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RESEARCH AND DEVELOPMENT TECHNICAL REPORT
CORADCOM-D0824-EAM-1383

HF Radio Communication System Design Assessment

Contract No. DAAK80-79-C-0824

Rockwell International Corporation
Collins Communications Systems Division
1200 North Alma Road
Richardson, Texas 75081

1 May 1980

Technical Task Report 3.2a - Evaluation of Present HF Equipment

Prepared for:
CORADCOM
US ARMY COMMUNICATIONS RESEARCH & DEVELOPMENT COMMAND
FORT MONMOUTH, NEW JERSEY 07703

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
Task Report 3.2a

2. GOVT ACCESSION NO.
AD-B053 115L

3. RECIPIENT'S CATALOG NUMBER
(9)

4. TITLE (and Subtitle)
(6) HF Radio Communications System Design Assessment. Technical Task Report 3.2a. Evaluation of Present HF Equipment,

5. TYPE OF REPORT & PERIOD COVERED
Technical Report, 1 October 1979 — 1 May 1980

6. PERFORMING ORG. REPORT NUMBER
(19) D0824-EAM-1383

7. AUTHOR(s)
(10) Calvin H./Cerva

8. CONTRACT OR GRANT NUMBER(s)
(18) CORADCOM
(15) DAAK80-79-C-0824

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Rockwell International
Collins Communications Systems Division
1200 North Alma Road
Richardson, Texas 75081

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
(12) 206

11. CONTROLLING OFFICE NAME AND ADDRESS
W15R3J
CENCOMS
Fort Monmouth, N.J. 07703 Attn: DRDCO-COM-RN-3

12. REPORT DATE
(11) 1 May 1980

13. NUMBER OF PAGES
211

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
DCASMA-Dallas, DCRT-GDCH
500 S. Ervay Street
Dallas, Texas 75201
Attn: Mr. John Yarbrough, ACO

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
TVE 10 DEC 1980
Distribution limited to U.S. Government Agencies Only. Other request for this document must be referred to CORADCOM (see block 11).

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)
Not approved for public release

18. SUPPLEMENTARY NOTES
N/A

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
High Frequency Communications (HF)
Evaluation of Present HF Equipments
Army, Navy, Air Force and Marine Corp
Tactical and Strategic

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This report has been prepared in accordance with paragraph 3.2a, contract DAAK80-79-C-0824. It provides an evaluation of present HF radio equipment applicable to Army tactical and strategic requirements.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

412082 LB

Technical Task Report 3.2a

Evaluation of Present HF Equipment

HF RADIO COMMUNICATIONS SYSTEM
DESIGN ASSESSMENT
STUDY

For:

UNITED STATES ARMY

COMMUNICATIONS RESEARCH AND DEVELOPMENT COMMAND

FT. MONMOUTH, NEW JERSEY

Contract No. DAAK80-79-C-0824

1 May 1980

Prepared by:

Rockwell International Corporation

Collins Communications Systems Division

1200 North Alma Road

Richardson, Texas 75081

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EXECUTIVE SUMMARY

HF equipment and system design have been largely ignored by the U. S. Army during the past ten years. This was in anticipation of achieving sufficient and effective communication via use of other frequencies and media. It is now apparent that HF is a more viable and useful tool than previously thought and deserves a role in the U. S. Army's communications system. The problem of now re-instituting HF as an integral part of U. S. Army communications is approached in this CORADCOM study as follows:

a. Determine the usefulness of present assets.

b. Determine what are the available and applicable existing equipments that may be used to augment or replace existing assets in the near-term (1980 - 1985). These equipments having been largely developed by industry for other military and commercial users.

c. Define technologies and developing equipments that meet U. S. Army post 1985 requirements in coping with "real life" environment.

d. Investigate specific areas for exploratory research and development for future application.

Efforts under this task are directed toward (a) above in which the final results determine the usefulness of present operational HF equipments.

In the evaluation of present operational HF equipment, site surveys were conducted, technical characteristics were compiled, equipment assessment reports were reviewed and conferences were held with military and civilian personnel in the various Army Commands. The objectives were to determine:

a. The status of present HF equipments.

b. Performance deficiencies.

c. Major problem areas.

d. Possible corrective actions that could be taken to extend the operating life of the equipments.

As the report will show:

(1) The design of existing HF radios is old and the equipments have reached a point where they are becoming difficult to logistically support.

(2) There is no one area where modification efforts can be expended that would provide a significant improvement in performance over the next four to five years.

(3) Designs of existing HF radios will meet the Army operational readiness requirment of 0.82, but the reliability and maintainability of the radios is not adquate to meet the latest communications availability requirement of 0.98.

(4) Operator and repairmen training methodologies should be evaluated and more basic operational and system maintenance theory should be included.

(5) The present equipments lack anti-jam, electronic counter countermeasures, and electromagnetic pulse protection against postulated threats.

(6) Frequency assignment methodologies and plans must be formulated to enhance operational performance and RFI/EMI reduction through the proper and more efficient assignment of frequencies.

(7) Technical Manuals and Operational Manuals for the equipments should be reviewed and the manuals should be prepared at a language level that is understood by present operators.

After review of the operational capabilities and status of present HF equipments, this report recommends that the Army develop HF radio requirements to meet the HF communications needs described in the INTACS Update as well as the strategic communications needs being developed by the Army Communications Command. Procurement actions should be initiated to provide the Army with HF equipments with adequate reliability and maintainability to meet the required communications availability.

Design attention should be focused on equipment which is tactically supportable in a real life environment. Training courses should re-incorporate study of HF propagation.

SECTION 1 - OVERVIEW

1.0 INTRODUCTION

This report is an analysis and assessment of operational military HF communication equipments. The report has been prepared in accordance with CORADCOM Technical Requirements entitled, "HF Radio Communications System Design Assessment". Paragraph 3.2a of the technical requirement calls for the evaluation of present HF equipment.

The overall investigation is intended to form the basis for a continuing research and development program to provide the Army with an adaptive, reliable, secure A/J means for long and short haul tactical and strategic HF communications in the 1985 time period.

To assess the status of operational HF equipments, a literature survey was conducted to identify the present equipments. This survey consisted of review of market surveys, technical manuals, advertisement brochures and company data sheets. In addition to the literature survey, military departments were visited for briefing by persons cognizant of production contract and equipment deployed. Appendix A delineates a listing of identified HF equipments by service (Army, Navy, Air Force, and Marines).

The more difficult task was the analysis and assessment of the status of HF equipments operational in the Army today. Interviews were conducted with personnel in the various service, material and development commands responsible for evaluation, procurement, system development, system maintenance and performance assessment, as well as logistics support personnel. It was rather easy to obtain subjective critique of the Army's present HF operational posture, but it was difficult to obtain substantiating documentation or analysis to show the reliability, maintainability, availability and operational ability of present equipments. The data on present equipment contained in technical manuals, operator manuals, data sheets, and brochures do not truly reveal the field operational posture. Investigation of any specific HF radio set did not reveal a predominate failure mode or reason for failure.

The headquarters, U. S. Army Signal Center, Ft. Gordon, Ga. provided a briefing on the Integrated Tactical Communication Systems (INTACS) HF update and the methodology used to reach their conclusions or recommendations for the Tactical

Communications user. The formulation, contents, and use of the Communications System Requirements (COMSR) Data Base in supporting the evaluation of communication needs was explained.

At the U. S. Army communications Command (USACC) in Ft. Huachuca, Arizona, a briefing on the status of the Army Strategic Communication requirements was provided plus some insight into the system architecture they were synthesizing to meet the needs for Camps, Posts and Stations, Nuclear Weapon Support (NWS), Defense Communications System (DCS) Interface, Military Assistance and Advisory Groups (MAAG), Military Affiliate Radio System (MARS) and Echelons Above Corps (EAC). The personnel of USACC also provide a critique of present HF equipments and operational deficiencies.

Visits to the Army and Navy MARS Directors and Stations provided insight into how the MARS networks were organized, the equipment that is presently used by the MARS stations, interoperability of MARS stations and planned improvements in the MARS networks as well as how these networks would be utilized in periods of crisis and conflict.

At Fort Ord, California, a first-hand observation of HF radio operation and repair at the Direct Support (DS) and General Support (GS) shops was provided by DARCOM Logistics Assistance Office (LAO). The LAO provided a critique of Army HF field equipment as well as maintenance and operating problems.

The visit to Sacramento Army Depot (SAD), in Sacramento, Ca., provided insight into how the Army is correcting major system design deficiencies through modification, the condition of equipments received from field, as well as the major problems of logistically supporting the equipments. The depot people as well as the Army Communications Electronics Engineering Installation Agency (CEEIA) provided critiques and data on HF equipment designs that induce failure, unreliable operation and reduce availability.

The CERCOM Product Assurance Directorate, Systems Performance Assessment Division provided assessment of HF radio set problems and evaluation of the equipments performance status. The U. S. Army Material Systems Analysis Activity (AMSAA) at Aberdeen Proving Ground, Maryland provided copies of field reports on HF radio equipment defects found in field visits. These defects are published in the R&D Field Liaison Program Digest that are published semi-annually.

The USACC Quality Assurance and Testing Detachment from Ft. Huachuca, Az., conducted an evaluation of the Cemetery HF radio network in Meyn, Soegel and Keeringhausen, Germany. The analysis of these equipments were provided as inputs. The main purpose of this exercise was to improve the operation of Cemetery Net HF Communications.

From the various visits, discussions, and reports, various opinions were obtained on the status, performance, reliability, and effective availability of HF communication. In addition, constructive critique was provided on measures that should be taken to improve HF communications performance. In general, it is felt that HF communications is a viable asset to the highly mobile tactical Army and provides a necessary emergency communication asset in strategic communication for crisis, conflict and contingency operation.

SECTION 2 - UNDERSTANDING THE PROBLEM

2.1 BACKGROUND - In 1976, the Integrated Tactical Communication Systems (INTACS) Plan virtually eliminated HF communication in all aspects from the Army. This plan significantly altered the Army's Tactical Communication System. The INTACS was based on a nodal architecture using VHF line-of-sight, satellite (single and multichannel), Multiple Subscriber Access (MSA), and TRITAC to provide communication from below battalion through the theater Army. INTACS was based on a specific force/scenario for a medium intensity NATO war at 0 plus 90 days. An update in the Communication Support Reqirements (COMSR) and change to a SCORES Europe III Scenario required a re-evaluation of INTACS. INTACS update Vol I and II March 1979, analyzes the force/scenario changes and modifies the Army's communication needs that were presented in the INTACS Plan.

2.2 KEY COMMUNICATION REQUIREMENTS

Intelligence/Electronic Warfare, Air Defense Artillery (ADA), Field Artillery (FA), Air Ground (AG), Logistics and Administrative Systems users expressed key communication requirements critical to the performance of their function during seminars conducted to re-evaluate INTAC. The following summarizes the communication needs:

a. There is a need for positive, reliable and available communications.

b. Alternate means are required to enhance availability and minimize vulnerability.

c. Mobility - Requirement for zero or fast set-up/tear down time or operation on the move.

d. Extended Ranges - Distance beyond the line-of-sight (LOS).

e. High Data Volume - Large amount that taxes common user systems.

f. High Speed Data Rates - greater than 32 kbps.

g. Non-Standard Data Rates - other than 75 x 2^N.

h. Responsiveness and Timeliness - real time or near real time.

i. Wide Distribution - simultaneous multiple receipients of a message.

Table 2.1 summarizes key communications requirements for battlefield automated data systems.

TABLE 2.1 SUMMARY BATTLEFIELD AUTOMATED DATA SYSTEMS

KEY REQUIREMENT	INTEL/EW	FIELD/ARTY	ADA	COMMAND/ CONTROL	ADMIN/LOG
HIGH MOBILITY	X	X	X		
EXTENDED RANGE	X		X		
HIGH VOLUME	X	X	X		Y
HIGH SPEED	X				
NONSTAND RATES	X				
FAST SOS	X	X	X	X	
WIDE DISTRIBUTION	X	X	X	X	

2.3 MEASURE OF EFFECTIVENESS AND EVALUATION CRITERIA

Methodologies were evaluated to develop viable evaluation criteria on a measure of effectiveness for operational HF radios. Present operational HF radios are nominally fifteen to twenty years old. The operating characteristics of radios are practically equivalent when compared in common use such as manpack, vehicular, airborne and strategic.

2.3.1 PRESENT HF RADIO OPERATING CHARACTERISTICS

The following are typical operating characteristics of today's HF radios:

Frequency Range	All radios operate in the range of 1.5-30 MHz. some are limited to the lower half of the band, or less.
Channels or Tuning increment	(a) Older radios are manual continuous tuning. (b) Later models have synthesized 1 KHz tuning increments. (c) The latest models have 100 Hz synthesized tuning increments.
Modes of Operation	All radios provide some of the following modes: SSB, ISB, USB, LSB, Voice AME, CW, TTY FSK
Transmit Power (PEP)	Manpack - 15 to 30 watts Vehicular - 100 watts Mobile/Fixed - 100-400 Watts Strategic - 1000 or 10,000 watts

Input Voltage	Manpack - Battery or 28V DC
	Vehicular - 28 V DC
	Mobile/Fixed 28V DC /110V AC, 50-400 Hz
	Strategic - 120/208V AC, 50-400 Hz
Tuning Time	6 Seconds
Security Devices	TSEC/KW-7 TTY only
Anti-Jam/ECCM	None
Nuclear/EMP Protection	None
Frequency Stability	1×10^8 short term
	5×10^7 per day
	1×10^6 long term
Antennas	WHIP: For Mobile
	Doublet: For Skywave Vertical Incidence
	V: Strategic Long Haul
Receiver Sensitivities	0.5 to 3.0 microvolts for 10dB (S+N)/N
	Depends on mode
Bandwidth	SSB 3KHz
	Strategic: 4 ISB, 12 KHz
Spurious Response	> 60dB
Intermod Products	40dB below two referenced tones at the receiver or transmitter output.
Data Rates	Voice, 75 bps, 300 bps, 1200 bps
Carrier Suppression	> 42dB
Receiver Selectivity	3dB Bandwidth 2500 Hz
	60dB " 6000 Hz
Setup Time	Manpack < 5 Minutes
	Vehicular < 5 "
	Fixed/Mobile < 15 "
	Strategic 4 to 6 Hrs
Weight (Lbs)	Manpack 7.5 to 50
	Vehicular 40.0 to 300
	Mobile/Fixed 100.0 to 1800
	Strategic 3500 to 42,000

In general, operating range depends on transmit power, antenna, type of soil for groundwave and ionosphere characteristics for skywave. Unusual communication conditions at HF have been cited, but for military operations a goal is to achieve 98 percent availability for a defined communications circuit. Ground wave capabilities are somewhat predictable. If the radio is designed to operate over poor soil conditions, then it can be assumed that the worst case has been taken care of. On the other hand, skywave propagation depends on the time of day, sunspot number, and season of the year. For skywave propagation, it is always questionableas to what percentage of the 2 to 30 MHz band is available for what percentage of the time.

2.3.2 INTACS MEASURE OF EFFECTIVENESS

In evaluation of INTACS candidate systems, fourteen primary categories were developed and listed in order of weight. These categories are defined as:

CATEGORY	WEIGHT	PERCENT	RATIO
Reliability	12,642	12.9	3.31
Quality of Service	11,172	11.4	2.92
Flexibility	9,310	9.5	2.44
Operability	9,115	9.3	2.38
Maintainability	8,232	8.4	2.15
Logistics Support	7,742	7.9	2.03
Mobility	7,350	7.5	1.92
Security	5,880	6.0	1.54
Compatability	4,900	5.0	1.28
Survivability	4,410	4.5	1.15
Radio Frequency Spectrum Required	4,018	4.1	1.05
Standardization	3,822	3.9	1.00
Total Weight	98,000	100.0	

Under each of these categories are sub-categories that contribute to the total weight. Each category has a broad definition and requires careful interpretation; however, the categories and weight do define an order of precedence in evaluation of links, equipment and information rates for communication nets.

The following are definitions of the categories used in the INTACS evaluation.

Reliability	The ability of the system to have equipment available and operational when needed. 98% availability.
Maintainability	The ability to provide the necessary maintenance for the communication systems.
Logistic Support	The ability to satisfy support requirements of the communications system in terms of power source, spare equipment, and spare parts.
Mobility	The ability of the system to provide users a communications capability during movements.
Security	The ability of the system to deny the enemy the capability of deriving useful intelligence from communications transmissions.
Electromagnetic Compatibility	The ability of radio communications equipment to function in an operational environment without suffering degradation through mutual interference.
Transportability	The ease of transporting communications equipment.
Survivability	The ability of the system to function during and after destructive physical and electronic attack.
Radio Frequency Spectrum Required	The number and width of radio frequency channels required toimplement the operation of a given radio system. This number is a function of the number of nets to be formed and is also dependent upon equipment range and location of net users.
Standardization	The degree to which the communications system uses common, compatible or interchangeable equipment.

2.3.3 PRESENT OPERATONAL HF EQUIPMENTS EVALUATION

2.3.3.1 Tactical Radios

The present HF equipment is old. Designs are traceable to 1955 through 1970 time frame. Supportability in some areas is becoming questionable. Likewise, maintainability is also becoming a problem. In the past 15 to 20 years maintenance philosophy has changed and the present classes of repairmen are not able to efficiently and effectively maintain the equipment. Repair personnel capable of and with the knowledge to repair the older radios are rapidly becoming unavailable. HF radio operators are in the same category as older repairmen. The earlier designed radios require manual tuning and basic knowledge of HF performance to operate. The product of the latest school of HF radio operators do not appear to have this capability.

Present HF radio equipment, when properly maintained and operated, functions well and provides a viable mobile flexible communication capability. Predominate use is Single Sideband (SSB) voice or Radio Teletype (RATT) communication. The HF radios have little or no A/J protection. Security is provided for RATT only. Power control is not included in the design. The HF radios are highly susceptible to intercept and DF by hostile electronic support measures. This enhances the enemy's capability to locate command posts and obtain information on the movement of forces. The antenna predominately used is the whip (35 feet/10 meters). The whip provides a degree of mobility and rapid erection, but it also radiates equally well in all directions and provides high susceptibility to detection and jamming.

With proper frequency assignment, it is possible to rapidly establish a net; however, it does require experienced operators. There are no means for net control.

The HF radios will provide communication beyond the normal line-of-sight of Combat Net Radio (CNR). They provide an extended range of command and control of vehicular or special forces operations.

The receive aspects are adquate, but the adherence to a 3 kHz band increases their susceptibility to jamming. There is no means provided to reduce bandwidth to gain advantage in a jamming environment. The older radio designs do not have the squelch feature. This results in operator annoyance and somewhat degrades his efficiency.

2.3.3.2 STRATEGIC RADIOS

There are only three or four operating HF radios that can be considered viable assets for strategic communications. (AN/TSC-38B, AN/TSC-25, AN/FRC-93 and AN/TSC-20). These radios are old and the equipment is becoming obsolete. For proper maintenance and repair, the major components must be sent to a depot. The equipments require extensive test equipment. TTY equipment combiners, multiplexers, and keyers are no longer in production. Support of these equipments is becoming economically questionable. The strategic equipments have a DCS interface capability; however, the DCS has de-emphasized the use of HF and the present DCS equipment and links serve only as a backup to satellite and cable communication assets.

The gateway stations Ft. Mead, Ft. Sam Houston and the Presidio in San Francisco are not operational on a full time basis. They are in need of upgrade. A need has been expressed for a new 10 KW transmit capability that incorporates the design features of the modified AN/TSC-38B.

There is a need to establish an emergency net in CONUS for conflict, crisis, and catastrophe management. The Army MARS net can perform this function to a limited degree; however, the Army MARS consists of 84 stations with 6000 civilian participants utilizing old or makeshift equipment. It is predominately a voice network with a limited TTY capability. It should be emphasized that this net has the asset of experienced operators, "the Hams". The Army MARS has some deployable teams that can be dispersed to catastrophe scenes and provide a reliable emergency communication capability until normal communications can be established.

2.4 ARMY HF COMMUNICATIONS NEEDS

A major factor in evaluating the present operational HF equipment is the capability of the equipment to transition into future systems and meet the future requirements. The Army has a significant inventory of HF radio and associated equipments and improved HF equipments will not be operational until the post 1985 timeframe. Improvements in the operational status of the equipment in the field today must be considered for the interim.

2.4.1 STRATEGIC NEEDS AND PLANS

The strategic forces are in the process of developing or defining an HF Radio Improvement Program (HFRIP). This plan will define the nets required for DCS Entry, Nuclear Weapon Support (NWS), Camps Posts and Stations, Military AFfiliate Radio System (MARS), Military Advisory and Assistance Groups (MAAG) and Echelons Above Corp (EAC). In addition, USACC is addressing the Federal Emergency Management Agency (FEMA) requirements.

2.4.2 TACTICAL HF NEEDS

INTACS Update Volume II provides a table that shows the needs or application of HF tactical radios. Table 2-2 shows key battlefield functional areas where HF communication nets would be used for Corps and below, Division and below, and Battalion and below.

TABLE 2-2

BATTLEFIELD FUNCTIONAL AREA WHERE HF COMMUNICATION WOULD BE USED

BATTLEFIELD FUNCTIONAL AREA	CORP & BELOW	DIVISION & BELOW	BRIGADE & BELOW	BATTALION & BELOW
MANUEVER	X	X	X	X
ARTILLERY	X	X	X	X
ENGINEER	X	X	X	X
AIR DEFENSE ARTILLERY	X	X		X
INTELLIGENCE/EW	X	X		
AIR-GROUND	X	X	X	X
SIGNAL	X			
MILITARY POLICE	X			
COMMAND & CONTROL	X	X	X	X

2.4.2.1 MANUEVER - INFANTRY AND ARMOR

In the functional area of manuever, the Armored Cavalry Troops (ACT) and Armored Cavalry Squadrons (ACS) would utilize HF communication nets to provide communication on the move.

The communications requirements of the close combat manuever are characterized as:

a. Highly voice intensive (90% of the requirements).
b. Highly mobile, requiring near continuous mobility - 55% of infantry requirements, 72% of armor requirements.

c. With range requirements within the generic combat net radio capability.

d. Requiring some allied interoperability - 10% of infantry requirements, 1% of armor requirements.

e. Reliant primarily on net accessibility and to a lesser degree on discrete address - armor 90% net/1% discrete, infantry 60% net/40% discrete.

f. Having varying requirements for positioning information transfer - 70% of infantry and 25% of armor requirements are used to some degree for this purpose. Analysis showed that 40% of armor and 70% of infantry requirements could not be satisfied by any single generic system, but that these could be satisfied by the integration of voice and data.

2.4.2.2 <u>AIR DEFENSE ARTILLERY (ADA)</u>

The ADA shows HF communications needs for Short Range Air Defense (SHORAD) nets for battery, battalion, Division ADA, and Stinger Teams. High missile Air Defense (HIMAD) HF communication nets are needed for I-HAWK, Target Acquisition functions, PATRIOT, and HAWK platoons. The ADA communications requirements are characterized as:

a. Relying heavily on voice backup to data operations - 70% or greater.

b. Relatively mobile - 90% requiring four moves per day or less.

c. Range requirements greater than generic combat net radio - 40% of requirements.

d. Requiring a significant degree of interoperability either with other U. S. services, allied services, or between data systems - 30% of requirements.

e. Significantly dependent on discrete (in this sense point-to-point) access capability - 40% of requirements.

f. Having a significant requirement for positioning information transfer - 40% of the requirements are used to some degree for this purpose.

The analysis further showed that approximately one-third of the requirements could not be satisfied by any single generic system.

2.4.2.3 FIELD ARTILLERY (FA)

HF communications needs have been identified for the FA target acquisitions, FA Battalion, Division Artillery (DIVARTY), Artillery Brigade, Corps Field Artillery Section (FAS) and General Support Rocket System (GSRS). The FA communications requirements are characterized as:

a. Relatively voice reliant - 50 percent of requirements.

b. Highly mobile - 75% require near continuous mobility.

c. With range requirements generally within the generic combat net radio capabilities, 10% exceed this range capability.

d. Requiring a low degree of interoperability and that only between data systems - 1% of requirement.

e. Highly reliant on both discrete and broadcast accessibility - 50% discrete addressable, 30% broadcast.

f. Having a significant requirement for positioning information transfer, particularly location information - 80% of the requirements are used to some degree to determine location. The analysis further showed that approximately 40% of the requirements could not be satisfied by any single generic system, but that these requirements could be satisfied by the integration of voice and data in an ADDS type system.

2.4.2.4 COMMAND AND CONTROL (C^2)

HF has been identified as a communication need in all battlefield functional areas from Corps to Battalion and below. C^2 communications requirements are characterized as:

a. Voice intensive - 80"of the requirements.

b. Relatively mobile - 30% move more than three times per day, none show a requirement to move more than 12 times per day.

c. With range requirements exceeding generic combat net radio - 40% of requirement.

d. Requiring a significant degree of interoperability - 40% require some interoperability of which 30% required allied interoperability.

e. Highly dependent on discrete access capability - 80% of requirements.

f. Having some requirement for positioning information transfer, particularly reporting - 5% of the requirements and used to some degree for this purpose. The analysis showed that approximately 4% could not be satisfied by any single generic system.

SECTION 3 - TECHNICAL DISCUSSIONS

3.1 HF RADIO DATA

This section of the report provides a compendium of technical and operational characteristics of all the military HF radio equipment on which data was available. Part of the data was obtained during site visits, part from technical manuals, and part of the data was obtained from equipment specifications. Data on HF equipment used by the Army, Navy, Air Force and Marine Corp are provided. In some cases, the equipments were part of a developing network or system that is evolving over a period of years and the HF equipments that are presently being used as well as the equipments that will replace it are shown. The Air Force Scope Signal Network and HF improvement program under GOR-01-78 as well as the Marine Corp Landing Force Integrated Communication System (LFICS) architecture are such programs.

During the data collection phase of this task, a major effort was expended to obtain performance assessment data on HF radio equipments in the form of failure reports regarding equipments reliability, maintainability, availability or performance in operational testing. The summary of data collected from HF radio evaluation on the AN/GRC-106, AN/GRC-122, AN/GRC-142, AN/VSC-3, AN/FRC-93, and AN/TSC-38B is presented herein. In addition a concept evaluation of an early warning system is discussed. Data obtained on HF radio problems delineated versus the Army Material Systems Analysis Activity is summarized.

Finally, instructive comments received on HF status, reliability, operability, and repairability from persons in the Army (civilian and military) that are intimately related to use of HF equipments are included. Appendix B is a compilation of the characterisitics, technical data, analysis, and assessment of HF radio.

3.2 ARMY HF RADIO EQUIPMENT

The Army HF equipments are categorized as Amplitude Modulated Single Sideband Radio Sets, Radio Teletypewriter Sets, Aviation Radio Communications Equipments. The extent of data available was the frequency range, number of channels, mode, transmit power, antenna, user, status, and weight (Reference (8)). The data that was available and presented in Appendix B-1 could only be used to provide an estimate of the numbers of different types of HF radios in existence and the various applications of HF radio communications, the communications capabilities of the radios, and the configuration of the equipment.

3.3 NAVY HF EQUIPMENTS

The Navy HF equipments are designed for surface ships, submarines, or fixed shore installation. Their equipment is somewhat more modernized. As noted, the specifications for the equipments are updated to October 1977. The specifications include the latest equipment modifications. If need be, the Navy could use the specifications for procurement without change. The Navy equipment is modularized into transmitters, receivers, and antenna couplers; hence, they have made an effort toward standardization. Using common receiver, and transmitters assures compatibility of operation. Appendix B-2 delineates the characteristics of Navy HF equipments.

3.4 AIR FORCE HF EQUIPMENTS AND PROGRAMS

The Air Force is initiating an HF improvement program to modernize their Vehicular/Transportable, Backpack Transceivers, Fixed Receivers, Fixed Transmitter, and Fixed Transceivers. Appendix B-3 provides a summary of the Air Force HF Improvement Program.

Appendix B-3 also delineates the salient features of the Air Force Scope Signal Program. The Scope Signal Network provides the Strategic Air Command (SAC) commanders positive control of globally deployed forces using HF single sideband communications. This network has a high availability (0.995), automatic link evaluation, built in test equipment to detect circuit degradation, and a 95% fault isolation down to card and module subassembly. The Scope Signal network is being implemented with off-the-shelf equipment with minimum modification to meet the user requirements.

The AF family of AN/TSC-60 HF transportable communication equipments used in the 407L Air Traffic Control System is described in detail in Appendix B-3. These equipments are tactical equipments deployed from the FEBA to as far as 1000 km back of the FEBA. The equipments use state-of-the-art HF equipment. They have digital control and equipment status analysis from the operators console. Each equipment consists of two independent radios. There are three versions of the AN/TSC-60. Depending on the version, they have a peak envelop power transmit capability of 1, 2.5 or 10 kw. The equipments are capable of USB, LSB, four channel multiplex, ISB, or compatible AM communications.

3.5 MARINE CORP HF EQUIPMENT

The Marine Corp Landing Force Integrated Communications System (LFICS) architecture calls for an extensive use of HF radios to meet their communication requirements. These communications assets will allow the Fleet Marine Force commander to exercise command and control of assigned tactical forces. The LFICS architecture will be time phased implemented from the present until the 1990 time frame.

The LFICS will provide voice and data communications services for Marine Corps Tactical Data Systems (TDS), communication centers, and individual subscribers. In addition, the LFICS will provide the interface to the DoD strategic voice and data communication nets, the Naval Telecommunication System (NTS), and other tactical communication systems needed for joint and combined operations in support of the Worldwide Military Command and Control System (WWMCCS).

The LFICS system is complex and includes a considerable number of communication equipments. Appendix B-4 provides a detailed description of HF radio equipments that are delineated in the LFICS architecture.

3.6 SUBJECTIVE CRITIQUE OF PRESENT HF COMMUNICATIONS

During facility visits and site surveys discussions were held with numerous persons who have considerable experience with HF communications. These persons have been involved with HF communications as designers, evaluators, and Hams. Also during the visits, observations were made that may represent a one-time quick look but they do provide an opinion. Appendix C provides a comprehensive summary of Army HF radio field assessments that have been conducted from 1974 to 1979.

3.6.1 ARMY COMMUNICATIONS COMMAND COMMENTS

The following comments were collected during a visit to the Army Communications Command (ACC) at Ft. Huachuca. The prime function of ACC is strategic communications.

a. In the past ten years, the Army has emphasized VHF/FM and satellites; HF has been eliminated from the Army requirements.

b. DCS has de-emphasized HF long haul communication and eliminated HF improvement funds from their budget.

c. The Army is slowly abandoning the large fixed strategic HF communications stations that provide intercontinental links and circuits.

d. The present instruction in service schools does not teach basic HF operation.

e. Present day HF systems have been automated with variable controls converted to push-buttons and push-buttons are not adjustable. A slight misalignment between HF equipment on a link render the link useless.

f. HF radio maintenance is a problem from the aspect that most HF equipment design is old and consists of discrete components and point-to-point wiring. Present day maintenance philosophy being taught is card and board replacement. Maintenance personnel trained under the present day concepts lack the knowledge to effectively trouble shoot and repair the older HF radios.

g. Present day radio operators are not being taught the basic fundamentals of HF radio operation. The experienced HF radio operators are becoming unavailable.

h. Simplicity in system design is not being stressed. Most modern HF radio designs are too sophisticated and this aggravates the maintenance problem.

The following comments are provided from a network or system operating point of view:

a. A significant improvement in HF operation could be achieved if the correct frequencies were assigned and used. The Army needs to develop an effective frequency management capability.

b. A considerable performance improvement could be realized at HF if the proper antenna were used and the sites were properly prepared with the antennas properly installed.

c. A significant HF performance would be realized if signal processing methods were developed that provide processing gain.

d. More effort in training and tactics would offer improvement to HF system performance.

e. The Army must improve the HF RFI/EMI and nuclear hardening of the HF equipments. This would improve some of the basic problems of operating in the overcrowded HF spectrum.

f. There is a need for improved secure communications for the voice networks.

3.6.2 AIR DEFENSE ARTILLERY (ADA)

The ADA expressed a need for improvement in HF equipments to provide effective communication beyond the line-of-sight. There is a need to provide an early warning capability for the short range air defense (SHORADS) teams. A data link capable of at least 1200 bits per second is needed to relay the Forward Area Alert Radar (FAAR) tracks to the ADA battalions. ECCM is needed for the SHORADS Command and Control links. Also, HF is needed to interface with NATO forces.

3.6.3. DARCOM LOGISTICS ASSISTANCE OFFICE (LAO) FT. ORD, CALIFORNIA

The comments that were received at this site visit are directed toward the AN/GRC-106 radio set. The major HF equipment used in the 7th Division is the AN/GRC-142 RATT Sets. There are 33 assigned or in use in the 7th Division.

a. There are circuit differences between different manufacturer's models of the AN/GRC-106. These differences have not been carried through in the Tech Manuals and this presents a maintenance problem for repairmen.

b. The Tech Manuals are not prepared in a language that is understandable by todays radio repairmen.

c. Operator Manuals are not prepared in a language that can be understood by the operators.

d. Army repairmen are not taught how to properly trouble shoot HF equipment. They don't have the capability to substitute test equipment.

e. Some test equipment is obsolete, outdated, and in some cases, not as accurate as the equipment it is used with.

f. Problems cannot be associated with any one component.

g. Parts supply is becoming a problem. Parts are difficult to procure and the support shops are experiencing unusual delays.

h. LAO people stated that the AN/GRC-106 design may be old but properly maintained and operated it is an effective system.

The GS and DS personnel supplied the following comments:

a. Tech Manuals are not current or accurate, and they are difficult to follow and use.

b. At any one time, possibly 30% of the HF equipment is considered effective.

c. At least 80% of the problems with the AN/GRC-142 RATT Set is operator related.

d. The TTY equipment is cited as a major problem. The TT-76 and TT-98 are old mechanical designs that are difficult to maintain.

e. The operators and repairmen are not trained in systems knowledge.

f. The repairmen are not taught the logic of trouble shooting equipment.

g. Work orders sent to the shops with the equipment very seldom define the problem. The shop people are left with trying to find the problem with equipment.

h. Assignment of operating frequencies is a problem. The frequency assignments are changed daily. The frequencies assigned are not selected from propagation charts. The person assigning frequency has a lack of knowledge of the basics in proper selection of HF frequency. In many cases, the assigned frequencies will not propagate and no action is taken to correct the situation.

i. The AN/GRC-106 modem MD-522 presents the greatest problem in repair. The repairmen and operators are not properly instructed in repair of this component.

j. There is a need for a simpler RATT system design. The design should be based on the intellectual level of soldiers that are expected to operate and maintain the system.

3.6.4 SACRAMENTO ARMY DEPOT (SAAD) COMMENTS

The following comments were provided by the SAAD Product Engineering Division and the Communications Electronics Engineering Installation Agency (CEEIA).

The comments are predominately with respect to strategic communications provided by the AN/TSC-20, AN/TSC-25, and AN/TSC-38B. Also comments are provided on the status of the AN/GRC-106. SAAD is well equipped for manufacturing, fabrication, repair, alignment, and test and evaluation of the above equipments. They maintain quality control at all stages. The persons performing assembly, alignment, and test of the equipment are competent and knowledgeable of their functions. Workmanship is excellent.

SAAD is the major repair depot for the Air Force and Army AN/TSC-38B's, the AN/TSC-25 and the AN/GRC-106 radio. In addition to total repair and maintenance of the radios and equipments, they do component repair such as card repair, tuners, synthesizers, multiplexers, combiners, power supplies, amplifiers, etc. They also have mockups to test the components after repair. Basically, an equipment or component leaving SAAD after repair is essentially new and well tested.

The following are comments provided by SAAD personnel on the AN/TSC-25, AN/TSC-38B and AN/GRC-106.

a. To improve the reliability and availability of the AN/TSC-38B, SAAD has completed a major design modification that involved basic redesign of the wiring harnesses, switches and controls, synthesizers, air conditioning equipment, cooling systems, and automatics controls.

b. The AN/TSC-38B system design is old.

c. The system is difficult to align and requires extensive test equipment not applicable to field maintenance.

d. Field maintenance and repair of the synthesizers is impossible. Replacement cost for the synthesizers is excessive.

e. Due to age, there are problems in sparing the translater, power supply, and inverter.

f. It is felt that the AN/TSC-38B is rapidly approaching the cannibalization stage.

g. Lack of provisioning is making it difficult to maintain effective turn-around times.

