come to a better understanding

The Disaster Relief Communications Foundation (**DRCF**) is a Non Governmental Organisation (NGO), a small registered charity, and we admit that our resources are limited. However we do try most conscientiously to make sure that what we say is generally agreed to be true, or at least valid opinion, by experts in the relevant fields. However if you know of something better that we do, we most sincerely welcome input, for future revisions of the book.

6.2.1 For field telephones

Field telephones are ruggedised telephones often designed to be left outdoors during use. Before you roll your eyes upward and 'tut' at this section consider something. No lesser organisations than the BBC, and most armies of the world still use field telephone systems in 1996 though they could easily afford radio systems. To see why, let's look at what a field telephone system is and what its advantages over, say walkie-talkies are.

An ordinary telephone system relies on power from a central switchboard or Private Automatic Exchange (PAX). This scheme is called the central battery system. (CB).The problem is that if you lose the power to your switchboard, you lose all of the phones. For this reason, though the BBC has PAX telephones laid out in, for example, a commentary box at an Outside Broadcast (OB) they do not totally trust to this system. Engineers would find that when they needed it most, when some kind of problem occurs, it would let them down.

An alternative system is called the Local Battery system (LB). Incidentally this was the type of telephone first used by the Edison Bell telephone system in 1876 or so. They are usually distinguished by a rather

comical looking crank handle sticking out of the front or side. This handle is called the Magneto handle, so the system is sometimes also called the Magneto system, though more modern designs are electronic and have a button marked 'call' or 'ring'. When the crank is turned (or the button pressed) the bell on the other phone rings.

The phones are connected up by wires. Just about any wire in existence is suitable, field telephones are not fussy. Large reels of Jumper wire or field telephone wire are very cheap, you can even use wire fences and an earth return . The phones are totally self contained, they don't need power or any kind of control system from anything else. This makes them very reliable indeed. To power the microphone in the telephone, there is a built in 3v battery called the polarising battery. The very good news it that this battery can be just about any disposable battery you can buy from anywhere, such as a bicycle or torch battery, it is not special in any way and even the voltage is not critical. They are switched on either when the phone is lifted off the hook, or by pressing a button on the handset labelled 'press to talk'.

How long do the batteries last? Well that depends, but as a guide, I have a collection of field telephones at home. My two boys age 5 and 3 play with them, and rather roughly. Not only have they never been able to break them, but the batteries have to be changed only about once per year, and only then because of ageing. I have one phone which had the same battery in for 3 years, and still worked perfectly straight from storage when it was needed.

Field telephones are tough and totally reliable. You will never loose sleep over charging up the batteries every 8 hours as with a walkie talkie. In any case, you may not trust your generator or mains supply enough to be sure that there will be power to charge your radios, whereas the field telephone batteries will work even when nearly totally flat, so they won't let you down without warning. They are also immune from interference and channel overloading, which often dog 'walkie talkies'. Privacy is enhanced because listening in would involve line tapping which is much more trouble to do without being caught. This deters the casual listener who may be allocated the same channel, or the person with a scanner.

Walkie talkies have the problem that if put behind or inside a building or in a dip in the terrain, they will not work. Furthermore, you may not get any warning of this until you try and it doesn't work. Whereas field telephones will work anywhere that you can get a cable to. The range of field telephones is rather academic, but over 100km is possible. The limiting factor will be how much cable you can bring to the site and have time to 'string up'.

```
Report=Report
```

```
The St.John Ambulance Brigade provide the First Aid coverage for the London
Marathon, an event which generates marathon numbers of First Aid cases. VHF
channels became so overloaded with higher priority calls that there was hardly
ever time for the information about dropped out runners to be sent to HQ for
logging. Worried relatives would realise that their loved ones had not finished
the race, and go to the St.John information point asking for the whereabouts of
their runner. This information was available on a computer in another wing of the
```

same building, (County Hall) but quite a long distance away. A temporary field
telephone line was installed in about an hour, and soon the information could be
passed in seconds from desk to desk.

Field telephones can be readily and cheaply purchased from Army surplus or via magazines for about
one tenth of the cost of a walkie talkie. They are also simpler in that you will not need a licence for them
as they don't use a radio channel, neither do the operators need licences.
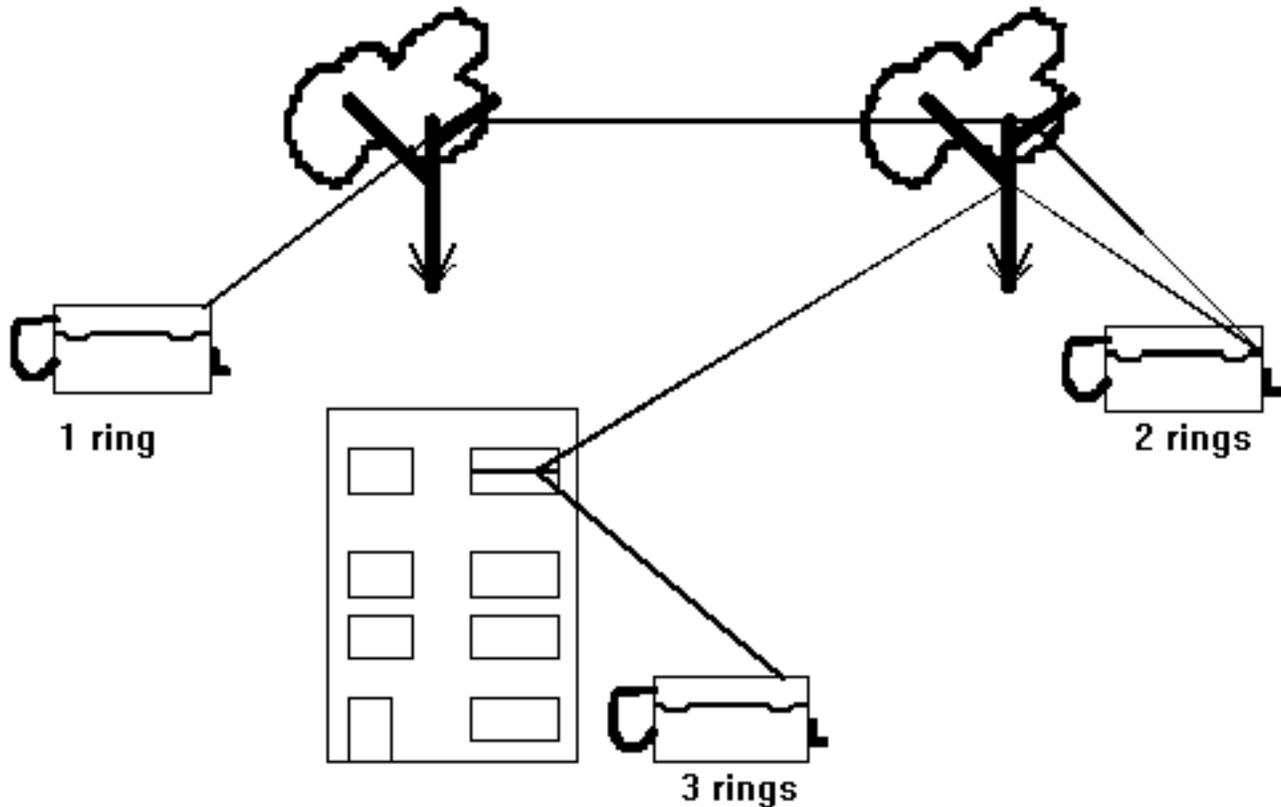
Fig 17 Field telephone systems lend themselves to improvised cabling schemes

6.2.2 Against field telephones

With all these selling points, why does everyone buy Walkie-talkies? The reason is , wires. The cost of
wire of the type needed is actually very little - that is not the problem, the problem is the laborious task of
stringing out the wires, a process called 'cabling'. This process does take some hours so it is unsuitable
for anyone constantly on the move.

Here we need to make a clear distinction between the cabling techniques, each has its own style.

- Temporary cabling.
- Semi-Permanet cabling.
- Permanent cabling.

Temporary cabling is what your first response will be. This means getting the cable from A to B with the least effort, therefore the least time spent of rigging up. I can lay and fix one reel of line (about 500m) in about half an hour in this way. Sometimes you may just lay the wires on the ground, if out of the way of footpaths and roads, and then use handy trees or buildings as makeshift telegraph poles when a road crossing is required.

Inside buildings, the wire can be fed into a window and then loosely tied to light fittings or taped to corners until a suitable position for the phone is reached. The reliability of the link now depends on keeping the line out of harm's way, so this is where imaginative improvising comes in. The line will probably be broken a few times while the best route is found, but the lines can be rejointed without any special tools if this is the case.

If you do this in an urban environment, you must remember to look out for adjacent power cables and never cable over them, always well under. This is so that if your cable comes undone at one of the verandas you tied it to, it will go slack and not touch the power cable, maybe electrocuting the person using the phone.

Despite being in a rush, you must take care to tie the line securely over paths and roads to avoid trip or strangulation hazards. On the other hand, you would want to use few enough knots that when the operation is over, or if the phone's position is to be changed, you can quickly reach and undo all the knots you tied, allowing the cable to be easily reeled in without damage and re-used. Recovering a reel of cable takes about half an hour.

Sooner or later someone is going to complain about the scruffy wiring and the fact that they can't close the windows or doors properly. Then you will have to smarten things up with a semi-permanent scheme. This means tidying up the wiring by clipping or taping it to the skirting board or door frames of the rooms. You may have to drill a small hole in the door frames and window frames to let the cable pass through unseen and let the doors close properly. All of this will take much more time, about 1 or 2 hours per 100 m. You would do this when the line is established and the panic is over, (unless there was not immediate panic in the first place), in which case you should do a neat job the first time.

By the time the installation becomes semi-permanent and if the line has to cross someone else's property, the owner will soon complain if your wiring over or past his place is scruffy. Worst of all, when the immediate crisis is over, the local officials may complain about the wiring crossing public land and in particular public roads, (on the other hand, seeing the state of some overhead wiring in urban areas, no one may notice unless you are really bad). If things have got to the stage that the locals can worry about such things, then probably you can go home anyway, but if you are in for a longer term commitment, then you can't expect to do this for very long, and therefore field telephones will be best used on your own camp, building, area of responsibility or compound.

In many cases, where law and order has broken down, wire may be very valuable and so will be cut down and stolen for the copper. Even if the wire is not copper, they will cut it down and strip it to find

out. This is a major problem in Africa for instance. Another problem is that in some countries, the government has a monopoly of communications of all sorts and so you will meet zealous opposition to unauthorised wires crossing public land.

6.2.3 Private Wires

If your installation is becoming more permanent, there is something else you may find worth while, a **Private wire**. If there is a telephone system in the town and if it is working, you should naturally use the phone to call the other offices that you need to contact. If the local phone system is not working or is not reliable, or the waiting time for connection is very long, you can make a special arrangement. In a 'private wire' scheme, one of the telephone lines around the area which would normally be connected to the local exchange, are diverted between the points you specify. If there is spare local cable capacity, then this is very easy and quick for the local engineers to do (the work will take about 2 hours once the administration is out of the way). You can now connect your LB phones to the wire and you have your own private hot line from point to point. Your system will work even if the local exchange has failed, and of course the line can never be blocked or busy.

Another good reason may be economy. Most companies charge for Private wires on the basis of distance from point to point, a fixed charge per quarter. If you make more than say four calls to a nearby place per day, you may find it much cheaper to install a private wire and LB phones, a sort of 'Hot Line'. You can talk all you want now, it won't cost any more than the fixed cost of renting the line.

6.2.4 PAX and PBX systems

These are private telephone exchanges. A Private Automatic eXchange (PAX) means that you can dial any phone wired up to the exchange, but not make calls to any phone outside of your system. A Private Automatic Branch eXchange (PABX or PBX) gives the same service as a PAX, but in addition also gives access to the PSTN. The advantage of a PBX is convenience. Everyone instinctively knows how to use a phone, so no training is needed for the users. The only major problem is typing out a good directory and keeping it up to date, and the laborious cabling needed.

```
=REPORT=REPORT=
```

```
This was the eventual solution used in Beirut. Radio systems became hopelessly
jammed by poorly disciplined over use of the channels. Private individuals started
to install PBXs in their living rooms, then fan out a spider's web of wires to any
who wanted service. In time these became connected together more or less
informally and eventually became connected to the PSTN by means of radio line
extenders. These systems are still the most reliable communication network in the
city at the time of my visit (1995) . The comical problem is that users need
several phones on their desk, one for the network in each block they might need to
communicate with.
```

You don't have to connect a PBX up to a PSTN line, but if you do then this will give access to PSTN by any phone on the network. If no PSTN lines exist in the area then you have the option of providing one by satellite service, such as Vsat, INMARSAT, or by a radio line extender. This means greater convenience as users can share this resource without going to the terminal, which can then be placed in a good position. Of course this will not improve the reliability of the PSTN line, but perhaps you can 'leap frog' a broken Exchange and connect to a line which is working better this way. HF radio Phone patches can also be arranged, but a radio operator would have to operate the radio, and a special phone patch system needs to be installed on one of the extensions. This is the system adopted on ships, for example.

Against PBXs, they depend on reliable power to the exchange. If your exchange power fails, or the exchange fails, you will lose all of the phones until service is restored. You will also have the same problems as with field telephones, namely that you need to carry out cabling to each and every phone separately. In fact the situation is worse than with Magneto phones because you cannot 'daisy chain' on phone from another. You have to provide a separate line to each phone.

PBXs vary in size and weight. DRCF has a 10 line PAX which is shoe box sized and weighs 5KG, but some designs are quite large and heavy. Older electro-mechanical designs are heavier but use no power at all when on standby, electronic ones use the same power whether idle or in use. It is unusual to find a design intended for portable use. The laboriousness of installation and the non-agility of PBXs means that they are best suited to longer term and shorter range applications rather than fast response disaster communications. It will take about half a day to install 10 lines, and when you move on, it will take half a day to dismantle the system.

