CHAPTER FOUR

RADIO TRANSMISSION PRINCIPLES, SYSTEMS AND EQUIPMENT

INTRODUCTION

4.01 This Chapter deals with radio signal principles (propagation), communication systems, radio transceivers and ancillary equipment in common use with emergency services.

VERY HIGH FREQUENCY (VHF) AND ULTRA HIGH FREQUENCY (UHF) PROPAGATION

4.02 LIMITATIONS

In the main, VHF and UHF systems operate in LINE OF SIGHT conditions. In other words, if two stations are able to make visual contact, communication will be possible However, if distance becomes too great then energy losses increase to the point where the signals become too weak to be received Smoke, bush fires, and some types of pollution may also reduce communication distances. It may seem that given these circumstances communication is not possible from behind objects such as buildings and hills because of a loss of line of sight conditions. However, other effects such as reflections and diffraction cause the radio signals to bounce off reflective surfaces or to curve over the top of hills and so allow effective communication to be maintained.

4.03 DEAD SPOTS

Reflected signals sometimes combine in such a way as to severely reduce signal strengths thus causing "dead spots". These dead spots are often highly localised and shifting the position of one transceiver by a metre or so, will often mean the difference between no communication and acceptable communication.

4.04 RANGE

The nominal range of a VHF or UHF system under ideal operating conditions can be approximately 50-100 km

4.05 EMERGENCY SERVICES USE

Emergency services predominantly use equipment in these bands operating in the SIMPLEX or REPEATER modes.

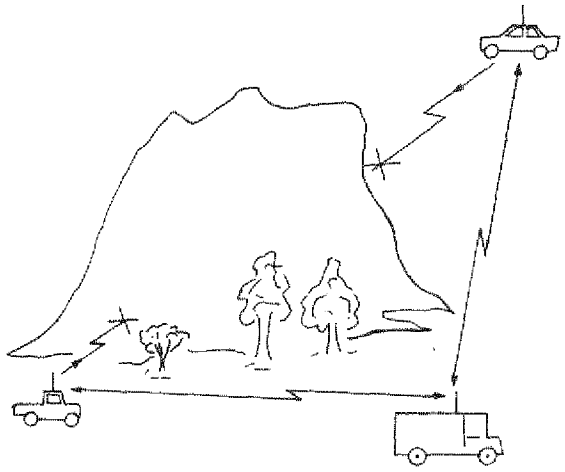

Figure 4:1
VHF UHF Line of Sight Signal Path

SUPER HIGH FREQUENCY (SHF) PROPAGATION

4.06 SHF radio signals operate OVER line of sight paths. Point to point communication services such as Telecom microwave links and Earth stations for satellite links are the predominant users of this band.

VHF/UHF BASE STATIONS

4.07 LOCAL CONTROL

To ensure optimum range, and provide best line of sight conditions, VHF and UHF base stations need to be sited in elevated locations. Where an elevated site is not available it is essential to install the antenna system on a high mast. If the base station and the control unit are jointly located, the configuration is known as a LOCAL CONTROL base station as shown in Figure 4:2.

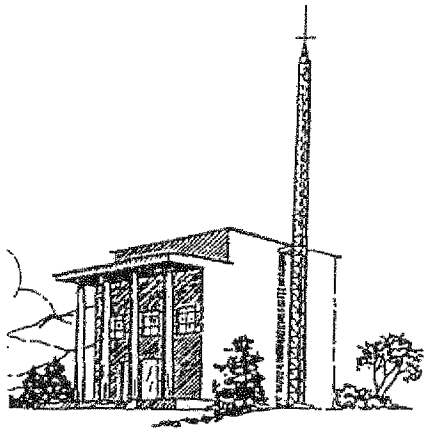

Figure 4:2
VHF UHF Base Station - Local Control

4.08 REMOTE CONTROL

Where an extended service area is required, and it is not practical to co-locate the radio base and its control, then these two elements are split, with the base station being installed at an elevated site and REMOTELY CONTROLLED via leased Telecom landlines, private landlines or a radio link.

