ESD-TDR-63-358

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OBJECTIVES GUIDE AND PERFORMANCE SPECIFICATIONS
FOR
TRANSPORTABLE COMMUNICATION FACILITY

TASK 4
CONTRACT AF19(626)-5
ICS-63-TR-174

PREPARED FOR

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INTRODUCTION

Part A of this document contains an analysis of requirements for dependable, transportable communication facilities that can be deployed globally during national emergencies and contingencies. It also provides engineering standards and design criteria and recommends research and development in support of such facilities. The design objectives and criteria conform with the requirements for an improvement in the mobility, reliability, and channel capacity of contingency communication facilities. They are presented as guidelines to assist in the realization of both short and long term objectives. Performance criteria believed to be within the present technology are presented in sufficient detail to permit conversion into equipment performance specifications.

Part B is a performance specification for a recommended transportable-modular (TRANSMOD) communication complex to fulfill the performance criteria established in Part A. This complex is intended for the Air Force inventory between 1965 and 1970. It represents concepts and equipments within the present technology. Significant advances will continue to be made in communication technology. Therefore, this performance specification should be reviewed, evaluated, and modified as necessary prior to contract award to avoid early obsolescence.

A cost analysis is not included as part of the performance specification because costs will depend on the requirements included in the detailed equipment specifications. However, an estimate indicates that a complete TRANSMOD complex is not likely to cost much less than $1,000,000.

PART A. OBJECTIVES GUIDE FOR TRANSPORTABLE COMMUNICATION FACILITY

1.0 PURPOSE AND SCOPE

A review of existing and programed transportable facilities designed for short, medium, and long haul point-to-point military communication reveals a conglomeration of HF, VHF, UHF, LOS microwave, and troposcatter facilities. These facilities vary in configuration and are designed for many different capabilities and degrees of interface compatibility. The purpose of this guide is to outline the factors that must be considered in the design of transportable communication facilities for contingency and limited warfare activities and to present design criteria and objectives that should be met to achieve the desired performance, compatibility, and quick reaction capability.

2.0 GENERAL

It is doubtful if any one transportable facility could be designed to meet the communication requirements of all types of global contingencies and at the same time provide optimum performance. However, a logical approach is to design a family of subsystems, based on a modular design concept, that could be assembled as the situation demanded. In the modular concept, functional capabilities can be increased by adding modules or "building blocks." This concept enhances the economy and flexibility of transportable facilities for overall Air Force requirements. The modular concept is therefore recommended for future limited warfare communication systems.

The degree of flexibility, transportability, and relative freedom from obsolescence achieved by the modular approach will increase compatibility, improve quick reaction capability, minimize logistic support problems, simplify training requirements, and result in an overall saving of funds. It will also meet requirements that cannot be satisfied by any one transportable facility. Another advantage of the modular concept is the fact that all the equipment is not enclosed in one van that might be lost or severely damaged in transit. Modules may be packaged so that an emergency operational capability can be provided even if one or more modules are lost or damaged in transit or after deployment. Each module should be capable of establishing communications on a limited basis during emergencies by means of a small HF transceiver with an AIRCOM pivotal station. For example, if the complete communication facility consists of an HF transmitting van, an HF receiving van, and a message center van, all three vans should contain a small transceiver to provide the commander with emergency means of communicating with his headquarters if the high-power transmitter were not operational.

The modules must be designed to fulfill a specified set of existing communication requirements but at the same time to resist obsolescence. A careful analysis of techniques, equipments, and requirements is necessary to achieve a suitable design for the basic van in which interchangeable communication modules may be installed.

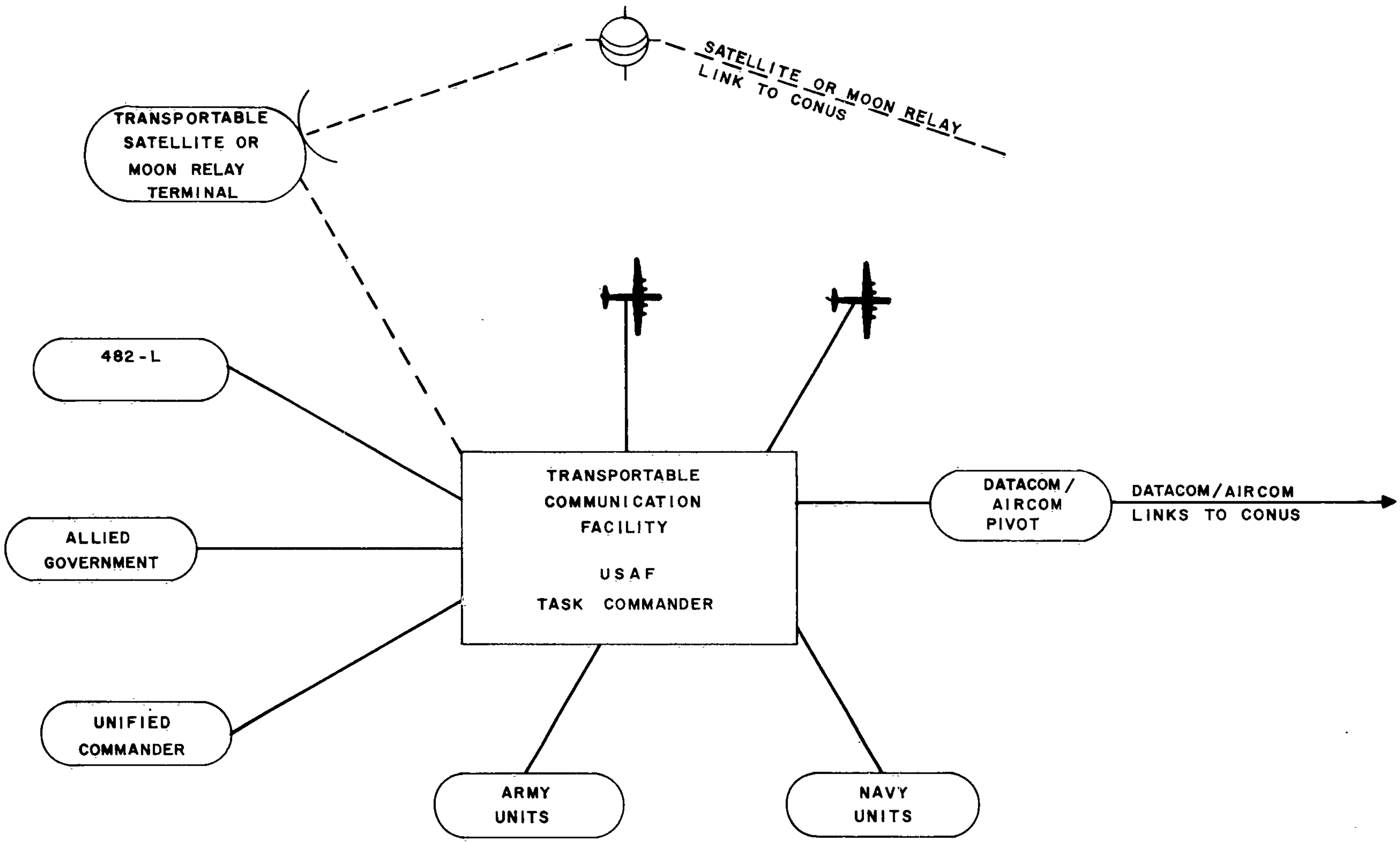
3.0 FACTORS TO BE CONSIDERED

Commanders of forces operating within a contingency area require communication facilities varying in complexity and capability in accordance with the tactical environment. The following factors should be considered in the design of communication modules. They are presented here to serve as guidelines and objectives in the preparation of definitive performance specifications and other procurement documents.

3.1 COMPATIBILITY

During overseas contingency operations it may be necessary for the Air Force task commander to communicate with other activities as shown in Figure A-1. Since the contingency situation cannot be predetermined, the equipment required to provide the maximum flexibility and compatibility must be included in the transportable facility. Figure A-1 indicates a requirement for as many as eight separate circuits, although some contingencies may not require this many. (This is another argument in favor of the modular concept whereby only the required facilities would be deployed.)

Requirements will depend to a large degree on path distances, terrain, and traffic volume. For example, elements of the unified command, the Army, and the local allied government may be located so that existing landlines, microwave, or tropo circuits could be used. In the future, orbiting satellite or moon relay communication links to CONUS may be available thus eliminating the need for a long haul point to point HF circuit to the DATACOM/AIRCOM pivotal station. Many routing combinations are possible. Therefore, a study of requirements is necessary to determine the best combinations of equipment in the transportable facility. Design objectives should include sufficient equipment to provide a minimum of three HF circuits which would provide simultaneous communication to three separate



COMMUNICATION LINKS

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terminals and all devices necessary to assure compatibility with landline, LOS microwave, troposcatter and G/A/G facilities.

The recommended approach is to provide a group of transportable modules consisting of van-mounted HF, microwave, troposcatter, and G/A/G equipment assembled to meet any contingency. All units should be packaged in vans of a standard configuration, and such ancillary items as primary power units, antenna supports, cables, connectors, equipment mounts, etc., should also be standardized.

3.2 CHANNEL CAPACITY

The trend in military communication is toward more and more circuits. This has resulted in frequency allocation problems within the RF spectrum, especially the HF portion. A common misconception is that transportable communication facilities deployed in a contingency area can use frequencies almost at will. In fact, permission to use radio frequencies must be obtained by U.S. forces from the local U.S. theater command that, in turn, must obtain approval from the host government. Frequencies cleared for bandwidths of 12 kc and 6 kc are virtually impossible to obtain on the short notice associated with contingency operations.

If more circuits are to be made available, they must be obtained by more efficient utilization of the available spectrum. This dictates the need for a comprehensive study and subsequent R&D action directed toward the development of techniques which will provide a greater number of channels and increased data rates with no increase in bandwidth requirements and the development of transportable equipments incorporating the necessary features. The efforts should be directed toward maximum utilization of the regular 3 kc voice frequency channel.

A high percentage of all Air Force communications during a limited warfare situation will continue to be by voice. A significant increase in the number of voice channels may be realized by employing analog speech compression and vocoder techniques which will reduce the bandwidth of normal speech signals. These compressed signals may be multiplexed onto the regular 3 kc band to provide two or more speech channels with no increase in overall bandwidth. More efficient utilization of the spectrum may also be achieved by applying advanced digital techniques for the transmission and reception of data. By employing multiplex equipment, the regular 3 kc channel will support various combinations of data rates from 600 to 2400 bps.

3.3 STORAGE AND OPERATIONAL ENVIRONMENT

The world political situation between 1965 and 1970 indicates the need for storing transportable communication facilities in strategic positions ready for deployment in limited warfare operations. The facilities may be placed in outside storage areas in a wide variety of climatic conditions for up to two years; therefore, they must be designed to withstand such storage and be fully operational on short notice. They must also be designed to withstand the operational effects of shock, vibration, high humidity, rain, snow, ice, winds, blowing sand and dust, salt atmosphere, salt spray, fungus, and high to low ambient temperature.

3.4 COMPLETENESS

These facilities must operate for several days with no outside support and for weeks or months with a minimum of outside support. Therefore, the facility should contain at least the following:

a. Tools and test equipment necessary for installation, operation, maintenance, and calibration.

b. Supplies such as paper, pencils, typewriter ribbons, etc., necessary for normal operation.

c. Spare parts, modules, and subassemblies necessary for maintenance.

d. Frequency control devices for the entire band over which the facility is expected to operate.

e. A primary power source and necessary fuel as required.

3.5 MOBILITY, TRANSPORTABILITY, AND CONFIGURATION

The modular concept will provide a family of facilities capable of being assembled and deployed as needed and augmented to achieve the degree of mobility and operational capability required. Communication facilities may be packaged in relatively small units transportable by small cargo aircraft. These small packages could be fitted with removable or retractable wheel assemblies to permit towing. These smaller modules could also be designed to permit loading on trucks. Large facilities such as those mounted in vans and semi-trailers have a limited transportability and can be deployed to relatively few air bases by large cargo aircraft. In addition, they are usually not capable of cross-country mobility.

Another very important consideration is helicopter transportability. Contingencies are likely to occur in relatively undeveloped, backward and remote areas where quite often the helicopter is the only means of transport. Therefore, consideration should be given to size and weight limitations of helicopters.

An analysis of existing and planned aircraft and ground vehicles is necessary so that optimum weight and dimensions for communication facilities can be determined.

3.6 IMPLEMENTATION TIME

To maintain a quick reaction capability it is necessary to keep the time required for setting-up contingency communication facilities to a minimum. A general rule is to limit the complexity of the facility to the degree that it may be set up and on the air within ten hours or less. Components and ancillary items associated with the facility should be stowed within the shelter in a manner to permit easy removal. In addition, they should be arranged so that a minimum of unpacking time is required. All hardware and tools necessary for assembly should be readily available.

3.7 PERFORMANCE

Since the facility may be called upon to provide communication nearly anywhere on the earth, it is necessary to determine general requirements for a wide range of path lengths and geographical locations. Many of the equipments and design and installation techniques associated with the engineering of fixed plant communication systems cannot be applied to transportable facilities. The temptation is to provide the greatest power possible since path lengths may be as great as several thousand miles; to provide the maximum number of channels since the quantity desired usually exceeds those available; and to provide elaborate antenna systems and redundancy to insure reliability. In the design of transportable facilities, this is not the most practical approach because consideration must be given to size, weight, mobility, complexity, logistic support, etc. Security, survivability, compatibility, and ability to withstand the transportable environment are considerations equally as important as the ability to communicate efficiently. The following performance criteria and guidelines are presented to serve as a basis for the design of transportable communication facilities.

3.7.1 Range

The communication requirements may be classified according to path length as: very short, short, medium, long, and ground-air-ground.

Very short distance circuits vary from a few hundred yards to a few miles and may include inter-van or intersite communication that can be provided by radio, wire, cable, or man-portable microwave equipment similar to the AN/TRC-56 and AN/TRC-92.

Short distance circuits have a maximum path length in the order of 30 miles and may include intersite paths; links from transportable communication centers to a ground based, mobile satellite communication van; and links to other commanders. Such links can be provided by transportable microwave equipment such as the AN/GRC-66.

Medium distance circuits are between 30 miles and about 150 miles that can be satisfied by transportable troposcatter equipment similar to the AN/TRC-90, AN/TRC-66, and AN/GRC-66.

Long distance circuits are in excess of 150 miles and may include circuits from the contingency area to CONUS via DATACOM/AIRCOM facilities, orbiting communication satellites, or moon relay facilities.

It is conceivable that all operational elements may be positioned so that most of the necessary communications links could be provided by employing transportable microwave and troposcatter facilities with a minimum number of HF links. On the other hand, some contingencies may require extensive use of HF links combined with low-power, man-portable microwave equipment for very short distance links and no regular microwave or troposcatter equipment.

To meet these widely varying requirements, it is essential for the Air Force to develop a complete family of transportable modules which will satisfy the requirement for various numbers of circuits over various path lengths.

In addition to HF, communication facilities such as microwave LOS and troposcatter are required to provide circuits in one direction or possibly two directions simultaneously, and only one or two antenna systems are associated with each set. However, many contingency and limited warfare operations may require two-way HF circuits in three different directions simultaneously. Based on these requirements, the following family of vans could be designed for assembly and deployment to satisfy the communication requirements of most contingency and limited warfare operations:

HF transmitter van (3 circuits, 3 directions)
HF receiver van (3 circuits, 3 directions)
Microwave/troposcatter van (24 channels)
Message center van
Cryptographic van
Utility van (maintenance and spares)
Switching and technical control van

3.7.2 Power Output

The RF power output of communication equipment is a very important consideration if reliable communications are to be realized. Many factors favor utilizing the maximum power that can be packaged into a transportable configuration. For example, it may be determined that an HF transmitter power output of 5 kw with present type transportable antennas would be adequate for most paths but 10 kw would be desirable to provide an extra margin of confidence. However, a decision to utilize the higher power must be given careful consideration to determine how it will affect the remainder of the system. For example, the higher power units are heavier and require a heavy duty antenna system capable of handling the RF power. In addition, primary power requirements are increased with consequent additional requirements for POL support. RFI and self-jamming problems may also be increased by using higher power.