6.2.5 Cordless PBXs

Cordless PBXs are like a small scale private Cellular Phone system. In addition to having wired extensions, there are also small, shoe box sized 'base stations' for mounting on the wall inside or your building. The user uses special phones looking like cellular phones. There are many versions of this, such as the international standard Digital European Cordless Telephone (DECT) system. The advantage is that because cabling is much simpler, set up speed is much quicker. Also the users have the advantage of total freedom within the coverage area of the system. My employers use such a system at our office and I wouldn't go back to being chained to my desk again at any price.

In fact the theoretical range is around 500M, but experience shows that 300M is the best practical range provided base station site is good enough (which is the critical factor). To cover a large area may require the installation of many base stations. One per floor per building is recommended.

Against them is the old problem of getting permission to use the frequencies .The DECT system is unlikely to be affected by another service, it is self-organising, but it would effect another existing service on the same frequency. Also they are more expensive than the wired line alternative, certainly much more expensive than a VHF simplex radio system. If money is no problem, go for this, but if it is then you have a hard task to justify it over 'walkie talkies'.

6.3 'Walkie-Talkies

The term 'Walkie Talkie' is a trademark of the Motorola Corporation. Around the late fifties very physically small valves were devised for fighter aircraft, to the point where a radio transceiver could be fitted into a box small enough to be carried in the hand. This was in contrast to earlier designs which were microwave oven sized, and had another ammo box for the batteries. To make them a bit more user friendly, they cleverly designed them with cups at the ear and mouth position so that they would automatically be used like a telephone handset. They first saw use in the Korean war and then later in the Vietnam war, when 'grunts' would direct helicopter gunships to their positions with them.

Today, as with the term 'Walkman', or 'PC', which are really trademarks, 'Walkie-talkie' has come to mean a hand held two way radio system. This history shows why experts curl their lips up when you say walkie talkie, and prefer one of several alternative names. Englishmen in particular hate to use the term, it sounds like baby talk to their ears and you can see them visibly shudder when they hear the words.

Here are some preferred names that you will hear in conversation to refer to walkie talkies, and an explanation of where they have come from and what they mean.

R/T or R/T set. This stands for Radio Telephone. This term was invented to distinguish this from a Wireless Telegraph (by morse code) in the 1920's, when valves were invented and this made modulation practical. In Regulations and laws, this is still what your set is called. In fact your signals may be called' emissions by radio telephony' in your licence. Today this term is completely obsolete because of the Public Land Mobile Network (PLMN) better known as the Cellular Phone system or Mobile Phone system. Today the makers of very small cellular phones make their terminals look like telephones and indeed act just like them too. This is to help users to identify with the concept , thus boost sales. You can see there is plenty of scope for confusion with the term Radio Telephone, that is why it is avoided these days (except by legislators).

Two-way radio. To many, the term 'radio' means a wooden box with ornate fretwork standing in a commanding position on grandads dressing table. This is actually a broadcast receiver. The word 'broadcast' is borrowed from a farming technique, where a farmer would sew a field by walking casually around it with a sack of seeds in his hand, and literally throw handfuls at random. This was of course very inefficient and has been replaced by seed drilling. Radio programmes from such organisations as the BBC are figuratively just cast out from the transmitter, to land any which way they will, with no attempt to control the reception at all.

Today, the meaning of Broadcasting in law is that a signal is sent over an area without controlling the receivers. There are special frequencies and laws covering Broadcasting, so be very careful never to say that you are 'Broadcasting' from your station, or the result could be an angry visit from a government inspector wishing to close you down. Two way radio is an unofficial but highly effective term by which

laymen will not visualise Broadcasting.

P.R.set, Stands for Personal radio set. This is a Police term because an individual radio is issued to an individual PC for his care (and he is answerable). Many people from a services or Private radio background use this term.

Portable radio. This means it is designed to be used while carried in the hand. In contrast to this term, a **Transportable** radio means one which can be carried from place to place, because it has handles on it and an internal battery, but is designed to be placed on the table when in use. You may wonder why anyone would do that if they had a portable set, but all will be explained later. One thing to watch out for is that in law, there is no distinction between portable and transportable, they both conform to the same regulations. You must take care with some people that they understand the difference between portable and transportable equipment when talking about it.

CB sets, CB stands for Citizen's Band and refers not to a type of radio as such, but to a set of laws and regulations regarding their use. CB sets are technically just like any others, but there are both advantages and disadvantages to their use, which we will discuss later.

Amateur Radio or **HAM Radio**. Again, like CB, this refers to a set of rules and regulations and not to radio equipment as such. However there are some interesting points about Amateur radio that need expanding on, so this is another subject that we will return to.

Handie Talkie or HT, A new buzzword used by many manufacturers and much beloved of the buzzword loving amateur radio fraternity. A person using this word probably has an amateur radio background, which is a good thing.

Handset. This really means the part of an ordinary telephone that you hold against your ear. Someone using this word is giving away that he has a background in Telephones,(which is no bad thing). Some radios have 'telephone lookalike' handsets instead of fist mics. This is good because it forces you to hold the mic at the right place, and provides a clear sound right into your ear.

Handheld. Good word.

Whatever its name, nearly everyone has seen or used a handheld. Because of their small size, convenience and ruggedness, they have found nearly universal acceptance by all serious organisations who can justify the expense of them, they are a completely mature product now, and modern designs are more similar than they are different.

6.3.1 Procedures

One off-putting thing about them is that it seems that no one who uses them can resist the urge to speak fluent martian gobbledygook when they pick one up. For some this is all part of the excitement, and knowing your 'rogers' from your 'wilcos' is all part of the rights of passage into the elite world of the airline pilots and other glamourous folk, but for others it is at best a turn off or at worst very intimidating. I have seen very intelligent and articulate mature professionals reduced to stuttering wrecks for fear of not incanting the right spells to make the thing work.

I want to tell you right now, that in most cases, ordinary language is quite good enough. There are quite elaborate procedures for some services such as Marine radio or Aeronautical service, and they do help a great deal when there is pressure to be clear and concise in the presence of many languages. But if you are not planning to organise much international air sea rescue on your handsets, don't bother.

There are however a few things you should not forget. First, unlike a telephone, it will not ring when someone wants to talk to you, so you must have it switched on all the time, and be listening to the channel all the time to hear if a message is for you. Sounds silly to say this, but we have come across cases where the system was not working because users had their sets turned off, thinking they would ring like a Mobile Phone.

Another point is that for historical reasons, most handhelds use what is called the SIMPLEX system. The technical details are not important but you can always tell a Simplex system because of a button, or bar, on the handset labelled 'PTT' or Press To Talk. You must hold down the PTT all the time you are talking, and remember to let go when you want to listen. Sounds simple but I have spent many frustrating hours with highly educated people before this becomes instinctive. You must say something when you have finished talking so that the other person knows when to talk and when to shut up. Usually this is done by saying 'over' before you let go of the PTT, but anything that makes it clear who should talk next is OK.

Don't forget that the Simplex system is a 'round table' or 'party line' discussion, but for technical reasons which aren't very interesting, only one person at a time can talk. The usual way of fixing this is for the previous speaker to clearly state who should speak next just before he says 'over'. Another way is to have a person called the 'Net Controller' to act like the chairman at a meeting, and decide who the next speaker will be.

By the way, this apparently annoying side effect of simplex, that all stations can hear everything said, is actually a great bonus. If you keep an ear open to what is going on, it is like having a rolling briefing constantly going on. In fact, sometimes someone may just say something to no one in particular just so that everyone can be informed, and understand the whole situation by the time they are called personally for comment. This is one reason why police, fire and ambulance services don't use mobile phones though they could easily afford them.[66]

6.3.2 Callsigns

Just as every car needs a number plate, so every radio has to have a Callsign, for the same reasons of tracking and administration. One example of this is in aircraft. You will see painted on every aeroplane, something like G-AVIR. This is not the number plate of the aircraft but its radio callsign. To avoid confusion if the line is a bit muffled, there is an agreed list of words that stand for each letter of the alphabet, called the international phonetic alphabet. The words had to be carefully chosen so that every race and culture could pronounce them and not get them confused. That is why a pilot of the aircraft just mentioned would call up the tower and say " Woodvale tower this is Golf Alpha Victor India Romeo, taxi clearance".[67]

Why did I mention this when I promised you could use ordinary language? The reason is that some administrations will issue a licence on the condition that every message starts and end with the callsign that they will decide upon. It will be printed on the licence document. So you may get stuck with "Lima Delta one five zero this is Whiskey Alpha three three five" when you would rather say " Hello Fred this is Bill, over". Your technical expert or administrator will probably tell you what callsigns to use. Having said that, you soon get used to it and I have many friends such as G0FTU, who's name I can not always remember!

You will recall that I said that the other person you wish to call should be listening to his radio. Actually this is not always the case, and he may be holding another conversation or doing something else just with the radio in earshot. You will first have to get the attention of his conscious brain, make his 'ears prick up', by what you say before waffling on with the question you were wanting to ask. The best way is to call his callsign and/or his name twice, then give your callsign and wait for him to call you back. If he doesn't, then try again a few moments later. You may say "Aidman one, aidman one, are you there Brian? this is aidman two, over".

Because you have a virtual party line, you should obviously not call until you have listened long enough to know that there is not already another conversation going on. Simplex is a very unforgiving one-at-a-time system and you will rudely bring the other conversation to a halt (unless of course your business is more urgent, in which case, do explain this by starting with the words 'Priority!,Priority!' or 'Break Break'). While you are talking, unknown to you, there may be other users impatiently hopping from foot to foot saying " get on with it you gas bag", so keep things as to-the-point as possible, and always make it clear when you have finished the conversation by saying something like 'over and out' or 'clearing the channel'.

This is not an instruction manual but I mentioned these points because it shows that you do need to think of training for your users if you expect to get value for money for your handhelds. Encourage your people to try them out, the moment of crisis is too late for them to become familiar with them.

6.3.3 What is the range of them?

This is the favourite question for users and the most dreaded one for the experts, who roll their eyes upward, draw a deep breath and then don't really answer the question at all. To find out why, lets take a closer look at our handheld.

The bulk of the handheld is probably the battery, in a clip at the bottom. Then there is the transceiver itself, with knobs and switches on it. Then sticking out of the top, is a part physically small and unglamourous, but at least as important as the other parts, a 'rubber duck'. This is actually not rubber but a helically wound steel antenna protected by a plastic outer sleeve. It happens that lower frequencies need bigger antennas, so in fact, to make the antenna of a size sensibly proportional to the radio, VHF or UHF frequencies are used in handhelds. Otherwise you would end up with floppy fishing rods which snag on everything and break the radio.

In theory a VHF or UHF radio signal has an infinite range, after all, the astronauts on the moon in 1969 told us of their 'giant leap for mankind' using VHF radios very similar to the handhelds in use today. You are not in space, but on the ground, and if I may make a point, quite close to the ground too, as many users clip the handheld to their belt when not in use. It happens that VHF and UHF don't penetrate through thick walls very well, and not through earth at all. This means that the range is 'line of sight' only.

You know as well as I do that this is not at all true, so what is the explanation of the fact that UHF radio works so well in built up areas when it should not? VHF radio waves have the property that they bounce off objects they encounter rather well. UHF is even better yet, so this explains why UHF is preferred for handhelds.

Imagine you lived in a chateau where every room was a copy of the hall of mirrors, except that the mirrors where badly tarnished and the windows nearly opaque. You can see that you could communicate from room to room by a flashing lamp very easily, especially in the dark. This is how the world looks to a UHF radio.

Now you can see why defining range is so difficult. You may have a lucky spot at both ends and have a range of tens of kilometres, but you may also get a disappointing few hundred meters. Finding out what the range is, is a matter of trial and error. Every time you change position, you should call up someone else to see if you are in a 'dead spot'. Sometimes just putting the radio to rest on a window shelf is enough to fix the problem, sometimes a more elaborate solution is needed. In any case, regular radio checks are a good idea as you will have no warning when you or the other party does move into a dead spot. Happily there are plenty of tricks for improving this situation and we will now move on to explain them.
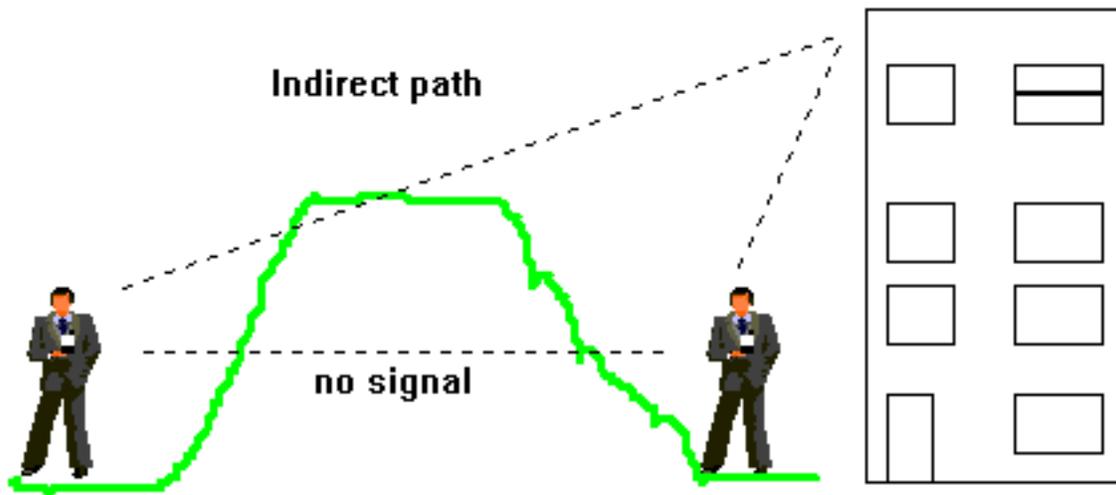
fig 18 Direct paths to handhelds can become blocked, but if you are lucky, an indirect path may also exist

By now you realise that the secret is not in the electronics, rather in the humble but very important antenna. The simplest thing to do is to ask someone to talk for a few moments, say count to 10, then move the radio around until the signal is strongest. This may put the radio in an awkward position for speaking into it, so an extension microphone can be used to make using the radio more convenient.

