OPERATIONAL CONCEPT AND PROCEDURES FOR HF RADIO IN THE BRIGADE COMBAT TEAMS

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TRANSFORMATION HIGH FREQUENCY (HF) RADIO SYSTEM (THFRS) - AN/PRC-150 FAMILY STANDARD OPERATING PROCEDURE (SOP) AND OPERATIONS CONCEPT (OC) FOR THE BRIGADE COMBAT TEAMS

PURPOSE: This SOP/OC is intended to describe the planning factors and operational procedures required to successfully use THFRS radios in the Brigade Combat Team (BCT).

WHY HF RADIO FOR THE BCT: HF radio (radio signals in the 1.6-3OMhz frequency spectrum) have the following characteristics that makes it an ideal communications system to support the fast moving wide area operations that the Brigade Combat Team will participate in:

I - HF signals travel longer distances over the ground than the higher frequency VHF (SINCGARS) or UHF (EPLRS/NTDR) signals do because they are less affected by factors such as terrain or vegetation.

2 - HF signals can be reflected off the ionosphere (a layer of charged gases surrounding the earth at high altitudes) in a way that will cover beyond line of sight (BLOS) areas at distances out to 400 miles without gaps in communications coverage.

3 - HF signals can be reflected off the ionosphere to cover distances of many thousands of miles for "reach back" communications.

4 - HF signals do NOT require the use of either SATCOM or retransmission (RETRANS) assets.

5 - HF equipment provided to the Brigade can be used either fixed station or on the move (OTM).

6 - HF systems can be engineered to operate independent of intervening terrain or mamnade obstructions.

HF (2-3OMhz) RADIO WAVE PROPAGATION: Radio propagation is the process by which electromagnetic energy (signal) moves from one point to another. Since radio waves propagate (move) the same way light waves do for this SOP/OC we can think of radio waves in terms of light. As with light rays, radio energy (signal) can travel from a point source outward in all directions just as a light spreads from a light bulb. For radio waves this is called an omni-directional signal. Figure 1 shows how radio energy (signal) decreases as distance from the source increases. Note that as the distance (range) doubles the signal strength is reduced to one quarter of what it was (proportional to I/d squared). Also as with light, radio signals can be focused to travel in a single direction similar to a flashlight beam. This is called a directional signal. The shaping of the radio signal is a function of the radios antenna system. Just as with light, radio signals can also be blocked by obstructions and bent (diffracted) over solid obstructions. This is similar to seeing the small amount of light that can be detected from a source behind a wall. All of these effects will be used to provide gap free tactical HF radio communications throughout the Brigades area of operations and back to its sustaining base. It is important to recognize that how the radio antenna shapes the signal pattern and the system operating radio frequency(s) are the two most critical factors in assuring HF communications for the Brigade.

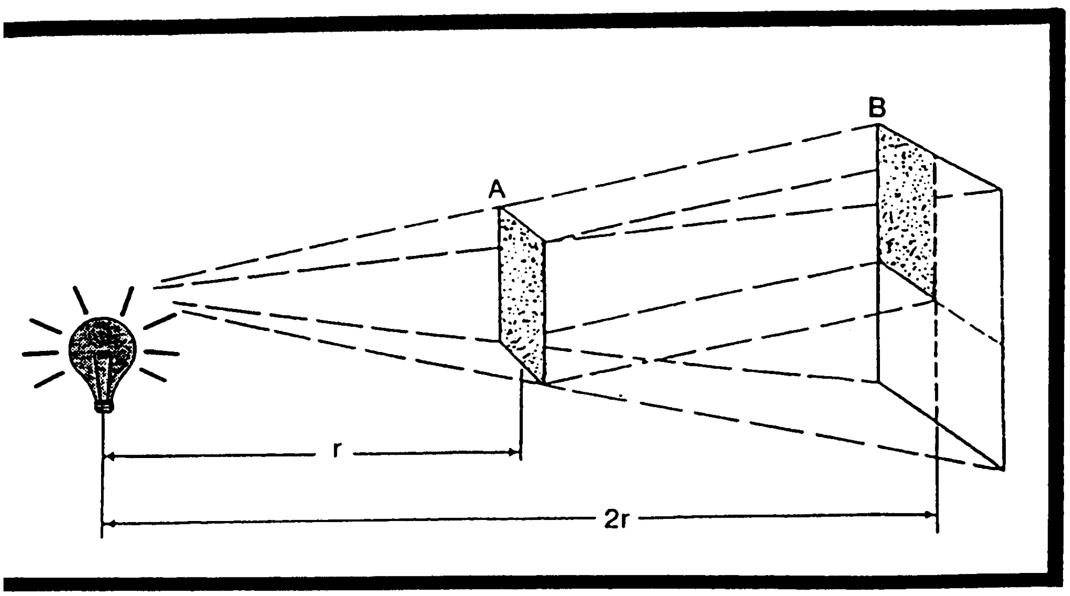


Figure 1 Spreading of Radio Energy.

POSSIBLE TRANSMISSION PATHS WITHIN THE BRIGADE OPERATIONAL AREA: Fig 2 shows possible radio paths between two stations located in the Brigade area of operations. It is assumed that most combat units in the Brigade will be located within a maximum distance of 400 miles from each other for purposes of this SOP/OC. Circuits of greater distances (reach back) will be covered under other sections of this SOP/OC. Fig 2 shows three possible low angle radio paths located along or near the surface of the earth. These paths are called ground-wave paths because they are close to the earth's surface or in contact with it. They consist of the (1) direct wave path. The direct wave consists of radio frequency energy that travels through the atmosphere and near the earth directly from one antenna to another. This is called the line of sight (LOS) mode of propagation. Maximum LOS distance depends upon the height of the antenna above the ground and whether or not the path is obstructed by terrain that will block radio signals. On flat ground, direct wave paths suitable for THFRS communications can be expected out to 6-8 miles before the curve of the earth blocks the signals. Direct wave communications can go much further if stations are located high on hilltops with no intervening obstructions so control of high ground and antenna height is important when using direct wave communications. (2) The ground reflected path like the direct path travels through the atmosphere but due to the lower "take off' angles from the transmitting antenna, the signal energy is reflected off the earth while traveling from the transmitting antenna to the receiving antenna. Depending upon the composition of the ground at the reflecting point the reflected energy can be considerably reduced when it arrives at the receiving antenna. Signals reflected off seawater lose almost no energy while signals reflected off a sandy desert become quite weak. When summed together the direct wave and the reflected wave are referred to as the space wave. As the two combine, they can result in either a stronger or weaker total signal depending upon the timing difference of the two signals as they arrive. The difference in signal phasing is caused by the longer distance traveled by reflected wave. Space wave signals will usually not be the predominate mode of communications in the BCT. The (3) surface wave path is the transmitted radio energy that travels along the boundary between the atmosphere and the earth's surface and is in actual contact with the earth's surface. The surface wave is greatly affected by the electrical conductivity of the earth in the path of propagation. With a good conductor such as seawater surface wave communications out to 1 00+ miles are possible. With a poor surface such as sand or frozen ground surface wave communications are greatly reduced. Surface wave signals are also greatly reduced by heavy vegetation or mountainous terrain. Surface wave signals can be made stronger over poor ground by using techniques that improve the conductivity of the earth near the antenna. Most HF ground-wave communications within the BCT will utilize surface wave signals. Space wave communications will predominate only when communicating from high ground to other high ground locations along the line of sight (LOS). Vertical monopole (whip) man-pack and vehicle antennas of various lengths are the antennas provided to produce the low take off angle energy needed to generate ground wave signals. Figure 3 shows the antenna energy pattern of the vertical monopole (whip) antenna. Note that the signal is along the surface of the earth and on the lower angles. There is much less energy on the higher angles and none directly overhead (vertical angles). The pattern resembles a doughnut so operationally, it can be very difficult to communicate with aircraft that are directly overhead while you can talk to aircraft many miles away that are receiving low angle energy from a vertical antenna.

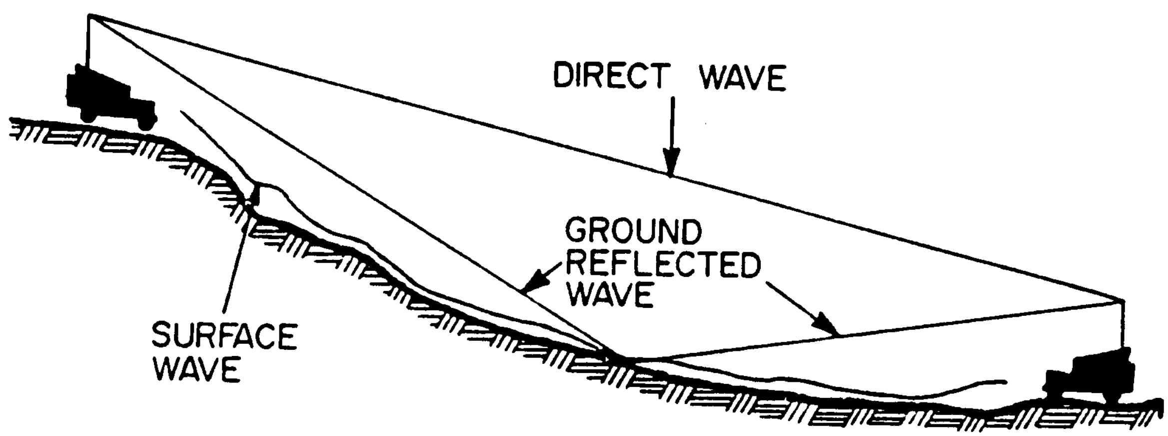


Figure 2 Groundwave components.

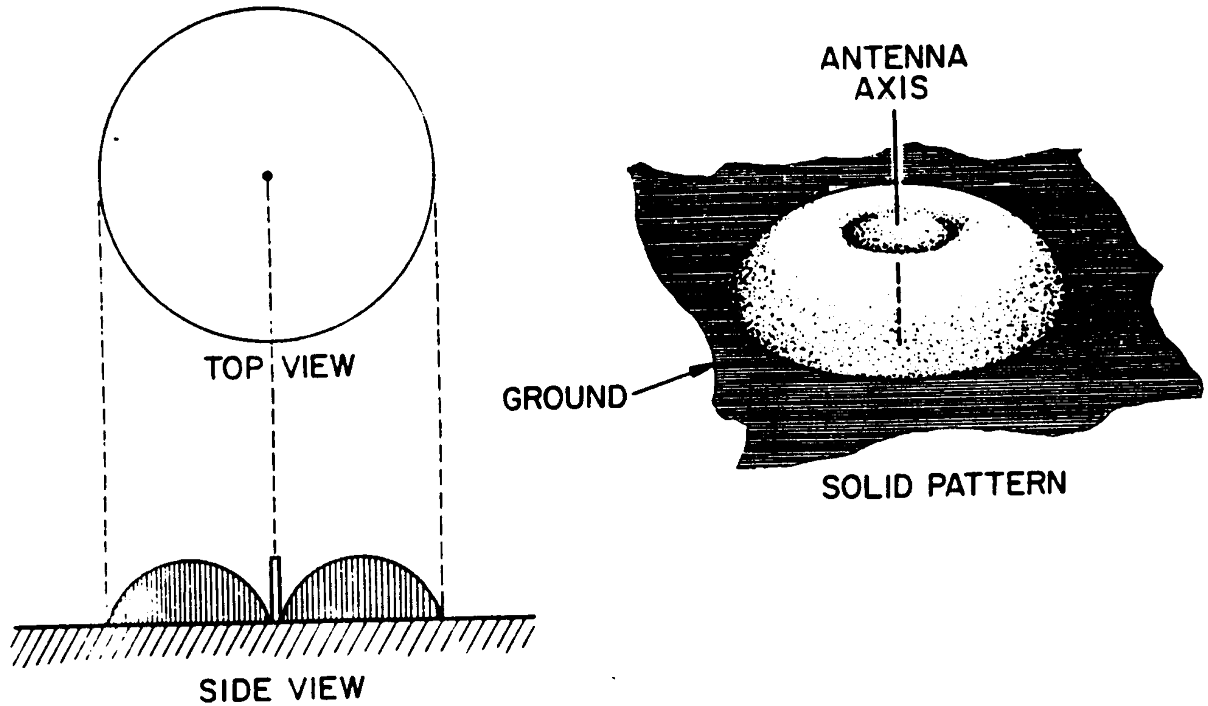


Figure 3 Radiation pattern of a quarter-wave vertical whip antenna.

THE IONOSPHERE: The ionosphere is an electrically charged region of atmospheric gases that surround the Earth. Ionization (electric charge) happens when solar radiation bombards atmospheric gas molecules and forces them to detach electrons leaving the gas molecule with a positive electrical charge called an ion and leaving free electrons in the atmosphere. Since positive electrical charges repel each other the gas ions tend to "bunch" in distinct "layers" of ions at heights of between 30 and 300 miles shown in fig 4. These charged areas will reflect radio signals back to earth if they strike the ionosphere at particular angles using particular frequency bands. Radio engineers have labeled these layers the D, E, F I and F2 layers (see fig 4). 3 factors determine whether a radio signal will be reflected back to earth and can be used by Brigade THFRS communications systems. They are (1) the higher the radio frequency the more likely the signal will penetrate the ionosphere rather than be reflected by it, (2) the current ion density determined by the amount of sun light (time of day, season, solar activity) at the time communications is desired, and (3) the angle at which the radio wave contacts the ionosphere. See figure 5 for details. Note - that at any time of the day, year, or solar activity (sunspot) cycle there is always available a band of radio frequencies that can be reflected off the ionosphere and will support HF communications. The Automatic Link Establishment (ALE) feature of THFRS will find these frequencies for the operator from the list of authorized frequencies in the radio database. Signals on these frequencies can be used for Brigade tactical HF communications over distances of hundreds of miles unless very unusual and rare solar activity is occurring. Also note that the angle at which the wave front contacts the reflecting layer is determined by the radios antenna system. Low angles of radiation are produced by the OE-5 05 and AT- IO 1 1 vertical whips and high angle radiation is produced by bending the whips into the horizontal position with the whip tilt adaptor or by using the RF- 1 912 or RF- 1 941 wire dipole antennas 30 feet OR LESS above ground.

