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UTILIZATION OF NASA LEWIS MOBILE TERMINALS FOR THE HERMES SATELLITE

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I. ABSTRACT

The high power of the Hermes satellite enables two-way television and voice communication with small ground terminals. The Portable Earth Terminal (PET) and the Transportable Earth Terminal (TET) were developed and built by NASA-Lewis to provide communications capability to short-term users. This paper describes the NASA-Lewis mobile terminals in terms of vehicles and on-board equipment, as well as operation aspects, including use in the field. The section on demonstrations divides the uses into categories of medicine, education, technology and government. Applications of special interest within each category are briefly described.

II. INTRODUCTION

The Communications Technology Satellite (Hermes) is a satellite which was launched by NASA on January 17, 1976 as part of a cooperative program between the United States and Canada. The satellite operates in the 12 and 14 GHz frequency bands and is capable of simultaneous two-channel operation using a 200 watt amplifier for Channel 1 and a 20 watt amplifier for Channel 2. This high-power transmitter operating at high frequencies enables two-way television and voice communication with small ground terminals. The Portable Earth Terminal (PET) and Transportable Earth Terminal (TET) were developed and built to provide satellite communications to short-term Hermes Users in various locations throughout the U.S. Previously, satellite communications have not been economically practical for these uses. Hermes Users are conducting experiments to demonstrate the feasibility of communicating across large distances and in remote areas via satellite utilizing small, less expensive earth terminals. Telecommunications experiments performed by various Users are in the areas of health care, education, community and special services.

The purpose of this paper is to describe the NASA-Lewis Research Center mobile terminals, their operation and utilization to date.

III. DESCRIPTION OF MOBILE TERMINALS

A. Portable Earth Terminal Description

The Portable Earth Terminal (PET) is a self-propelled vehicle used as a portable satellite communications terminal. PET is equipped with a studio and satellite transmitting and receiving equipment capable of full duplex color television interaction between experimenters. The program can originate in either the on-board PET studio or from studio and conference rooms in nearby buildings. Figure 1 shows PET in the transport-mode configuration and Figure 2 shows the terminal on-location in its transmit mode of operation. PET has a roof-mounted 2.4m (8 ft.) diameter parabolic antenna interfacing with a 500 watt, 14 GHz wideband TV transmitter and a 12 GHz wideband TV receive system. Presently, narrowband audio communications of the terminal is limited to reception only. The addition of narrowband audio transmit capability is planned for PET.

1. Vehicle

The PET is a self-contained, gasoline engine driven vehicle capable of operating independently of external power sources. It is 10.7m (35 ft.) long, 2.4m (8 ft.) wide and 3.9m (12 ft. 11 inches) high and weighs approximately 15,400 Kg (34,000 lbs.) when fully equipped to support a demonstration. The studio compartment is 4m (13 ft.) in length and has a table and couch-type seating for teleconference participants (Figure 3). Figure 4 shows the layout of equipment in the vehicle.

Basically, the vehicle is a bus built by the Blue Bird Commercial Vehicle Division of Fort Valley, Georgia with a modified body and chassis designed to meet the NASA-Lewis mobile ground terminal requirements. A heavy-duty, truck-type, 8-cylinder engine is used to propel the vehicle. In addition to the standard automotive air conditioner furnished with the engine, the vehicle is equipped with a central heating and air conditioning system. This climate control system enables PET operations throughout the U.S. year around.

A hydraulic leveling system consisting of four jackscrews is employed to stabilize and level the vehicle on-site. This facilitates antenna pointing and tracking.

The electrical system is a 120/208 volt AC, three (3) phase, four (4) wire configuration. Vehicle electric power can be supplied by either the local on-site power company or by its own two air-cooled, gasoline-driven electric generators. Each generator is rated at 15.6 KVA, 0.8 power factor with a voltage regulation of $\pm 3\%$. One generator supplies power for housekeeping functions which include the central heating and air conditioning system, and the other generator is used for antenna and electronic equipment operations. One twelve (12) volt battery is used for each generator for startup. These batteries are in addition to the batteries which supply vehicle engine startup power.

A self-contained battery charger enables all batteries to be charged from local power when operating in this mode.

2. Equipment

The antenna system consists of a collapsible roof-mounted 2.4m (8 ft.) diameter parabolic reflector with cassegrain feed and linear orthogonal polarization. When the vehicle is in transit, the antenna lays horizontally and rests on the vehicle roof. After the antenna is erected manually on-location, two electric motor-driven actuators are used to position the antenna in both azimuth and elevation. Final antenna pointing can be accomplished manually or by means of the associated automatic step-tracking controls using the spacecraft beacon signal.