The following comments were provided on the AN/TSC-25:

a. The AN/TSC-25 Radio Central is of the 1955 design era.

b. The manuals for this system have been rescinded because they are out of date with the modifications that have been incorporated.

c. Work on the AN/TSC-25 requires the use of commercial manuals, depot overhaul standards, engineering installation packages, and continuation sheets.

d. The AN/TSC-25 is rapidly becoming difficult to maintain and repair.

e. Production of the RATT multiplexers, keyers, and combiners have been discontinued by Northern Radio (bought out by Harris Corp.). This is a significant part of this radio control.

f. The system is approaching the cannabilization stage due to age of components and discontinuance of production of key TTY components.

The AN/GRC-106 status, defined by SAAD Production Engineering Division

a. The radio set design is nearly twenty years old.

b. It is getting difficult to spare. Components are out of date and production.

c. Turn-around time for depot repairs are increasing due to inability to procure sufficient components.

d. In the tuning section, and final amplifier section, cannibalization has started to expedite depot repair time and an attempt to get components back to the field rapidly.

e. From the condition of components arriving at the depot, (methods of removing from the radio set and packaging for shipment) the repairmen in the field appear to be inexperienced in the maintenance and handling of the equipment. Some repairs are arriving at the depot that could have adequately been made at a DS or GS shop.

CEEIA emphasized the following with regards to Army HF equipments:

a. The strategic Army needs a new 10 KW mobile or fixed station HF Radio Central. It should have the following features:

b. Be easily transportable

c. Be of modular design

d. Be easily adjustable.

e. Allow all maintenance from the front

f. Cooling air flow should be designed to come in the top and out the bottom of the racks to improve heat removal and reduce maintenance.

g. Proper air circulation paths should be designed into the racks.

h. Plug in chassis should be used in place of flexible cables.

i. Interface complexity should be reduced by designing the complexity in the chassis or drawers.

j. Lightning protection should be provided.

k. There is a need for frequency management and methods to select the frequency to be used. Barry Research chirp sounder was suggested.

l. A more reliable modem is needed such as the Barry Research time diversity modem to improve link reliability and availability.

m. The use of 1.6 or 2 MHz as a lower required design frequency should be evaluated. Most communication at HF is done above 3 or 4 MHz. Raising the lowest HF operating frequency would significantly reduce the equipment size weight and complexity.

3.7 ANALYSIS OF HF EQUIPMENT DATA

This section provides the technical data that was collected on presently operational HF equipments. Data were collected from the Army, Navy, Air Force, and Marine Corp. It was not possible to evaluate the reliability, maintainability, operability, or availability from the data sheets. In general the only determination that could be made was that a considerable number of the radios were on the order of 15 to 25 years old.

In an attempt to determine the posture of HF radios an attempt was made to review or sample work order forms DA-2407. These forms are not kept more than 90 days. From the forms that were reviewed it was not possible to determine why the radio was sent to the shop for repair. Also, after the radio was repaired it was not possible to determine what had failed. There were hours recorded on the time spent checking the radio but not what was done.

At the Cameron Station Communications and Electronics shop there were over 4000 DA-2407 forms with the HF radio data mixed in. The DS, GS, or electronic shops do not send the failure or maintenance data to any central record file.

From time to time the Army has conducted assessments of various HF radio sets. Data and comment on these assessments are provided in Appendix C. In general the reliability, maintainability, and availability appear adequate. The general comments lead one to believe that the radios are completely satisfactory. Radio system availabilities range from 0.9 to 0.95. Based on these numbers, there is no way that a radio link or circuit availability of 0.98, (a requirement delineated in INTACS, or the Army Command and Control Master Plan) can be achieved, except through redundancy.

With the exception of the assessment of Cemetary Net system AN/FRC-93, and the AMSAA observations, there has been no total evaluation of HF radios for four or five years.

Subjective statements by repair personnel in the field imply that a primary problem is the present schooling of operators and repairmen.

In one case there was an indication that HF radios were not being operated regularly by the divisions or battalions.

There were statements provided that the Tech Manuals are outdated, are not accurate, difficult to follow, and not written in a language that the repairmen and operators can understand. In one case, LAO personnel showed that the repair parts nomenclature didn't coincide with the system description and they were not nomenclatured with proper federal stock numbers.

Proper frequency assignment was another area that was highlighted several times. This may be a problem where sky wave is used but should not be significant for operation where ground wave is the communication path.

As the data is reviewed in Appendix C, it can be readily recognized that there are conflicting comments on the status of Army HF radios. As often stated, it appears that there is no one problem that can be defined as a major contributor to the so called degraded performance of HF radios.

SECTION 4 - ARMY HF RADIOS EVALUATION

4.1 ARMY HF RADIOS EVALUATION

An attempt was made to develop a methodology to evaluate present HF Army radios. A desirable evaluation would be to numerically rate each radio set. The wide variance in parameters make such scoring impractical.

Section 2.3.1 lists a set of typical technical requirements that generally describe todays HF radios. The parameters are discussed in the following paragraphs.

4.2 CHARACTERISTICS CONSIDERATION

4.2.1 FREQUENCY RANGE: All the radios do not cover the 2 to 30 MHz HF band. Some only cover the lower part of the band, 2 to 12, 2 to 17, 2 to 6, etc. This definitely limits operability and flexibility. Figure A-1 in Appendix A shows the typical frequency range of Army HF radios.

4.2.2 CHANNELS AND FREQUENCY INCREMENTS: The older HF radios use crystal control and continuous tuning. Some of the earlier models have incremental synthesized steps of 1000 Hz. The later models offer 100 Hz synthesized tuning increments. Some provide tuning between increments and some do not. With a variation of tuning methods, interoperability will be a problem unless highly skilled operators are used. Compatibility will also be a problem.

4.2.3 MODE AND TYPE OF SERVICE: All the radios are designed to operate in the upper or lower sideband, amplitude modulated equivalent, CW or FSK. A few are designed for burst communication. In most radio sets FSK is at a 75 bit per second rate (100 words per minute).

4.2.4 TRANSMIT POWER: Transmit powers as well as planning range vary widely. There does not appear to be a relationship established (for example short range lower power long range high power). Depending on the circuit and communication mode, difficulties would be encountered in defining the quality of service.

4.2.5 ANTENNAS AND TUNING UNIT

The majority of recommended antennas are the whip, doublet, or long wire. Some radio sets define an antenna tuning unit and some do not. Most HF sets in operation today have manual tuning. This is a problem in reliability in that new operators have difficulty in tuning and this results in burnout or failure of the transmitter.

4.2.6 RECEIVER SENSITIVITY: The receive sensitivities range from 0.7 to 3 microvolts into a 50 ohm load to provide a 10 dB (S + N)/N radio. Based on predicted noise levels in the HF frequency range these sensitivities are adequate.

4.2.7 SECURITY: Secure transmission is provided for TTY circuits at HF using the TSEC/KY-7. Presently, there is no modem to provide secure voice transmission in the HF frequency range. HF radio transmissions are highly susceptible to intercept and DF. They are vulnerable to hostile electronic support measures and analysis by SIGINT and COMINT.

4.2.8 AJ AND ECCM

Frequency assignment, bandwidth, and equipment characteristics limit the HF systems to take action against intentional jammers. Few systems have the capability of narrow band operation in the CW mode to mitigate the jammers capability. The only ECCM protection that can be achieved with an HF net is multiple frequency assignment that would force the jammer into a broad-band mode to attack all recognized operating frequencies. The present HF radio equipment does not have power control which would make direction finding by the hostile electronic warfare more difficult. High power antenna coupler tuning times mitigate the use of frequency hopping as an ECCM technique at present.

4.2.9 FREQUENCY STABILITY: As noted in paragraph 2.3.1 the older HF radio sets (present day equipment) have short term frequency stabilities of 1×10^8, 5×10^7 per day; or long term stability of 1×10^6 per month. Operationally these stabilities using the FSK or voice mode of operation should be adequate. In some situations it might require operator experience to set up a link or adjust the receiver to provide quality on the link. An experienced operator can recognize frequency stability problems and take care of them in setting up a link or communication circuit; however, the radio must have continuous tuning or fine tuning capability to maintain link alignment.

4.2.10 RELIABILITY, MAINTAINABILITY, AND AVAILABILITY

Reliability, maintainability and availability are interrelated. Availability of a radio set is more stringent than the availability of a communication circuit or link. Today's military communication standards expresses communication link or circuit standards at 0.98 or 0.99. This places stringent requirements on HF radio equipments reliability and maintainability. It is questionable if the operational HF equipment can meet the required link or circuit availabilities.

Operational HF equipment is some 15-20 years old. Spare parts and supply of critical components is becoming difficult. In some cases, the components are no longer in production and replacement or equivalent components are not readily available. This is slowly deteriorating the R&M of present HF radios and requiring cannabilization to maintain some capability. It is also adversely affecting the availability of radios and systems operation.

4.3 INTACS MEASURE OF EFFECTIVENESS

Section 2.3.2 delineates the INTACS evaluation criteria and measure of effectiveness used to evaluate various communication candidate systems to meet Army tactical communication system user requirements. Based on the INTACS measure of effectiveness, it is readily seen why HF was eliminated from Integrated Tactical Communication Systems. The following discusses the 13 measures of effectiveness.

4.3.1 RELIABILITY

It appears that the present day HF radios reliability is not adequate to meet the 98% radio or link availability requirement stated in INTACS.

4.3.2 QUALITY OF SERVICE

According to the INTACS definition, the present HF operator capability must be considered, as well as reliability of equipment and availability of the link at the assigned frequency. Present operators have difficulty operating in an established net. Setting up a new link or net in a timely manner is dependent upon the definition of a timely manner. If five or ten minutes is acceptable, then present HF equipment may meet the quality of service criteria.

4.3.2 FLEXIBILITY

HF operation is flexible within limits of data requirements or mode of operation. Single channel voice should be the easiest and most rapid communication mode to establish with HF. RATT at 75 bps is likely the next easiest. Secure TTY will be more difficult.

4.3.4 OPERABILITY

If one is operating with an AN/GRC-106 to another AN/GRC-106, then operability would not be a major problem. Attempts to operate with different radio sets poses a problem because of tuning, frequency increments and frequency stability, as well as operating frequency range of the radios.

4.3.5 MAINTAINABILITY

There are indications that maintainability in MTTR is not adequate to meet the 98% availability requirements.

4.3.6 LOGISTIC SUPPORT

Because of age, logistic support of present day HF equipment is becoming critical. Mean down times of the AN/GRC-106 are as great as 38 days.

4.3.7 MOBILITY

HF can provide voice communications while on the move, but having to operate with a 35 foot whip on the move poses a problem. Shorter antennas will require a re-design of the tuning network to meet this requirement.

4.3.8 SECURITY

As defined in the INTACS measure of effectiveness (MOE), present HF equipment lack security.

4.3.9 ELECTROMAGNETIC COMPATIBILITY

During site surveys, it was pointed out that HF equipments have difficulty operating in close proximity with one another. Part of the problem is the limited number of frequencies available and this forces the same frequency to be assigned to many users. For example, the 5th Corps has 85 HF frequencies assigned to it. These must be shared by 600 to 700 HF radios and RATT sets. These would be dispersed in an area of 140 KM by 205 KM. It is only logical considering the nature of HF as well as the existence of other HF (commercial) radios that interference would be a problem.

4.3.10 TRANSPORTABILITY

One aspect of the HF that makes it attractive is transportability. It can be readily moved into crisis and conflict areas to provide an initial communication capability.

4.3.11 SURVIVABILITY

Destructive attack is difficult to overcome; however, HF can withstand electronic attack (ECM) and survive, but present HF equipments have little or no protection against Electromagnetic Pulse (EMP). The receivers and the tuning elements in the transmitter are subject to destruction from EMP.

4.3.12 RADIO FREQUENCY SPECTRUM

Normally an HF frequency assignement is for a 3 KHz increments of bandwidth, but the number of frequencies available and the number of frequencies that are useful limits the 28 MHz of bandwidth considerably. For sky wave it is conceivable that only a 2 to 4 MHz part of the total band would be useful.

4.3.13 STANDARDIZATION

Most of the present HF radios are of unique design. The number of common interchangeable parts is nill. Basic components such as resistors or compacitors are common and possibly some of the vacuum tubes, but that is the limit of standardization and common components.

4.4 REVIEW OF HF SYSTEM ANALYSIS

The Army HF radio systems have been evaluated in 4.2 in terms of the normal characteristics that one would see on a radio such as frequency range, mode, tuning increment, transmit power bandwidth, selectivity, spurious radiation, stability, temperature, size, and weight. These characteristics only provide an indicator of the radios limitations. In general as long as radios have a common band of operation, identical modes in that band, and tunability within that band, and reasonable stability communications can be established at HF. For example from the MARS station in Arlington, VA, transmitting 2 KW PEP, it was possible to establish voice communications with an aircraft carrier off the east coast of Africa at noon. It was also possible to establish communication to Cutler, Maine and then establish a voice communication link between Cutler, Maine and the carrier. The HF equipment at the MARS station was of 1950 design. Also from the MARS station voice contact was made in New Jersey transmitting only 20 to 30 watts PEP. The MARS nets operate quite efficiently with a wide varity of equipments, some purchased and some designed by the ham operators themselves, and some of the equipment is military surplus. These nets are readily established and operate but over all they are set up because of timing, frequency, and operating procedures. The radios used, in general, have the same characteristics but they do not have to meet a stringent communication requirement of 98% availability. They were operating in a benign environment, with a reliable power source. The contact with the aircraft carrier was not a scheduled contact and it was calling with the hope that a path would be open to Washington.

INTACS MOE criteria places a realistic hostile environmental outlook on HF. These evaluation criteria define a quality of service required in a dense environment subject to international interference with a limited number of available frequencies, and requiring the radio sets to be highly mobile. Speed of service requires the establishment of communication between two end points in less than thirty seconds. In addition the communications must be secure.

Hence, we have two different systems operating in the same frequency under different sets of criteria. Theoretically to meet the INTACS availability of 0.98 the terminal radios must have an availability of 0.9933. This requirement is not applicable to the MARS network. We are also comparing equipment designed 10 years before the 98% availability requirements was established. The availability of the equipment when it was designed was in all practical purposes satisfactory. It was designed to meet an operational readiness criteria of 82% . However, the equipment design for communication criteria has become more stringent and the older designs do not satisfy the modern tactical requirement. The MARS operating characteristics cannot be interpreted into INTACS requirements.

Requirements for strategic, and tactical systems must be developed in terms of the users needs. Comparing 20 year old system designs with recently developed stringent requirement will yield the obvious results. The old systems cannot compare faborably.

SECTION 5 - SUMMARY AND CONCLUSIONS

5.1 SUMMARY

The goal of this task was to make an assessment of presently operational HF radios. To accomplish the task, present day communication requirements were reviewed, such as INTACS UPDATE and the requirements delineated in this document by various users. Methods of assessing the capabilities of HF were evaluated. Site visits were made and conversations were held with persons most familiar with the present posture of HF radios. Technical characteristics and operating limitations of HF radios were compiled and cataloged. Assessment and evaluation data on as many HF radios and equipment as could be located are presented in detail as well as conclusions reached by the evaluating teams. In general, a truly numerical evaluation or assessment of present HF radios was not realistic. It was found that old radio designs were being compared with recently developed communication operational criteria that is more stringent; hence, the older radio designs are not capable of meeting the later requirements. There are needs for HF radios in tactical and strategic application to supplement and complement other communications systems. In some cases HF is needed to rapidly establish initial communications. In other cases HF is needed to provide a communication capability that cannot be effectively and reliably provided by other communication systems.

5.2 CONCLUSIONS

The services have a significant investment in HF radio equipment. The majority of US Army HF radio designs are 15 to 25 years old. In the past two to three years the Air Force, Navy and Marine Corp has initiated programs to improve the HF equipments to meet the latest communications requirements.

The problems of present U.S. Army HF equipments and their performance cannot be attributed to one factor. The following are the conclusions that were reached after an analysis of data gathered during this assessment.

a. The present HF equipment design is old. Its design, reliability and maintainability was adequate to meet the DA OR requirement of 0.82. Recent communication availability requirements of 0.98 places more stringent requirements on the communication equipments reliability, maintainability, and availability.

b. The age of the equipment and the termination of manufacture of some parts and components will make the logistic support more difficult and increase mean down time. To maintain the equipments in the field it may be necessary to cannibalize components. There are some indications that some radios and components have reached the early stages of cannibalization tactics to keep radios in the field.

c. The HF radio field is in a transitional phase. Operators and repairmen, who are experienced in the present HF radios, are moving to higher management levels in the Army or are leaving the service. The present radio repairmen and operators are trained with different operational and maintenance philosophies. The operational HF equipment was constructed by point-to-point wiring while modern electronics design is by boards, cards, and modules. These difference design philosophies require different maintenance and trouble shooting methods.

d. The technical manuals appear to have been neglected or errors in the manuals were not reported. In one case there were indications that improved maintenance techniques developed by DS and GS shops were not reported or promulgated for other units benefits.

e. Frequency assignment in HF is critical for sky wave operation. For ground wave it is less critical but necessary to mitigate EMI problems. There does not appear to be an effective frequency management plan to provide guidance in the proper assignement of frequency. From all indication it is questionable if the propagation prediction charts are used consistently.

f. For operators to become proficient in HF they must operate their radios. There is some indication that HF radio operators rarely use their equipments. At least, they are not operating the HF radios sufficiently to become proficient.

g. The maintenance depot appears to be adequately staffed and equipped to perform the necessary repair and checkouts to assure the radios are in proper operating condition for field use once the radio has been serviced at the depot. In fact,they are capable of providing significant engineering changes on the complete radio equipment and accessory components.

h. As indicated in the Army's planning documents there is a need for HF for tactical and strategic communications. These tactical needs are summarized as:

1. Mobility.
2. Communication beyond the line-of-sight.
3. Communication in built up areas.
4. Nap-of-the-earth operations.
5. Early warning nets for the air defense artillery.
6. Interoperability with allied forces.

Strategic needs are:

1. Camps, Posts, and Station nets.
2. Nuclear weapon support.
3. Military Assistance and Advisory Groups.
4. Reconstitution in the event of crisis.
5. Crisis and conflict management.
6. CONUS emergency nets.
7. Development of OCONUS gateway stations.

i. Improvement of reliability, availability, and operability of the present HF equipment will require considerable redesign and modification as well as the introduction of new procedures and equipment to enable more optimum management of the HF nets.

j. The present HF equipment lack an ECCM capability and they are susceptable to intercept and direction finding by hostile ESM.

k. Secure communication can only be provided for TTY transmissions. Voice security must be developed.

SECTION 6 - RECOMMENDATIONS

6.1 INTRODUCTION

The following recommendations are made based on HF equipment comments obtained during site survey and conferences held with Army personnel during the evaluation of present Army HF radios.

These recommendations are based on the following assumptions:

a. There is a definite need for Army tactical and strategic HF communication as defined in the INTACS update and the Army Command and Control Master Plan.

b. The HF communication equipments must provide link availabilities of 0.98.

c. The Army has a considerable investment in HF radios. For example:

5000 - 6000	AN/PRC-74's
11000	AN/GRC-106's
38	AN/TSC-38's
18	AN/TSC-25's

6.2 NEAR TERM 1980 TO 1985

During this period necessary R&D programs and material acquisition of available replacement equipments should be initiated. There are no known major design modifications that could be incorporated into existing US Army equipment that would greatly improve the availability of the equipment. Modification to the Technical Manuals may offer some improvement in maintainability but the gain would be minimal.

Repairmen and operators school instruction plans should be reviewed and the basic operation and maintenance instruction should be revised to provide more detailed HF operation, trouble shooting methodologies, and repair techniques compatible with the equipment that is in the field. The course should include instruction on installation and siting of equipment.

An improved method training HF operators and repairmen in the field should be developed and implemented.

An improved methodology of frequency management should be developed that considers operation at HF as well as frequency assignment to mitigate EMI.

The types of equipment required to meet the INTACS requirement as well as strategic equipments should be identified. Equipment requirements should then be developed in accordance with the measure of effectiveness requirements delineated in the INTACS Update Volume II and in paragraph 2.3.2 of this report.

Evaluation of state-of-the-art equipments should be made to obtain performance data to assist in the development of equipment requirements.

Greater effort should be made to operate the HF equipments on a regular basis. The nets should be set up and used continuously.

Studies and developments should be initiated to improve the HF communication security, AJ, ECCM, and nuclear environment performance. As reliable communication techniques are developed in this area they should be incorporated in the equipments technical requirements.

End-to-end link secure communications for all modes must be provided to meet the JCS requirements. This equipment must be defined.

The procurement and implementation of available equipment such as state-of-the-art teletypewrit and perforators should be initiated.

HF radio modular design concepts must be considered as part of the design requirements. Commonality of components that does not exist with present HF equipment must be developed to reduce maintenance time, cost, and logistic support.

Some state-of-the-art manpack and vehicular equipment have been developed and essentially meet military requirements. The potential for these equipments to replace existing equipments is discussed in Task 3.2b Available and Applicable Existing and Developing Equipments for Interim Use.

The ability of the state-of-the-art equipments to meet the Army user needs can only be determined through operational testing in well simulated or real life electromagnetic environments.

A logisitc support capability must be developed and clearly defined in the technical manuals.

Technical manuals that effectively support the equipments and are usable by operators and maintenance personnel must be available with the equipment and school courses. These documents must be developed along with the equipment.

Activities recommended for future periods will be the subject of other parts of this study.

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APPENDIX A

IDENTIFIED OPERATIONAL HF

RADIO EQUIPMENTS

APPENDIX A

IDENTIFIED OPERATIONAL HF RADIOS

The following lists are identified operational HF radios. These were obtained from the Frost and Sullivan Market Survey of Communications Systems. Tables A-1, A-2, A-3, and A-4 lists the Army, Air Force, Navy and U.S. Coast Guard HF radios. There was no other data given other than shown in the tables.

Figure A-1 was derived from FM-24-1, 30 September 1976, Combat Communications. This list identified Army Tactical Communications HF radios. The figure does show the frequency limitation of the radios.

These lists of equipments were used as a guide to obtain performance characteristics of HF equipment for comparison and analysis.

TABLE A-1

HF COMMUNICATIONS EQUIPMENT

U. S. ARMY

AN/DESIGNATION	DESCRIPTION	CONTRACTOR	USE
ARC-44	HF/VHF Radio	Lapointe, Bendix	OV-1, OH-47
ARC-95	HF Radio	Sunair	OH-6
ARC-98	SSB, HF Radio	Hoffman	Helicopters, RDT&E
FRC-93	SSB, HF Transceiver	Collins	Ground
FRC-147	SSB, HF Solid State Radio	Motorola	RDT&E
FRT-62	HF Radio Transmitter	Technical Material Corp.	---
GRC-106	SSB-HF Radio	G.D. Cincinnati Elect., Magnavox	Tactical Comm.
MRC-( )	HF Radio Set	Collins	Tactical Comm.
MRC-92	UHF-HF Comm.	Collins	Tactical Comm.
MSC-53	HF-VHF-UHF Flight Ops Central		
PRC-62	SSB/HF Radio	RCA	RDT&E only
PRC-64	HF Radio	Delco Radio	Tactical Comm.
PRC-70	SSB HF-VHF Radio	G.D. Cincinnati Electric	RDT&E only
PRC-74	SSB, HF Radio	Hughes	Tactical Comm.
TLQ-15	Countermeasures Set HF Freq. Range		
TRC-133	SSB-HF Radio	Collins	Tactical Comm.

TABLE A-1

HF EQUIPMENT (Continued)

U. S. ARMY

AN/DESIGNATION	DESCRIPTION	CONTRACTOR	USE
TRC-146	HF Comm. Set	Collins	Tactical Comm.
TRC-169	HF Transceiver	Collins	Tactical Comm.
TRQ-20	HF Mobile Brdcst. System		
TSC-38	HF/SSB Comm. Central	Raytheon	Tactical Comm.
TSC-74	HF & VHF		
TSQ-70 & TSQ-72A	HF-VHF-UHF		
TSW-7	HF-VHF-UHF		
URC-40	HF Radio Set	Motorola	Part of USC-3V
URC-87	SSB, HF Man-pack Radio	Southcom Int.	Tactical Comm.
VRC-81	HF Comm Sys.	Collins	Tactical Comm., for Dutch Armed Forces
MRC 95	HF Comm Sys.	Collins	U. S. Army

TABLE A-2

HF EQUIPMENT

AIR FORCE

AN/DESIGNATION	DESCRIPTION	CONTRACTOR	USE
ARC-58	SSB, HF Command Radio	Collins, Sperry	KC-134, VC-137 B-52, B-58
ARC-112	HF Radio Set	Collins	F-111
ARC-123	HF Radio Set	Cincinnati Electronics	F-111
ARC-154	HF/VHF Radio Set	Avco	Various Fighter Acft.
GRC-153, 154	Comm. Central HF-VHF-UHF	Collins	Tactical Comm.
MRC-94	HF/UHF Comm. Central	Collins	Tactical Comm.
MRC-108	HF-UHF-VHF	Collins	Tactical Comm.
TSC-15	SSB-HF Comm.	Collins	L-Systems
TSC-60, 60A	SSB-HF Comm. Center	Collins	407-L
UCC-4	SSB-HF Muliplex Equipment	Lenkurt, Honeywell	----

TABLE A-3

HF TYPE EQUIPMENT - NAVY

AN/DESIGNATION	DESCRIPTION	CONTRACTOR	AGENCY	USE
ARC-38	SSB Command Radio	RCA, Doughboy Collins	Navy "	C-13, C-133 C-12
ARC-174	SSB HF Radio	"	CG Army	GRR UH 60B
ARC-94	SSB, HF Radio	"	Navy	P-3, CH-53, CH-46
ARC-102	SSB, HF Command Radio	"	"	CV-2
ARC-132	HF Radio	"	"	A-7, F-4
ARC-142 & ARC-143	HF Radio Airborne UHF Radio	RCA	"	P-3C
ARC-153	HF Radio Set	Collins	"	S-3A
AR-157	" " "	"	"	E2C
ARC-161	" " "	"	"	P-3C
ARC-191	" " "	"	"	C-130
RC-170	HF Multi-Mode Radio	RCA	"	---
BRA-21	MF, HF Antenna	Granite	"	Subs
FRR-23	HF Radio Receiver	RCA	"	Shore Communications
FRT-83, 84	HF Radio Transmitter	R. F. Comm.	"	For Coast Guard Comm. & ASW Shore
FRT-85	HF Radio Transmitter	Continental	"	---
MRC-87	Tropo-HF & UHF	Collins	"	Tactical Comm.
PRC-47	SSB, HF-AM Pack Radio	"	"	Tactical Comm.
PRC-104	SSB, HF Transceiver	Hughes	"	Tactical Comm. for Marine Corps
PRC-105	SSB, HF Transceiver	Collins	"	Tactical Comm. for Marine Corps

TABLE A-3

HF TYPE EQUIPMENT

(Cont'd)

AN/DESIGNATION	DESCRIPTION	CONTRACTOR	AGENCY	USE
SRA-51	HF Receiving Antenna	Westinghouse	Navy	Shipbased
SRC-16	Comm. Central HF	Collins	"	NTDS
SRC-23,23A	HF Radio Set	Collins	"	MTDS, Link II
SRC-30XN-1	HF/UHF, SSB Radio	Naval Under-Water Lab.	"	RDT&E
			"	
SRC-503	HF Transceiver	---	"	Shipbased
SRD-19	HF/VHF Direction Finding	---	"	Shipbased
TRC-75	SSB-HF Radio	Collins	"	Marine Corps Tactical Comm.
URC-32,32A	HF Transceiver	Collins, Lapointe	"	Shipbased
URC-35	HF Radio Set	G.D. Harris Corp.	"	Part of WRC-1; Shipbased
URC-58V	SSB, HF Radio	Harris Corp/RF Comm. Division	"	Ships
URC-75	Radio Set HF	Collins	"	---
URC-88	GF Multi-mode Radio	RCA	"	Ship, Subs & Ground
URR-64	HF Radio Receiver	Technical Material	"	---
URT-23V, 24	HF Radio Trans-mitter	RF Comm.	"	Shipbased, DD 963
URT-23	HF Radio Trans-mitter	Int'l Signal	"	Part of WRC-1
VRC-80	HF Transceiver	Collins	"	Vehicular Application
WRC-1	HF Radio Set	Bendix, Hughes, Stewart-Warner	"	Ships
WRT-4	MF-HF Radio Transmitter	Hoffman	"	SSBN

TABLE A-4

HF EQUIPMENT

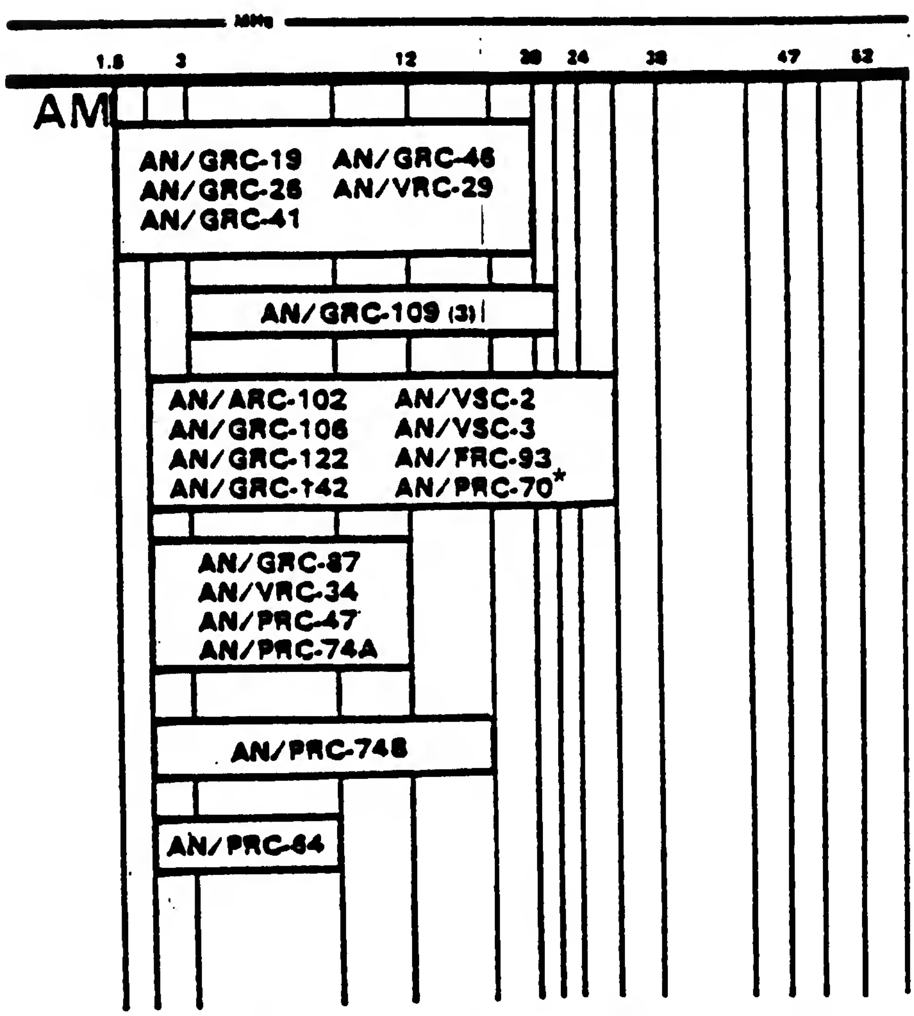
U. S. COAST GUARD

AN/DESIGNATION	DESCRIPTION	CONTRACTOR	USE
URC-58	SSB, HF Radio	Harris Corp/ RF Comm. Div.	Small Craft, Vehicle, Base Stations
URC-77	SSB, HF Radio Transceiver	Scientific Radio Systems	----

FIGURE A-1

ARMY HF RADIOS DEFINED IN

TM 24-1 COMBAT COMMUNICATIONS



*AN/PRC-70 OPERATES AM FROM 2-30 MHz; FM FROM 30 TO 76 MHz

APPENDIX B-1

ARMY HF RADIOS TECHNICAL CHARACTERISTICS

B.1 ARMY HF RADIO EQUIPMENTS

B.1.1 ARMY AMPLITUDE MODULATED (AM) AND SINGLE SIDEBAND (SSB) RADIO SETS

These AM radio sets are capable of short, medium, and long-range communications. They are used in manpack, fixed station, vehicular and shelter mounted configur-ations, and are designed for single channel voice, Frequency Shift Keying (FSK), Narrow-frequency Shift Keying (NSK), Continuous Wave (CW), Modulated Continuous Wave (MCW), or Singe Side Band (SSB) voice communications.

Planning ranges are the approximate distances a radio signal can be transmitted if all conditions are ideal. Terrain features, type of antenna, ionospheric conditions, and transmitter power will have to be considered when planning a radio system.

The HF radios and equipments described in this section are the AN/FRC-93, AN/GRC-19, AN/GRC-41, AN/GRC-87, AN/VRC-34, AN/GRC-106, AN/GRC-109, AN/PRC-41, AN/PRC-41A, AN/PRC-47, AN/PRC-64A, AN/VRC-24A, and AN/TRC-68A. Codes-Burst Transmission Group AN/GRA-71 is described as well as antenna group AN/GRA-50.

A brief summary is provided for each radio set. Table B-1 summarizes the Army Amplitude Modulated SSB Radio Sets. Note that Park Hill or ANDVT may provide future secure voice capability.

B.1.1.1 AN/FRC-93

The AN/FRC-93 is a high frequency (HF) commercial single-sideband radio set adapted for military use. It can operate on either Upper Side Band (USB) or Lower Side Band (LSB) and is designed to be used in fixed or semi-fixed application. Current tactical speech security equipment is not compatible with the AN/FRC-93; therefore, secure voice is not a mode of operation.

The AN/FRC-93 major components are the receiver-transmitter RT-718 power supply, PP-4151 or PP-3990 control group, C-6118 amplifier, AM-3979 crystal unit set CK-31.

B.1.1.2 AN/GRC-19

The AN/GRC-19 is an HF medium-power, AM voice and CW radio set designed for vehicular installation. It serves as the basic radio set for several radio teletypewriter configurations and also can be used as a retransmission facility. Current tactical speech security equipment is not compatible with AN/GRC-19; therefore, secure voice is not a mode of operation. The AN/GRC-19 is being replaced by radio set AN-GRC-106.

The major components of the AN/GRC-19 are the Transmitter T-195 and Receiver R-392.

B-1.1.3 AN/GRC-41

The AN/GRC-41 is an HF radio transmitting and receiving station which provides communications facilities for CW and AM voice operation. The set is designed for either half or full-duplex operation and can be used in mobile, semi-fixed, or fixed applications. Current tactical speech security equipment is not compatible with the AN/GRC-41; therefore, secure voice is not a mode of operation.

The major components of the AN/GRC-41 consists of the transmitter T-368C/URT, receiver R-390/URR, and antenna tuning unit BC-939-B. Junction box JB-60-A provides remote connections for a telephone TA-312/PT and telegraph key J-45.

B.1.1.4 AN/GRC-87 and AN/VRC-34

The AN/GRC-87 and AN/VRC-34 are HF low-power AM receiver-transmitters. The AN/GRC-87 is designed for man-transportable use and the AN/VRC-34 is for vehicular installation. Current tactical speech security equipment is not compatible with the AN/GRC-87 or the AN/VRC-34; therefore, secure voice is not a mode of operation.

Major components of these radios consist of receiver-transmitter RT-77/GRC-9, generator G-43/G (AN/GRC-87), dynamotor DY-105/GRC-9X (AN/VRC-34), battery BA-317/U (AN/GRC-87), antenna AT-101/GRC-9 or AT-102/GRC-9 antenna, vehicular whip.

B.1.1.5 AN/GRC-106

The AN/GRC-106 is an HF, SSB radio set used primarily as a mobile link in a communications network. It may also be used in fixed and semi-fixed applications, and it has an AM mode to make it compatible with standard AM radio sets. The AN/GRC-106 is now being used as the basic radio set with all of the newer SSB radio-teletypewriter configurations. The AN/GRC-106 and 106A are identical except that the AN/GRC-106 uses an RT-662/GRC and the AN/GRC-106A uses an RT-834/GRC. Current tactical speech security equipment is not compatible with the AN/GRC-106; therefore, secure voice is not a mode of operation. The AN/GRC-106 replaced radio set AN/GRC-19.