MAXIMUM USEABLE FREOUENCY (MUF)- **LOWEST USEABLE FREOUENCY (LUF). ' Each layer of the ionosphere has a frequency that is the highest that the layer will reflect. The exact frequency is determined by the amount of ions in the layer. As seen in fig 5. the lower frequencies are reflected by the lower layers while the higher frequencies penetrate the lower layers and are reflected back by the higher layers. To cover the largest tactical area** of operations possible the highest frequency that will reflect should be used since the higher the reflecting layer the wider the area covered by the reflection (see fig 5.). Since the ionosphere is always changing a general rule when in manual operation is to select a frequency 15% lower than the actual MUF to avoid problems. This frequency is called the frequency of optimum traffic (FOT). Signals on frequencies that exceed the MUF go through the ionosphere and are lost in outer space. The MUF is also different for different angles of reflection. Signals on lower takeoff angles can utilize higher frequencies for communications because they will be reflected. The ALE mode of THFRS will automatically prevent signals with a frequency above the @ from being selected for operations. A-LE will select the best radio frequency for communications on a continuous basis if used. A limitation of HF radio is the high radio noise (static) level on HF frequencies. Radio noise comes from sources in outer space, lightning in the earth's atmosphere, and man-made sources. Noise on a particular system depends mainly on location and season. For each situation there is a frequency (LUF) below which there is to

THE EARTH'S ATMOSPHERE (SIMPLIFIED)

DAY CONDITION

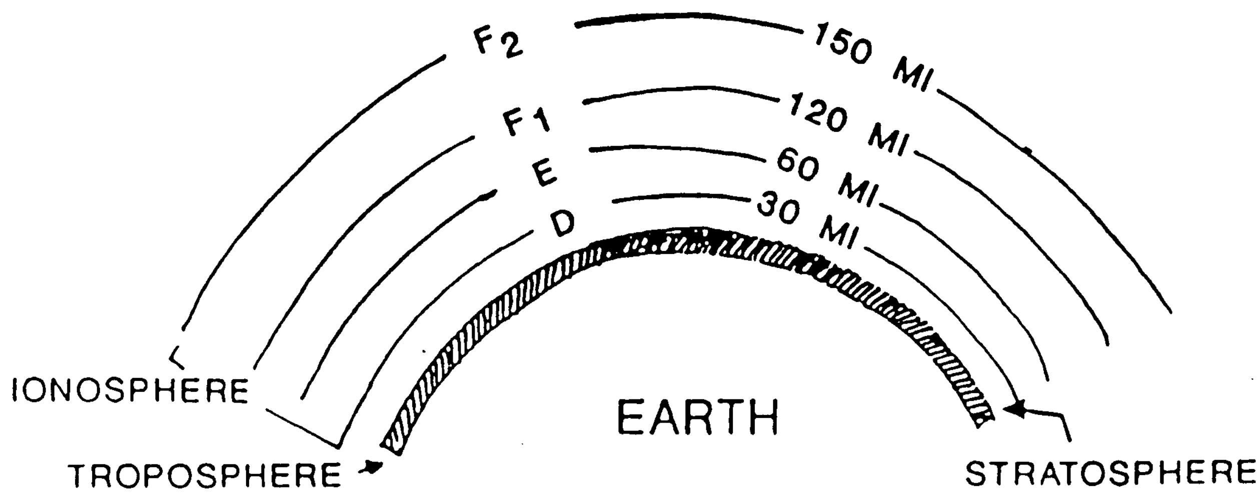


figure 4

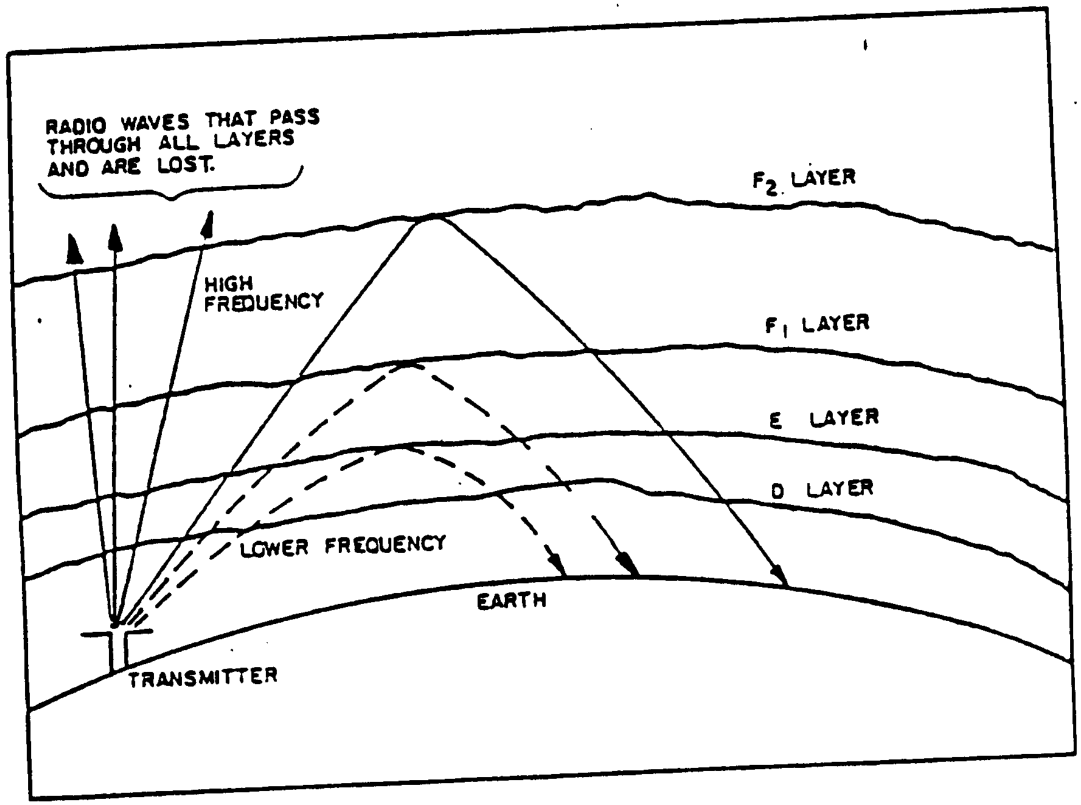


Figure 5. Skywave transmission paths.

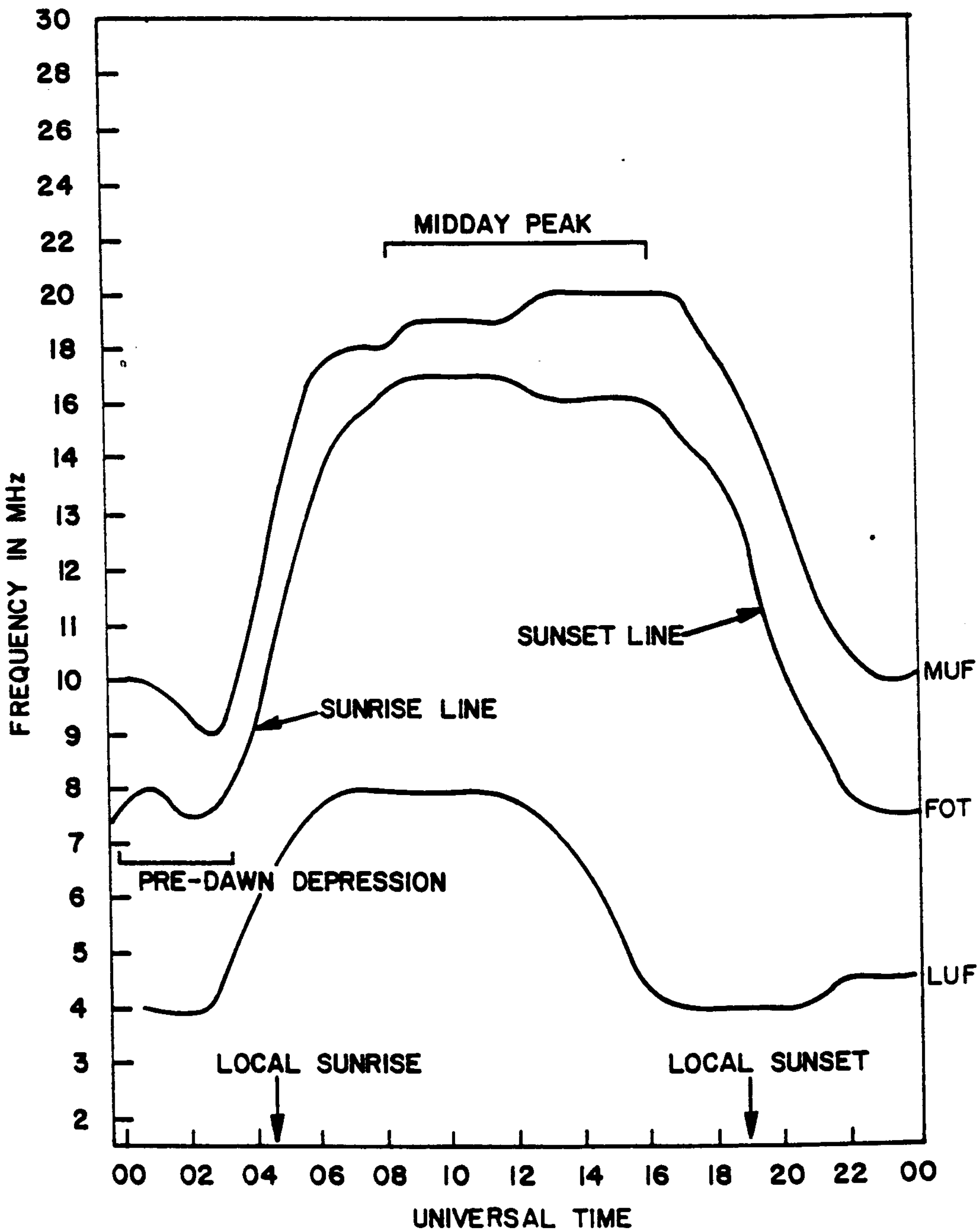


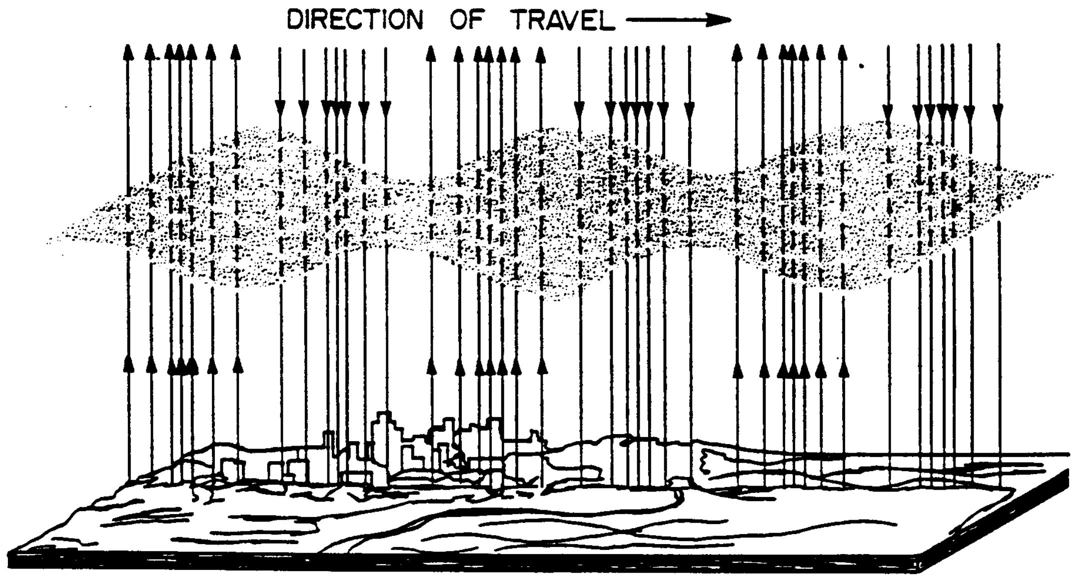
Figure 6 Important features of a typical propagation chart. (M=MUF; F=FOT; L=LUF).

high a noise level for communications. LUF is affected by transmitter power, antenna gain and directivity and absorption of signal by the lower layers of the ionosphere. LLTF is defined for this SOP as the lowest frequency at which a 90% probability of communications exists. The ALE, MODEMS, and VOCODER features of the THFRS are designed to make the LUF as low as possible by being able to operate in a high noise environment. This widens the range of operational frequencies available for communications. A typical plot of MUF/FOT/LUF is shown in fig.7. Note the range of frequencies between the @ and the LUF over the entire day. Under almost every circumstance there is a range of HF radio frequencies that will be suitable for Brigade communications. It is the responsibility of the operator and the system manager to obtain frequency assignments in this range for operations. To aid in frequency selection sky wave and ground wave predictions and prediction software are available through frequency management channels. It is the responsibility of the Brigade S-6 frequency manager to predict HF radio frequency requirements, obtain authorized frequencies between the predicted @ and LUF, and provide them to the THFRS operators and system managers. When using ALE the radio itself will test the propagation conditions and select the best operational frequency. ALE in the BCT will be set to accomplish this every half hour under normal operating conditions.

ANTENNAS: THE SINGLE MOST IMPORTANT FACTOR IN RELIABLE TACTICAL HF COMMUNICATIONS IS THE ANTENNA. At HF frequencies this is especially true. In order to select the best antenna for a particular Brigade operation, the following concepts must be understood by the THFRS operator and system manager.

Wavelength and frequency - For best radio perfon-nance, there is a specific relationship between antenna length and operational frequency. All radio signals travel at the speed of light. The wavelength at a particular frequency is the distance traveled by light as it completes I cycle of its motion. In order to calculate this distance (in meters) the speed of light (in meters) has to be divided by the operational frequency in cycles per second (cps). After simplifying the math wavelength (in meters) is equal to 300 divided by the frequency in Mega-hertz (millions of cycles per second) As an example, the wavelength of a 3 Mhz HF signal is 300 divided by 3 (300/3) or 100 meters. This means that in the time it takes to complete I cycle at 3 Mhz the signal has traveled I 00 meters. Knowing how to calculate wavelength is important because signal strength depends upon the length of the antenna and the amount of current flowing through it. For maximum current (signal) at a given frequency, the antenna needs to be **!/2** wavelength or, multiples of V2 wavelength long.

Resonance - The strength of a signal radiated from an electrical conductor that has a radio frequency (RF) current flowing depends on the length of the conductor and the amount of the current. For a given frequency, maximum current flows and maximum signal is produced when the conductor (antenna) is **!/2** wavelength long or multiples of that length. An antenna that radiates most of the energy flowing in it is said to be resonant. At the frequencies most used by the Brigade for fixed communications the wire antennas (AT1912, RF-1941) provided are constructed using lengths that are close to resonance and are therefore very efficient. Mobile antenna lengths can range from less than 10 feet to as much as 32 feet. These antennas are physically to short to be resonant. In order to make the short



Vertical polarization.

Figure 7 Horizontal polarization.

antennas radiate as strong signal as possible, antenna couplers such as the RF-382 or RF5830 are provided. Couplers allow RF current to flow to the short antenna and dissipate energy that is not radiated as signal but is instead, reflected back from the antenna towards the radio. The ratio of radiated power to reflected power is called the voltage standing wave ratio (VSWR). It is important to keep this ratio low (less than 2: 1) for highest efficiency. High VSWR will not physically damage the THFRS equipment. Antennas whose length is close to resonance do not require couplers to function since the antenna radiates all energy. When a coupler is needed to match an antenna it should be located as close to the antenna as possible for best efficiency. When configured for mobile operation the coupler may be located near the transmitter reducing the power at the antenna. This is acceptable for mobile operations or when at the brief halt. It is Brigade policy that whenever possible more efficient ground mounted (resonant) wire antennas will be used. Antenna couplers may also be dismounted and located at the antenna feed point to reduce signal loss when practical. When not practical, due to operational constraints antenna couplers will remain on the vehicle and the coupler output connected to the antenna via the cables provided even though efficiency is reduced slightly.

Polarization - polarization is the directional relationship of radio energy coming from an antenna to the surface of the earth. As a rule antenna fields are vertical if the antenna is physically vertical and horizontal if the antenna is physically horizontal. The intensity of a horizontal signal traveling in contact with the ground (ground-wave/surface-wave) drops rapidly because in effect the electric field is short-circuited by the earth. A vertically polarized signal does not lose strength nearly as quickly because it does not contact the earth as much. In the Brigade, ground-wave communications will be the primary mode of short distance (0-20miles) communications. Man-pack, ground mounted, and vehicular vertical antennas are provided for this purpose. Horizontal antennas and adaptors that "tilt" vertical antennas into a horizontal position are provided for long distance (0-400 miles) sky-wave communications. These antennas provide the high take off angles necessary for beyond line of sight HF communications. All antennas in a brigade radio net must have the same polarization. Mixing polarization of antennas in a net as a rule will result in significant loss of signal strength due to cross polarization. S-6's will therefore assure that all stations in a net will have the same (horizontal or vertical) antenna polarization when possible. Surface wave communications over seawater should always use vertical polarization because the electrical properties of seawater will greatly reduce the signal strength of a horizontally polarized surface wave signal. Figure 7 shows the concept of vertical and horizontal polarization.