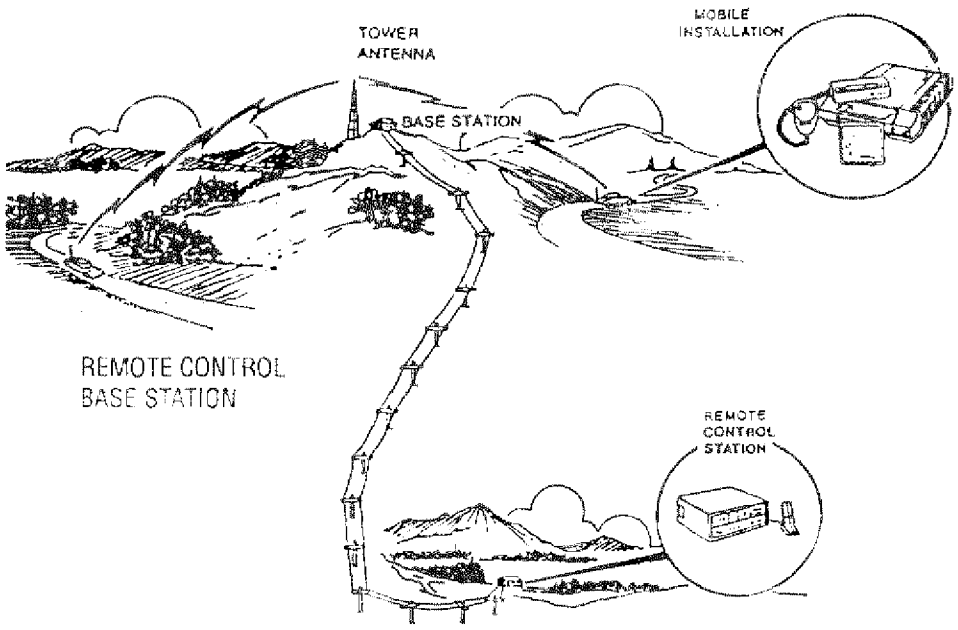

Figure 4:3
VHF/UHF Base Station - Remote Control

4.09 When operating a VHF UHF mobile or portable radio to this type of Base Station, the communication path will be between the Base Station and the mobile portable radio. Other mobile radios operating on the network may not be heard by all users unless they are in the immediate vicinity.

4.10 REPEATER BASE STATIONS

When using repeaters the following points should be considered:

a. There is virtually no difference in the radio coverage area between a base station or a 'Talk Through Repeater Base Station' located at the same site. However, if a manually controlled Base Station is not practical, and direct mobile to mobile communications is to be maintained then a 'Talk Through Repeater Base Station' must be employed.

b. A 'Talk Through Repeater Base Station' functions by receiving a signal and simultaneously retransmitting it automatically without intervention of a base station operator. Separate transmit and receive frequencies are necessary to achieve 'Talk Through Repeater' operation. As this type of base station is often located on a dominant elevated site, mobile to mobile communication is usually possible in excess of 100 km.

c. A further advantage of repeaters, is that they always radiate a fixed amount of power. This means that if a 1 watt handheld radio is able to access the repeater, then its effective operating power is raised to the power of the repeater. This significantly extends the range of the low powered equipment.

d. When communicating with the aid of a repeater it should always be remembered that this involves accessing the repeater not the radio on the other end of the communication path.

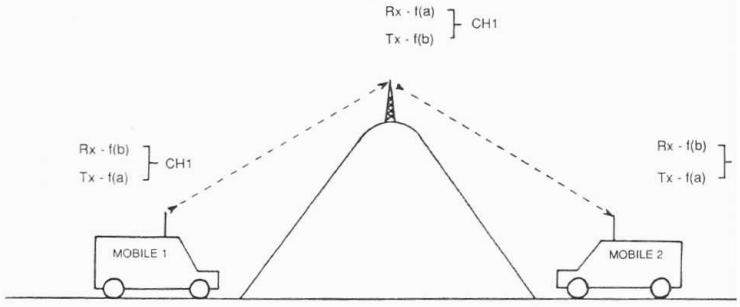

Figure 4:4
Repeater Base Station

4.11 PORTABLE RADIO BASE STATIONS

Base stations including repeaters can be presented in a portable configuration. These are normally operated with a portable antenna and mast and are usually powered by portable generator and battery back-up. They are temporarily deployed in areas that require enhanced communication facilities. Care must be taken to ensure that these base stations are not located in areas that may cause interference to other radio communication services. It is therefore recommended that portable radio base station equipment be installed by qualified personnel only.