The vehicle studio consists of video and audio equipment necessary for two-way teleconferencing. A color TV camera, color monitors, microphones and speakers are part of the normal studio complement. This equipment can be set up within the vehicle or in an adjoining building.

A block diagram of the satellite communications system is shown in Figure 5. The wideband color TV transmitter is comprised of a 14 GHz modulator and upconverter with audio subcarrier frequencies of 5.14, 5.36 and 5.79 MHz. The output stage of the transmitter is a 500 watt klystron-type high power amplifier. The receive system utilizes a two-stage preamplifier before the signal is fed to beacon, wideband video receive and narrowband audio receive subsystems. The two-stage preamplifier consists of a parametric amplifier followed by a tunnel diode amplifier. A portion of the pre-amp signal is directed to the 12 GHz beacon downconverter and IF receiver which operates the automatic step-tracking controls for the antenna. The TV wideband receive subsystem consists of a 12 GHz receiver and demodulator unit. Narrowband audio receive capability is accomplished on PET by means of a 12 GHz downconverter and IF receiver combination.

Wideband and narrowband transmit and receive hardware described above interface with video and audio input and output equipment. This equipment consists of the color camera, tape recorders, mixers, selectors, time-base corrector, amplifiers, character and sync generators and monitors. Test equipment, which is also carried on-board the vehicle, includes signal generators, vector scope, waveform monitor, frequency counter and a noise generator for signal-to-noise measurements. All electronic equipment (video, audio and test), except for the studio hardware, is rack-mounted in the forward section of the vehicle.

3. Performance Characteristics

a. Uplink

The PET is capable of processing three NTSC video sources through its video switcher and processor. One signal is selected for transmission to Hermes. The uplink modulator is frequency agile and can be tuned to Hermes bands 1 or 2. The modulator has a nominal video deviation sensitivity of 9 MHz peak, providing a modulation index of 2.

Audio sources are processed through mixers and fed to the PET audio switcher. The audio switcher can select as many as three audio signals to modulate separate subcarriers in the uplink modulator. The modulator output is then a composite, video/audio, single carrier FM/FM transmission. The modulator output is fed to a klystron high power amplifier (HPA). The HPA has a saturated output power of approximately 500 watts and an instantaneous bandwidth of 50 MHz. The HPA has a manual tuning range of 500 MHz so that it can be used for either Hermes band. HPA output power is controlled by an adjustable attenuator between the modulator output and the HPA output. Typical HPA outputs required for excellent quality video received at a similar terminal is 80 watts. To date, weather conditions from clear to heavy overcast with light rain have not caused this power requirement to change significantly. The HPA output is directly waveguide coupled to the roof-mounted 2.4m (8 ft.) cassegrain-fed antenna. The antenna gain at the transmit frequencies is approximately 48 dB. The typical EIRP requirement is 66 dBw and maximum capability is 74 dBw. Table 1 shows a nominal uplink performance estimate based on known spacecraft parameters and measured performance.

b. Downlink

The PET antenna feed system utilizes an orthomode coupler and receive port band pass filter for transmit/receive isolation. The receive system has a 150^{o}K parametric amplifier front end providing a net G/T of approximately 23 dB/^{o}K. The paramp and TDA following it provide a total gain of approximately 30 dB. The preamplifier output is fed through the vehicle roof directly to the downlink demodulator. The demodulator threshold is -98 dBw. It is the compliment of the uplink modulator providing outputs of baseband video and three channels of audio. Table 2 shows a typical downlink performance estimate based on known parameters and actual signal-to-noise (S/N) measurements.

B. Transportable Earth Terminal Description

The Transportable Earth Terminal (TET) is an easily transportable wideband receive and narrowband transmit terminal capable of operating anywhere in the United States. TET consists of two parabolic reflector antennas, one 3m (10 ft.) in diameter and the other 1.2m (4 ft.) in diameter, and an electronics shed mounted on a flat trailer. A one-half ton pickup truck, with a camper canopy-type back for equipment storage, is used to tow the trailer. The receiver, transmitter and test equipment are rack-mounted in the electronics shed. The terminal is shown in Figure 6. TET can receive color TV (video and audio), and relay these signals by cabling to a building at the demonstration site for viewing on monitors. The signal can also be recorded on video tape. The narrowband transmitter can be utilized as a return audio link which is especially useful in a question and answer-type demonstration.