Vertical (whip) antennas. - Ground wave HF communications are most effective when using vertical polarization over a good conductive ground. BCT man pack radios are provided the I 0-foot long OE-5 05 antenna and vehicular radios are provided the 32-foot long AT- IO 1 1 antenna. Whip antennas are most efficient when they are between ¼ and 5/8 wavelength long at the lowest operating frequency. At HF frequencies normally used in the Brigade the whips are far to short for efficient operation. Tuning devices (such as the RF382 antenna coupler) are provided to electrically match a physically short or long antenna to the radio and the transmission line. The Brigade will use the physically longest antenna possible under the operational conditions in order to achieve best performance. For

Example, the 10-foot OE-505 man-pack antenna can be replaced by a vertical wire tied to a support such as a high tree branch under many conditions to improve antenna efficiency. Any good heavy wire conductor can be used including field telephone wire or the wire from the RF- 1 941 wire dipole antenna kit provided with the radios. The end of the vertical wire must be insulated from the support. The feed end of the wire antenna is connected to the radio via the wire adaptor provided with the radio. In order to further improve antenna efficiency and increase signal strength on the lower (surface wave) radiation angles, radios in man-pack operation should be given a "tail" wire connected to the radio ground post. The "tail" will provide a low resistance return path for antenna currents. "Tail" wires are not provided but can be locally fabricated from computer ribbon cable, communications wire, or ground strap braid. "Tails" should be as long as possible but not interfere with the carrying of the radio. The man-pack "tail" concept is shown in fig 8. Along with height orientation is also very important when operating in the man-pack configuration. The antenna must be kept as vertical as possible to produce the best surface wave signal and also to avoid losses due to cross polarization (see Fig 8). It is also important to operate from areas that do not have energy robbing obstructions such as trees and buildings when possible (see fig 9). When ever possible man-packed radios should be removed from the operators back and operated from the ground. This will reduce the capacitive coupling to ground effects of the operators body that reduces signal strength. In addition, when the man-pack radio (AN/PRC-150) is operated from the ground the ground stake kit should be connected to the radio ground terminal and driven into the earth. This kit is provided with every radio and is designed to provide a low resistance return path for ground currents. This dramatically improves signal strength and communications efficiency. Signal strength can be improved even more by connecting "radial" wires to the ground. Radials need to be constructed from insulated wire and connected on one end to the radio ground terminal. Ideally, radials should be 1/4wavelength long and secured to the earth on the ends by means of nails, stakes etc. Distribution of the radials should be symmetrical. In operational terms for the brigade, 4 wires (more if possible) of a practical length should be crossed in the center (X) and the center connected to radio ground. The wires should be spread by 90 degrees and secured (see fig 10). Using ground radials improves vertical antenna performance (gain) by allowing more current to flow in the antenna circuit and by lowering the takeoff angle of the antenna pattern. This produces an increase in ground-wave signal strength on the low angles where it is the most useful for tactical communications (see fig I 1). For vehicular operation both fixed and on the move the 32-foot AT-101 1 antenna is provided. Under operational conditions it will not always be possible to use all 32 feet of this antenna and keep it in the vertical position for best ground wave performance. The antenna should always be kept as vertical as possible and as long as possible under the operational circumstances. The radiation pattern for a vehicular mounted vertical whip is essentially onmi-directional however the mass of the prime mover under the antenna will distort the antenna pattern in the direction of the vehicle mass and provide signal gain in that direction. This can be exploited by pointing the mass of the vehicle in the direction of the weakest station in a net or in the direction of the highest priority station in a net to improve system operations (see fig 12).

Half-wave Doublet or Wire Dipole antenna - The THFRS provides two types of wire horizontal dipole antennas for fixed location operations at beyond ground wave distances.

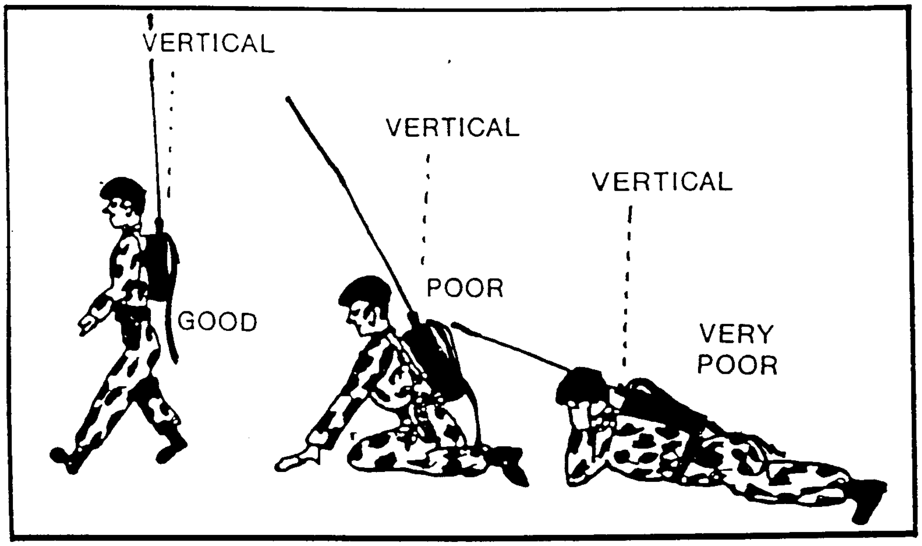


Figure 8 If Operating Ground Wave Best Results Should Be Obtained With the Whip (vertical) and Use of a Dangling Ground Plane Enhancement Tail

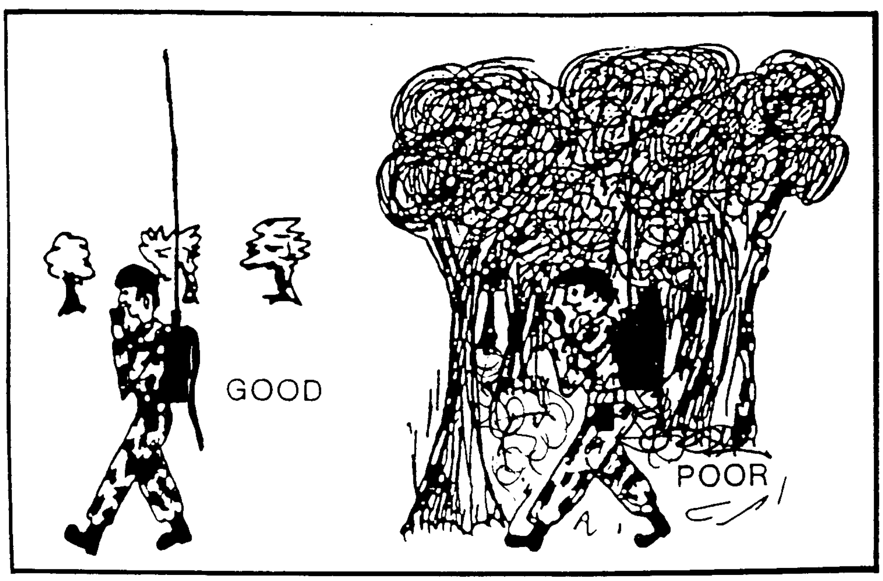


Figure 9 Where Possible Find a Clearing (no matter if ground wave or NVIS is being used)