A better approach to reliability is to increase the effective radiated power. One method of achieving this is by development of more efficient antenna systems than are presently available for transportable use.

The RF power outputs for the various media indicated below should be adequate for reliable communication in most contingencies.

Very short distance portable microwave: in the order of .1 watt

Short distance microwave: a minimum of 1 watt

Medium distance troposcatter: a minimum of 1 kw

Medium and long distance HF SSB: 500 watts, 2.5 kw, and 5 kw selectable by the operator

Ground-aerospace-ground VHF and UHF: 20 to 50 watts

3.7.3 Modulation Techniques and Modes

In general, HF equipment should be capable of operating in the SSB, ISB, CW, and FSK modes as well as compatible AM; microwave and troposcatter equipment in the PCM/FM, PAM/FM, or SSB modes; and G/A/G in

SSB, ISB, AM, or FM. The types of circuits required include voice, data, teletype, and graphics. To permit more efficient use of the overall spectrum in connection with HF, VHF, UHF, and SHF, it is recommended that further efforts be directed toward developing and/or applying modulation techniques which will enable passing increased information over the regular 3 kc voice frequency channel.

3.7.4 Frequency Coverage and Emission

Facilities designed for contingency operations should include equipment capable of operation in the assigned military bands associated with HF, VHF, UHF, microwave, troposcatter, and communication satellite equipment.

3.7.5 Frequency Stability, Calibration Accuracy, and Control

High-frequency receiving equipment should be designed for a frequency stability of 1 part in 10^8 or better by employing frequency synthesizers tunable in 100 cycle increments over 2 to 30 mc. This degree of stability is required in the interest of high circuit reliability when used to receive signals from an equally stable transmitter; however, it is reasonable to expect that transportable facilities may be required to net with ground facilities which have not been stabilized to this extent and with airborne facilities which will appear to the receiving equipment to drift because of doppler shift caused by the relative motion. Therefore, a form of automatic frequency control (AFC) should be included. Transmitting equipment should have the same order of frequency stability as receiving equipment. The stability of microwave and troposcatter equipment should be 1 part in 10^6 or better.

3.7.6 Security

Secure circuits are of primary importance during limited warfare operations since traffic originated by the commander utilizing the transportable facility involves critical information pertaining to movement of forces, plans, intelligence reports, etc. Therefore, secure teletype, data, and voice circuits are considered essential in the design of transportable facilities.

3.7.7 Anti-Jam Capability

Consideration must be given to the electromagnetic environment within which the transportable facility may be deployed and the proximity to the enemy so that design objectives may be established to incorporate some of the anti-jam techniques now under development. This effort should include an analysis of equipment design and human engineering problems associated with anti-jamming operational techniques. Associated with jamming is the possibility of interference. Transportable facilities may be placed in operation relatively close to other electromagnetic radiating equipments such as VHF/UHF, radar, microwave, troposcatter, power motors, generators and teletype equipment. Further R&D effort should be devoted to the development of anti-jam modulation and demodulation techniques and devices.

3.7.8 Circuit Reliability

HF circuits should operate over path lengths from approximately 100 to 3000 miles with a mean overall path efficiency of 90%. The reliability of other types of circuits should approach that achieved by comparable fixed plant systems. This means that the equipment must be designed with adequate power, good antenna gain and efficiency, and a safety margin which will assure reliable circuits even though the siting, assembly, orientation, etc., may not be optimum. Allowances should be made for the fact that relatively unskilled personnel may set up the equipment.

3.7.9 Equipment Reliability & Maintainability

Reliability is frequently thought of in terms of mean time between failures (MTBF). Though this is important, it is by no means sufficient to characterize total system reliability. In addition to MTBF, equipment reliability involves ease of repair and simple preventive maintenance procedures. Good system design includes packaging the equipment for easy maintenance. Transportable facilities must be designed to be maintained by personnel without highly specialized training. Electronic and electrical equipment should be designed to fail-safe. Reliability requirements should include design criteria for rapid troubleshooting and repair techniques. Technical and quality control equipment and procedures should be as simple as practicable. Self-check maintenance equipment should continuously monitor the condition of critical equipment and actuate audio and visual alarms when equipments fail or approach tolerance limits. Standby equipment should automatically be switched into service. Design should be such as to permit personnel to accomplish repair by replacement of plug-in modules.

3.8 HUMAN ENGINEERING

For the man-machine interfaces, all readouts and displays should be as simple as possible and designed for maximum clarity. Operator controls should be few in number and functionally grouped. Color-coding and specially shaped controls should be used. The facility should be simple to set-up, operate, maintain, and repair. Immediate access to communication circuits should be obtained by merely pushing a button or operating a switch.

Adequate space should be provided for operating personnel to perform their duties. Operating space within the vans should be designed on the basis of 15 square feet of floor space per operator.

Unfavorable environment can cause discomfort and fatigue. The following table lists the level or tolerance ranges for the most important internal environmental conditions in transportable communication vans:

Condition	Level or Range
Light	30 ft candles, minimum (at desk height)
Noise	50 db above ASA ref (max)
Air velocity	100 ft/min (max)
Temperature	70° to 80° F
Humidity	40% to 60%

3.9 ANTENNA SYSTEMS

Highly transportable, broad-band antennas and light-weight antenna supports capable of rapid erection are required. There are economic advantages in using higher gain antennas and less powerful transmitters. Within limits, increased radiated power in a given direction can be achieved more economically by use of efficient high gain antennas than by use of higher transmitter power.

The desired angle of radiation of HF antennas is a function of path length and should be designed into the antenna system for optimum performance. This is not difficult when designing antennas for fixed point to point circuits but is more complex when the antenna is to be transportable and must operate over a very wide frequency band, over varying path lengths, in different geographical locations. This capabilty could be achieved by providing a group of antennas, but that is contrary to the concept of limiting size, weight, and volume. The design objective is to provide a single, light-weight transportable HF antenna that will provide relatively high take-off angles for lower frequencies and short paths, and lower take-off angles for higher frequencies and long paths. This should be accomplished with a minimum gain of 5 db over the frequency range of from 2 to 30 mc.

When separate HF antenna systems are used for transmitting and receiving, the problem of too many antennas occurs. Instead, it is recommended that an efficient multicoupling device be developed to permit an antenna to simultaneously transmit 1 kw of RF power and receive a signal that is 100 db down from that, at frequencies differing by approximately 2%, without interference between the two signals.

It is also recommended that R&D effort be devoted to the investigation of applying new materials and techniques to produce lightweight antennas that can be reduced to a small volume for storage and transit and be mechanically and/or pressure-erected for operation. Possibly some techniques developed for spacecraft antennas may be applied to the design of antennas for ground based communication facilities. Pressure-erection techniques have been applied to troposcatter and microwave antennas; however, very little has been done in the development of pressure-erected and mechanically unfurlable antennas for operation at the lower frequencies. Some success has been achieved with full-scale models of pressure-erected log periodic arrays (70-700 mc) and a linear array of helix antennas (2300 mc) which are pressure-erected and retain their shape after all internal pressure is relieved. One approach is to form aluminum foil tubes that can be rolled up to form small packages. It was found that an aluminum foil tube of several inches diameter is an excellent pressure-erected structure. Tests show that the basic aluminum foil is greatly improved by adding a film of tough plastic such as Mylar.

The greatest challenge in building unfurlable antennas for transportable facilities is the development of techniques for folding and unfolding them while still retaining mechanical stability and the capability of withstanding severe climatic conditions. Mechanical erection techniques offer advantages in mechanical stability and durability although the ratio of unfurled-to-furled size is lower. Further research into both techniques and all other phases of unfurlable antenna design is indicated.

3.10 PRIMARY POWER

Continuing efforts must be directed toward designing communication equipment with low primary power consumption so that the sizes and weights of both the equipment and the supporting primary power source may be held to a minimum. At the same time, R&D efforts must be devoted to reducing the size, weight, and volume of power generating equipment to keep abreast of communication equipment developments. In fact, major improvements in electronics equipment to reduce weight and volume for transportable applications are without significance if this is not accomplished. For example, the power generation and distribution equipment associated with many existing transportable communication facilities exceeds the supported electrical and electronic equipment in size, weight, and volume.

Specific areas recommended for study are the application of solid state devices to permit low primary power consumption and the application of primary power sources with a high power-to-weight ratio. It is unlikely that all communication equipment will be solid state during this time frame; however, a combination of electron tubes and solid state devices operated from a combination of AC and DC sources to achieve a net reduction in primary power requirements should be considered. Many R&D programs are attempting to develop lightweight, reliable, primary power sources for space programs as well as military air and ground support. The following power sources and prime movers may be applicable to transportable service: advanced design gas turbines, Stirling cycle engines, and fuel cells.

Four hundred cycle primary power sources have been employed with some transportable facilities in an effort to hold volume and weight to a minimum or to operate with equipment originally designed for airborne service. In fact, there have been recommendations to standardize on the combination of 400 cycle communication equipment and 400 cycle power sources for transportable applications. Solid state technology should ultimately produce equipment substantially reduced in weight and volume. Therefore, it is considered more practicable at this time to concentrate efforts on solid state devices and primary power sources rather than make the transition from 60 cycle AC, to 400 cycle AC, and then to the solid state DC combination. During the interim, the combination of 400 cycle equipment and 400 cycle power sources may be practicable for certain transportable applications if the desired degre of reliability is achieved. Maximum use should be made of available solid state communication and power supply equipment during this interim period to keep weight and volume to a minimum.

The 400 cycle source may consist of a gas-turbine engine driving a 400 cycle generator that can furnish AC power directly to AC operated communication equipment. DC power would be furnished through a solid state charger and battery combination and through DC to DC solid state converters that convert the low voltage DC battery power to high voltage DC. When 400 cycle primary sources are used with communication facilities, most of the communication equipment should be designed to operate directly from 400 cycles. However, if it is necessary to use some devices that operate from 60 cycle AC only, solid state frequency converters can be installed to convert the 400 cycle primary power to 60 cycle primary power.

The advantages of 400 cycle power units are higher power-to-weight ratio and simplicity. Improvements required in the gas turbine are noise reduction, increased efficiency, lower fuel consumption, and lower cost. Diesel driven 60 cycle generators may be the most practicable for some applications during this time frame. Present advantages of the diesel engine over the gas turbine engine are lower cost, lower fuel consumption, longer life expectancy, and quieter operation. Also, more existing equipment can be operated from 60 cycle AC power.

3.11 AIR CONDITIONING AND HEATING

Air conditioning and heating facilities are usually an integral part of overall transportable facility design. In view of the anticipated areas of operation, humidity control should also be included in transportable communication facilities for limited warfare. Heating may be accomplished by electric or multifuel heaters either incorporated in the air conditioning system, in separate portable units, or a combination of both. Subjects requiring further investigation are:

a. Investigate the feasibility of circulating conditioned air under pressure through equipment racks and cabinets for cooling equipment, with a separate cooling system for personnel.

b. Include humidity control devices capable of efficient operation in humid jungle climates.

c. Monitor R&D programs so that promising developments in the area of lightweight, efficient air conditioning and heating units can be promptly exploited. Some developments in aircraft air conditioning might apply to ground-based transportable service.

4.0 EQUIPMENT DEVELOPMENTS

Most of the features associated with transportable communication equipments can be realized by use of available components and materials and by application of present technology. However, more work needs to be done to reduce size, volume, weight, power drain, heat production, and cost while at the same time increasing life expectancy, reliability, and overall efficiency. The following paragraphs are a few examples of equipments on which such improvements should be made.

4.1 TRANSMITTERS

It is now practicable to design completely solid state transmitters for operation in the frequency range of from 2 to 30 mc with power outputs of 100 watts or more; however, for power outputs in the order of 500 w, 1, 2.5, and 5 kw, it is considered more practicable to design small, solid state exciters capable of driving linear amplifiers employing electron tubes that require relatively low driving power. The present objective is a HF SSB transmitter capable of 5 kw peak envelope power output over the range of 2 to 30 mc and including an exciter, synthesizer, automatic tuning assembly, and crystal-lattice filter assembly. It should provide four channels of 3 kc each. The entire transmitter should be mounted in a standard 19 inch rack suitable for shelter mounting and weighing no more than 500 pounds. VHF and UHF transmitters for operation in the 100-156 and 225-400 mc range for ground-air-ground service can be hybrid units with solid state devices in all stages except the driver and power amplifier stages. They should have power outputs of approximately 20 watts.

LOS microwave transmitters with power output in the order of 1 watt can be designed with solid state devices in all stages except the klystron oscillator and power amplifier stages. When power outputs of 1000 watts or more are desired to provide troposcatter operation, it is more practicable to employ relatively small, lightweight exciters to provide driving power for power amplifiers which, in turn, will provide the required higher level RF power output.

4.2 RECEIVERS

Receiving equipment for operation in the 2 to 30 mc band should be completely solid state. Receivers for the VHF and UHF bands (for ground-air-ground communication) and for microwave and troposcatter facilities may be either completely solid state or units employing both solid state devices and small electron tubes. For some applications (such as ground-air-ground) receiving and transmitting functions may be combined in transceivers in which common use of oscillators and amplifiers for transmitting and receiving is employed.

4.3 FREQUENCY CONTROL

Frequency control devices such as synthesizers should be completely solid state and should have stability in the order of 1 part in 10^8 per day or better after a 24 hour warm-up period, under the worldwide service conditions. In the interim period, stability in the order of 1 part in 10^6 is acceptable.

4.4 TUNING CONTROL

Every effort should be made to reduce the volume and weight of remotely operated frequency selection and tuning devices for RF equipment while at the same time reducing complexity and increasing reliability.

4.5 MULTIPLEX EQUIPMENT

Although transistorized telegraph and telephone multiplex equipment is available, further improvements should be made to reduce their volume and weight. For example, design efforts should be directed toward developing a solid state voice frequency telegraph carrier which would provide 16 full-duplex teletype channels and be capable of space diversity and frequency diversity reception and transmission at 100 wpm. The unit should occupy no more than one-half of a 19 inch equipment rack and weigh no more than 300 pounds. Further improvements are also needed in the area of solid state relays to replace electro-mechanical relays.

4.6 POWER SUPPLIES

The problems associated with transportable equipment power supplies are primarily confined to three areas:

a. Converting any AC primary power source to a higher DC voltage for operation of such items as RF transmitting equipment

b. Converting an AC primary power source to a lower DC voltage for the operation of solid state low-current devices

c. Converting an AC primary power source to a lower or higher frequency.

The first two problems can be solved by employing solid state devices such as converters, inverters, battery chargers, etc, which are presently available;

however, further work is needed to improve the efficiency of such items and reduce their volume and weight. Reasonable care in system design will eliminate the third problem by insuring that all equipment will operate directly from the primary power source which is part of the transportable facility. If necessary, electronic equipment can be designed to operate from power sources varying in frequency from 50 to 400 cycles, but this increases the weight, volume, and cost of such equipment.

4.7 AUDIO PROCESSING AND CONTROL EQUIPMENT

Minor improvements in some existing speech and audio processing and control equipment such as amplifiers, equalizers, vocoders, electronic hybrids, phone patches, speech compression devices, compandors, tape recorders, telephones, etc, could result in highly compact, efficient devices which would have wide application in transportable communication equipments.

4.8 TELEPRINTERS

The development of lightweight, ruggedized teleprinters such as the AN/TGC-14 and AN/TGC-15 has been a step forward in providing machines for transportable military use; however, further improvements are required to reduce the weight, cost, and power consumption. The use of telegraph terminal equipment using codes other than 5 bit code and transmitting isochronous code patterns should not be overlooked.

4.9 CRYPTOGRAPHIC EQUIPMENT

Cryptographic equipment should be developed to employ solid state devices throughout and possibly other improvements in mechanical design to reduce the volume, weight, and power consumption.

4.10 SWITCHING EQUIPMENT

Continuing efforts should be directed toward improving equipment for switching speech, data, and teletype in transportable communication complexes serving commanders and other users in the field. Reductions in weight are highly desirable.