1. <u>Vehicle</u>

The TET is a flat-bed trailer with stabilizing jacks towed by a half-ton pickup truck. The trailer is 6.7m (22 ft.) long, 2.4m (8 ft.) wide and weighs approximately 2,700 Kg (6,000 lbs.). A single phase source of 115 volt AC electrical power is required at the demonstration site. TET can be quickly set up on location.

2. <u>Equipment</u>

The two terminal antennas are fix-mounted to the bed of the trailer. The 1.2m (4 ft.) antenna has manual adjustments for azimuth and elevation while the 3m (10 ft.) antenna uses an electrical drive system for each axis. The fiberglass electronics shed is mounted forward of the antenna. It is 2.4m (8 ft.) wide, 1.8m (6 ft.) deep and 2m (6½ ft.) high.

The wideband color TV receive system includes the 3m (10 ft.) antenna, a paramp and downconverter mounted on the back of the antenna and a 12 GHz demodulator. Voice link transmission is accomplished by means of a 14 GHz narrowband unit whose output is directed into a 15 watt Travelling Wave Tube (TWT) power amplifier. The 1.2m (4 ft.) antenna is used to uplink to the satellite. TET carries video and audio equipment, including two video monitors, microphones, an audio mixer, and a tape recorder, required to interface the transmit and receive signals with the User's demonstration facilities. Figure 7 indicates the TET transmit/receive configuration.

3. Performance Characteristics

a. Uplink

The TET uplink capability is limited to single carrier narrowband audio transmission. The Hermes SHF frequency utilization plan (Figure 8) defines the five frequencies in each band to which the uplink modulator can be tuned. The system incorporates no audio switching. Microphone sources are processed through a mixer to the uplink modulator. Carrier, peak-to-peak deviation, is approximately 100 KHz. The output of the modulator goes through a variable attenuator for uplink power control. A 15 watt amplifier is used to drive the 1.2 meter uplink antenna. The net system EIRP is approximately 53 dBw. Audio quality received at typical Hermes terminals, such as PET, has been excellent.

b. Downlink

The TET receive system is designed for wideband video. A 3 meter antenna with a parametric amplifier provides the terminal with a G/T of approximately 23 dB/^{o}K. The output of the paramp is fed to a video demodulator. The demodulator is capable of two audio subcarrier demodulation. The video and program audio outputs of the demodulator are fed directly to remote monitors. Received video quality is excellent.

IV. OPERATIONS

A. Advance Preparations

PET and TET operations begin with requests from potential demonstrators culminating in a formal Demonstration Request. This contains basic information on the demonstration such as organization, contacts, sponsor, location, concept, scope of public interest; as well as time, terminal locations, and type of transmission. Schedules for the mobile terminals are made considering these elements and logistic requirements, as well as spacecraft time availability.

Following approval of a Demonstration Request, details of the proposed demonstration are arranged. The most vital step in these arrangements is the site survey, which considers factors such as spacecraft boresight, potential interference by and to other transmissions (such as navigational radar), availability of electric power, cable runs for video and audio equipment, and vehicle space and clearance problems. Telephone service, video and audio interfaces, vehicle routing, personnel accommodations and transportation are other important considerations. All but the simplest demonstrations require a frequency plan, outlining exact transmit and receive frequencies for each participant, including audio sub-carrier frequencies, and special requirements, such as "looping back" received signals for retransmission. Besides the frequency plan, a checkout procedure, outlining the steps to be followed during the pre-event checkout, is a necessity. Generation of these plans and procedures is ordinarily the responsibility of the sponsoring experiment.

B. Field Operations

On arrival at the demonstration site, PET or TET is positioned according to the requirements of the site survey, leveling jacks are deployed, and the set-up process begins.

For PET, the first task is connection to the power source. A 208 volt AC, 3 phase, 60 amp (or greater) source is connected through the 50m long PET power cable. Next, the 2.4m antenna is erected, the electrical drive system activated, and a rough-pointing toward the spacecraft performed using compass and inclinometer. After feedhorn and subreflector installation, and waveguide connection, the antenna is fine-pointed using the spacecraft beacon signal as a homing source.

Succeeding steps include removal of the klystron tube from storage and installation into the high-power amplifier; programming and checking of the audio switcher, and checking of the video switcher. Remaining activities are dependent upon the demonstrator's programming, but typically encompass camera, monitors, microphones, audio mixer and video/audio tape recorder, lighting and other studio arrangements, as well as cable connections and runs. Upon successful completion of these tasks, PET is ready for the pre-event checkout.