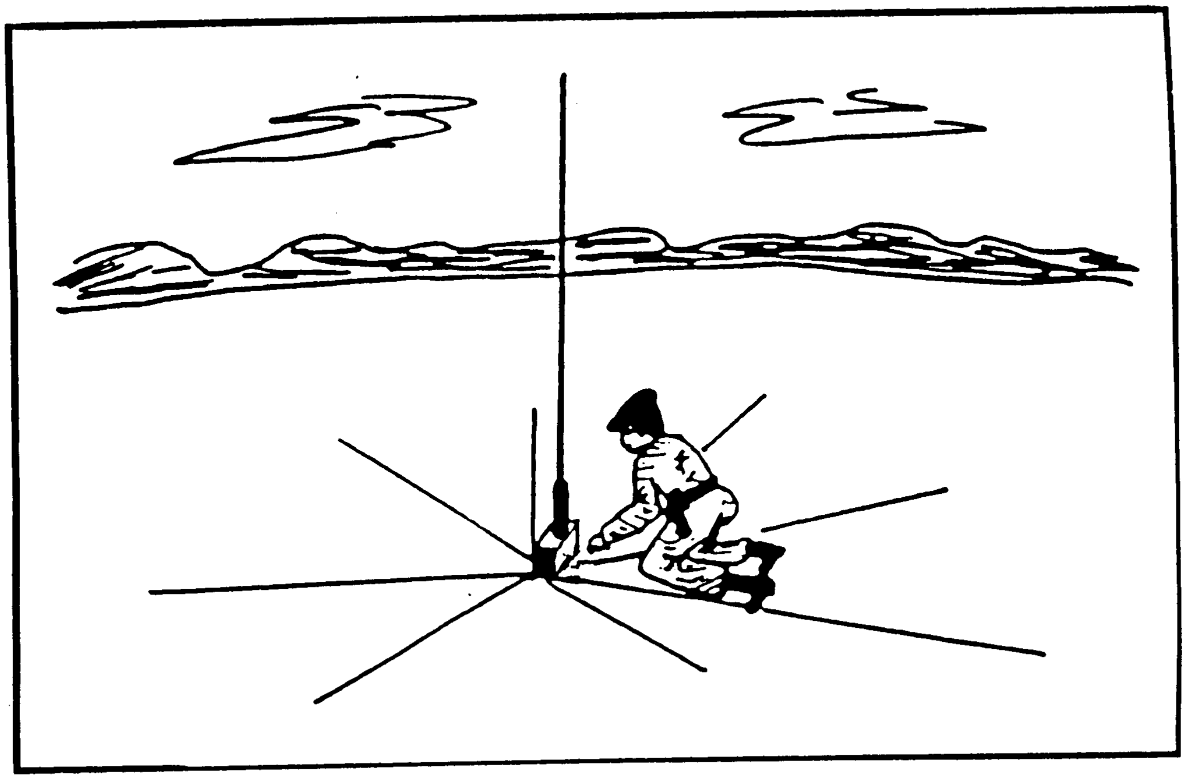


Figure 10 ManPack Operation (at halt)--Note Use of the Ground Screen

WHIP PERFORMANCE

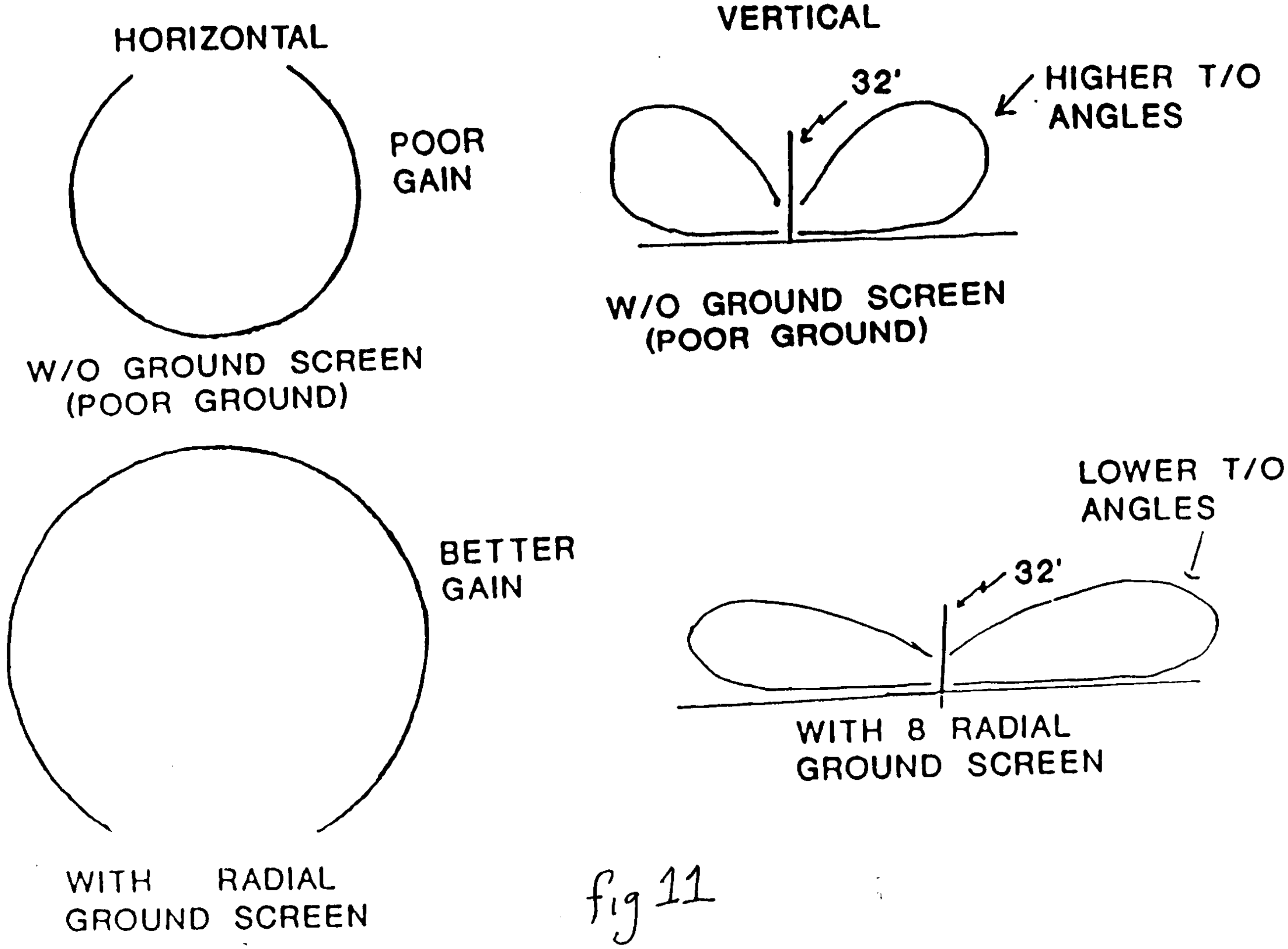


fig 11

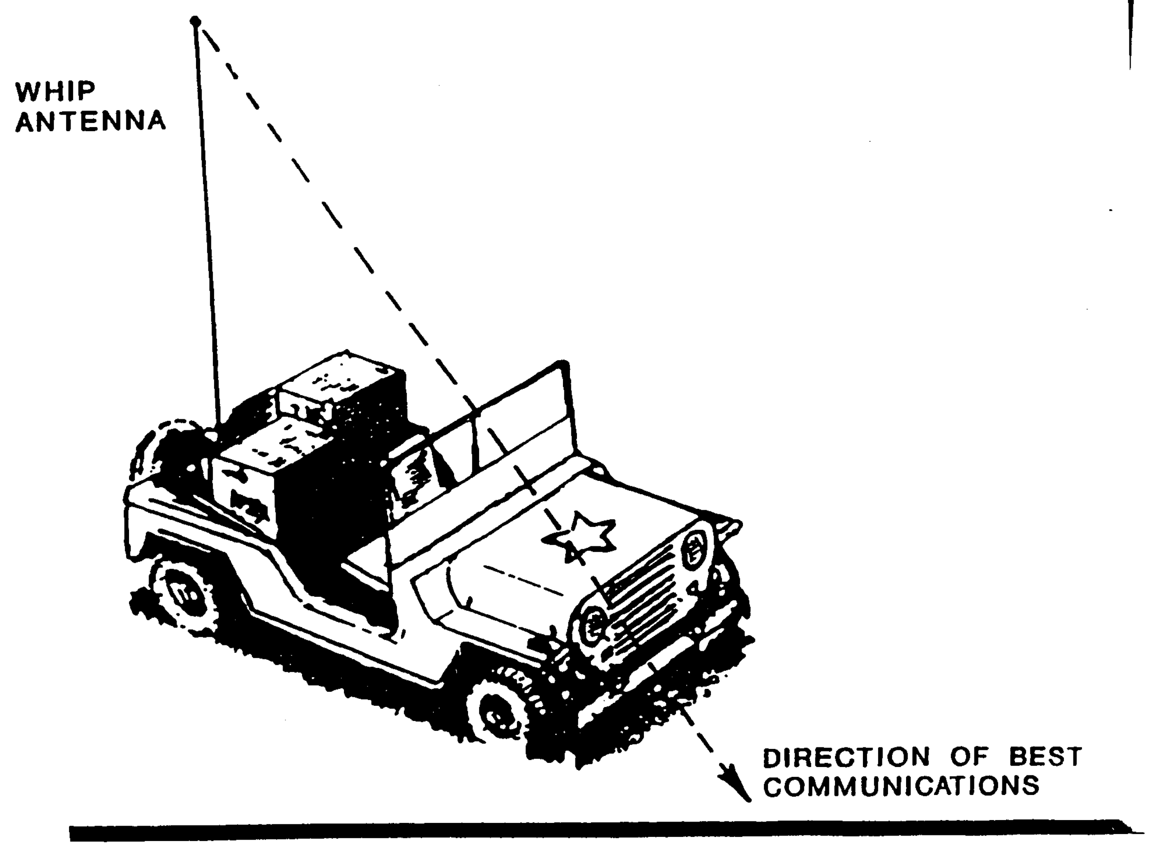
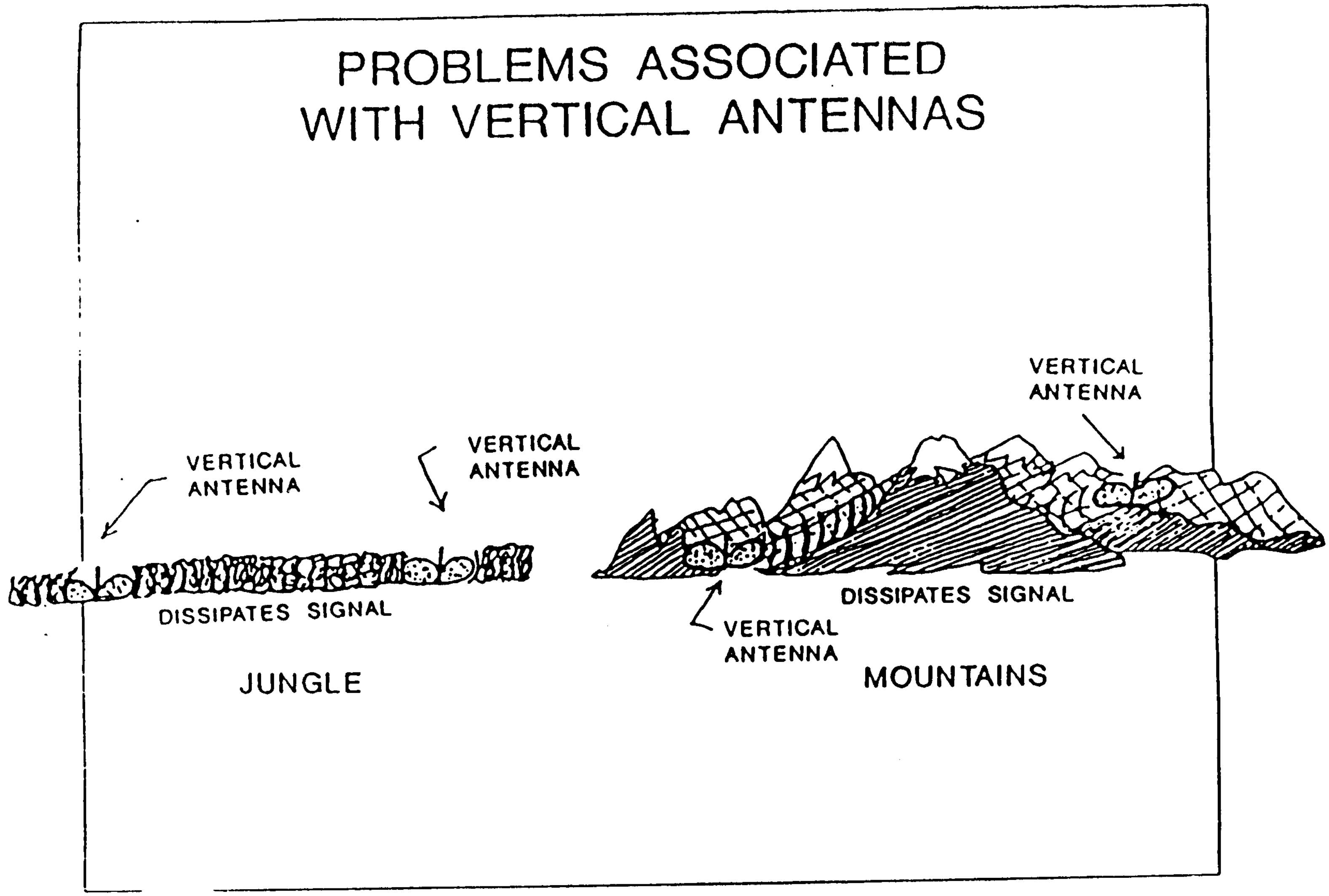


fig 12

Vehicle Chassis as a Counterpoise for Surface Wave Operation.

These antennas will overcome the problems encountered when using vertical antennas in unsuitable situations (see fig 13). The antennas provided are the RF- 1 941 light weight wire dipole and the AT- 1 912 dipole with 30 foot mast kit. The AT- 1 912 is provided only with the 400watt base station configuration. A horizontal dipole consists of two 1/4wavelengths of wire supported at the ends and connected to the radio in the center (see fig 14). If the antenna is kept physically 1/4wavelength or less off the ground at the operating frequency, or laid on the ground, or at even buried under the ground the antenna pattern produced is that of an "inverted teardrop" (see fig. 14). The bulk of the energy radiated is on angles between 30 and 90 degrees. Since much of the radio signal is directed upward, where it can be reflected back to earth by the ionosphere this mode of propagation was named Near Vertical Incidence Sky wave (NVIS) mode. The relationship between antenna height above real electrical conducting ground and signal gain is shown in fig 15. As a rule Brigade stations will try to elevate dipole antennas to 30 feet and leave them there since the best average high angle gain is attained in the N'VIS frequency band at this height. The NVIS frequency band is as a rule 2-4Mhz at night, and 4-8Mhz in the day. Exception, in desert and artic areas the ground is not very conductive. This means that the antenna may perform better if it is physically lower or even on the ground since real conducting ground could be many feet below the surface in these areas. Dipole heights will have to be adjusted to match actual operating conditions. The basic NVIS inverted teardrop antenna pattern remains the same for all dipole heights 1/4wavelength or less. Only the signal strength (gain) will change. Once a radio signal on a frequency that will be reflected is selected and the dipole is at a correct height the signal will return to earth in an omni-directional pattern with a radius of hundreds of miles. Note dipoles can be made directional off their broad sides by putting them close to V2wave above ground. The Brigade will NOT normally erect dipoles this high and omni-directional communications will be used for most operations. The NVIS signal after reflection has no holes and no "dead spots" or "skip zones" since all the energy is coming down from above. This makes NVIS an ideal mode for Brigade size operations over wide areas and at extended distances. Fig 16 shows the distance that can be expected by radiating signals on all angles. Figure 14 shows strong high angle NVIS signal generated by dipoles on all angles above 45 degrees. Figure 16 shows that energy on all angles above 45 degrees will when reflected give a strong radio signal at distances from 0 to 300 miles. This is a good match for Brigade communications needs such as TOC to TOC and "reach-back" communications. Communications in urban areas (MOUT) will also be made easy by using NVIS since all energy comes from above and will not be as readily absorbed by urban structures. NVIS using ground mounted wire dipole antennas will be the most efficient means of HF communications when stations are located at beyond line of sight (beyond ground-wave) distances from each other.

On the move (OTM) NVIS operations - As previously described each THFRS vehicular radio is equipped with an AT- 1011 32 foot (whip) antenna. When in the vertical position this antenna does a good job radiating vertically polarized surface wave HF signals when on the move. The length the AT-1011 (32 feet) is often too long to be practical under operational conditions. In this case, the AT-1011 should be shortened by removing antenna sections until a practical length for the operational conditions are found. Shortening the antenna will make it less efficient for both transmitting and receiving so operators should not make the antenna less than IO feet long under most conditions. The RF-382 antenna


PROBLEMS ASSOCIATED
WITH VERTICAL ANTENNAS
VERTICAL
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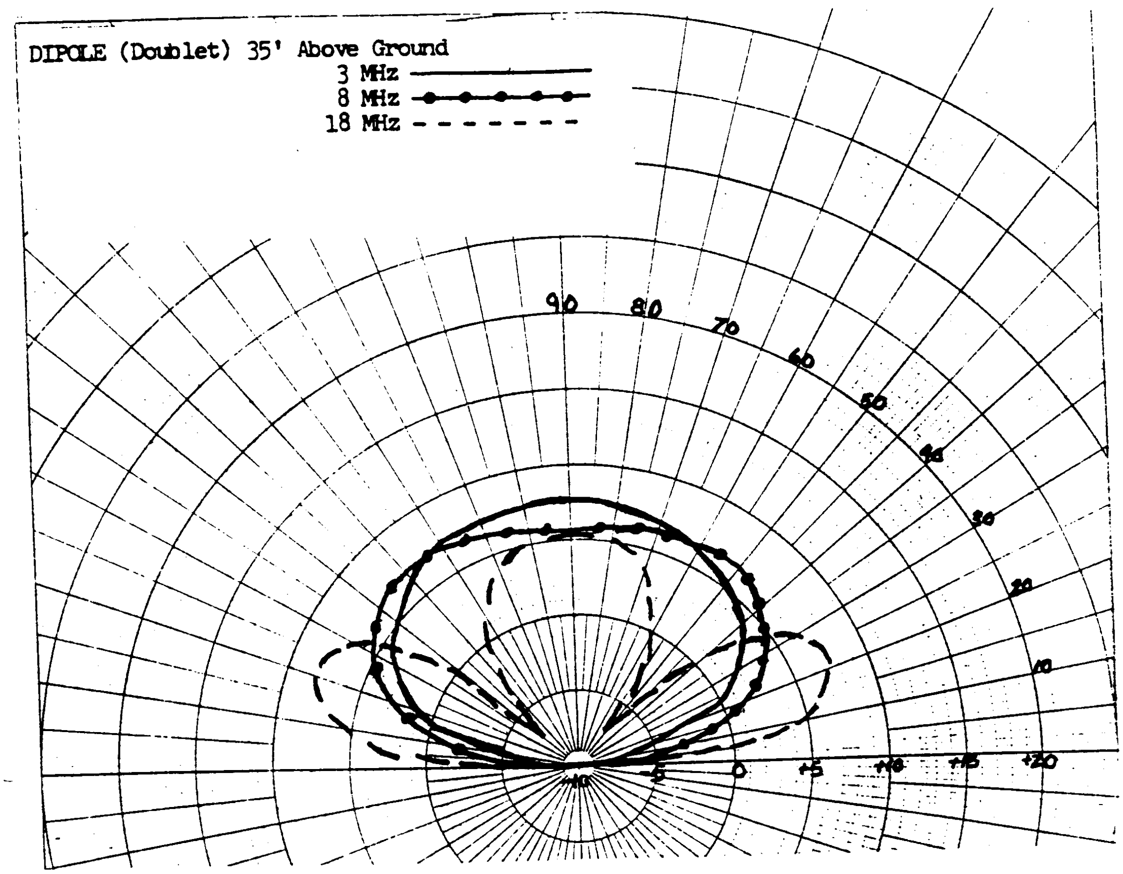
ANTENNA
DISSIPATES SIGNAL
MOUNTAINS

fig 13


DIPOLE (Doublet) 35' Above Ground
3 MHz
8 MHz
18 MHz
90
80
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50
40
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20
10
-10
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0
+5
+10
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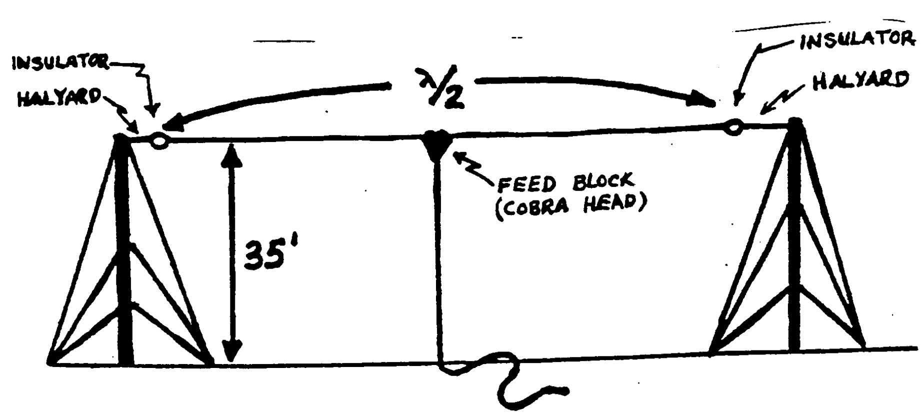
fig-14


INSULATOR
HALYARD
λ/2
INSULATOR
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(COBRA HEAD)
35'

