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# Operational Procedures for Ground Station Operation: ATS-3 Hawaii-Ames Satellite Link Experiment

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# **Operational Procedures for Ground Station Operation: ATS-3 Hawaii-Ames Satellite Link Experiment**

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Space Administration

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# OPERATIONAL PROCEDURES FOR GROUND STATION OPERATION:

## ATS-3 HAWAII-AMES SATELLITE LINK EXPERIMENT

Kenji Nishioka and Emanuel H. Gross

Ames Research Center

### SUMMARY

The process of transferring remote sensing technology to state and local governments in the Western Regional Applications Program (WRAP) region would be enhanced especially for remote areas if good data communications can be provided. This will enable participants in WRAP access to Ames Research Center computers to gain experience in conducting digital analysis of Landsat data. An experimental voice and data communication link using the ATS-3 satellite between Hawaii and Ames was implemented to determine if such links were feasible for the above purpose. The initial experience gained in training the Hawaii participants in satellite communication station operations indicated the need for a reference document on the operational procedures for such stations. This document provides these procedures.

This document describes the overall communication network and its operational procedures along with the hardware used. But the primary utility of this document is in the detailed step-by-step operational procedures provided in sections 2, 3, and 4 to help newly initiated personnel to operate the satellite communication station (in Hawaii). Provided in section 1.3.1.1 are the transmit and receive channels used and their frequencies. Details such as switch settings for activating the station to the sequence of turning switches on are provided. Like details for shutting down the station is also provided. Methods and procedures for troubleshooting common problems encountered with communication stations are similarly provided. Basically, this document will provide anyone with a short one or two day training in station operation, the capability to operate the satellite communication equipment.

### 1.0 OVERALL SYSTEM DESCRIPTION

This manual provides hardware descriptions and operational procedures for the ATS-3 Hawaii-Ames satellite computer link. It is intended to provide basic step-by-step instructions on the use of the equipment on the Hawaii end of the link and is intended to supplement 1 or 2 days of training in station operation.

The purpose of the Hawaii-Ames satellite link experiment is to determine whether satellite links are feasible for operational use and to expand the analytical capabilities of the Hawaii participants in the Western Regional Applications Remote Sensing Project.

## 1.1 Description of Hawaii-Ames Satellite Link

The system can probably be best described if the overall satellite link is visualized. Figure 1 shows the link schematically. The General Electric (GE) transmitter-receiver units (also referred to here as the GE Console) for both Hawaii and Ames are essentially the same as are the Vadic modems and antennas. Built into the GE console is a remote control unit that allows a separate remote console to control operation of the transceiver from up to 183 m (600 ft) away. Amplifiers and line levelers are provided at both ends; at the GE console end and at the remote console. For this application, the remote console unit is a GE Deskon unit with an auxiliary microphone for voice communication.

A Texas Instrument (TI) model 725 is used as the remote computer terminal for data communication. The TI 725 has been modified so that the terminal is now wired directly to a four-wire Vadic modem. The acoustic coupler built into the terminal is bypassed. The Vadic modem is hard-wired to the GE Deskon unit.

The GE Deskon unit remotely controls the transmitter and switches between data and voice communication. Thus, the flow of information for data communication is from the computer terminal to the Vadic modem, through the GE Deskon and over the link shown in figure 1, terminating at the Ames TENEX-ILLIAC IV computers, and back over the link to the Hawaii computer terminal. For voice communication, the Deskon is switched to voice. When the switch on the microphone is depressed, the voice signal goes through the GE Deskon over the link and terminates at the Ames GE Console speakers. Ames answers by using the microphone attached to the GE Console. At the Hawaii end, voice communication can also originate at the GE Console by switching the remote disable switch (see fig. 2) on the GE Console.

There are two receivers in the GE Console; a narrow-band and a wide-band receiver. Both receivers can be used for either voice or data. The wide-band receiver is preferred for data communication because of its wider peak-to-peak signal deviation capability.

The main components in the satellite link between Hawaii and Ames are described in the following paragraphs of section 1.2. The state operators and users of the link also can refer to the manuals listed in section 6 for additional details.

## 1.2 Hardware

The major hardware components required for this satellite link application and some pertinent details of their operational characteristics and functions are described below.