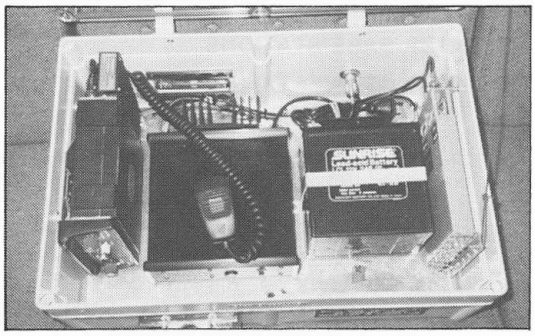

Figure 4:5
Portable Repeater Base Station

HIGH FREQUENCY RADIO OPERATION

4.12 COMPLEXITIES AND VARIABLES

The operation of High Frequency (HF) radio is complex and a number of variable factors can assist or restrict communications. Considerable training and experience is necessary for effective use of HF radio. While VHF and UHF systems are usually employed for line of sight communications, HF remains an effective medium for communication over short, medium and long distances. Distances in excess of 3000 kilometres are within the capabilities of HF radio.

4.13 HIGH FREQUENCY (HF) PROPAGATION

HF propagation has two distinct features, GROUND WAVE and SKY WAVE:

a. Some of the energy radiated from the transmitter follows the ground contours and is termed GROUND WAVE. Ground wave transmissions are usually short range, because a significant amount of energy is absorbed by the terrain during transmission. Pure ground wave transmissions are not subject to fading.

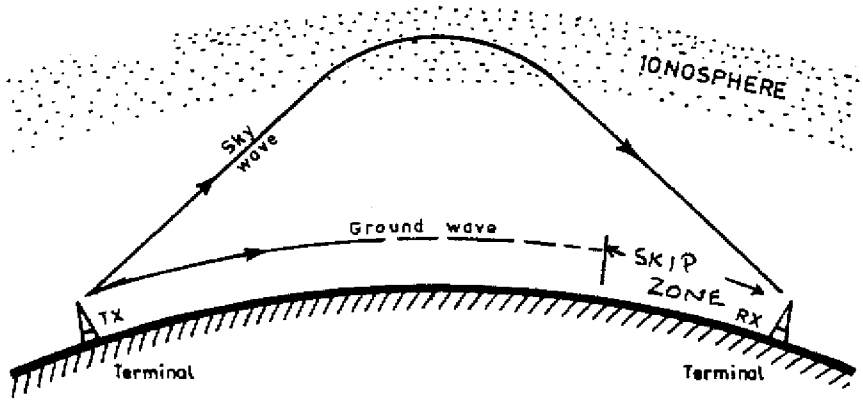

Figure 4:6
HF Propagation

b. The situation with SKY WAVE transmissions is totally different. Energy from the transmitter is radiated into the ionosphere. The ionosphere is formed by layers of gas surrounding the Earth. Gases within these layers are ionised (electrically charged) by radiation from the sun and become conductive. The layers refract or bend the signals back towards Earth. This allows transmission over considerable distances.