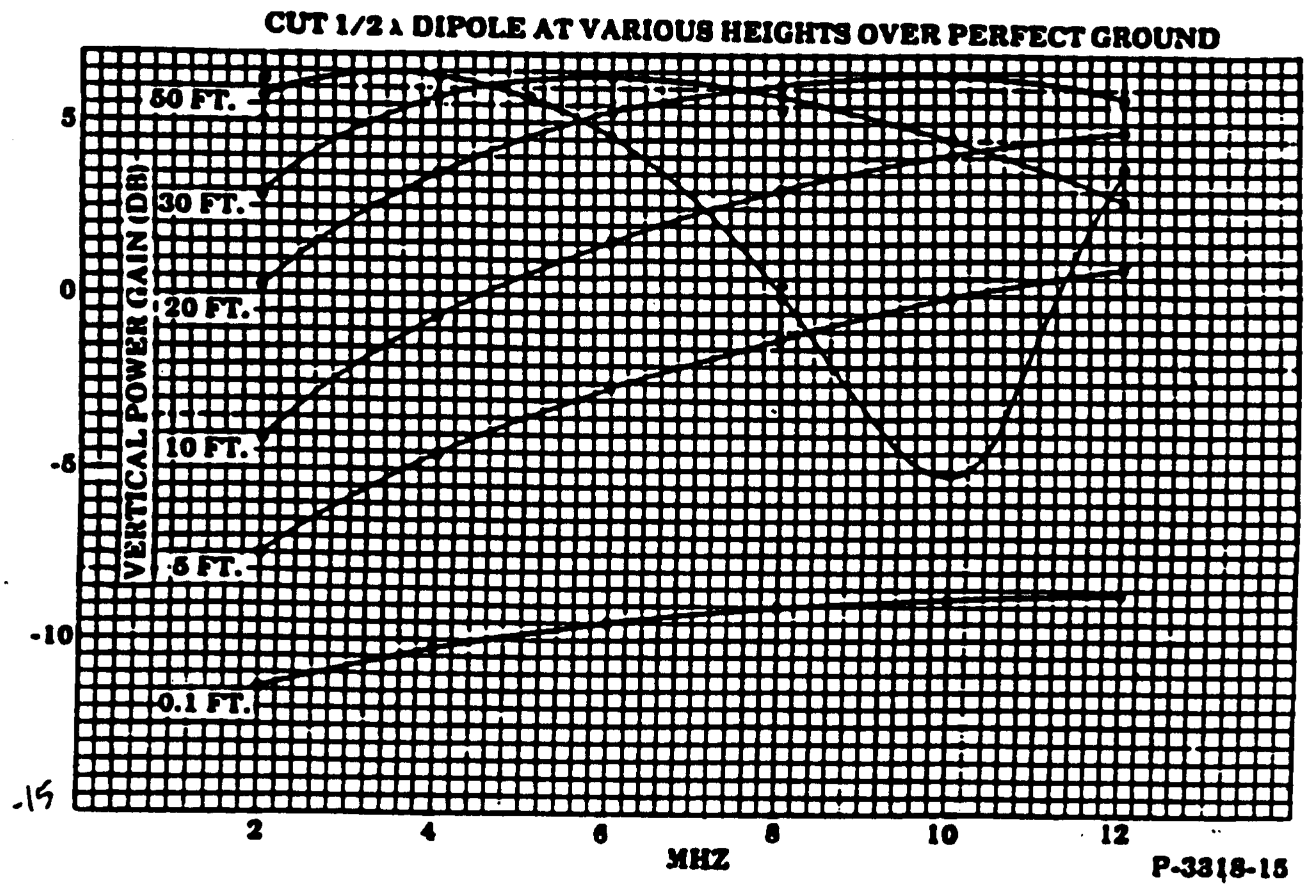

Figure 15 CUT 1/2 λ DIPOLE AT VARIOUS HEIGHTS OVER AVERAGE GROUND

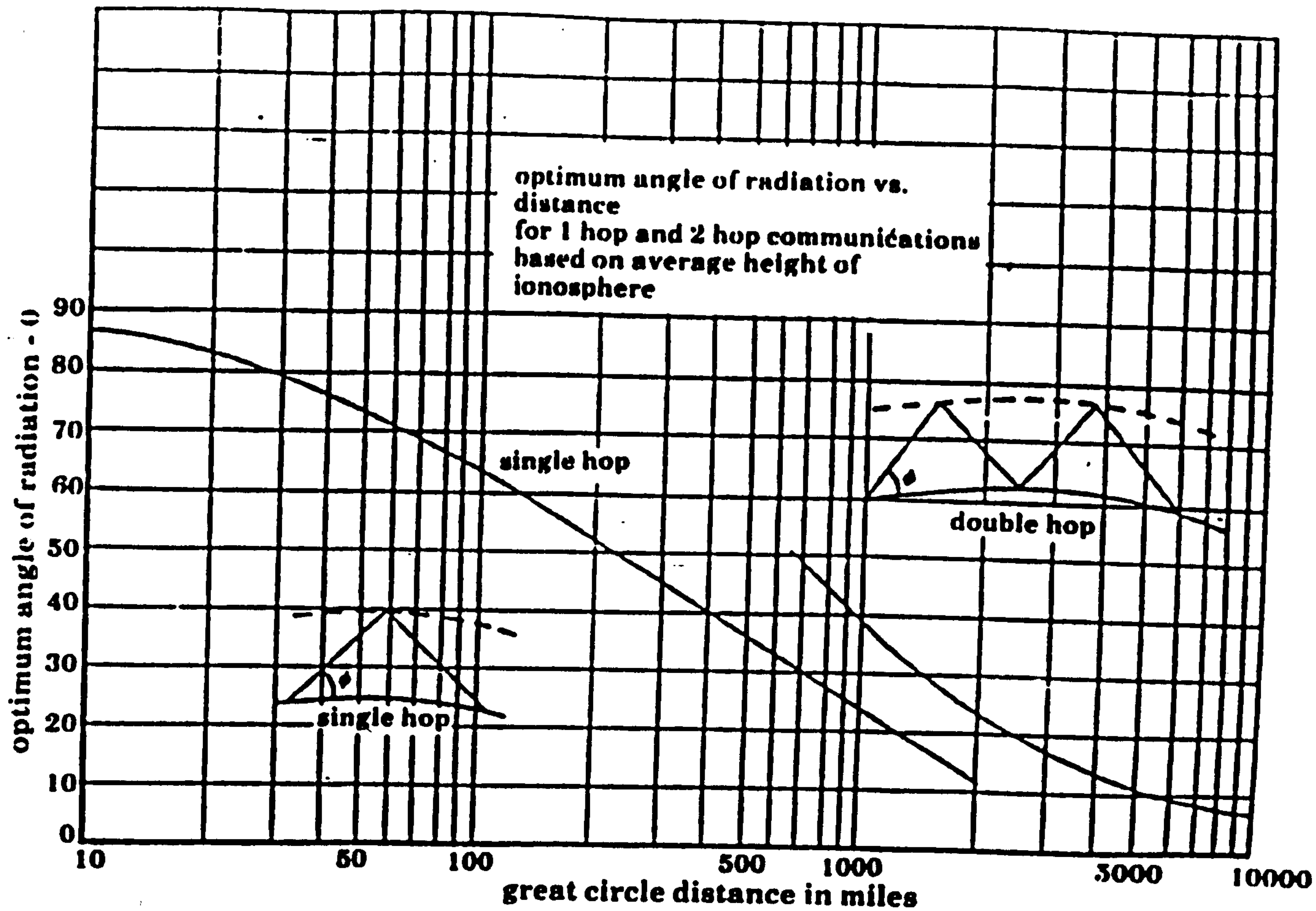

Figure 16 Radiation angle vs. range (from The Rules of the Antenna Game).

USE OF WHIP-TILT ADAPTER

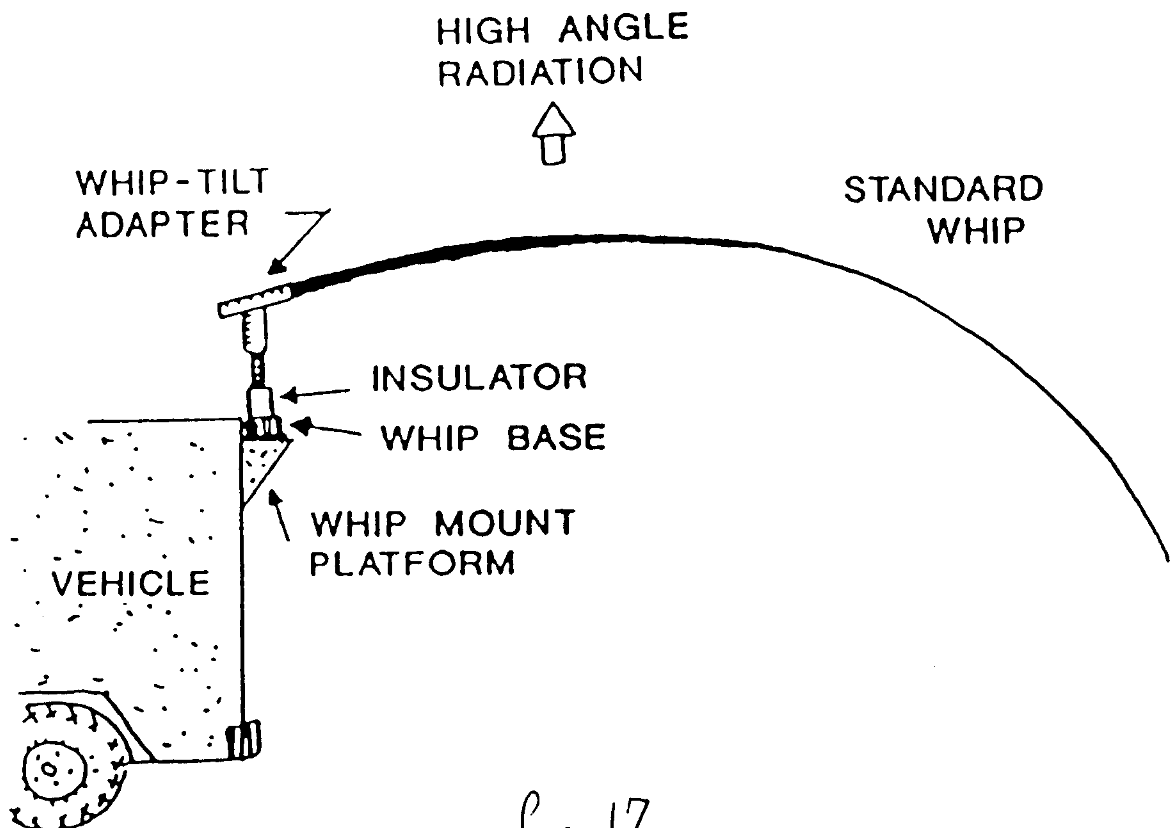

fig 17

coupler will tune a short antenna without a problem and the omni-directional antenna pattern will remain for short antennas however signal strength will be greatly reduced when using very short vertical antennas. This same antenna when "tipped" horizontally either forward or backward will also produce an NVIS (dipole) antenna pattern. In order to facilitate whip antenna "tipping" the antennas are located in a rear comer of either the IAV or shelter that they are mounted on. The antenna base is also provided with a 7 position 6 ₄ whip tilt adaptor" that will allow any length of AT-1011 antenna to be "tipped" into either the forward facing or rear facing horizontal position. When at the brief halt, the antenna can be tipped backwards to form a classic dipole, the AT-1011 whip being one half and the vehicle/shelter/IAV forming the other half of the dipole antenna (see fig 17). When tipped backward, a classic "inverted teardrop" low height dipole antenna pattern is produced. If possible at the longer halts the antenna should extended past 32 feet to by replacing it with the wire from the RF-1941 antenna kit to make an even more efficient antenna. Ideal wire length will be V4-wave-length at the operational frequency. When communicating on the move, the AT-1011 must be "tipped forward" over the vehicle for operational reasons. Again, the antenna should be as long as possible for best efficiency but practically cannot be much longer than the length of the vehicle, (usually less than 20 feet). Shortening the antenna again makes it less efficient but in this configuration, the antenna and the vehicle form what engineers call a transmission line antenna (see fig 18). While this antenna does not have the ideal inverted teardrop NVIS shape that the wire dipole or rear tipped whip has, it does produce enough energy on the near vertical angles for NVIS communications. For missions such as motorized reconnaissance, movement to contact, convoy control, etc the bent forward whip will be the antenna of choice for Brigade operations.

Antenna location considerations - The Brigade is a tactical fighting organization and when engaged in combat operations will never be able to always locate its fixed and mobile radio assets at technically ideal positions for communications operations. Brigade HF communications planners should however attempt to comply with as many of the following citing criteria as possible in order to gain the best technical advantage for the tactical situation.

I - Use ground radials and ground stakes under vertical antennas to improve antenna efficiency and lower take-off angles for better ground-wave communications.

2 - Place vertical antennas on higher spots if possible to enhance ground-wave communications.

3 - Place all antennas above reasonably smooth earth if possible to reduce antenna pattern discontinuities and distortion due to ground reflections.

4 - Avoid placing vertical antennas behind metal fencing that will shield ground-wave signals.

5 - Avoid placing vertical antennas near vertical conducting structures such as masts, light poles, trees, and metal buildings. Antennas need to be at distances of at least one

ARMY "HUMMER" WITH A FORWARD-TILTED WHIP USING THE WHIP-TILT ADAPTER

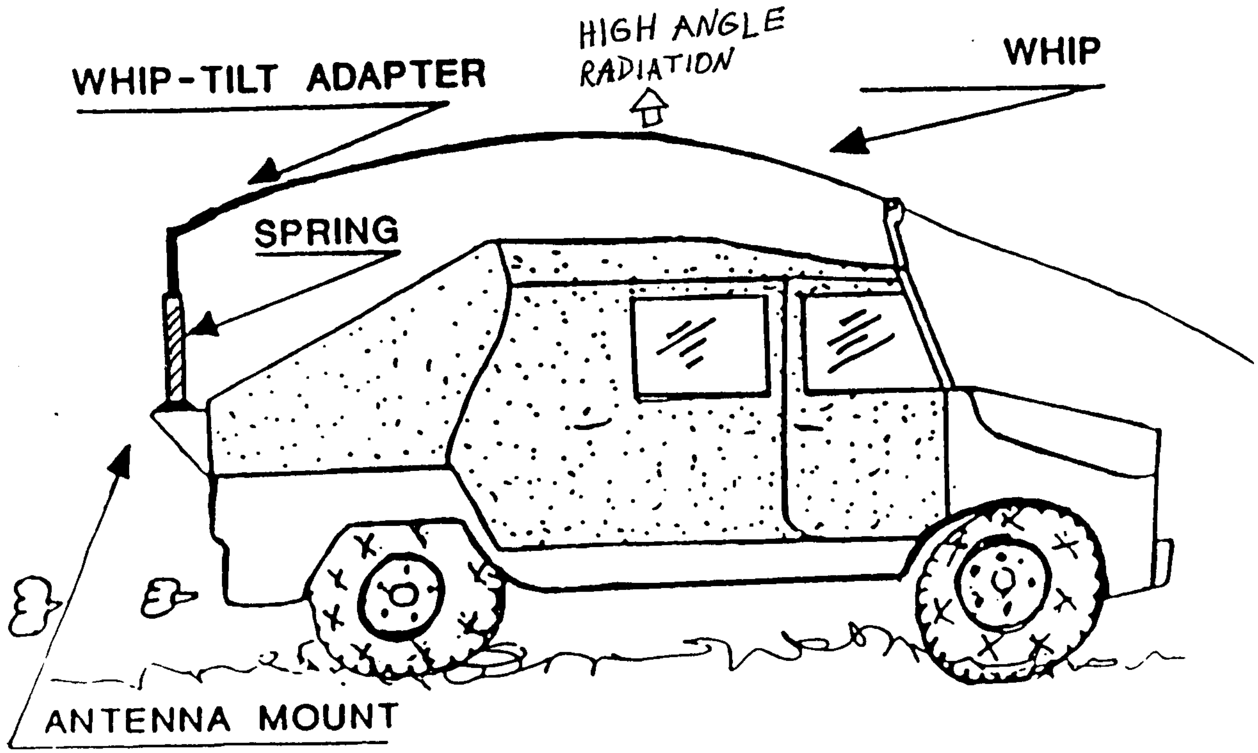

fig 18

wavelength or more to eliminate major pattern distortions and antenna impedance changes caused by induced currents and reflections.

6 - Separate antennas as far as practical to reduce interference effects between radio and antenna systems.

Remember, that wire dipoles and tipped whips on vehicles can be placed in defilade since they radiate signals on high angles while vertical whips will have their signals greatly reduced if they are in covered positions.