### 1.2.1 Transmitter

The transmitter unit is part of the complete self-contained GE transceiver housed in a 1.8-m (6-ft) console. A schematic of the console face is shown in

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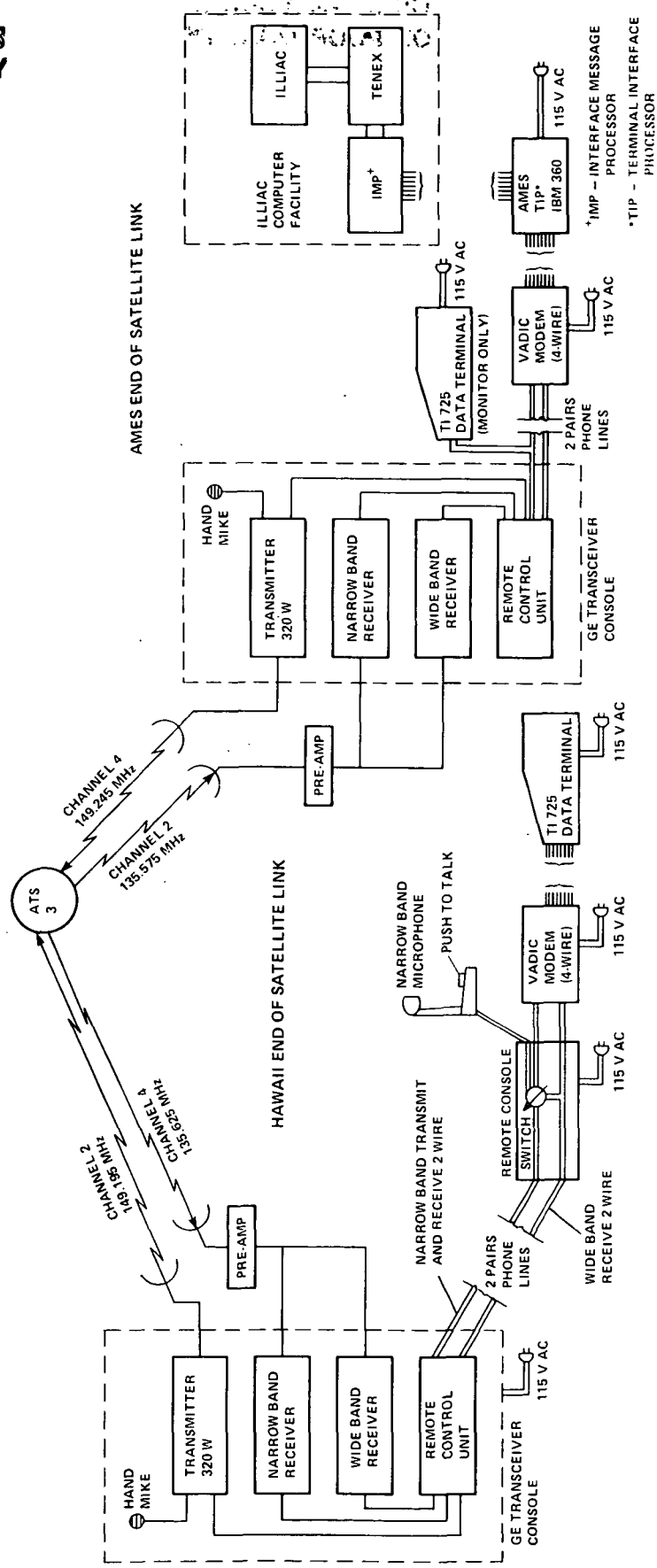


Figure 1.- Schematic of Hawaii-Ames satellite link.

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figure 2 and a photograph of the GE Console is shown in figure 3. The necessary components, such as switches, power supplies, protective fuses, meters, and speakers, are contained in the GE Console. All that is required to make the unit operational are antennas, cables, and input power of 115 V ac at 15 A.

The exciter for the transmitter is composed of a two-section varactor phase modulator capable of a maximum peak-to-peak signal deviation of 36 to 40 kHz. The selected channel frequency is phase-shifted proportionally to the modulation signal fed to the exciter. This phase-shifted signal is fed to the linear driver stages where about 5 W of power are produced. This signal is padded and fed to the linear final, which contains a signal-detect circuit. When a signal is detected in the transmitter section, the power amplifier section switches on the high voltage (about 3 kV) to a (4-250-B) high-power amplifier tube which produces about 360 W of rf power at 149 MHz.