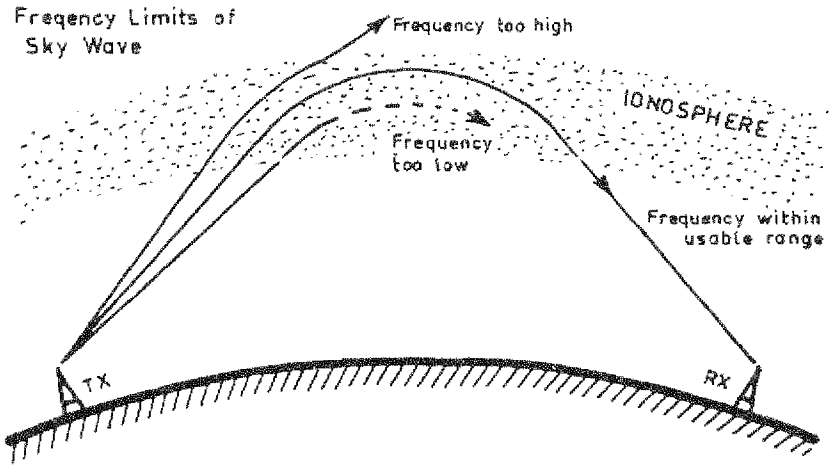

Figure 4:7

c. This situation is complicated by the fact that the ionosphere varies in height and density with time of day, season and solar activity. Solar storms can completely disrupt HF transmissions.

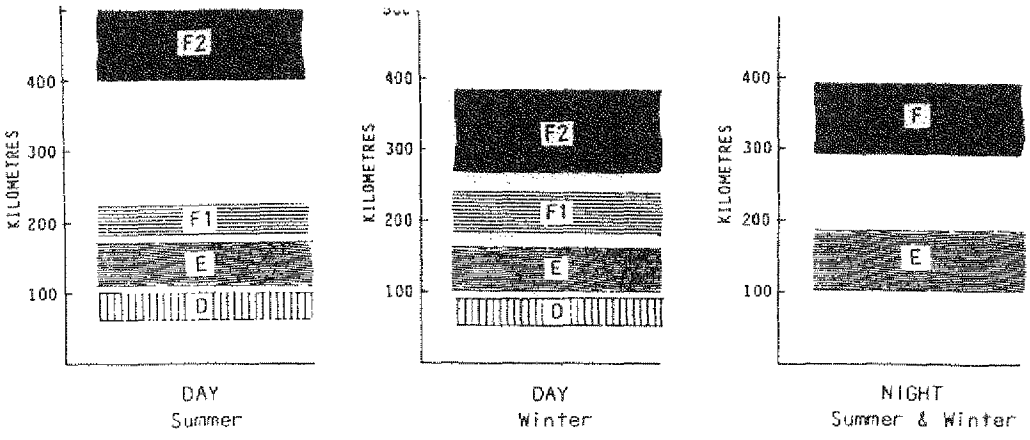

Figure 4:8

d. The ionospheric layers also bend signals at varying degrees depending on the frequency in use. This means that operating frequencies must be carefully chosen according to the time of the day and the distance of the communication path required. Generally, lower frequencies are more suitable for night time use while higher frequencies are chosen for day-time use. Due to alteration in the height and composition of the ionosphere, fading occurs on HF transmissions.

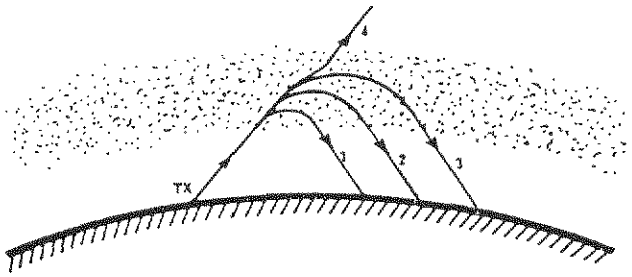

Figure 4:9

e. There may be a gap in the coverage of the transmitter between ground wave and sky wave. This is termed the SKIP ZONE or DISTANCE. The signal in this zone is too weak to be of any useful purpose. The problems associated with the skip zone may be overcome by relay techniques via a third station that has sky wave communication with both ends of the link. Additional procedures that may assist include changing frequency or changing the type of antenna in use.