TET's power requirements are two 115 volt AC 20 amp lines. The 3m antenna is erected and coarse pointed using hand tools. If voice-back transmission is required, the 1.2m antenna is deployed and pointed. Fine pointing of the antennas is accomplished by feeding a receive signal from the spacecraft into a TV monitor and tweaking the antenna fine-tune adjustments for maximum signal quality. For the 3m antenna, electrically powered jackscrews provide the fine control.

After the antennas are pointed, the baseband interface connections are made for the demonstrator's specific programming needs. These would include audio mixer and microphone connection to the transmitter, receiver video output connections into TV monitors, projector, video tape recorder and audio public address system setup.

After internal checks, the system is ready for full-scale checkout through the spacecraft to the interactive terminal.

C. Checkout

Two checkouts normally precede a demonstration. The first, on the U.S. day before the event, is a thorough end-to-end checkout, which establishes operating parameters. The second, just prior to the event, verifies settings and allows for minor adjustments. A complete end-to-end checkout has proven to be invaluable when mobile terminals are involved. Each demonstration is different in content, location, setup or procedures, and seldom is there working experience between the terminals.

Checkouts follow basic procedure established for all experimenters. While in telephone contact with the NASA-Lewis

Test Conductor, the terminal transmitting via the spacecraft 200 watt tube establishes its uplink power setting. When the receive station confirms reception of video and audio, it transmits video and/or audio via the spacecraft 20 watt tube. Once these power levels are established at the transmitter sites, the end-to-end check begins to confirm the operation of echo suppressors, cameras, microphones, audio mixers, video switchers, monitors, projector, etc. The program activity is also run through to determine the acceptability of pre-program planning. When satisfactory operation is achieved at all locations, and equipment settings noted for reference, by mutual consent, the checkout is concluded.

On the event day, some time at the beginning of the event time is devoted to the final checkout. This can be as little as 15 minutes and serves to verify satisfactory operation before programming begins.

V. DESCRIPTION AND RESULTS OF DEMONSTRATIONS

Tables 3 and 4 are a chronology of mobile terminal demonstrations through mid-October, 1977. Each use is also coded into major categories corresponding to the categories of the Symposium: Medical, Educational, and Technical. A fourth category, Governmental, is also needed for these demonstrations.

A. Medical

A significant proportion of both PET and TET demonstrations have involved medical content. The PET tour through Idaho and Montana in August/September 1977 consisted of duplex transmissions from hospitals in Boise, Pocatello, Missoula, Kalispell, Great Falls and Billings to the University of Washington Medical School in Seattle. Most sites conducted a cancer conference plus a consultation process such as pediatrics, internal medicine, family medicine or OB/GYN. Besides, the usual interfaces with TV receiving, projection and recording equipment, visual data were also taken from an ultra-sound scanner (colposcope). Some of the highlights of this series were broadcasts directly from examining rooms and real-time consultations with Seattle physicians.

TET's participation in medical technology programming includes a demonstration in Indianapolis where TET received a conference from Lister Hill in Bethesda followed by a program from Johns Hopkins in Baltimore. COMSAT's portable terminal in Baltimore transmitted a bronchoscopy, a cytoscopy and an eye operation from Johns Hopkins to TET. Several viewers found watching the eye operation on a 10 foot TV screen more realistic than they expected.

Other examples of point-to-point medical use are the PET-to-TET series in Alabam, the American Medical Association's Rural Health Conference in Seatlle and the Rehabilitation Services Administration's program to Madison. In Alabama, PET transmitted from the University of Alabama to TET in Dothan, where nurses in Alabama, Florida and Georgia had assembled for a training course. During the Rural Health Conference, PET operated in a duplex mode with the Lister Hill Center in Bethesda. A key feature of this experiment was the working group sessions after the formal addresses. The Rehabilitation Services Administration in Fishersville, Virginia, using a Goddard Space Flight Center portable transmitter, demonstrated devices and techniques for aiding the disabled to the University of Wisconsin. TET received the broadcast and provided an audio link back to Fishersville.

The mobile terminals have also been used for broad distribution of medical programming. At INTELCOM 77, PET participated in a complex linkage during a broadcast on vaccines. PET and the Lister Hill Center established a duplex video link. PET also retransmitted the signal from Lister Hill in a different transmit band to Ottawa, Goddard, the SECA network, and Rosman. Rosman, in turn, retransmitted the signal to ATS-6 for reception by the ATS network. TET took part in the American Hospital Association demonstration by receiving TV from Atlanta, GA and feeding it back into a microwave distribution system. The system, called "Megahertz" connects twenty hospitals which are members of the Greater Cleveland Health Association. Similar distributions were taking place simultaneously in Indianapolis, IN and Dallas, TX with even larger numbers of hospitals.