VHF radio;

The Secret is in the position
of the Antenna

6.3.4 External antennas

If that doesn't work, you can try extending the antenna out of the room altogether. This is only possible where the antenna can be unplugged from the radio, or an extension lead can be plugged in. An extension lead can then be plugged into the socket where the antenna just came out, and the extension lead, (specially made from 50 ohm co-ax cable and fitted with co-ax sockets of the correct type and gender), can be lead out of the room and to the highest point it will reach, (or the point with the clearest view towards the place you want to communicate with). However the extension lead will have some loss of signal, which will get worse as the cable gets longer. In fact the cable should be only about 100m long at the most, unless you use special (more expensive) so called 'Low Loss' cable.

You cannot use the antenna that just came off your radio. You must use a special design intended to work

away from the radio. However there are many good designs available 'off the shelf'. Suitable models include, the dipole, the base loaded whip, the ground plane radial, the Slim Jim or the helical counterpoise whip and very many more.

There are as many opinions as their are experts about which is best, but the bottom line is that you are trading size and weight for efficiency. Remember that you have to personally carry this antenna on the 'plane and across rubble for days in order to fix it up, the shop won't deliver it for you. I recommend the lightest, easiest quarter wave whip with helical counterpoise, Ideally, these should be supplied with a large, strong clip, so that they can be quickly clipped onto a pipe or veranda rail, or failing that, they can be taped into a good position or tied with string.

```
=REPORT=REPORT=
```

```
The St.John Ambulance brigade use this technique at, for example, football
grounds, where the metalwork in the frame of the stands make handheld performance
very poor despite the very short distances. A small whip antenna with a helical
counterpoise is clipped to a position clear of the metalwork, then a length of co-
ax cable is led into a first aid post, situated under a metal stand. An ordinary
handheld radio is then plugged in to the cable and powered by its own battery. The
results are always very satisfactory and the cost is a small fraction of that of
building a permanent base station which may be used only a few times a year. With
practice, a very satisfactory antenna can be rigged up in about half an hour.
```

In any event, I can assure you that it is worth the effort, the difference of even modest height is like night and day. The losses in the cable are more than compensated for by the better antenna position. The problem is that you have now sacrificed mobility. You can easily use your ordinary handheld to connect to the external antenna, no problem. There is then no security problem as when the room is left unattended, the radio can be just clipped to someone's belt and carried off. But as it will take a few minutes to fix up the antenna again, you may decide to leave the antenna fixed up in position until the location is no longer needed.

The next obvious logical step is to rig an external antenna system up and leave the radio connected and in the room all the time. This has the advantage that any user has reassurance that the equipment will always be there when needed. However this is only practical where security is assured, or there is usually someone there. However if this is so, then the set-up could be in place long enough to be worth investing some hours in siting the external antenna in a really good spot. What you now have is a **Base Station,** this is a theme to which we will return later.

If you have a really good spot for your antenna, with a good view over the area, then you are really on to something good. Whereas individual handhelds may be out of contact with each other, they could well be in good contact with you at your base station. If there is someone at the base station, then they can write down messages from one handheld, and repeat them to another, overcoming some of the serious

limitations with handhelds.
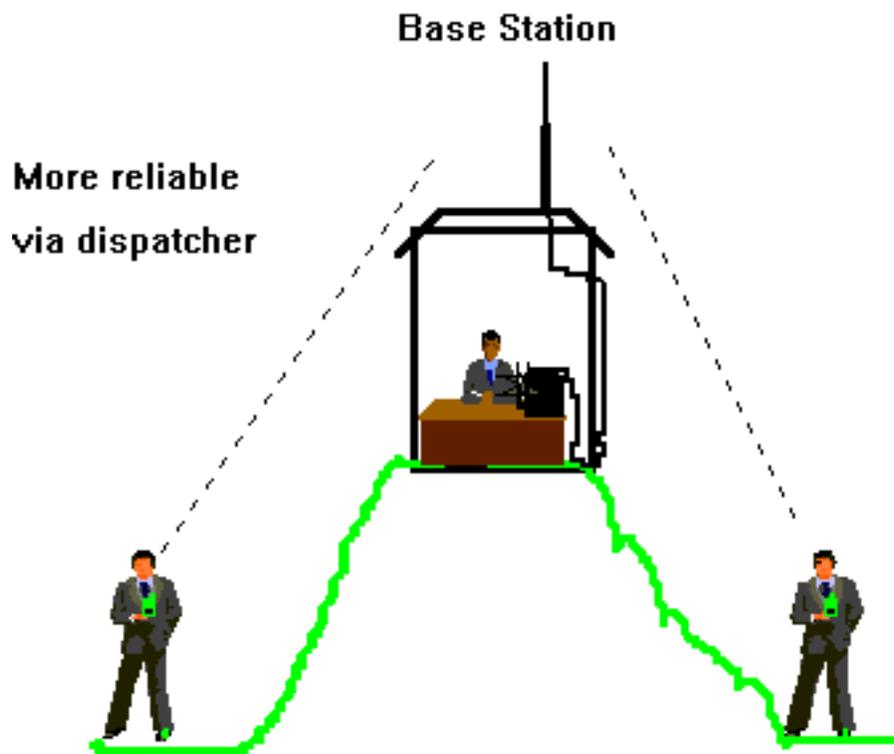
fig 19 If you can install a Base Station in a good position and have reliable manning, this is much better.

I want to stress here that the **secret is in the position of the antenna, mostly its height**, and not the power of the transmitter or anything else. A perfectly ordinary handheld connected to the antenna by an extension lead is just as good a base station as a more elaborate set up. However, there may be justification for something more elaborate and I promise to explain all as we go. I am going to come back to the subject of base stations, but now I think it is time to change subject to that of a Mobile station.

6.4 Mobile Stations

A rather funny name this, as mobile means moving and station means not moving. The reason for this odd name is that the licence for a radio transmitter is called in law a Radiocommunications Station licence, so legally at least you have a mobile radio station. A mobile station means that the equipment is mounted in a vehicle and is designed to be operated while driving and on the move. (or else it should be called Transportable).

I make no apologies for saying again that the **important thing is in the antenna**. Vehicles have the advantage that weight is less critical a problem so a much bigger and heavier antenna can be fitted to a vehicle. The antenna will have a greater 'gain', meaning signals will sound stronger. Furthermore the metal in the vehicle itself helps the whole effect to be even better, but this is only so if you install the antenna in a good position and bond it well to the earth of the vehicle.

A further point is that as vehicles tend to be on the open road and in clear open spaces more than a person is, then the range of line of sight from the antenna is probably going to be much, much more than from a handheld. Whereas a handheld may give 2km range, a mobile can have a 20km range.

You don't have to have a permanently mounted radio in the vehicle to gain these advantages. In the case of an emergency there may not be time to install a mobile radio into the vehicle, or security aspects may go against the whole idea. You can use a so called 'Magmount' antenna. This is a quarter wave or three quarter wave antenna with a powerful magnet on the bottom. The antenna is mounted on the roof of the vehicle and right in the centre of the roof. It is held in position by the magnet, only direct brushing by trees will dislodge it.

The feeder cable can then be let into an open window in the vehicle, and an ordinary handheld can be connected to the magmount. The radio can then be connected to the cigarette lighter of the vehicle to draw power. This then gives the flexibility that you have a charged handheld to use when you get out of the vehicle. You should then disconnect the magmount, locking it up in the car, and connect the rubber duck to the radio for portable use. This arrangement is used by many radio amateurs for example, and is highly effective and secure.

6.5 Power Output

Up to now, I have been saying that power doesn't matter very much, and antennas are the secret, but now I will have to say more about power levels. As mentioned before, handhelds have such poor antenna positions that the range will be limited more by topography than anything else. Even though the signals do bounce as I have said, there is a loss each time this happens, so the signal gets weaker as it bounces each time to reach the other unit. You might think the solution would be to simply raise the power of the transmitter in the handheld, but there is a problem.

About two thirds of the size, and certainly the weight of a handheld is its battery. This needs to be big enough to power the radio until the user can get back to base and recharge the battery. Recharging can take from 4 hours to 16 hours depending on the design of the charger, but usually the battery in a handheld is designed to be used during a working day of about 8 hours, and charged in the rest of the night. If your day is longer than 8 hours then a better alternative is to use batteries that can be unplugged from the bottom of the handheld, and replaced with another one which was charged earlier. (obviously you need to have enough chargers to charge both at night).

Actually if your battery does go flat, you may get no warning of this and be missing vital messages , so in practice it is good to change a battery about half way through the day, during lunch break. This means carrying your spare battery around with you to do this, or arranging a fresh battery for pick up at the place you have lunch.

Handhelds use very little power when just listening on the channel for a call, but very much more when

the user talks. Typically, a battery life may be quoted at 8hrs standby time (listening without speaking) or 30 minutes 'talk' time, or sum of the two.

Therefore to make the batteries last longer, they would have to be much bigger and heavier. The irony is that they would soon get bigger than the rest of the whole handheld. There is only one way to reduce battery size, that is to reduce transmitter power.

However we have just seen that a mobile station may have a greater range because of a better antenna, and thus because of that, it will be worthwhile having a higher power transmitter. This in turn will be possible because a vehicle battery has much greater capacity than a handheld one, so the extra current drain is not a problem.

6.6 Transportable units

We need to think of this at our base station. If you think you will ever want to communicate with a mobile station, then you should use a higher power transmitter at the base station, or you may be able to hear the mobile calling you, but the mobile won't be able to hear you replying. This is where your transportable unit comes into it's own. Transportables have higher output power than handhelds, so in addition to being larger, they also have larger and heavier batteries. This is why the resulting unit looks so ungainly. In addition, they also often have their battery chargers built in to the unit. This is important because it will prevent the all important charger being forgotten or put on the wrong truck and sent in another direction (which has happened).
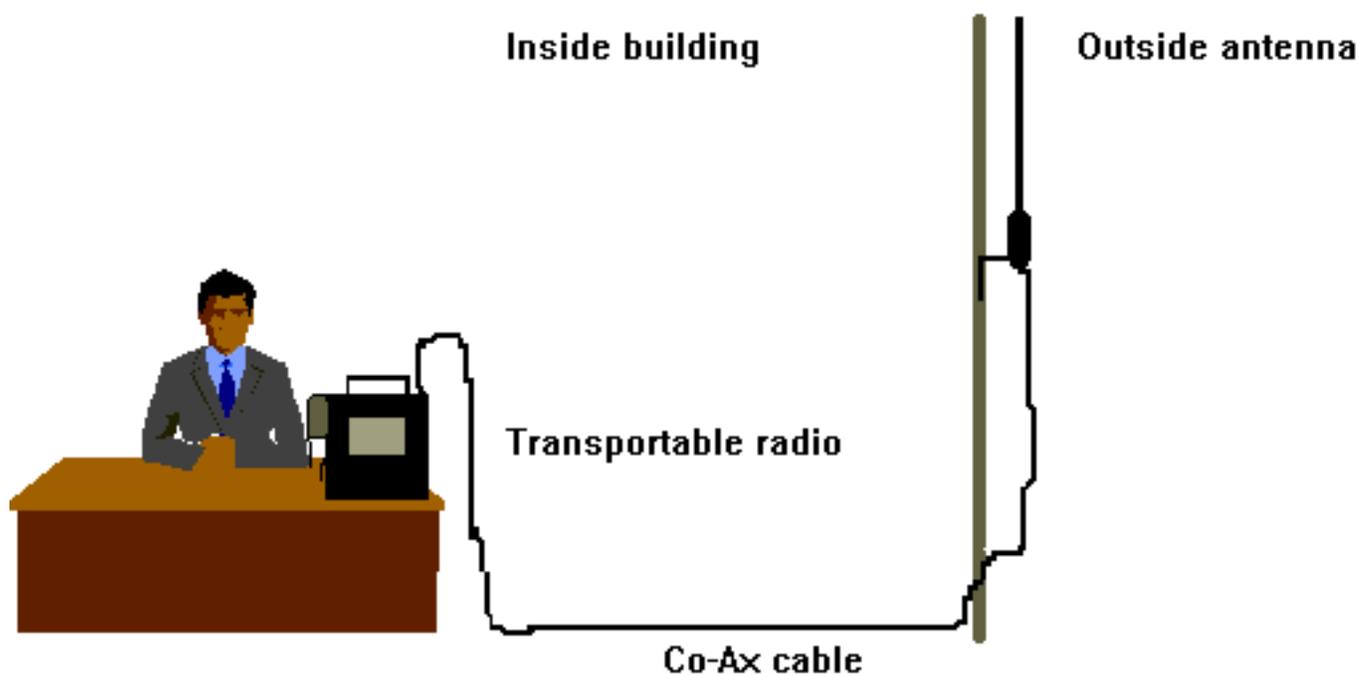
fig 20 A transportable unit should be used with an external antenna.

Transportables usually come with a rubber duck helical antenna built in, intended for use while on the move, but to use this when stationary would be to throw away the advantages of them. You should use a transportable in conjunction with a temporary external antenna, such as one that can be clipped to a fitting in a good position.

6.7 Base Stations

If you are in the happy position of being in a good spot all day, then it will be worth while the hours it will take to put the antenna in a really good spot and even use or improvise a modest mast to improve the height. If you now have such a base station you would be using it frequently to repeat messages for handhelds, so you would perhaps assign someone to permanently keep an ear on the channel at all times. However you may have the problem that the spot which is good for a base station is not ideally where staff would be in attendance at all times, so the site for a base station may turn out to be a compromise between these two factors.