4.11 PERFORMANCE MONITORS AND TEST EQUIPMENT

To simplify operation and maintenance, minimize down-time, and prevent damaging equipment, self-checking devices such as performance monitors, fault indicators, protective devices, and alarms must be incorporated in equipment designed for the transportable environment. Efforts should be directed toward combining these functions with a view toward reducing complexity, weight, volume, cost, and power consumption and improving reliability. Further efforts are also needed to reduce the volume and weight and increase the ruggedness of portable and rack mounted test equipment such as signal generators, electronic voltmeters, frequency counters, and spectrum analyzers.

4.12 CHANNEL QUALITY CONTROL EQUIPMENT

Overall quality and reliability of both fixed-plant and transportable Air Force communication facilities is significantly improved when designated personnel are assigned the responsibility for controlling technical functions and the quality of all information contained on channels entering and leaving a communication complex. These individuals must be provided with displays, monitoring equipment, and devices for localizing, identifying, and correcting certain troubles and for measuring and adjusting levels and distortion on voice, teletype, and data channels. Although all technical and quality control functions necessary in fixed plant installations may not be practicable for inclusion in their transportable counterparts, it is recommended that improvements be made to reduce the weight, volume, power consumption, and cost of those items of equipment considered essential to achieve comparable channel quality and circuit reliability.

5.0 SUMMARY OF DESIGN OBJECTIVES

The following areas require further investigation and/or research and development:

a. Develop standardized shelters, C-E equipment racks, and ancillary items that can be assembled as necessary and transferred from shelter to shelter to satisfy a wide range of communication requirements.

b. Investigate the following modulation techniques, transmission modes, and devices to determine their suitability for utilization in transportable facilities for limited warfare: FM, PCM, PAM, spread spectrum techniques (such as QFM, RADAS, frequency hopping, etc.), digital data, digitized speech, vocoders, speech compression, and graphics.

c. Develop devices and techniques for reducing setup time, including easily erected, high gain, HF, VHF, UHF, microwave LOS, and troposcatter antennas and antenna support mechanisms.

d. Investigate techniques, materials, parts, and processes to increase equipment reliability.

e. The design of transportable communication facilities capable of withstanding all environments, including climate extremes, a wide range and combination of shock and vibration, long storage periods, radiation, blast, etc, is a very costly proposition. It is therefore recommended that studies be continued to accomplish the following in connection with environmental control and isolation:

1. Determine the degree of immunity to environmental conditions that should be designed into equipment.

2. Determine the advantages and disadvantages of complete ruggedization versus protection of equipment by extensive utilization of shock mounts, thermal barriers, etc.

3. Develop specifications that clearly define the environmental conditions which Air Force transportable C-E systems must be capable of withstanding, and develop design specifications that definitize equipment to withstand such environments.

f. Develop devices and techniques to increase communication security and anti-jamming capabilities.

g. Develop miniaturization and solid state techniques applicable to transportable units to reduce heat production, weight, volume, and power consumption and increase reliability and life expectancy.

h. Establish design criteria, determine application of presently available devices, and continue R&D work associated with primary power sources suitable for transportable C-E facilities.

i. Design simple read-outs, displays, and switching and patching devices which will reduce man-machine interface problems, provide quick reaction command and control capabilities, and minimize the possibility of human error.

j. Investigate and develop equipment, devices, and techniques which will increase the surface mobility of Air Force C-E facilities and close the gaps that presently exist in the deployment cycle.

k. Develop small, efficient air conditioning, heating, and ventilating units.

l. Develop a transportable unit which can be operated both as a LOS microwave facility and a troposcatter facility. Capability should include a minimum of 24 voice frequency channels over a nominal range of 30 miles in the LOS mode and at least 24 voice frequency channels over a nominal range of 150 miles in the troposcatter mode.

m. Design multicouplers which will permit simultaneous, interference-free transmission and reception from a single HF antenna.

n. Develop speech compression devices for radio circuits which will permit more efficient utilization of the available frequency spectrum. The goal is six voice channels over a regular 3 kc radio channel.

6.0 INTERIM SYSTEM DESIGN

Until such time as the recommended developments are available, an interim, transportable, modularized, communication facility should be designed and procured to meet present and immediate future requirements.

PART B. PERFORMANCE SPECIFICATION FOR TRANSPORTABLE, MODULAR COMMUNICATION FACILITY

1.0 SCOPE

This specification covers the requirements for a transportable, modular, communication facility hereafter referred to as "TRANSMOD." Included are requirements for transportable vans containing HF transmitting equipment, HF receiving equipment, microwave/troposcatter equipment, message center facilities, cryptographic equipment, switching and technical control equipment, and maintenance facilities. The specification gives the requirements for the facility as a whole rather than treating each unit separately.

Design objectives include the application of solid state and microminiaturization techniques. The modular design concept includes standard racks, mounting devices, and wiring to permit transferring HF transmitting and receiving equipment, teletype machines, telegraph multiplex equipment, ground-air-ground equipment, and other equipments from one van to another to achieve flexibility. This concept also includes solid state printed circuit cards which are electrically and mechanically interchangeable. Objectives include the application of techniques to minimize set-up time, and the design of each van to permit ease of transportation. The facility should be made as self-sufficient as practicable, with minimum requirements for outside support for extended periods. Design objectives also include provisions for withstanding severe environmental conditions.

2.0 APPLICABLE DOCUMENTS

The following documents, of the issue in effect on the date of invitation for bids, form a part of this specification and apply to the extent specified herein:

Specifications

MIL-S-52059	Shelter, Electrical Equipment
MIL-E-4158	Electronic Equipment; General Requirements for
MIL-E-4970	Environmental Testing, Ground Support Equipment, General Specification for
MIL-E-5220	Extinguisher, Fire, Aircraft, Type A-20
MIL-P-8686	Power Units, Aircraft Auxiliary, Gas Turbine Type, General Specification for
MIL-G-5572	Gasoline, Aviation, Grades 80/87, 91/96, 100/130, 115/145
MIL-G-5624	Fuel, Jet, Grades JP-4 and JP-5
MIL-G-3056	Gasoline, Automotive

MIL-C-5809	Circuit Breakers, Trip Free, Aircraft, General Specification for
MIL-W-5088	Wiring, Aircraft, Installation of
MIL-T-4807	Test; Vibration and Shock, Ground
MIL-E-4970	Environmental Testing, Ground Support Equipment, General Specification for
MIL-M-8090	Mobility Requirements, Ground Support Equipment, General Specification for
MIL-STD-188A	Military Communication System Technical Standards
ARDC Manual (ARDCM 80-6)	Handbook of Instructions for Aircraft Ground Support Equipment Designers

3.0 GENERAL DESCRIPTION

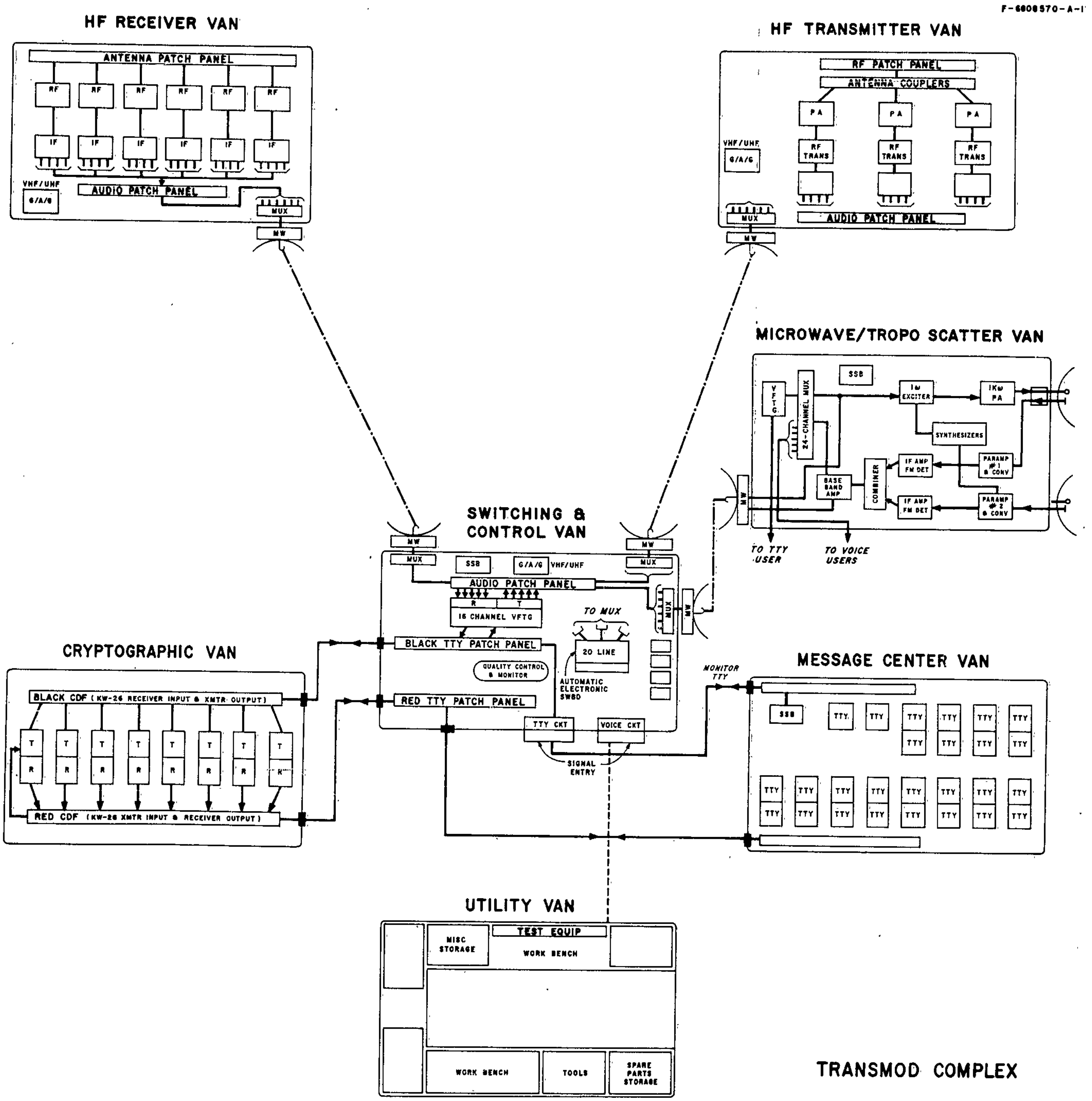
The complete TRANSMOD facility (Figure B-1) shall consist of the following seven transportable vans:

HF transmitter van
HF receiver van
Switching and technical control van
Gryptographic van
Message center van
Microwave/troposcatter van
Utility van (maintenance and spares)

Each van shall include retractable or removable undercarriages to assure transportability by land, sea, air, and rail. Land transportability shall include transportability on the bed of a standard military vehicle (with the undercarriage removed or retracted) and type III mobility as specified in MIL-M-8090C when towed by a standard military vehicle (with the undercarriage installed or extended). Each van shall be transportable by any cargo aircraft with a loading and carrying capability equal to or exceeding that of the C-119 and by any helicopter with a sling lifting capability equal to or exceeding that of the H-37.

TRANSMOD equipment technical characteristics are summarized in Table B-1. In addition, a small SSB transceiver shall be installed in all but the cryptographic and utility vans.

The HF transmitter van shall be equipped with three transmitters that can be operated simultaneously to provide HF circuits in three directions. Each transmitter shall be adjustable to select output power of 500 watts, 2.5 kw, and 5 kw peak effective power. Multiplexing and filtering devices shall be provided as an integral part of the transmitting equipment so that



TRANSMOD COMPLEX

FIGURE B-1

TABLE B-1

TRANSMOD EQUIPMENT TECHNICAL CHARACTERISTICS

	HF Equipment	VHF/UHF G/A/G Equipment	Inter-Van Microwave Equipment	Microwave/Troposcatter Van: LOS Microwave Mode	Microwave/Troposcatter Van: Troposcatter Mode
Range	3000 mi	LOS dependent on aircraft altitude	LOS	30 mi	Over 100 mi
Frequency	2-30 mc	VHF, 118-156 mc UHF, 225-400 mc	7125-8400 mc 14,000-15,400 mc	1700-2400 mc 4400-5000 mc	
Channels	12 VF	VHF, 4 preset UHF, 19 preset	12 VF	24 VF	
RF Power	Selectable 500 w pep 2.5 kw pep 5 kw pep	VHF, 20 w UHF, 20 w	Low band, 1 w High band, 100 mw	1 w	1 kw
Frequency Stability	1 part in 10^8	0.0025%	0.002%	Trans. 0.002% Receive 0.001%	
Emission	CW, USB, LSB, ISB, FSK, Compatible AM	AM	FM	FM	
Antenna	Whip, dipole, log-periodic	VHF, discone UHF, discone Combined VHF/UHF rotatable log-periodic	Parabolic as integral part of the man-portable package	Two parabolic 15 ft dia	
Set-up Time	4 man-hours	1 man-hour	1 man-hour	2 man-hours	

the three RF circuits may be divided into 4 channels, each capable of transmitting voice frequency signals, to provide a total of 12 voice frequency channels over the HF equipment.

The HF receiver van shall be equipped with six receivers which can be operated simultaneously to provide diversity reception of HF signals from three directions. Each of the three RF signals may be divided into 4 voice frequency channels for a total of 12 channels.

The switching and technical control van shall be equipped with a 20-line automatic telephone switchboard, a 16-channel VFTG multiplex, red and black teletype patch panels, VHF and UHF ground-air-ground transceivers, and equipment to monitor and control the quality of all circuits.

The cryptographic van shall include KW-26 cryptographic equipment to provide eight, full-duplex, secure radioteletype channels.

The message center van shall include teleprinters and ancillary equipment to terminate eight full duplex secure channels, four full duplex non-secure channels, two weather intercept channels, and other message center equipment to permit message storage, manual tape relay, and tape preparation.

The microwave/troposcatter van shall be equipped with all devices necessary to permit operation in either the LOS microwave or troposcatter mode. Power output in the microwave mode shall be a nominal 1 watt and in the troposcatter mode, 1 kw. The van shall be equipped with all audio and multiplex equipment necessary to provide up to 24 voice frequency channels.

The utility van shall be equipped with work benches, storage facilities, tools, test equipment, technical publications, spare parts, and all other items necessary to maintain the complete TRANSMOD complex, including all van-enclosed equipment and externally operated items such as antennas, power units, air conditioners, cables, etc.

Six man-portable microwave sets shall be included to provide inter-van communication with two spare sets. Eight man-portable multiplex sets shall be furnished for operation with these microwave sets. Each multiplex set shall provide 12 inter-van voice frequency channels, including 1 inter-van order wire. All of these sets will be installed in the HF transmitter van, the HF receiver van, the switching and technical control van and the microwave troposcatter van. Cable assemblies and all necessary connectors shall be provided to interconnect these and other vans when the microwave is not used.

In addition to the VHF and UHF G/A/G set installed in the switching and technical control van, racks, equipment mounts, antenna brackets, wiring, and all other devices necessary to permit installation and operation of these sets shall be included as an integral part of the HF receiver van and the HF transmitter van so that the equipment may be installed therein when desired. Power for the vans will be supplied by 400 cycle, gas turbine driven units, separate from the vans.

4.0 MODULAR CONCEPT AND CONFIGURATION

Each van with its equipment is a modular part of the complete complex and may be deployed as necessary to meet a wide variety of contingencies. In turn, major items of equipment, such as HF receivers, HF transmitters, VFTG, portable microwave sets, G/A/G sets, and user instruments which may be transferred from one van to another, are modular parts of the van-units. Circuit elements, such as IF strips, audio amplifiers, filters, oscillators, converters, etc, in the form of plug-in printed circuit cards, are modular parts of equipments and shall be mechanically and electrically compatible with more than one item of equipment. The complete TRANSMOD facility shall consist of communication elements mounted in modified S-141/G shelters that may be assembled as necessary to meet various communication requirements. The seven vans shall contain certain items of equipment configured and mounted in racks that are standard for all vans, thus permitting the installation or removal of this equipment to provide the correct combination of communication facilities.