Brigade HF radio equipment - The THFRS hardware is a family of HF radio equipment based upon the AN/PRC- 1 5 O(C) man-pack radio. By adding various power amplifiers, couplers, antennas, software, and ancillaries to the man-pack radio various vehicular and base-station configurations can be built. The configurations used by the Brigade are:

1 - AN/PRC- 150(C) 20-watt man-pack radio

2 – AN/PRC-104(V)1 20 watt vehicular radio using internal coupler

3 – AN/PRC-104(V)2 20 watt vehicular radio using external RF-5830 Power Amplifier/Antenna Coupler

4 – AN/PRC-104(V)3 150-watt vehicular radio with RF-382 external Antenna Coupler.

5 - AN/TRC-210(V)2 400 watt base-station radio set.

The heart of THFRS is the 10 pound 10.5 x 3.5 x 13.2inch AN/PRC-150(C) man-pack radio (see fig 5). This radio and all ancillaries needed for man-pack operations are provided to all configurations being built. This was done so that each THFRS user will have a "jerk and run" HF radio capability to use in the event that they must separate from their wheeled, armored, or base-station platform. 2 BB-5590, BB-590 or BB-390 standard batteries power the software controlled manpack radio. This provides an output power level of 1, 5, or 20 watts of AM single sideband (SSB) power across the 1.6 - 30 MHz spectrum. The radio is also capable of providing 1, 5, or 10 watts of FM signal on frequencies between 30 and 60 MHz. The waveform in this frequency range is either 16kbs wideband FSK for data transmission or 16kbs digital voice that makes the radio interoperable with SINCGARS in the non-hopping, encrypted or plain text digital voice mode. This mode is a very useful feature when tactical necessity dictates the need for communications with units who have no HF communications. Standard analog voice FM mode with VINSON COMSEC is also provided which will allow interoperability with organizations still equipped with pre-SINCGARS tactical FM radios. This includes many of our worldwide potential allies and our own reserve components that still have large quantities of this type of equipment.

The AN/PRC-150(C) is a fully software defined radio, so new features or new revisions of existing standards, can be added to the radio through software not hardware upgrades Integrated into the THFRS receiver/transmitter (R/T) also known as the RT1964D(P)(C) are modes of operation and other features that in the past required many separate hardware ancillaries and system interfaces to achieve. Embedded THFRS operating features include:

a) **automatic link establishment (ALE)** - Mil-Std- 1 88-144B ALE is provided in THFRS. ALE is capable of dealing with HF radio propagation variables in real time in order to establish the best communications link for the current conditions. THFRS assigns each member of an HF radio net a unique address. It also assigns each net a list of authorized frequencies. A sounding signal is sent on each frequency authorized to a net at a predetermined time as the radios scan the frequencies. If a sounding signal is detected during the scanning process, a link quality analysis (LQA) is performed on the received signal. The signal also contains the address of the transmitting station. This data is stored by the radio. Based upon the data the radio automatically selects the best frequency for communications at that time and the net is opened for traffic. The ALE process is repeated periodically Individual calls (point to point), group calls (point to multipoint), and broadcasts are all accommodated by the ALE system. ALE greatly improves the probability of successfully establishing a useable communications system on the first try. This saves net time and reduces channel loading. More importantly, ALE removes the guesswork from the frequency selection process and eliminates the need for many of the hard to train frequency management and engineering skills that past generations of HF equipment required. ALE is a major factor in the resurgence of tactical HF radio because it eliminates the basis of many past circuit reliability problems that were rooted in poor radio frequency selection techniques. For more information on ALE see An-ny Communicator Spring 1994.

b) **Modulators/Demodulators (MODEMS)** - Radios cannot transmit or receive digital data or digital voice information directly. Digital signals must be converted into data formats that are suitable for transmission over narrow band (3Khz bandwidth) voice radio channels found in all tactical HF radios including THFRS. Received signals must reverse this process. In the RT- 1 964D this is the function of the built in MODEM(s). The RT- I 964D provides 3 basic kinds of MODEMS. They are 1) slow speed audio frequency shift keying (AFSK), 2) high-speed parallel tone, and 3) high-speed serial (single) tone MODEMS. The high speed MODEMS are suitable for both digital voice and data communications. Low speed MODEMS are used for data (message text) communications. A standard low speed AFSK MODEM capable of operation at rates of 75, 150, 300, and 600 bits per second (bps) is provided. This type of signaling is standard in virtually every HF data system built worldwide over the last 40 years. At this time THFRS will use this mode when communicating with older radios still in use in the US forces (e.g. the AN/GRC- 1 93) or with older HF radio-teletype sets used by our allies. FSK signaling along with analog voice signaling is the "common denominator" present in almost every HF radio in the world so it remains useful particularly in coalition warfare. A high-speed parallel tone type MODEM is also embedded in the THFRS. This MODEM produces 39 sub-carrier audio tones that fit within the 3 kHz wide radio audio channels. A process called Quadrature Differential Phase Shift Keying (QDPSK), which simply means that the data is represented as a shift in the phasing of an audio tone that can take 4 (quadrature) possible states, modulates each of these tones. These phase shifts are then distributed, interleaved, and synchronized over 39 sub-carrier tones contained in the narrow band (voice) channel. This type modulation is excellent for recovering signals that have been sent over a radio path that is subject to multi-path and signal fading effects because all tones will not fade at the same time. If the data is coded and spread over all the sub-carrier tones the signal processing techniques produce performance that is many times better than the same radio circuit using older FSK modulation. The THFRS 39-tone MODEM provides data rates between 75 and 2400 bps. In recent years the third type MODEM provided by THFRS called the serial or single tone MODEM has eclipsed the use of the 39-tone MODEM. Serial tone MODEMS are easier to build and perform better than parallel tone MODEMS under most conditions. Serial tone will be the most widely used data mode in THFRS. THFRS will normally use the 39-tone waveform only when communicating with other systems that have only a 3 9-tone capability. The Mil-Std-188-110B serial tone MODEM embedded in THFRS uses phase shift keying (PSK) on a single carrier frequency to represent data. Many small shifts in phase can be created to represent various binary states. The addition of amplitude shifts to the phase shift information can also be used to increase the amount of information contained during any time interval. The serial tone MODEM in THFRS can be used at data rates of 75 to 9600 bps depending upon path conditions. In addition to US standard serial tone MODEM capabilities NATO STANAG 4285 (75-2400bps) serial data mode and STANAG 4415 (75bps) robust serial data mode used when severely degraded circuit conditions exist are provided to enhance operations with equipment built to NATO standards.

c) **Electronic Counter-Counter Measures** (ECCM) - THFRS provides a robust frequency hopping waveform for use with serial tone data (75-2400bps) and digital voice (600 or 2400 bps) to reduce the effects of interfering signals or intentional jamming by an enemy. This capability also lowers the probability of intercept and detection (LPI/LPD) by hostile forces.

d) **Voice communications** - Both analog and digital voice modes of communications are provided. In digital mode voice signals are converted into digital representations and coded to correct errors (VOCODER). The digital voice representations are then transmitted by the serial tone MODEM at rates of 2400 bps for clear channel operation or at a slower rate of 600 bps for better performance over degraded channels. 600 bps digital voice can provide effective voice communications in environments where signal strength and noise are actually equal.

e) **Cipher modes** - THFRS has embedded NSA certified US Type -1 encryption capability. Standard KY-99, KY- I 00, KG-84C, and KY-57 modes are provided for interoperability with compatible systems. Also embedded in the AN/PRC- I 50(C) is the internationally used CITADEL encryption system useful for coalition operations.

f) **COMSEC key management and fill** - THFRS will accept COMSEC keys from a variety of COMSEC load devices such as the KYK- 1 3, KOI- 1 8, KYX- 1 5, and AN/CYZ- I 0 via the standard fill connector located on the front panel. Unique to THFRS is the COMSEC ignition key (CIK) which is contained in the radios removable Keypad/Display Unit (KDU). By removing the KDU the COMSEC is rendered inert. The KDU can be easily removed, safely stored, and reinstalled. This removes the need to remove and reload COMSEC every time the radio is left unattended.

g) **Transparent Internet Protocols (IP)** - In anticipation of the Army's transformation to an IP based architecture for the Army Battle Command System (ABCS), THFRS has provided internally the necessary connectors and Internet protocols. This will allow seamless integration and direct connections with devices such as commercial and military PC workstations, laptops, routers, servers, etc without the need for additional external hardware and software "gateways".

h) **System management** - THFRS includes not only the radio hardware but also the means to manage/select the various features and modes of radio operation without having to enter data via the radio KDU. Every S-6 section in organizations deploying THFRS will also receive an army Common Hardware System (CHS) laptop computer with radio programming application (RPA) software. The RPA software has a user friendly Microsoft Windows "look and feel" and will allow the Operators to define and configure radio nets, assign ALE addresses, select presets for MODEMS, store communications plans etc. Information can then be transferred to individual radios via a data transfer cable to the front panel radio data connector. This capability greatly reduces operator stress and errors in data entry when compared to using the KDU as the means of setting up the radio. KDU data entry remains available if needed.

Radio Programming Application - Two methods of entering system required data into the THFRS radio are provided. They are data entry through the Keyboard Display Unit KDU on the radio front panel or through the use of a laptop computer and Radio Programming Application (RPA) software. The RPA software will run on any laptop computer platform that provides a speed of 200 Mhz, a minimum 64Mb of memory (Ram), and the Windows 98, Windows 2000, or Windows NT operating system. RPA will install itself on any hardware with this capability. Once installed operators need only enter planning information such as authorized radio frequencies, radio configuration data, ALE information, radio presets, frequency hopping information etc into the RPA and the RPA will configure the radio hardware through the radio data port. RPA can be used to reprogram the radios with modified parameters as required. Multiple sets of system information can be stored as separate plans for contingency operations. The Brigade S-6 will select the number of plans to be stored in the RPA at each echelon based upon the Brigades operational planning. Once created, plans can be transported by floppy disk media, transmitted over the air, or printed. RPA generated information will be used as the HF input data to the Brigade SOI.

The basic programming procedures for the THFRS hardware and radio programming application (RPA) are shown below. Operators will note that since the THFRS is a software based/software programmable radio there are many operator-selected options. Please refer to the proper equipment manuals for a more detailed explanation of what these options are and when to use them. Items in **BOLD** print indicate a default value. Default values have been selected that will achieve a high level of system operation and reliability under the most common conditions that the Brigade will encounter.

Under unusual circumstances, the operator may be required to change a particular value from the default value in order to improve system perfon-nance under a particular operational condition. Changes from default values should only be made by direction of the unit S-6. Operators will also be required to enter standard information such as frequency and address data into the radio in order to operate. Operators need to pay careful attention when entering data and to double-check themselves frequently to avoid errors. Since this equipment is digital and software controlled errors in data entry may result in the failure of the system to operate properly.

IT CANNOT BE STRESSED TOO OFTEN THAT ANTENNA AND FREOUENCY ARE THE TWO MOST CRITICAL FACTORS IN MAKING HF COMMUNICATIONS WORK FOR THE BRIGADE. PROPER SELECTION OF ANTENNAS FOR LOS OR BLOS MODES COUPLED WITH SELECTION OF FREOUENCIES THAT WILL EXTEND GROUNDWAVE DISTANCE OR BE REFLECTED OFF THE IONISPHERE AS APPROPRIATE ARE ESSENTIAL.

AN/PRC-150(C) HF Manpack Radio

Includes:

*ON672486-010	Radio Chassis Assy., RT-1694D(P)(C)/U
*10075-1399	Handset
*10303-1008-01	Ground Stake Kit
*10372-0240-01	OE-505 Whip Antenna
*10372-1230	Y-Adapter Cable Assy.
*10511-0704-012	Cable Assy., KDU
*10513-4800-02	Battery Box
*l05l5-0103-4100	Operator Manual
*10535-0775-AOO6	Cable, Assy., Remote, PPP (Data)
*RF-3016-03	CW Key

BASIC PROGRAMMING PROCEDURES

PURPOSE. This is a sequential guide and items should be programmed in the order presented as they apply to the operational scenario. While navigating through the radio menu structure, the Left/Right arrow keys on the KDU keypad are used to select the item to be programmed, and the Up/Down arrow keys are used to scroll through the available parameters for each item. Default settings on a zeroized radio for each item are shown in bold where applicable.

NOTE: Press ENT **(Enter) after each step or change to save programmed features.**

GENERAL RADIO PROGRAMMING

COMSEC PROGRAMMING (CITADELKEYS PROGRAMMING) I . ENTERING A NEW KEY

a. Press **PGM**
b. Select **COMSEC**
c. Select **CITADEL**
d. Select **KEYS**
e. Select **ENTER**
f Key Type **(R-F-5800,** RF-5022/PRC-138)
g. Enter Key Name (Can be up to 4 alphanumeric characters long) or leave as default.
h. Use alphanumeric keys to enter 32 character key
i. Load AVS Key (NO, YES) If yes enter 12 number key.

2. UPDATE EXISTING KEY
   a. Press **PGM**
   b. Select **COMSEC**
   c. Select **KEYS**
   d. Select **UPDATE**
   e. Use Up/Down arrows to select correct key to be updated f Select **YES** to update
3. ERASE EXISTING KEY
   a. Press **PGM**
   b. Select **COMSEC**
   c. Select **KEYS**
   d. Select **ERASE**
   e. Use Up/Down arrows to select correct key to be erased
   f. Select **YES** to erase
4. CRYPTO MESSAGE INDICATOR
   a. Press **PGM**
   b. Select **COMSEC**
   c. Select **MI** (Used to lengthen the crypto sync time manually. Default setting the length is selected automatically by the radio - recommended)
   d. Crypto MI **(DEFAULT,** I X, 3X)

NOTE: U.S. ARMY UNITS WILL NOT NORMALLY USE CITADEL CRYPTO UNLESS OPERATING WITH ALLIED FORCES ONLY EOUIPPED WITH THIS SYSTEM. CITADEL IS NOT APPROVED BY THE NSA AS A COMSEC SYSTEM. CITADEL WILL NEVER BE USED WITHIN THE BRIGADE FOR OPERATIONS.

COMSEC PROGRAMMING (TYPE I KEYS PROGRAMMIN@

! NOTE: Unlike CITADEL, Type I Encryption keys are loaded with a U.S. COMSEC loader (e.g. KYK-13, KOI-18, CYZ-10A). The loaded keys are assigned to selected channels during the System Presets. Refer to the END of this guide for brief instructions on COMSEC loading.

1 . ERASE EXISTING KEY

a. Press **PGM**
b. Select **COMSEC**
c. Select **TYPE I**
d. Select **KEYS**
e. Select **ENTER**
f. Use Up/Down arrows to select correct Crypto type to erase.
g. Use Right/Left arrows to tab to Crypto key then use Up/Down arrows to select key to erase.
h. Select **YES** to erase

2. VIEW SPECIAL KEYS

a. Press **PGM**
b. Select **COMSEC**
c. Select **TYPE I**
d. Select **KEYS**
e. Select **SPECIAL**

f. Use Up/Down arrows to view status of **SPECIAL** keys

COMSEC CONFIG PROGRAMMING *(TYPE I)*

1 . CONFIGURE TYPE I KEY PARAMETERS

a. Press **PGM**

b. Select **COMSEC**

c. Select **TYPE I**

d. Select **CONFIG**

e. Select **ENTER**

f Select **ALL.**

g. Select **ENTER**

h. PT Beeps **(ENABLED,** DISABLED)

2. CONFIGURE TYPE I ANDVT-BD PARAMETERS

a. Press **PGM**

b. Select **COMSEC**

c. Select **TYPE I**

d. Select **CONFIG**

e. Select **ENTER**

f Select **ANDVT-BD.**

g. Select PREAM **(STAND,** ENHAN)

h. Select TRN SEQ (6,9,12,15,30,60)

<u>PROGRAM RADIO SETTINGS</u>

1. Press **PGM**

2. Select **CONFIG**

3. Select **RADIO**
   a. Transmit Power **(HIGH,** MEDIUM, LOW) use lowest power possible to save battery and improve EW characteristics
   b. BFO (0**Hz,**-40OOHz to +40OOHz in 10Hz Steps)

c. Squelch (**OFF**, ON) use squelch when signals are strong to cut off audio noise when receiving

d. Squelch Level (HIGH, **MEDIUM**, LOW) adjust as appropriate. Higher levels require strong receive signal/audio levels. CAUTION: weak signals may be lost if squelch level is to high.

e. FM Squelch Type (NOISE, **TONE**) use noise squelch when operating with equipment that has no tone capability.