B. Education

Most of the educational broadcasts to date have been TET applications, especially the early uses. These, typically, consisted of programs stressing space technology and applications transmitted from Lewis Research Center to TET, which fed its signals into a school. In Rockford, IL, the feed was to a cable TV company, with subsequent distribution to the entire school system. With the introduction of the narrowband audio system in November 1976, two-way question-and-answer periods became possible.

The Council on Exceptional Children, an organization devoted to the training of the handicapped child, used PET to give wide geographic coverage to its 1977 Annual Conference in Atlanta. Transmission from Atlanta went to the SECA network for redistribution. An audio return from Westinghouse in Baltimore, using a temporary narrowband system, provided question-and-answer capability.

C. Technical

Technical applications for the mobile terminals can be further categorized into demonstrations of existing technology and demonstrations of new technology. The very existence of the mobile terminals (small, readily portable) is a demonstration of the technology available from a high-powered satellite such as Hermes. The interactive teleconferencing mode has been made available by these terminals for demonstrations such as INTELCOM 77 where several distribution schemes were utilized.

New technology is exemplified by Hermes U.S. Experiment 24, Digitally Implemented Communications Experiment (DICE) (Ref. 1, 2, 3). DICE equipment was mounted in PET and used in a series of transmissions during the International Communications Conference (ICC 77) in Chicago. The PET in Chicago and COMSAT Laboratories in Clarksburg, MD received and transmitted low bit-error rate digital TV during the conference.

D. Government

Governmental applications of satellite communications have caused considerable excitement among users. PET participated in Senate hearings from Springfield, IL to the Senate Committee in Washington, and a teleconference between constituents in Raeford, NC and their Congressman in Washington. For the Senate Hearings, ten people gave their testimony in the Federal Courthouse in Springfield, IL. PET uplinked this testimony thru Hermes to Goddard, where it was transmitted via microwave and landline to the Dirksen Senate Office Building in Washington. Senators and staff were able to examine the witnesses using the interactive teleconference mode. In Raeford, students at the local high school had the opportunity to ask their Congressman direct questions of importance to the Raeford area. This was followed by a meeting of county commissioners who were able to include their Congressman via Hermes. More detailed information is contained in Reference 4.

In addition to the Congressional Teleconferencing, PET has served as the link between a National Mayors' Conference in California and the Secretary of HUD, Patricia Roberts Harris, in Washington. Secretary Harris used the studio on-board PET, which was located at the HUD building, to adrress the mayors and answer their questions.

At Syracuse University, fifty career government officials, students in the Midcareer Development Program of the Maxwell School of Citizenship, discussed health care services with Canadian government officials. Another group of students (government TV and radio broadcasting officials from Europe, Africa, and Asia) examined provincial government with Canadian provincial officers at a later session.

TET's participation in government affairs occurred in Rockford, IL, where it served as the satellite link between a school board meeting in Rockford and a school official in Cleveland, Ohio, and between a city council in Rockford and a suburban mayor at the Lewis studio in Cleveland. These connections were one-way video and two-way audio, utilizing the narrowband voice transmitter above TET.

VI. CONCLUSIONS

The mobile terminals have been in operation since February 1977 (PET) and May 1976 (TET). Each has demonstrated the use of high power satellites in the 14/12 GHz band to numerous enthusiastic viewers. Requests for use of the terminals have increased beyond the available opportunities.

VII. REFERENCES

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2. A. Gatfield, H. Suyderhoud, and C. Wolejsza, "System Design for the Digitally Implemented Communications Experiment (DICE)," Conference Record, 1977 International Conference on Communications, ICC'77 - IEEE, 1977, Vol. 1, pp. 1.1-1, 1.1-5.

3. A. Gatfield, "CODIT, A Digital TV System for Communication Satellites," Horizon House International Telecommunication Exposition, Intelcom 77, Atlanta, Georgia, October 9-15, 1977, Paper 3.8.2.

4. F. B. Wood, "Videoconferencing Via Satellite: Opening Congress to the People," Royal Society of Canada Hermes Symposium, Ottawa, Canada, November 29 - December 1, 1977.