During field operations, the HF vans may be physically separated by a few hundred yards or even several miles in order to place the receivers in a low noise area and to minimize local interference and self-jamming. However, TRANSMOD shall be designed to permit interchanging HF receiving and transmitting equipment and VFTG equipment when it is desired to deploy a single HF van with voice and teletype receive and transmit capability. In addition, antenna couplers, filters and other devices necessary for duplex operation of HF equipment in a single van shall be provided in both the HF transmitter and HF receiver vans. Design shall include provision for transferring the following equipment:

1 transmitter
4 receivers
1 teleprinter set
1 G/A/G set
4-wire subscriber instruments
1 16-channel VFTG

In addition to the VHF and UHF G/A/G set installed in the switching and technical control van, racks, equipment mounts, antenna brackets, wiring, and all other devices necessary to permit installation and operation of these sets shall be included as an integral part of the HF receiver van and the HF transmitter van so that the equipment may be installed therein when desired. Power for the vans will be supplied by 400 cycle, gas turbine driven units, separate from the vans.

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1 transmitter
4 receivers
1 teleprinter set
1 G/A/G set
4-wire subscriber instruments
1 16-channel VFTG

This equipment shall be designed to permit transferring to and from the HF receiver, HF transmitter, message center, and microwave/troposcatter vans. With one transmitter removed, the HF transmitter van shall have provisions for accepting four receivers, one 16-channel VFTG, one G/A/G set, and one teleprinter set. With four receivers removed, the HF receiver van shall have provisions for accepting one transmitter, one 16-channel VFTG, one G/A/G set, and one teleprinter set. The message center shall have provision for accepting one 16-channel VFTG, and the microwave/troposcatter van shall have provision for accepting one 16-channel VFTG and one teleprinter set. All except the cryptographic and utility vans shall have provision for accepting a minimum of four, 4-wire telephone instruments and shall have cable terminal boxes for connecting a minimum of twelve landline user circuits in addition to terminals for the interconnection of vans via cable.

It is intended that equipment will be transferred from one van to another prior to deployment; however, since the equipment may be transferred in the field, it shall be designed to permit handling without special lifting or hoisting equipment. Careful consideration must be given to the design, packaging, and installation of those items that are to be transferred from one van to another. This includes particular attention to such items as equipment racks, mounts, wiring, cables, connectors, etc. The preferred approach is to provide pre-wired racks in the HF receiver, HF transmitter, message center, and microwave/troposcatter vans.

The following are examples of possible van combinations. Two examples are given for each configuration:

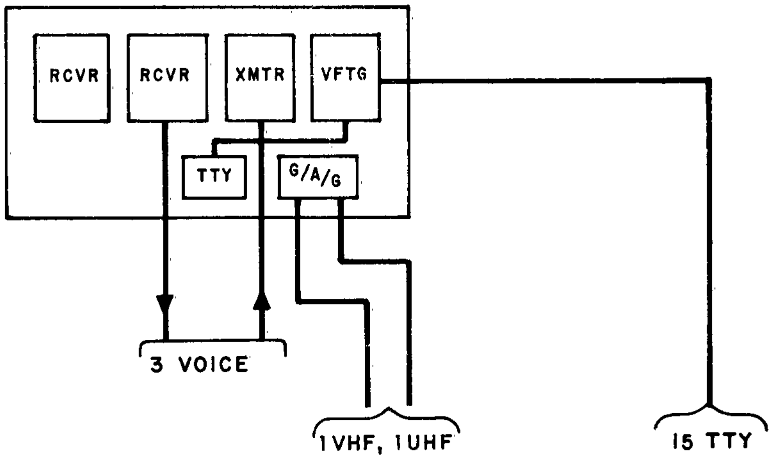
4.1 SINGLE VAN

Example 1 (Figure B-2). One HF receiver van with a transmitter, VFTG, VHF/UHF G/A/G equipment, and one teleprinter set installed. This configuration provides 16 teletype and 3 voice channels, and 2 G/A/G channels.

Example 2 (Figure B-3). One HF transmitter van with four receivers, VHF/UHF G/A/G equipment, and one teleprinter set installed. This configuration provides 16 teletype and 7 voice channels, and 2 G/A/G channels.

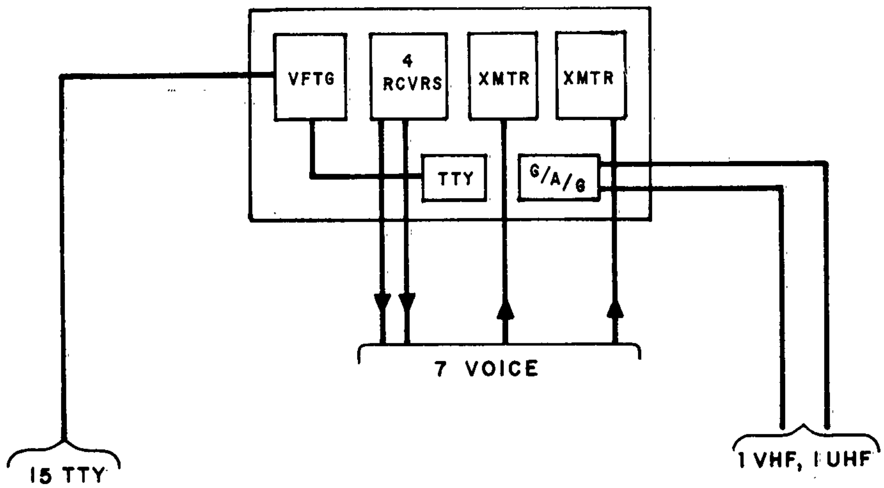
4.2 TWO VAN CONFIGURATION

Example 1 (Figure B-4). One HF transmitter van with four HF receivers and the UHF/VHF G/A/G equipment installed; and one message center van