By the way the term **base station** refers to the way you use the site, not to the type of equipment installed there. You do not have to install an imposing panel looking like Heathrow approach radar to make it a base station. You may find that the base station is a rather disappointing sight, a scrawny looking radio rather like the one you have seen in the vehicle that brought you. No matter, it is how it is used and where it is sited that makes the difference, not what the equipment is.

```
=Report=Report=


The Lebanese Red Cross/Crescent have to provide their own communications for the
city of Beirut, which was shattered by the recent war. They have their central
control situated in a high spot in the mountains just facing the city, and thus
are able to contact both stations in the city and in Lebanon and Syria to relay
messages for the Red Cross/Crescent. They also pass personal messages of a
humanitarian nature from members of the public who hopefully submit desperate
notes in handwriting. (there is nothing else in most villages but the Red
Cross/Crescent radio). Impressed by how well this was working I visited the base
station, to find a small team of very enthusiastic young volunteers, men and
women, Christian and Muslim, bent over a homely, improvised table with a dozen
very ordinary VHF 'mobile type' radios (apparently) haphazardly jumbled about.
Hand written notes in Arabic were being passed from one person to another with
speed and relayed on. They were a little embarrassed at the 'informal' technology,
but I assured them that they were doing much better than some well equipped radio
rooms I have seen, because of how they were using their equipment rather than how
expensive it was. By the way, today they do have a splendid hi-tech control room,
but I hope the superb morale of the Lebanese Red Cross/Crescent communications
department is not changed.
```

One solution to the problem of having to have the Base Station in an inconvenient position is a 'remote controlled' Base station. In this arrangement, the base station itself is placed in a position which is best

for the antenna system. While the controls are placed at a position where you can expect staff to be present. This is done by using specially made basestations which can be remotely controlled. There then has to be a cable from the basestation to the remote controller. In most designs, ordinary telephone cable can be used, then temporary cabling rather like that used in field telephones can be rigged, enabling the placing of the base station on the top floor of an adjacent building, while the controller is in the office, perhaps at street or basement level.

For a more permanent arrangement, a private wire can be arranged from the local telephone administration, connecting the two points. This will however cost you a installation fee plus a quarterly fee for the maintenance of the line. This is the method used by HM[68] Coastguard and the Air traffic control authorities among others. This explains their fantastically long reach as they select towers on top of high hills for their basestations, while the air traffic controllers headphones are connected to them by telephone lines (private wires).

If a private wire is not practical, or there are not staff at any location to handle traffic, then another alternative can be tried. The repeater.

6.8 Automatic repeaters

Usually called simply Repeaters or sometimes Relay Stations, these automatically repeat messages just as the radio operator would do at the base station, (if he were not having a break). Naturally it does not do it by writing the messages down and speaking them out but another way.

The receiver at the repeater receives the incoming message as usual, but instead of putting the voice out on a loudspeaker, the output is connected straight into the 'microphone' socket of the transmitter. The receiver has circuits to detect when someone is talking, and switches on its transmitter, boosting the signal and putting it out of its own transmit antenna, (which is obviously in the best position you can possibly find). The other handhelds receive this strong signal from the repeater transmitter, and so hear loud and clear signals from the sending handheld, giving the impression that the handheld itself has a greater range. This is the system used by for example police forces, which explains why their handhelds seem to have such a good range.
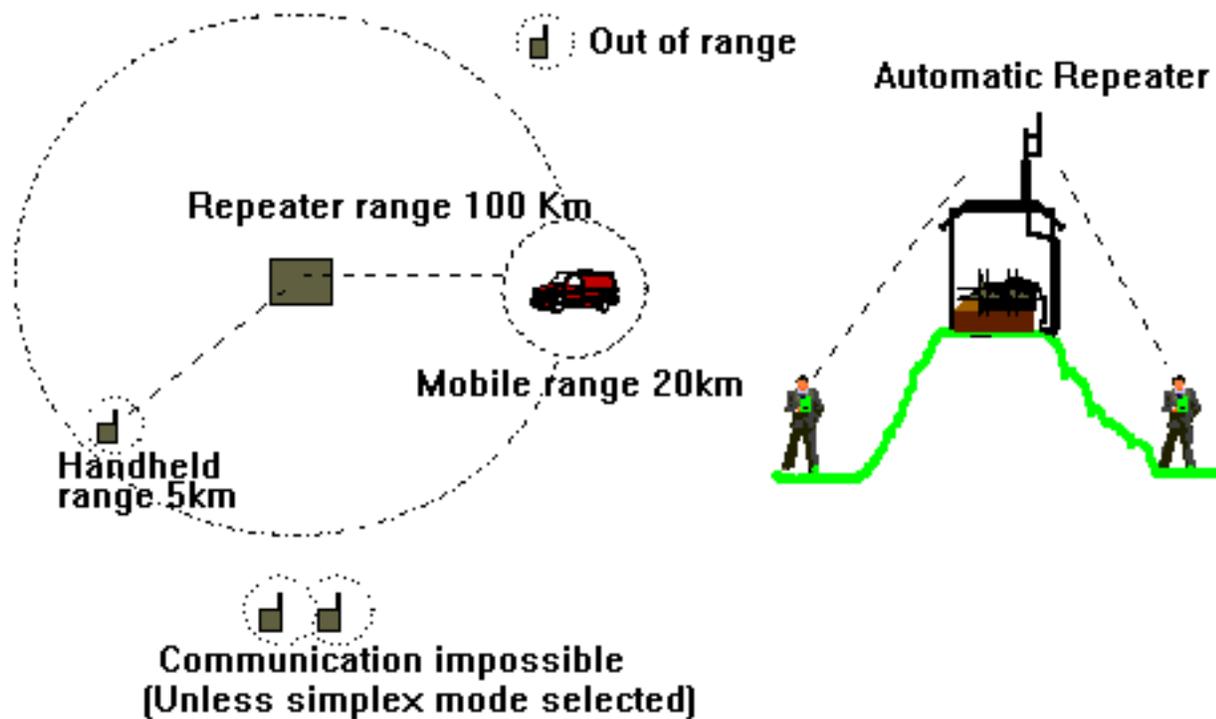
Fig 21 Repeaters boost range but need fallback schemes in case of failure

However their are some snags with repeaters. For technical reasons that I will have to explain later, if you set your radios to work with repeaters, they then cannot work without them. Therefore if your repeater is not working either because of a fault, loss of power, it has been stolen, or it never seems to have made the right truck somewhere, all of your radios will not work until you fix your repeater.

Also, if your handhelds stray out of the area of coverage of the repeater, say by driving to another town on the other side of a hill, they will not work with each other, which will confuse the users no end. If you choose to use repeaters you must guard them with zeal. Someone will have to check them to change the batteries or top up the fuel in the generator at least every 8 hours. You have just put all your eggs in one basket, so you must take extra care with the repeater.[69]

Because of the vulnerability of repeaters, you will need to have a fall back strategy, but in order to understand the problems and solutions with them, I will have to get more technical about channels.

6.9 Channels

Probably somewhere on your handheld or transceiver there will be a control marked CH or Channel. Typically it will have some positions marked A-B or 1-6. It may seem that contacting another radio would be as simple as just selecting the right channel, unfortunately this is not so and there are many complications. To examine them lets just take a short step back and look at how radio works.

In the days before radio, carrier pidgeons were used to carry messages. When the pigeon arrived at the

destination, it was ignored. The important thing was the message strapped to its leg. When radio first came in, the term carrier wave was often used as an analogy with the pigeons. The carrier wave transports the message to the receiver, where the carrier wave is discarded and the message is extracted and read.

However, here the analogy ends. For one of the useful things about radio, is that the carrier can be at various frequencies. A part of the transmitter will set the frequency of the carrier before the message is put on, by a process called Modulation, in another unit called the Modulator. In the receiver at the other end, a special part of the receiver called the Tuner, can let in only the frequency wanted by the operator. The allowed in carrier then has the message removed by a unit which does the opposite to the Modulator, called the Demodulator.

If we set the tuner of the receiver to the same frequency as the carrier at the transmitter, and if we use the same type of demodulator as the transmitter had modulator, then the radio link will work. Actually there is only one modulation system commonly used in handhelds today, the FM system (12.5khz separation or 25khz separation) so you would be unlucky to have a modulation system mismatch. Frequency is another thing.

Apart from some exceptions which I promise to come back to later, you will likely have applied to the host government in the country you are operating in for a (PMR) or (Private Mobile Radio Licence). You will then be allocated a frequency by the government, rather than your choice. You may be lucky enough to have permission for more than one frequency, but again, they will be set by the government. To stop people illegally using frequencies for which they do not have a licence, most governments forbid the use of radios in which the user can select any frequency, but rather, specify channellised equipment.

Prior to the introduction of Synthesizers, a crystal would be fitted into the radio, one for each frequency used, by a technician in a workshop. Today this is done by computer or diode programming, but it means that the user can not select the frequency directly, only select the ones fitted into his radio. There are several problems with this.

One problem is that if your radios were programmed by different technicians, they may have been programmed in a different order to other sets. Therefore the frequency on channel 1 for one set, may be channel 3 on another, and channel D on another. Never assume different handhelds will work together until you have checked every channel. If they don't work, don't assume that they are not programmed, but test all channels until you know which are which. The best thing is not to let this happen to you by carefully controlling who programmes your radios and having some kind of plan to standardise things. If you have the luxury of having the frequencies written on a plate on the back of the radio, this is better, but some organisations insist that the actual frequencies be kept secret.

If you are working with a different organisation, then very likely their sets will be on different frequencies to yours. There is no point in saying, call me on channel two, because their channel two may be a different frequency to yours. On the other hand, if you are going to be working with another

organisation a lot, you will have to tell them the frequency of your channels so that their engineer can programme their sets accordingly.

You would then need to arrange that the common frequency appears on the same position of channel knob in the sets of both organisations, as people are sure to say, 'call me on channel 2' rather than '165.475MHz '. Interworking is not always possible. Sometimes regulations or jealousy prevent this information from becoming available so you will need to check that this is OK before doing it. Sometimes the technical details of the radios do not make it possible, for example if one organisation has VHF and one has UHF.

There is a further complication regarding repeaters. Remember I said that the repeater listens to a handheld then transmits it out by its own transmitter. But this should be impossible because the receiver would then become jammed by its own transmitter, and never hear another word from the handheld. Quite true, so a tricky trick is used. The transmitter puts the signal out on a different frequency to the one the receiver is tuned to. This is called the Duplex system.

The upshot is that the handhelds have to know to listen to the output frequency, but when the PTT button is pressed, re-tune to the repeater input frequency. Because the repeaters antennas are usually higher than the handhelds, the repeater output frequency, or handheld input is called the downlink. The handheld output frequency which is the repeater input is called the uplink. It would be too much to expect operators to remember all of this, so the channel selector knob is programmed to arrange this automatically when you select a certain channel number. So you can see that **some channels are two frequencies!**

The bad news is that if the repeater were faulty, or not put up yet, then the handhelds would not hear each other because they would not be set to listen to the transmit frequency of each other. There are two solutions to this problem. The best one is to apply for a simplex frequency in addition to your duplex pair. This means that you manage without a repeater if you didn't have one by simply changing to the other channel. The problem is that everyone would have to know this and change accordingly.

Another idea is to programme one of the channels to the output frequency of the repeater, but arrange simplex programming on that channel. This could cause confusion because someone would be sure to hear the repeater when flicking channel knob, then wonder why no one could hear him when he calls. If you have only one licence for one duplex channel , but have two channel radios, then programme simplex mode on the downlink frequency. This has the advantage that users can be warned to switch to the other channel when the repeater's failure is learned of, because they will still be listening to the downlink frequency in receive mode.

Again, you would need to explain what you had done to your users, so some form of instruction is needed or your investment will be wasted.

A further complication is that the government may not allocate a duplex channel to you, in which case

you cannot use a repeater. In that case, you have the option of a remote base station arrangement. Remote basestations also offer the advantage that if they fail, handhelds that are in range can still talk to each other, and to mobiles or transportables, so the problems of working in failure mode are less severe.

6.9.1 Trunked repeater systems

Another problem with repeaters is that a handheld could quite easily stray out of the area of coverage of the repeater. If the area of operation is larger than the area of coverage of the repeater, then another repeater will have to be built on a site suitable for coverage of the new area. There are two problems with this, firstly the users will have to know what the coverage areas of the respective repeaters are and they will have to know of and have their radios programmed with the frequency for the other repeater. The other problem is that it is not possible to communicate with users on the other repeater.

One solution to this problem is to couple or link the two repeaters together, either by a landline link or by a radio link.

```
=Report=Report=


The USA Radio Amateur Civil Emergency Service (RACES) have the privilege to do
this. Upon a command tone from a handheld station, the amateur radio service
repeaters will pick up and relay anything that the other one(s) in the same group
can hear. This results in the coverage of the handhelds becoming region wide. -
RACES
```

To overcome the problem of users having to keep re-tuning the radios, more ambitious trunked radio systems are in use. With these, the radio automatically scans for the strongest signal and re-tunes to it. This does mean that the radio has to have the appropriate control systems built in, and it has to be correctly programmed.