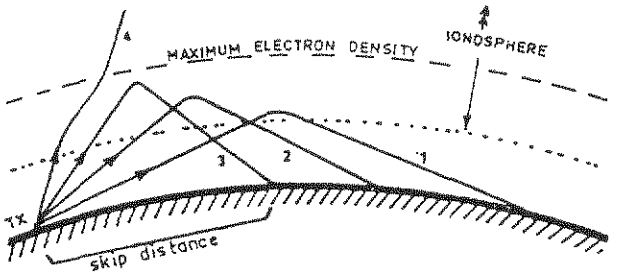

Figure 4:10

4.14 IONOSPHERIC PREDICTION SERVICE (IPS)

The Ionospheric Prediction Service (IPS) is a Commonwealth Government Agency that studies the characteristics of HF transmission and issues predictions on the performance of HF sky wave communications over designated distances and frequencies according to the date and time of day. This service is available on request.

4.15 IPS produces a three monthly calculator that indicates the optimum frequency to be used over a given distance at a given time of the day. The agency provides a number of other services including training, warnings of unusual solar activity and a recorded telephone information service that is amended daily.

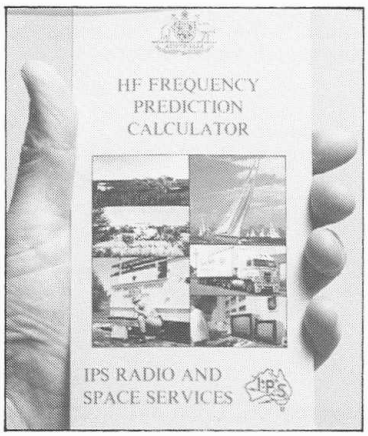

Figure 4:11

HF BASE STATIONS

4.16 LOCAL CONTROL

Fixed HF radio base stations may be controlled locally or remotely. Locally controlled bases have their transmitter and receiver combined (transceiver) and connected to an external antenna. The transceiver is usually a mobile radio connected to a mains operated 12 volt DC power supply.

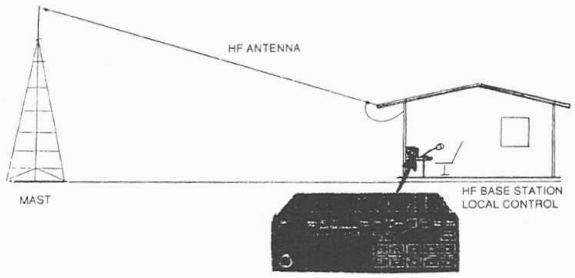

Figure 4:12
HF Base Local Control

4.17 REMOTE CONTROL

Due to local electrical noise problems, or difficulty in finding sufficient space for antennas, HF transceivers may be remotely located, but controlled from a central point via leased Telecom landlines, private landlines or a radio link.

4.18 When multiple HF services are co-located, it may be necessary to separate transmitters and receivers. This is achieved by installing all transmitters at one site and all receivers at a separate site.

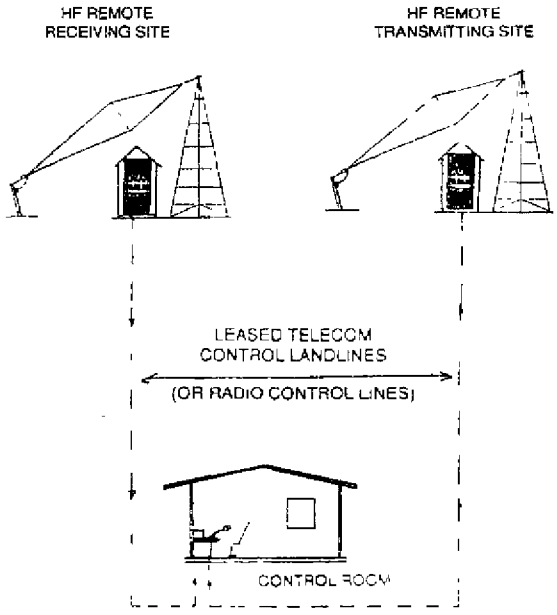

Figure 4:13
Remote Control of HF Base Station Equipment with Separate Transmitter and Receiver Sites

4.19 STATION SITING

To achieve optimum performance, HF base stations should be sited so that they,

a are located away from electrical noise sources such as power lines, industry, computers, portable generators etc;

b. allow sufficient space to erect antennas with appropriate orientation, and

c. are installed in areas with good soil conductivity (moist ground)

HF MOBILE RADIO COMMUNICATIONS

4.20 TRANSCEIVERS

HF Mobile Transceivers are used to provide communication from vehicles operating in the field. Several interference problems may be encountered as a result of the following:

a. Proximity to power lines and other external sources may cause electrical interference.

b. Vehicle electrical components such as:

(1) spark plugs;

(2) alternators,

(3) oil and fuel sensors,

(4) windscreen wiper motors; and

(5) engine management computers.

c. Proximity to other vehicles.

d. Proximity to industrial areas and machines.

e. Atmospheric conditions, such as thunderstorms or high humidity.