The AN/GRC-106 major components are RT-662/GRC or TR-834/GRC, radio frequency amplifier AM-3349, antenna; vehicular whip, or AN/GRA-50.

TABLE B-1 - ARMY AMPLITUDE MODULATED (AM) & SINGLE SIDEBAND HF RADIO SETS & ASSOCIATED EQUIPMENT

	Frequency Range Mhz	Number of Channels	Tuning	Type of Service	Transmit Power (Watts)	Antenna	Security	USER	RANGE PLANNING	WEIGHT
AN/FRC-93	3.4 - 5.0 6.5 - 30.0	130 Channels Crystal Controlled	Continuous in 299 khz. bands	3A3J (USB/LSB) 0.1A1 1.1A1	Pep. RT-718 100W, RT-718 with AM-3979 1000W PEP	Whip or doublet	No secure voice	Special Forces Base Camp, USACC, Field Artillery	Ground Wave 80 KM Sky Wave	95 Lbs
AN/GRC-19	1.5 to 20 Transmit Receive 0.5 - 32	7 Preset Auto Tuned Channels	Contin-uous	6A3 0.1A1		Whip 15 ft AN/GRA-4 AN/GRA-50	None	National Guard Army Reserve	80 KM	121 Lbs
AN/GRC-41	Transmit 1.5 - 20 Receive 0.5 - 32	NA	Contin-uous	6A3 0.1A1	400W PEP 0.1A1 450W	Whip Long Wire Doublet	None	COMMZ	1600 KM	5235 Lbs 2377 KG
AN/GRC-87, AN/VRC-34	2-12	Contin-uous	Contin-uous	6A3 2A2 0.1A1	7 PEP 15 15 PEP	Long Wire AT-101/GRC-9 AT-102/GRC-9	None	Special Application	16-50 KM	32 Lbs 14.5KG
AN/GRC-106 AN/GRC-106A	2-29.9999	28000	Digital Receiver has ±6 Hz Vernier	3A3J 3A3A 0.1A1 0.1A1	400 PEP 400 " 200 " 200 "	15 Ft. Whip Doublet AN/GRA-50	None	Division through COMMZ	Ground Wave 80 KM Sky Wave 160-2400 KM	128 Lbs 58.1 KG
AN/GRC-109	Transmit 3-22 Receiver 3-24	24	Crystal Control Transmit	Transmit 0.1A1 Receive: 3A3 2A2 0.1A1	10 to 15W	nverted V, Adjust-able Based on Frequency	None	Special Forces, Forward Area Patrols	121 KM	55.5 Lbs 25.2 KG

TABLE B-1 - ARMY AMPLITUDE MODULATED (AM) & SINGLE SIDEBAND HF RADIO SETS & ASSOCIATED EQUIPMENT (CONT'D)

	Frequency Range Mhz	Number of Channels	Tuning	Type of Service	Transmit Power (Watts)	Antenna	Security	USER	RANGE PLANNING	WEIGHT
AN/PRC-47	2-11.999	10,000	1kHz Spacing	3A3J 0.1A1	High 100W PEP Low 20W PEP	Whip AS-1320/ PRC-74 Long Wire AS-1321/ PRC-74	None	Special Forces	Short & Intermediate Ground Wave	190 Lbs 86.3 KG
AN/PRD-64A	2.2 to 6	4	Crystal Control	Transmit 6A3 1.1A1 Receive 6A3,1.1A1 3A3J	5.W PEP 1.5 W	Quarter-Wave, Half Wave Whip	None	Special Forces, Operates with External Coder-Burst Transmission GR-40 AN/GRA-71	24 Km Ground Wave	7.5 Lbs 3.4 KG
AN/PRC-74,74A AN/PRC-74B AN/PRC-74C	2-11.999 2-11.999 2-17.999	10,000 16,000 16,000	1 KHz Spacing	3A3J 0.1A1	15W PEP	AS-1887 Slanted Wire, Dipole	None	Special Forces Forward Area Patrols Air Assault Div.	40 Km Ground Wave, AM 10 Sky Wave	Dry Batteries 41.5 Lb/18.8 KG Wet Batteries 29.5 Lb/13.4 KG PP-4515 50 Lb/22.7 KG
AN/PRC-70	2-30 30-76	280,000	100 Hz Increments Digital Synthesizer	SSB AM CW FSK, FM	30 PEP 7.5 PEP 30 30, 30	Whip	None	Man Pack adaptable to Acft & vehicles	4,000 Km Sky Wave	20.5 Lbs, 9.3 KG less Battery Case
AN/GRA-71	N/A	N/A	N/A	Keys Transmitter for CW FSK NSK	Electrical Signals to Key Transmitter at 300 WPM	N/A	N/A	Use with AN/GRC-109, AN/PRC-64, AN/PRC-74A,74B, 74C	N/A	9.5 Lb 4.3 KG
AN/GRA-50 Antenna Group	1.5 - 30	N/A	Measuring Tape & Reel	Less than 500W, 50 Ohms	Doublet	N/A	N/A	Doublet Antenna for HF Radios for fixed or semi-fixed Instln.	Skywave Transmission Mode	11.25 Lbs 5.3 KG

B.1.1.6 AN/GRC-109

The AN/GRC-109 is a compact, portable HF radio set used for CW communications under a wide range of climatic conditions. Transmissions can be made using the built-in hand key, an external hand key, or an external high speed automatic keyer such as Coder-Burst Transmission Group AN/GRA-71. Two power supplies and a voltage regulator permit operation from a variety of power sources. Current tactical speech security equipment is not compatible with AN/GRC-109; therefore, secure voice is not a mode of operation.

The AN/GRC-109 major components consist of the Transmitter T-784/GRC-109, Receiver R-1004/GRC-109 Power Supply, PP-2684/GRC-109 and Power Supply PP-2685/GRC-109

Power input 75 to 260V AC, 40 to 400Hz or 6V DC

Power source - any appropriate AC power source, DC generator G-43/G, 6V DC wet or dry battery.

B.1.1.7 AN/PRC-47

The AN/PRC-47 is an HF SSB radio set which provides CW and USB voice communications. It also provides FSK communication when operated with an FSK converter. The AN/PRC-47 may be used in portable, vehicular, or fixed station applications. Current tactical speech security equipment is not compatible with the AN/PRC-47; therefore, secure voice is not a mode of operation.

The AN/PRC-47 consists of the following major components: Receiver-Transmitter RT-67/PRC-47, Battery Terminal Adapter MX-4430/PRC-47, Antenna AS-1320/PRC-47

B.1.1.8 AN/PRC-64A

The AN/PRC-64A is a battery operated, low-power HF radio set designed to receive and transmit CW and AM voice signals. In addition, single-sideband voice signals may be received by using the beat frequency oscillator (BFO). CW signals may be transmitted by use of a built-in hand key or an external high-speed, automatic keyer such as Coder-Burst Transmission Group AN/GRA-71. Current tactical speech security equipment is not compatible with the AN/PRC-64A; therefore secure voice is not a mode of operation.

The major components of the AN/PRC-64A are the AN/PRC-64A, Battery BA-1509/PRC-64.

B.1.1.9 AN/PRC-74

The AN/PRC-74 is a low-power, transistorized SSB radio set used for voice and CW communications. It is designed primarily as a manpack set in areas where direct line-of-sight communications are not possible. Except for the difference in the frequency range of the AN/PRC-74B and AN/PRC-74C all models are essentially the same. Current tactical speech security equipment is not compatible with the AN/PRC-74; therefore, secure voice is not a mode of operation. Coder-Burst Transmission Group AN/GRA-71 can be used with all lettered models.

Major components of the AN/PRC-74 consist of the radio set AN/PRC-74, antenna AS-1887/PRC-74, slanted wire and dipole, power supply PP-4514/PRC-74. Power input requirements are 10.5 to 17V DC, 12 to 31V DC or 110/220V AC.

Power sources are BA-30, seventy each or BB-418/U, ten each. With the PP-4514/PRC, vehicular power or any appropriate AC power sources can be used.

B.1.1.10 AN/GRA-71 CODER-BURST TRANSMISSION GROUP

The AN/GRA-71 is composed of an electromechanical morse-code generator that enables an operator to record messages (in morse-code characters) on magnetic recording tape. It has a keyer device to convert the tape recorded morse code characters into equivalent electrical impluses for "keying" an associated transmitter; and a keyer adapter device that contains the electronic circuitry for supplying power to the keyer unit and adapting its output to the transmitter.

The AN/GRA-71 is used with radio sets AN/GRC-109, AN/PRC-64 and lettered models of the AN/PRC-74.

Major components of the AN/GRA-71 consist of semi-automatic tape coder MX-4496/GRA-71 manual tape coder MX-4495/GRA-71, keyer adapter MX-4498/GRA-71, keyer MX-468/GRA-71 and recording tape MA-9/GRA-71.

B.1.1.11 ANTENNA GROUP AN/GRA-50

The AN/GRA-50 is a doublet antenna assembly designed to increase the communications distance of HF radio sets when in fixed or semi-fixed installation. The frequency range is 1.5 to 30 MHz. It can be used with any HF radio set that has the proper frequency range and a transmitter output power of less than 500 watts, and an output impedance of approximately 50 ohms.

The major components on the cable assembly CG-678/U, 2 halyards MX-2706/U, 2 antenna wire assemblies CX=83-3/G, insulator IL-4/GRA-4, and measuring tape 44.4m (156 ft).

B.1.2 ARMY RADIO TELETYPEWRITER (RATT) SETS AND ASSOCIATED EQUIPMENT

These sets provide medium and long-range single channel voice, FSK, NSK, CW, MCW or SSB voice communications. They are vehicular or shelter mounted and can be operated while stationary or mobile.

Planning ranges listed are the approximate distances a radio signal can be transmitted if all conditions are ideal. Terrain features, type of antenna, atomospheric conditions, and transmitter power must be considered when planning a radio system.

The requirements described in this section consist of the radio set AN/GRC-26D, radio teletypewriter sets AN/GRC-46 and AN/VRC-29, AN/GRC-122, AN/GRC-142, AN/VSC-2, and AN/VSC-3, radio receiving set AN/MRR-8, radio transmitting set AN/MRT-9. Table B-2 summarizes the Army RATT sets characteristics.

B.1.2.1 RADIO SET AN/GRC-26D

The AN/GRC-26D is a high-power, shelter-mounted, radio teletypewriter station designed for use in mobile, fixed, or semi-fixed application. In addition to the RATT operation, it is also capable of AM voice and CW communications. Facilities are provided for secure operation in the FSK mode by using electronic teletypewriter security equipment TSEC/KW-7. However, current tactical speech security equipment is not compatible with the AN/GRC-26D; therefore, secure voice is not a mode of operation. The AN/GRC-26D has been replaced by radio teletypewriter set, AN/GRC-122.

The AN/GRC-26D major components are the transmitter T-368, receiver R-390, Modem MD-239, converter CV-16, teletypewriter TT-98, teletypewriter TT-76, and radio frequency tuner TN-339.

The input power is 115 V, AC, 50 to 60 Hz and the power source is a PU-619 or PU-294

The system has the capability for space diversity operation with receiving antennas spaced 183 to 274 meters (600 to 900 ft) apart.

TABLE B-2 ARMY HF RADIO TELETYPEWRITER (RATT) SETS AND ASSOCIATED EQUIPMENT

	FREQUENCY RANGE MHz	NUMBER OF CHANNELS	TUNING	TYPE OF SERVICE	TRANSMIT POWER	ANTENNA	SECURITY	USER	RANGE PLANNING	WEIGHT
AN/GRC-26D	Transmit 1.5-20 Receive 0.5-32.0	Continuous Tuning	Continuous	Transmit 6A3, 0.1A1 1.1A1 Receive 6A3, 0.1A1 1.1A1 3A3A	50W 0.1A1 400W 6A3	Whip 15 Ft Doublet Long Wire	FSK Mode TSEC/KW-7 No Secure Speech	National Guard and Army Reserves	1600 Km	5660 Lbs 2570 KG
AN/GRC-46 AN/VRC-29	Transmit 1.5-20	Continuous Tuning	Continuous	6A3 0.1A1 1.1A1	100W Max	Whip 15 Ft Doublet AN/GRA-4 AN/GRA-50	Non-Secure Voice	National Guard and Reserve Forces	Ground Wave 80 Km Sky Wave 160 to 2400 Km	300 Lbs 317.8 KG
AN/GRC-122 AN/GRC-142 AN/VSC-2 AN/VSC-3	2-29.999	RT 662 28,000 RT 834 280,000	1000 Hz 1000 Hz (Digital)	3A3J USB 3A3A USB 0.1A1 0.1A1 DSB Rx Only	400W 3A3A 3A3J 200W 0.1A1 1.1A1	Whip 15 Ft Doublet AN/GRA-50	Non-Secure Voice TSEC/KW-7	Division thru COMMZ AN/USC-2 -Airborne Air Assault Div. AN/USC-3 Infantry Armored Div.	Short & Intermittent Range Ground-Wave	GRC-122 769.1KG 1695 Lbs GRC-124 831.7KG/1832 Lbs
AN/MRR-8 (Receiver)	0.5-32	Continuous Tuning	Continuous	6A3 1.1A1 3A3A 0.1A1 2A2	N/A	Whip Long-Wire	FSK Mode TSEC/KW-7 No Speech Security	Corp and COMMZ	160 Km	2116 KG 4660 Lbs
AN/MRT-9	Transmit 1.5-20 Receive 0.5-32	Continuous Tuning	Continuous Tuning	6A3 0.1A1 1.1A1	400W 450W 450W	Whip Long-Wire	No Secure Voice FSK Mode Secure TSEC/KW-7	Corp and COMMZ	160 Km	2280 KG 5021 Lb.
AN/PRC-15	2-30	280,000	100 Hz STEPS	LSB USB AM CW	Man Pack 15W Mobile or Vehicle 100W	Whip Long-Wire Dipole		Man Pack; Mobile or Fixed Station		19.8 Lbs 9 KG

B.1.2.2 AN/GRC-46 AND AN/VRC-29 RADIO TELETYPEWRITER SETS

The AN/GRC-46 and AN/VRC-29 are medium-power, general use HF-AM radio sets normally used in RATT operation. Secure FSK operation is possible by using electronic teletypewriter security equipment, TSEC/KW-7. However, current tactical speech security equipment is not compatible with the AN/GRC-19; therefore, secure voice is not a mode of operation. The AN/GRC-46 and AN/VRC-29 are similar, except that the AN/GRC-46 is shelter mounted and the AN/VRC-29 is mounted in armored personnel carriers. The AN/GRC-46 is being replaced by AN/GRC-142 and the AN/VRC-29 by AN/VSC-3.

Input power is 27.5 V, DC and the vehicle is the power source.

The major components consist of the radio transmitter T-195/GRC-19, radio receiver R-392/URR, modulator MD-203/GR frequency converter CV-278/GR, reprefor-ator transmitter teletypewriter TT-76/GGC, and teletypewriter TT-98B/FG or AN/UGC-4.

B.1.2.3 AN/GRC-122 RATT FAMILY

The AN/GRC-122 family consists of medium-power, vehicular mounted HF-SSB radio sets used primarily for RATT operations, however, they are capable of AM and SSB voice and CW operation. With the addition of a Navy standard 1 KW radio frequency amplifier AM-3924/URT and antenna coupler AN/URA-38A, the AN/GRC-122 becomes an AN/GRC-122(V2). This modified version provides the capability for long-range communications of 3862 km (2400 mi). The AN/GRC-122 and AN/GRC-142 are both shelter mounted. The AN/VSC-2 is mounted in a jeep and the AN/VSC-3 in an armored personnel carrier. Except for minor changes, all sets are similar and will replace the older family of RATT sets: AN/GRC-122 has replaced AN/GRC-26D, AN/GRC-142 will replace AN/GRC-46, AN/VSC-2 has replaced AN/VSC-1, AN/VSC-3 will replace AN/VRC-29. Secure FSK operation is possible when the above sets are used in conjunction with electronic teletypewriter security equipment TSEC/KW-7. However, current tactical speech security equipment is not compatible with AN/GRC-106; therefore, secure voice is not a mode of operation.

The AN/GRC-122/142 is deployed in the division through COMMZ. The AN/VSC-2 is deployed in airborne and air assault divisions and the AN/VSC-3 is deployed in infantry and armored divisions.

Using the RT-662 the equipment has 28,000 channels spaced at 1 KHz. Using the RT-834, the equipment has 280,000 channels spaced every 100 Hz.

B.1.2.4 AN/MRR-8 Radio Receiving Set

The AN/MRR-8 is an air or vehicular-transportable shelter containing HF-AM radio receivers and associated equipment. It can provide four diversity or eight non-diversity circuits and includes facilities for audio and teletypewriter (TTY) monitoring. Secure operation is possible in the FSK mode by using electronic teletypewriter security equipment TSEC/KW-7; but current tactical speech security equipment is not compatible with the R-390; therefore, secure voice is not a mode of operation.

The AN/MRR-8 is deployed with Corps forces and COMMZ.

The major components of the AN/MRR-8 is the R-390/JRR Receiver, Frequency shift convertor CV-116/URR, teletypewriter repreforator-transmitter TT-76/GGC, teletypewriter TT-98/FG, antenna group AN/GRA-4, whip antenna mast base MP-68-B, and antenna mast sections MS-116A/117A/118A.

The input power requirement is 115V AC, 60 Hz and the power source is the PU-286/G.

B.1.2.5 AN/MRT-9 RADIO TRANSMITTING SET

The AN/MRT-9 is an air or vehicular transportable shelter consisting of HF-AM radio transmitters and associated equipment. It is capable of simultaneous transmission of voice and teletypewriter signals. The receiver (R-39) in the AN/MRT-9 can be used for tuning the transmitters or for receiving voice and teletypewriter signals. Current tactical speech security equipment is not compatible with the AN/MRT-9; therefore, secure voice is not a mode of operation. However, secure operation is possible in the FSK mode by using electronic teletypewriter security equipment TSEC/KW-7.

The AN/MRT-9 is deployed with the Corps forces and COMMZ. The major components consists of the transmitter T-368/URR, receiver R-390/URR, modulator MD-239/GR, frequency shift converter CV-116/URR, teletypewriter repreforator-transmitter TT-76/GGC, teletypewriter TT-98/FG, antenna group AN/GRA-4 and mast sections MS-16A/117A/118A

The AN/MRT-9 input power is 115V AC, 60 Hz and the power source is the PU-319/U.

B.1.3 ARMY AVIATION RADIO COMMUNICATIONS

These radio sets provide single channel voice, data, SSB voice, CW, MCW, FSK or NSK communications, and automatic direction finder (ADP) or homing beacon signals.

The various uses of the sets are:

- Aircraft emergency rescue signaling
- Aircraft-to-aircraft communications
- Aircraft-to-ground station communications
- Ground station-to-ground station communications
- Aircraft navigation
- Airborne re-transmission stations

The equipment described in this section consists of the radio set AN/ARC-102, flight coordination center AN/TSC-61A, communications center AN/TSC-74, aircraft control central AN/TSQ-70A, landing control central AN/TSQ-72A. The control and communication centers are a composite of VHF, UHF, as well as HF equipment only those shelters that contain HF equipment are highlighted. The HF equipments in these shelters has been described in this or other sections of this report.

B.1.3.1 RADIO SET AN/ARC-102

The AN/ARC-102 is a lightweight HF-AM/SSB radio set used to provide communications between aircraft in flight and from aircraft-to-ground stations. Current tactical speech security equipment is not compatible with AN/ARC-102; therefore, secure voice is not a mode of operation. The AN/ARC-102 has replaced radio set AN/ARC-59. This radio set is deployed in the CH-47, CH-54, OV-1, U-21 and UH-1 helicopters. The major components consist of the receiver-transmitter RT-698, radio set control C-3940 and power inverter PP-3072. The antenna is a long-wire with a minimum length of 13.72 meters.

B.1.3.2 AN/TSC-61A - FLIGHT COORDINATION CENTER

The AN/TSC-61A is a transportable unit that provides facilities for air traffic coordination and in-flight assistance within an assigned zone of responsibility. Altitude, time and distance flight plan data for airborne aircraft can also be coordinated in the AN/TSC-61A. The AN/VRC-46 is the only radio set within the

AN/TSC-61A which is capable of secure voice operation. The AN/ARC-51BX, -73A, and 102 are not compatible with the current tactical speech security equipment. The AN/TSC-61A replaced Flight Coordination Center AN/TSC-63.

The HF component of the AN/TSC-61A is the AN/ARC-102. The following is a list of major components that show the frequency coverage.

AN/TSC-61A MAJOR COMPONENTS

QUANTITY	COMPONENT	FREQUENCY
3	Radio Sets,AN/ARC-51BX	225 to 399.95 MHz
3	Radio Sets, AN/ARC-73A	116 to 151.95 MHz
2	Radio Sets, AN/ARC-102	2 to 29.9999 MHz
3	Radio Sets, AN/VRC-46	30 to 75.95 MHz
3	Antennas, AS-112, AT-197, AT-912	2 to 29.9999 MHz
1	Long Wire	2. to 29.9999 Mhz
1	Teletypewriter Set, TT-99/TG	

The AN/TSC-61A input power is 12/220 V AC, 50 to 600 Hz. The power source is the PU-406/M.

B.1.3.3 AN/TSC-74 COMMUNICATION CENTER

The AN/TSC-74 is a shelter-mounted control center for a ground communications system. Facilities are available for connecting one land-wire teletypewriter to the shelter, S-280/G. The AN/TSC-74 provides ground-to-aircraft voice communications and ground station-to-ground station voice and teletypewriter service. Radio set AN/VRC-46 can provide secure voice service; but the AN/GRC-106 is not compatible with the current tactical speech security equipment. The AN/GRC-106 is the HF communication component of the AN/TSC-74. The AN/TSC-74 is used for air traffic control.

The following table delineates the quantity, major component and frequency range of the major complement.

AN/TSC-74 MAJOR COMPONENTS

QUANTITY	COMPONENT	FREQUENCY
2	Radio Sets, AN/GRC-106	2 to 29.999 MHz
3	T letypewriter Sets AN/UGC-4	---
2	Radio Sets, AN/VRC-46	30 to 79.95
4	Antennas, AN/GRA-4	2 to 30
2	Antennas, AN/GRA-50	2 to 30 (doublet)
2	Antennas, AT-912 or AS-1729	30 to 79.95
2	RATT Sets, MD-522/GRC	---
2	Generator Sets, PU-405	---
2	Telegraph Terminals, TH-22	---
3	Teletypewriters, TT-76C	---
1	Air Conditioner, 18,000 BTU	---

The input power to the AN/TSC-74 is 230V AC, 60 Hz. The power source is the PU-405.

B.1.3.4 AN/TSQ-70A - AIRCRAFT CONTROL CENTRAL

The AN/TSQ-70A is an air or ground-transportable communications unit that provides facilities for air traffic control within and around an airfield. It provides communications with aircraft in flight and movement assistance for aircraft on the ground. This system further provides air traffic regulation, aircraft separation, and landing and take-off control. Receiver-transmitter RT-524 can provide secure voice operation, but radio sets AN/RAC-51BX, -73A and -102 are not compatible with the current tactical speech security equipment. The AN/ARC-102 is used to provide the AN/TSQ-70A HF communications capability. The following table delineates the quantity frequency range and major components of the AW/TSO-70 aircraft central.

AN/TSQ-70A MAJOR COMPONENTS

QUANTITY	COMPONENTS	FREQUENCY
3	Radio Sets, AN/ARC-51BX	225 to 399.95 MHz
3	Radio Sets, AN/ARC-73A	116 to 151.95 MHz
1	Radio Set, AN/ARC-102	2 to 29 MHz
3	Antennas, AS-1729	---
3	Antennas, AT-112	---
3	Antennas, AT-197	---
1	Antenna, AT-1011D	---
1	Generator Set, PU-619/M	---
1	Receiver, R-511	---
3	Receiver-Transmitters, RT-524	30 to 75.95 MHz

The prime power for the AN/TSQ-70A is 115/230V AC, 60 Hz and the power source is the PU-619/M.

B.1.3.5 AN/TSQ-72A - LANDING CONTROL CENTRAL

The AN/TSQ-72A is used at an airfield to provide air traffic regulation, aircraft identification, separation, in-flight assistance, ground approach radar control, and ground traffic control. Various radio sets are provided to facilitate the control of aircraft. Radar set AN/TPN-18 is used to assist aircraft landing and interrogator set AN/TPX-44 provides an IFF capability with a range of 125 km (78 mi). Radio set AN/VRC-46 can provide secure voice operation, but radio sets AN/ARC-51BX, -73A and -102 are not compatible with the current tactical speech security equipment. The AN/ARC-102 provides the AN/TSQ-72A with HF coverage. All radio equipment is installed in an S-280/U shelter.

The following table delineates the AN/TSQ-72A major components, the quantity and frequency range of operation.

AN/TSQ-72A LANDING CONTROL CENTRAL

QUANTITY	COMPONENT	FREQUENCY
3	Radio Sets, AN/ARC-51BX	225 to 399.95
3	Radio Sets, AN/ARC-73A	116 to 151.95
1	Radio Set, AN/ARC-102	2 to 29.0
4	Radio Sets, AN/VRC-46	30 to 75.95
1	Radar Set, AN/TPN-18	---
1	Interrogator AN/TPX-44 Set	---
2	Generator Sets, PU-401/M	---

Figure B-1 shows the AN/TSQ-72A deployment configuration. The close proximity of a wide range of electromagnetic radiating systems show the potential for EMI/RFI problems.

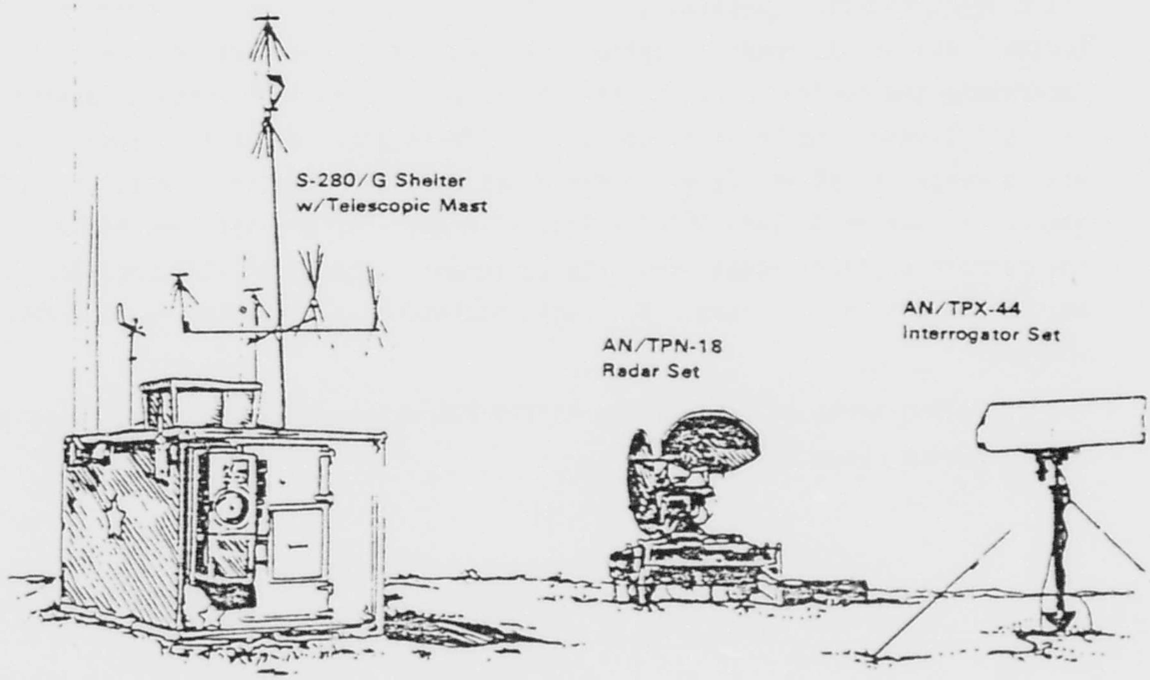


FIGURE B-1 - AN/TSQ-72A DEPLOYMENT CONFIGURATION

B.1.4 ARMY STRATEGIC HF COMMUNICATIONS EQUIPMENTS

The AN/TSC-20, AN/RSC-20A, AN/TSC-25 and AN/TSC-38 are the only strategic HF Communications Centrals that were identified in the present HF equipment search. (The AN/FRC-93, described earlier, could be considered as a strategic system from its application in the Cemetary Net). These equipments have a DCS interface capability of four independent sideband 3 KHz channels. Presently, there are 38 AN/TSC-38B Communication Centrals in service today and 18 AN/TSC-25's.

B.1.4.1 AN/TSC-20, AN/TSC-20A COMMUNICATION CENTRALS

The AN/TSC-20 and AN/TSC-20A, Communications Centrals are air and land transportable one kilowatt independent sideband radio teletypewriter facilities capable of simultaneous transmission and reception of voice and teletypewriter signals in the 2 to 30 MHz range. They also provide access to the long haul radio facilities of the radio terminal shelter from distances up to 10 miles.

The AN/TSC-20 provides two 3 kHz VF channels; one full duplex voice channel and eight teletype channels. The AN/TSC-20A is equipped with three 2-wire/4-wire hybrids which can provide duplex on two additional 3 kHz channels. In both the AN/TSC-20 and AN/TSC-20A, one voice frequency channel is used for terminal-to-terminal engineering orderwire service.

Both the AN/TSC-20 and 20A contain equipment to terminate one duplex, link-encrypted, teletype channel and one duplex voice channel. Two identical user enclosures, which may be located up to 10 miles from the radio terminal shelters each provide one duplex teletype and once voice channel to the radio terminal shelter by VHF radio link.

In addition to the secure teletype channel, seven duplex non-secure teletype channels are provided to wire subscribers. Under adverse radio propagation conditions, the reliability of the teletypewriter circuits may be increased by using 4 channel diversity (tone diversity) on both ends of the high frequency radio circuit. During such use, the number of available teletype channels is reduced to four.

Space diversity is provided at the HF sites by using two antennas, receivers and converters

The AN/TSC-20 equipment is controlled by USACC/DA. It is Category C. The design era of the AN/TSC-20 Communication Central is estimated as 1985.

B.1.4.1.1 AN/TSC-20 TECHNICAL CHARACTERISTICS

The following material delineates the technical and physical characteristics of the AN/TSC-20 Communication Central.

OVERALL SYSTEM

Number of VF Channels	4
Number of Teletypewriter Channels (on one of the VF channels)	8 maximum
Transmission Range	2,500 miles (approx.)
Transmission Range Between Radio Terminal Shelter and Each Subscriber Package	10 miles (approx.)
Number of Channels Between Radio Terminal Shelter and Each Subscriber Package	1 speech plus teletypewriter, full duplex
Radio Terminal Shelter	
Power Requirements	
Technical Load	7.5 kW
Utility Load	8 kW
Voltage	120 or 208 volts AC
Frequency	60 Hz
Phase	3
Transmitting Frequency Range	2.0 to 32.0 MHz
Power Output	1 kW RF (PEP)
Type of Transmission	Independent sideband
Modulation	AM Suppressed Carrier
Antennas	Doublet or sloping V

Receiving	
Frequency Range	0.5 to 32.0 MHz
Types of Signals Received	Modulated CW (A2), Voice (A3), ISB (A9)
Antennas	2 double-doublets or 2 sloping Vs
Communications Link to Subscriber Packages	
Radio	
Number of Channels	2 (1 send and 1 receive)
Frequency Range	132 to 150 MHz
Type of Modulation	AM
Transmitted Carrier Output Power	7 watts, continuous duty
Antenna	AT-588/TRC-42
Landline	
Type	Field wire or spiral-four cable
Number of Circuits	2 (1 send and 1 receive)
Type of Circuits	Speech plus teletypewriter
Subscriber Package	
Power Requirements	
Consumption	1,186 Watts
Voltage	120 Volts AC
Frequency	60 Hz
Phase	Single
Communications Link to Radio Terminal Shelter	
Number of Channels	2 (1 send and 1 receive)
Frequency Range	130 to 150 MHz
Transmitted Carrier Output Power	7 Watts, continuous
Antenna	AT-588/TRC-42
Generator Set, Electric	120/208 Vac, 60 Hz, 10 kW, 3 phase

PHYSICAL DATA	LENGTH	WIDTH	HEIGHT	WEIGHT
Radio Terminal Shelter, S-141/G	144"	81"	81"	
Total System Weight:				
AN/TSC-20				18,179 lbs
AN/TSC-20A				19,449 lbs
PU-619/M (2 ea)	172"	83"		4,630 lbs

TRANSPORTABILITY

Air	1 ea C130B airplane or 2 ea CH47A helicopter
Land	1 ea M125 10 ton truck

PERSONNEL REQUIREMENTS

Installation	24 hours (terminal only)
Operation	8 men for terminal; 1 man ea for user package

B.1.4.2 AN/TSC-25 COMMUNICATIONS CENTRAL

The following material discusses the characteristics of the AN/TSC-25 Communication Central. This system while still operational is a design from the 1955 era.

B.1.4.2.1 AN/TSC-25 DESCRIPTION

The AN/TSC-25, Communications Central, consists of one S-141/G (modified) shelter which contains all transmitting, receiving and processing equipment. The shelter is air-conditioned for all-weather use. Two trailer mounted generators are furnished which provide the necessary power.

ISB, duplex operation permits simultaneous transmission and reception of both voice and teletype traffic. Upper and lower sidebands of 6 kHz bandwidth each provide two 3 kHz voice frequency channels. Two channels are normally used for long haul voice traffic, one channel for an engineering orderwire, and the fourth for up to eight teletypewriter circuits.

Transmit teletype traffic may be originated locally (one channel) or enter on any of seven subscriber lines. The local and two subscriber circuits may be link-encrypted. In addition to space diversity, channel diversity (tone diversity) may be employed during periods of adverse radio propagation. The use of tone diversity will limit the number of available channels to four. Two duplex voice circuits are available to local subscribers through a patch panel. Two transmitters use a sloping V antenna. Two sloping V antennas permit space diversity reception.

B.1.4.2.2 AN/TSC-25 MAJOR COMPONENTS

Shelter, Electrical Equipment, S-141/G	1 each
Radio Set, AN/FRT-53	2 "
Radio Set, AN/FRR-41	1 "
Teletypewriter Set, AN/FGC-25X	2 "
Multiplexer, AN/GGA-12	1 "
Demultiplexer, AN/GGA-13	2 "
Terminal, Telegraph, AN/FGC-77	1 "
Air Conditioner, 36,000 BTU/Hr	1 "
Security Equipment, TSEC/KW-7	2 "
Security Equipment, TSEC/KW-26	1 "
Generator, Gasoline, 10 kW, PU-619/M	2 "

B.1.4.2.3 AN/TSC-25 TECHNICAL,PHYSICAL & TRANSPORTABILITY DATA

TECHNICAL CHARACTERISTICS	TRANSMIT AN/FRT-53	RECEIVE AN/FRR-41
Frequency Range	2.0 to 32 MHz	0.5 to 32 MHz
Tuning Increments	Continuously tunable	Continuously tunable
Type of Transmission	ISB, DSB, AM, CW, FSK	ISB, DSB, AM, CW, FSK
Power Output	1 kW (PEP)	
Sensitivity		3 microvolts for 10 dB (S&N)/N
Antennas (less Masts)	Sloping V or doublet	2 sloping V
Generators (AC)	2 ea (CE-105 AC/ WK8) 15 kVA diesel engine or 2 ea 10 kVA diesel engine. Each generator supplies 120/208 V, 60 Hz, 3 phase, 10 kVA	

PHYSICAL DATA	LENGTH	WIDTH	HEIGHT	WEIGHT
Shelter, S-141/G	261"	99"	107"	10,450 Lbs
PU-619/M				4,630 "

TRANSPORTABILITY

Air	1 ea C130B airplane, or 2 ea CH 47A helicopter
Land	1 ea 2 1/2 ton truck

B.1.4.3 AN/TSC-38B HF COMMUNICATIONS CENTRAL

The AN/TSC-38B Communications Central is of the late 1950 design era. A total of 38 systems are in existence today. Eighteen are assigned to the Army and twenty are assigned to Air Force. Twelve AN/TSC-38B Communication Centrals are under the control of the Join Chiefs of Staff as contingency terminals. Figure B-2 shows the AN/TSC-38B site plan.