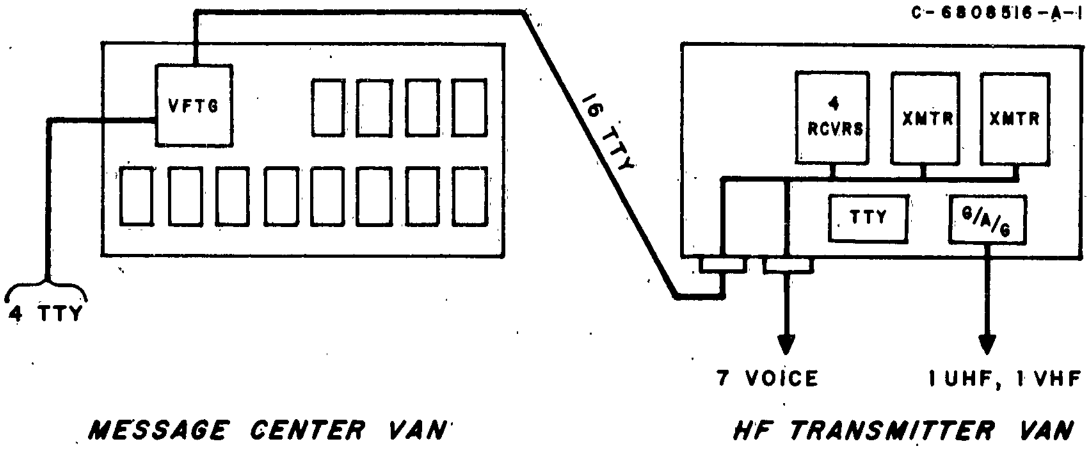
MODIFIED HF RECEIVER VAN

FIGURE B-2



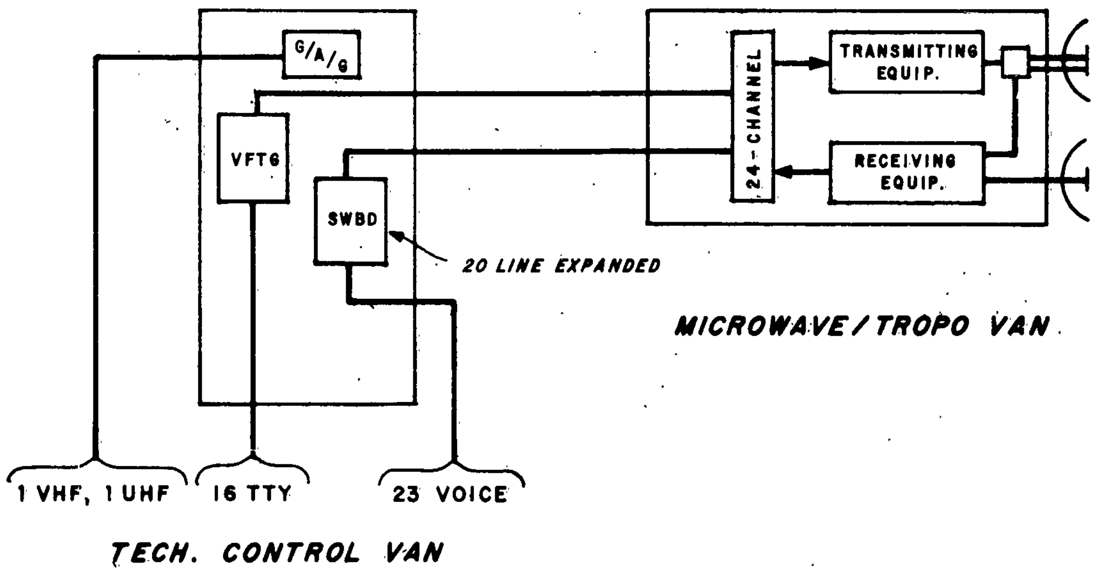
MODIFIED HF TRANSMITTER VAN

FIGURE B-3



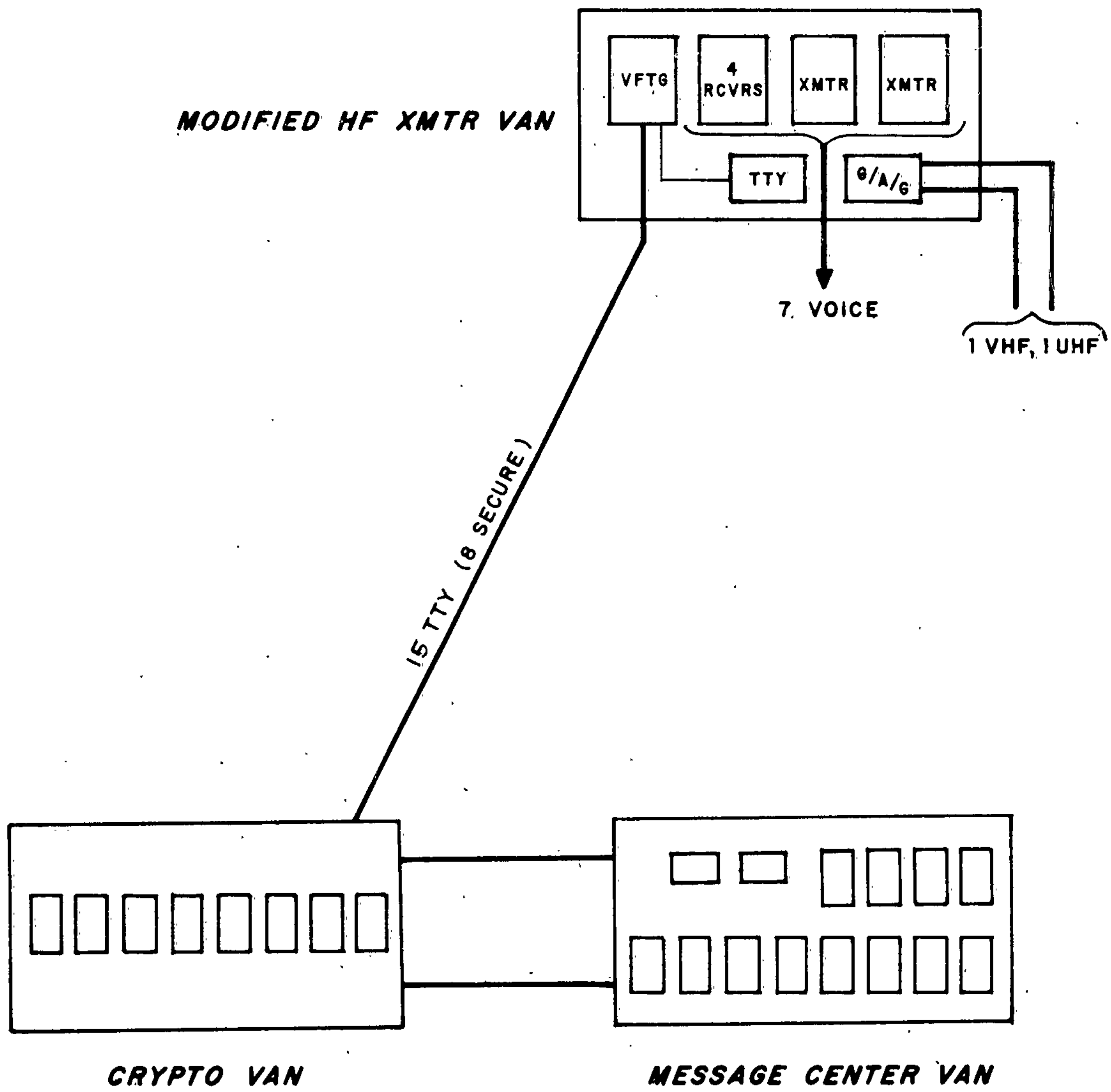
TWO VAN COMPLEX

FIGURE B-4



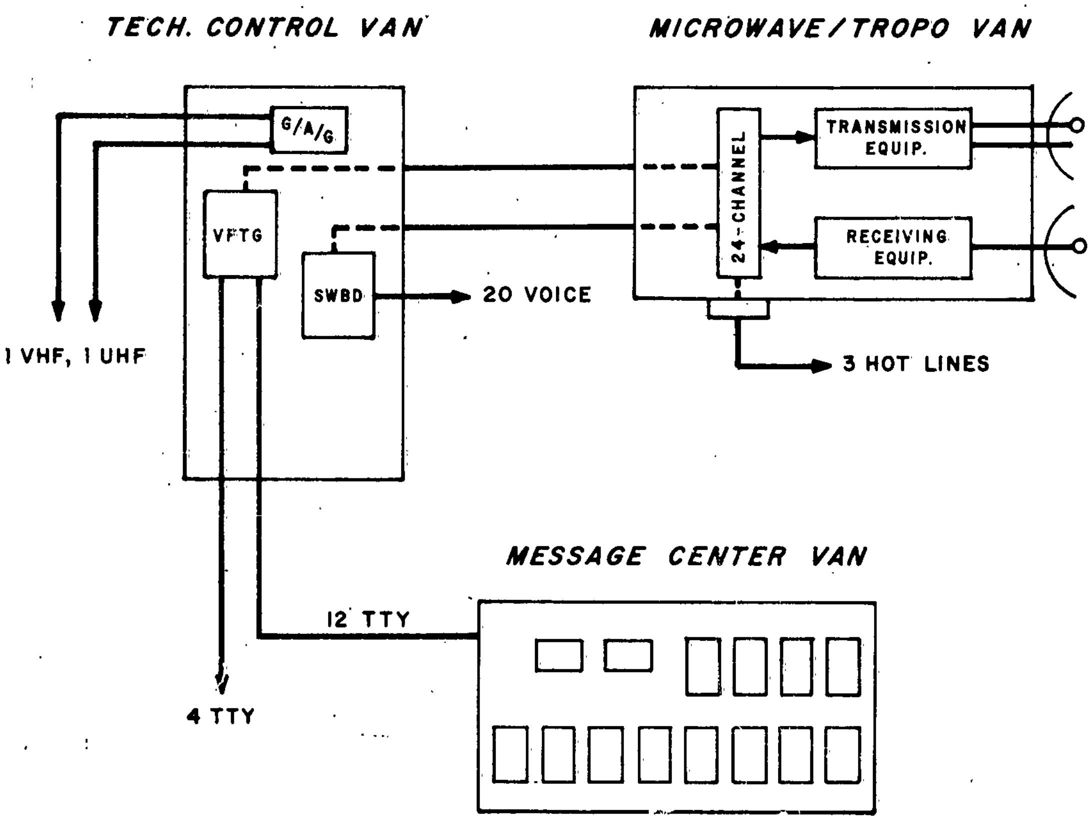
TWO VAN COMPLEX

FIGURE B-5



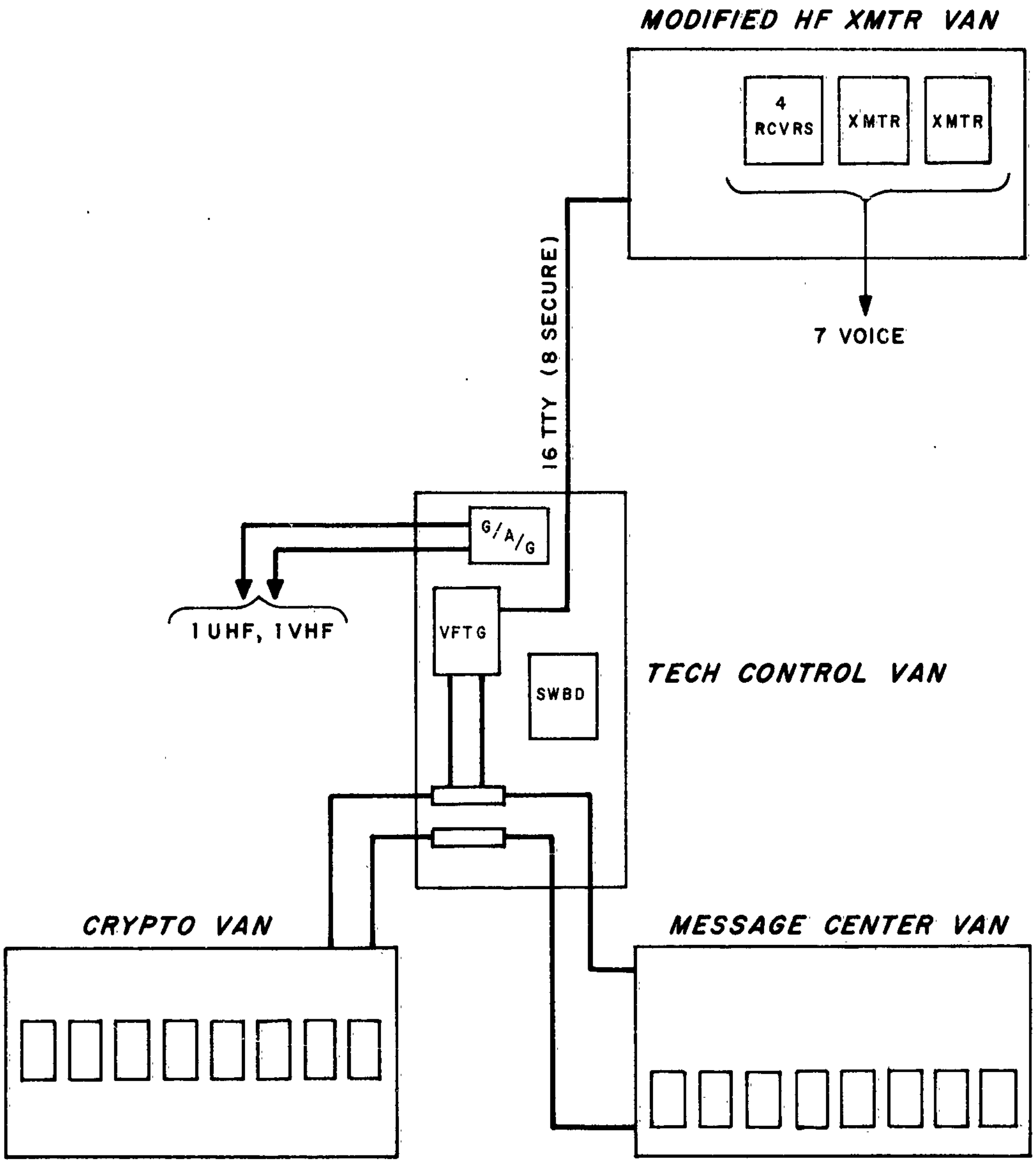
THREE VAN COMPLEX

FIGURE B-6



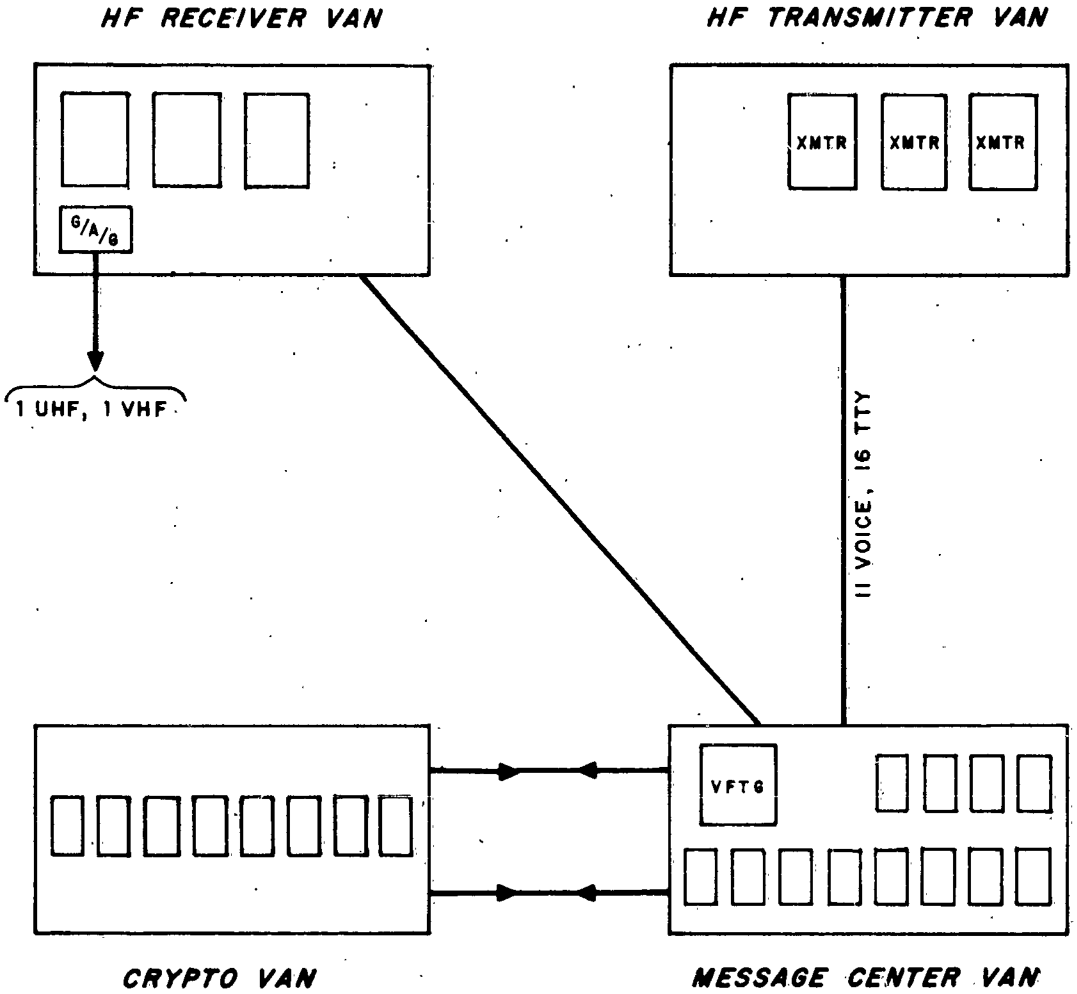
THREE VAN COMPLEX

FIGURE B-7



FOUR VAN COMPLEX

FIGURE B-8



FOUR VAN COMPLEX

FIGURE B-9

with VFTG installed. This configuration provides 16 full duplex teletype channels, 7 voice channels, and 2 G/A/G channels.

Example 2 (Figure B-5). One microwave/troposcatter van and one switching and technical control van.

4.3 THREE VAN CONFIGURATION

Example 1 (Figure B-6). One modified HF transmitter van, one message center van, and one crypto van to provide encryption of eight teletype channels.

Example 2 (Figure B-7). One microwave/troposcatter van, one switching and technical control van, and one message center van to provide 16 teletype circuits and 23 voice circuits via tropo or LOS microwave. Of the 23 voice circuits, 20 may be switched and the remaining 3 may be strapped through on a hot line basis.

4.4 FOUR VAN CONFIGURATION

Example 1 (Figure B-8). One modified HF transmitter van with four receivers installed, one switching and technical control van, one cryptographic van, and one message center van to provide 16 full duplex teletype circuits (8 secure and 8 non-secure), 7 HF voice circuits, and 2 G/A/G circuits.

Example 2 (Figure B-9). One HF transmitter van, one HF receiver van with G/A/G equipment, one cryptographic van, and one message center van with VFTG to provide HF circuits in three directions simultaneously with a total of 16 teletype and 11 voice circuits, plus 2 G/A/G circuits.

5.0 COMPATIBILITY AND STANDARDIZATION

TRANSMOD shall be designed so that mechanical, electrical, and electronic parts which have a common function are standardized to minimize logistic problems and permit interchangeability. Plug-in modules shall be standardized to be electrically and mechanically interchangeable among several items of equipment. For example, RF equipment associated with TRANSMOD should be designed to utilize interchangeable printed circuit plug-in modules which are common to audio stages in HF, VHF, UHF, microwave and troposcatter equipment. Other audio devices such as line amplifiers, monitor amplifiers, telephone amplifiers, etc, shall also be designed to utilize common plug-in audio stages. Low-level RF amplifiers, IF amplifiers, oscillators, mixers, detectors, etc, should also be standardized to the extent practicable. Items such as cables, connectors, patch panels, performance monitors, fault indicators, alarms, protective devices, synthesizers, etc, shall be standard throughout TRANSMOD.

Compatibility includes technical performance that assures proper interfaces with fixed plant and transportable communication facilities used by other military services. This includes DATACOM/AIRCOM stations, STARCOM/UNICOM stations, the Naval Communications System, 412L systems, 482L systems, U.S. and allied aircraft, military and civilian telephone exchanges, and other equipments used by the Air Force, Army, Navy, and Marine Corps. This specification does not include data terminal equipment to work with DATACOM stations; however, TRANSMOD shall be provided with sufficient rack space to permit addition of all devices necessary to insure compatibility with DATACOM if required by the procuring activity.

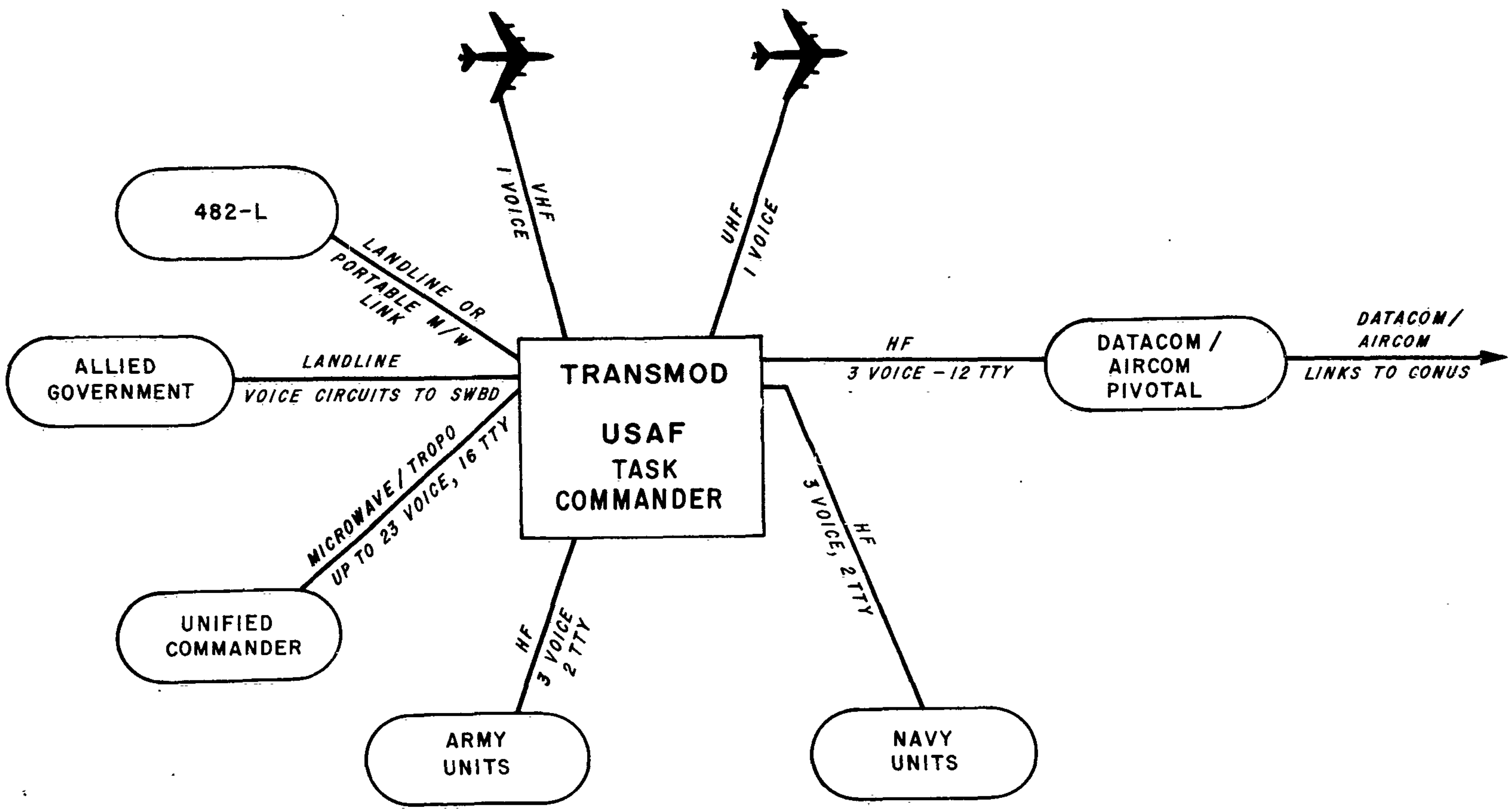
The facility shall be designed to provide voice and teletype circuits via HF radio from a remote site to any fixed AIRCOM, STARCOM, or Naval Communications System pivotal station. Teletype multiplex equipment and voice channel multiplex equipment shall be compatible with equipment used by those services.

Ground-air-ground VHF and UHF shall employ modulation and channelization compatible with cargo, fighter, bomber, and fixed wing aircraft used by U.S. and allied forces. Single sideband equipment shall be designed to operate in the AM mode.

6.0 CHANNELIZATION

TRANSMOD shall include sufficient equipment to provide HF circuits in three directions simultaneously, one microwave/troposcatter circuit, intershelter microwave circuits, switching for local users, and trunks to remotely located users. Each of the three HF circuits provides four voice frequency channels that may be used for voice or teletype signals. The microwave/troposcatter van provides up to 24 voice channels, or teletype channels as required. Ground-air-ground equipment will provide one VHF voice channel and one UHF voice channel. In addition, transportable microwave equipment for inter-van communication can be used for communicating beyond the TRANSMOD facility. The automatic electronic switchboard may be connected to landlines to provide communication between TRANSMOD and nearby elements of the operation.

Figure B-10 illustrates typical channelization between the USAF task commander and other command elements during a limited warfare operation. Channelization depends on operational conditions, and many combinations are possible.



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TYPICAL CHANNELIZATION

FIGURE B-10

7.0 MAJOR COMPONENTS

7.1 HF TRANSMITTER VAN

The HF transmitter van shall include three identical sets of transmitting equipment, each capable of providing four 3 kc voice frequency channels. The equipment specified in the following paragraphs shall be installed and suitably connected in this van to provide the capability specified.