4.21 WHIP ANTENNAS

The antenna is a critical part of HF mobile transmission and reception. Its purpose is to transmit and receive a signal from the radio transceiver in the vehicle efficiently. There are two types of HF mobile antenna in common use:

a. **Auto-Tune Antenna** - These antennas are automatically tuned according to the frequency selected. This operation is accomplished by the operator from within the vehicle.

b. **Tapped Whip Antenna** - This type of antenna has various taps inserted along its length marked with frequencies corresponding to those channels fitted to the transceiver. A 'Wander Lead' plugged into the appropriate tap is used to select the frequency required. Any surplus 'Wander Lead' is to be neatly wrapped around the antenna rod below the required frequency socket. When the lowest frequency is used the 'Wander Lead' is to be removed from the antenna. The 'Wander Lead' is a critical piece of the antenna in that each whip has a unique length of lead in millimetres. This length is stamped on the antenna and is measured from plug tip to plug tip. Replacement by longer or shorter leads will degrade the performance of the antenna.

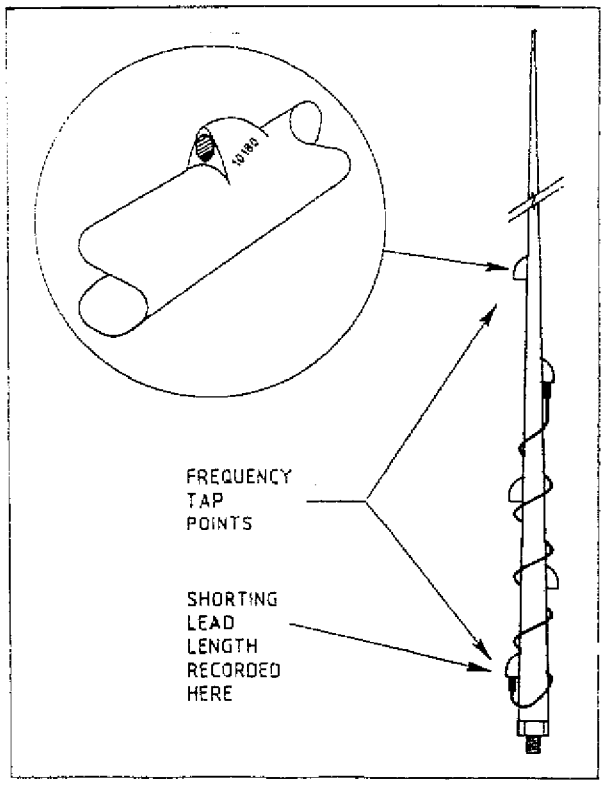

Figure 4:14
Tapped Whip Antenna

4.22 PRECAUTIONS

It is recommended that no person be permitted within approximately one metre of an HF mobile antenna when the transceiver is being operated, as this will degrade the performance of the equipment. Holding the antenna during transmission may cause skin burns.