B.1.4.3.1 GENERAL DESCRIPTION

The AN/TSC-38B Communications Central is an air or land transportable system. It provides complete radio and wire line communications terminal facilities to both telephone and teletypewriter wire line sbuscribers. The entire system is contained in Communications Central Group AO-7998/TSC-38B and Communications Support Group AO-8036/TSC-38B.

The AO-7998/TSC-38B uses shelter, electrical equipment S-414/TSC-38B to house all the operating equipment necessary for limited system operaton. The OA-8036/TSC-38B uses a pallet to carry the generator sets and antenna equipment required for full system capabilities.

The AN/TSC-38B has two separate radio terminals, one primary and one secondary. The primary radio terminal has a 10 kW power output and two receivers operating in space diversity with sloping V antennas. The secondary radio terminal has a 1 kW power output and receiver with whip antennas. Each radio terminal provides up to four duplex voice frequency channels.

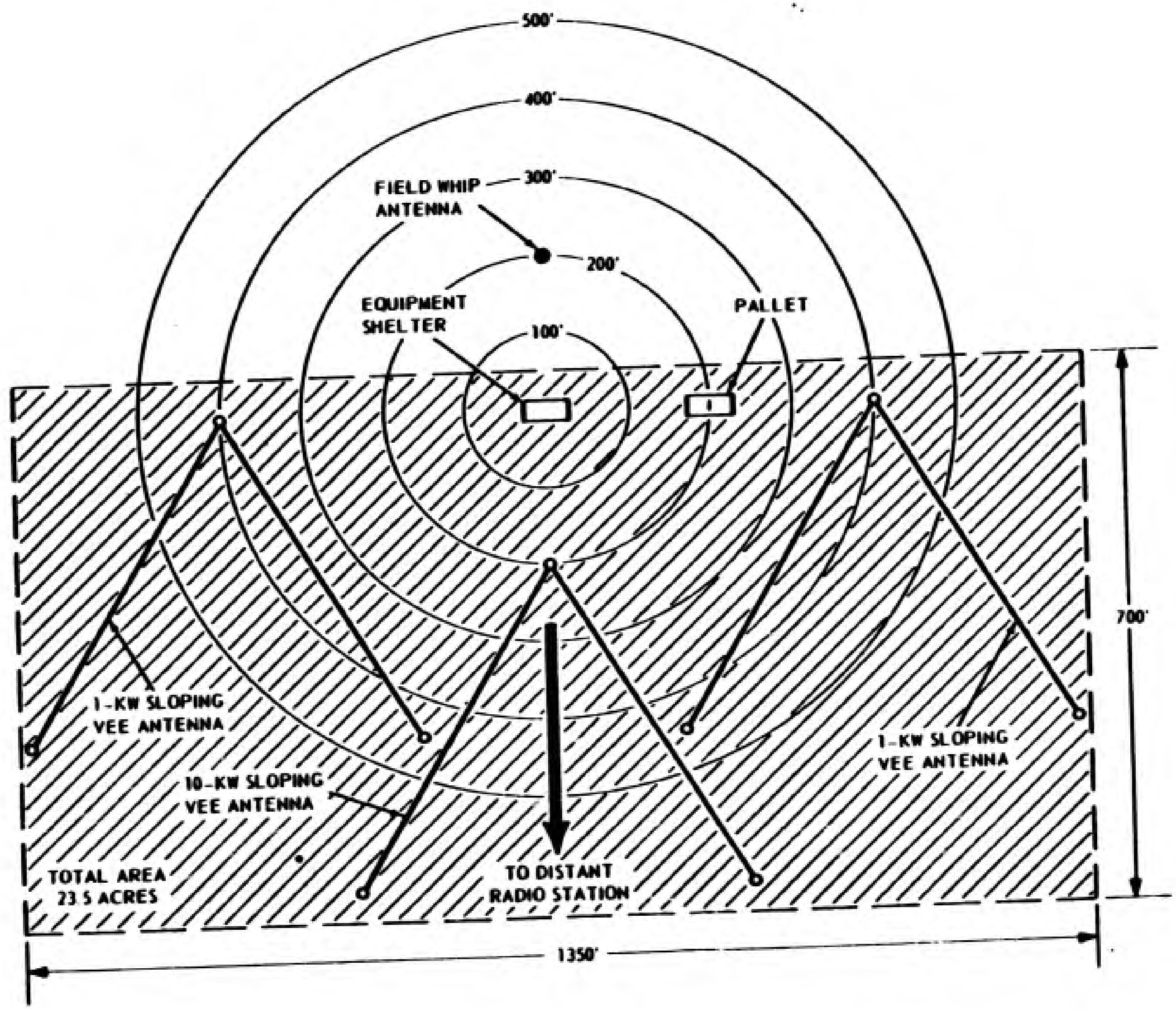


FIGURE B-2 AN/TSC-38B SITE PLAN

B.1.4.3.2 OPERATIONAL CHARACTERISTICS

Through use of system control facilities equipment, any radio circuit may be connected to any wire line subscriber for communication purposes. Three of the twelve telephone wire lines are implemented in such a way that these subscribers may exercise remote control of the primary or secondary radio terminals. Frequency and operational modes may be selected on a preset basis, or individually controlled after the AN/TSC-38B system operator has placed the desired radio terminal in the remote control mode.

The teletypewriter facilities effectively provide three voice frequency telegraph terminals (VFTG). A 16-channel VFTG is associated with the primary radio terminal, and a 2-channel VFTG is arranged for use with either radio terminal. A single channel wideband VFTG is arranged for use with either radio terminal. One of the radio-derived voice channels is used for each VFTG.

Two duplex secure teletypewriter terminations are also provided. These terminations may be patched into the system and used on any of the VFTG terminal channels.

Primary power for the AN/TSC-38B is provided by two gas turbine generator sets located on the pallet. However, provisions are included within the equipment shelter to permit use of other generator sets or standard commercial power. Power for the AN/TSC-38B is applied to two buses. The non-technical bus supplies power to the air conditioner and frequency changer. The remainder of the system is supplied power by the technical bus.

B.1.4.3.3 TERMINAL CHARACTERISTICS

Radio Subsystem	
Primary Radio Terminal	
Frequency Range	2 to 29.9 MHz
Tuning Increments	100 Hz steps
Frequency Stability	1 part in 10^8 per day
Tuning	Automatic
Control	Automatic from: Local switch select Local frequency shift keying (FSK) dial pulse select. Remote FSK dial pulse select/push-to-talk (PTT) over remote 2 wire or 4 wire telephone line

Power Output	10 kW
Receivers	Two, space diversity
Frequency Separation	Receivers operate within 10 percent of transmitting frequency
Channelization	Four independent 3 kHz channels in a 12 kHz spectrum
Antennas	
Transmit	One sloping V antenna (10 kW)
Receive	Two sloping V antennas (1 kW)

Secondary Radio Terminal

Frequency Range	2 to 29.9 MHz
Tuning Increments	100 Hz steps
Frequency Stability	1 part in 10^8 per day
Tuning	Automatic
Control	Automatic from: Local switch select Local FSK dial pulse select Remote FSK dial pulse select/PTT over 2 wire or 4 wire telephone line
Power Output	1 kW
Receiver	One
Frequency Separation	Receiver operates within 10 percent of transmitting frequency
Channelization	Four independent 3 kHz channels in a 12 kHz spectrum
Antennas	
Transmit	36 foot whip (shelter mounted)
Receive	36 foot whip (remote tripod mounted)

Telephone Subsystem

Type	Automatic dial
Connection Plan	4 wire
Number of Lines	20
Loop Operation	Common battery
Loop Voltage	28 Vdc nominal
Internal Termination	600 ohm balanced
Operator Assist	Dial Service Assist (DSA) position
Line Terminal Units	12
Type Subscriber	4 wire FSK dial, FSK PTT (3) 2 wire FSK dial, FSK PTT (3) 4 wire DC dial (12) 2 wire DC dial (12) 4 wire common battery (CB) manual (12) 2 wire CB manual (12) 4 wire local battery (LB) ringdown (12) 2 wire LB ringdown (12) 4 wire switchboard trunks (12) 2 wire switchboard trunks (12) 4 wire FSK dial switchboard trunks (3) 2 wire FSK dial switchboard trunks (3) Note: Any combination of 12 lines accepted without exceeding 3 FSK subscribers

Nonsecure Data Sybsystem	
Primary VFTG Terminal	
Number of Channels	4 wire full duplex (16)
Channel Frequencies	425 to 2,975 Hz
Frequency Shift	Nominally ± 42.5 Hz
Mode of Operation	Space diversity and frequency
Channel Keying Speed	60 to 100 words per minute (WPM) teletypewriter capability
Secondary VFTG Terminal	
Number of Channels	4 wire full duplex (2)
Channel Frequencies	2,125 and 764 Hz
Frequency Shift	Nominally ± 42.5 Hz
Mode of Operation	Non-diversity (normal), 1-channel in-band frequency diversity
Channel Speed	60 and 100 WPM teletypewriter capability
Wideband VFTG Terminal	
Number of Channels	4 wire full duplex
Channel Frequency	2,000 Hz
Frequency shift	Nominally ± 42.5 Hz
Mode of Operation	Non-diversity with secondary radio terminal, space diversity with primary radio terminal
Channel Speed	60 and 100 WPM teletype capability and output
Test Message Generator	
Power Distribution and Lighting Subsystem	
AC Converter	1
Inverter	1
Input	42 Vdc

Output	Regulated 28 Vdc 120 Vac 3 phase, 4 wire, 60 Hz 120 Vac single phase 60 Hz
Utility Subsystem	
General Sets	Two (60 kW primary power) 120/208 240/416 Vac, 3 phase, 4 wire, 400 kHz, 0.8 power factor
Air Conditioner	1
Cooling Capacity	27,000 Btu/hr at 124°F ambient and 90°F dry bulb, 75°F wet bulb return air
Heating Capacity	9 kW (30,735 Btu/hr) in two steps
Air Quantity	Approximately 935 cubic feet per minute (includes 100 cubic feet per minute fresh air) at 0 inch static pressure
Input Power	208 volts, 3 phase, 400 Hz, 30 amperes
Frequency Converter	1
Input	
Voltage	208/120 Vac, ± 10%, 3 phase, 4 wire, Wye-connected
Frequency	47 to 63 Hz and 380 to 420 Hz
Output	
Voltage	120/208 Vac + 15%, -10%, 3 phase, 4 wire, Wye-connected
Frequency	400 Hz

PHYSICAL DATA	LENGTH	WIDTH	HEIGHT	WEIGHT
CE Shelter	267"	99"	107"	12,620 Lbs
60 kW Generator, (with dolly)	243"	96"	101"	12,805 "
RLP Antennas	145"	43"	53"	2,200 "
Maintenance (S-280) Shelter	267"	99"	107"	9,840 "
Connex	96"	72"	72"	4,500 "

TRANSPORTABILITY

Air	2 ea C 130 or 1 ea C5A airplane
Land	2 " 5 ton tractor or 2 ea 2 1/2 ton truck

PERSONNEL REQUIREMENTS

Installation	10 men, 4 hours each
Operation	10 men

APPENDIX B-2

NAVY HF EQUIPMENTS

B.2 NAVY HF RADIOS AND EQUIPMENTS

This section describes basic Navy HF equipments that can be assembled in various numbers to form a shipboard, submarine, or fixed station. Table B-3 summarizes the Navy HF equipments.

B.2.1 HF RADIO RECEIVER R-1051/URR

The R-1051/URR receiver is designed, developed and manufactured in accordance with Military Specification MIL-R-23637G (EC) dated 28 October 1977. It is designed for use in surface ship, submarine, or fixed shore installations. The following summarizes the salient features of the receiver:

Receiver Type	Triple Conversion, Super Hetrodyne
Frequency Range	2 to 30 MHz
Tuning Increment	100 Hz synthesizer with continuous tuning between 1000 Hz increments
Number of Channels	280,000
Frequency Control	Digital Synthesizer referenced to 5 MHz internal or external standard
Frequency Stability	1 X 10^8 per day
Operating Modes	LSB, USB, ISB, AM, CW and RATT
Sensitivity 10 dB (S+N)/N	
SSB Modes	0.6 Microvolts
CW & RATT	0.9 Microvolts
AM Mode	3.0 Microvolts
Input Impedance	50 Ohms
Reliability	2000 Hrs MTBF
Temperature Range	
Operating	0 to 50°C(32°to 122°F)
Storage	-62 to + 75°C
Power Consumption	70 Watts
Primary Power	115VAC, single phase, 48 to 450 Hz
Image Rejection	90 dB
Audio Output	(600 ohm balanced or unbalanced remote output load) 60 milliwatts minimum
Audio Distortion	< 2%

NAVY SHIP/SHORE HF RADIOS

EQUIPMENT NOMENCLATURE	FREQUENCY (MHz)	NUMBER OF CHANNELS	TUNING	TYPE OF SERVICE OR MODE	TRANSMIT POWER	ANTENNA	MATCHING UNIT OR COUPLER	SECURITY	USER	PLANNING RANGE	WEIGHT	SIZE
AN/URC-35	2 to 30	280,000	Digital	LSB USB AM CW	100W 100W 25W 50W		CU-937( )/UR		General purpose surface ships Fixed shore installations Amphib. landing craft		218 lbs.	5.44 ft^3
AN/URT-24( )	2 to 30	280,000	Digital	LSB USB ISB AM CW RATT ISB-RATT	100W 100W 100W 25W 50W 50W 50W		CU-937( )/UR		Surface Ship Submarine Fixed shore installations		185 lbs.	5 ft^3
CU-937( )/UR	2 to 30	Continuous	Remote Controls on RF Amplifier AM-3007	LSB USB ISB AM CW RATT	150W	15,25,35 Foot Whip			Surface Ship Fixed shore installations		30 lbs	1.83 ft^3
Transmitter Exciter T-817( )/UR	2 to 30	280,000	Digital	LSB USB ISB AM CW RATT	250MW 250MW 250MW 62.5MW 125MW 125MW				Surface ship and fixed shore installations		75 lbs	1.3 ft^3
Receiver R-1051( )/UR	2 to 30	280,000	Digital	LSB USB ISB AM CW RATT	N/A	N/A	N/A		Surface ship Submarine Fixed shore installation		91 lbs	1.5 ft^3

Height	7 In. (17.75 cm)
Width	17 3/8 in. (44.13 cm)
Depth	18 1/2 in. (47 cm)
Weight	75 Lbs (34 kb)
Manufacturer	Stewart-Warner Corporation Chicago, Illinois

B.2.2 HF TRANSMITTER AN/URT-24

This transmitter was designed and manufactured in accordance with Specification MIL-T-24038D(EC), 28 October 1977. It can be used for surface ship, submarine or in fixed shore installations. The following data summarizes the operating features of the AN/URT-24:

Frequency Range	2 to 30 MHz
Tuning Increment	100 Hz Synthesizer
Frequency Stability	1 X 10^8 per day using T-827G/URT internal 5 MHz Standard
Operating Modes	AM, CW, USB, LSB, RATT & simultaneous ISB telephone and RATT
RF Power Output	
SSB & AM	100 Watts PEP
CW & Teletype	50 Watts average into a 50 ohm load Automatic power limiting for VSWR 1.1
Keying Rate	80 bps RATT 32 bps CW Selectable ± 85 or ± 425 Hz. RATT FSK
Audio Input	30 ohm local, 600 ohm remote. Audio impression allows input levels to T-827G/URT as great as 20 dB above standard input level.
Antenna	Whip 15, 25, or 35 ft. with a standard 12 wire remote control system using up to 3 radio control sets.
Reliability	C-1138/UR 500 Hrs. MTBF
Primary Power Source	115V AC; single phase 48 to 420 Hz

Power Consumption	500W Max. transmitting 120W Standby
Temperature Range	0 to 50°C operating -62 to 75°C Storage
Relative Humidity	90% continuous duty cycle
Height	17 1/2 in. (44.5 cm)
Depth	19 3/4 in. (50 cm)
Width	18 7/8 in. (48 cm)
Weight	225 Lb. (102 kg)
Manufacturer	Stewart Warner Corp., Chicago, IL

B.2.3 <u>HF RADIO SET AN/URC-35</u>

The AN/URC-35 is a digitally tuned transceiver intended for general purpose voice and CW communications. It can be used in surface ships, fixed shore installations, amphibious landing craft, vehicles, and aboard ship as an emergency radio. This radio transceiver was designed and manufactured in accordance with Military Specification MIL-R-287076(EC), 28 October 1977. The following data provides operating characteristics of the transceiver.

Frequency Range	2 to 30 MHz
Tuning Increment	100 Hz, Synthesized
Frequency Stability	1 X 10^{8}
Operating Modes	USB, LSB, AM, CW, RATT
Keying Rates	32 bps CW Mode 80 bps RATT Mode
Transmit Power	
SSB	10W PEP
AM	25W Carrier
CW	50W Carrier
Audio Input	30 Ohm local, 600 Ohm remote Audio compression allows input levels as great as 20 dB above standard input level. SSB 250 mW PEP, AM 62.5 mW carrier
Antennas	35 Foot Whip 25 Foot Whip AT-1047/U

<u>Noise</u>	With the audio input terminated in 600 Ohm, No audio input, transmitter terminated in 50 Ohm Key down condition - 37 dBM Key up condition - 115 dBM 1W a 3 KHz Bandwidth
Intermod Distortion	IMP 35 dB below either tone of a two tone. RF envelop at 250W PEP
Opposite Sideband	60 dB below a single tone output of 62.5 mW
Suppression	
Carrier Suppression	50 dB below a 62.5 mW tone
Harmonic Suppression	45dB below a single 62.5 mW tone
Power Supply Hum	45dB below an RF output of 62.5 mW 1000 Hz tone
Frequency Response	Less than 1 dB variation 300 to 3500 Hz
Primary Source	115V AC; 48 to 420 Hz or 24 to 30V DC
Power Consumption	500W max at rated transmit power
Operating Temperature Range	28°C to +50°C
Humidity	0 to 100 Percent
Reliability	MTBF 500 Hrs.

<u>Receive Mode</u>

Sensitivity

Mode	CW	AM	USB/LSB
IF Bandwidth (KHz)	0.4	6.0	3.0
Sensitivity Micro-volts	0.45	6.0	1.2

<u>Selectivity</u>

<u>USB/LSB MODE</u>

Pass Band	-3dB	300 to 3500 Hz
	-60dB	carrier to ± 5100 Hz
Ripple	3dB	Peak to Valley

AM MODE

Pass Band — -3dB ± 3500 Hz

Ripple — 3dB Max

-60dB ± 9.5 KHz

CW MODE

Pass Band — -3dB ± 200 Hz

-60dB ± 500 Hz

Ripple — 3dB Max.

Max Undistorted Output — RF input 1000 Microvolts, undistorted output 60 mW into a 600 Ohm load

Signal to Hum — All Modes 45dB with 6mW standard output

Manual gain — Provide 125 dB variation in over all amplifier carrier

AGC — Maintain audio output within ± 3dB for RF input variation from 5 to 100,000 microvolts

RF Input Protection — Protect the receiver against 100V RMS open circuit input voltage

DIMENSIONS & WEIGHTS

DIMENSIONS AND WEIGHTS

UNIT	WIDTH IN. (cm)	DEPTH IN. (cm)	HEIGHT IN. (cm)	WEIGHT Pounds (Kg)
Receiver Transmitter RT-618 ( )/UR	17 3/8 (44.13)	18 1/2 (47.0)	7 (17.75)	75 (34.0)
RF Amplifier AM-3007 ( )/URT	17 3/8 (44.13)	16 1/2 (42.5)	7 (17.75)	80 (36.4)
Shock/Vibration Mount MT-3761/UR	19 3/4 (51.0)	16 3/4 (43.2)	3 5/8 (9.35)	17 (7.52)
Antenna Coupler CU-937 ( )/UR	12 (30.5)	22 (56.0)	12 (30.5)	30 (13.6)
Remote Control Unit C-9044 ( )/URC-35	8 (20.3)	6 (15.2)	6 (15.2)	6 (2.72)
Interconnection Box	11 1/2 (28.2)	8 (20.3)	5 1/2 (14.0)	10 (4.54)

B.2.4 HF TRANSMITTER T-827 ( )/URT

Military Specification MIL-T-23645F(EC), 28 October 1977 covers the transmitter (exciter) T-827 ( )/URT and associated accessories. This equipment is digitally tuned, intended for general purpose voice, CW, and RATT communications. It has been designed for surface ship, submarine, or fixed shore installations. The T-827 ( )/URT is normally used as an exciter for linear power amplifiers in the AN/URT-23 ( ) or AN/URT-24 ( ). The following delineates salient operating characteristics of this equipment.

Frequency Range	2 to 30 MHz
Tuning Increments	100 Hz synthesizer controlled
Number of Channels	280,000
Frequency Selection	Digital
Frequency Stability	1 X 10^8
Operating Mode	LSB, USB, ISB, AM, CW, RATT (Single or Multichannel) ISB/RATT (LSB Audio/Single Channel Teletype USB)
RF Outputs	
USB/LSB	250mW PEP
ISB	250mW PEP
CW/RATT	125mW Carrier
AM	62.5 mW Carrier
Maximum RF Output	250mW PEP before limiting
Intermod Distortion	All intermodulation products 35dB below either of two equal tone envelop at 250mW PEP
Harmonic Suppression	Second harmonic output 40dB below a single tone output of 62.5 mW. All other harmonics greater than 45dB.
Carrier Suppression	In USB and LSB, the carrier suppression shall be greater than 50dB below a 62.5 mW single tone output
Opposite Sideband Suppression	The opposite sideband shall be 60dB below a single tone level of 62.5 mW

RATT Keying		Keying speeds of 80 bands using FSK frequency shifts of 850 Hz or 170 Hz centered at 2000 Hz.
Frequency Drift		After initial stabilization period (48 Hrs) drift rate shall not exceed 1×10^8 per day. Long term drift shall be less than 2.5×10^{-9} per day over a period of 60 days.
<u>Response</u>		
SSB	3dB	300 to 3500 Hz
	20dB	50 to 4000 Hz
Peak to Valley		< 3dB
Prime Power Source		115V AC, 48 to 420 Hz, Single Phase
Power Consumption		< 70 Watts
Size and Weight		Width 17 3/8 in (44.13CM) Depth 18 1/2 in (47.0 CM) Height 7 in (17.76 CM) Weight 75 lb (34 kg)

B.2.5 <u>HF ANTENNA COUPLER CU-937 ( )/UR</u>

Military Specification MIL-A-23547G(EC), 28 October 1977 delineates the design requirements and characteristics of antenna coupler CU-937( )/UR. This is a remotely tuned coupler which may be used for surface ship and fixed shore installations. The coupler provides a means to match 15, 25, or 35 foot (4.572, 7.650, or 10.698 meter) whip antennas over the 2 to 30 MHz frequency range. The coupler is designed to handle 100 peak envelop power outputs of radio sets (AN/URC-35 or radio transmitter AN/URT-24. The following are salient characteristics of the coupler.

Frequency Range	2 to 30 MHz
Method of Tuning	Course tuning is remote from a tuning code generated by RF amplifier
Equipment Arrangment	CU-937( )/UR is installed at the base of the associated antenna. Separation of antenna and coupler shall not exceed 91 meters.

Modes of Operation	LSB, USB, ISB, AM, CW, RATT
VSWR	The tuned VSWR when measured at the high power amplifier output is less than 1.5:1
RF Power	The coupler is capable of handling 100 Watts PEP
Primary Power Source 1	22 to 30 Volts DC
Reliability	MTBF 16,000 Hours
Temperature Range	MIL-E-16400 Class 2
Humidity	100%
Size and Weight	Width 12 in (30.5 CM) Depth 22 in (56 CM) Height 12 in (30.5 CM) Weight 30 lb (13.6 kg)

APPENDIX B-3 AIR FORCE HF IMPROVEMENT PROGRAM, SCOPE SIGNAL NET, AND AN/TSC-60 FAMILY OF HF RADIOS

B.3 AIR FORCE HF EQUIPMENTS AND PROGRAMS

This section discusses the Air Force HF programs as defined by the Air Logistics Command Assistant HF Program Manager at McClellan AFB, Sacramento, CA. Two major HF programs that the Air Force is presently pursuing are SCOPE SIGNAL and GOR-01-78. Scope Signal will provide Strategic Air Command Commanders positive control of globally deployed deterrentforces using SSB HF communication. GOR-01-78 defines the AF HF improvement program. The AN/TSC-60 air traffic control system defines a typical family of Air Force tactical ground HF radios.

B.3.1 GOR-01-78

GOR-01-78 is discussed in this report because it presents an insight into the Air Force HF equipment status and it provides some insight as to the Air Force intentions.

In 1978, the Air Force analyzed their HF equipments status and came to the conclusion that:

1. Their HF radios were old (in some cases 30 years old).
2. Support of the equipment was no longer feasible.
3. The equipments were no longer economical to maintain.
4. The AF has a need for a reliable communication for command and control of tactical and strategic communication.

Based on this evaluation, the Air Force prepared GOR-AFLC-01-78 which defined the AF HF communications requirements. Based on the GOR PMD (Program Management Directive) PDM-USAF R-Q9011(4), 1 March 1979, and PAD (Program Acquisition Direction) PAD AFLC-LOA-001 (25) were prepared and circulated through the AF staff for comment, and approval. Based on these directives the AF HF improvement plan will be initiated to upgrade the AF HF communication radios for vehicular transportable, backpack transceiver, fixed receiver, fixed transmitter and fixed transceivers applications. The following tables are a summary of the Air Force analysis of their present inventory and status of HF radio equipments presented in GOR-01-78.

Table B-3-1 Vehicular/Transportable HF Radio Equipments

PRESENT EQUIPMENTS	DESIGN ERA	SUGGESTED REPLACEMENT
AN/MRC-117	1956	
AN/GRC-158	1957	
AN/TRC-75	1956	AN/PRC-105
AN/TRC-89	1956	
AN/TRC-146A	1958	
AN/TSC-15	1959	AN/TSC-60
HF-113	1958	
MRC-95	1957	
AN/GRC-157	1964	
AN/GRC-106	1964	

Total quantity of Air Force inventory - 313

4 Equipments	Marginally supportable
6 "	Not supportable

Table B-3-2 Backpack Transceivers

PRESENT EQUIPMENT	DESIGN ERA	SUGGESTED REPLACEMENT
AN/PRC-47	1956	AN/PRC-104
AN/PRC-74	1956	AN/PRC-104
AN/PRC-74B	1956	AN/PRC-104

Total quantity of present equipment in use - 918, Supportable - None.

Table B-3-3 Fixed Receivers

PRESENT EQUIPMENT	DESIGN ERA	SUGGESTED REPLACEMENT
AN/FRC-30	1955	R-390
AN/FRR-61	1961	R-390
HC-130	----	R-390
AN/FRR-70	1964	R-390
HC-150	----	R-390

Number of receivers in use 23, Supportable - None.

FIXED TRANSCEIVERS

PRESENT EQUIPMENT	DESIGN ERA
AN/GRC-154	1965
KWMZ-2A	1958
KWT-615	1956
SC-901X	1963
SC-901XA	1963

Number of transceivers in use - 2015, supportability marginal. The average age of the equipments shown in the tables is 23 years. The number of systems shown represents a significant sunk cost. The number of equipments in use is 3,485. A few replacement equipments were indicated. There was no schedule or cost data provided for the total program. As indicated in the tables, a major problem appears to be supportability. As a rough estimate, and if the Air Force replaces all the radios, it is conceivable that the total program could cost on the order of $250 million.

Basically, the Air Force procurement plans are to purchase off-the-shelf equipment and minimize modifications to meet the user requirements. The Air Force is stressing modular design and commonality to minimize life cycle costing. The use of off-the-shelf equipment would tend to shorten the program schedule, reduce cost and have minimum impact on operability.

B.3.2 AF SCOPE SIGNAL PROGRAM

Scope Signal is a V phase program to provide SAC commanders positive control of globally deployed deterrent forces using HF single sideband communications. This system is discussed in this report because the architecture, system design, and implementation of the systems has been initiated. The program is in Phase III, and the procurement of equipment has been initiated. Scope Signal will replace the SAC Giant Talk network. In Phase II, three CONUS stations containing 27 HF/SSB equipment levels (receiver, exciter, linear power amplifier), a training facility, a software support facility and ALERT Panels at three designated command posts. The command posts will be located at McClellan AFB, Offutt AFB, and Andrews AFB. These command post act as gateway stations for connectivity to YAKUTA AB, Clark AB, March AFB, Elemendorf Station, Thule AB, Croughton AB and Mid-East Stations. Other phases of Scope Signal will consolidate, co-locate and replace AF ground stations in the Pacific, Europe, and CONUS.

B.3.2.1 NETWORK DESIGN

The network is designed so that under the direction of a single ALERT Panel Command up to 12 transmitters at 12 worldwide stations can be seized within 30 seconds and voice transmission of Emergency Action Messages (EAM) from National Command Authorities (NCA) to SAC airborne forces can be initiated. The network interfaces with AUTOVON/DCS system and utilizes dual tone multiple frequency (DTMF) signaling for control and interconnection of assets.

B.3.2.2 SCOPE SIGNAL STATION

Each Scope Signal Station is equipped with four-channel independent sideband receivers and exciters and 10 KW linear power amplifiers. All stations are identical in design and equipped for a maximum of twelve levels of HF equipment. All levels of equipment are directly accessible through 200-line digital electronic switch (PBX) at each individual station. The major components of a typical station in the CONUS network include: the pre-programmed ALERT Panel at the designated Command Post for initiating the special signaling Alert functions; the electronic switch; local control facilities, HF radios; RF switching equipment, and extensive diagnostic equipments.

Three operator consoles (expandable to five) at each station are equipped to allow remote control of all radio equipment and monitoring the status of each transmitter and receiver. The operators also perform audio patching of transmitters and receivers for subscribers, by selecting appropriate conference bridges. The DTMF audio is extended to control the radio equipments. Associated equipment for voice operated switching (VOX) keys the transmitter and provides muting of the receiver audio.

Special features of the system design include extensive use of built-in test equipment (BITE) and remote diagnostics for on-line fault monitoring of the station equipment. Continuous digital sensors in the radio equipment identify and detect fault for display at BITE control consoles (CRT terminals) at the remote radio sites as well as at each operator's console. It is also possible for the operator to initiate a total system test function for actual measurements and CRT display of significant parameters including; exciter input level, transmitter output, transmitter antenna input power, transmitter antenna VSWR, receive signal level, receive signal plus noise-to-noise ratio, and received signal frequency off-set. All tests are under microprocessor control with measurements and indications displayed at the operator's CRT.

Distributed commercial microprocessors with high reliability were selected to perform the functions of BITE and remote control of the radio equipments.

Modular microprocessor systems will provide a software support facility to maintain each computer program configuration item.

B.3.2.3 SYSTEM AND EQUIPMENTS CHARACTERISTICS AND SPECIFICATIONS

The following delineates salient SCOPE Signal network performance characteristics:

- System Function - World Wide Alert Transmit Mission
- Station Availability - 0.995
- Station MTBF - 2,000 Hrs.

Network monitoring provides:

- Simple interface for operator initiation of system test.
- Automatic measurement of system parameters.
- Automatic RF loopback performance assessment.
- Early detection of circuit degradation.
- 95 Percent fault isolation to the card/module sub-assembly.

The following material delineates the HF communications equipment specifications.
Manufacturer:

COLLINS HF-8054/54A FOUR CHANNEL INDEPENDENT SIDEBAND HF RECEIVER

SPECIFICATIONS :

Electrical Characteristics

Frequency range	250 kHz to 29.9999 MHz
Tuning Steps	10 Hz with optional 1-Hz steps
Frequency stability	With temperature compensated crystal oscillator: Not more than 5×10^{-7} from 0 to +50°C (+32 to +122°F). Dr ft rate not more than 3×10^{-8} per week. High stability oven standard (optional): Not more than 1×10^{-8} from 0 to +50°C (+32 to +122°F). Drift rate not more than 3×10^{-8} per week.

	External standard (optional) 0.1, 1.0, or 5-MHz input. Stability same as external frequency standard
Frequency tune time	2 ms typical (5 ms maximum)
Sensitivity (SSB)	0.25 to 1.6 MHz, -2μV hard; 1.6 to 29.9 MHz, 0.7 μVhard (10 dB (s + n)/n).
Modes of Operation	ISB(A3A, A3J, A3B, A9B); AM (A3,A3H); CW (A1, A2).
Bandwidths	16 kHz, (AM, CW), 2.85 kHz (ea ISB channel) Optional filters available for AM, CW use includes 0.2, 0.5, 1.3, 6-kHz bandwidths.
ISB channel characteristics (ea channel) frequencies given are relative to carrier frequency)	2dB bandwidth, 250 to 3100 Hz; -60dB response. - 250 maximum +3550 minimum
Differential delay	500 μs max. differential delay, 600 to 2900 Hz.
Antenna input impedance	50Ω nominal; unbalanced
RF overload protection	Up to 100-V hard RF input
Audio outputs	Line - 600Ω, 0 dBm nominal, balanced Headphone - 600 , +10 dBm max. Speaker - 8 nominal, 2 W peak.
Squelch	Operates on audio signal-to-noise radio. Applicable to speaker output only.
AGC threshold	1 μV maximum
AGC control	6dB max rise in audio output for signal increase from 1 μV to 2V.
Primary power	100, 115, 215, 230 V AC ± 10%, single phase, 47 to 63 Hz; 100W, max.

Environmental Characteristics

Temperature	Operating, 0 to +50°C (+32 to +122°F). Non-operating, -57 to +71°C (-71 to +160°F). Test per MIL-STD-810C.
Humidity	0 to +95% without condensation to 50°C (+122°F). Test per MIL-STD-810C.
Altitude	Operating: 3,048m (10,000 ft), 0 + 50°C (+32 to +122°F); 4,572 m (15,000 ft), 0 to +25°C (+32 to +77°F). Non-operating: 12,192 m (40,000 ft), -57 to + 71°C (-71 to +160°F). Test per MIL-STD-810C.
Shock	Bench handling per MIL-STD-810C
Vibration	1.5g, 5.5 Hz to 55 Hz per MIL-STD-810C.

Physical Characteristics

Weight	20.4 kg (45 lb) max.
Mounting	EIA 19-inch rackmounting
Height	178 mm (7 in.)
Width	483 mm (19 in.)
Depth	574 mm (22.6 in.)

COLLINS HF-8014/14A FOUR CHANNEL INDEPENDENT SIDEBAND HF EXCITER

SPECIFICATIONS

Electrical Characteristics

Frequency Range	1.6000 to 29.9999 MHz
Tuning steps	100 Hz with optional 10-Hz and 1-Hz steps
Frequency Stability	With temperature compensated crystal oscillator: Not more than 5×10^{-7} from 0 + 50°C (+32 to +122.5°F Drift rate not more than 3×10^{-8} per wk.

Frequency Stability (Cont'd)	With high stability over standard (optional): Not more than 1 X 10^{-8} from 0 to +50°C (+32 to +122°F). Drift rate not more than 1 X 10^{-8} per week. With external standard (optional): 0.1, 1.0, or 5-MHz input. Stability same as external frequency standard.
Frequency tune time	2 ms typical (5 ms max.).
Modes of operation	ISB (A33, A9B, A3J), AME (A3H), CW (A1), reinserted pilot carrier (A3A).
ISB channel characteristics (ea channel) frequencies given are relative to carrier)	2dB bandwidth; 250 to 3100 Hz -60dB reponse; -250 Hz max, +3500 Hz minimum.
Differential delay	500 μs maximum differential delay, 600 to 2900 Hz.
Audio Inputs	600- line input, 0 dBm nominal, adjustable from -26 to + 10dBm.
Microphone input	Dynamic mike, -55 dBm front panel jack.
RF output	200 mW PEP minimum with 0-dBM input
Tune power output	100 mW PEP minimum
Pilot carrier	20 ± 1dB, adjustable over -13 to -23dB, referenced to rated output.
Carrier suppression	55dB below each tone of a 2-tone test signal at 200-mW PEP output.
Intermodulation	50dB below each tone of a 2-tone test signal at 200-mW PEP output.
CW mode frequency	Tuned (carrier) frequency. Audio sidetone provided.