7.1.1 HF Transmitting Equipment

The HF transmitting equipment shall be modular in design and shall employ solid-state techniques throughout the audio, IF, and low level RF stages. Maximum use shall be made of printed circuit cards which are physically and electrically interchangeable with printed circuit cards employed in the HF receiving equipment. Modules shall translate four voice frequencies channels into a composite IF frequency, thence into an RF signal in the 2 to 30 mc band for amplification within the exciter. The exciter shall furnish the drive power for the linear power amplifiers. Three power amplifiers shall be provided, each capable of 500 watt, 2.5 kw and 5 kw peak effective power over the range from 2 to 30 mc. The overall performance of the HF transmitting equipment shall meet the following specifications:

a. Stability: 1 part in 10^7 after 1 hour warm-up and 1 part in 10^8 after 1 day warm-up, controlled by synthesizers tunable in 100 cycle steps.

b. Modes of emission: CW, compatible AM, USB, LSB, ISB and FSK.

c. RF channel tuning: Equal incremental steps separated by 100 cycles over the complete band of 2 to 30 mc.

d. Channels: Four independent voice channels such that two 3 kc voice frequency channels are frequency multiplexed onto the upper sideband and the remaining two 3 kc voice frequency channels are multiplexed onto the lower sideband to occupy a total RF bandwidth of 12 kc. Suitable devices shall be included to permit use of any one or all of these four channels.

e. Output impedance: The transmitters shall include devices necessary to match an unbalanced impedance of 50 ohms. Suitable matching devices and/or antenna tuning units shall be provided to match all HF antennas specified herein over the frequency range of from 2 to 30 mc so that one type of coaxial cable with a nominal impedance of 50-52 ohms may be used between all HF receiving and transmitting equipment and the specified antennas.

f. Harmonic emission: The second harmonic radiation shall be at least 50 db down. Higher order harmonics shall be at least 55 db down.

g. Output distortion: Third and higher order inter-modulation distortion products shall be at least 50 db down.

h. Spurious emission: All non-harmonically related spurious output shall be at least 50 db down.

i. Carrier suppression: Carrier suppression shall be at least 55 db.

j. Hum and noise: Hum and unweighted noise shall be at least 55 db below either of two equal tones when the transmitting equipment is driven to maximum peak effective power ratings.

k. Automatic load and level control: Suitable circuitry shall be included in the exciter and linear power amplifier to limit peak power automatically and to maintain uniform power gain over the specified frequency range.

l. Carrier insertion: A control shall be provided to control the amount of carrier inserted over the range of from -40 db to full carrier.

m. Crystal filters: Four voice frequency channels shall be multiplexed to sideband signals by means of crystal filters. The band-pass characteristics of the filters shall be ±1 db from 350 cps to 3040 cps with rejection of 55 db at the carrier frequency and rejection of 60 db at 6310 cps.

7.1.2 Patch Panel

A patch panel shall be furnished and installed to provide patching for 12 voice frequency channels. This patch panel shall be between the multiplex equipment associated with inter-shelter communication and the input to the radio transmitting equipment. Channels 1 through 12 of the multiplex shall be patched through the panel to channels 1 through 12 of the RF equipment. All multiplex and radio equipment inputs and outputs shall appear on jack strips to permit re-routing channels as desired.

7.1.3 Antenna Couplers and Filters

Antenna couplers and tuning units shall be provided to permit automatic matching to whip antennas and dipole antennas to permit.

simultaneous operation of both transmitting and receiving equipment from the HF transmitter van when four receivers are transferred to this van from the HF receiver van.

7.1.4 RF Patch Panel

An RF patch panel shall be installed to permit connecting any of the antennas to any of the RF transmitting equipment. Four spare RF connectors shall be provided.

7.1.5 VHF/UHF G/A/G Equipment

Rack space, wiring, transmission lines, antenna feed-through, antenna brackets, and all other devices necessary to install and operate the VHF and UHF G/A/G equipment (paragraph 7.3) shall be installed.

7.1.6 Inter-Van Communication

Microwave sets and multiplex sets (paragraph 7.8) shall be installed.

7.1.7 Antenna Assemblies

The following antennas and antenna supports shall be furnished as part of the HF transmitter van. They shall comply with the requirements specified in paragraph 7.10.

3 each log periodic antennas, including supporting masts
2 each fiberglass whip antennas, each 35 ft. long
2 each dipole antenna assemblies, including 4 masts, each 60 ft. long

7.2 HF RECEIVER VAN

The HF transmitter van shall include six identical sets of receiving equipment each capable of providing four voice frequency channels in diversity. The receiving equipment specified in the following paragraphs shall be installed in this van.

7.2.1 HF Receiving Equipment

The HF receiving equipment shall be of modular design, using solid-state printed circuit cards which are physically and electrically interchangeable with those employed in the HF transmitting equipment. The overall performance of the HF receiving equipment shall meet the following specifications:

a. Tuning: Over the frequency range from 2 to 30 mc in 100 cycle increments.

b. Stability and calibration accuracy: 1 part in 10^7 after 1 hour warm-up, and 1 part in 10^8 after 24 hour warm-up.

c. Modes: Each receiver shall be capable of operation in A1, A3a, A3b, A9c, and compatible AM modes.

d. Channels: Each receiver shall be capable of receiving 3 kc voice channels contained within a 12 kc RF channel utilizing 12 A3a emission, separating the composite signal into four 3 kc voice channels by means of four filters, four separate IF amplifier channels, detectors, and suitable audio amplifiers.

e. Automatic frequency control: The receivers shall contain automatic frequency control for locking onto the pilot carrier of a relatively unstable transmitter.

f. Automatic gain control: Each receiver shall include automatic gain control (AGC) circuitry automatically and independently to control each of the four 3 kc channels. The AGC shall maintain the receiver output within ±2 db for an input variation of 100 db with reference to 1 microvolt.

g. Sensitivity: An input of 0.5 microvolt or less shall produce a 10 db signal to noise ratio over the frequency range from 2 to 30 mc.

h. IF rejection: IF rejection shall be 100 db or greater at any operating frequency in the range from 2 to 30 mc.

i. Image rejection: Image rejection shall be greater than 60 db over the specified tuning range.

j. Spurious response: The spurious response, other than image, shall be no less than 80 db below the response to the desired frequency over the specified tuning range.

k. Adjacent channel rejection: Adjacent channel rejection shall be 60 db or better.

l. Radiation: Undesired radiation from the receiver over the specified tuning range shall be less than 1 microvolt as measured at the antenna terminal.

m. Desensitization: With a 1 microvolt signal in the desired channel and a signal 70 db above 1 microvolt in the adjacent channel, the 1 microvolt desired signal shall not be reduced more than 3 db.

n. Hum and noise: Hum and noise shall be at least 50 db below the level of a received signal containing two tones of equal amplitude when the receiver is adjusted to provide the rated output.

o. Input impedance: Receiver input circuits shall be designed for connection to 50 ohm or 70 ohm unbalanced transmission lines with a voltage standing wave ratio no greater than two to one over the tuning range.

p. Audio response: Audio response shall be ±1 db over the range from 200 cps to 4000 cps.

7.2.2 Patch Panel

A patch panel shall be installed in the HF receiver van to provide patching for the voice frequency channels. Patching will include facilities for 12 voice frequency channels plus an additional 3 channels for space diversity teletype reception. This patch panel shall be connected between the multiplex equipment associated with inter-shelter communication and the radio receiving equipment.

7.2.3 RF Patch Panel

An RF patch panel shall be installed in the HF receiving van to permit connection of any of the antennas to any of the RF receiving equipment. Four spare RF connectors shall be provided.

7.2.4 VHF/UHF G/A/G Equipment

Rack space, wiring, transmission lines, antenna feedthrough facilities, antenna brackets and all other devices necessary to install and operate the VHF and UHF G/A/G equipment (paragraph 7.3) shall be installed.

7.2.5 Inter-Van Communication

Microwave sets and multiplex sets (paragraph 7.8) shall be installed.

7.2.6 Antenna Assemblies

The following antennas and antenna supports shall be furnished as part of the HF receiver van. These antenna assemblies and antenna supports shall meet the requirements specified in paragraph 7.10.

3 each log periodic antennas, including support masts
2 each fiberglass whip antennas, each 35 ft. long
2 each dipole antenna assemblies, including four masts each 60 ft. long

7.2.7 Antenna Couplers and Filters

These and other devices must be installed to permit simultaneous operation of both transmitting and receiving equipment from the HF receiver van when the transmitter is transferred to this shelter from the HF transmitter van.

7.3 SWITCHING AND TECHNICAL CONTROL VAN

The switching and technical control van shall be equipped with complete switching, patching, monitoring and testing facilities for all teletype, telephone, and radiotelephone circuits to and from the other TRANSMOD vans and to and from users. These devices shall be designed and installed to prevent inadvertent cross-patching of clear classified traffic into outgoing radio, wire, and cable circuits. In addition, sufficient physical isolation, separation, shielding, and filtering shall be included to prevent radiation and conduction of classified teletype data prior to encryption. The equipment specified in the following paragraphs shall be installed in the van.

7.3.1 <u>20-Line Automatic Electronic PBX Switchboard</u>

The switchboard shall be of modular construction, lightweight, and fully transistorized. It shall be capable of switching local and remote user circuits on a 4-wire basis to provide inter-shelter and user communication via inter-shelter microwave and/or inter-shelter cable, and to provide communication to external user lines. Devices shall be included to accept calls from and to all military and commercial dial and manual central offices. The switchboard shall be designed to switch 20 lines and 4 trunks with provision for expansion in groups of 4 lines to handle up to 40 lines by simple insertion of plug in modules. It shall provide a cordless attendant's position to assist users. Conference service shall be provided to connect all seven vans plus an outside call by dialing the van extensions in a prescribed sequence without assistance from the attendant. Wall mounted and field type 4-wire telephone sets shall be provided in each shelter to operate in conjunction with this switchboard. These instruments shall be equipped with digit keys in lieu of the conventional dial for signaling.

7.3.2 <u>Voice Frequency Telegraph Terminal (VFTG)</u>

One transistorized 16 channel VFTG terminal shall be installed in the switching and technical control van. This unit shall be designed to permit patching any combination of the teletype receive and transmit channels to the three HF circuits and the microwave/troposcatter circuits for simultaneous transmission and/or reception of teletype to and from several directions. The VFTG equipment shall be capable of space diversity and frequency diversity reception with signaling speeds of 100 wpm. The channels shall employ standard frequency assignments from 425 to 2975 cps, spaced at 170 cps, and employ frequency shift capability of ±42.5 and ±425 cps.

This VFTG shall be compatible with the following equipments: AN/FCC-7, -8; AN/FGC-29, -60, -61, -61A; AN/TCC-30; and AN/UCC-1. Design shall include all ancillary equipment in a single standard 19 inch rack, and total weight shall not exceed 300 pounds. The frequency stability of the output signal from each channel shall be ±0.5 cps. Back-to-back distortion at 75 bauds shall not exceed 5% on channel 1 and shall not exceed 3% on all other channels. The DC input and output circuits of the VFTG receiving and transmitting units shall be capable of operating with polar or neutral keying, at the user's option, on signal loops from 20 ma to 100 ma with voltages as high as 150 volts.

7.3.3 Patch Panels

"Red," and "black," and audio patch panels shall be installed in the switching and quality control shelter to permit complete cross-patching and testing of equipment. The red will be used for patching of all clear, classified teletype signals; the black patch will be used for patching all encrypted classified teletype signals, and unclassified signals. The audio patch panel will be used to patch all voice frequency teletype tones to the multiplex equipment for transmission via microwave or inter-van cable to and from the HF vans and the microwave/troposcatter vans. The red jacks and associated red patch cords shall be sufficiently different from all others utilized in TRANSMOD to prevent inadvertent cross-patching of clear classified traffic into the system radio and wire lines.

7.3.4 VHF/UHF G/A/G Transceivers

Two transceivers shall be installed in the switching and technical control van to provide VHF and UHF G/A/G radio communication. These units shall be completely transistorized in the low-level RF states and shall employ interchangeable printed circuit cards. Each of the units shall employ amplitude modulation and shall occupy no more than 18 inches of the standard 19 inch rack space, including power supplies and control units. Each transceiver unit shall weigh no more than 30 pounds.

The VHF transceiver shall operate in the frequency band of 118 to 156 mc with a power output of 20 watts, and the UHF transceiver shall operate in the frequency band of 225 to 400 mc with a power output of 20 watts. It shall be possible to operate both units simultaneously.

Both units shall operate from 115 volt, 3 phase, 400 cycle power. Both units shall be automatically tuned, and frequency selection shall be accomplished by a control unit located in the rack with the transceivers. The VHF unit control shall provide selection of four preset channels and selection of all channels in the band 118 to 156 mc, and the UHF unit control shall provide selection of 19 preset channels with manual selection of the full complement of 3500 channels each separated 50 kc. These units shall be equipped with voice operated relays to permit two-way operation through the 4 wire switchboard from remote user instruments. All devices shall be installed to permit operation of this equipment from local or remote positions. Rack space, wiring, antenna brackets, etc, shall be provided to permit installing the VHF/UHF G/A/G sets in the HF transmitter, HF receiver, and microwave/troposcatter vans when required. Frequency stability shall be 25 parts in 10^6 (0.0025%) or better for both VHF and UHF G/A/G equipment.

7.3.5 Inter-Van Communications

Three 12 channel multiplex units and three man-portable microwave sets shall be installed in the switching and quality control van. In addition, rack space, wiring, brackets, cable entrance facilities, and all other devices necessary to permit installation of one additional 12 channel multiplex set shall be provided to permit expansion when it is desired to relay the 24 voice frequency channels from the microwave/troposcatter van through the switching and technical van for distribution.

7.4 CRYPTOGRAPHIC VAN

The cryptographic van shall be equipped with eight TSEC/KW-26 on-line synchronous cryptographic sets to provide full duplex operation for eight secure channels. In addition, the following equipment shall be installed in the shelter:

a. Two central distribution frames (CDF), one for red lines and one for black lines. All red and black circuit connections, patch panels, cables, connectors, CDF's, cables, and other devices shall be installed in accordance with existing security regulations and specifications.

b. One teletype set for test purposes.

c. Patch panels wired to permit connection to the input and output of TSEC/KW-26 equipment for test purposes.

d. A master level-set chronometer.

e. File cabinets and/or safes as required by existing security regulations.

f. Work benches, desks, and storage cabinets as space permits.

g. Crypto destruction kit.

7.5 MESSAGE CENTER VAN

The message center van shall be equipped with all devices necessary to provide normal message center operational facilities and teletype equipment to terminate eight full-duplex secure teletype channels, four full-duplex non-secure teletype channels, and two weather monitor (receive only) machines. The equipment specified in the following paragraphs shall be installed in this van to provide the capability specified.

7.5.1 Teletype Receiving Equipment

Eight teleprinter sets, without keyboards, shall be installed to terminate the receive side of the eight secure teletype circuits. These machines shall be suitably wired through red central distribution frames and red patch panels to the output side of the TSEC/KW-26 receivers located in the cryptographic van. Eight printing reperforators shall be connected to the receive side of these circuits to provide a punched tape in addition to the page copy contained from the page printer. Four teleprinter sets, without keyboards, shall be wired through black CDF's to the black patch panel to terminate non-secure circuits. Four reperforators shall be connected to these four circuits to provide a punched tape of all messages received. These reperforators shall be wired so that they can be disconnected. Two teleprinter sets, without keyboards, shall be installed to monitor weather information.

7.5.2 Teletype Transmitting Equipment

Twelve teleprinter sets shall be installed on the transmitting side of the 12 full-duplex teletype circuits (8 secure, 4 non-secure). Each machine shall include a keyboard transmitter-perforator, page printer, printing reperforator, and tape reader-transmitter contained in a single package, physically independent of one another except for a common drive motor for the printing reperforator, keyboard, and tape reader-transmitter.

7.5.3 Ancillary Equipment

All equipment necessary for normal message center operation shall be installed in space available within the message center, This shall include items such as a clock, safe, filing cabinets, typewriter, desk, etc.

7.6 MICROWAVE/TROPOSCATTER VAN

The microwave/troposcatter van shall be designed for primary use as a 1 kw troposcatter unit for operation over paths of 100 miles or more. It shall include an exciter with a minimum RF output of 1 watt that can be used as a LOS microwave transmitter over nominal path lengths of 30 miles. It shall operate in the dual diversity mode in the 1700 to 2400 and 4400 to 5000 mc frequency ranges and shall provide 24 voice frequency channels plus an order wire.