In multi-channel 'pool' systems, each repeater station has not just one channel, but several channel available for use. The same repeater can then be used by different unrelated services, all of whom benefit from the repeater's coverage. When a user presses the push to talk button on the handset, a short data message is sent from the handheld requesting an uplink channel to the repeater. If there are no spare channels available at the repeater, then the user hears a low pitch 'boop' sound, followed by a 'pip-pip-pip' sound when a channel has become free and been allocated. When the 'pip-pip-pip' has been heard, the user can now speak.
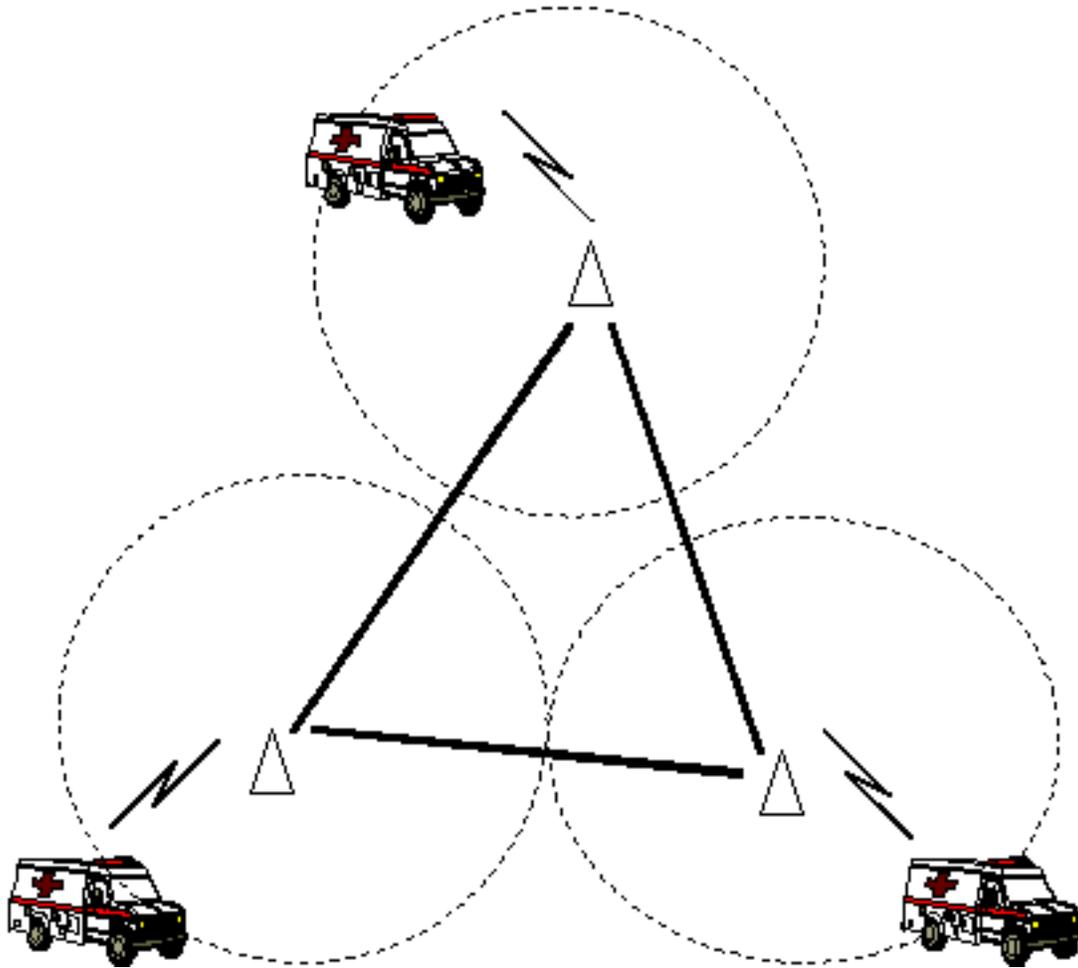
fig 22 A trunked system links repeaters together to provide a wider area of coverage while keeping operaton of the radio as simple as a simplex system. This method also retains the benifits of point to multipoint communications.

In the mean time, all the other handsets which are programmed to be in the same group as the sending handset will have been 'paged' by the system, and will have tuned in to a downlink frequency on the repeater who's service area they happen to be in.

More advanced versions such as the Ericsson/GE EDACS system are digitally scrambled, making unauthorised overhearing, by journalists for example, impossible. EDACS also offers the possibility for a handset to 'join' and 'unjoin' groups as the needs requires. For example, a Red Cross unit would be only in the Red Cross group normally, but once on the scene, may decide to join the same group as the local fire/police/medical services are on in order to co-ordinate their efforts better.

The advantage of this is that there is virtually no limit to the size of the area that can be served by such a system, while there is no knob twiddling to be done by the user and so it feels just like a simplex walkie-talkie to him.

The disadvantage is that 'ordinary' radios will not work with a trunked system unless they are specially programmed to do so. This means in fact that you have to be given radios by the operators of the trunked

network. This could present a problem as they are quite expensive and so it is unlikely that there will be many floating spares at very short notice.

Also, the system needs to be set up by engineers and so is unsuitable for use in the first phase of a disaster. However it is ideal for the case where regional planning policy provides for such a system for the local emergency services, for instance. If you are planning ahead for disaster communications in a known area, try to get permission to use the local administration's trunked network and obtain handsets and mobiles on their system.

6.10 CB

Citizens band as it is called in the USA, UK and other countries, refers to a band of frequencies which have special rules. Any private citizen is free to go to the Post Office and purchase a CB licence, renewable annually, entitling him to set up a radio transmitter provided it conforms to certain rules. So far, this is really not different to anything else mentioned above. The result is that there is such a large mass market for sets which conform to these rules, that the prices of the transceivers on these bands tends to be about one quarter of that for any other band. If cost is your priority, then this may be for you. However there are some things that you need to be aware of.

For one thing, not all countries have a band allocated to citizens personal radiocommunications, so it could be illegal to use them. Some countries have their CB frequency band on a different frequency to the 27MHZ used in the UK and the USA, so the price advantage may be lost as cheaper equipment will not work. Additionally, the USA specifies AM modulation whereas the UK specifies FM.

Another problem is the frequency itself. 27MHZ is a frequency with big problems. Most of the time it acts like VHF, as a purely line of sight mode, but not bouncing off walls of buildings very well, reducing its effectiveness in built up environment. However it does perform well at rolling over gentle and smooth terrain. The problem is that due to the influence of the sun, every 11 years it becomes liable to long distance 'skip' causing its signals to bounce off the Ionosphere and giving the band fantastic ranges. Well what is wrong with that, you ask quite rightly? The problem is that now you will have strong interference from USA and S America which will make the channels hard to use for local messages as they will be swamped by strong signals from excited (and illegal) high power stations.

A further problem is to do with the wavelength of 27MHz. It is about 11 meters long, as opposed to about 70cm for UHF. This apparently boring detail has a profound effect on antenna size. For example external antennas have to be about 5 meters long, making them much larger heavier and more expensive than the titchy UHF equivalents. The biggest effects though are on the handhelds. A whip on a handheld would have to be at least 2.5m long, like a fishing rod, in order to be efficient. Even if you try helicals, the sizes become like horse whips and are not really handy.

By far the biggest problem is the popular success of the band. Many thousands of ordinary people, and in

particular young operators having their first taste of communications technology are on the CB. As they are not required to pass an exam in procedures, this means that discipline on the band is notoriously bad.

To add to that, many CB users feel that their band should be used only for personal use, and greatly resent the use of the band for 'serious' use. You can see why; commercial users would block it all day with traffic that should really be sent on the proper commercial frequencies set aside for that purpose. Therefore you may find yourself subject to hostile 'jamming', and a great deal of intimidation designed to make you move over to a proper commercial frequency.

On the other hand, if you are operating in an area where a disaster is in progress, CB users are unlikely to feel that way, and on the contrary, you may find may useful local contacts who are in a position to be of help to you . Nearly all countries supporting CB have disaster relief networks such as 'React' to help you in this way.

Whether legal or not, you may find that the CB band is the only one which is common to all agencies working in some areas. We saw before that interworking between agencies can be fraught with technical difficulties, but you may have CB in common with them, in which case the channels are the same frequencies for both organisations. Unfortunately, repeaters are forbidden on the band as duplex working is not allowed.

CB equipment is so relatively cheap that it is not a bad idea to pack at least one transportable with external antenna, and perhaps a handheld too, just in case it comes in handy. If it doesn't, you can always use it for shopping trips.

6.11 Amateur Radio

Amateur radio, (or Ham radio) is another set of international laws enabling private individuals to operate radio stations for their own self training and entertainment(see part 1, 3.4) In this respect it is like CB. But there are also many differences, many of which are very important to know, so without giving an exhaustive lecture about amateur radio, let's look at some of the more important points.

Let me return to the theme of handheld radios again. You will recall that some of the problems with CB are associated with the large antennas and liability to jamming. Amateur radio does not suffer from these problems because there are many frequency bands allocated to amateur use, one of which is in the VHF band and one in the UHF band, both of which are ideal for handheld units.

Amateurs are required to sit an exam before being allowed to take to the air, and are required to keep good behaviour or they risk losing their licence. All of which adds to greater discipline on the amateur radio bands. A further plus is that repeaters are allowed on these bands, and furthermore, a large network

of them already exists.

Local amateurs are probably well drilled in the arts you need for communicating in the local area. They will understand the local topology, for example, and already know what is possible and how. They will also know about the coverage of the local repeater system and packet nodes. Even if you decide to deploy your own system, Amateurs can advise you about what to deploy where and even be able to help you with some of the hardware you may need. Best of all, it won't cost you anything!

Another advantage is that the Amateur radio bands are defined by international law, so you will have a common pool of agreed frequencies to use for interworking with other organisations. This has the advantage that there will be no need to wait for a frequency to be allocated to you, you could start to use the channels immediately.

With all these plus points, you may wonder why everyone does not use the amateur bands. The reason is that in law it is strictly forbidden for any person who does not have an Amateur radio licence to operate on the band. So you would need to either take a Radio Amateur with you, or get the users to obtain their own licences.

In practice the situation is much better. The International Telecommunications Union (ITU) is very well aware of the practical problems faced by disaster and aid organisations in moments of crisis, and are also well aware of the benefits that radio can bring. In Resolution 640 (see 5.2), radio amateurs are encouraged to 'meet the needs of international disaster communications'. There is a full consideration of all this in chapter 5, but here is a brief summary.

The British regulations, for example, say that a licensee can allow a 'representative of a user service organisation' to use his equipment, but only under his ' presence and direct supervision'. As to what is the definition of a 'User service organisation' and what constitutes 'direct supervision' depends of the interpretation of the rules by the government in who's territory you are working.

In the case of breakdown of authority in the area concerned, this may provide you with a way of circumventing red tape and getting equipment into the area as you won't be intruding on any existing users frequency. This fact alone may be enough to allay fears from existing users, and create less barriers to get you on the air as soon as possible. Invoking resolution 640 provides you with a legal framework for operating, which will keep you out of trouble, provided you obey the locally applicable regulations but you must demonstrate absolute maturity in how you exercise the privilege so provided.

It would be illegal to use the Amateur bands for an extended period for a long term aid operation. Another point is that you have absolutely no right to hog any channel, or to cause interference to any other Amateur operator. Whatever the case, finding someone in your organisation or team with the will to obtain an Amateur licence is obviously no bad thing.

There are however security implications in using the Amateur service, I have covered this before in part 1, but I thought this a good time to repeat it again. The Amateur Radio Operators working with you are unlikely to embarrass you, but many others will be listening in with great interest. It will be like doing your laundry in the town square, with passing strangers looking on. Ideally you would like to solve this problem by using data systems such as packet radio, in which case you would want to scramble the data before sending. The problem is that it is strictly forbidden for an Amateur station to send messages in anything other than 'plain language'.

By contrast, your organisation rule book may insist that you preserve the confidentiality of those you are serving, making passing such information in such a public forum out of the question. This issue means that the use of Amateur radio may be limited to logistical matters, but in any case this will depend on what the policy of your organisation, the policy of the host nation regarding sending coded messages by amateurs, and how urgent your need is.

A further problem is that amateur networks are designed to relay written messages from net to net until they arrive at their destination. It takes quite some minutes for even a simple message to be spoken over the air, written down, checked, and spoken again to the next net controller etc. until the message arrives at the addressee. If this requires, for example, four repetitions of the message, then it can take 20-30 minutes to ask a question and get a reply. Again, packet operation improves this situation.

6.12 HF Radio

Whatever we do, the range of VHF and UHF radio systems will be about 50-100km at best, so what if we either don't have a high spot to rig our antennas, or the range to the next base is more than the range of our equipment?. One answer is HF Radio.

There is another better book dealing with the setting up of HF radio stations for aid organisations, "**Where There Is No Telephone**", (see bibliography) so I will not repeat the fine work covered in its material. However, while you are waiting to get your copy, I will go over some of the main points.

For a fuller discussion of how HF radio works, see the **Appendix " How HF Radio Works"**. Basically we need to remember that we are reflecting our signals off the underside of the ionoshpere,our marvellous shield, protecting us from radiation in space and making life on earth possible. However the shield is built to keep radiation out, not radio in. It is different under the day part where the sun is stronger and the shield is higher and more active, than it is under the night time part where it is lower. As we rotate under it, the frequencies that will work well by day will not work well by night.

The bottom line is that you will need to have at least two frequencies or more, (at least 2MHz apart), to give reliable HF radio contacts. It then depends on the skill of the operators to decide which frequency to use, but it is always better to use the higher one by day and the lower one by night. The best thing would be if we could get our experts to predict the best frequencies for us, and then apply for licences at frequencies near to the best ones selected by our experts.

6.13 Allocations

The sad fact is that this will not be the case. We will have to apply for a licence for a frequency from the government of that country, but we will be just one of many applicants. The result will be that we will be stuck using the frequencies that the government issues. Therefore we may find that our frequency is only any good at certain times of day, leaving us cut off the rest of the day. If this is so, it is important to carry our regular radio checks with the other stations in our organisations to see that they are still in contact with us. Over a period of a year, the pattern will emerge of how our network is performing.

Further bad news is that your licence may insist that you share the frequency with other users, and specify a time for you to use the frequency. If you are in a skip zone (dead zone) at that time, you are out of luck, and should re-apply to the government explaining your problem.