Inband hum and noise	50dB below 200-mW output.
Peak Clipping	Peak clipping at IF frequency adjustable over 0- to 12-dB range
Primary Power	100, 115, 215, 230V AC ± 10%, single phase, 47 to 63 Hz Input power, 80W max.
Environmental Characteristics	
Temperature	Operating, 0 to +50°C (-71 to +160°F). Test per MIL-STD-810C.
Humidity	0 to +95% without condensation to 50°C (122°F). Testper MIL-STD-810C
Altitude	Operating: 3048 m (10,000 ft), 0 to +50°C (+32 to +122°F) 4572 m (15,000 ft), 0 to +25°C (+32 to +77°F). Non-operating: 12,192 m (40,000 ft), -57 to +71°C (-71 to 160°F). Test per MIL-STD-810C.
Shock	Bench handling per MIL-STD-810C.
Vibration	1.5 g, 5.5 to 55 Hz per MIL-STD-810C.
Physical Characteristics	
Height	178 mm (7 in.)
Width	483 mm (19 in.)
Depth	574 mm (22.6 in,)
Weight	20.4 kg (45 lb) max.
Mounting	EIA 19-inch rack mounting

COLLINS HF-8022 10-KW LINEAR POWER AMPLIFIER

SPECIFICATIONS

Electrical Characteristics

Frequency range	2.0 to 30.0 MHz
Power output	10-kW PEP or average
Rf input power	Not more than 100-mW PEP or average required for rated output.
Input impedance	50 nominal, 1.3 to 1 vswr max. (unbalanced)
Rf load impedance	50 nominal, 3 to 1 vswr max. (unblanced)
Bandwidth	16 kHz, 0.1 dB variation over 4-kHz segment
Intermodulation distortion	2-tone source: 40dB below either one of two equal tones at 10-kW PEP output.
Rf noise	At least 50 dB below either one of two equal tones at 10-kW PEP output
Harmonic attenuation	80dB below fundamental frequency into at 10 kW into 50 load.
Tuning Time	6 seconds nominal, 10 seconds max. after receipt of rf power.

Environmental Characteristics

Altitude	Operating: 0 to 3,048 meters (0 to 10,000 ft). Non-operating: 0 to 15,240 meters (0 to 50,000 ft).

Environmental Characteristics (Cont'd)

Temperature	Operating: -30 to +55°C (-22 to +131°F). Non-operating: -62 to +70°C (-78 to +158°F).
Humidity	0 to 95% to relative humidity
Vibration	5 to 15 Hz: 0.0762 cm (0.03 in) double amplitude or 1g, whichever is less.
Shock (without doors or trim panels)	3 impacts in ea direction in ea of 3 planes, except vertical from the top, for a total of 15 impacts. Ea impact at 15 g for 11-ms duration.
Cooling Air	A variable-speed, squirrel-cage blower provides sufficient cooling to entire power amplifier. Adequate air margin exists under all specified environmental conditions.

Physical Characteristics (without trim)

Width	16.8 cm (46 in.)
Height	175.3 cm (69 in.)
Depth	63.5 cm (25 in.)
Weight	754 kg (1660 lb).

Power Requirements

Power source	3 phase, 47 to 63 Hz
Line voltage	208, 225, 243, 360, 390, 422 ± 5% volts
Line load (at 10 kW average output)	23.0 kW at 0.95 pf

Options and Accessories

AC-8076	T/R relay
CA-8021	Side panel trim
CA-8023	Front doors trim
CA-8025	Top and rear trim
TS-8021	PA maintenance panel
TS-8022	Universal PA card extender

B.3.3 AN/TSC-60 FAMILY

The AN/TSC-60(V) series is a family of transportable HF communication facilities. Single-sideband communication modes include voice, tone modulated CW, multichannel VFTG TTY and Compatible AM.

The AN/TSC-60(V) is a 1970 design. It is part of the AF 407L Air Traffic Control System (ATCS). These transportable HF communication systems provide communication between the following sites - Direct Air Support Center (DASC), Control and Reporting Center (CRC), Control and Reporting Post (CRP) and Tactical Air Control Center (TACC). Deployment of the sites with respect to the FEBA are: DASC:0 to 5 KM CRC:50 to 100 KM, CRP:50-100 KM, and TACC nominally 1,000 KM. There have been 159 AN/TSC-60 systems manufactured. Presently, there is a design improvement program to upgrade the system using Rockwell/Collins HF-80 equipment.

B.3.3.1 AN/TSC-60 DESCRIPTION, OPERATION AND COMMUNICATION FEATURES

The systems of the AN/TSC-60(V) series provide 1, 2.5 or 10-KW power outputs in the AN/TSC-60(V) 1, 2, or 3 models, respectively. Each system is dual in that it includes two independent radios. In the AN/TSC-60(V)3, for instance, one radio has a 2.5 KW output, while the other can be either 2.5 KW or 10 KW. This versatile design allows tailoring of a system to meet mission requirements.

All AN/TSC-60(V) systems use state-of-the-art equipment that provides digital control, maximum interchangeability, reduced spares requirements, and ease of operation and maintenance. The equipment is designed to meet DoD standards and the requirements for TADIL-A operation.

All operation and maintenance functions of AN/TSC-60(V) systems can be conducted from the operator's console. The following operation functions can also be conducted from a remote control unit supplied with the shelter: on/off, mode and frequency selection, keying and voice modulation and FSK audio.

Radios and terminal equipment are housed in a S-141( )/G (Modified) transportable shelter that can be moved by fixed-wing aircraft (C-130 or larger), helicopter, 2.5-ton truck, or transporter.

Antennas and cables are contained on an MX-4521/TSQ-45 auxiliary pallet during storage or transportation. The external air conditioner is mounted on this pallet to meet air conditioning requirements which are minimized by venting the power amplifiers directly outside the shelter. Figure B-3 is a system diagram of the AN/TSC-60.

The AN/TSC-60(V) series can be operated in upper sideband, lower sideband, four channel multiplex, independent sideband, or compatible AM. Modes of operation include voice, speech-plus-TTY (85-Hz shift), CW, and up to 16 channels of 85-Hz-shift TTY. The systems can be operated simplex or duplex (switch selectable). Figure B-4 shows the audio frequency spectrum use.

By proper selection of modes, a wide variety of communications requirements can be met - from such minimum requirements as a single voice or CW channel to such maximum requirements as simultaneous full duplex operation of three speech-plus-TTY channels and 16 VFTG channels on one radio frequency and four speech-plus TTY channels on another. The radio functions can be controlled from the operator's console or from remote locations.

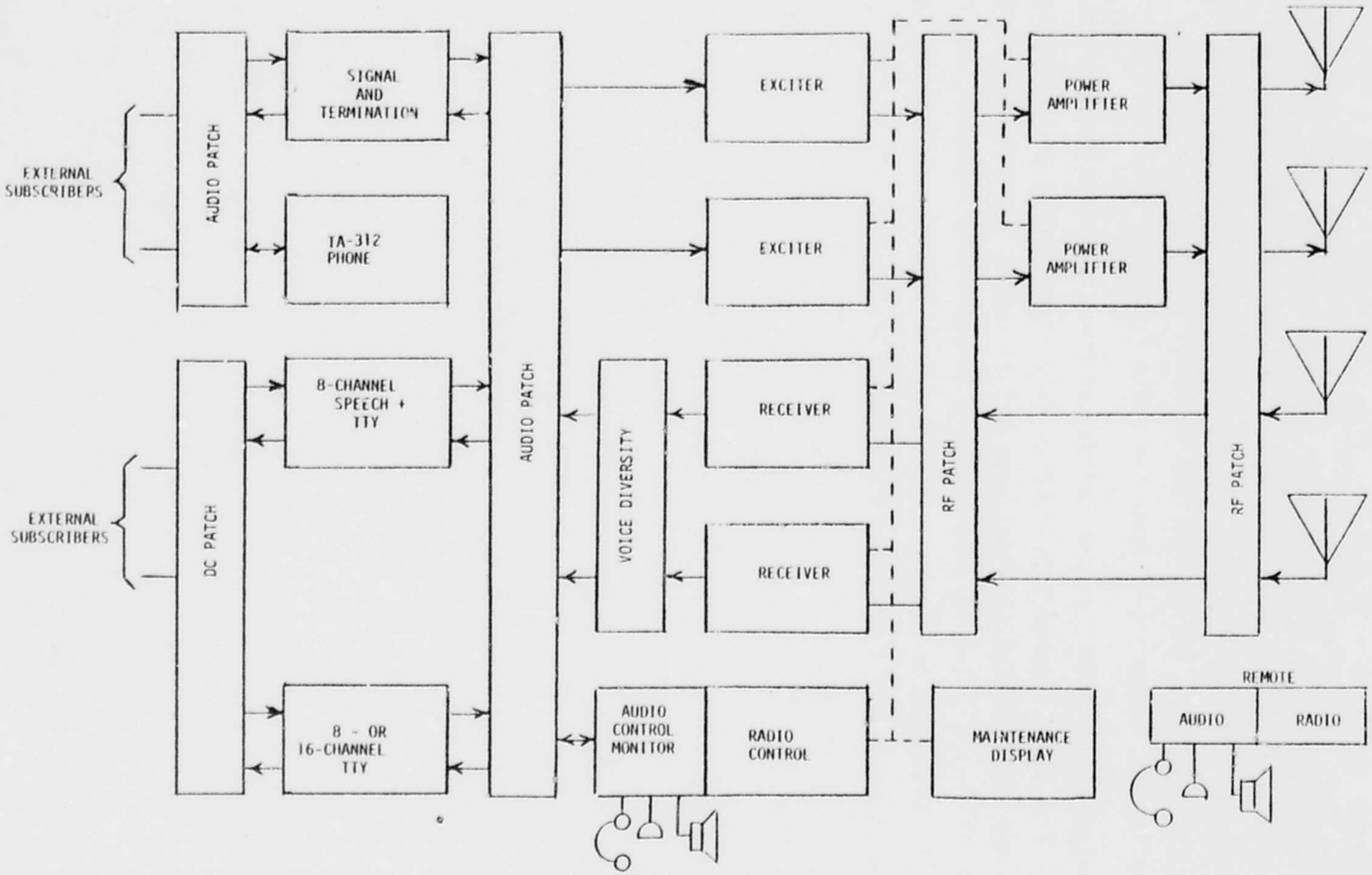


FIGURE B-3 - AN/TSC-60 SYSTEM CONFIGURATION

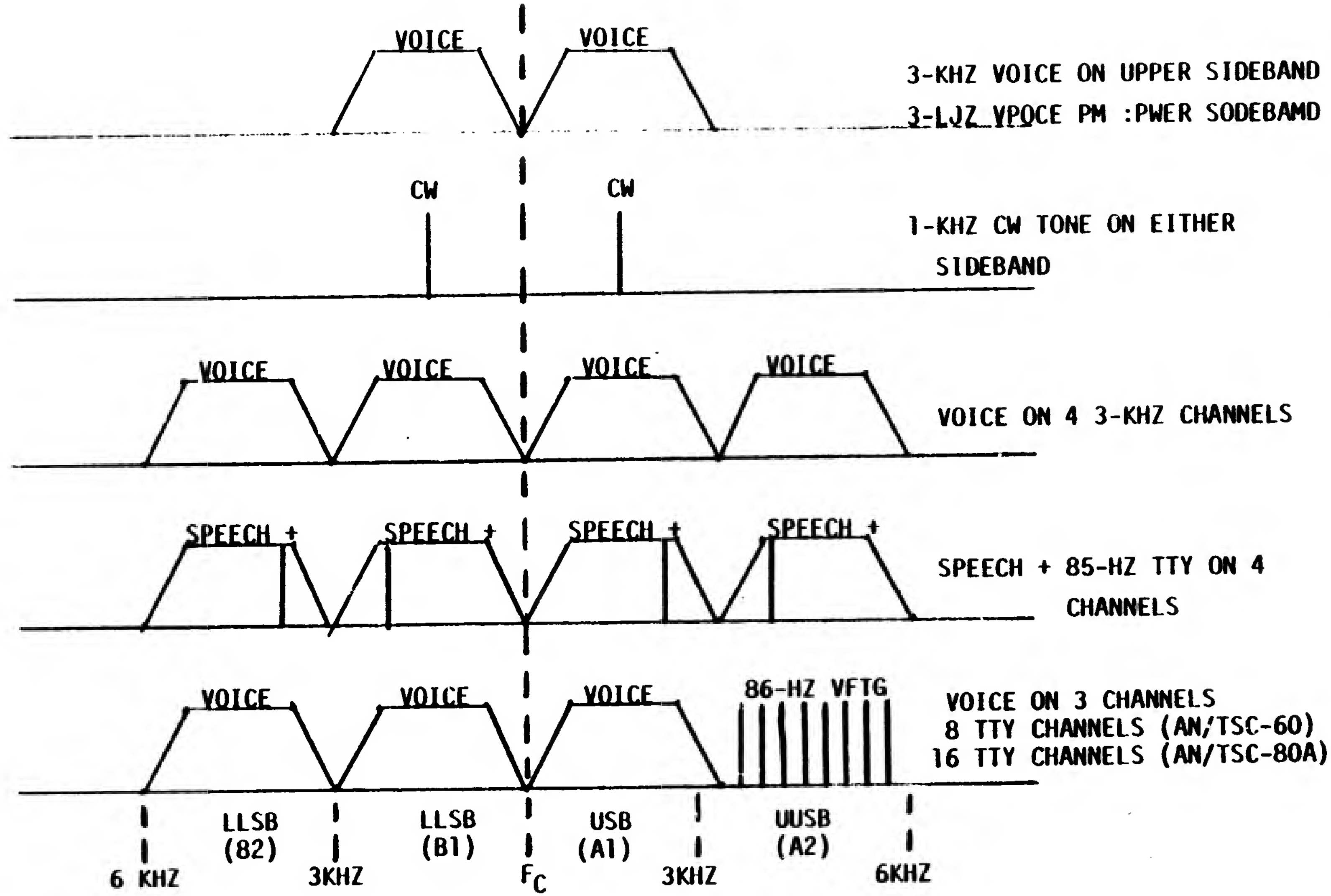


FIGURE B-4 - AN/TSC-60 CHANNELIZATION & DCS INTERFACE

FEATURES

- DCA CIR 330-175-1 HF Radio
- JCS PUBS 10 data radio (TADIL-A)
- DCA CIR 330-175-1 FSK TTY terminal
- Transportable antennas
- Remote control of radios
- General purpose telephone line terminal equipment
- Helo-lift weight
- Built-in digital performance monitoring
- 280,000 selectable RF frequencies in 0.1-kHz increments
- Two independent radios per terminal
- Four 3-kHz audio channels per radio
- Ease of maintenance
- High commonality among systems for reduced spares requirements
- Air-conditioned
- Rapid deployment/installation
- Space available for equipment expansion

B.3.3.2 AN/TSC-60 SPECIFICATION

The following material delineates the AN/TSC-60 operating specifications.

SPECIFICATIONS

GENERAL

- AN/TSC-60(V)1: Dual 1-KW transportable HF communication system.
- AN/TSC-60(V)2: Dual 2.5-KW transportable HF communication system.

- AN/TSC-60(V)3: 1 ea AN/TSC-60(V)2 system plus 1 ea OZ-11/TSC-60(V)3 10-kW power amplifier shelter and associated directional antenna
- Shelter: S-141( )/G (Modified)
- Auxiliary Pallet: MX-4521/TSQ-47
- Weight: (Estimated):

  AN/TSC-60(V)1: Shelter 1676 kg (3725 lb), pallet 840 kg (1866 lb)

  AN/TSC-60(V)2: Shelter 2482 kg (5516 lb) pallet 1277 kg (2839lb), antenna pallet 1321 kg (2935) lb)

  OZ-11/TSC-60(V)3: 10-kW shelter 1629 kg (3620 lb), pallet 1052 kg (2339 lb)
- Size (Outside Dimensions):

  Shelter: 2032 mm (80 in)w, 3607 mm (142 in)l, 2286 mm (90 in)h

  Pallet: 2057 mm (il in)w, 2743 mm (108 in)l, 1549 mm (61 in)h
- Transportability: Fixed-wing aircraft, helicopter, truck, rail, ship or dolly
- Power: 120/208 V ac 50/60- or 400-Hz, 3-ph, 4-wire
- Environment:

  Non-operating and Storage: -62° to +71°C (-80° + 160°F) to 15,240 m (50,000 ft)

  Operating: -54° to +52°C (-65° to 125°F) to 3,657.6m (12,000 ft)

AUDIO SYSTEM

- External Lines: 8 ea, 2- or 4-wire local battery lines
- Line Signaling (Ring Thru): 8 lines, 20 or 50 Hz
- Radio Signaling (Ring Thru): 8 lines, switchable to 1600 Hz, 2600 Hz, or an fm 2150/2450-Hz signal shifted at a 69-Hz rate
- Switching: All lines manually patchable to any radio channel at jackfield
- Control: Local/remote audio control/monitor panels
- Telephone: 1 ea TA-312/PT field telephone

VFTG TERMINAL EQUIPMENT

- Speech-Plus-TTY Terminal: AN/UCC-3(V)1 provides 8 speech plus 8 TTY channels (85-Hz shift) at 2805 ± 42.5 Hz
- TTY Terminal:

  AN/TSC-60(V)1: AN/UCC-3(V)2 provides 8 channels (85-Hz shift) VFTG (switchable to 4-channel diversity and split operation)

  AN/TSC-600(V)2: AN/UCC-3(V)3 provides 16 channels (85-Hz Shift) VFTG (switchable to 8-channel diversity and split operation).
- Data Circuits: All loops full-duplex compatible with 60/20-mA neutral or 20-mA polar DC circuits and 1275 ± 42.5-Hz VFTG audio circuits.
- Loop Supply: Loop battery provided for all lines, external battery operation is selectable.
- Switching: Audio and DC jackfields
- Control: Central test and monitor for all VFTG

RADIO SYSTEM

- Transmitters

  AN/TSC-60(V)1: 2 ea AN/GRT-17 exciter and OG-88 power power amplifier, 1-kW pep/avg rf power output

  AN/TSC-60(V)2: 2 ea AN/GRT-17 exciter and OG-90 power amplifier, 2.5-kW pep/avg rf power output

  AN/TSC-60(V)3: Same as AN/TSC-60(V)2 except that the output of one exciter can be applied to an OG-89 power amplifier, 10-kW pep/avg rf power output in the OZ-11/TSC-60(V)3 shelter

- Receivers: 2 ea AN/GRR-18, ssb and compatible am (selectable voice diversity)
- Channels: Four 3-kHz audio channels per radio
- Mode: Voice and data, TADIL-A compatible
- Frequency Range: 2.0000 to 29.9999 MHz
- Tuning: Automatic, 0.1-kHz increments, 280,000 frequencies
- Control: Local or remote up to .402 km (0.25 mile) with 10 wires per remote control unit (20-kHz bandwidth)
- Frequency Stability: 1 part in 10^8 per day
- Operation: Simplex/full-duplex per radio, VOX or PTT
- Maintenance: Continuous equipment status monitor display and fault isolation.

- Antennas:

AN/TSC-60(V)1:	1 ea transmit orthogonal
	1 ea receive orthogonal
	2 ea 9.75 m field-or shelter-mounted whips (one transmit/receive and one receive only)
AN/TSC-60(V)2:	1 ea transmit orthogonal
	1 ea receive orthogonal
	3 ea directional field-mounted antennas (transmit/receive)
OZ-11/TSC-60(V)3:	1 ea 10-kW directional field-mounted antenna

APPENDIX B-4

MARINE CORP

HF RADIO EQUIPMENTS

B-4 MARINE CORPS HF EQUIPMENT

This section of the report delineates the characteristics of Marine Corps HF communication equipments. The data on these systems were taken from the Landing Force Integrated Communications System (LFICS) architecture. (1 December 1978). This architecture lists 17 HF communications equipments utilized in LFICS. The equipments that will be emphasized here will be the AN/PRC-104, AN/PRC-105, AN/GRC-A3 and AN/MRC-138. These equipment feature the latest designs and all are relatively close to an operational capability. They have been designed as replacements to several of the equipments designated in the LFICS architecture. Salient features of these equipments are summarized in Table B-4.

B.4.1 RADIO SET AN/PRC-104

The AN/PRC-104 is a manpack HF radio that will be principally used by reconnaissance forces. It is possibly one of the latest designs in military HF equipments. The design for the radio is in the 1972 to 1975 time frame. The Marine Corps has designated this radio to replace the AN/PRC-47.

The AN/PRC-104 is a 20-watt transceiver and will be used by military forces engaged in reconnaissance missions to establish and maintain voice, CW, and encrypted voice communications with their headquarters, adjacent units and other conventional forces equipped with tactical single sideband (SSB) radio sets. These forces will be operating on foot in jungle, desert, coastal or mountainous terrain, sometimes located behind enemy lines. The radio set will be used in all types of weather and terrain and shall be capable of withstanding the shock encountered during parachute delivery or helicopter delivery where normal setdown is impractical.

The radio set will provide the necessary manpack communication capability in an ultra-lightweight package so that the operator of the equipment maintains maximum freedom of movement. In addition, the design shall emphasize simplicity of operation and maintenance. The radio set components consist of the basic receiver-exciter (RT-1209), power amplifier/coupler (AM-6874), portable whip antenna, detachable battery pack, audio accessories, and load-carrying kit.

TABLE B-4 MARINE CORPS HF RADIO

	FREQUENCY RANGE MHz	NUMBER OF CHANNELS	TUNING	TYPE OF SERVICE	TRANSMIT POWER	ANTENNA	MATCHING UNIT	SECURITY	USER	RANGE PLANNING	WEIGHT
AN/PRC-104	2-30	280,000	100 Hz STEPS	SSB UAB/ LSB Voice CW Encrypted Voice	20W	Whip 32 Ft Resonant Dipoles	Automatic Tuning	Secure Voice	Man Pack Reconnaissance	Ground Wave 40 Km	14.0 Lbs 6.4 Kg MTBF 2500 Hr MTTR 15 Min
AN/PRC-105	2-30	280,000	100 Hz STEPS	See AN/PRC-104	100W				Two Man Portable		
AN/MRC-138	2-30	280,000	100 Hz STEPS	See AN/PRC-104	400W				Vehicular		
AN/GRC-193	2-30	280,000	100 Hz STEPS		400W				Base-Station		

The receiver exciter (R/E) of the AN/PRC-104, RT-1209 will be used as the basic unit in development of the AN/PRC-105, AN/GRC-193, and AN/MRC-138. These HF radios have a higher transmit power capability of 100 watts, and 400 watts amplifier antenna coupler, and tuning unit must be provided.

The AN/PRC-104 has an Interim Operational Capability (IOC) for January 1981 with the First Marine Amphibious Forces. The following delineates the salient features of the AN/PRC-104:

Frequency	2 to 29.999 MHz fully synthesized
Channels	280,000 in 100 Hz steps
Temperature Range	-46°C to + 71°C-50°F to 160°F
Warm-up Time	5 seconds to reach frequency stability
Antenna Tuning	Automatic, 3 second average
Antenna	Whip, long wire, dipole, AS-2259 NVIS (Near Vertical Incident Skywave)
Reliability	MTBF 2500 hrs. MTTR 15 min.
Weight	14 Lbs (6.36Kg) with battery
Size	12 1/2 X 10 1/2 X 2 5/8 in. 31.75 X 26.67 X 6.655 cm
Operating Time with Battery	16 Hrs. 9:1 receive transmit duty cycle 5.5 ampere-hr., AgZn (silver zinc) re-chargeable
Operating Voltage	20 to 32 Vdc
Transmit Power	20 Watts PEP ± 2dB
Modes	Voice, Data, CW, LSB, USB
Data Rate	300 words/min TTY or burst CW
Intermodulation Products	28dB below two 20 watt equal tones
Harmonic Radiation	-60dB
Carrier Suppression	-45dB
Unwanted Sideband	-45dB
Hum and Noise	-55dB
Audio Input	-56dBM into 150 ohm voice, 0dBm into 600 ohm data

Output Protection	Infinite VSWR
Receiver Sensitivity	10dB SINAD, 1.4 microvolts, open circuit from 50 ohm source
Selectivity	
USB/LSB	3dB Bandwidth - 2500 Hz 60 dB Bandwidth - 6000 Hz
AGC	Maintain audio output 0 to 6dB input receive signal varies 100 microvolts to 0.3 volts
AGC Attack Time	30 milliseconds
AGC Release Time	750 milliseconds to 1.5 seconds max. for voice and CW
AGC Release Time Data Mode	60 to 130 milliseconds
Audio Distortion	For audio outputs between 5 and 0-1 milliwatts less than 5% distortion
Security	Park HILL

B.4.2 RADIO SET AN/PRC-105

The AN/PRC-105 uses the AN/PRC-104 receiver exciter unit RT-1209. The AN/PRC-105 is a two-man portable unit with a 100 watt PEP power output. The AN/PRC-105 weight is given as 30 pounds and the volume is 0.2 ft^3. Other than transmit power, weight, and size, the operating characteristics and modes of the AN/PRC-105 would be identical to the AN/PRC-104. The AN/PRC-105 will be used as a base station. Security will be provided using PARKHILL. The AN/PRC-105 is presently in full scale development and scheduled for completion in the FY 84/85 time frame.

B.4.3 RADIO SET AN/MRC-138

The AN/MRC-138 is a vehicular version of the AN/PRC-104. It will use the AN/PRC-104 receiver exciter unit RT-1209. The AN/MRC-138 provides reception and transmission in USB, LSB, CW and data modes. The AN/MRC-138 is scheduled field installation in June of 1980 and will replace the AN/MRC-83A. The following are the technical characteristics of the AN/MRC-138:

SYSTEM COMPONENTS:

1 Receiver-Transmitter, Radio: RT-1209/URC

1 Amplifier, Radio Frequency: AM-6645/MRC-138

1 Antenna: AT-1011/U

1 Coupler, Antenna: CU-2064/MRC-138

CHARACTERISTICS:

Frequency Range: 2 to 29.999 MHz tunable in 100 Hz increments
Modulation: SSB (selectable USB or LSB)
Modes: Voice, Teletype (FSK), data, CW
Tuning: automatic and remote
Power Output: 400 W (max)
Power Requirements: 22-30 VDC
Security:Parkhill (TSEC/KY-65)
Installation: vehicular
Number of Channels: 280,000
Bands: 8
Size: 1.81 ft^3
Weight: 101 Lbs.

B.4.4 RADIO SET AN/GRC-193

The AN/GRC-193 is an HF single sideband (SSB) radio set designed for shore installations. The set provides transmission and reception in USB, LSB, CW and data modes. The AN/GRC-193 will use the AN/PRC-104 receiver transmitter unit RT-1209. It is similar to the AN/MRC-138, but is ground mounted. The AN/GRC-193 is scheduled for field installation in June of 1980. It has been designated as a replacement for the AN/TRC-75. The AN/GRC-193 consists of the following components:

1 Amplifier: RF AM-6645/GRC-193
1 Antenna Coupler: CU-2064/GRC-193
1 Receiver-Transmitter: RT-1209/URC

The following are technical characteristics of the equipment:

Frequency Range 2 to 29.999 MHz tunable in 100 Hz increments
Modulation: SSB (selectable USB or LSB)
Modes: Voice, Data, TTY, CW, Secure Voice
Power Output: 400W (PEP)
Power Source: 22 to 30 VDC (PP-7333)
Security: PARKHILL
Installation: Fixed
Number of Channels: 280,000
Tuning: Automatic or Remote
Size: 1.81 ft^3
Weight: 101 Lbs.

B.4.5 COMMUNICATION SYSTEM AN/TSC-95

The TSC-95 will provide more reliable and efficient long-haul HF communication for a deployed MAGTF. Developmental efforts in the areas of high speed data modems and time diversity modems should ensure that either the 2,400 band TYC-5A Mobile Data Communications Terminal or lower speed teletypewriter circuits can be accommodated with significant performance improvement. The TSC-95 will be composed of a TRC-171; a shelterized HF communications central; and a TGC-46, a shelterized teletypewriter central.

Technical Characteristics:

Frequency Range: 2 to 29,999 MHz
Range: 0 to 2400 km (0 to 1500 miles)
Transmission: SSB (Selectable USB or LSB)
Modes: voice, DEPSK, FSK, CW
I/O Channels: one secure voice, two TTY, full duplex
Transmission Rate: TTY (75 or 150 band), data (2400 band)
Power: 10 kW

Replaces: TSC-15
Previous Nomenclature: HFCC
Requirement Documentation: Proposed ROC for HF Communications Central

B.4.6 COMMUNICATIONS CENTRAL AN/MRC-( )

The MRC-( ) is a complete two-way secure communication system for long distance, point-to-point and ground-to-air communications in the HF and UHF frequency bands. The MRC-( ) will perform a similar function to the MRC-87A with a GRC-193 in place of the TRC-75 and a PRC-75A in place of the PRC-41. MRC-( ) will provide ECCM protection in the UHF range.

Technical Characteristics:

Frequency Range: UHF, 225 to 399.93 MHz; HF 2 to 29.9999 MHz tunable 100 Hz increments
Transmission: UHF-AM, HF-AM, SSB
Modes: voice, FSK, CW, data
Channels: UHF-7,000 at 25 kHz spacing; HF-280,000 at 100 Hz increments
Power Output: 10 W max UHF, 200 W (pep) HF

Components:

1 RT-1209/URC

1 AM-6745

1 CU-2064

1 RT-976/PRC-75

1 Secure Voice Equipment: TSEC/KY-58

1 Secure Voice Equipment: TSEC/KY-65

Replaces: MRC-87

Requirement Documentation: ROC-CCC-111

B.4.7 RADIO SET AN/MRC-83A

The MRC-83A provides two-way voice, CW, and teletype communications in the HF band for vehicular configuration. It is vehicular mounted on truck, utility, 1/4 ton, 4 x 4, M151A2.

Technical Characteristics:

Frequency Range: 2 to 29.999 MHz, tunable at 1 kHz increments

Modulation: SSB (selectable USB or LSB)

Modes: voice, CW, FSK

Power Source: 115 VAC, 400 Hz 2.5 kW; 26 to 29 VDC, 10-135A

Weight: 4190 lb (with utility truck)

Size: 11.5'L x 5.0'W x 4.9'H (282 ft^3); 1/2 ton vehicle, 11.5'L x 5.0'W x 6.3'H (362 ft^3)

Installation: vehicular

Number of Channels: 28,000

Control: crystal

Components:

1 Antenna: AT-1011/U

1 Power Supply: CY-2695/MRC

1 Radio Set: AN/TRC-75

1 Cable Assembly, Special Purpose: (p/n 545894300)

1 Handset: H-33E/PT

1 Loudspeaker: LS-166/U

1 Power Supply: PP-2352/UR

1 PU-656 AIM

B.4.8 RADIO SET AN/GRR-17

The AN/GRR-17 is a general purpose, dual conversion, superheterodyne, HF receiver. It is operationally compatible with radio sets AN/TRC-75 and the AN/PRC-47.

Technical Characteristics:

Frequency Range: 2 to 29.999 MHz
Modes: voice, CW, FSK
Modulation: AM
Power Source: 115 VAC, 50 to 400 Hz, 50 W, or 24 VDC, 24 W
Weight: 53.6 lb
Size: 1.6 ft^3
Number of Channels: 28,000 at 100 Hz increments

Components:

1 Receiver, Radio: R-1490/GRR-17
1 Case, Transit: D-43611 G1

Replaces: R-388, R-390

Requirement Documentation: MC SOR CC-1.3 of 8 Dec 66

B.4.9 COMMUNICATIONS CENTRAL AN/MRC-87A

The MRC-87A is a complete, mobile, two-way secure voice communications system. Operation is possible either in motion or in fixed configuration. The unit provides HF, UHF, long distance and local, two-way, point-to-point, and ground-to-air secure communications. The radios are vehicular mounted on truck, utility, 1/4 ton, 4 x 4, M151A2.

Technical Characteristics:

	RT-695A/PRC-41	AN/TRC-75
Modulation:	AM	SSB
Mode:	Voice	FSK, CW, Voice
Frequency Range:	225 to 399.99 MHz	2.0 to 29.999 MHz
Number of Channels:	1,750	28,000
Channel Spacing:	100 kHz	1 kHz
Bands:	1	- - -
Power Output:	3W	1000 W (High) 400 W (Low)
Power Source:	28 VDC, Vehicular	28 VDC, Vehicular

Installation: vehicular

Size: 435 ft^3

Weight: 3,489 lb.

Components:

- 1 Amplifier: AM-6669/PRC
- 1 Power Supply: PP-2352/UR
- 1 Radio Set: AN/TRC-75
- 1 Receiver-Transmitter: RT-695A/PRC-41
- 1 Secure Voice Unit: TSEC/KY-38 (not provided with basic unit)
- 1 Secure Voice Unit: TSEC/KY-65 (not provided with basic unit)
- 1 Case, Electronic Equipment: CY-2600/TRC-75
- 1 Case, Electronic Equipment: CY-2695/MRC-83
- 1 Case, Secure Voice Assembly: (MCSC, Albany, Georgia)

Comments: Will be replaced by the MRC-( ).

B.4.10 RADIO SET AN/MRC-124

The AN/MRC-124 is a two-way HF, UHF mobile communication unit. COMSEC (VINSON & PARKHILL) may be used in conjunction with the radio set.

Technical Characteristics:

	RT-671/PRC-47	RT-695/PRC-41
Frequency Range:	2 to 11.99 MHz	225 to 399.9 MHz
Transmission:	AM	AM
Mode:	Voice, MCW	Voice, X-mode
Number of Channels:	10,000 in 1 kHz increments	1750 in 100 kHz increments
Power Output:	100 W	3 W

Power: 27.5 VDC (Vehicular)

Vehicular Installation

Weight: 139.15 lb (less vehicle)

Size: 9.12 ft^3 (less vehicle)

Components:

- 1 Antenna: AS-1320/PRC-47
- 1 Antenna: AS-1404/PRC-41
- 1 Receiver-Transmitter: RT-671/PRC-47

1 Receiver-Transmitter: RT-695/PRC-41

1 Speech Security Equipment: TSEC/KY-38

1 Mounting, Receiver-Transmitter: MT-2976/PRC-41

1 Power Distribution Box: J-2889/MRC-124

B.4.11 RADIO SET AN/PRC-47

The PRC-47 is an HF upper sideband transceiver providing CW and USB voice communications. With a suitable converter the R/T may be used for FSK communications. The PRC-47 may be operated in either portable, vehicular-mount, or fixed station modes and it may also be operated remotely.

Technical Characteristics:

Frequency Range: 2 to 11.999 MHz tunable in 1 kHz increments

Modulation: AM(USB)

Mode: voice, CW, FSK

Power Output: 100 W (high) and 20 W (low)

Power Source: 115/230 VAC, 40 to 410 Hz or 26.5 VDC

Weight: 82 lb

Size: 4.5 ft^3

Number of Channels: 10,000

Components:

2 Antenna: AS-1320/PRC-47 1 AS-1321/PRC-47

1 Battery BB-451/U or BB-626/U

1 Headset: H-33D/PT

1 Battery Terminal Adapter: MX-4430/PRC-47

1 Receiver/Transmitter: RT-671/PRC-47

1 Cable, Power (AC): CS-8398/PRC-47

1 Cable, Power (DC): CS-8394/PRC-47

1 Cable, Power (Battery): CS-8395/PRC-47

1 Case, Radio Set: CY-3700/PRC-47

1 Headset: H-70C

1 Handset: H-33D/PT

1 Loudspeaker: LS-166/U

1 Telegraph Key: J-45

Comments: To be replaced by the AN/PRC-104 and AN/PRC-105

B.4.12 RADIO SET AN/TRC-75

The TRC-75 is an HF SSB radio providing long-range communications for voice, CW, or teletype. The TRC-75 is used with the MRC-83A, MRC-87A and the TSC-15.

Technical Characteristics:

Frequency Range: 2 to 29.999 MHz tunable in 1 kHz increments

Transmission: SSB (selectable USB, LSB, or ISB)

Modes: voice, FSK, CW

Power Output: SSB, 900 W (pep); AM, 180 W (pep); CW and FKS, 700 W

Weight: 325 lb

Size: 17.1 ft^3

Power: 155 VAC, 400 Hz, 2.5 kW, 30

Components:

1 Amplifier: AM-2306/TRC-75

1 Antenna Coupler: CU-749/TRC-75

1 Oscillator-Converter: CU-786/TRC-75

1 Receiver: R-761/ARC-58

1 Transmitter: T-730/TRC-75

1 Antenna Coupler Control: C-2848/TRC-75

1 Radio Set Control: C-3141/TRC-75

1 Headset: H-78C/AIC

1 Microphone: 602KK

Comments: Will be replaced by AN/GRC-193

B.4.13 FORWARD AREA TACTICAL COMMUNICATION SYSTEM (FATCS) HIGH FREQUENCY RADIO VAN AN/TSC-95

This system is contained in two shelters which provides a landing force commander with the capability of effecting a reliable Fleet Marine Force (FMF) mobile command Termination with a Naval Communication Station. The high-frequency transmit and receive shelter utilizes standard Navy equipment URT-20A transmitters, R1051 receivers, URA-38 couplers, URA-17 comparator/converters, antennas.