TABLE 1

Uplink - Hermes Band 1	
HPA P_o (80 watts)	19 dBw
Feed Loss	-0.5 dB
Antenna Gain (2.4m)	48.0 dB
EIRP	66.5 dBw
Path Loss	-207.6 dB
Margin	-1.0 dB
S/C Antenna Gain (0.6m)	37.6 dB
S/C Recvd. Power	-104.5 dBw
S/C Recvr. P_N	-123.1 dBw
S/C Recvd. C/N	18.6 dB

TABLE 2

Downlink - Hermes Band 1	
S/C TEP P_o (180 watts)	22.6 dBw
S/C Feed Loss	-0.8 dB
S/C Antenna Gain (0.6m)	36.3 dB
S/C EIRP	58.1 dBw
Path Loss	-206.4 dB
Margin	-1.0 dB
Antenna Gain (2.4m)	47.0 dB
Recvd Power	-102.3 dBw
Rcvr. P_N	-129.5 dBw
Recvd Net P_N	-122.2 dBw
Rcvd C/N	20.1 dB
FM Improvement	21.6 dB
Unweighted S/N	41.7 dB

TABLE 3 - NASA LERC MOBILE TERMINAL DEMONSTRATIONS

PET USES

DATE	EVENT	*TYPE	TERMINAL LOCATIONS PET	TERMINAL LOCATIONS OTHER
3/01/77	Mayor's Conference	G	Washington,DC	Menlo Park, CA
3/3-10/77	Intergovernmental Comparisons	G	Syracuse, NY	Ottawa
3/31/77	AMA Rural Health Conference	M	Seattle, WA	Bethesda, MD
4/13/77	Conference on Exceptional Child	E	Atlanta, GA	SECA Network and Baltimore, MD
4/15/77	Congressional Teleconference	G	Raeford, NC	Washington, DC
6/08/77	Senate Hearings	G	Springfield, IL	Washington, DC
6/10-15/77	ICC 77	T	Chicago, IL	Clarksburg, MD
7/07-19/77	U. of Alabama Telemedicine	E/M	Birmingham, AL	Dothan, AL
8/23/77	Governor's Conf. - Cancer Conf.	G/M	Boise, ID	Seattle, WA
8/25/77	Medical Conference	M	Pocatello, ID	Seattle, WA
8/28/77	Medical Conference	M	Missoula, MT	Seattle, WA
9/01/77	Medical Conference	M	Kalispell, MT	Seattle, WA
9/06/77	Medical Conference	M	Great Falls, MT	Seattle, WA
9/08/77	Medical Conference	M	Billings, MT	Seattle, WA
10/09-11/77	Intelcom 77	T	Atlanta, GA	Ottawa, GSFC, Lister Hill, SECA, ATS Network

*Type coding is: E - Educational
G - Governmental
M - Medical
T - Technical

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TABLE 4 - NASA LERC MOBILE TERMINAL DEMONSTRATIONS

TET USES

DATE	EVENT	*TYPE	TERMINAL LOCATIONS TET	TERMINAL LOCATIONS OTHER
5/10-21/76	Bicentennial Celebration	E	Kalamazoo, MI	Cleveland, OH
8/3-14/76	Museum of Science	E	Chicago, IL	Cleveland, OH
10/29/76	Space Education	E	Pecatonica, IL	Cleveland, OH
11/01-12/76	Space Technology for Schools	E/G	Rockford, IL	Cleveland, OH
3/15-17/77	Career Opportunities	E	Chicago, IL	Cleveland, OH
4/18-20/77	SECA Conference	T	Gulf Shores, AL	Cleveland, OH
5/23/77	Indiana U. Telemedicine	M	Indianapolis, IN	Bethesda,Baltimore,MD
6/01/77	Teaching of Handicapped	E	Lexington, KY	Menlo Park, CA
7/07-19/77	U. of Alabama Telemedicine	M	Dothan, AL	Birmingham, AL
8/30-9/01/77	American Hospital Association	M	Cleveland, OH	Atlanta, GA
9/27/77	Rehabilitation Services Conf.	M	Madison, WI	Fishersville, VA

*Type coding is: E - Educational

G - Governmental

M - Medical

T - Technical

Figure 1. - Portable Earth Terminal.

Figure 2. - Portable Earth Terminal configured for operation with spacecraft.