Whereas with VHF, the secret is the height of the antenna, in HF radio, **the secret is in the frequency you use**. You should get expert opinion about what frequency band to apply for.

> # HF radio:
> # The secret is in the frequency

Once the licences are issued and their terms and conditions are known, only then should the equipment be ordered and purchased. The licence may specify certain technical restrictions on the radios and antennas to be used, so you should get an expert to look over the details for you before you purchase to make sure that the equipment will meet 'type approval'. Type approval varies from county to country, and is different from Europe to Africa for example. Pester your salesman until you are quite happy that the equipment meets the type approval for the country in which it will be used , there are lots of bad stories about this.

6.14 Antennas

See 3.1.3

The type of antenna you buy will depend upon the frequency you are intending to use, the physical space that you have to erect it and the range and direction of the other station or stations you are intending to call.

There is more information on this in "Where There Is No Telephone" and in part 1 CH 3.1.3 of this book, but here is a summary of the main points.

Once the frequency has been decided upon (by the host government) you now must specify this to the supplier of the antenna. If you have been allocated more than one frequency, then it is possible to have the same antenna designed to work with several frequencies, in which case you must specify this to your antenna suppliers.

Another alternative is to use Broadband antennas, or Long Wire antennas with an automatic or manual Antenna Tuning Unit.(ATU). Or you can use temporary 'bobbin type' antennas which are physically wound out to the right size when the frequency is chosen. This is better for those on the move as it is very compact.

In any case you may end up with an antenna which is physically about 50M long, so you may have to take this into account when selecting antenna type.

If you are communicating to another place, the direction of which is known, then a beam is better, concentrating your power in that direction. If you are working mobile stations then an 'inverted V' might be better, offering both vertical and horizontal polarisation.

Good installation of HF antennas is very important, especially with respect to their height, bearing and earthing. Make sure that whoever installs the antenna has the instruction manuals from the maker and has access to advice about the installation of it.

The choice of make and model of radio is much less important than the frequency and the antenna, but you should choose something that your people can understand, and has a reputation for reliability and prompt maintenance in your area and is **type approved** in the country you are working in. One way of simplifying things is to buy locally.

6.14.1 Scanners

If you have been allocated more than one frequency, then a scanner, allowing you to listen to the frequencies one at a time, at say one second intervals, is a very good idea. Then if callers don't get through on the higher frequency, they might try the lower one. The problem is that if you don't know that the higher one has faded out, you may be listening to a dead band without knowing it.

Scanning receivers can be programmed to switch from frequency to frequency so that you can listen on all the frequencies that you may be called on. Naturally this means that the calling person needs to make a call at least 15 seconds long in order for the scanner to visit that frequency and open the speaker long enough for the person to recognise his callsign. Separate scanners have to be connected in such a way

that they will be disconnected from the transceiver when transmit is selected, by connection to an external RX antenna socket on the back of the transceiver.

A much better way is to specify a transceiver which is capable of scanning by itself, not all models offer this but it is highly recommended.

6.15 HF Amateur Radio

The Amateur service can be used in a disaster, provided the Host government has given its permission. By invoking ITU Resolution 640 and the Tampere convention, you can use the HF radio bands allocated to the Amateur service (see ch 5). This will also solve the problem of interworking with other groups in the area. Amateur bands in the 3.5, 7 and 10 MHZ band are all excellent for local contacts, but as usual you must organise who listens to what frequency and when.

Amateur radio transceivers can be purchased which can also be used in a general coverage mode and thus be used both on amateur and commercial frequencies. This will enable the same radio to be used for local calls and for long distance phone calls via a coast station such as Portishead Radio. Another important point is that Amateur bands are not restricted to just voice communications. Other more advanced data communication modes are very common, indeed were developed on the Amateur bands. To see why you would want to get an already complicated situation even more complicated. Let's look at them on the next section.

6.16 Data by radio

There are many radio data systems, but by far the most common in 1996 are:

- Packet

- Tor

Before we look at them, we must ask, why spend time and money on them when we can make do with something simpler? Perfectly good question. Technical whizz kids just love gadgets, so they are likely to insist on their indispensability sometimes for reasons less than logical. Data communications systems will cost you more to purchase. Not only because you will need special, (but not too expensive) extra circuits, but because you will need a computer or terminal to process the data.

Now, I have used computers every day for many years, in fact the whole of this document was written on various lap top computers. I would never be without one on my travels around the world, but I still can't decide weather I love them or hate them. A fixed desk top computer connected to the mains is one thing, but when you start to travel with a computer it is quite another. Is it robust enough to handle the bad

knocks?, did you remember to charge it? Where is the charger? Yes, computers are not totally reliable yet. If your PC won't do the business for any one of a hundred reasons, you will have egg all over your very red face Trust me, I know.

Never trust techno-wizzgadgets. If you are really serious about reliable communications, then always have a back up plan, preferably a simpler system, to fall back upon if your flagship sinks. For example you may arrange a voice check on the link say two or three times a day at a scheduled time convenient to both operators. If the data system has failed, you will learn of this at the 'sked' and be passed any missing traffic.

Now that I have said that, I still think that Data communications systems are a very good idea, why? Because if they can be connected to a regular radio, and if they are working, good. If not, then you have not lost anything **provided you take the kind of precautions just mentioned.**

6.16.1 The problem

```
=REPORT=REPORT=
```

```
In one recent case, a DRCF engineer was sent on a very dangerous journey through a
civil war zone with a mission to find out why a Humanitarian aid communication
system was not working. The problem?, nothing wrong with the equipment, but people
were too busy to sit near to the radio all day, so very often callers would call
the station while no one was there. Hearing no answer they assumed that there was
a technical problem, and having lost faith in the system, stopped using it.
```

Wouldn't it be nice if you could just write out a message for the station at the other end at a printer on their desk, or in their car. Then they could read it when they had time, a kind of do-it-yourself Internet. Of course you would want something that told you if the message got through or not, but think, you could write your message and get on with your very important work instead of wasting time with knobs, dials and roger-wilcos.

You may smile and sigh at this fanciful dream from the far future but don't. Its here now, it definitely works, and its relatively cheap.

6.16.2 Packet Radio

The Packet radio system (I will discuss AX25) is most suitable for VHF and UHF systems. It gets its name because of the way it converts your data into 'packets' with an address on the outside and the contents on the inside. You connect a small box called a Terminal Node Controller (TNC) to your ordinary radio's microphone and headphone socket, you don't even have to open up the radio. Then you connect either a computer or a 'terminal' to the box. Terminals can take the form of a small thermal

printer with a keyboard attached, such as the famous TI703, or some portable electric typewriters can be adapted for this job.

To use the system you just type `"connect station 1"`, for example into the keyboard. Then it writes `" connected to station 1"`. From then on anything you type comes out at the other end on the screen or paper, perfectly simple. If the other person is there at the time, you can even hold a two way conversation. At the end of the message you type "disconnect" and it replies "disconnected". There are many advantages to having messages in text, and we have covered them in chapter 1.2.3 , so if you have not read that, please do so now.

You may wonder what if the station is out of range of your VHF set. Normally, if you do not have a repeater, you would be out of luck, but packet radio has another very pleasant surprise up it's sleeve.

6.16.3 Digipeating

TNC's talents don't end at just connecting as in our first example. They can also take in messages and then pass them on to someone else who is in range of it, but out of range of the sender. This is called Digipeating (digital repeating). Any or all stations can be digipeaters. You can pass messages over thousands of miles, if you know the routing to send it.

AX25 needs the sender to type in the route like this `Connect station 1 via station 5`, then all is the same. However some more intelligent systems can work out the routing for themselves. If you are using digipeaters which are usually in the same position, and which are normally switched on, then digipeating is ok, but otherwise some other ideas are worth looking in to.

6.16.4 Mailboxes

Suppose my equipment is out of range of the sender or the other station is not always switched on, or I am a mobile station and my route via the digipeaters is different from the usual, then I won't get anything, so what now? The most common fix is to designate one of the stations to be a mailbox. This will have to be one which has a good power supply as a computer will now have to be on all the time to act as a mail server, in other words be running a special programme and preferably one which is in a position of good radio coverage.

To send a message to the mailbox is also simple, the sender types `"send station6 at mailbox1"` instead of the usual command. To retrieve messages, you just connect to the mailbox via the digipeaters as usual, then after typing in a password, you can privately read your mail.

There are many exciting ways of using packet radio, but this is not an exhaustive manual on all modes so time to ask another question. What if you are out of range of any VHF working digipeaters? There are

two methods, satellite systems, and the HF radio equivalent of packet, TOR.

6.17 Satellite Packet Radio

This system, called 'Satellife' (see appendix) was invented especially for aid organisations by volunteer communications experts at Volunteers in Technical Assistance (VITA). A packet radio Digipeater/mailbox is built aboard a Low Earth Orbiting Satellite (LEO). The satellite passes low over the earth about four time per day. You type your message into your TNC, then it waits until the satellite passes over next time, and beams the message up. At the same time, messages become beamed down by the satellite. It is rather like a global roving mailman.

The plus side to this is that not only is the equipment very inexpensive to purchase, but the service is free. The system has access to Internet in order to traffic messages to users not so equipped. There are more details about this in the appendix.

6.18 Teleprinter Over Radio (TOR)

Teleprinter Over Radio (TOR) can also be known as Simplex Teleprinter over Radio (SITOR) or Amateur Microprocessor Teledata over Radio (AMTOR). They are more similar than they are different.

In most ways, TOR is used just like packet radio is, but there are some differences also.

There are in fact packet radio systems that work over HF radio. These have the advantage that they can send the full ASCII character set, making it possible to send messages generated by computer mail programmes. However straight packet is much less reliable over HF radio and so a special version called PAKTOR has been developed and I will come to that later. For now we will stick to TOR.

TOR is used in a way very similar to packet. The user first types into the keyboard the receiving station's selective callsign, then waits for a 'connected' indication from the terminal. From then on, you can type out information that is guaranteed to arrive just as you typed it, on the other station's screen or paper. This is achieved automatically, by sending the letters you typed three at a time, and then checking that they are OK at the other end. If they are not, then they are repeated until they are correct. All this is done automatically so there is no need for the users to know about any of this. A big plus is that it can work even if the equipment is un-attended, thus freeing people for more important jobs. Tor is very mature now and is used by such organisations as the CICR(Comitee International Red Cross). There are also mailboxes available for TOR just as there are for packet.

The disadvantage of TOR is that for reasons of history, it can only transmit letters of the alphabet, numbers and a few punctuation symbols. You can therefore not transfer ASCII coded computer data over it directly, but of course programmes exist for filtering out unsupported characters, if you do write the

message on a computer and forget.

6.18.1 Pactor

The Pactor system is a highly successful development from the TOR systems just mentioned. It took the best of the TOR and Packet systems and combined them into one. It was invented by a group of German radio amateurs who wanted to exchange computer data files and found the limited character set of AMTOR too restrictive for their liking. There are three big advantages of Pactor.

1) It can transmit the whole ASCII character set, in other words upper case and lower case letters, and can transmit all of the symbols appearing on your computer keyboard. At first this may seem like only a small victory, but it means that pactor can carry files generated by electronic mailing systems, for example. Another less obvious advantage is that it can transmit computer files which are not messages at all, such as spreadsheets, or even programs themselves.

2) It transfers data much faster than TOR, four times faster, at a rate of 200 Bauds for Pactor as against 50 for TOR. there is also a version transferring data at 800 Bauds. (However this is still reletively slow compared with PSTN line and modem).

3) More advanced error correction systems are used so that the chances of the message arriving without corruption, even over a bad circuit, are better.

The Humanitarian aid community soon showed interest in this mode and a special version was developed for them, known as Swiss-PTC (Pactor Controller). It was a big hit and generated high demand for traffic. It is not exactly the same as normal amateur pactor in order to discourage unintended listners from copying information not intended for them .

```
=Report=Report
```

```
In one case, a journalist was 'listening in' to SITOR signals across a Red Cross
frequency, using AMTOR equipment, when he intercepted some private remarks from a
Red Cross field team intended for internal use at the Red Cross HQ. He illegally
used the contents of the message he had intercepted to write a newspaper report
which was so sensational that it caused a big diplomatic incident. The result was
huge costs to the Red Cross, due to the cost of relocating the persons mentioned
in the article. Though Humanitarian aid organisations are hardly the CIA, they do
work in very tense environments and so there is always the need to prevent
messages getting into the wrong hands and being taken out of context, not to
mention mischievous use of information by unscrupulous journalists.
```

To improve speeds still further took much more effort from the experts. More advanced modems and

dedicated data coding chips were then added to the system in order to develop a faster and yet more reliable system which would have a speed of 800 Bauds. However with so many stations already using pactor and Swiss PTC, it was arranged for the new system to automatically recognise the correct system and select that one, while remaining compatible with ordinary SITOR as well. The new system became known as PTC-2.

Pactor is now the favourite system for use by Humanitarian aid organisations at time of writing in June of 1996, and such as the ICRC, IFRC, UNHCR etc. use it as standard. In fact it is part of the IFRC automated electronic mail system. It enables Red Cross offices in areas where there are no data services, to access the electronic mailing system in Geneva and all without the aid of radio operators in the radio room. The main advantage is that, because the Red Cross have private frequencies, there are no costs to pay other than the first cost of the equipment.

6.19 CTCSS

Continuous Tone Controlled Squelch System (CTCSS) is offered on most VHF and UHF sets. It often happens that you have to share a frequency with another user, and their constant chatter is bothersome to listen to, leaving you to turn your volume down so low that you can't hear your own people calling you.

In a CTCSS scheme your sets emit a continuous tone while the PTT is pressed, but this is not heard in your loudspeaker. Instead, a circuit inside your set checks to see if the signal is one of yours, and if so, switches on the speaker. If not, then the speaker stays silent and your nerves are spared.