Used with the teletypewriter central AN/TGC-46 it makes up the Forward Area Tactical Communication System AN/TSC-95.

Technical Characteristics:

Frequency Range: 2 to 29,999 MHz

Transmission: SSB (selectable USB, LSB, or ISB)

Modes: CW, FSK, Voice Frequency Carrier Telegraph & Voice

Components:

1 Attenuator: Model 8329
2 Ant Coupler (XMIT): CU-938/URC-38
2 Ant Coupler Control Units: C-3698/URA-38
1 Audio Freq Amp (monitor): TMA-525
2 Control Radio Sets (1 installed 1 remote): C-1138/UR
1 Dummy Load: Model 374/NM
1 Intercomm Terminal
3 Receivers: R-1051/URR
2 Xmiter Set: AN/URT-23A(V)
1 Xmit Audio Patch Panel: SB-1212
1 Ant Multicoupler (REC): MC-1002N
3 Ant Mounting Brackets
1 Signal Line & Remote Connector Panel
2 Ant Entry Panels (1 XMIT, 1 REC)
1 Xmit Antenna Patch Panal
1 Rec Antenna Patch Panal
1 Rec Audio Patch ADC
1 Xmit Coupler Control Cable Patch
1 Air Conditioner
1 Power Panel, Transformer & Switch
1 Antenna: AS-2259
1 Antenna (32-foot whip)
1 MDF
1 Base Shock mount: MT-1029/VRC
1 Power Supply (for RT-524A/URC)
1 Power Supply (for KY-8 or KY-38)
1 Receiver Xmiter (provided by user): RT-524A/VRC
Security Device (provided by user): KY-8/KY-38

Previous Nomenclature: DCS Entry Radio

B.4.14 TACTICAL FREQUENCY MANAGEMENT SYSTEM (TFMS) AN/TRQ-35

The Tactical Frequency Management System (TFMS) is designed to characterize as fully as technically feasible the propagation and occupancy environments of the tactical operating bands. The TFMS performs spectrum analysis and accumulates channel statistics in order to determine the best available channel for any one of the system's users.

Technical Characteristics:

- Frequency Range: 2 to 30 MHz
- Number of Channels: 9333
- Channel Spacing: 3.0 kHz
- Analysis Bandwidth (3dB): 6.0 kHz
- Monitor Modes: USB, LSB or AM
- Monitor Tuning: ± 2 kHz from indicated center frequency
- Display Type: bar graphs on refresher 5" CRT
- Display Formats: "current" giving most recent thresholds crossed; updated each 10 sec
  "current 5 min" giving histograms for each threshold during current 5-min block
  "last 5 min" giving percent of time threshold crossed in last 5-min block
  "last 30 min" giving percent of time each threshold crossed in last 30 min
- Display Frequency Range: selectable between 100 kHz (33 channels) and 500 kHz (167 channels)
- Power Requirement: 115/230 VAC, 47 to 440 Hz, 400 W
- Weight: 120 lb

Components:

- 1 Transmitter: TCS-4B
- 1 Receiver: RCS-4B
- 1 Spectrum Monitor: RSS-4
- 1 Short Range Broadband HF Antenna: 32A-2

Previous Nomenclature: TFMS

APPENDIX C

ASSESSMENTS OF ARMY HF RADIO PERFORMANCE

C.1 ASSESSMENTS OF ARMY HF RADIO AND EQUIPMENTS

The data presented here is derived from HF equipment assessments and reports prepared on these assessments. These reports cover various time segments from 1974 through 1979. The major emphasis in this section is on Army equipments. The Navy, Air Force and Marine Corps have initiated HF improvement programs through studies, R&D, development, and production efforts. These programs will be described in other parts of the overall study.

C.2 RADIO SET AN/GRC-106

C.2.1 BACKGROUND

The AN/GRC-106 HF radio set is in wide use in the Army today. From data presented in reference (12) there have been 11,025 AN/GRC-106 radio sets produced between 1964 and 1974. The manufacturers have been General Dynamics (developer), Magnavox Corp., and Cincinnati Electronics. The AN/GRC-106 family of radios consists of the AN/GRC-106 and 106A. The major difference is the AN/GRC-106 is tuned in 1 kHz increments and the AN/GRC-106A is tunable in 100 Hz increments. This family of radios are also a part of the AN/GRC-122, AN/GRC-122A, AN/GRC-122B, AN/GRC-142, AN/GRC-142A, AN/GRC-142B, AN/VSC-2, and AN/VSC-3.

The basic development contract for the AN/GRC-106 was awarded to General Dynamics/Electronics, Rochester, New York in June 1960. Development and operational testing was conducted from 1962 to 1967. The AN/GRC-106 radio set was assigned type A classification in November 1962. The radio sets are deployed worldwide with the greatest concentration in CONUS and Europe. Internationally, these radios have been sold to Turkey, Jordan, Spain, Brazil, Iran, Argentina, Columbia, and Peru. A license has been granted to the Israeli firm Tadiran to produce the AN/GRC-106.

C.2.2 RELIABILITY HISTORY

For the AN/GRC-106, quantitative reliability or maintainability requirements are contained in the applicable Military Characteristics for Medium-High Frequency, Tactical, Single-Sideband Radio System approved by Department of the Army in June 1960. There is no Qualitative Material Requirement (QMR) for this equipment.

A Reliability Index Determination (RID) test was conducted on production sets for 2000 hours each under the original production contract with the General Dynamics Corporation. There were 32 relevant failures under the specified test conditions during the 10,000 hours of testing at a 9:1 receive-to-transmit radio, resulting in a 312 hour MTBF.

A new RID test program was completed by the Magnavox Company in February 1970 using sets incorporating engineering changes by General Dynamics/Electronics (GD/E) to correct major deficiencies discovered in the GD/E procurement. There were 164 relevant failures in 25,862 hours of testing under controlled stress conditions of temperature, vibration and input voltage at a 1:1 receive-to-transmit radio resulting in a 158 hours MTBF.

C.2.3 FIELD PERFORMANCE OF THE AN/GRC-106, OCTOBER TO DECEMBER 1974

Two field visits were made in 1974 which resulted in the collection and assessment of data on the operational performance of the AN/GRC-106.

In October 1974, a five man USAECOM team consisting of Product Assurance Directorate, Maintenance Directorate, and Electronics Technology and Devices Laboratory representatives visited Fort Hood, Texas, to interview both operator and maintenance personnel, to review work order registers and entries, and to note component densities of the AN/GRC-106 configurations. In December 1974, a similar visit was made to Fort Bragg, North Carolina.

The objective of the data collection was defined as:

a. To identify parts or modules which qualify for product improvement.

b. To assess equipment field performance in terms of Mean-Time-Between-Failures.

c. To assess equipment maintainability in terms of Mean-Time-To-Repair.

d. To assess equipment availability as a measure of equipment performance, maintenance effectiveness, and combat readiness.

e. To obtain an experience profile of operators and maintenance personnel and augment data assessment with opinions.

In the evaluation of collected data, an attempt was made to establish components failure patterns, reliability in MTBF, maintainability in MTTR, availability, and operability through interviews with operators and maintenance personnel. The following summarizes the results of the investigation.

C.2.3.1 AN/GRC-106 FAILURE PATTERN ANALYSIS

A list of parts/module failures from DA-2407 work orders covering a period of 3 months prior to the investigation were analyzed. In the analysis parts/modules, replacement/year/equipment (θ) were in the limits of: $0.018 < \theta < 0.086$. The

0.018 represents one part failure in a three-month period, based on 1845 hours operation per year. The component failure rate of 0.086 (the worst observed) would mean replacement of the part 8.6 times in 100 years.

The conclusion of this investigation was that there was no definite failure pattern established and no single part that could be defined as a candidate for product improvement.

C.2.3.2 AN/GRC-106 RELIABILITY ANALYSIS

The reliability was defined n Mean-Time-Between-Failure (MTBF). Reliability was based on equipment operating time. Operator interviews were used to evaluate the percentage of time the equipment was in the field and garrison, the hours of operation in the field, and the hours of operation in garrison. Based on equipment failures obtained from work orders, the following summarizes component and system reliability:

COMPONENT RELIABILITY

	AMPLIFIER	RECEIVER/TRANSMITTER	MODEM
	AM-3349	RT-622 or RT-834	MD-522
MTBF (Hrs)	1140	1440	2780

SYSTEM RELIABILITY

	VOICE RADIO	SIMPLEX TTY	DUPLEX TTY
	AN/GRC-106	AN/GRC-142A/B	AN/GRC-122/A/B
MTBF (Hrs)	637	517	380

The conclusions reached on the reliability of the AN/GRC-106 and its family of configuration was that reliability was satisfactory for the type and complexity of the equipment

C.2.3.3 MAINTAINABILITY (MTTR)

Data for maintainability was taken from direct support (DS) and general support (GS) work orders. The repair times include diagnostic and test time.

COMPONENT MAINTAINABILITY

(MTTR IN HRS)

	AMPLIFIER	RECEIVER/TRANSMITTER	MODEM
	AM-3349	RT-622, RT-834	MD-522
MTTR (DS)	2.48	2.19	2.42
MTTR (GS)	8.69	4.13	8.50

SYSTEM MAINTAINABILITY

(MTTR IN HRS)

	VOICE	COMPLEXITY	DUPLEX TTY
	AN/GRC-106	AN/GRC-142/A/B	AN/GRC-122/A/B
MTTR (DS)	2.44	2.44	2.36
MTTR (GS)	6.65	6.93	6.18

The conclusion reached on the maintainability of the AN/GRC-106 and its various applications, is that, maintainability is satisfactory considering the complexity and type of equipment.

C.2.3.4 AN/GRC-106 AVAILABILITY

Operational availability (Ao) has been defined* by the following relationship:

$$Ao = \frac{MTBM}{MTBM + MDT}$$

MTBM = Mean time between maintenance

MDT = Mean down time

$$MTBM = \frac{365 \times \text{component density} - \text{total down time}}{\text{Number of maintenance actions}}$$

$$MDT = \frac{\text{Total time down}}{\text{Number of maintenance actions}}$$

Data for MTBM and MDT was collected from work order registers and post property book.

*AMC Phamplet AMCPAM-706-134: Engineering Design Handbook, Maintenance Guide for Design, 3 October 1972.

COMPONENT AVAILABILITY

	AMPLIFIER	RECEIVER/TRANSMITTER	MODEM
	AM-3349	RT-662 or RT-834	MD-522
Ao	0.9597	0.9741	0.9815

SYSTEM AVAILABILITY

	VOICE RADIO	SIMPLEX TTY	DUPLEX TTY
	AN/GRC-106	AN/GRC-142/A/B AN/VSC-2/3	AN/GRC-122/A/B
Ao	0.9348	0.9175	0.8938

C.2.3.5 OPERATOR AND REPAIRMAN INTERVIEWS

Operator interviews solicited information concerning MTBF, deficiencies in equipment and maintenance, significant problems, and cable breakdowns. Maintenance personnel, both direct support and general support, were asked questions concerning their technical qualifications test equipment/tools support availability,significant technical problems, opinion of operators technical judgment and general opinion of equipment.

DS maintenance personnel were further asked about ease of getting stock replacement parts/modules, exchangeability and interchangeability of subassemblies/ modules, etc., and about cable faults.

The biggest problem with the equipment, in the operator's opinion, was that the AN/GRC-106 become excessively hot, often to the point where it would "pop out". After about a half hour of "cool down" it would be operable again.

Another problem that concerned many of the operators was difficulty in tuning and loading the AM-3349. This is a matter of training and could be related to the overheating problem.

Additional data are required to analyze the overheating problem. Cables in general present no problems, however, significant cable damage was noted in the CS-10099/U interconnect cable; apparently due to the AM-3349 bouncing out of the GAMA goat rack. An EIR digest article was prepared by ECOM calling attention to proper clamping procedures outlined in the TM which, if followed, will avoid this problem.

Several operators felt that the only improvement to the system would be to the reliability of the teletypewriters.

The following are conclusions reached from operator and maintenance personnel interviews:

Eighty-one percent of the operators consider the AN/GRC-106 reliable, are confident that it will perform when needed and, in general, consider it a good radio set. The biggest problem, in the opinion of all operators surveyed, is overheating during transmit mode.

Maintenance personnel with an average seven years experience and seventy percent school trained, consider the radio to be outstanding. The biggest problems in their opinion are the blower protect circuit and the 1A3 module; however, these are not critical problems. Additionally, they report that twenty-nine percent of deadlined radios were returned to the user without requiring corrective actions, as determined from the DA 2407 forms. Finally, eighty-five of the shops cannot exchange bad modules for good inasmuch as they do not stock the full range of modules. This is manifested in an average of thirty-five days wait for parts/modules.

C.2.3.6 <u>CONCLUSIONS OF 1974 AN/GRC-106 FIELD PERFORMANCE EVALUATION</u>

The following are conclusions that are reached from the evaluation of the 1974 field performance evaluation of the AN/GRC-106 and its family of configurations:

a. There is no definite failure pattern with the radio set.

b. The component and system reliability of the AN/GRC-106 was satisfactory.

c. The component and system maintainability is adequate.

d. The availability of the AN/GRC-106 and its family of configurations is adequate.

e. A distinct majority of the operators and maintenance personnel consider the AN/GRC-106 to be reliable and outstanding.

C.2.4 FIELD PERFORMANCE OF AN/GRC-106 RADIO SET, FEBRUARY 1976

This section summarizes the findings of a product assurance team that visited ten operational European sites in November and December 1975 to evaluate the operational performance of the AN/GRC-106. To collect data on the AN/GRC-106 the team interviewed operators and maintenance personnel, and reviewed work order registers and entries on the AN/GRC-106.

The following are a list of objectives set for the evaluation of the AN/GRC-106:

a. To identify parts or modules which qualify for product improvement.

b. To assess equipment field performance in terms of MTBF.

c. To assess equipment maintainability in terms of MTTR.

d. To assess equipment availability as a measure of equipment performance, maintenance effectiveness, and combat readiness.

e. To obtain an experience profile of operators and maintenance personnel and augment data assessment with opinions.

The total sample size consisted of 360 AN/GRC-106 radio sets. During the course of visits, 50 operators and 16 maintenance personnel were interviewed, and 550 maintenance actions were recorded. Substantially all equipment configurations encountered employed the RT-834 as opposed to the RT-662.

C.2.4.1 RESULTS OF THE FIELD VISIT

Reliability, maintainability, availability, failure patterns and interviews for this field visit were calculated in the same manner as delineated in paragraph C.2.2 of this report. As in the referenced report, both the CONUS and USAREUR data are presented for comparison.

C.2.4.2 RELIABILITY

COMPONENT RELIABILITY

		AMPLIFIER AM-3349	RECEIVER-TRANSMITTER RT-662 OR RT-834	MODEM MD-522
MTBF:	USAREUR	720 Hrs	694 Hrs	2638 Hrs
	CONUS	1140 Hrs	1440 Hrs	2780 Hrs

SYSTEM RELIABILITY

		CONFIGURATION I	CONFIGURATION II	CONFIGURATION III
		Voice Radio: GRC-106(*)	Simplex Teletype GRC-142/A/B	Duplex Teletype GRC-122/A/B
MTBF:	USAREUR	365 Hrs	314 Hrs	216 Hrs
	CONUS	637 Hrs	517 Hrs	380 Hrs

It was concluded that the reliability of the AN/GRC-106 and its family of configurations is satisfactory and within the realm of expectations for equipment of this type and complexity. Differences between CONUS and USAREUR are attributed to the approximate nature of the data available and procedures used.

C.2.4.3 MAINTAINABILITY

Maintainability is expressed in terms of MTTR. Data for this computation were obtained from work orders (form 2407) for periods of approximately three months prior to the field visit. Active repair time includes diagnostic and test time as well as actual repair time.

Figures resulting from the USAREUR visit are shown on the first line, from the CONUS visit as reported in the original assessment letter are shown:

COMPONENT MAINTAINABILITY

		AMPLIFIER AM-3349	RECEIVER-TRANSMITTER RT-662 or RT-834	MODEM MD-522
MTTR	USAREUR	3.33 Hrs	3.44 Hrs	2.20 Hrs
DIR SUP	CONUS	2.48 Hrs	2.19 Hrs	2.42 Hrs
MTTR	USAREUR	5.97 Hrs	6.13 Hrs	5.25 Hrs
GEN SUP	CONUS	8.69 Hrs	4.13 Hrs	8.50 Hrs

SYSTEM MAINTAINABILITY

		CONFIGURATION I	CONFIGURATION II	CONFIGURATION III
		Voice Radio GRC-106(*)	Symplex Teletype GRC-142/A/B VSC-2/3	Duplex Teletype GRC-122/A/B
MTTR	USAREUR	3.39 Hrs	3.24 Hrs	3.31 Hrs
DIR SUP	CONUS	2.44 Hrs	2.44 Hrs	2.36 Hrs
MTTR	USAREUR	6.03 Hrs	6.02 Hrs	6.05 Hrs
GEN SUP	CONUS	6.65 Hrs	6.93 Hrs	6.18 Hrs

C.2.4.4 AVAILABILITY

Availability as shown here is defined in paragraph C.2.3.4 of this report.

COMPONENT AVAILABILITY (Ao)

	AMPLIFIER AM-3349	RECEIVER-TRANSMITTER RT-662 or RT-834	MODEM MD-522
USAREUR	.9664	.9728	.9898
CONUS	.9597	.9741	.9815

SYSTEM AVAILABILITY (Ao)

	CONFIGURATION I Voice Radio GRC-106(*)	CONFIGURATION II Simplex Teletype GRC-142/A/B VSC-2/3	CONFIGURATION III Duplex Teletype GRC-122/A/B
USAREUR	.9402	.9306	.9053
CONUS	.9348	.9175	.8938

The availability of the AN/GRC-106 and its family of configurations is considered adquate and compares favorably with other radios of similar complexity. Maintenance policy of tuning in both RT and amplifier when either requires maintenance is unique and reduces Ao. This requirement is due to necessary realignment of components if interchanged. Component Ao (hence system Ao) would appear to be higher if the amplifier and receiver-transmitter did not have to be turned into maintenance together; however, inasmuch as the paired realignment improves system performance, it also contributes to maintaining high system Ao.

C.2.4.5 FAILURE PATTERNS

A list of parts/modules replaced or adjusted was compiled from maintenance work order data and covered a three-month period of time just prior to November 1975. Failure patterns are tabulated with replacement rates extrapolated to one year for assessment purposes. A pattern failure is defined as the replacement of two (2) or more parts/modules during the three-month period. All parts/modules replaced only once during the three-month period represent less than .018 replacements/year/equipment.

PARTS/MODULES	REPLACEMENTS/YEAR/EQUIPMENT
	AN/GRC-106
1A3	.094
Electron Tubes	.086
Wiring	.083
2A9	.047

The 1A3 module is contained in the RT unit. The 2A9 assembly is contained in the AM-3349. Most electron tube replacements are the power amplifier tubes of the AM-3349. "Wiring" pertains to the inside of both units. No particular part/module in the MD-522 exhibited a sufficient failure rate to establish a listing above.

Of all the parts/modules replaced, the 1A3 module has the highest observed replacement rate.

Based on an estimated operating time of 2429 hours per year, it would be replaced 9.4 times in a 100 year period. This is not considered critical. All other observed failure rates are lower than this.

The following conclusions were made on failure patterns:

a. No parts or modules can be considered as candidates for product improvement.

b. Although tubes are not a major problem, they do contribute to equipment failures when not replaced during preventive maintenance.

C.2.4.6 INTERVIEWS

Interviews with equipment operators and maintenance personnel were conducted at USAREUR sites during November and December 1975. Operator interviews solicited information concerning MTBF, confidences in equipment and maintenance, significant problems and cable breakdowns. Maintenance personnel, both direct support and general support, were asked questions concerning their technical qualifications test equipment/tools support availability, significant technical problems, opinion of operators technical judgement and general opinion of equipment. DS maintenance personnel were further asked about stock replacement modules and cables.

Based on the interviews conducted, the team reached the following conclusions:

a. Sixty-four percent of the operators interviewed in USAREUR consider the AN/GRC-106 reliable, are confident of performance when needed, and in general, consider it a good radio set. The biggest problem, in the opinion of all operators surveyed, is that the equipment runs too hot and is difficult to load and tune.

b. Maintenance personnel express substantially unanimous opinion that the radio is outstanding.

c. Insufficient training and/or limited experience and ability have been found to be the major cause of tuning, loading, and overheating problems.

C.2.4.7 OPERATOR FAULT ANALYSIS CAPABILITY

With respect to equipment submitted to organization and direct support shops, maintenance personnel found the following results from equipment check out:

RESULTS OF CHECK-OUT	AN/GRC-106
Fault correctly identified by user; (Fault found)	25%
Fault correctly identified by user; other faults also found	36%
Fault incorrently identified by user; (different fault found)	25%
Fault incorrectly identified by user; no fault found	14%

Maintenance personnel expressed an 83% confidence in replacement modules and 77% confidence in replacement cables and connectors with respect to performance upon installation. Average turn-around time for exchanged modules was found to be 16 days.

Improper tuning is believed to be the major cause of the overheating problem. Unfamiliarity with the finer points of the set's operation is considered as the reason for the expressed 24% "fair" and 12% "poor" opinion expressed by the minority of operators interviewed in USAREUR.

C.2.4.8 PARTS REPLACEMENT ANALYSIS

The item exhibiting the highest number of failures was the power amplifier tube 8332/4CX350F. An improved tube, 8904/4CX350FJ, has been adopted for use with the AN/GRC-106A. This tube is operationally superior and should have a longer life span. Power amplifier tubes normally have a limited life and the failure rate exhibited by these tubes during the site survey is not considered excessive. The failure rate of the other items which failed also are not considered excessive. The following table below lists the parts which failed most frequently.

TABLE OF MOST FREQUENTLY FAILED PARTS
SYSTEM DATA COLLECTION (SDC)

NAME AND FSN	DESCRIPTION	ASSEMBLY AFFECTED	NUMBER OF FAILURES DURING SDC
Power Amplifier 5960-226-5368	Electron Tube: MIL Type 8332/ 4CX350F	RF Amp AM-3349 Chassis Assy 2A1	22
Freq Standard 5820-226-5368	Frequency Standard Module	Rec-Trans RT-834/GRC	4
Transistor 5960-728-2072	Transistor: Type 2N3150	RF Ampl AM-3349	2
Transistor 5961-889-4120	Transistor: Type 2N1486	Rec-Trans RT-834/GRC	4

The data shows the equipment performed satisfactorily during the SDC period, although the MDT of 38 days is considered excessive. Due to the failure of support maintenance activities to report all information, it was not possible to accurately determine what impact the varicus elements of downtime had on MDT. It can only be assumed that the nonavailability of parts and other higher priority work contributed most to downtime.

The data also shows that very little usage was logged on the radios. On the average, each radio operated only .7 hours per day. This is considered a lesson learned by ECOM and corrective action has been taken in subsequent SDC plans to include in the sample only those equipments which are expected to be utilized. This .7 utilization rate includes those operating times during which preventive maintenance (PM) was being performed. Should these hours not be included, the utilization rate would be considerably less. Although the data was not reported in a manner in which the PM proportion of usage could be extracted, it is felt that a considerable amount of usage was logged strictly for the performance of PM.

C.2.4.9 <u>SUMMARY AND CONCLUSIONS OF EUROPEAN SITE VISITATION</u>

a. Radio set AN/GRC-106 is one of major complexity with an extremely large number of electronic parts densely packaged. The reliability, maintainability, and operational availability of the set and its family of configurations are considered satisfactory and typcial of tactical equipment/systems of this nature and complexity.

b. Based on analysis of data collected, module failure modes are generally non-repetitive and infrequent. Therefore, no parts or modules were considered as candidates for product improvement.

c. The majority of operators consider the radio to be reliable, dependable, and in general, good. The biggest problem in the opinion of all operators surveyed was difficulty in tuning and loading and resultant overheating.

d. Maintenance personnel are practically unanimous in their opinion that the radio is outstanding. The 1A3 module and electron tubes show the highest replacement rates, although these rates are not critical.

C.2.5 MATERIAL READINESS OF AN/GRC-106 RADIO SET

Army Material Systems Analysis Activity (AMSAA) over a period of time observed the field performance of the AN/GRC-106, and based on their observation and data collected, they prepared the following comments on the AN/GRC-106 radio set contained in reference

C.2.5.1 AMSAA OBSERVATION AND COMMENTS ON THE AN/GRC-106

a. The field Liaison Division of AMSAA has observed, during trips to active Army units, that most combat arms battalions cannot reliably communicate using their assigned radio teletype (RATT) equipment. This condition does not exist in signal battalions.

b. All RATT equipment uses the AN/GRC-106, a high frequency, single side band radio and is the source of most user complaints concerning RATT. the radio consists of two pieces: a receiver-transmitter and the power amplifier, AM-3349. The AM-3349 is the source of most of the problems associated with the AN/GRC-106.

c. Attempts to find out why the users are having difficulty with the AN/GRC-106 have revealed the following:

(1) No single cause for difficulty can be identified.

(2) The equipment is complex and requires a well-trained operator.

(3) The operators manual, TM 11-5820-520-12, provides minimal information on the radio only. It does not explain how to check the antenna, or what to do if the AM-3349 will not "tune" properly.

(4) The school training does not teach RATT as a system, only as components. The wiring of the various components and the care and handling of antennas is not taught.

(5) Operators in non-signal battalions cannot get on-the-job training because most NCOs (MOS 31G) are not experienced in RATT or AN/GRC-106 operation.

(6) If the RATT equipment is set up and tuned by experienced people, the typical operator can keep it operating properly. A shut down and move to a new location causes problems.

(7) Most field training exercises do not require the use of RATT and hence its lack of availability is not highlighted.

d. Both TRADOC and FORSCOM have experienced similar findings. It is understood that the Signal School's training has been identified and that Command emphasis at Fort Hood has resulted in improved RATT capability. DARCOM is preparing some minor improvements in the AN/GRC-106 radio's blower motor and antenna mast.

e. AMSAA is concerned that, although some effort by each involved command has been initiated, the coordination and total solution may be inadequate to overcome the observed difficulties of RATT systems.

C.2.5.2 CHRONOLOGY OF AN/GRC-106 OBSERVATIONS BY AMSAA

The following are observations made by AMSAA on the AN/GRC-106 Radio Set. The comments on the AN/GRC-106 received by AMSAA personnel is presented here as they appear in the referenced memorandum. The comments in the report do not coincide with the assessment analysis made in CONUS 1974 and Europe 1975.

a. October 1974 - Trip 75L02 to Ft. Benning

Mech Inf Company said they could not keep VSC-3 system running. Admitted that operator may be problem. If maintenance tuned and started up system, operator could keep it going, but system would not work in the field.

b. December 1974 - Trip 75L03 to V Corps Germany

Talked to a Sig. Bn. They had no problem with RATT. Used it "all the time." Talked to Armored Cav Regiment - They had nothing but troubles with RATT. GRC-106 was major problem followed by RATT cables.

c. <u>July 1975 - Trip 76L01 to Ft. Hood</u>

Sig Officers complained that they could not keep the RATT system operating. With maintenance help it would work in garrison, but the "trip to the field site" broke the system, and it wouldn't work in the field.

d. <u>September 1975 - Ft. Carson</u>

Discussion with Brigade Sig. Officers and ECOM FMT at Brigade Sig. meeting admitted that no one used radio teletype because they couldn't keep it going. Would operate in garrison, but not in field.

e. <u>December 1975 - Trip 76L03 to Ft. Campbell</u>

Tried to find the causes of troubles with RATT and the GRC-106. They had VSC-2s (jeep mounted RATTs). Most operators had "no troubles." They blamed the GRC-106 as being most temperamental and most difficult to tune. Checked with DS maintenance. They did not have a school trained repairman. Their sole GRC-106 repairman was self-trained from TMs. He could not identify any particular fault that caused consistent troubles. The AM-3349 was the major piece giving troubles. About 33% of the trouble is not in the GRC-106, but is found in the antenna cabling or the RATT wiring. Operators do not receive training on system wiring. DS maintenance evacuates 60% of what it receives to GS maintenance. I did not get to GS maintenance.

f. <u>December 1975 - April 1976</u>

Made inquiry of ECOM Quality Assurance. Not aware of any problem - cited system assessment and sent me copy.

Inquired of Sig. School. Knew of training problems - say they were changing course to include system wiring. Were also preparing a TEC training package on operation of RATT to send to field. Europe was first, approximately, January 1977, then others.

Located a course that included repair of GRC-106 being taught at Ft. Sill. Informed 801st Maintenance at Ft. Campbell.

g. <u>September 1976 - Trip 7T101 to Ft. Riley</u>
One Mech Inf E-5 operator rated the GRC-106 as the best radio in the Army. He thought other people did not understand and did not try to understand RATT equipment.

h. <u>December 1976 - Trip 77L01 to Ft. Lewis</u>
Talked to Signal Bn and ADA Bn about RATT. Sig. Bn. operates OK, ADA Bn operates, but with difficulty. Sig. Bn. Maint. (they do their own DS) complained of many failures in protection circuits, but nothing else wrong. Check w/709th DS Main. about ADA system. They require that whole RATT rig be brought in - most trouble in cables or AM 3349, but no one cause could be identified. Check w/GS (Post) Maint. They identified trouble with one blower protection circuit and pin pointed one transistor in this circuit. Also provided sample.

i. <u>January 1977</u>
Tried to define problems with RATT and determine effect on Army of not using RATT means to communicate.

(1) <u>Sig School Combat Devel</u> - They know of problems with training. Don't believe hardware replacement is justified. Plan to replace RATT below Division level in mid-1980s with fascimile using FM radio. Evaluating concept in Europe now. TEC training package never made. Instead have video tape.

(2) <u>FORSCOM</u>: Knows of problem. Have analyzed at Ft. Hood and Ft. Lewis. Troubles are: training operators, manuals, material, command interest, alignment procedures. They are working closely with Ft. Hood and ECOM FMTs. Due to command interest and ECOM training of operators and maintainers systems are doing very well at Ft. Hood. Agree with H. Forst that most Communications NCOs (MOS 31G) are not trained in RATT or GRC-106 operation. Army-wide operational rates on GRC-106 and RATTs are within DA specs, but the data is doubted.

(3) NMC: Red Team Assessment report on GRC-106 mailed January 14th cites problems with whip antenna, lack of shock mounts, manuals, and better OJT. Operator is not part of problem.

C.2.5.3 AMSAA CONCLUSIONS

a. Signal Bn and a few Mech Units do make the RATT system work. It can be done.

b. Most Combat Arms Bn can't reliably use RATT or HF voice (GRC-106). Cause is believed to be:

(1) Poor school training when available.

(2) No one in organization capable of providing OJT or reinforcing school training. (i.e., NOCs not proper for the job).

(3) Equipment is complex and needs knowledgeable operators.

(4) Manuals are insufficient to provide information needed on theory and understanding of HF, SSB radio or on the GRC-106 radio.

c. A program to redesign the GRC-106 is probably not justifiable in light of its eventual replacement.

d. A program to improve the manual and training could and should be carried out.

C.2.6 RED TEAM ANALYSIS OF THE AN/GRC-142 RADIO TELEGRAPH SET

In 1977, the U. S. Army Maintenance Management Center (USA MMC) conducted an analysis of the AN/GRC-142 RATT set. This analysis was conducted because the equipment failed to meet the Department of the Army (DA) Operational Readiness (OR) standard of 82% for eight quarters. The analysis noted deficiencies in personnel, training, technical manuals and tools.

C.2.6.1 DESCRIPTION

The AN/GRC-142 is a shelter-mounted, vehicular-transportable radio teletypewriter set operating in the high frequency (HF) range of 2 to 30 megahertz (MHz). It provides continuous wave (CW), single-sideband (SSB), and compatible amplitude modulation (AM) and voice and radio teletypewriter modes of operation. The AN/GRC-142, or a system that is equipped and functionally identical, (i.e., AN/GRC-122, AN/VSC-3) can be found in almost every battalion size unit. Densities vary from one in a Maintenance Support Battalion to twenty-four in a Corps Signal Battalion.

There are presently three models of the AN/GRC-142 being used by active Army units. They are the AN/GRC-142 and the AN/GRC-142A (App A) which are installed in Shelter S-318, originally transported by a 3/4-ton vehicle, and the AN/GRC-142B (App A) installed in Shelter S-250, originally transported by a 1-1/4 ton vehicle. All are scheduled to be transported by the M880 series vehicles as they become available except those units assigned the M-561 Gama Goat.

The basic components of the AN/GRC-142, and their functions, are as follows:

a. Radio Set AN/GRC-106 is the basic radio receiver/transmitter.

b. Modem, Radio Teletypewriter MD-522/GRC converts to the direct current teletypewriter code for frequency shift signals which modulate the transmitter during the transmission mode. The process is reversed during reception.

c. Mast Base AB 652/GR provides the physical interface between the AN/GRC-106 Radio Set and the 30-foot whip antenna (when used).

d. Antenna Group AN/GRA-50 provides components required for construction of a doublet antenna.

e. Control Group AN/GRA-6 allows the AN/GRC-142 to be operated from a remote position.

f. Teletypewriters TT-98/FG and TT-76A/GGC are used or receive teletypewriter code messages.

The AN/GRC-142 provides simplex (one-way reversible) radio teletypewriter and SSB voice communications up to 100 miles, with greater range obtainable under favorable sky wave conditions. It provides for interoperation with existing HF radio teletypewriter and voice communications sets such as the AN/GRC-26 and -46.

Radio Teletypewriter Set AN/GRC-142 was developed concurrently with its basic Radio Set AN/GRC-106. The USCONAEC approved military characteristics (MC's), June 1960, for medium and high power SSB radio sets, were used as the initial criteria for evaluating the radio teletypewriter set because there were no approved MC's or qualitative material requirements (QMR's) for such systems.

C.2.6.2 OPERATIONAL READINESS

Radio Teletypewriter Set AN/GRC-142 failed to meet the worldwide OR rate prescribed by AR 750-52 for eight quarters. The DA standard for not operationally ready supply (NORs) of 8% was consistently exceeded and has been one of the factors contributing to the poor readiness posture of the AN/GRC-142. The achieved rate for not operationally ready maintenance (NORM) has been intermittently above and below the DA standard of 10% over the past eight quarters.

The low OR rate which includes all models of the AN/GRC-142, is compounded due to the fact that a major component, the AN/GRC-106 Radio Set, has not met its prescribed OR rate for the past eight quarters.

The inherent characteristics of the reporting system as set forth in TM 38-750 tend to distort the overall readiness picture of the AN/GRC-142. Basically, the system is red, even if operable, if the transporting vehicle is inoperable. The vehicles used to transport the AN/GRC-142 have not met their DA standard for eight quarters.

C.2.6.3 PERSONNEL DEFICIENCIES

The following military occupational specialties (MSO's) are required to operate and maintain the AN/GRC-142:

a. MOS 5C Radio Teletypewriter Operator

b. MOS 5F Radio Teletypewriter Operator (Non-Morse)

c. MOS 31B Field Communications-Electronics Equipment Mechanic

d. MOS 31E Field Radio Repairman

e. MOS 31J Teletypewriter Repairman

f. MOS 31T Field Systems COMSEC Repairman

Interviews with unit personnel at organizational, DS and GS levels and ECOM Field Maintenance Technicians (FMT's) identified training of operator personnel (MOS 05C and 05F), and maintenance personnel (MOS 31B and 31E) as a major problem contributing to the high deadline rate for the AN/GRC-142. Operator personnel directly out of MOS training schools generally do not have the skill level required without additional training.

Operator deficiencies are clearly identifiable in the following common problem areas:

a. Improper grounding of the AN/GRC-142 shelters and generators. Also, failure to extend the shelter ground to the generator ground.

b. Improper tuning of the AN/GRC-106 Radio. Tuning of the radio is accomplished by putting the radio in a simulated transmit mode. The tuning process is attempting to match the transmitter output to the antenna. This must be done within two minutes or transmitter damage could occur. Many new operators have problems with this tuning procedure.

c. Improper use of the doublet antenna. Antennas must be erected for the specific operating frequency. When the operating frequency is changed, the antenna must be retuned. Failure to do this will cause transmitter damage.

d. Failure to understand and use the proper mode of operating of the Modem MD-522A. Various modes of operation are possible to provide flexibility.

e. Transmitting for long periods of time. Excessive transmit time will cause the radio to overheat, causing power amplifier failures.

f. Failure to insert the proper code key in the KW-7 secure device.

g. Lack of basic understanding of the total system and the interconnection of the various equipments. The 05C and 05F have a difficult time when anything out of the ordinary occurs.