Protective circuits for the high voltage, excess current, minimum current, undervoltage, overvoltage, filament current, and other conditions are provided in the high-voltage section of the transmitter. The exciter is protected by fuses in the power supply. The fuses in the rear of the high-power amplifier are for bias supplies to the high-power transmitter; however, the main protection for the high-power amplifier is a large circuit breaker to the right of the control panel near the top of the GE Console, labeled "Plate." No specific meters are set up for monitoring deviation of the transmitted signal. However, for the linear final there are four meters at the top of the GE Console. The meter at the extreme left (fig. 3) indicates the received signal strength; the other three meters are used to monitor high-power amplifier plate voltage, plate current, and power output. A time delay is built into the high-voltage circuits for the linear amplifier to allow the filament of the high-power tube to warm up sufficiently before the high voltage is turned on. This delay is typically about 1.5 min, but varies depending on the ambient temperature surrounding the GE Console.

The meter at the extreme right (fig. 3) on the top of the GE Console can be connected to the grid circuit of the linear final and the grid control adjusted accordingly. It also can be connected to the forward-reflected power module (labeled "output power" in fig. 2) that is in the upper right-hand corner of the linear amplifier. When the knob is rotated 180°, the signal read by the "Transmitter" (see fig. 2) meter is this reflected signal power. By reading both the forward and reflected signal powers, the VSWR (voltage standing wave ratio) or the reflection coefficient, which is an indication of the impedance mismatch of the antenna circuit, can be established.

### 1.2.2 Receivers

The two receivers in the GE Console are installed one below the other. The upper receiver is narrow-band, the lower wide-band. The receivers are true FM receivers and can demodulate FM and phase modulated signals. A limitation occurs as lower and lower frequencies are processed by the circuit because a phase modulator-demodulator cannot handle a dc signal. Thus, between 500 Hz to 10 kHz, the phase modulator circuit will produce the same kind of output that a true FM receiver would.

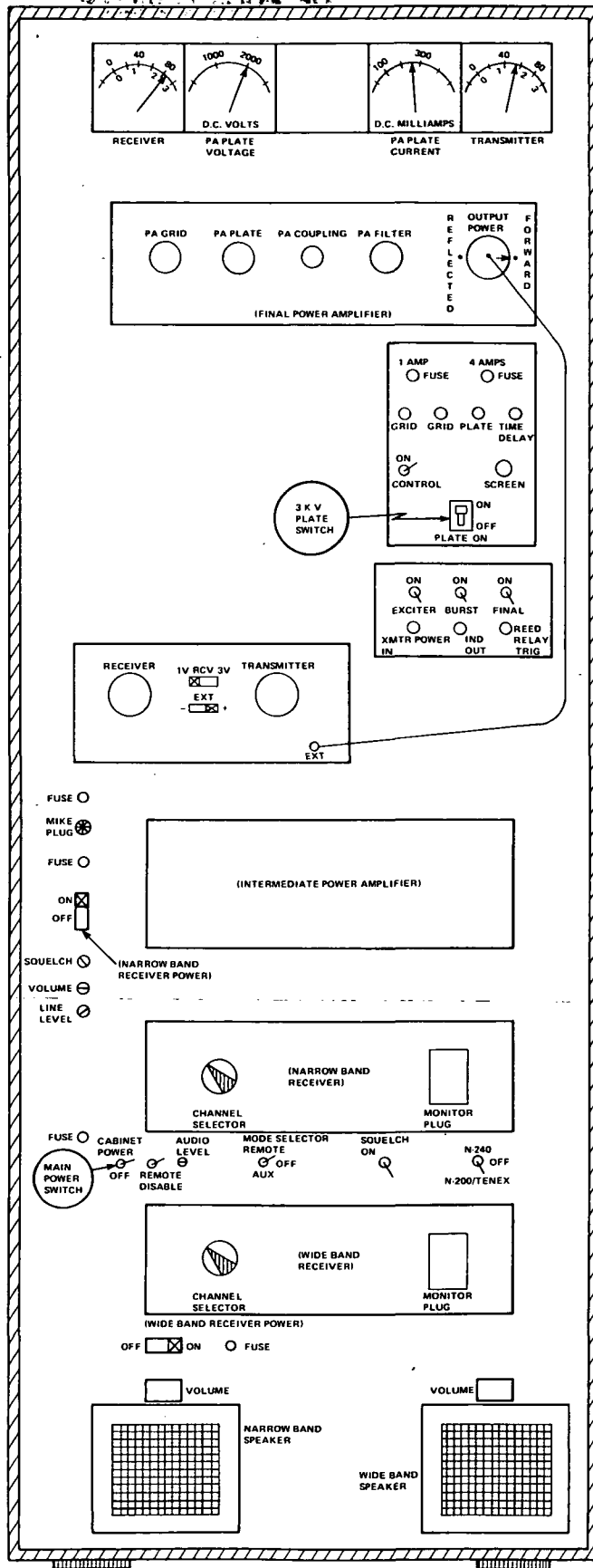


Figure 2.- Schematic of GE transceiver console.