Voice frequency multiplex equipment shall be installed to separate the combined baseband signal into individual voice frequency channels for distribution directly from this van to telephone user dropouts. Provision shall also be made to permit connection to the inter-van microwave system at baseband for relay to the switching and technical control van. A pre-wired rack and all other devices necessary for connection and operation of the VFTG specified in paragraph 7.3.2 shall be installed in this van to provide full teletype service when the switching and technical control van is not deployed. With the VFTG multiplex installed in this van, it shall be possible to route channels through the inter-van microwave equipment at baseband while at the same time dropping out voice and teletype circuits for direct user service from the microwave/troposcatter van.

Patching and switching facilities shall be furnished to provide any combination of dropout circuits. The necessary elements of the set shall include devices and circuitry to provide automatic bandwidth control for improved threshold margin when receiving weak signals. Transmitting and receiving equipments shall be designed as broadband units and shall be equipped with plug-in passive filter modules to provide variable bandwidth in RF and IF stages. Means shall also be provided to bypass the filters when they are in place and broadband operation is desired. Frequency synthesizers shall be employed to control the frequency of transmitting and receiving equipment. These synthesizers and other frequency control devices shall have the degree of stability necessary to provide an overall stability of 0.002% in the transmitting elements and 0.001% in the receiving equipment.

7.6.1 <u>Transmitting Equipment</u>

The transmitting equipment shall include an exciter and power amplifier meeting the following specifications:

a. Exciter: Emission shall be F9 with a power output of 1 watt or more sufficient to drive a 1 kw power amplifier. All devices shall be furnished and installed to permit bypassing the 1 kw amplifier and feeding the antenna directly for LOS microwave operation.

b. Power amplifier: The power amplifier shall amplify the modulated output of the exciter to the desired power level of 1 kw. The complete power amplifier, including all control circuitry, power supply klystron, and RF plumbing, shall occupy no more than 4 feet of rack space.

7.6.2 <u>Receiving Equipment</u>

Receiving equipment shall include duplexers, combiners, and all other devices necessary to provide dual diversity operation. It shall meet the following specifications:

a. Bandwidth control: The receiving equipment shall be designed to provide automatic bandwidth control that will automatically decrease the bandwidth of the receiver as the input signal strength approaches the level that would normally be the threshold for the receiver. The automatic reduction in bandwidth shall lower or extend the receiver threshold at least 6 db, thereby increasing the fade margin and making it possible to utilize weaker signals.

b. Noise figure: The receiving equipment shall be equipped with a parametric amplifier to provide an overall receiver noise figure not greater than 4 db.

7.6.3 <u>Antenna Assembly</u>

The antenna assembly shall be 15 feet in diameter. It shall have a gain of at least 41 db (over isotropic) for all frequencies within the 1700 to 2400 and 4400 to 5000 mc ranges. The antenna assembly shall be either the ring mounted inflatable type or the sectionalized metal type and shall be constructed of lightweight, high strength, durable materials. It shall be designed to withstand repeated and strenuous usage under the service conditions specified herein. If inflatable antennas are furnished, suitable air compressors shall be properly connected to maintain proper inflation of the antennas. The contour of the parabolic reflecting surface shall be capable of being maintained within ±1/16 wavelength at 5000 mc. The antenna shall be held up by a mechanism consisting of telescopic vertical and horizontal outrigger members designed to support it in high-velocity winds. All devices required for erection and orientation shall be included. Additional technical characteristics are:

a. Beamwidth: Beamwidth as measured between half power points shall not exceed 1.1° in either the E or H plane of polarization for any operating frequency within the range specified. Side lobes within 90° of the main lobe shall be down at least 16 db, and lobes in excess of 90° shall be down at least 28 db.

b. Polarization isolation: At least 30 db.

c. Weight: Each antenna assembly, including the antenna, antenna support, and all installation hardware, shall be stowable in the van during transit, shall be packaged in a transit case or skeleton framework suitable for lifting by helicopter, and shall weigh no more than 1000 pounds.

d. Antenna feed: Bi-polarized feedhorn.

e. Az-El adjustment: All devices shall be provided to permit azimuth adjustment of at least ±15° from center position and elevation adjustment of at least -5° and +10°.

7.6.4 <u>Ancillary Equipment</u>

The microwave/troposcatter van shall include a duplexer to permit simultaneous transmission and reception by means of a common antenna feedhorn, fault indicators, performance monitors, alarms, dummy loads, and amplifiers to control the levels at baseband and voice frequency. The van shall also include a pre-wired rack with all devices necessary to permit the installation of an AN/TGC-15 teleprinter for monitoring teletype channels when the VFTG multiplex equipment is installed, and a pre-wired rack for the installation of VFTG multiplex equipment.

7.7 UTILITY VAN

The utility van shall furnish storage space for spare parts, and shall include maintenance equipment and work space for maintenance personnel. It shall include built-in and portable test equipment. The utility van shall be capable of being transported to permit maintenance visits to other shelters on a scheduled or emergency basis. Since it may be moved frequently, it must be capable of withstanding severe shock and vibration.

Wherever possible, electronic, electrical, and mechanical components shall be capable of being transported when mounted in normal operating position. Small items which are not mounted shall be stored in compartments designed to protect them while in transit. Storage compartments for delicate instruments shall be padded drawers designed to fit each item of equipment and its accessories. Labels shall be attached to identify each drawer. Compartments shall be equipped with latches that prevent them from accidentally opening when the van is in transit. All other items shall be equipped with devices to fasten them quickly in place and prevent them from moving about while the van is in transit. No special tools shall be required to prepare for the transit condition.

Spare parts shall be included for all communication-electronics equipment, antennas, engine-generator sets, and air conditioning sets in sufficient quantities to permit operation of TRANSMOD for a period of at least 30 days with no outside supply of maintenance parts. A system shall be provided to permit rapid location of spare parts and provide a means of controlling stock levels. This shall include labels, locator cards, cross-reference, and other aids necessary. The items to be provided shall consist of but are not limited to the following:

- Work benches with vises
- Electronic equipment repair kit
- Teletype repair kit
- Electronic test equipment (both portable and mounted)
- Racks, shelves, cabinets, drawers, bins, etc, for the storage of portable test equipment, spare modules, tools, etc.
- Technical publications
- Portable battery chargers
- Portable engine-generators
- Antenna spares
- Antenna repair kits
- Emergency lighting devices and trouble lights
- Maintenance expendables such as wire, tape, solder, hardware
- Power tools
- Binoculars for antenna inspection
- Fire extinguishers
- Vacuum cleaner for cleaning electronic equipment

7.8 INTER-VAN COMMUNICATION

Multi-channel traffic and order wire communication between vans shall be provided by a lightweight, portable microwave and multiplex package similar to the AN/TRC-56 or AN/TRC-92. The design of the inter-van microwave transmitter-receiver set and multiplex shall be such that the equipment may be mounted in racks in the vans or in weatherproof carrying cases for operation outside the vans. The multiplex set shall be completely solid-state. The microwave set shall be solid-state with the exception of the transmitter klystron and receiver local oscillator klystron.

The microwave carrying case shall be in two sections so that the antenna may be separated from the set and placed outside the van while the rest of the equipment is inside the van. It shall also be possible to combine the receiver-transmitter and antenna cases to form a single, weatherproof microwave unit. The antenna assembly shall include an all-weather radome. Optical sighting devices shall be included as part of the assembly to assist in orienting the antenna. The entire microwave assembly shall be equipped with a tripod support assembly that may be attached to the carrying case for positioning the set on the van roof.

Frequency modulation shall be employed, and the power output shall be at least 1 watt in the 7125 to 8400 mc band. The RF bandwidth shall be adequate to pass twelve 4 kc voice channels, data channels, and an order wire. The order wire channel shall have in-band signaling which can be operated from the multiplex package. The order wire shall be used for intercommunication between TRANSMOD vans.

Frequency division multiplex sets shall be provided to work in conjunction with the inter-van microwave sets to multiplex voice, teletype, and data channels. This unit shall be fully transistorized, shall weigh no more than 100 pounds, and shall provide twelve 4 kc voice frequency channels plus the capability of providing 1200 bps data channels. Modulation, harmonic distortion, phase distortion, frequency response, and other technical characteristics shall meet CCITT standards. The switching and technical control van shall be equipped with three microwave sets and four 12 channel multiplex sets; the microwave/troposcatter van shall be equipped with one microwave set and two 12 channel multiplex sets. The HF transmitter van and HF receiver van shall each be equipped with one microwave set and one multiplex set. Spare microwave and multiplex sets shall be furnished as specified by the procuring agency to provide communication between TRANSMOD and other elements involved in a limited warfare operation.

7.9 GAS TURBINE-GENERATOR SETS

The primary power source for TRANSMOD shall be a 20 kw, 400 cps, gas turbine driven generator set that, when used singly or in combinations two or more, shall satisfy the input power needs of each TRANSMOD van. The generator set shall be self-contained and shall include a gas turbine prime mover with controls, a brushless generator with regulator, an instrument and control panel, a line contactor and controls, a 28 VDC battery, a fuel tank, a fuel pump and controls, and a unit enclosure. The general requirements are;

a. Rating: The set shall be rated at 20 kw, 1.0 to 0.8 power factor (lagging), 3 phase, 4 wire, 120/208 volts, grounded neutral, 400 cps constant frequency AC when subjected to the environmental conditions specified herein.

b. Weight and volume: The set shall be lightweight and as compact as possible with maximum total limits of 400 pounds and 24 cubic feet respectively.

c. Initial activiation at site: The set shall be designed to permit setting up, starting, and assuming rated load within 1 hour following deployment to any communication site under the environmental conditions hereinafter defined.

d. Maintenance and servicing: The set must be able to operate continuously for a minimum of 72 hours between routine maintenance shutdowns, and shall have a minimum service use of 1500 hours between overhauls, when provided with routine maintenance as prescribed by the manufacturer. The set shall be designed to be serviced with standard tools.

e. Environmental limits: The set shall be capable of being started at altitudes from sea level to 15,000 feet. Rated performance should be attainable at 10,000 feet with an ambient temperature of 95° F. The set shall start and operate satisfactorily at ambient temperatures from -65°F to +125°F. The set should be designed to meet essentially all the cold weather and desert-tropical operating conditions defined in MIL-E-4158B and MIL-E-4970A. In addition to the ambient temperature extremes, these conditions shall include exposure to salt atmosphere, sand and dust, insects, fungi, wind, ice, fog, mildew, and rainfall that can be encountered in the worldwide environment.

f. Starting system: The set shall be equipped with a DC starter motor. The starter assembly shall include a clutch and a motor relay which will disconnect the motor from the turbine and DC power source, respectively, upon completion of the starting cycle. The set shall be capable of starting at -65°F with a 28 volt heavy duty nickel cadmium battery to be furnished with each set. The starting system shall be suitable for complete automatic starting at all ambient temperatures between -20°F and +125°F. In addition, all devices necessary to permit manual starting shall be provided.

7.10 ANTENNA ASSEMBLIES

The following antenna assemblies in the quantities specified herein shall be furnished as part of TRANSMOD. (Other antenna assemblies are described in paragraph 7.6.3.) All assemblies shall be complete with necessary guying kits and erecting kits and shall include erecting devices such as winches, special tools, mounts, anchors, and insulators. Structural fuses shall be employed on log periodic and dipole antennas to prevent serious damage when the antennas are subjected to high winds. Captive hardware, captive tools, and color coding of elements shall be employed to simplify assembly of all antennas.

All HF transmission lines furnished with TRANSMOD shall be the coaxial type with a nominal impedance of 50-52 ohms. Only one type of cable shall be furnished for all HF antennas. Matching devices will be furnished as necessary to assure proper termination of all transmission lines.

Supports for both the log periodic and dipole antennas shall be capable of withstanding vertical and horizontal loads as may be encountered when supporting log periodic antennas and be of sufficient height to assure proper performance of the antennas specified herein. These units shall be erectable by mechanical means to a minimum height of 60 feet. All devices necessary for erection of the masts shall be included. Non-metallic antenna guys and supports shall be synthetic fiber rope.

7.10.1 Log Periodic Antenna

The log periodic antenna furnished as part of TRANSMOD shall meet the following requirements:

a. Weight: The maximum weight of the complete log periodic assembly, including all hardware, support mast, balun, and transit case but excluding coaxial transmission lines, shall not exceed 250 pounds.

b. Maximum stowed volume: The stowed volume of the complete assembly shall not exceed 50 cubic feet.

c. Maximum stowed length: The maximum stowed length shall not exceed 12 feet.

d. Erection time: The antenna shall be designed so that two men can erect the entire assembly in 2 hours or less.

e. Environment: The antenna shall be capable of withstanding winds of 100 mph with no ice, and winds of 50 mph with 1/2 inch of radial ice. The assembly shall include replaceable structural fuses which will fail when these limits are exceeded.

f. Frequency: 4 to 30 mc

g. Gain: The gain shall be between 10 db and 13 db relative to an isotropic antenna over the specified frequency range.

h. Input impedance: A balun shall be provided as part of the antenna assembly to match a 50 ohm coaxial transmission line.

i. Power handling capability: 5 kw peak effective power.

j. VSWR: The VSWR shall not exceed 2.1 over the specified frequency range.

k. Azimuth beam pattern: The nominal azimuth beamwidth shall not exceed 80°.

l. Elevation plane pattern: The elevation plane pattern shall provide high take-off angles of approximately 70° at 4 mc and lower take-off angles of approximately 10° at 30 mc.

m. Polarization: Horizontal.

n. The log periodic antenna shall be designed so that the 2 to 4 mc dipole antenna and filter network specified in paragraph 7.10.2 may be mounted on the mainmast and arranged to be fed either from a separate RF transmission line or by a common transmission line.

7.10.2 Dipole Antennas

Adjustable dipole antennas shall be provided as part of TRANSMOD. Adjustments shall include the capability of providing resonant half-wave antennas over the range of 2 to 30 mc. The design shall include a method of easily adjusting the antennas to proper length without actually cutting the elements. Jumpers may be used only at the ends of the elements. It shall be possible to lower the antenna to the ground without lowering the antenna supports. Minor adjustments of element length shall be possible while the antenna is erected.

In addition, a simple dipole antenna assembly, adjustable to resonance over the frequency range from 2 to 4 mc, shall be included as part of the log periodic antenna assembly. This dipole antenna shall be supported at the center by the log periodic mast. It shall include a frequency-sensitive RF filter device that will present a low impedance to frequencies below 4 mc and a high impedance to frequencies above 4 mc so that it can be used in conjunction with the log periodic antenna and fed by the same RF transmission line. With this antenna, the frequency range of the entire assembly is extended downward to cover the 2 to 4 mc range, with a correspondingly higher take-off angle for shorter hops. It shall also be possible to disconnect this dipole and filter combination from the log periodic transmission line and feed it with a separate transmission line from a second transmitter, thus providing two antennas with a single main support. This combination may be used to provide antennas for short hop and long hop HF transmission paths without deploying the 2 to 30 mc dipole antenna.

7.10.3 Vertical Whip Antennas

Vertical whip antennas furnished as part of TRANSMOD shall be 32 feet in length and shall be constructed of fiberglass in light sections. They shall include tuning units to match the antenna to a nominal impedance of 50 ohms over the frequency range of 2 to 30 mc. The antenna base insulator and mounting shall be included as part of the HF transmitting van and HF receiving van.

7.10.4 VHF-UHF G/A/G Antennas

One VHF discone antenna and one UHF discone antenna shall be provided with TRANSMOD to provide G/A/G communication. These assemblies shall include all masts, mounting hardware, and transmission lines. The mounting assemblies shall be compatible with the mounting facilities provided on the HF transmitter, HF receiver, switching and technical control, and microwave/troposcatter vans. In addition, two identical log periodic antennas shall be provided. These antennas shall be designed to operate over the frequency range of 118 to 400 mc. These assemblies shall include all masts, mounting hardware, and transmission lines compatible with the mounting facilities on the vans that accommodate them. In addition, devices shall be provided to permit polarizing the antennas in the vertical and horizontal planes without lowering the antennas. These mechanisms shall be hand-operated with positive locking devices that may be operated from the ground.