Radio Silence (**OFF**, ON) use radio silence when directed. Will not allow radio to transmit in any mode.

g. Internal Coupler (**ENABLED, BYPASSED**) use bypass when using RF-382 or RF-5830 external couplers.

h. FM Deviation (**8.0kHz**, 6.5kHz, 5.OkHz)
i. CW Offset (0Hz, **1000Hz**)
j. Rx Noise Blanking (**OFF**, ON) use only when in a high receive noise envirom-nent.
k. Compression (OFF, **ON**)
1. 2OW AMP Coupler (**MEMORY TUNE**, LEARN TUNE, DISABLED)
m. Radio Self ID (**001 - 254**) obtain from unit SOI
n. Error Beeps (**OFF**, ON)

PROGRAM DATA PORT SETTINGS

1. Press **PGM**
2. Select **CONFIG**
3. Select **PORTS**
4. Select **DATA**

a. Data Rate (19.2 Kbps to 75 bps) **2400 bps** Use higher data

rate on clear channels with strong receive signals. Slow data rate to improve operations under poor, high noise, low signal strength conditions. Rates to change on order of the S-6.

h. Data Bits (**8**, 7)

c. Stop Bits (**1**, 2)
d. Parity (**NONE**, ODD, EVEN, MARK, SPACE)
e. Flow Control (**NONE**, XON/XOFF, HARDWARE)
f. Echo (**ON**, OFF)
g. Level (**RS232**, MIL- 1 88)
h. TX Clock Source (**INTERNAL**, EXTERNAL, RECOVERED)
i. Key line (**RTS**.AUX-AUDIO)

MESSAGE (ROUTING INCOMING DATA)

1. Press **PGM**
2. Select **CONFIG**
3. Select **MESSAGE**

a. Route Modem Data To (**DTE PORT**, RDP, FILE)
h. Route ARQ Data To (DTE PORT, **RDP**, FILE)

AUXILIARY AUDIO PROGRAMMING

I . Press **PGM**
2. Select **CONFIG**
3. Select **AUDIO**

a. Aux (MUTE, **UNMUTE**)
h. Sidetone Audio (MUTE, **UNMUTE**)

SET RADIO TIME OF DAY (TOD) See SOI and OPORD for formats and procedures. Brigade will normally use 24-hour clock and ZULU time.

1. Press **PGM**
2. Select **CONFIG**

3. Select **TOD**
   a. LJTC Offset (Use Up/Down keys to select or "-" offset then use numeric keys to select correct offset value)
   b. Time Format (I 2-HR, **24-HR)**
   c. New TOD (Press numeric keys to enter TOD)
   d. Date Format (MM-DD-YY, DD-MM-YY, **YYYY-MM-DD,** ZULU)
   e. New Date (Press numeric keys to enter new date)

LPC (NOISE CANCELLATION) PROGRAMMING

1. Press **PGM**
2. Select **CONFIG**
3. Select ⟶
4. Select **LPC**

- Noise Cancellation (ON, **OFF)** Use LPC nois e cancellation when operating in a high noise environment.

OPTIONS (PREPOST CONFIGURATION) External pre/post selectors are provided with the AN/VRC- I 04(V)3 150w vehicular set and the AN/TRC-2 I O(V)2 400w base-station set to reduce interference. Always select this option.

I . Press **PGM**
2. Select **CONFIG**
3. Select -+
4. Select **OPTIONS**
   a. EXT POST SELECTOR **(ENABLED,** DISABLED)
   h. EXT Preselector **(ENABLED,** DISABLED)
   c. EXT RX Filters **(ENABLE DURING** SCAN, DISABLE DURING SCAN)
   d. EXT Scan Rate (FORCE SLOW SCAN, USE ALE SCAN RATE)
   e. Prepost Antenna **(SINGLE RX/TX,** SEPARATE RX/TX)

CHANNEL PROGRAMMING

I . Press PGM
2. Select **MODE**
3. Select **PRESET**
4. Select **CEIANNEL**
   a. Enter desired channel number (000- 1 99) see unit SOI
   h. Enter desired **RX FREQUENCY** see unit SOI
   c. Enter desired **TX FREQUENCY,** or press **ENTER**
   d. Modulation **(USB,** AME, CW, FM, LSB) see unit SOI

   e. AGC Speed (SLOW, **MED,** FAST, DATA, OFF) select for conditions. Use to obtain steady receive signal level.
   f IF Bandwidth NOTE: **Options are dependent on modulation type selected.**
   - USB or LSB (2.0 kHz, 2.4 kHz, 2.7 kHz, **3.0 kHz)** Use narrow bandwidth to reduce noise and interference on order of the S-6.
      - AME (3.0 kHz Only)
      - CW (0.5 kHz, 0.35 kHz, 1.0 kHz, **1.5 kHz)**
   g. RX Only (YES, NO)
   h. Enable Hail TX NOTE: **Not available for channel 000** (YES, NO)
   i. Max TX Power (00000 WATTS this is default, for maximum transmit power). Use to limit power and save battery life.

   See SOI or OPLAN for power limits
   j. Enable SSB Scan (YES, NO) NOTE: **Selecting** yes **automatically places current channel in scan list.**

5. Repeat step 4 for the remaining channels to be programmed.

MODEM PROGRAMMING

1. Press **PRGM**

2. Select **MODE**
3. Select **PRESET**
4. Select **MODEM** (Different modem types have different options available, please consult the radio operations manual for a detailed explanation of settings):
   a. Select the modem preset name you wish to modify. **Note: In a zeroized radio, modem presets are given default names MDML to MDM20.**
   b. Enter desired name up to 15 characters (e.g. 24SERIAL)
   c. Select MODEM TYPE (e.g. SERIAL)
   d. Select DATA RATE (e.g. 2400)
   e. Select INTERLEAVE: (e.g. SHORT)
   f. Select MODE: ASYNC (or SYNCHRONOUS, as required)
   g. Select DATA BITS: 8
   h. Select STOP BITS: 1
   i. Select PARITY: NONE
   j. Select ENABLE?: YES
5. To program the next modem preset, press Up arrow, select modem preset name and repeat steps a - j. For Brigade operations all nets will use the SERIAL MODEM at the highest data rate and shortest interleave possible for the conditions. Changes will be made on order of the S-6. Use of other MODEMS will only occur when operating with other forces not equipped with serial tone MODEMS.

<u>**AUTOMATIC LINK ESTABLISHMENT PROGRAMMING**</u> See SOI/OPLAN for programming data.

1 . CHANNEL GROUP PROGRAMMING
   a. Press **PGM**
   b. Select **MODE**
   c. Select **ALE**
   d. Select **CHAN GROUP**
   e. Select **ADD** CHANNEL **GROUP**
   f Enter desired CHANNEL **GROUP NUMBER**
   g. Select **ADD CHANNEL**
   h. Enter desired **CHANNELS** for channel group
   i. To modify, review, or delete channel groups, at step **e** select **REVIEW** or **DELETE** then use the Up/Down arrow keys to view options for each selection.
2. SELF ADDRESS PROGRAMMING
   a. Press **PGM**
   h. Select **MODE**
   c. Select ALE
   d. Select **ADDRESS**
   e. Select **SELF**
   f Select **ADD!** NOTE: **You** *must* **enter a 3 character Self Address or ALE will not function. Example: 123 must be entered first then any address containing from 1-15 characters, numbers or a combination can be entered.**
   g. Enter your own **SELF ADDRESS** (e.g. RAD1).
   h. Enter **CHANNEL GROUP** to associate with this address
   i. To review or delete Self Addresses, at step **f** select REVIEW or DELETE. See unit SOI for self-address and channel group input data.
3. INDIVIDUAL ADDRESS PROGRAMMING
   a. Press PGM
   b. Select MODE
   c. Select ALE
   d. Select **ADDRESS**
   e. Select INDIVIDUAL by pressing **Up** arrow

f. Select **ADD**
g. Enter an **INDIVIDUAL ADDRESS** (e.g. @2).
h. Enter **CHANNEL GROUP** to associate with this address
i. Select correct **ASSOCIATED SELF** (e.g. RT I) by pressing Up cursor.
j. Repeat (e - i) for remaining **INDIVIDUAL ADDRESS(es).**

k. To review or delete Individual Addresses, at step **f,** select **REVIEW** or **DELETE.**

4. NET ADDRESS PROGRAMMING
   a. Press **PGM**
   h. Select **MODE**

   c. Select **ALE**
   d. Select **ADDRESS**
   e. Select **NET** by pressing **Up** arrow
   f Select **ADD**
   g. Enter an **NET ADDRESS** (e.g. RTO)
   h. Enter **CHANNEL GROUP** to associate with this address
   i. Select appropriate **ASSOCIATED SELF** (e.g. RAD I)
   j. **ADD NET MEMBERS** (Ensure all net members are programmed in the **same order** on all radios used)

   k. To review or delete Net Addresses, at step **f,** select **REVIEW** or **DELETE.**

5. ALE CONFIGURATION PROGRAMMING
   a. Press **PGM**
   b. Select **MODE**
   c. Select **ALE**
   d. Select **CONFIG**
   e. Max Scan Channels **Note: This is a critical parameter. It must be set to the number of channels that have been programmed into the channel group to be scanned**
   f. Listen Before TX **(OFF,** ON)
   g. Key To Call **(OFF,** ON)

   h. Max System Tune Time **Note: This is a critical parameter. It must be set to the worstcase tune time for any radio in the network.** If time is unknown start with 20 seconds as system tune time.
   i. Link Timeout **(OFF,** ON)

   j. Link To Any Calls **(OFF,** ON) when a station transmits the address ANY, any ALEcapable radio that receives the transmission will stop scanning and automatically respond to the call.

   k. Link To All Calls **(OFF,** ON) when a station transmits the address ALL, any ALE-capable radio will stop scanning, but will not respond (transmit).
   1. AMD Operation **(ENABLED,** DISABLED)
   m. AMD Auto Display **(ENABLED,** DISABLED)
   n. Scan Rate **(ASYNC,** 2, 5)

6. LQA EXCHANGE PROGRAMMING
   a. Press **PGM**
   b. Select **MODE**
   c. Select **ALE**
   d. Select **LQA type (EXCHANGE,** SOUND)
   e. Select **ADD**
   Select INDIVIDUAL **or** NET as desired

g. Select desired addresses)

h. Select the desired **START** TIME

i. Select the desired **REPEAT INTERVAL** Under normal operating conditions LQA interval will be every 30 minutes. Changes will be on order of the S-6

7. LQA SOUND PROGRAMMING
   a. Press **PGM**
   b. Select **MODE**
   c. Select **ALE**
   d. Select **LQA**
   e. **Select LQA type** (EXCHANGE, **SOUND)**
   f Select **ADD**
   g. Select **SELF ADDRESS** to be used
   j. Select the desired **START TIME**
   k. Select the desired **REPEAT INTERVAL**

8. AMD CREATE (TX MSG)
   a. Press **PGM**
   b. Select **MODE**
   c. Select **ALE**
   d. Select **AMD**
   e. **Select TX-MSG**
   Select **TX-MSG (EDIT,** REVIEW, DELETE)
   g. Press **ENTER** twice
   h. Enter message using **KEYPAD**
   i. Press **ENTER** to save
   j. Press **CLR** to escape

9. AMD REVIEW/DELETE (RX MSG)
   a. Press **PGM**
   b. Select **MODE**
   c. Select ALE
   d. Select **AMD**
   e. **Select RX-MSG**
   f Select **RX - MSG (REVIEW, DELETE, COPY)**
   g. Press **ENTER**

<u>HOP PROGRAMMING NARROW BAND/WIDEBAND/LIST HOPPING</u>

1 NARROWBAND HOP PROGRAMMING
   a. Press **PGM**
   b. **Select MODE**
   c. Select **HOP**
   d. Select **CHANNEL**
   e. Select **ADD**
   f Enter channel to be added (must be in the range 00- 1 9)
   g. Hop Type, select **(NARROW,** WIDE, LIST)
   h. Enter **CENTER FREQ** in MHz
   i. Press numeric keys to enter a 1 - 8 digit **HOP CHANNEL ID**
   j. Press alphanumeric keys to enter up to 8 character **TOD MASK**
   k. Auto respond (YES, **NO)**

2. WIDEBAND HOP PROGRAMMING
   a. Press **PGM**
   b. Select **MODE**
   c. Select **HOP**
   d. Select **CHANNEL**
   e. Select **ADD**
   f. Enter channel to be added (must be in the range 00-19)

g. Hop Type, select WIDE
h. Press numeric keys to enter LOWER FR.EQ'in MHz
i. Press numeric keys to enter UPPER FREQ in MHz
j. Press numeric keys to enter a I - 8 digit HOP CHANNEL ID
k. Press alphanumeric keys to enter up to 8 character TOD MASK
1. Auto respond (YES, NO)

3. LIST HOP PROGRAMMING
a. Press **PGM**
h. Select **MODE**
C. Select **HOP**
d. Select **CHANNEL**
e. Select **ADD**
f Enter channel to be added (must be in the range 00- 1 9)
g. Hop Type, select **LIST**
h. Select **ADD** List Members
i. Press numeric keys to enter frequencies in MHz. Must enter 5 frequencies minimum, 50 frequencies maximum between 2 and 29.000MHz.
Press **CLR** to exit Add Freq List menu.
k. Select **NO** to exit Add List Members menu
1. Press numeric keys for 1 - 8 digit **HOP CHANNEL ID**
M. Press alphanumeric keys to enter up to 8 character **TOD MASK**
n. Auto respond (YES, **NO**)

4. HOP EXCLUSION BAND PROGRAMMING
a. Press **PGM**
b. Select **MODE**
c. Select **HOP**
d. Select **EXCLUDE**
e. Select **ADD** Exclude Band
Press numeric keys to enter the Exclude Band Number from 0 - 9
g. Press numeric keys to enter the Lower Freq
h. Press numeric keys to enter the Upper Freq

5. HOP CONFIGURATION PROGRAMMING
a. Press **PGM**
b. Select **MODE**
c. Select **HOP**
d. Select **CONFIG** Use the Up/Down arrow keys to view available selections (shown in parenthesis with the default in bold) for each of the following:
Manual Sync (**YES**, NO)
- Hail RX (**YES**, NO)