C.2.6.4 TECHNICAL MANUALS

The technical publications required to support the operation and maintenance of the AN/GRC-142 are generally well accepted by user personnel. There are 57 manuals involved when considering the end item down to the discrete component level. For purposes of this analysis only those manuals which represent problem or potential problem areas will be discussed.

TM 11-5820-520-12 contains operator instructions, organizational maintenance instructions, and organizational repair parts and special tools list (RPSTL) for the AN/GRC-106 Radio Set.

a. A readability review shows the manual to be written at the college reading level (Grade 13-16) which exceeds the reading level of the typical radio operator/repairman (8-9th grade).

b. The manual does not adequately definitize presentation maintenance procedures for the antenna base. This contributes to tuning and overheating problems with the amplifier AM-3349/GR.

c. 54 percent of the repair parts are not properly identified.

d. Complete source, maintenance, and recoverability codes are not provided.

e. Repair parts are not properly keyed from illustrations to parts list.

TM 11-5820-520-34 is the Direct and General Support Maintenance Manual for the AN/GRC-106 Radio Set. This manual does not have a section performance standards for DS as required by MIL-M-63019 (TM). The DS performance standard should provide a direct go-no-go basis on which the tester could reject or pass the repaired equipment. Readability review shows this manual to be written at 8-9th grade level which is satisfactory for the typical repairman.

TM 11-5820-520-34P-1 contains the RPSTL for DS, GS, and depot maintenance on AN/GRC-106. This manual has 348 pages and Section II (Repair Parts List) has 249 pages with no subgroup listing, making it difficult to identify the 2,728 repair parts listed.

a. Only two positions of the five position SMR codes are provided. The user is handicapped to the extent stated in d. above.

b. The Mast Base AB-652/GR is listed in the MAC as a repair item for DS; however, no repair parts are listed in the manual.

TM 11-6625-333-15 contains the operator instructions, DS, GS, and depot maintenance instructions and RPSTL for the ME-165/G Standing Wave-Ratio Power Meter.

a. A readability review indicates that the text is written to the 10-12 grade level which is cause for some concern based on reading problems experienced by USASIGS personnel with the reading ability of 25 percent of students. (It is also noted that this is a monitoring device for the output of the AM-3349 Amplifier which is a well identified problem area of the AN/GRC-106 Radio Set).

b. An NSN validity review indicates that 40% of the listed support items require corrective action.

C.2.6.5 TOOLS

During this analysis, maintenance personnel were questioned relative to availability and quality of tool kits used to perform maintenance on the AN/GRC-142 at all levels. These include the TK-100/G, TK-101/G, and TK-105/G.

The tool kits were generally described by organizational DS and GS repairmen as having deteriorated in quality to the point where many items had to be replaced. When replacements were received they were of equally poor quality.

Specific findings in this category consisted of the following items:

NSN	ITEM	DEFICIENCY	TOOL KIT NO.
5120-00-228-9504	Wrench, Comb	Easily Deformed	101/G
5120-00-228-9595	" "	" "	101/G
5120-00-228-9506	" "	" "	101/G
5120-00-228-9507	" "	" "	101/G
3439-00-465-1649	Soldering Iron	Does not get hot enough	105/G

C.2.6.6 TEST EQUIPMENT

Field visits and discussion with operator and maintenance personnel at all levels indicate that the types of test equipment authorized are adequate. There is concern, particularly at the DS level, in cases where authorization is limited to one-of-a-kind items. If that one item is deadlined, they are unable to perform their mission. Critical items identified were Signal Generator AN/GRM-50 and Dummy Load DA-75/U.

Many of the RT module adjustments of the AN/GRC-106 are relatively simple in nature. TM 11-5820-520-34 procedure for these adjustments is complicated because of the need of Radio Simulator SM-442 which is only authorized at GS level. These adjustments could be easily accomplished at DS level by using the RT unit (in lieu of the SM-442) and a set of extender cables. These extender cables are already available as part of the SM-442, and could be acquired by maintenance units if they were added to the TM's list of tools and test equipment required. The TM would also need to be re-written to simplify these alignment procedures. Module alignment would then be within the reach of all DS maintenance without the need of a complicated and expensive piece of TMDE. It would also have an appreciable effect on material readiness by reducing RT module turn-around time. ECOM should revise alignment procedures, maintenance allocation chart (MAC) and RPSTL in order to effect alignment of selected modules at the DS level.

C.2.6.7 <u>AN/GRC-142 USER COMMENTS</u>

a. The AN/GRC-142 is one of the better communications systems in the Army inventory; but, improvement is desirable in the AN/GRC-106 Radio Set, MD-522 Modem and internal shelter cabling.

b. Early model systems which are badly in need of overhaul/rebuild, are not getting the proper attention.

c. ECOM response and follow-on corrective action in connection with Equipment Improvement Reports (EIR's) and Recommended Changes to Publication (DA Form 2028) have been neither timely nor effective in solving identified user problems.

d. Operator and maintenance personnel spend too much time performing duties not related to assigned MOS.

e. Training on repair of the AM-3349 Power Amplifier should be intensified in the MOS 31E course at Fort Gordon, GA.

f. Repair cycle float items should be increased in quantity.

g. The AN/GRC-142B is the preferred item due to the additional operator space.

h. AN/GRC-142 problems are increased when the system is transported by the M-561 Gama Goat due to the extreme vibration.

C.2.6.8 CONCLUSIONS OF ANALYSIS OF THE AN/GRC-142

a. General - The AN/GRC-142 Radio Teletypewriter Set is fully capable of performing its intended mission when properly used and maintained. The AN/GRC-142 system has not met the DA established OR standard during the past eight quarters.

b. The improvements, presently scheduled or being considered in the areas of training, technical documentation and hardware (AN-GRC-106) should improve the OR status of the AN/GRC-142. Cost effectiveness should be a major consideration in any improvement action on the AN/GRC-106 due to its age and recent advancements in the state-of-the-art.

(1) Operator induced failures generate a NORS/NORM situation that is not representative of the true reliability, availability and maintainability (RAM) parameters of system. This problem should be resolved by TRADOC and FORSCOM.

(2) The level of operator/maintenance personnel training expected by field commanders is significantly different from that administered by USASIGS personnel. This problem should be resolved by TRADOC and FORSCOM. The Integrated Technical Documentation and Training (ITDT) concept should be investigated as a means of bridging the gap between the school and field environments.

(3) Technical publications are written to a level that is generally above the reported reading level of user personnel.

C.2.7 RATT SETS AN/GRC-142 and AN/GRC-122 TOTAL ASSESSMENT

In 1977 the Army Electronics Command, Product Assurance Directorate, Systems Performance Assessment Division conducted an assessment on the AN/GRC-122 and AN/GRC-142 RATT sets based on reported equipment problems. The field assessment was conducted at Fort Lewis, WA, 21-30 March 1977 and USAREUR, Germany, 16-27 May 1977.

C.2.7.1 BACKGROUND

The AN/GRC-142 and AN/GRC-122 operate in the frequency range of 2.0 to 29.999 megahertz (MHz). The transmitted power output is 400 (maximum) watts, peak envelope power. The AN/GRC-142(*) and AN/GRC-122(*) provide armored vehicles with a modern, highly stable radio teletypewriter set with a ground wave of at least 50 miles (80.45 kilometers (km)) nominal (groundwave); 100 (160.9 km) to 1,500 (2413.5 km) miles (skywave), depending on terrain, frequency, antenna, time, and atmospheric conditions.

The AN/GRC-122 is similar to the AN/GRC-142 except that the AN/GRC-122 provides duplex operation. This means that simultaneous transmission and reception is possible. The AN/GRC-122 also provides a pony circit (teletypewriter order-wire (ow) transmission and reception over landlines) when not operating on the duplex mode. Both radio teletypewriter sets include provisions for local (mobile or fixed) or remote operation, and are vehicular and/or air-transportable. Remote operation requires additional equipments not supplied as part of the AN/GRC-142 or AN/GRC-122.

The AN/GRC-142 and AN/GRC-122 may be netted with each other or with equipment such as Radio Teletypewriter Sets AN/VSC-2, AN/VSC-3, the AN/GRC-46 series, AN/VRC-29, AN/GRC-114, and the AN/GRC-26 series. Both the AN/GRC-122 and AN/GRC-122 use the radio set AN/GRC-106.

C.2.7.2 PERFORMANCE PROBLEMS

Equipment Improvement Reports (EIRs) as well as Field Service Operational Activity Reports (FSOARs) concerning the AN/GRC-122 and AN/GRC-142 delineated the following problems:

a. Radio Set AN/GRC-106 overheating.

b. Improper tuning of AN/GRC-106.

C.2.7.2.1 FIELD ASSESSMENT AT FORT LEWIS, WA.

The results of the field assessment at Fort Lewis, WA, indicate that the AN/GRC-142 is performing satisfactorily in the field, the operational readiness (OR) of the AN/GRC-142 located at For Lewis was 96.31%.

C.2.7.2.2 FIELD ASSESSMENT USAREUR GERMANY

The most significant problems reported in Germany were:

a. Lack of proper operator training on tuning radio set AN/GRC-106.

b. Overheating of AN/GRC-106.

c. Insufficient training of operators on interfacing components within the AN/GRC-142 system.

d. Insufficient training of Direct Support (DS) maintenance personnel on interfacing the components within the AN/GRC-142 system.

e. Insufficient training on the operational capabilities of Modem MD-522A.

f. Long periods of operation of teletype equipment cause the AN/GRC-106 amplifier to overheat.

g. High noise level and electromagnetic interference with all shelter equipments.

C.2.7.3 CONUS AND OCONUS AN/GRC-142 RELIABILITY

The following are reliability data for the AN/GRC-142 components:

COMPONENT	MTBF (HOURS)
Radio Set AN/GRC-106	186.0
Modem MD-522( )/GRC	366.8
Teletypewriter TT-98/FG	244.5
Teletypewriter TT-76( )/GGC	282.2
Power Supply PP-4763/GRC	2751.5
Power Supply, Inverter PU-724	11006.0
Loudspeaker LS-166/U	13757.5
Telephone Set TA-312/PT	11006.0
Handset M-29/U or H-33/PT	6878.7
Local Control C0434/U	2684.3
Heater	1000.5
Cables	1000.5
Switches	7337.3
Control Boxes	3668.6

CONUS and OCONUS system reliability for the AN/GRC-142 was calculated to be 48.1 hours.

The referenced report concludes that the AN/GRC-142 reliability is satisfactory and within the realm of expectations for equipment of this type.

C.2.7.4 AN/GRC-142 MAINTAINABILITY

The following are AN/GRC-142 component maintainability data for CONUS and OCONUS direct support.

COMPONENT	MTTR (HRS)
Radio Set AN/GRC-106	3.56
Modem MD-522( )/GRC	6
Teletypewriter TT-98/FG	4.46
Teletypewriter TT-76( )/GGC	2.84
Power Supply PP-4763/GRC	No failures reported
Power Supply, Inverter PU-724	No Failures Reported
Loudspeaker LS-166/U	3
Telephone Set TA-312/PT	37

The following are general support maintainability data for the AN/GRC-142 components.

COMPONENT	MTTR (HRS)
Radio Set AN/GRC-106	6.82
Modem MD-522( )/GRC	3.75
Teletypewriter TT-98/FG	No Failures reported
Teletypewriter TT-76( )/GGC	" " "
Power Supply PP-4763/GRC	9
Power Supply Inverter PU-724	No Failures reported
Loudspeaker LS-166/U	" " "
Telephone Set TA-312/PT	" " "
Miscellaneous Components, Switches, Cables, Fuses, Etc.	20.5

Direct support system maintainability was determined to be 3.75 hrs. MTTR.

General Support system maintainability was determined to be 8.08 hours MTTR.

The maintainability conclusions for the AN/GRC-142 system is that the MTRR is satisfactory.

C.2.7.5 OPERATION READINESS (OR)

Through data collected from DA Forms 2407 and Post Property Books, the following OR was calculated for the AN/GRC-142: CONUS - 0.9631, and OCONUS 0.9873. This is well within DA requirements of 0.82 or better.

C.2.7.6 USER OPINIONS

During the assessment, interviews with equipment operators and maintenance personnel were conducted at each military post. Operator interviews solicited information concerning MTBF, confidences in equipment and maintenance, and significant problems. Maintenance personnel, both DS and GS, were questioned concerning their technical qualifications, test equipment/tools support availability, significant technical problems, opinion of operators technical judgement and general opinion of equipment. 75 percent of the operators interviewed considered the AN/GRC-142 reliable and are confident that it will perform when needed; overall, they consider it a good system. Maintenance personnel with an average of 5.7 years experience and 100% school trained consider the system to be "good". However, they reported that 24% deadlined components of the system are free of fault. The AN/GRC-122 and AN/GRC-142 operators and maintenance personnel questioned (Fort Lewis and Europe) concluded that this system was reliable and easily maintainable.

C.2.7.7 AN/GRC-142, AN/GRC-122 SYSTEM PERFORMANCE

Although assessment found performance satisfactory, major problems encountered are still consistent with previous EIRs and USAMSAA findings:

a. Radio Set AN/GRC-106 overheats.

b. Radio Set AN/GRC-106 loses calibration during long field trips on rough terrain.

c. Radio Set AN/GRC-106 overheats in extended communication periods when used in conjunction with teletype equipments.

d. TT-98/FG and TT-76/GGC sensitive to road conditions.

e. Users desire larger shelters with air conditioning.

f. Insufficient training in troubleshooting AN/GRC-122 and AN/GRC-142 as a system. Improved training for operators and DS personnel would be helpful.

g. Equipment performance reports show high noise level and electromagnetic interference with all shelter equipment operating.

h. Repair of teletypewriters does not seem to be a major problem. Repair of the AN/GRC-106 radio and MD-522 Modem, however, are major problems in all DS/GS maintenance units. DS maintenance consists of diagnosing and replacing inoperative modules, troubleshooting and replacing component parts on the chassis and front assemblies, and certain alignments. The modem and radio are almost completely transistorized and electronically complex. The 31E repairman receives no solid state electronic theory, limited instruction on use of diagnostic test equipment, and just enough instruction on the AN/GRC-106A and MD-522A to become acquainted with the equipment. Most school trained repairmen, while displaying a fair amount of confidence in repairing the AN/VRC-12 FM family radios, generally lack the confidence and skill level required to repair the AN/GRC-106A and MD-522A. Again, adequate skill levels have to be developed in the field by refresher training on radio and modem theory, supervised OJT, and experience.

C.2.8 AN/FRC-93 EVALUATION

In the fall of 1978, the Quality Assurance and Testing Detachment of the US Army Communications Command, Fort Huachuca, Arizona sent a team to conduct an evaluation of the Cemetary Net high frequency radio network at Meyn, Kellinghusen, and Soegel, Germany. This part of the report summarizes the findings and evaluation of these sites as delineated in reference 15, 16, and 17.

C.2.8.1 SITE INITIAL STATUS AND EQUIPMENT PROFILE

The following material delineates the sites initial condition and defines the HF equipment profile.

C.2.8.1.1 MEYN SITE, 9-14 September 1979

When the team arrived at the site, the radio equipment was operating in a degraded condition and considerable effort was required to attain optimum performance. Problems encountered were due mainly to the age of the equipment. Deficiencies were corrected to the maximum extent possible during the evaluation.

Table C-3 Meyn Site HF Equipment Profile

Equipment	Data
Equipment type	HF A3J (SSB)
Equipment Manufacturer	Collins Radio Company
Date of Initial Installation	Unknown
Total Frequencies	6
HF Equipment	4 AN/FRC-93 Transceivers
	4 30L1 Amplifiers
Antennas	6 Half-wave dipoles
Transmission Line	6 RG-213
Site Coordinates	Lat 54^{o} 45' 50.5"N Long 09^{o} 22' 45.4" E

C.2.8.1.2 KELLINHUSEN SITE, 14-17 SEPTEMBER 1979

A technical evaluation of the Kellinhusen, Germany, high frequency radio station was performed from 14 through 17 September 1979. During the evaluation, maximum emphasis was placed on optimizing the equipment. When the team arrived at the site, the radio equipment was operating in a degraded condition and considerable effort was required to attain optimum performance. The first echelon maintenance was good. Problems encountered were due mainly to the age of the equipment.

Table C-2 Kellinghusen HF Equipment

Equipment	[ata
Equipment Type	HF A3J (SSB)
Equipment Manufacturer	Collins Radio Company
Date of Initial Installation	Unknown
Total Frequencies	6
HF Equipment	4 AN/FRC-93 Transceivers
	4 30L1 Amplifiers
Antennas	7 Half-wave Dipoles
Transmission Line	7 RG-214
Site Coordinates	Lat 53° 58' N
	Long 09° 43' E

C.2.8.1.3 SOEGEL SITE, 11-14 OCTOBER 1979

A technical evaluation of the Soegal, Germany, high frequency (HF radio station was performed from 11 through 14 October 1979. Tne as-found condition indicates that the equipment was degraded. This is due primarily to the age of the equipment and the lack of an effective maintenance program. Vehicles parked under the antennas are causing distortion of the fields resulting in high voltage standing wave ratios. This can be remedied by replacing the support poles and raising the entire high frequency antenna configuration to a minimum height of 60 feet. Command emphasis is required to insure that deficiencies in Table C-2 are corrected in a timely manner.

Table C-3 Soegel Site HF Equipment Profile

Equipment	Data
Equipment Type	HF A3J (SSB)
Equipment Manufacturer	Collins Radio Company
Date of Initial Installation	Unknown
Total Frequencies	12
HF Equipment	4 AN/FRC-93 Transceivers
	6 30L1 Amplifiers
Antennas	12 Half-wave Dipoles
Transmission Lines	12 RG-213
Site Coordinates	Lat 52° 51' 11" N
	Long 07° 31' 26" E

C.2.8.2 HF EQUIPMENT CONDITION

The analysis of the equipment at the three sites is essentially identical. The following summarizes the team's evaluation of the HF equipment and deficiencies.

Analysis of equipment performance in the as-found revealed that it was in a degraded and substandard condition. Primary causes of the degradation are the age and worn condition of the equipment and inadequate maintenance.

A number of problems were encountered on the AN/FRC-93 transceivers and 30L1 power amplifiers (PA) that affected their operational performance. These problems varied from insensitive receiver performance to low transmitter output power. The age of the equipment and operational considerations make full specification performance impractical. The primary performance degradation was transmitter output power. Transmitter output power level was degraded because the transmitters must be operated in a broadband mode due to frequency assignments. Some operational frequencies are near the equipment intermediate frequency (5 to 6 MHz); as a result, power output was nominally degraded by 3dB (half-power) or more.

A number of tuning and alignment problems were encountered with the AN/FRC-93 transceivers which were corrected to the maximum extent possible. The following problems were observed in all units:

a. Low transmitter power output.

b. Insensitive receivers.

c. Low RF grid drive levels.

d. Functional switch and relay problems.

e. Carrier balance out of adjustment.

f. PA's automatic limiting circuit out of adjustment.

g. All bands out of alignment.

h. PA's not neutralized.

i. Grid drive not neutralized.

j. Equipment dirty and dusty.

All transceivers evaluated on site required considerable adjustment to obtain optimum performance.

Instructions were left with site personnel to periodically verify that the equipment does not degrade from the performance level obtained by the test team.

One 30L1 PA had two bad tubes. All four tubes were replaced to preserve amplifier tube balance. One tube had a bad solder connection in the plate circuit which was subsequently corrected. All of the other PA's that were tested on site operated satisfactorily.

C.2.8.3 <u>SITE ANTENNA CONFIGURATION</u>

At the Soegel site the antennas are approximately 40 feet high, and the main road to the US detachment passes under the antenna configuration. Vehicles are often parked under the antennas which cause high voltage standing wave ratios (VSWR). The antennas should be raised to a minimum height of 60 feet to help eliminate the VSWR problem.

At all sites the close proximity of the antennas will obviously cause pattern distortions that will definitely affect their coverage capability. Verification of proper antenna radiation would be difficult and expensive; however, the antennas are not installed in a recommended configuration. Figure C-1, C-2, and C-3 show the antenna installation and operating frequencies.

At all sites the antennas and transmission lines did not have any protection from lighting strikes or other high voltage transient phenomenon. A practical protection against this type hazard is a "Blitz Bug" lighting arrester device. The cost on the commercial market is $4.50. This item does not have a Federal Stock Number (FSN).

C.2.8.4 <u>SITE PERSONNEL TRAINING</u>

While the team was on site, considerable effort was devoted to training on site personnel in the following HF radio areas:

a. Equipment tuning procedures.

b. Identification of malfunctions and diagnostic techniques.

c. Basic maintenance instructions and procedures (as maintenance level on site allowed).

HF training within the Army, especially for this type of system, appears to be inadequate to properly prepare on site operators and maintenance personnel for this mission. The primary areas of concern are knowledge of equipment maintenance and basic radio circuits, equipment problem identification and description, and relation of the problem to symptoms so that adequate corrective action can be accomplished by on site personnel at AMSF.

C.2.8.5 <u>COMMENTS AND RECOMMENDATIONS</u>

The following were team's comments on the equipment and recommendations to maintain site operation:

The HF equipment is old, has been in use for an extended period of time, and had deteriorated to the point where it requires intensive maintenance. In view of this, management should seriously consider replacement of the equipment. If this cannot be accomplished in the near future, consideration should be given to implementing the following:

Cycle the existing equipment through the supporting area maintenance supply facility (AMSF) or other support activity, such as Tobyhanna Army Depot, to restore it as near as possible to the manufacturer's original condition. Establish a highly motivated and well qualified team to periodically visit each site to troubleshoot, repair, and optimize the equipment. This team

SOEGEL

SITE COORDINATES:

52° 51' 11" N

007° 31' 26" E

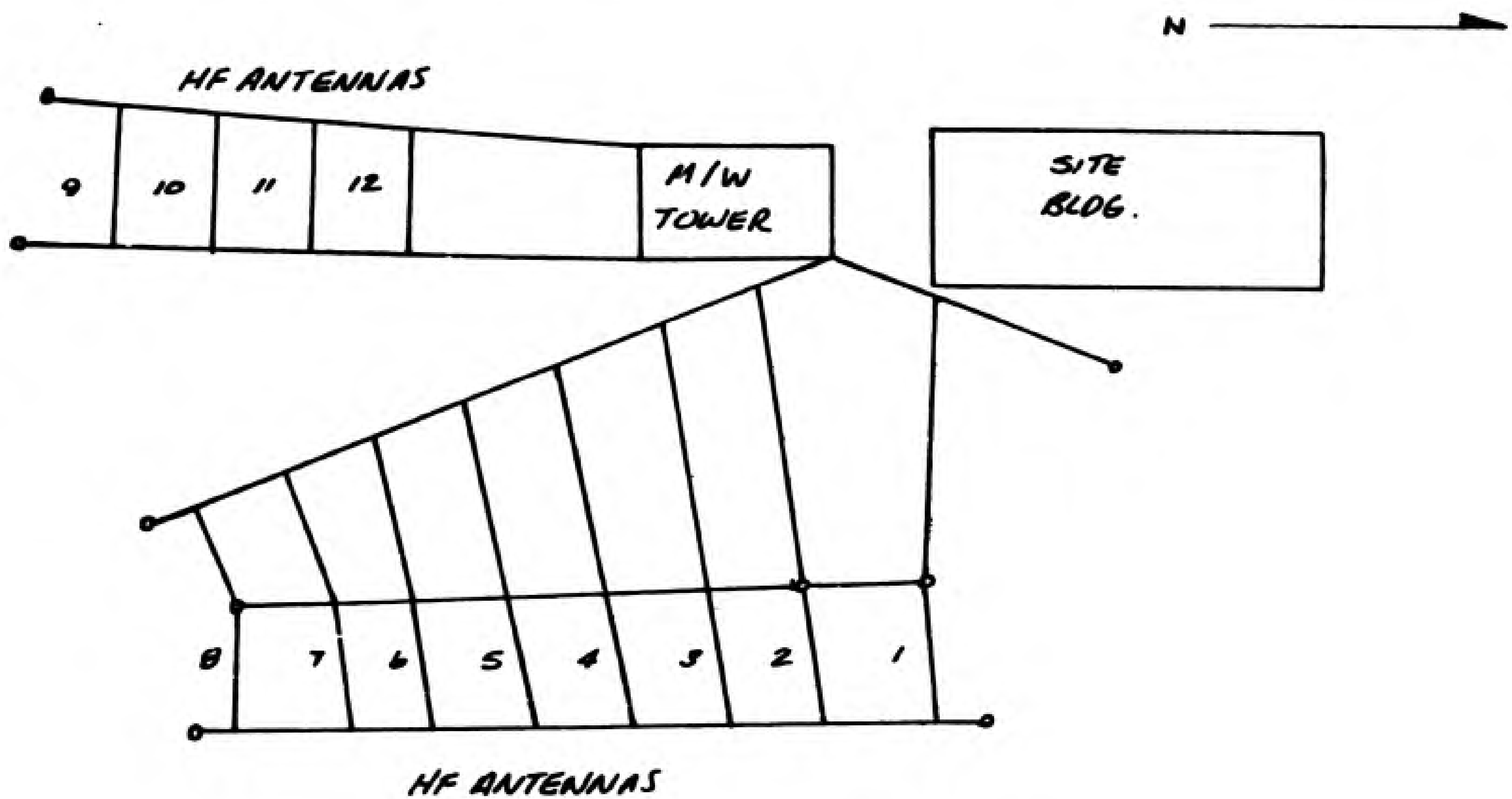


Figure C-1 Soegel Site Layout

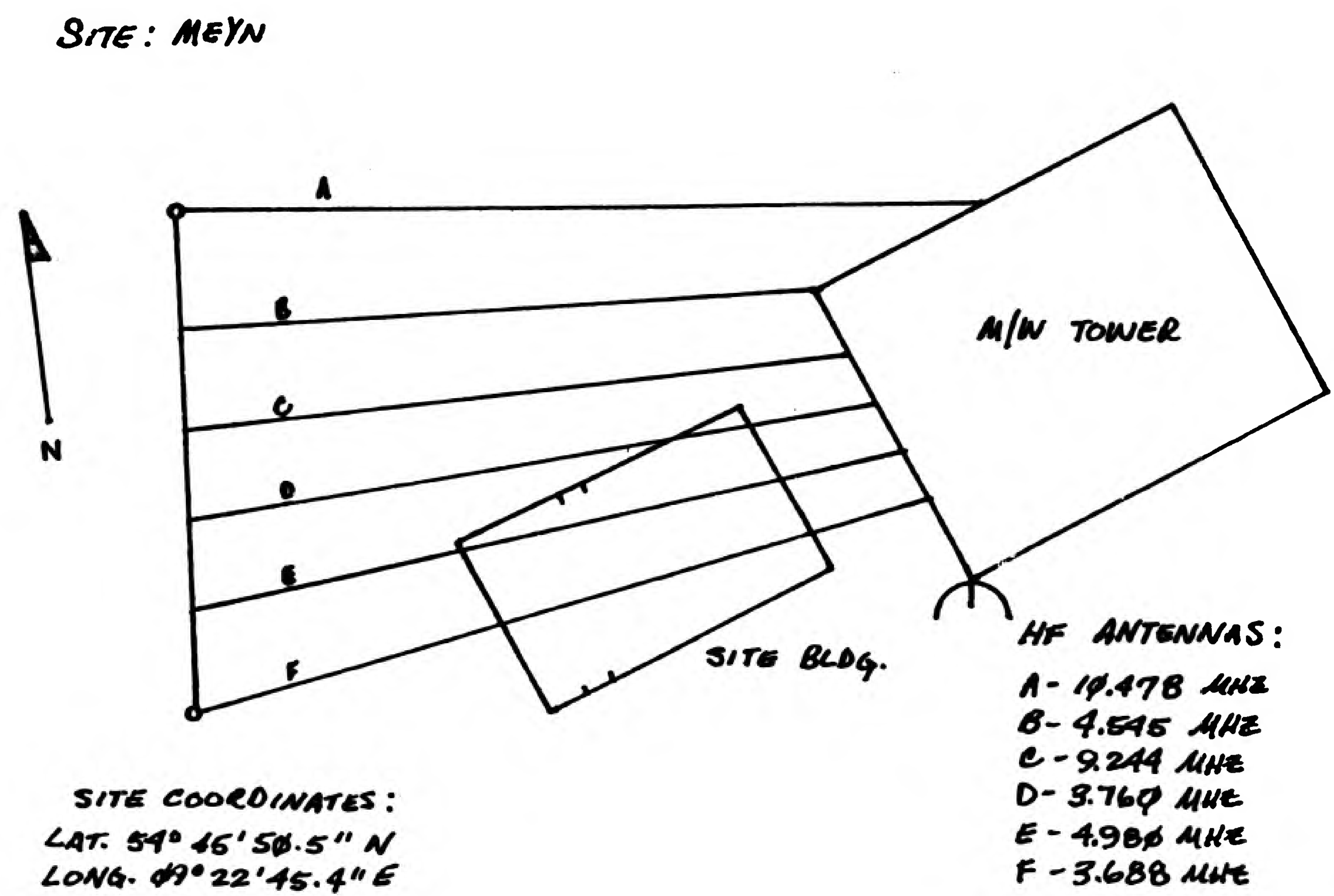


Figure C-2 Meyn Site Layout

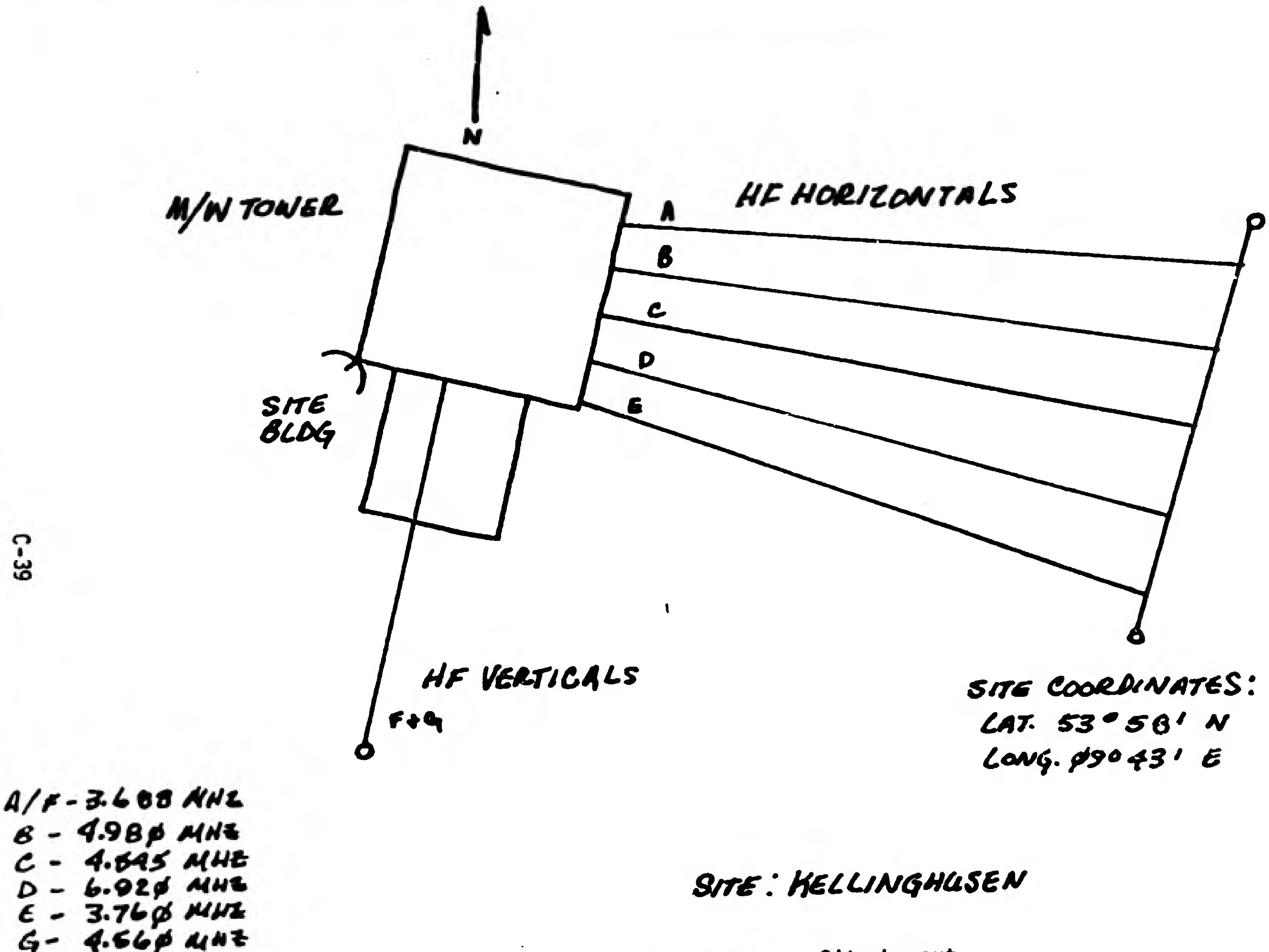


Figure C-3 Kellinghusen Site Layout

could also provide training in radio maintenance and operation to augment the knowledge of on site personnel.

The HF dipole antennas are in close proximity to each other, therefore, a serious problem occurs when a transceiver is keyed to activate the transmit position. When the push-to-talk (PTT) function is activated, high RF potentials are induced which damage equipment components. The potentials are high enough to burn out the transceiver input RF transfor (T3). A temporary solution to eliminate or reduce this hazard is to interconnect the PTT functions of all operational radios. This eliminates the high RF potentials from the transceiver front end by effectively disconnecting the receive inputs from all transceivers when one PTT function is activated.

C.2.8.6 SITE DEFICIENCIES AND RECOMMENDED CORRECTIVE ACTIONS

Table C-4 Deficiencies & Recommended Corrective Actions

NUMBER	DEFICIENCY	RECOMMENDED CORRECTIVE ACTION
1	Inside plant transceivers & high power amplifiers were operating in a degraded condition.	Consider replacing the equipment or cycle existing equipment through AMSF or other support activity to restore it. Schedule periodic visits by qualified HF personnel to evaluate, repair, and optimize all transceivers, antennas, transmission lines, and switching equipment
2.	At the Soegel site, vehicles parked under the antennas were causing high VSWR's.	Replace the support poles to raise the entire HF antenna configuration a minimum of 60 feet above ground.
3.	Distorted radiation patterns may be caused by antennas in close proximity to each other.	Consider using broadband dipoles and radio multi-couplers which would reduce the number of antennas required at any location.

Table C-4 (Continued)

NUMBER	DEFICIENCY	RECOMMENDED CORRECTIVE ACTION
4	Antennas and transmission lines did not have light-nigh protection.	Install adequate lightning protectors on antennas & transmission lines.
5	The as-found condition of equipment indicated a lack of properly trained per-sonnel.	Provide training to on site personnel
6	The high RF from antennas close to the transceivers were burning out the input tuned transformers (T3) when the PTT's were acti-vated.	Connect the PTT's together to prevent the input tuned transformers (T3) from burning out.

C.3 AN/TSC-38B HF COMMUNICATION CONTROL ENGINEERING ANALYSIS

An engineering analysis was performed on the AN/TSC-38B HF Communication Central in 1977. The object of the analysis was to determine the modification that would be required to provide the following reliability, maintainability, availability, and transportability characteristics.

a. Improve the reliability and maintainability of the AN/TSC-38B such that the complete radio terminal will operate through a 30 day contingency deployment without a field correctable failure.

b. Improve the reliability of the equipment such that the unit can be operated as an RF transmission facility for an additional 60 days without a field correctable failure.

c. Improve the transportability of the euqipment such that the unit can be transported over a combination of highway and rough gravel roads for 100 total miles and be fully operational on arrival at a contingency site.