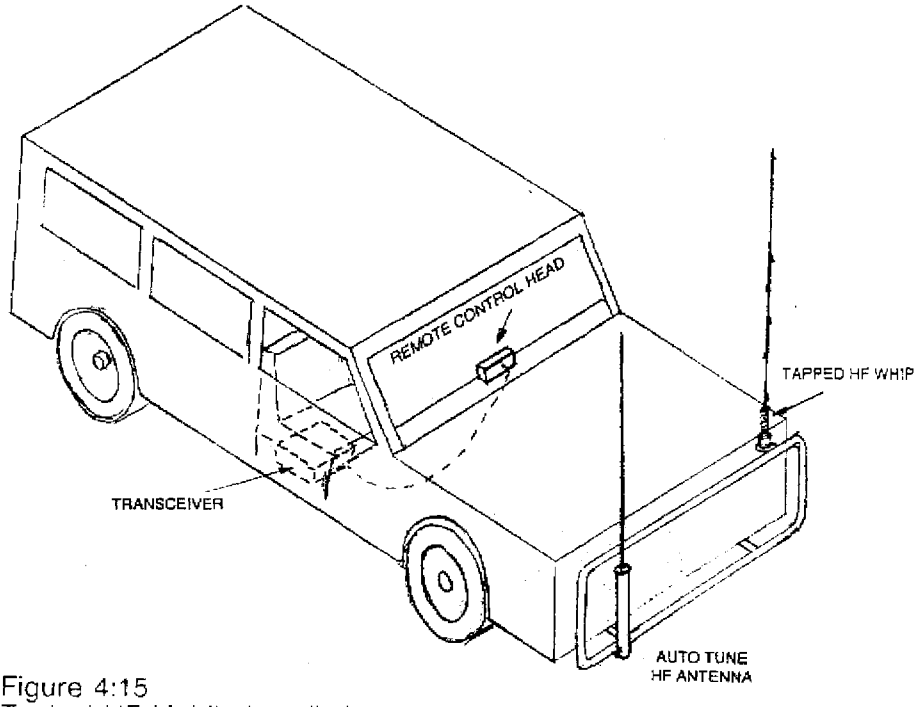

Figure 4:15
Typical HF Mobile Installation

HF PORTABLE RADIO COMMUNICATIONS

4.23 TRANSCEIVERS

The HF portable radio transceiver is generally a low powered unit and consists of a mobile transceiver attached to a rechargeable battery pack, enclosed in a carry case.

4.24 ANTENNAS

The antenna can be either a shortened tapped whip, similar to the mobile version, or an external wire antenna.

a. When used with a tapped whip antenna it is recommended that a sheet of metal, space blanket, or similar material, be placed underneath the transceiver when it is being operated on the ground. An alternative is to place the transceiver on the bonnet of a vehicle, thus providing the necessary ground plane (artificial earth).

b. When used with an external wire antenna the performance of the radio is enhanced. An internal antenna tuning unit enables the

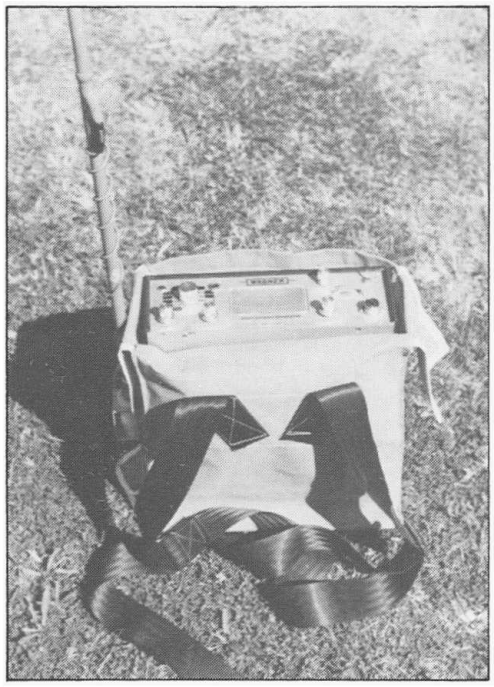

Figure 4:16
HF Manpack Portable Radio

OPERATING HF RADIOS

4.25 BASIC OPERATING STEPS

a. Switch off the MUTE control if fitted and adjust the volume desired level.

b. Select the correct operating frequency according to the time of day and communication distance as per IPS or other technical instructions.

c. Check that the right antenna is connected.

d. Tune the antenna or select the proper tapping for the frequency concerned. Some antennas are broadband or automatically tuned and do not require adjustment.

e. Make the call.

f. If no contact is made or the results are poor, arrange with the other operator to try alternative channels until best communications are achieved.