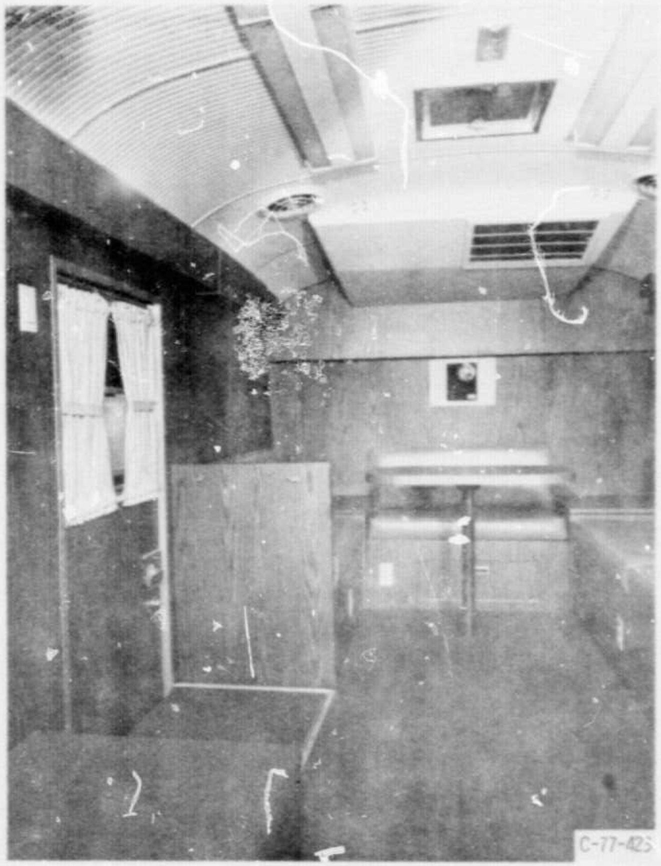

Figure 3. - PET studio compartment.

Figure 4. - PET equipment layout.

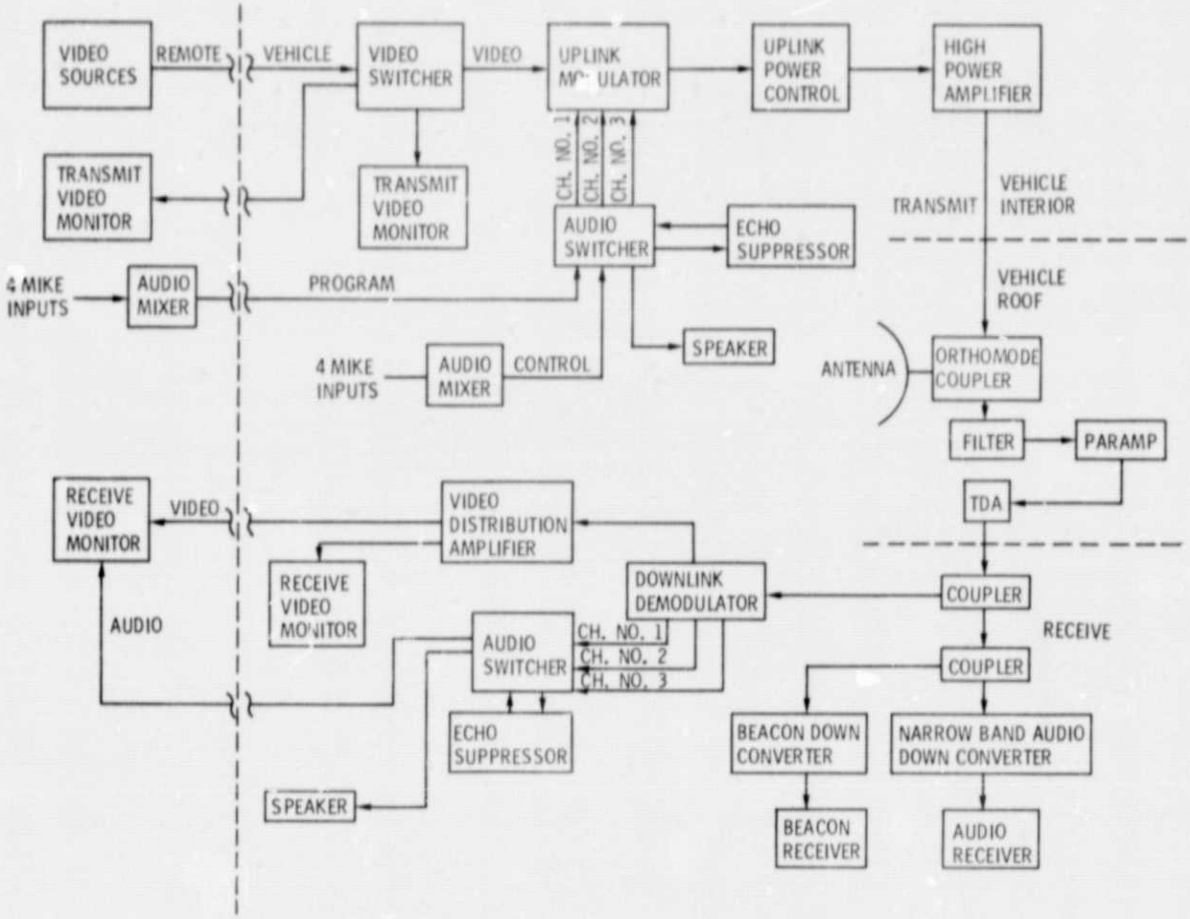

Figure 5. - PET system block diagram.