C.3.1 AN/TSC-38B BACKGROUND INFORMATION

The AN/TSC-38B was fielded in the late 1960's and was designed for use as a mobile, air transportable, high frequency radio communications terminal to provide long haul communications from contingency sites into the Defense Communications System (DCS). The system was designed to operate independently as an RF transmission and communications terminal facility or in conjunction with other transportable equipments in support of a major contingency operation. When used independently as a communications terminal and HF transmission facility the AN/TSC-38B can provide automatic dial telephone service to twelve subscribers, terminate two secure and one non-secure TTY circuits and provide TTY transmission service to 16 additional TTY subscribers. The AN/TSC-38B has two independent sideband (ISB) transmitters, one with ten (10) KW and the other with one (1) KW output capability. The one KW transmitter is normally used as back-up for the 10 KW transmitter; however, simultaneous operation of the transmitters is possible. The primary power for the AN/TSC-38B is three phase, 208V, 400 Hz. Two tubine-driven 60 KW 400 Hz generators are supplied with the system. The system is also designed to operate from a three phase, 208V, 60 Hz source. Though the feature has never been used, the AN/TSC-38B was designed to operate as a remote controlled transmission facility.

Another capability which was designed into the AN/TSC-38B which was not used and was eliminated in the early years of use was short term (15 minute) operation from a self-contained battery source. The requirements for operation from two different frequency power sources, remote operation, and emergency operation from self-contianed batteries have contributed greatly to the very poor in-service reliability of the AN/TSC-38B. The addition of these capabilities also made the system much more complex and difficult to maintain. The equipment is mounted in an S-141 electronic equipment shelter and is mounted on a M-689 dolly set for mobility.

The AN/TSC-38B was constructed using equipments which were available either in the Army inventory or listed in various manufacturers catalogs. With the exception of the teletype equipment, the Contractor, Ratheon Inc., Lexington, MA., selected the types of equipments to be used, engineered the physical layout and required interface devices, interrack wiring, and the power distribution frequencies and short-term emergency operation from a self-contained battery source resulted in a very complex, unusual, and difficult to maintain power distribution system. The government requirement to install all of the equipments and subsystems in a S-141 Electronic Equipment Shelterment imposed severe space contraints upon the contractor.

C.3.2 PRELIMINARY SYSTEM INVESTIGATION

Two AN/TSC-38B equipments (Serial Numbers 3 and 5) were transferred to Sacramento Army Depot (SAAD) from 11th Signal Group assets and a preliminary inspection was performed by SAAD and USACEEIA in December 1976. These two equipments were not operational on arrival and were in very poor condition. The wiring harnesses were deteriorated beyond repair due to chaffing and abrasion, broken wires, shorted wires, and broken plugs on the cable assemblies. The exciters for the 10 KW and 1 KW transmitters and the primary and secondary receivers bore evidence of overheating, had broken and missing components, broken wires and intermittent solder connections. All other components in the system, though not in as poor condition as the receivers and exciters, were in bad need of overhaul and reconditioning. The 10 KW Linear Power Amplifiers (LPA) were in very poor condition, bore evidence of considerable field maintenance, had broken and missing parts, and worn mechanical linkage to the tuning components. Complete depot overhaul of all electrical and mechanical components of the inspected AN/TSC-38B equipments was necessary before a complete evaluation of the reported deficiencies could be accomplished.

The AN/TSC-38B was assigned to and operated by both Army and Air Force Units. Both users reported extreme difficulty in operation, maintenannce and transportability of the system. The noise levels were very high in the entire shelter and were a hazard to the health of the operators in the operations area. Examination of the user reports and verbal information supplied by the user indicated the AN/TSC-38B must be the most unreliable and most difficult to maintain transportable communications system in the Army inventory. User estimation of the MTBF was six hours operating time, and no other records are available to support that any of the AN/TSC-38B systems had operated with all subsystems functioning for a substantial period of time.

Deficiencies listed in the tasking documents, evaluation reports from other military departments and equipment failure reports from many sources were analyzed to determine the types of failures which were occurring in the AN/TSC-38B. The reported failures were categorized as follows:

a. Failures due to deteriorated equipment.

b. Failures due to excessive heat.

c. Failures due to Transient Failure Modes inherent in the equipment.

C.3.3 FAILURE MODES ANALYSIS

Failures in many of the individual equipments of the AN/TSC-38B appeared to be caused by excessive heat. Failures in the 200A 28 VDC power supply, transmitter exciters, receivers, 10 KW transmitter and the teletype MUX equipments were due to overheating. Transient failure modes also existed in many of the equipments. This type failure mode was prevalent in the 1 KW transmitter, the 28 VDC power supply, and the CV-2100 frequency changer for the air conditioner. Transient failures are practically impossible to correct using normal maintenance procedures; they are extremely difficult for technicians to recognize, and always require engineering modifications to correct.

C.3.4 ENGINEERING CHANGE REQUIRED TO CORRECT THE AN/TSC-38B

The engineering changes required to modify the AN/TSC-38B to meet the reliability, maintainability, and availability goals ranged in scope from the simple addition of resistors to developing a new air conditioning system which operates on either of two primary power frequencies (60 and 400 Hz); a complete redesign of the signal and control wiring and a complete revision of the cold air distribution system.

C.3.5 MODIFIED SYSTEM TESTS

The modified AN/TSC-38B was tested at the Sacramento Army Depot for 96 hours without a correctable failure. The system also met the transportability requirement. It was then transported to Fort Huachuca for 90 days user tests. A modified AN/TSC-38B system was set up at Fort Irwin (near Barstow, California) and operated 24 hours/day for 30 days without failures.

C.3.6 CONCLUSIONS

The following are conclusions provided by the Director, Communication Engineering Directorate:

a. The reliability and maintainability of the modified AN/TSC-38B may be improved to the extent that the units are satisfactory for service.

b. The government requirements for the unused remote and emergency battery operation capabilities unnecessarily increased the complexity, reduced the reliability and made maintenance of the AN/TSC-38B very difficult.

c. The transient failure modes should have been recognized and corrected by the prime contractor.

d. The prime contractor should have designed a better air distribution system.

e. The government requirement to concentrate so many major systems components in such a small space contributed to the failure of the AN/TSC-38B to provide reliable service.

f. Repair and maintenance of the AN/TSC-38B were impossible tasks for Army personnel due to the existence of many transient failure modes, the inherent complexity of the control and power distribution system and the inadequate cold air distribution system.

C.3.7 RECOMMENDATIONS

The following recommendations were provided by the Director, Communications Engineering Directorate for future communications systems design programs.

a. Remove requirements for communication system specifications which unnecessarily increase the complexity and cost of the equipment.

b. Determine the field reliability and maintainability of transportable communications systems early in the life cycle througn performance of user tests and analysis of equipment failure reports

c. USACEEIA prepare standard specification guide for transportable communications systems. These specificiations should include the lessons learned from this project to include the air distribution systems, human factors engineering, maintainability and reliability engineering.

d. Require engineering design review's on all contracts for transportable communications systems.

APPENDIX D

SITE SURVEYS

D.1 INTRODUCTION

The material contained in this Appendix delineates information obtained from various site surveys, including trip report memoranda.

D.2 SITE VISITS

D.2.1 NAVY MARS NC-1 W4USN

The Navy MARS Station W4USN is part of a net that includes Eastern CONUS, the Atlantic Ocean and the Mediterranean. This net consists of 132 Fleet Ship Stations, 8 overseas shore stations and 84 shore stations in CONUS. W4USN is not manned full time; however, each day at 1200 the net is activated. Frequency assignments for the net are made through the Chief Navy/Marine Corp MARS.

The station predominately operates in the 7 to 20 MHz frequency range. W4USN has 17 HF frequencies assigned and shared with other stations in the net. The net does not have any dedicated circuits. The W4USN has the capability to receive and record RATT messages on a 24 hour basis. The Navy MARS cannot directly enter the Army or Air Force MARS nets. The main reason is frequency assignment. To send a message through the Army or AF MARS net, W4USN must transmit the message on VHF to either Fort Meade or Andrews Air Force Base MARS. The traffic through the NC-1 MARS station consisted of 52,000 phone patches and 958 RATT messages in 1979. W4USN is limited to a 2KW PEP transmit capability. The equipment in the station is 1959 vintage and consists of KWM-2 Collins S Line, R-1051 receiver, and Drake TR-7. While the equipment is old it is well maintained and the station chief is a very experienced HF communicator.

D.2.2 NAVY TELECOMMUNICATION GROUP

A visit was made to the Chief Navy/Marine Corp MARS (NAVMARCORMARS) to understand the complete system operational concepts. A paper prepared by Chief, NAVMARCORMARS delineates this Mission and Function, Structure, Teletype System, Afloat Program, VHF Repeater System, Equipments and funding.

In addition to the paper received, the following information was provided:

- NAVMARCORMARS has 127 HF frequencies assigned in the 2-27.5 MHz frequency band.
- Marine Corps Mars (MARCORMARS) works in the Navy MARS Net until a crisis develops; at that time, MARCORMARS will be used to support the Marine Corps tactical or long haul communication requirements.

- The MARCORMARS is a budget line item in the Marine Corps.
- Presently, the Marine Corps is upgrading their MARS station with state-of-the-art Harris HF communications equipment. The estimated cost is $2K to $3K per terminal.
- The network has never been tested in a national drill or exercise, but there are several occasions when it supported emergency situations.

D.2.3 ARMY MARS

A meeting was held with the Director, Army MARS CONUS at Ft. Ritchie, Md., to obtain a knowledge of the Army MARS System.

The Director, Army MARS CONUS is responsible for MARS stations in CONUS, Alaska, Panama, Puerto Rico, Virgin Islands, and Hawaii. Under the Director, Army MARS CONUS, there are three area officers located at Fort Meade, Fort Sam Houston, and Presidio, Ca. These coincide with the CONUS Army military areas. Below this level of MARS, participants are volunteer. Each state has an assigned director with a supporting staff selected by the state director. The Army MARS area officers are responsible for frequency management, emergency coordination, and training.

The Army considers the MARS communications network as a thin line, emergency reconstitution communication capability that supplements and complements normal communication channels. Several situations were described where MARS was used to provide a military post commander communication until the normal communications could be established.

The Army MARS is assigned approximately 127 HF frequencies in the 2 to 30 MHz HF frequency band. Some stations have a VHF capability. Each station is assigned to two nets. The nets are defined as Regional, State and Continental. The Fort Meade MARS station is designated as the European Gateway and the Presidio is designated as the Pacific Gateway.

The Army MARS communication is predominately SSB voice. The gateway stations are equipped with TTY. Some stations, other than gateway, have a TTY capability but this depends on the Army Commander. Basically, the military MARS sites are considered as emergency communications for the base commander. The Army views MARS as a subsystem in the Army CONUS communications system.

The Army MARS is trying to build a 24 hour backbone system consisting of Fort Meade, Fort Sam Houston, and the Presidio.

The Army MARS does not have an on-line secure capability. Some stations have a capability to conduct phone patches using Radio Wire Integration (RWI).

Communication exercises simulating emergency conditions have been run using the MARS net. Some MARS stations have a mobile capability (called jump teams) that moves into the scene of the emergency or disaster (Three Mile Island).

The Army MARS equipment is the AN/FRC-93 (1950-1953 vintage). The AN/KWT-6 is used in European MARS stations only. Some thought is being given to equipping the Army MARS stations with the SUNAIR 1 KW solid state ISB, SSB, GSB-900 equipment. The cost is estimated at $4000.00. This MARS equipment will be installed at the Gateway stations first. The Presidio would be the first to receive the equipment followed by Fort Meade. Army MARS is also interested in the Harris HF Communications Equipment.

There are approximately 32 Army MARS stations and 6,000 affiliated civilian stations. The typical radio equipment in the civilian station is the DRAKE TR-7. The Army has provided some civilian stations with modems and TTY equipment.

The stateside MARS stations are power limited to 2 KW PEP. The gateway stations have a 5 or 10 KW average power transmit capability.

D.2.4 SPECIAL FORCES, FT. BRAGG, N.C.

Special Forces (SF) delineated that their function was primarily covert. Their total need for HF should not impact the Army HF Improvement Program. SF units have requirements to operate ranges as great as 10,000 km. They need light weight, highly mobile, reliable, and available equipment. A low silhouette antenna with directivity is a definite need. The radio should be designed with low probability of intercept capability from direct transmission as well as spurious electromagnetic emissions. Power control is another advantage so that messages can be transmitted with the minimum of power. In all probability, Special Forces will communicate in a burst mode at designated reporting times.

D.2.5 NELEX, RESEARCH AND DEVELOPMENT TELECOMMUNICATIONS DIVISION

The Acting Director of NELEX defined the Navy HF Improvement Program (HFIP) mission as supporting the fleet communications and providing an alternate for SATCOM or other communications links. The major Navy efforts in their HFIP is as follows:

1. A tuner/coupler for transmitting whip antennas.
2. A narrowband firm-ware configured modem.
3. An HF receiver designed for a high noise environment. Synthesized, remotely controlled, wideband (BW 3 kHz, goal of 100 kHz instantaneous, rapid hopping, and inexpensive).
4. An exciter to match the above receiver.
5. A broadband, highly linear power amplifier.
6. A wideband modem for ECCM application. The advanced development is being completed.
7. A broadband RF distribution system.
8. A communications/channel evaluation subsystem using standard communication transmitters and receivers and modulation formats.

Of these efforts the Army should be especialy interested in Items 2, 3, 4, 6 and 8. Some technical detail should be available on Item 2 and possibly 6. The Army will have to obtain details on 3, 4, 6 and 8 directly from the Navy.

D.2.6 CAMERON STATION, COMMUNICATIONS AND ELECTRONIC MAINTENANCE DIVISION

A visit was made to Cameron Station to discuss maintenance philosophy and procedures for Army HF radios. This facility provides maintenance for Army HF radios for the Military District of Washington and supporting units.

The major HF radios repaired at this facility are the AN/GRC-106, AN/GRC-122 and AN/PRC-74. The HF radio equipments arrive at Cameron Station predominately from Vint Hill Farms Station and Fort Meyer. This station is equipped to provide maintenance for HF, VHF, and UHF communications equipments associated with seven or eight radio nets in the Washington, DC vicinity.

Army regulations require that a DA-2407 Maintenance Request Form be filled out for each equipment repaired. Regulations also require that the form be filed for 90 days at maintenance facility. This form describes the unit being repaired, the problems and symptoms of the unit, the work done on the unit at the maintenance facility, the time expended, and cost of repair parts. A copy of the maintenance request form is provided to the organization requesting repair action. The data contained on the maintenance request form is not forwarded to any other Army Organization. The data is not used to evaluate reliability, maintainability, equipment performance assessment, or life cycle costing for the equipment, or to define critical problem areas of an equipment.

The information of repair data on HF radios at Cameron Station is in a file of approximately 4000 maintenance request forms. These maintenance forms contain repair data on a wide variety of electronic equipments.

Evaluation of the maintenance forms show that there was no single component in any HF system that could be readily defined as a major problem. The problems varied from cables, connectors, switches, and various other components. Most of the equipment failures could be associated with the operator.

D.2.7 DEFENSE COMMUNICATIONS ENGINEERING CENTER (DCEC) TRANSMISSION ENGINEERING DIVISION (220)

The meeting was held at DCEC to determine the DCA participation in HF communications and the HF interface requirements to enter the DCS. It was stated that DCA uses HF communications as a contingency operation only. Presently, there is little effort devoted to HF system improvement or advanced technology by DCA.

The interface with DSC is 4 channel independent sideband, centered on the assigned frequency and occupying a band of ± 6 KHz. The AN/TSC-38B supposedly has this capability.

DCA stated that Army and DCA had gotten out of long-haul HF communications because of the inability to support 2400 bps channels. The basic problems were defined as distortion, interference, timing and frequency assignments.

D.3 TRIP REPORTS

This section of Appendix D provides copies of trip reports that cover details of visits to various institutions.

MEMO TO: HF File

FROM: C. H. CERVA

SUBJECT: FT. Ord Visit 17 and 18 March 1980

REFERENCE: (a) Significant Activity Report, 20 Jan. 1978, U. S. Army Electronics Command, Europe Technical Assistance Office 5-3-78.

(b) Red Team Analysis of AN/GRC-143 Radio Teletypewriter Set, July 1977, U. S. Army Maintenance Management Center.

1. **Persons Contacted**:

Lt.Col. Sakayeda DARCOM LAO
Mr. George Kirby " "
Mr. Thomas Tierney " "
Capt. Sanders, 127th Signal Battalion
CW-2 Mr. Reeves " " "
CW-3 Mr. Fritzgerald, 7th Division Direct Support

2. The purpose of this site visit was to assess the HF radio operation and performance in an infantry division. The HF radio system used by the 7th Division is the AN/GRC-142 Radio Teletype (RATT) System. The prime components are the AN/GRC-106 HF radio; Teletypewriter TT-76, perforator TT-98 and TSEC/KY-7 communication security is provided for RATT operation only. The total equipment is installed in a "Gama Goat" type vehicle. The 127th Signal Battalion has 33 AN/GRC-142 RATT sets assigned to it to provide division communication. As a general rule, the range between RATT sets is 10 to 15 miles (16 to 24 km). On some occasions the operating range could be as great as 60 miles (96 km), but this situation is unlikely.

The General Support (GS) shop provided a bench test setup of the AN/GRC-106 to demonstrate the problems with the HF radio. The AN/GRC-106 is a 1960-1964 vintage design. The repairman in GS emphasized that the original design systems by General Dynamics is superior to the Magnovox design.

There are circuit differences between the two designs and these changes are not carried through in the equipment technical manuals. Problems with the AN/GRC-106 cannot be attributed to any one particular area in the system. In some cases, because of age, various components are getting difficult to procure and there are unusual delays in receiving ordered parts. At one time, the tuning turret was a problem. Over 50% of the turrets failed; however the turret problems seemed to go away. It was pointed out that at one point the tuning turrets were becoming loose and shearing the contacts.

The personnel in GS emphasized that the AN/GRC-106 Tech Manuals are not current, accurate, and are extremely difficult to use. They indicated that the repairmen in the field are not capable of using the manuals. They attribute this to the intellectual level of the repairmen. In an attempt to ease the problem, they have developed simplistic instruction sheets that more than supplement the information in the Tech Manuals. This information is maintained in the 7th Division in an attempt to improve the repairmen and operator performance. The following summarizes and provides the comments of the 7th Division General Support personnel.

(a) The AN/GRC-106 may be an old system using circuity and parts dated to the late 1950's to early 1960's but properly maintained and operated it is an effective system.

(b) The tech manuals are not written in a language level that the radio repairman or operators understand.

(c) Some test equipment called for in the manuals is obsolete, outdated, not available, or in some cases not as accurate as the AN/GRC-106. In particular in frequency stability and drift.

(d) The Army repairmen are not capable of substituting test equipment when the recommended test equipments are not available.

(e) Experienced CERCOM personnel have difficulty following the tech manuals. This is with respect to schematics that are fragmented, parts lists, and cabling information.

(f) In the opinion of CERCOM personnel that support GS people, the start up or turn on procedures defined in the tech manual are in error and require too much time. Turn on time prescribed in the tech manual could require ten minutes. Logical reasoning may require only two minutes to place the system in operation.

Direct Support of the 127 Signal Battalion is allocated three HF radio repairmen. They have only one. They lack the capability to repair the modems. They have no operational test radio to assist in repair and trouble shooting. The AN/GRC-106 equipment is generally shipped back to the Directorate of Industrial Operation (DIO). This means that the equipment is tied up in repair for a long period of time (two to three months).

The Signal Battalion DS people feels that the AN/GRC-106 or AN/GRC-142 has an availability of 30%. This means that at any one point in time only 30% of the equipments are operational. Low reliability and availability are attributed to operator problems (not properly trained, distinct lack of knowledge of the equipment). The TTY equipment is a major problem. Eighty percent of the problems are attributed to the operator and lack of knowledge in proper cabling of the equipment. The use of polarized cable plugs would help. This would assure the proper interconnection of the system. The DS people feel that:

(a) There is a need for a simpler system design. A designed based on the intellectual level of the present people required to operate and maintain the system.

(b) New TTY equipment is needed. The TT-76 and TT-98 are old designs. They are predominately mechanical systems as opposed to modem equipment that is electronic and more reliable.

(c) Most problems with the AN/GRC 142 are operator induced. This is attributed to lack of training, and lack of effective operating experience.

(1) The HF radio operators and repairmen are too narrowly trained.

(2) The operators and repairmen are not trained in system knowledge and operation.

(3) The repairmen are not taught logic in trouble shooting.

(d) Assignment of operating frequencies are a problem. The frequency assignments are changed daily. The frequencies assigned are not selected from propagation charts. The person assigning frequency has a lack of knowledge of the basics in proper selection of hf frequency. In many cases the assigned frequencies will not propagate and no action is taken to correct the situation.

The Division DS Electronic Shop handles radio, radar, as well as other electronic equipment. The opinion of the division DS is that the AN/GRC-106 is basically a good radio. The major problem is operating personnel and operator induced failures from lack of training. In the field there is a tendancy to play musical chairs with the equipment. The AN/GRC-106 Radio Frequency Amplifier AM-3349, and Receiver Transmitter Unit RT-622/GRC must be adjusted and tuned together. Substitution of the units will result in radio problems. The operation and maintenance manuals are not adequately used by field personnel. The basic problem is that they do not understand the manuals. The AN/GRC-106 modems MD-522/GRC are difficult to repair and give the DS shop extreme difficulties. The DS Shop test equipment is antiquated and somewhat unreliable. There is a two or three week period over a year when a team is brought on base to do all test equipment calibration. During this period the DS shop is essentially closed down. The DD-2407 forms that are sent to the DS shop with the equipment for repair are not adequately filled out to define the radio failure or defective operational problem. There appeared to be only one person in the DS shop who had reasonable knowledge of the AN/GRC-106 to perform maintenance functions.

Reference (a) and (b) were provided to delineate AN/GRC-142 deficiencies in meeting DA Operational Readiness (OR) Standards.

Reference (a) was provided to show an analysis of the VII Corps. OR rates for radio teletype equipment AN/GRC-122, 142, and AN/VSC-3. This analysis shows that while the Corps was not meeting the DA Operational Readiness Standard of 82% because of related AN/GRC-122, 142 and AN/VSC-31, the failure reasons were related to other factors (not communications and electronics).

Reference (b) defines why the AN/GRC-142 failed to meet DA OR Standards. This report delineates deficiencies in personnel, training, technical manuals, and tools.

Mr. Gearge Kirby and Mr. Thomas Tierney of DARCOM Logistic Assistance Office (LOA) provided fuidance during the visit to Ft. Ord. They showed a bench set-up of the AN/GRC-106 radio and the operating features as well as the potential problem areas:

Antenna Tuning and Loading
Turret Alignment
Vacuum Tuning Capacitor
Final Amplifier Heating
Filament Voltage Control
Over Temperature Sensor
Tech Manuals (TM)
Checkout Procedures
Cabling
Operator and Maintenance Training

It was emphasied that the AN/GRC-106 radio is an old system with circuitry, parts, and designs that date to the late 1950's or early 1960's, however, experienced operators have little difficulty in operating the system. A critique by LOA personnel is that the TM is not written at a language level that the operators and maintenance personnel can read or understand. The TM is in need of upgrading. Experience with the equipment has modified operational, maintenance, and alignment procedures. The present TM does not contain these modifications. Some of these procedures that are used in the field may have not been submitted to the proper source to implement a TM upgrade. This is the experience aspect of AN/GRC-106 operation.

The LAO field personnel have the feeling that repairmen and operators are not taught hf basics at the service schools. Predominately this includes operating frequency, equipment set up, proper grounding and proper installations of antennas. In some cases AN/GRC-142 TTY sets have been set up in the field within ten or twenty yards of each other. This has resulted in interference and the problem of front end burnout. Equipment has been found installed at a site without the system ground and this contributes to performance degradation. Tuning the transmitter and loading the antenna is a normal operating procedure that is improperly done even with tuning and loading charts printed on the front of the equipment. Many of the operators do not have a working knowledge of the basic tools such as pliers, wrenches, screw drivers, allen wrenches, and tuning elements.

The radio operators in the field do not get sufficient operating time on the radio sets. In particular, they are assigned to various sundry duties that take priority over their basic MOS as a radio repairman or radio operator.

The DARCOM LAO personnel are extremely knowledgable of the AN/GRC-142 RATT set as well as the AN/GRC-106 Radio Set. They are extremely capable of providing maintenance or operational guidance when required. The DS and GS shop leaders (normally warrant officers) are knowledgeable and capable in maintenance and operation of the AN/GRC-142 RATT set. There appears to be a lack of radio repairmen in the DS and GS shops.

SACRAMENTO ARMY DEPOT (SAD) 19 AND 20 MARCH 1980

Persons Contacted:

Mr. James Pittman, Production Engineering Division 916-388-2591

Mr. Eldon Davidson, Communication Electronics Engineering Installation Agency (CEEIA) 916-388-2568

Reference:

(a) Operator and Organizational Maintenance Manual, Communications Central AN/TSC-38B, TM 11-5895-356-12-1, March 1970.

(b) Final Report, AN/TSC-38B HF Communication Central Engineering Analysis, CEEIA, Ft. Huachuca, 22 September 1978.

(c) JCS Contingency Station (Table of Equipments).

(d) Field and Depot Maintenance Manual, Communications Controls, AN/TSC-20 and AN/TSC-20A, TM 11-5895-288-35, 11 January 1963.

(e) AN/TSC-25 Communications Shelters Modified for Low Level Operations by Sacramento Army Depot, Interim Narrative, 19 May 1979.

Mr. James Pittman of the SAD provided a tour of the overhaul facilities for the AN/TSC-25, AN/TSC-38B and AN/GRC-106 equipments. SAD is well equipped for manufacturing, fabrication, repair, alignment, and test and evaluation of the above equipments. They maintain quality control at all stages. The persons performing assembly, alignment, and test of the equipment are competent and knowledgeable of their functions. Workmanship is excellent.

SAD is the major repair depot for the Air Force and Army AN/TSC-38B's, the AN/TSC-25 and the AN/GRC-106 radio. In addition to total repair and maintenance of the radios and equipments, they do component repair such as card repair, tuners, synthezisers, multiolexers, combiners, power supplies, amplifiers, etc. They also have adequate mockups to test the components after repair. Basically an equipment or component leaving SAD after repairs is essentially new and well tested.

Reference (a) was provided by SAD for an understanding of the AN/TSC-38B system. Reference (b) delineates the complete overhaul and design modification that was undertaken at SAD; also, Reference (b) provides basic background on the AN/TSC-38B. AN/TSC-38B design deficiencies corrected at SAD were as follows:

Wiring Harness Redesign

Switches and Controls

Synthezisers

Air Conditioner Equipment Redesign

Cooling System Redesign

Work Area Exoansion

Relocation of Equipment

Automatic Control Modification

Rework of Manuals

Remove Remote Control

Reference (b) delineates the work done in the above areas to improve the AN/TSC-38B reliability, maintainable prior to the AN/TSC-38B modification at SAD, the estimated MTBF was six hours. After the modification, a system was set up and operated for 900 hours. Some failures occurred but there was no effort to estimate MTBF, MTTR, or availability. Another system was set up at Ft. Irwin near Barstow, CA and operated for 30 days, 24 hours/day without failure. These tests tend to show an improvement in the AN/TSC-38B realiability, but no data was taken on the failure or repair time for a detailed analysis.

There are 38 AN/TSC-38B communication centrals in the service today. Twenty are assigned to the Army and eighteen are assigned to the Air Force. Twelve of the AN/TSC-38B are assigned to the JCS contingency stations. There are eight AN/TSC-38B assigned to Ft. Huachuca, two in Karlsruhe, Germany (only one operational) and one at the Readiness Command, McDill Field, Florida ICS entry. Location of all AN/TSC-38B systems was not possible.

The AN/TSC-38B was fielded in the late 1960's. The component designs and design techniques probably are late 1950's concepts; hence the system design is old. The system is difficult to align and requires extensive test equipment (accurate signal generators, spectrum analyzers, etc.). This limits field maintenance to essentially modular replacement. In particular, the synthesizers are an old design. Field maintenance is impossible and replacement cost is excessive. For example, to replace the receiver/exciter it is estimated that the cost would exceed $300,000.00. Original cost was on the order of $42,000.00. There are problems in sparing the translater, power supply, and inverter. For example, the transisters in the 28V power supply chopper are out of production. The original cost for these components was $20.00. A recent quote showed their cost at $110.00. The initial provisioning for the AN/TSC-38B was not good and what remains is dwindling rapidly. Product Engineering at SAD feels that the AN/TSC-38B's are rapidly approaching the cannibalization stage. Because of a lack of provisioning it is difficult to maintain effective turn-around time for components at SAD. This is going to project into a field maintainability problem. One other problem with the AN/TSC-38B is that it is difficult to operate with other systems in the TTY mode due to drift rates. To operate the 38 in the TTY mode the drift rate must be less than 1 Hz.

The AN/TSC-25 Radio Central is a 1955 design vintage. It operates from 2 to 30 MHz and has a DCS interface capability. The AN/TSC-25 and AN/TSC-38B will operate with each other. The peak envelope power of the AN/TSC-25 is 1Kw. Presently there are 18 AN/TSC-25 Communication Centrals located at Ft. Bragg and Ft. Huachuca. Some modifications have been made on this system by TMC. (The R-390 receiver, sideband multiplexer, and Receiver Stabilization Unit (RSU)). The TTY has been modified for low level operation ± 6 volts. The AN/TSC-25 tech manuals have been rescinded because they are out of date with the modification SAD is working on the systems with bits and pieces of commercial manuals, depot overhaul standards, engineering installation packages (EIP) and continuation sheets. Of the eighteen AN/TSC-25's only four have been completely modified. Presently five are at SAD for modification.

The AN/TSC-25 is rapidly becoming difficult to maintain and repair. For example, the RATT multiplexers, keyers and combiners were manufactured by Northern Radio. Northern Radio was bought by Harris and they are no longer in the business of manufacturing these components. There are sixty-four multiplexers and keyers per communication central. The AN/TSC-25 is also rapidly approaching the cannibalization stage.

The AN/TSC-38B and AN/TSC-25 consumes a considerable amount of the maintenance facility and manpower at SAD. The maintenance, repair and modification of these systems is costly.

The AN/GRC-106 radio repair facility at SAD handles all aspects of repair components through total radio set. The subtle difference between the General Dynamics and Magnavox manufacturing techniques causes difficulties in supply of components. A substitution in transmit tubes was made and the differences were not noted. A discriminator in the tuning network was redesigned and the difference was not noted. The design of the vacuum tuning capacitor and mounting brackets were changed. There is a difference in case designs. There are also design differences in the tuning elements mounted on the turret. These differences not only make depot repair complex but also cause problems in field maintenance. In some cases, it requires the stocking of different components to perform the same functions.

SAD receives components, sub-assembly units, sub-units, as well as complete radio sets for repairs. They have mockups fixtures and production test equipments to check out the major sub-assemblies, and components repaired. Quality control is maintained at every level of repair. Certain components are difficult to procure and there is an indication that cannibalization has started at the depot to refurbish systems and to provide as fast a turn-around time as possible. In some cases the components are difficult to procure, lead times as much as six months or so were indicated. There was evidence that some sub-assemblies shipped back to the depot were packaged wrong and this resulted in damage to components in shipping.

A major problem is proper field removal of defective components from the radio set. The component removal by field personnel adds to the repair problems in the depot and in some cases renders good components next to useless. For example, leads on components are cut short, brackets are broken to remove components. Likewise improper installation of components such as the turret (not properly tightened) will ruin two or three other components.

Proper alignment of the AN/GRC-106 requires the receiver/transmitter unit RT-662/GRC or RT-834/GRC and radio amplifier AM-3349 be aligned as an assembled radio set. This includes the interconnecting cable (doggie-bone). There is sufficient intercoupling between the units and adjustment to compensate for component differences that the radio set will perform inefficient or degraded conditions; hence, a radio set properly adjusted at the depot and packaged for shipment to the field results in an interchange of units. The field personnel do not realign the radio set and will replace either an amplifier unit AM-3349 or a receiver/transmit unit RT-622 without realignment check. The equipment operates degraded.

The AN/GRC-106 status, refined by SAD Production Engineering Division is that:

(a) The radio set design is nearly twenty years old.

(b) It is getting difficult to spare. Components are out of date and production.

(c) Turn-around time for depot repairs are increasing due to inability to procure sufficient components.

(d) In the tuning section, and final amplifier section cannibalization has started to expedite depot repair time and an attempt to get components back to the field rapidly.

(e) From the condition of components arriving at the depot, (methods of removing from the radar set and packaging for shipment) the repairmen in the field appear to be inexperienced in the maintenance and handling of the equipment. Some repairs are arriving at the depot that could have been adequately been made at a DS or GS shop.

DISCUSSION WITH CEEIA AT SAD

CEEIA emphasized the following with regards to Army HF equipments:

(a) The strategic Army needs a new 10 kw mobile or fixed station HF Radio Central. It should be:

(1) Easily transported

(2) Modular design

(3) Easily adjustable

(4) All maintenance from the front

(5) Cooling air flow should be designed to come in the top and out the bottom of the racks to improve heat removal and reduce maintenance.

(6) Proper air circulation paths should be designed into the racks.

(7) Plug in chassis should be used in place of flexible cables.

(8) Interface complexity should be reduced by designing the complexity in the chassis or drawers.

(9) There is a need for lightning protection.

(10) There is a need for frequency management and methods to select the frequency to be used. Barry Research chirp sounder was suggested.

(11) A more reliable modem is needed such as the Barry Research time diversity modem to improve link reliability and availability.

(12) The need of using 1.6 or 2 MHz as a lower required design frequency should be evaluated. Most communication at HF is done above 3 or 4 MHz. Raising the lowest HF operating frequency would significantly reduce the equipment size weight and complexity.

Visit to McClellan AFB, Sacramento, Ca., AF Air Logistics Center (ALC), 21 March 1980

This visit was made to get information on Air Force programs in HF radio. The following persons were contacted at ALC.

Mr. Joseph Fekete AF HF Program Manager, 916-643-5652, Autovon 633-5652.

Mr. Patrict Moniz AN/TSC-60 Program Manger, 916-643-4956, Autovon 633-4956.

Mr. Remo Vinassa Engineering Development, 916-643-5465, Autovon 633-5465.

The AF analyzed their HF equipments status and came to the conclusion that:

(1) Their HF radios were old, in some cases 30 years old.
(2) Support of the equipment had stopped.
(3) The equipments were no longer economical to maintain.
(4) The AF has a need for a reliable communication for command and control of tactical and strategic communication.

In 1979 a survey was made of existing AF HF equipment, user communication requirement as well as developing HF equipments. Based on this evaluation, the AF prepared GOR AFLC 01-78 which defined the AF HF communications requirements. Based on the GOR PMD (Program Management Directions) PMD-USAF R-Q9011 (4) 1 March 1979, and PAD (Program Acquisition Direction PAD AFLC-LOA-001 (25) were proposed and circulated through the AF staff for comment, and approval. Based on these directives the AF HF improvement plan will be initiated to up grade the AF HF communication Radios for Vehicular/Transportable,Backpack - Transceiver, Fixed Receiver, Fixed Transmitter, and Fixed Transceivers applications. Staffing of the directives is nearly complete and sometime in late April or early May the AF HF program office is planning on a joint service meeting to define the AF program. (I gave Mr. Fekete Mr. DeJulios name and phone number as a possible person who might be interested in such a meeting.)

The major AF program today is SCOPE SIGNAL. It is a five phase program to provide the AF worldwide hf coverage to its strategic forces. Presently they are in phase III. In this program the AF is attempting to standardize on equipments to mitigate logistics support. The AF is looking for off-the-shelf equipment that can be readily modified to meet the requirements. They are stressing modular design. Security will be VINSON or PARKHILL. Adaptive HF is under consideration but the AF feels it needs defined and identified. The present HF equipment being designed by the AF will provide A/J with brute force. The contractor will define ECCM or ECM protection and inclusion in a system will depend on requirements.

The AN/TSC-60(V) is being designed by Collins. It is a 1972 vintage design. The Collins brochure adequately defines the system.

In ALC engineering the discussions where rather general. Basically AFCC Scott AFB ILL has cognizance over all AF communciation systems. Mr. Adcock is responsible for system frequency management. The ALC Engineering was more interested in discussing the Army HF evaluation programs. It was mentioned that in 1965/1966 time frame the AF through SRI was developing the CURTS (Common Users Radio Transmission Sounding) to evaluate and assist in proper frequency selection. The AN/TRQ-35 was discussed as well as BEER CAN.