There are however some rather disturbing down sides to CTCSS. One of them is that if you recall, only one user at a time can use a frequency, so how can you tell that another user is not on the frequency? You can't, neither can they. They might be blasting across your calls and wiping you out without knowing it, and you likewise.

Hopefully they are fitted with a system which will not let them transmit unless the channel is not occupied, but if you are also so fitted, there is potential for a problem. If you press and talk, but the channel is occupied, you will transmit nothing but think you are transmitting. Actually there will be a light or beep indication on the control panel of the radio, but will all of your people think of that? They might either think a message has got through that hasn't, or lose faith in the system when it doesn't work.

```
=Report=Report=


The volunteer St.John Ambulance brigade in London, England are a front line
ambulance group. They supplement the London Ambulance Service and are often faced
with a busy day of calls from the public, needing vital life saving assistance at
once. The Ambulances are dispatched from the HQ near Baker St., in the west end of
```

```
London, by simplex radio system in the VHF band. Suddenly without warning, a very
powerful station, callsign 'Zero Base', started to come on the same frequency as
was used for ambulance dispatch. It often happened that urgent messages to
ambulances were lost, garbled and delayed when this new station just transmitted
across the weaker ambulances. Pleas to the dispatcher of the intruding station
were ignored. In time it was discovered, by St.John engineers, that a private
security company had been allocated the same frequency as the brigade, but were
using CTCSS in order to have 'privacy'. CTCSS does not give real privacy and you
must understand what is actually happening when you use it.
```

A further problem is, suppose another organisation needs to contact you urgently and tunes to your frequency expecting to contact you. You won't hear them unless they also know of and have programmed in the CTCSS tone.

Frankly I think it isn't worth using CTCSS in simplex mode given the problems, unless the interfering stations are always weaker than yours.[70] However it is used by the UNDHA for example in their repeater systems. We must make sure that our repeater will not pick up random interference (of which there may be plenty) and block our repeater by holding it in the transmit position. By using CTCSS, the repeater will only open when our mobiles are transmitting. The repeater downlink should be stronger than any adjacent signals so the problems are much smaller than the advantages.

> ## Warning
>
> CTCSS and SELCALL do NOT provide real privacy as some salesmen claim,
> it is an illusion. You cannot hear other stations on the same frequency,
> but they can easily hear you.

6.20 SELCALL

Selective Calling (SELCALL) is another scheme to overcome the problem of having to listen to other people's chat. There are various methods of it but the basic idea is the same. Each station has a built in circuit board with a unique code. Only when the code is heard will the speaker be switched on. The sender of the message must first send the SELCALL code before trying to call the other station. SELCALL produces a very distinctive sound, like dyslexic pan pipes.

There are however two features that SELCALL offers that are different from CTCSS. One is that you can call all or only one station. You can arrange it so that when the SELCALL is received, a bell sounds in the building or the horn sounds on the vehicle. This could alert the staff to an incoming call without them having to be in earshot of the radio at all. Another feature is called revertive calling. With this, you will get an indication of some sort at the sending end if the receiving station received the code and has set off

its alert horn. This can give you reassurance that the system is working.

However there is also a problem with SELCALL. It often happens that key leaders are doing more than one job in on going emergency. Suppose for example that the Duty officer has the SELCALL 101. When you call this SELCALL his personal radio and only this one will switch on. This is fine if he is carrying that particular set. Suppose that same person is also acting as first officer of the Disaster Action team at the same time. To call the First officer the SELCALL would be 102, for example. This would mean that the officer would have to carry both handsets in order to receive both calls. The situation would become more complicated if he then got in a vehicle and found that his handheld will not work so well inside the metal of the car, as the car mobile station does with its much better antenna.

Given time, some quite bizarre scenarios can occur resulting in people having to carry several handsets around. and despite all that, have to remain near to a transportable set to receive calls intended for him in a supposedly fixed position. With SELCALL it is possible to bring back some of the bad old problems with phones and mobile phones.

The solution is for a person who is away from the radio which is normally assigned to him, to defeat the SELCALL system so that he can hear calls for him. This is done by pressing a 'def' button on the radio or, via a menu, defeating the SELCALL system. It also means that callers need both to SELCALL him and give a spoken call so that he will hear the call if listening by ear.

Another solution is for the sender, upon not receiving a response from the called mobile, to then send the group call SELCALL. A group call SELCALL means that the sender enters in a code which is recognised by all of the mobiles in a certain group. Having opened the speakers on all mobiles, the sender can then speak out the callsign and name of the person required. When the person answers, he can state the SELCALL of the radio he is using, and the call can be set up again thus closing the other radios off during the conversation.

6.20.1 Pagers (Beepers)

A pager is a small and light radio receiver. It's size and weight mean that it is far more convenient to carry personally than, for example, a mobile phone or a two way radio. They are designed for optimum battery life, so that they can last about one month before the battery has to be changed. They are usually powered by an ordinary disposable battery of the type that can be purchased from nearly any general store. To add to that, they are much cheaper to buy and about one fourth of the cost to run than for example a mobile phone.

A typical use for them is for callout alert. In some models, there is a loud tone when the pager is called, in some there is the option of a vibration alert so that the user will not be embarrassed if in a meeting or sound sensitive area. In this case the user will have to have pre-arranged the meaning of the alert, and either go to a pre-determined meeting point or call a phone number. Some models of pager have more than one paging sound in order that several different predetermined messages can be sent.

More expensive models feature a small screen which may have either numbers or letters and numbers on its screen. In that case, a message can be left on the screen for the user to read later should he not hear the beeper. The pager usually remembers the last 10 messages. The sender can now send a phone number to be dialled, or a radio callsign to be called, or even leave a message (usually of up to 255 characters) giving further details of the reason for the alert.

These days pagers have become the backbone of many organisation's callout plan, with most emergency services depending on pagers to alert key staff quickly in the case of emergency. However there are some disturbing aspects to paging that you have to be aware of and have prepared for before you trust them totally. First though, lets review how they work.

Pagers are radio devices usually working at frequencies around 160MHZ. The area of coverage of them will depend entirely on the coverage of the radio base station network to which the user has subscribed. If the user roams out of the area for which he has paid a subscription, then the base stations in that area will not be programmed to call the pager and the call will be lost. If the radio waves become blocked to the user, for example if the user goes underground or in a screened place in a building, then the call will be lost. The problem is that if the alert did not reach the user for any reason, the sender will not know this. Pagers are usually one way devices and so the sender does not know if the call succeeded or failed. If the user fails to respond, the sender just has to keep paging and re-paging until the user answers.

If the base station has been disabled by a disaster, for example by having the mast knocked down by a storm, then the signal will not be transmitted at all. Like all radio base stations, Paging transmitters do not stand alone but need two vital services from the ground, Power and Line. A typical Pager station has enough battery back-up for about 8-16 hours operation without mains power. A long power outage will stop that station from working.

The paging stations have to know what pagers to call. To do this, the paging station receives a so called 'Paging list' from a control computer, usually situated very many miles away. This paging list in turn must come to the station usually by telephone line private wire. If the lines are down to the station then the station will have no paging list to send.

The sender has to alert the paging computer system by phoning the office of the paging company and either speaking to an operator, or typing the message from his phone pad. If the telephone system is out of order, then you cannot call the paging centre.

For a small area of operation, say over a 10KM radius, a 'stand alone' private paging system can be installed. The coverage area of the system will now depend entirely on the position of the antenna of the transmitter. These systems are usually basic tone only systems but have the advantage that they are independent of the local telecom net, have no running costs apart from the initial cost of the equipment, and are usually very quick to install. On the down side, You do need a radio licence for such devices unless the government has allocated a special general paging frequency for such private systems.

Apart from the same vulnerability to disaster as other conventional systems suffer, paging systems often only cover areas where there are concentrations of business users, that is, not rural areas. This is so because the profit margins on paging operations are quite small, whereas the cost of a paging station may be just as high as for any radio base station. There may be future systems operating from satellites to offset this problem, when installed, users would have global availability. However if the user cannot call his office to ask for instructions, the usefulness of these global pagers is much reduced, so in fact paging may be best used in conjunction with another mobile communications system.

In the future it seems that paging will have competition from the mobile phone sector. The latest mobile phones are only slightly bigger and heavier than a pager, and the user has to carry a phone anyway in order to reply to the page. As the latest mobile phone systems are digital, there is little complication in building in paging capability into the phone itself. In the Short message service (SMS) offered by the GSM (Global System for Mobilecommunications) system for example, messages of under 255 characters are passed over the call set up channels, so that the message charge is very low.

The message is stored in the phone as numbers or text in much the same way as a pager, including a helpful beep. The big advantage is that the GSM system positively knows if the message was received or not, and is able to notify the sender. It is even possible for the user to reply to the sender to acknowledge what action he will take. It seems that there are no complications to adding such a service to the future satellite services, and so they all plan to offer such a service.

In the future this will mean that the sender can call the message centre over a satellite link, and have the paging message sent down on a satellite link also, meaning immunity from ground disaster at last!

6.21 Line extenders

Line Extenders, also called 'Radio in the local loop',', these are a method of extending a telephone line by radio. A station is set up in a town where there is working telephone system, and a line is connected to the station. At the other end, a telephone is connected to a special device, which carries out the conversion of signals automatically. Versions also exist enabling many mobiles to access the line, thus enabling telephone service to be extended to them.

Line extenders are a mature and reliable product now, and they are used all over the world to provide telephone service to areas where the wiring does not penetrate. The equipment is compact and fairly cheap. The problem is that it is only as good as the local telephone exchange that you have connected to. If international connections in the area are poor, you will have not gained much over the other global methods, except perhaps cheapness. In a disaster, the local phone system will be either destroyed or severely overloaded, so it may be best not to trust only to this method. Long term aid missions though can benefit from this arrangement very cheaply.

6.22 Mobile Phones

Many users of the communications systems mentioned so far are heartily fed up with what we have provided. They are very unhappy with the fact that they almost always have to read a complex looking manual and spend hours by trial and error before they can use the system which their engineer is so satisfied with.

What seems so much like second nature to engineers is actually hostile to users who feel that they are much too busy to fiddle with such irrelevancies. We are living in a new era, the 'customer is always right' attitude means that users are much less likely to put up with us techno-people if we don't deliver what **they** want.

Just about everyone can use a telephone. That is why the mobile phone service is so popular. This is a great technical achievement. Behind the scenes, millions of dollars worth of computers and a huge network of base stations are invisible to the user. That is why when asked what they would really wish for, nearly all aid workers rock their head to one side, sigh, and confess that they want a mobile phone.

The public mobile phone system, also known as the cellular phone system is properly known as the Public Land Mobile Network (PLMN). Mobile phone systems work in a way similar to the other systems we have described. They need base stations to connect to. In the case of a disaster, they are not likely to be working. This is because few base stations have diesel generators, and usually have battery backup for only 8 hours of service once the mains goes off. Also, they rely on lines or microwave links going to a parent computerised switching system called the Base Station Controller (BSC) or Mobile Telephone Switching Office (MTSO). If these lines are disrupted, or the BSC has failed, then you are out of luck.

Even if the PLMN survives the disaster, one big problem is that most base stations have capacity for less than only 30 calls per cell. In a disaster, the working stations are sure to be busy with calls from local people, and you may have to wait a long time before there is a free channel at the base station to carry your call. You also have the problem of finding someone to sell you the mobile phones for the system in operation, and setting up a valid subscription to the service. This will be very hard as the local people will no doubt have beaten you to it.

The operator of the system has a different perspective. When asked "is your system still working", he will look at his toll ticket tape, recording the money earned, and reply with a smile of satisfaction that it is working very well indeed, thank you. They rarely remember to mention that the control channels that set up the calls are completely overloaded, and in fact users are finding the system nearly useless because there is rarely a free channel when anyone tries to call them, the call then fails.[71]

Other users in the cell may have bottomless pits of money at their disposal, and so having seized a channel, they hold it sometimes for days in order not to lose contact with their office. In fact, most

systems offer the capability for the operator to allow only calls from 'emergency services' to get through. In practice this is seldom switched on because of the loss of money this would involve. This is a sensitive subject and one which operators are often reluctant to discuss.

If the area has the Global System for Mobilecommunications (**GSM**) operational in the area, you are in a much better position. GSM phones are standard over the whole world, so you could bring GSM phones from Britain, and use them in Beirut or Siagon without a problem. If people in Britain phone you **on your usual number**, the system will find you wherever in the world you are, and put the call through even if the caller has no knowledge of where you are. This is called International Roaming, and is a great triumph of GSM.

Unfortunately there are still some snags. It may be that the operator of the PLMN in the disaster area has not signed a Roaming agreement with your operator at home, in which case roaming will not be possible. A bigger problem is that the GSM system is not by any means universal, so there are many places where incompatible systems are in use, so your phone can't be used. Also, in may countries, mobile service is provided only in cities, leaving no service at all once outside well populated areas.

6.23 Emergency Mobile Phone systems

Several manufacturers make quick fit emergency mobile phone systems. They consist of a kind of advanced base station, and special mobile phones for use with them. The problem is that they usually only offer connection within the area that the base station covers. Sometimes an outside line connection is available by satellite connection by dialling a number but usually not. The big problem is that to do this they require several duplex frequencies, one for each simultaneous call plus one for the control frequencies. You could not use it unless the government authority in the area agrees. This could take quite some time. In addition, it is much more expensive than the conventional systems just described but not any more effective, so you would need to justify the cost.

Another solution is the DECT system, a self organising mobile communications system rather like a mini mobile phone network. This has been described in ch 6.2.1.