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Figure 6. - Transportable Earth Terminal (TET).

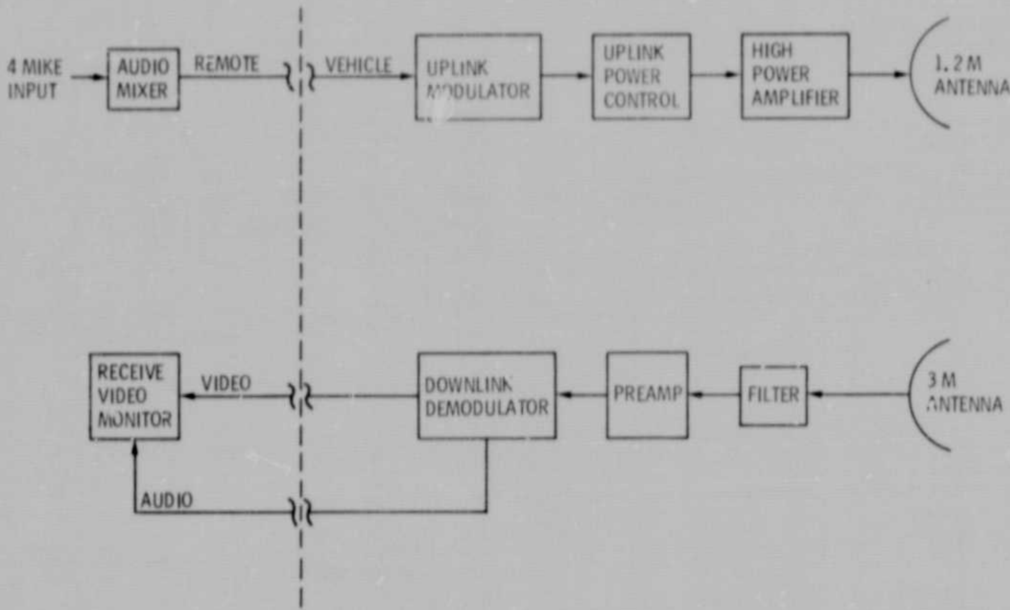

Figure 7. - TET transmit/receive configuration (system block diagram).

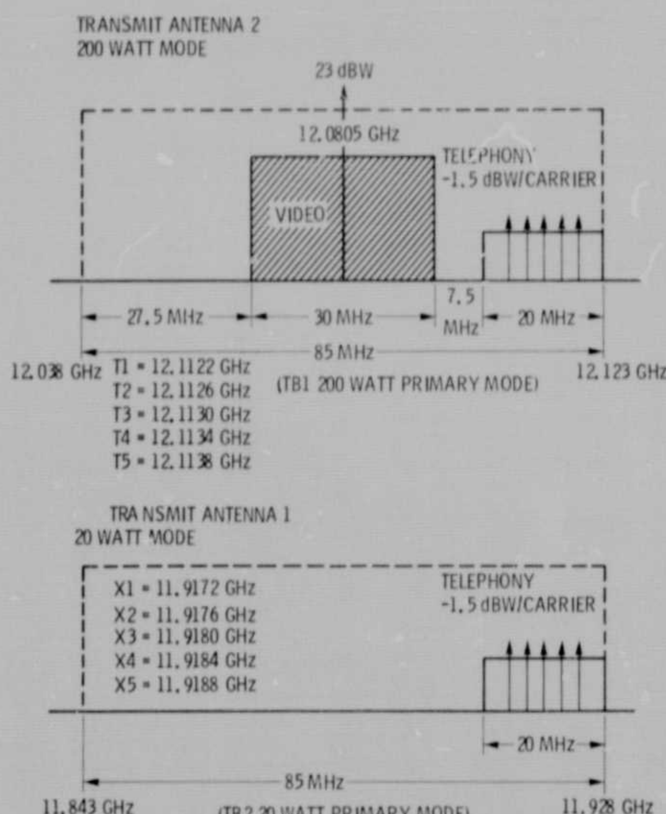

Figure 8. - SHF frequency utilization plan.