<u>SYSTEM PRESET PROGRAMMING</u>

1 . FIX MODE SYSTEM PRESET
a. Press **PGM**
h. Select **MODE**
c. Select **PRESET**
d. Select **SYSTEM**
e. System Preset To Change (On a zeroized radio, system presets are given default names of **SYSPREI** to **SYSPRE75**) Use the Up/Down arrow keys to select the preset to chan,--,,@
Preset Name (Press the alphanumeric keys to enter a name up to 9 characters in length)
g. Radio Mode (Select **FIX**)

h. Channel Number (Enter the channel number to associate with the preset)

i. Modem Preset **(OFF** or use the Up/Down arrow keys to enter a preconfigured Modem preset)
j. Select **Encryption TYPE** (TYPE I, CITADEL, NONE)
k. Select **Crypto MODE** (e.g. KG-84R)
1. Select **Encryption KEY** (e.g. TEKO I)
m. Select **PT VOICE MODE** (CLR, CVSD, AVS, DV6, DV24)
n. Select **CC/CT VOICE MODE** (DV24, NONE, DV6)
o. Select **ENABLE** (YES, NO)

2. HOP MODE SYSTEM PRESET
   a. Press **PGM**
   b. Select **MODE**
   c. Select **PRESET**
   d. Select **SYSTEM**
   e. System Preset To Change (On a zeroized radio, system presets are given default names of **SYSPREI** to **SYSPRE75)** Use the Up/Down arrow keys to select the preset to change
   f. Preset Name (Press the alphanumeric keys to enter a name up to 9 characters in length)
   g. Radio Mode (Select **HOP)**
   h. HOP Channel (Select HOP Channel to associate with this preset)
   i. Modem Preset **(OFF** or use the Up/Down arrow keys to enter a preconfigured Modem preset)
   j. Select **Encryption TYPE** (TYPE I, CITADEL, NONE)
   k. Select **Crypto MODE** (e.g. KG-84R)
   1. Select **Encryption KEY** (e.g. TEKOI)
   m. Select **PT VOICE MODE** (CLR, DV6)
   n. Select **CC/CT VOICE MODE** (DV6)
   o. Select **ENABLE** (YES, NO)

3. ALE MODE SYSTEM PRESET
   a. Press **PGM**
   h. Select **MODE**

   c. Select **PRESET**
   d. Select **SYSTEM**
   e. System Preset To Change (On a zeroized radio, system presets are given default names of **SYSPRF,L** to **SYSPRE75)** Use the Up/Down arrow keys to select the preset to change
   Preset Name (Press the alphanumeric keys to enter a name up to 9 characters in length)
   g. Radio Mode (Select **ALE)**
   h. Associated Self (Select **Self Address** to associate with this preset)
   i. **Modem** Preset **(OFF** or use the Up/Down **arrow** keys to enter a preconfigured Modem preset)
   j. Select **Encryption TYPE** (TYPE I, CITADEL, NONE)
   k. Select **Crypto MODE** (e.g. KG-84R)
   1. Select **Encryption KEY** (e.g. TEK01)
   m. Select **PT VOICE MODE** (CLR, AVS, DV6, DV24)
   n. Select **CC/CT VOICE MODE** (DV24, NONE, DV6)

   o. Select **ENABLE** (YES, NO)

RADIO OPERATIONS

SELECTING **RADIO MODE**

1. FIX MODE Press MODE (#3) button on KDU until FIX is displayed and press ENT or wait and the radio will automatically enter FIX mode.
2. ALE MODE Press MODE (#3) button on KDU until ALE is displayed and press ENT or wait and the radio will automatically enter ALE mode.
3. HOP MODE Press MODE (#3) button on KDU until HOP is displayed and press ENT or wait and the radio will automatically enter HOP mode.

PLAIN/CIPHER TEXT (PT/CC/CT) OPERATION ROTATE fimction switch to desired position.

SETTING RADIO OPTIONS The Option menu is selected by pressing the OPT button on the **KDU while in FIX, A-LE, or HOP mode. The Option menu is mode specific. The following options are common to all modes of operation.**

I . GPS-TOD N/A.

2. RETLTNE when selected will retune currently selected channel. Will not retune while scanning.

3. RADIO OPTIONS Options **are global and affect the entire range of channels and presets in use.**
   a. Press **OPT**
   b. Select **RADIO**
   c. TX Power (LOW, MED, HIGH)
   d. BFO (+/- 4kHz in IO Hz steps)
   e. Squelch Level (LOW, MED, HIGH)
   f. FM Squelch Type (TONE, NOISE)
   g. Radio Silence (ON, **OFF)**
   h. Internal Coupler **(ENABLED,** BYPASSED)
   i. RX Noise Blanking **(OFF,** ON)
   j. Radio Self ID

4. SCAN OPTIONS
   a. Press **OPT**
   b. Select **SCAN**
   c. Enable SSB scan **(NO,** YES)

5. TEST multiple tests can be performed without test equipment by using this feature. Refer to the operator's manual for a detailed description of each test available.

NOTE: The following options are mode specific and are only available if the feature is installed in the radio and it is the current operating mode.

6. ALE OPTIONS
   a. Press **OPT**

h. Select **AJE**

c. Select **LQA**

d. EXCH or SOUND Use **EXCHANGE to perform a two-way link analysis between your radio and another radio or group of radios on all pre-programmed frequencies. Use SOUND as a passive, one-way transmission, from your radio to another radio or group of radios.**

e. Scores select an individual or net name and scroll through the channels and available scores.
f. TX-MSG Used to transmit pre-entered AMD messages.
9- RX-MSG Used to review received AMD messages.

2. HOP OPTIONS, Same as ALE options

ALE OPERATIONS

1. ALE Scan Operation
   a. Radio will begin scanning when ALE mode is selected.
   b. To stop scanning press **CLR**. To resume scanning press **CLR** again.
2. Placing an ALE call.
   a. Press **CALL** key
   b. Select CALL TYPE (MANUAL or AUTOMATIC) Manual call allows you to select a specific channel to call on and automatic will start calling on the channel with the highest LQA score.
   C. Select ADDRESS TYPE (INDIVIDUAL, NET, ANY, ALL)

3. Terminating an ALE Link. To terminate an ALE link press **CLR** button. The radio will display

"TERMINATE LINK". Scroll to YES and press **ENT**.

HOP OPERATIONS

1. HOP Operation
   a. Press **MODE** button to select HOP.
   b. Press **PRE** button to select desired HOP preset.
2. Manual Sync.
   C. Press **CALL** key
   d. Manual SYNC type (REQUEST, **BROADCAST**)

   NOTE: The easiest form of sync is broadcast. Only I station in the net should perform the broadcast, which will sync the entire listening stations. If your station does not receive a sync, you must send a Sync Request by selecting **REQUEST** and pressing **ENT**.

COMSEC LOADING CYZ10

1. PRESS **ON** TO ACTIVATE CYZIO (**ANCD**)
2. PRESS MAIN MENU KEY UNTIL **RADIO** IS OBSERVED
3. PRESS **LTR LOCK** TO OFF AND PRESS ARROW KEY TO SELECT **RADIO** THEN **ENTER**
4. SELECT **COMSEC** THEN **N <ENTER>**
5. SELECT **LD** THEN **<ENTER>**
6. SELECT **TEK** THEN **<ENTER>**
7. USE **PG UP** TO SELECT KEY AND THEN **<ENTER>**
8. CHOOSE **QUIT** THEN **<ENTER>**

9. CONNECT CYZIO TO RADIO **(Jl8)** THEN PRESS **DOWN** ARROW KEY
10. TURN MODE SWITCH TO **LD** ON RADIO
I 1. SELECT FILL DEVICE - **KYK-13** THEN **<ENTER>**
12. SELECT CRYPTO TYPES AND PRESS **<ENTER>**
13. SELECT KEY TYPE - **TEK**
14. ENTER KEY NUMBER (**1-25**)
15. PRESS <**ENT**> ON RADIO TO INITIATE FILL
16. PRESS **CLR** TO SELECT NEW CRYPTO TYPE
17. REPEAT STEPS 12 - 15 FOR ADDITIONAL FILLS
18. MOVE SWITCH OUT OF LD POSITION.
19. DISCONNECT CYZ IO

NOTE: YOU CAN LOAD 25 KEYS INTO EACH COMSEC TYPE FILL POSITION.

Radio Programming Application (RPA). The RPA is a computer program that runs on any PC or laptop machine using the Windows NT operating system version Win 98/NT or later. Hardware requirements are modest and only require 64 MB of RAM and a speed of 200 Mhz. The program is used to create radio plan(s) to support operations and load them into the AN/PRC-150 hardware. Multiple plans can be stored to handle future operations and contingencies. The RPA will provide the following functions:

1- Define radio channels, frequencies, and ALE addresses
2- Program radios through the serial port
3- Store multiple communications plans
4- Set up hopping nets
5- Generate red keys and programming
6- Generate reports

RPA operation is defined below. Refer to RPA manual for a detailed explanation of the ftmctions shown.

SELECT PLAN INFO TAB

A. ENTER NAME OF AUTHOR
B. ENTER DESCRIPTION

SELECT CHANNELS TAB

A. DEFINE CHANNELS
B. PRESS DOWN ARROW AND SELECT DESIRED CHANNELS

NOTE: DO NOT USE CHANNEL 000 (SCRATCHPAD)

C. SELECT DEFINE BUTTON
D. ENTER RX FRERQ
E. PRESS DOWN ARROW AND SELECT MODULATION TYPE(USB)
F. CHECK ENABLE HAILS AND ENTER A HAIL KEY (00-99) IF THIS WILL BE USED AS A HOPPING HAIL CHANNEL.
G. REPEAT STEPS A-F FOR ADDITIONAL CHANNELS.

SELECT CHANNEL GROUP TAB

A. PRESS DOWN ARROW AND SELECT DESIRED CHANNEL GROUP
B. SELECT DEFINE BUTTON
C. HIGHLIGHT CHANNEL GROUP MEMBER AND SELCECT ADD BUTTON

D. REPEAT STEPS A-C FOR ALL CHANNEL GROUP MEMBERS

NOTE: CHANNEL GROUP SHOULD BE LIMITED TO A MAXIMUM OF 10 CHANNEL GROUP MEMBERS

SELECT STATIONS TAB

A. ENTER STATION MANE (USED FOR CLARIFICATION)

B. SELECT DEFINE BUTTON

C. ENTER RANDOM 3 NUMBER DUMMY SELF ADDRESS

D. PRESS DOWN ARROW AND SELECT DESIRED CHANNEL GROUP
E. SELECT ADD
F. ENTER OPERATIONAL SELF ADDRESS (THIS ADDRESS IS NOT SECURE)
G. SELECT ADD
H. REPEAT STEPS F -G FOR ALL REMAINING STATIONS IN THE COMM PLAN

SELECT ALE NETWORKS TAB

A. ENTER NET ADDRESS
B. SELECT CHANNEL GROUP
C. SELECT DEFINE BUTTON
D. SELECT THE '+'BOX UNDER MEMBER STATIONS
E. SELECT THE OPERATIONAL SELF ADDRESS OF MEMBER STION
F. SELECT ADD TO BUILD NET MEMBERSHIP
G. REPEAT STEPS A-F TO ADD ADDITIONAL NET MEBERS

RADIO CONFIGURATION SETTINGS

A. SELECT RADIO FROM THE TITLE BAR
B. SELECT CONFIGURATION FROM THE DROP DOWN LIST
C. SELECT STATION TAB

1. SELECT DESIRED POWER LEVEL (LOW,MED,HIGH)
2. ENABLE SQUELCH IF DESIRED
3. SELECT FM SQUELCH TYPE (TONE,NOISE)
4. SELECT (SAVE AS DEFAULT) BUTTONR
5. SELECT EACH STATION NAME FORM DROP DOWN LIST AND SELECT RESET DEFAULTS BUTTON TO SETUP ALL STATIONS WITH IDENTICAL PARAMETERS.

D. SELECT ALE TAB

1 .UNCHECK LINK TO ALL CALLS
2. UNCHECK LINK TO ANY CALLS
3. CHECK LISTEN BEFORE TRANSMIT
4. SELECT SYNC RATE (ASYNC)
5. SELECT MAX TUNE TIME (2)
6. SELECT LINK TIMEOUT (5 MINUTES)
7. CHECK AMD OPERATION (90 CHARACTER NON-SECURE
8. CHECK AMD AUTO DISPLAY
9. SELECT SAVE AS DEFAULT BUTTON
10. SELECT EACH STATION NAME AND SELECT RESET DEFAULTS
11. SELECT OK

RADIO HOP NET SETTINGS

A. SELECT RADIO FROM THE TITLE BAR
B. SELECT HOP NETS FROM THE DROP DOWN LIST
C. 5900H TAB

1 . SELECT NET NUMBER (1-19)
2. SELECT DEFINE
3. ENTER NET NAME
4. SELECT NARROW BAND
5. ENTER CENTER FREQUENCY
6. ENTER TOD MASK (RANDOM 8 ALPHANUMERIC CHARACTERS)
7. ENTER ADDRESS FOR DESIRED STATION TO AUTO RESPOND TO SYNC (NORMALLY NET CONTROL STATION)
8. REPEAT STEPS FOR ADDITIONAL HOP NETS
9. SELECT OK

RADIO PRESETS

A. SELECT MODEM PRESET TAB

1 . ENTER PRESET NUMBER (1-20)
2. SELECT DEFINE BUTTON
3. ENTER MODEM PRESET NAME ((ie. SE24) SERIAL TONE 24OOBPS)
4. SELECT INTERLEAVING (LONG)
5. SELECT MODE (SYNC)
6. SELECT DATA RATE

NOTE: FOR HARRIS TACCHAT APPLICATION, SELECT MODE TYPE OF ARQ. THIS MODEM WILL AUTO BAUD BASED ON SNR DATA.

B. SELECT SYSTEM PRESET TAB

1 . ENTER PRESET NUMBER (1-75)
2. SELECT DEFINE
3. ENTER PRESET NAME
4. SELECT RADIO MODE (FIX,ALE,HOP)
5. SELECT ENCRYPTION TYPE (TYPE 1)
6. SELECT MODEM PRESET TO BE USED WITH THIS SYSTEM PRESET

NOTE: ONLY ACTIVE WHEN DATA DEVICE IS CONNECTED

7. SELECT DIGITAL VOICE FOR CT (DV6)
8. SELECT DIGITAL VOICE FOR PT (DV6)
9. SELECT CHANNEL NUMBER TO ASSIGN FOR FIX MODE, HOP NET FOR HOP MODE.
10. SELECT CRYPTO MODE (KG84R) FOR APPLICATIONS USING THE ARQ MODEM)
11. SELECT ENCRYPTION KEY TO ASIGN TO PRESET
12. APPLY TO DESIRED NET

RADIO VALIDATION

A. SELECT VALIDATION BUTTON

RADIO PROGRAM

B. CONNECT 10535-0775-AOO6 CABLE TO THE J3 CONNECTOR OF THE RADIO AND TO COMM PORT 1 OF THE PC

C. SELECT RADIO PROGRAM

D. SELECT STATION NAME FROM THE DROP DOWN LIST OF RADIOS TO BE PROGRAMMED

E. CHECK THE BOX TO SET RADIO TOD OF ALL RADIOS FROM THE SAME PC

F. ENSURE RADIO IS ON AND IN PT MODE AND SELECT PROGRAM BUTTON

G. SELECT YES

H. REPEAT STEPS A-F FOR ALL RADIOS IN RADIO NET OR SAVE FILE TO DISK AND SUPPLY TO OTHER STATIONS WITH RPA VERSION 3.2.2 TO PERFORM PROGRAMMING FUNCTIONS.

I. SELECT SAVE AND FILE CLOSE WHEN PROGRAMMING COMPLETE.