7.11 AIR CONDITIONING, HEATING, AND HUMIDITY CONTROL

In keeping with the modular concept, the air conditioning equipment shall be in standardized units which may be used singly or in multiples, depending upon the cooling/heating capacity desired. The unit shall be of the all-weather, vapor-cycle, electric powered type and should have a nominal cooling capacity of 36,000 BTU/hr (3 tons) at an ambient dry bulb temperature of 125°F. and a recirculated air inlet temperature of 100°F. In addition, the unit shall have a heating capacity of 20,000 BTU/hr at an ambient dry bulb temperature of -65°F. The units shall be designed to permit connection to the vans in parallel; however, they shall also be capable of being connected in cascade, with the output of one unit connected to the input of the other. The following specifications apply:

a. Operating life: The unit shall be capable of operating for 5000 hours without major overhaul. It shall be capable of such operation after a storage of up to 2 years.

b. Reliability: The mean time between failures should not be less than 320 hours of unit operation.

c. Electrical: The air conditioner shall operate from 3 phase, 4 wire, 120/208 volt, 400 cps alternating current power sources. The maximum power requirement shall be 8.5 kw with a power factor of 0.80.

d. Size: The volume of the air conditioner shall be 18 cubic feet or less and shall be designed to be transported in the aisles of the TRANSMOD vans. It shall weigh no more than 300 pounds. The unit shall be fully enclosed in a rigid, lightweight metal enclosure, insulated to prevent heat loss and sweating. The case and all openings shall be weather tight to preclude the entrance of wind driven rain, dust, and snow. The doors, latches, handles, and covers shall be hinged and when in the non-operational condition shall be maintained in a flush position. The cabinet shall be so made as to provide easy access to all the components of the refrigeration, fan, power, and control systems. The cabinet should be so constructed that the units can be stored one unit upon another.

7.12 USER INSTRUMENTS

Four-wire telephone sets utilizing tone keying and tone ringing shall be provided to terminate telephone and radiotelephone channels. Desk sets and/or wall-mounted sets and field sets shall be provided. They shall be basically the same electrically. They shall be equipped with a tone signaling keyset, receiver volume control, tone-ringer volume control, a receptacle for connecting a headset, and a headset in-out switch. They shall be equipped with both a handset and headset. A keyset with 12 keys shall be used instead of the conventional dial. Keys shall be 1 through 0 for priority calls, and C for conference calls. The desk sets shall operate on a common battery basis from the van-enclosed DC power sources, and the field sets shall operate on a local battery basis or on a common battery basis from the van-enclosed DC power source.

Both sets shall be designed so that two sets can be connected independently of the switchboard for communication between the van interior and exterior for maintenance, antenna alignment, etc. In this case, signaling will be accomplished by lifting the handset and depressing any key on the keyset. Each of the seven TRANSMOD shelters shall be equipped with a wall-mounted telephone set. This set shall include an operators handset with single receiver, a boom-mounted microphone, and a coil cord of sufficient length to permit the operator to observe and adjust all equipment in the shelter while wearing the headset when the headset is connected to the wall-mounted telephone set. In addition, a field set shall be provided with each of the seven shelters. A total of 10 spare sets (5 field sets and 5 desk sets) shall be provided. In addition, desk sets shall be provided and installed in the crypto and message center vans.

7.13 TECHNICAL CONTROL AND TEST EQUIPMENT

All equipment necessary for monitoring, testing, analyzing, calibrating, aligning, adjusting, implementing, operating, and maintaining TRANSMOD shall be included to control the technical quality and levels of circuits, channels, and individual equipments. This shall include built-in and patchable performance monitors, built-in fault indicators, and portable test equipment. Most of the latter will normally be located in the utility van; however, this does not preclude the use of portable test equipment in other vans. Meters shall be installed to monitor the operation of DC teletype loops, battery charges, emergency batteries, primary power inputs, RF inputs and outputs, audio levels, etc. Devices such as amplifiers, distortion analyzers, equalizers, etc, shall be provided to control the quality and levels of critical incoming and outgoing channels. Teletype distortion measuring equipment and devices for regenerating and correcting such distortion shall be supplied. Equipment for analyzing, adjusting, monitoring and trouble-shooting single sideband signals shall also be included.

Self-checking devices and diagnostic devices shall be provided as an integral part of communication equipment to indicate equipment failure or degradation in performance. Maximum use shall be made of built-in test equipment, and meters shall be included in circuits requiring voltage, current, or power changes and adjustments and in circuits that may change in performance during normal operation. All equipment adjustments shall be located to permit the operator to read the associated meter while making adjustments, and all meters shall be visible from the front of equipment. If several voltages can be displayed in turn on a single meter, multi-position and ganged switches shall be used where one meter can be applied to several test points. These multi-position switches shall be clearly marked to identify the circuits to which the meter is connected and the significant electrical quantity being measured. Maximum use shall be made of automatic test devices and go-no-go devices to permit rapid analysis under field conditions. Meters and associated switching or patching devices shall be provided to permit connection to all external telephone lines and internal audio circuits to measure levels.

7.13.1 Technical Control Equipment

The major items of technical control equipment to be installed in the switching and technical control van are those associated with the quality control of teletype signals and audio signals. This equipment shall include but is not limited to the following:

a. Direct current milliammeters calibrated in 100-0-100 milliamperes to monitor teletype loop current.

b. A digital distortion analyzer to provide comprehensive distortion analysis of all synchronous and stop-start signals with readings displayed on a front-panel meter to indicate percentage of distortion.

c. A test pattern distortion generator which will transmit test patterns with distortion varying upward from zero in steps of 1% to approximately 50%.

d. A time base generator to provide timing signals at the desired baud rate for the distortion analyzer and test pattern distortion analyzer. Baud rates normally encountered shall be provided by means of plug-in printed circuit cards, with the desired baud rate selectable at the operator's option by a panel-mounted switch.

e. A 5 inch cathode ray oscilloscope with associated circuitry to permit analyzing the waveshape of single teletype characters.

f. An audio distortion measuring set to measure levels, distortion, hum, and noise on incoming and outgoing audio circuits. This set shall have the following technical characteristics: distortion measurements from 50 to 18,000 cps; noise and hum measurement from 30 to 45,000 cps; distortion range from 0.1% to 30%; noise range from -80 db; power level range from -60 dbm to +20 dbm; input impedances 10,000 ohms and 100,000 ohms.

g. A transistorized audio oscillator for the testing and alignment of channels. This item shall have an audio output of up to 1 watt over the frequency range from 20 to 200,000 cps, with a maximum distortion of 1% at an output of 1 watt, and a response of ±1 db over the frequency range.

h. A frequency counter with a display consisting of eight non-blinking rectangular indicating tubes in line for an eight digit display. The counter shall be designed with completely solid state components and shall be rack mounted. It shall measure frequencies up to 30 mc and have a stability of not less than ±3 parts in 10^9 per day or better.

i. A rack-mounted oscilloscope for analyzing waveforms.

j. All devices necessary to analyze and adjust levels of all audio circuits entering and leaving the switching and technical control van.

7.13.2 HF Radio Test Equipment

The major items of test equipment to be installed in the HF transmitter and HF receiver vans are those associated with frequency measuring, testing as single sideband signals, and measuring and controlling of incoming and outgoing audio signals. Both shelters shall be equipped with a frequency counter and devices necessary to analyze and adjust the levels of all audio channels entering and leaving the vans. The HF transmitting van shall include a single sideband spectrum analyzer with cathode ray tube display, an integral two-tone audio generator, and an RF tuning head to measure transmission bandwidth, residual hum, carrier amplitude, harmonics, distortion, and other characteristics of the HF transmitter.

7.14 VANS

All vans shall be the S-141/G type conforming to MIL-S-52059, with the exception that the overall external length shall be increased to 156 inches (13 feet). Each van shall be equipped with a lightweight retractable or removable wheeled undercarriage. Each van, with its specified load and with wheels removed or retracted, shall be designed to permit loading on the beds of standard military vehicles for cross-country mobility, shall be capable of type III mobility when towed with the wheeled undercarriage in place and/or extended, and shall be equipped with lifting and tie-down eyes to permit transport by cargo aircraft and helicopter.

The vans shall include all mounting brackets, entrance ports, connectors, ducts, panels, and other hardware to:

Interconnect vans by means of multi-conductor cable
Mount VHF and UHF G/A/G antenna supports
Mount the inter-van microwave package and/or antenna assembly
Connect the output from the gas turbine 400 cycle generator

Accept the flexible air conditioning ducts
Provide feed-through for RF transmission lines to and from antennas.
Provide distribution of conditioned air
Provide lighting
Provide power outlets and a power distribution panel
Provide cable entrance

Weatherproof corridors shall be provided to interconnect the switching and technical control van, the message center van, and the cryptographic van in an "inverted T" configuration. Since the doors of these vans shall face the corridor, it will be necessary to provide a door in the corridor assembly and a set of access stairs. The corridor shall be constructed of lightweight, durable material; shall be collapsible to occupy the minimum possible space when stowed in the transit condition; and shall include all hardware and instructions for unpacking, assembly, installation, disassembly, and packing. No special tools shall be required to perform these operations, and maximum possible use shall be made of captive hardware.

8.0 IMPLEMENTATION

TRANSMOD shall be designed to minimize the time required for implementation or set-up of each van. The design shall be such that no more than 240 man hours will be required to set up the seven vans. The major portion of set-up time will be expended in erecting and orienting antennas; therefore, design of TRANSMOD shall include devices that reduce this time to the absolute minimum. The following should be considered in the design of antenna assemblies and supports:

a. Design to include the minimum of critical assembly and installation steps.

b. Include captive hardware.

c. Include plastic, weather-proof instruction plates.

d. Design transit packaging so that equipment is stowed and removed in proper sequence for assembly and disassembly.

e. Color-code and number component parts of antennas and antenna supports to facilitate identification and to indicate assembly sequence and/or location.

f. Provide a transit, compass, and other devices necessary to orient antennas.

g. Make antenna supports simple to erect, operate, and maintain and able to withstand rough field handling. Telescopic elements are not recommended unless they can function properly when dented and when covered with dirt, sand, ice, and mud. Manual erection with the use of cables, pulleys, hoists, or winches is recommended rather than hydraulic or pneumatic erection.

h. Provide means for adjusting microwave and troposcatter antennas in azimuth and elevation with the antennas installed. Azimuth and elevation angle indicators calibrated in 0.5° graduations shall be attached to antenna assemblies and shall be closely readable with the naked eye. In addition, leveling indicators and telescopes shall be included to provide a means of optically orienting antennas.

9.0 CIRCUIT RELIABILITY

Every effort shall be made to achieve a TRANSMOD overall circuit reliability approaching or equal to that of the fixed-plant counterparts. Siting, set-up, alignment, operation, and maintenance instructions shall be provided with this objective in mind. Troposcatter equipment shall be designed to provide 24 voice frequency channels over paths exceeding 100 miles with a 99% reliability or better. HF equipment shall be designed to operate over path lengths of from 300 to 2500 miles or more with a mean overall path efficiency of 90% when operated with all 4 channels loaded to full capacity.

10.0 PROTECTIVE DEVICES AND ALARMS

Maximum use shall be made of circuit breakers to reduce logistic problems associated with the supply, storage, and issue of a wide variety of expendable fuses. All switches, fuses, circuit breakers, and interlocks shall interrupt the ungrounded site of power circuits, and some form of front panel indicator shall be included for each such device employed. Fail-safe visual and aural alarms shall be included as part of each TRANSMOD facility to indicate operation out-of-tolerance and failure of critical circuits and protective devices.

RF transmitting equipment shall have visual and aural alarms to indicate inadequate power output or excessive VSWR. There shall be a combination alarm and protective device with adjustable limits so that the alarms will be activated when one limit is reached, and the transmitting equipment will be shut down at the extreme limit.

11.0 HUMAN ENGINEERING

Equipment density is necessarily high in some vans, and the space available for operator personnel may be less than the 15 square feet per person considered desirable for operator efficiency. With this limitation in mind, it shall be of prime importance to simplify operator functions, eliminate safety hazards, and control the environment within the van to avoid discomfort, fatigue, and other conditions that may cause degradation of human performance. Interior color, lighting, noise level, air velocity, temperature, and humidity shall be controlled to promote operator efficiency. All man-machine interfaces such as controls, readouts, displays, switching and patching devices, alarms, protective devices, technical control devices, and speech input-output devices shall be designed to simplify operator functions, reduce the possibility of error, and optimize efficiency. Van-mounted equipment and items normally installed and operated outside the van shall be designed to simplify assembly/disassembly, operation, and maintenance.

12.0 MOBILITY/TRANSPORTABILITY

All vans shall be designed to achieve optimum load balance and payload to gross weight ratio. The maximum gross weight of any van shall not exceed 6000 pounds, excluding wheeled chassis (if removable) and excluding equipment which is normally operated external to the van.

12.1 LAND MOBILITY

All vans, when mounted on the wheeled chassis, shall be capable of being towed over paved highways at a maximum speed of 60 mph, over graded gravel roads at an average speed of 20 mph, and over unimproved roads and trails and cross-country terrain. When mounted on standard military 2 1/2 ton cargo trucks, the vans shall withstand transport over paved highways at a maximum speed up to 60 mph, over gravel roads at speeds in excess of 20 mph, and over cross-country terrain and unimproved roads at a maximum speed of 20 mph.

12.2 HELICOPTER TRANSPORTABILITY

All vans shall be designed to be capable of being picked up by helicopter, transported while suspended from the helicopter, and lowered to the ground. The vans and lifting eyes shall have adequate strength to withstand 3.5 G acceleration in any direction with the van suspended by its lifting eyes.

12.3 AIR TRANSPORTABILITY

All vans shall be designed so that three vans mounted on standard military 2 1/2 ton cargo trucks can be transported by the C-133 cargo aircraft. When removed from the cargo trucks, the design shall be such that a complete TRANSMOD facility which includes seven vans and ancillary items such as antennas, power units, air conditioning, cables, etc) can be transported by two C-133 cargo aircraft or three C-130 cargo aircraft.

12.4 RAIL TRANSPORTABILITY

All vans shall be capable of rail shipment on a standard 40 foot flatcar. During rail transport, the vans shall be capable of being blocked, loaded, and braced in accordance with the minimum methods and standards set forth in the loading rules pamphlet of the Association of American Railroads. In this transit condition, the vans shall be capable of withstanding umping speeds of 9 mph.

13.0 CLIMATIC SERVICE CONDITIONS

All vans and ancillary equipment of TRANSMOD shall be designed and constructed to withstand any combination of the following climatic service conditions. There shall be no deterioration of materials, no mechanical or electrical damage, and no change in performance which could in any manner prevent the facility from meeting the specified requirements.

13.1 TEMPERATURE

a. Unsheltered equipments: This category, that includes the van and all equipments normally operated external to the van (antenna masts, guy lines, outdoor cables, power units, air conditioners, etc) shall operate over the temperature range of -65°F to +125°F. Winterization kits can be used as necessary for cold weather unsheltered operation of certain equipment.

b. Sheltered equipment: Sheltered equipment shall operate within tolerance over the internal (van) ambient temperature range of 0°F to +125°F.

13.2 PRESSURE (ALTITUDE)

a. Non-operating: All vans and ancillary equipment shall be capable of being transported at altitudes of up to 50,000 feet above sea level.

b. Operating: All communications-electronics equipment shall operate without degraded performance at altitudes of 10,000 feet above sea level.

13.3 CLIMATIC EXTREMES

The van and all equipments which are normally operated externally shall be capable of withstanding the following climatic service conditions:

a. Humidity: Up to 100% relative humidity at a minimum temperature of 100°F, including condensation due to temperature changes.

b. Rain: Up to 2 inches per hour.

c. Snow: Up to 1 inch per hour.

d. Ice: 1 inch of ice measured radially to exposed surfaces.

e. Wind: Up to 65 knots in any horizontal direction without requiring tie-downs or guys. Unsheltered equipment which is normally operated with guys or tie-downs shall be capable of withstanding 120 knots in any horizontal direction when suitably guyed or tied down.

f. Blowing sand and dust: As encountered in areas such as desert regions.

g. Salt atmosphere and salt spray: As encountered in coastal regions for extended periods.

h. Fungus: As encountered in warm, damp areas. This will involve maximum use of non-nutrient materials.