6.24 Position finding systems

At first, position finding may seem to be an unnecessary complication to an already expensive and complex operation. but consider for a moment the kind of problems faced by field staff. In the first phase, a 'rec' team will have to assess the needs of the prospective clients. Often, the team are driving in a place where they have never been before, and often without the aid of road signs because they have been destroyed by the disaster, are in an unreadable script, or have never been provided. Even a map is useless unless you know your present position. Upon reaching the scene of the greatest need, they will now have to find the name of the place that they have found, but again, will they be able to do that, or

unambiguously pronounce the name of the place?

Having compiled their report and moved on, the main supply vehicles must now find the same place, so that the 'clients' identified by the 'rec' team can be helped without delay. Finding and then re-finding places becomes so difficult that many operations leave this job of distribution to local militias or other 'helpful' persons. The result is often that the supplies end up in the hands of 'sergeant Bilko' types and find their way into the black market economy rather than to the needy victims. Clearly, delivering the supplies that you have paid for to the users that you have intended is much better.

Safety is another factor. Should your field staff get into trouble and urgently need help, the rescue teams cannot help unless they accurately know the position of the distressed field team. This is why, at sea, the very first thing a ship must send over the radio during a mayday call, is its position. If the radio then fails, the rescue ships at least know where to go to find out what is wrong.

These then are among the many reasons why a humanitarian aid field unit may want quite accurate position fixing. Until about 1995, such devices were much to expensive and impractical for use by such small NGO's with small budgets, but by 1995 all that has changed. By that time, hand-held battery powered units with all the desired capabilities were about USD 300-500, which is about the same size weight and cost as one handheld radio. The dominant system is use at the time of writing, at the end of 1996 is the Global Positioning System (GPS).

By the turn of the century it is expected that most of the new LEOsat satellite phone systems will offer position fixing as a standard part of the service and so very soon position fixing will become an indispensable part of the many new products and services. For the moment though, let us look at some of the ways of using GPS.

GPS was developed for position fixing at sea in the air, and for the positioning of missiles. The GPS receiver on the ground finds its range to two or more satellites that could be in view of him. A computer inside the GPS unit computes its position based on the range to those satellites and the position of the satellites at the time the ranges were made. For the satellites to know their position, they have to have accurate clock, so a further bonus of GPS is very accurate time.

At sea or in the air a latitude and longitude position is very useful. There are few other relative landmarks to reference to anyway. On the ground however we want to find our way along a road network to reach a certain town or village, so for the position information to be any use at all, we would need to have maps with the lat and long grid printed over them. I have to tell you now that most useful road maps do not offer this, whereas most useful lat and long maps are not much good at showing ground detail and in any case cannot be purchased at an airport petrol station.

The alternative is to use 'relative positioning'. Suppose that you arrive at a city in the disaster zone, and are given a road map, that you purchased at the airport petrol station, to find your way to the next

rendezvous. What you would do is go to a place on the map which is very distinct. Go there (or send someone there) and Using the GPS, find the exact position of this place. It will now become a WAYPOINT. Record this waypoint in your book and agree with other members of your organisation the name of this waypoint and its absolute (lat and long) position. You will have to do this because other teams may have a different map with a different scale, colour code scheme, icon scheme and grid system to the one you are using.

Your map will hopefully have a reasonable scale printed on the border, and an indication of which way is north, though this is usually (but not always) the direction pointing straight up. Now mark the position of the place you want to go next. This will be another waypoint, you can name it what you like but the place name on the map is best (provided you can read and pronounce it!). Using a ruler and divider, you can draw a line between the two places and measure the line. You now know the direction and range of the other waypoint. You can now type this information into your GPS, and it will remember the location of the two waypoints, and even calculate the absolute lat and long of the other waypoint for you.

Well, that was jolly good schoolboy fun, but why did we do that? As you drive down the rutted roads in the bad weather for hours, you will probably wonder where you are and if you are going in the right direction at all. Your GPS will probably be battery powered, so rather than leave it on all the time you should switch it on only when you need position information. You would then switch on your GPS, and ask it what is the range and direction, from where you are now, to any of the waypoints you have entered into its memory. You will get a readout saying, "270 degrees 7Km". Now you can pinpoint yourself on the rather sparse map you have, even without any grid marks on the map and even if there is no landmark at that point. Furthermore, if you have a compass, you can use the direction for steering, provided the road system is simple enough. However you must be clear if the baring shown on the GPS screen, is the baring FROM the waypoint or TO it (or you could be driving the wrong way.. it has happened).

When you arrive at the scene of some obvious need, you can ask GPS for the position, and create a new waypoint at this spot. You can then use the relative information about how far away from another known waypoint this is, to draw its position accurately on you map. You can also use the absolute lat and long position to send to the other teams by radio, so that they can mark it in on their maps and find their way more easily. They will also know if they have got the right spot.

Used wisely, GPS can give a great deal of time and money saving help, and all at very modest outlay. GPS will probably be in service for many years to come and so you can invest without fear of the equipment becoming obsolete very soon. However it is important to remember to ask for a model that can calculate waypoints and give relative positions, or GPS will be useless without lat and Long maps, which you can bet will not be available to you. You should also share waypoint information with other teams, and collect positions from them. This not only saves misunderstanding, but adds a significant safety factor, you never know when they will fail to report and you will have to find them without being able to communicate with them. You should likewise report to someone else what waypoints you are expecting to be visiting before your next communication.

There are other systems than GPS for position finding, some based on ground based transmitter stations, such as Decca, Omega and Loran. However these are vulnerable to the user straying out of the range of the system, and to the failure of the ground based radio base stations providing the signals. The advantage of spaced bases systems such as GPS, Transit and Glonass, is that they are immune from land based disasters, and have global coverage.

6.25 The Future

In the future we could have advanced satellite systems offering global mobile phone systems at a very reasonable cost. When that happens, then the users will at last have what they think they really need. It is also thought that there will be a kind of satellite version of packet radio, giving access to Internet. A world wide library system called World Wide Web will make it possible to for example fetch maps and photographs of a place together with a detailed guidebook about it instantly on your screen. You will be able to read this book on your screen as it too will be on the WWW (it is hoped).

However this will not make your investment in the conventional systems obsolete because the future systems may be just as prone to overloading as the present ones are. Therefore you should consider them to be your secondary system until they mature, well into the first decade of the 21st century. It is an exciting future for the communications industry, but also a confusing one, that is why DRCF is here to help you. Future revisions of **Disaster Communications** will include anything promising that comes up. To do this we need your help, both financially and with information.

There is also excitement on the legal front. Remember all the legal hurdles to getting even a simple system set up? Well in 1996 there will be an International Convention on Emergency Telecommunications, which, it is hoped, will clarify and simplify the situation. The aim is to make moving equipment across borders easier and setting up emergency communications systems rapid and efficient by bringing in new legislation. It is hoped that many countries will sign up for an agreement to allow a waiver of the usual red tape in the case of an acute emergency, but of course there will be many terms and conditions to be met by prospective foreign rescue teams. The DRCF will be here explain them.

6.26 Training

Everyone realises the need for better training of key staff in the arts of Emergency Telecommunications. Not just techno- waffle for the boffins, but down to earth clear grounding for the decision makers in our business.

Many of the decision makers in aid and disaster work are intelligent, experienced and highly motivated people. Few however have any kind of telecommunications background and this often results in the application of technology which is sometimes less than appropriate. These are busy people who need

courses that will fill their needs for keeping up to date with todays can-do technology but keeping the language at popular level.

The DRCF and several other groups are actively working on establishing a framework for defining target groups for training and developing such courses. It is hoped to be able to offer theoretical and practical courses covering all aspects of this work, from a co-operative and co-ordinated base, within a time scale of about two years.

This book will be updated and expanded as experts submit more input to it. In addition it is proposed to add smaller booklets about topics which attract popular attention.

We have a lot to do before the International Decade for Natural Disaster Reduction (IDNDR) is out!

---

[66]In fact they go to the trouble of arranging 'talk through' systems on their duplex base stations to give this effect.

[67]See Appendix for the full International Phonetic Alphabet.

[68]The antennas for Liverpool Coastguard's Marine Rescue Centre at Bootle are on top of Blackpool Tower, giving a commanding coverage of the Irish Sea.

[69]The UNDHA portable repeater for use at a disaster site has enough self contained battery power for 24hrs sustained operation.

[70]A personal opinion, your experts may advise otherwise.

[71]During the Koybe earthquake disaster, the mobile phone system survived in tact. The operators claim that service was provided without overload throughout the rescue period- Ericsson.

CHAPTER 7

7 SUMMARY

The needs of disaster and aid users are in some respects different.

Disaster communicators want something small, light, portable and working now, no awkward if's and buts. They have only 12Hrs notice for planning time and must be on station in 24Hrs. Installations will be temporary, so no installation engineering is needed.

Aid users want something at the camp or office, semi-fixed, reliable and easy to use and hard to abuse, (you can't always tell who will end up using it). The difference is that there is usually some time to plan and engineer the installation. As installations are permanent, then better engineering is desirable.

Technology can do wonderful things for us but at a price. You must ask how much money you want to spend.

If you have USD 10,000 then standard-M with is direct dial convenience and dead easy operation may appeal.

For USD 5,000, Standard-C with its professional reliable Text system and small size may be for you.

Or for USD 1-2,000, HF radio will do a splendid job in the right hands.

Probably the best value for money is in the use of the Gateway service from Portishead Radio by HF radio and using the Phonetext mode, where the problems of time mismatch are obviated.

Planning an adequate Power supply needs much careful thought.

By far the biggest problems you will face will be the political ones. Getting the paperwork wrong will mean failure to be able to use the equipment you have spent so much money on. Make sure you take good advice from the appropriate authorities before attempting to bring anything in to a country.

7.1 System integration

By now you will have realised that operating a communications network is much more involved than it first appears. If you can, then recruit a Radio Officer with varied current experience or radiocommunications specialist to take care of these matters for you. Otherwise, there are consultants

who can take care of these matters for you, they will charge you for their services but they will save you money in the long run by improved communications.

Another strategy is to find an organisation like yours, which seems to have a good communications system. You could then either contract their technicians to help you with your network, or just get permission to study and copy their most successful ideas. Another approach may to a Memorandum of Understanding (MoU). This is a kind of 'contract' in which you agree to use their resourses under certain specified conditions ,in return for some kind of favour.

7.2 Turnkey contracts

This is more for Long term 'aid' projects and not suitable for Emergency comms. Turnkey contracts mean that the contractor will do all the work needed to fix up a working network for you. All you have to do is 'open the door' or 'Turn the key' and step in to a working system.

Here is a warning;

When you order equipment from a manufacturer, he will deliver just what you ordered. He is not a mind reader, remember 'The customer is always right! so he will faithfully ship out what you say to where you say. We at DRCF have many stories on record from frustrated users and manufacturers alike who shipped out equipment that could not be made to work when the box was opened in Africa.

This happened because the buyers did not specify ALL of the parts needed to turn a basic radio into a working installation. Often there was not a radio technician for hundreds of miles around so already hard pressed staff decided to do without the equipment rather than spend time trying to fix it up.

Even when equipment is installed before shipping, it is often found to be incomplete or unsuitable when arriving in the field because of inadequate quality supervision by experienced specialists. The root cause of that is the shortage of the specialist experts in this vital field.

One way around this is to have your own communications Department[72] in your group who have someone responsible for all these complex matters. But it is important to recruit the right person for this demanding job.

Another way is use either hired experts from a good consultancy company, or the experts from the dealers of the equipment that you decide to buy.

When you specify a TURNKEY contract from a Systems Integration House, you may gasp at the price you are quoted, but this will be a proper reflection of the true cost of the operation whether completed by you or the dealer. On the other hand, spending money on equipment which didn't work at the moment it was really needed will not go down well in any boardroom, and be a treacherous betrayal of the poor foot

soldier at the front end of the job, who will have frustrating equipment inadequacies to add to his other heartbreaks.

7.3 Maintenance

As Murphy's rule so well puts it.. "anything that can go wrong will go wrong". You need to think about repairing and maintaining your system. Your system must be installed correctly in order for the mean time between failures (MTBF) of your system to be respectable. You need to have your system regularly inspected and maintained by competent technicians in order to prevent faults from occurring and when faults do occur, you want fast solutions to get you back on your feet.

In the first response to a disaster situation, this means that you will have to have highly competent technicians 'on call' ready to go out with your equipment in the first line of support staff. They will need to be well briefed, drilled and properly equipped for any installation and repair work they may need to do. In the second line, you will need to have rapid access to the spares needed to bring you back on line again, all of which means preparation in order that stores and spares arriving on the scene are the ones needed and can do the job. In the longer term, you will need to have contracts with a reliable maintenance company, and keep them informed about what type of equipment you have and how it is maintained.

None of this is exciting stuff, but you cannot afford to ignore the frailties of the technology we need for today's operations.

Use technology but don't trust it.

There is nothing more human than a machine.

7.4 DRCF's role

The DRCF can also help with advice and also with men and equipment ready to go out in the field. However our resources are limited at the moment so you may need professional help even after DRCF help has been sought. In the future it is hoped to expand our operation to meet the obvious need vacuum in this field, but we will never replace the work of the dealers and consultants and neither would we wish to.

In DRCF's case, with limited resources, yet a need to be insured against equipment failure and a desire to be most flexible, we have chosen to use Standard-C and HF radio side-by-side. This gives the best of both worlds at the most reasonable cost. Standard-C gives reliable, compact and quick-pop-up service with text hard copy, while HF radio is for phone calls and as back up for the standard-C. Another

important reason for not forgetting HF radio is that it may be needed in local mode for contacting other local agencies in the area using only HF radio.

Individual cases though require much thought at the planning stage, so we would always recommend the services of a consultant before spending large amounts of money.

May I wish you **73's**, which is radio code for "Best Wishes"

Mark Wood, Stockholm Sweden, June 1996

The Disaster Relief communications Foundation (UK).

---

[72]The CICR have such a special department staffed by former Marine Radio Officers for this reason.