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Figure 3.- GE transceiver console.

To the left of the narrow-band receiver are a switch and three controls. The switch turns the narrow-band receiver power supply on or off, and the three controls are for volume, line level, and squelch. The receiver controls work as a normal control would - counterclockwise for off and clockwise for increasing volume or decreasing squelch.

Squelch control is provided on the narrow-band receiver, which automatically switches out the receiver when the microphone is keyed. A squelch defeat circuit also allows the squelch to be set so that the receiver is operable even during transmission. The wide-band receiver is not squelched during transmission; as a result, it is always listening, unless the operator manually squelches the receiver at the GE Console.

The narrow-band receiver (NBR) can operate from a deviation of 1 to 2 kHz up to a peak deviation of 12 kHz, depending on signal strength, before distortion occurs. As the signal level into the receiver decreases, the bandwidth essentially narrows by a factor of 2 to 1, so at threshold the peak deviation that the receiver can handle without distortion is about 6 kHz. As the signal strength increases to a maximum value, the peak deviation that can be received without distortion is 12 kHz. The wide-band receiver (WBR) works in the same manner except that the minimum signal level bandwidth is about 12 kHz peak and the maximum is about 24 kHz. The maximum detectable signal with the preamplifier installed is of the order of -122 to -124 dBm (reference is 1 mW in 50 ohms). A typical signal is about -90 to -100 dBm.

The receiver inputs are strapped together by a quarter-wave matching section at the rear of the GE Console. Essentially, these are two pieces of (75-ohm cable) quarter-wavelengths tied together with a "T" to 50 ohms. This provides equal phase, equal amplitude to both receivers 3 dB down from the main signal, and an impedance balance so that the receivers each see 50 ohms; since the transmission line also sees 50 ohms, no mismatch or imbalance in the receiver inputs can occur.

The audio outputs of both receivers go to speakers at the bottom of the GE Console. Each speaker has an "L" pad such that the impedance of the drivers for the receivers are kept constant, even though the volumes are increased or decreased. The outputs of both the wide-band and narrow-band receivers are fed to the remote control unit at the bottom of the GE Console; from there, a standard telephone line completes the connection to the remote control unit (see fig. 1 and sec. 1.2.4).

### 1.2.3 Frequencies

The transmitter frequency is centered at 149.220 MHz, which is the center channel frequency. Typically, the channels run 25 kHz per channel. The center channel is channel 3, at 149.22 MHz, Channel 2 would be 25 kHz below that, or 149.195 MHz; Channel 4 is 25 kHz above the center channel at 149.245 MHz.

The receiver center frequency is 135.600 MHz; it is Channel 3. Twenty-five kilohertz below that would be Channel 2 at 135.575 MHz and Channel 4 at 135.625 MHz. These frequencies for Channels 2, 3, or 4 on the transmitter or

the receiver can be selected by rotating a channel selector control knob. Typically, Channels 2 and 4 are used on ATS-3 operations and Channel 3 is used on ATS-1 operations. However, from time to time, any of these channels, including Channels 1 or 5 can be used for both ATS satellites. Channel 1 is 20 kHz below Channel 2, and the receive frequency is 135.555 MHz; the transmit frequency is 149.175 MHz. Channel 5, in either case, would be 20 kHz above the Channel 4 frequency; for transmit it would be 149.265 MHz and for receive 135.645 MHz. For the Hawaii-Ames satellite link, the Hawaii station will operate on Channel 2 transmit and on Channel 4 receive; Ames will operate diametrically opposite that, Channel 4 transmit and Channel 2 receive.

#### 1.2.4 Deskon

The Deskon unit (GE's name for the remote control console) is used to control the GE Console remotely for both voice and data transmissions in Hawaii. The Deskon contains a power supply, an audio amplifier, speaker, and connections for a microphone and a Vadic modem. The power supply is required for the audio-amplifier and for dc switching of relays within the Deskon and the GE Console. This function is accomplished through the same pair of wires that are used to carry the narrow-band signal from the GE Console to the Deskon, and in the transmit mode to carry the modulated audio signal from the Deskon to the GE Console to modulate the transmitter. The audio amplifier in the Deskon is similar to an intercom system that can be switched from input to output. Thus, the amplifier can be used as a preamplifier for amplifying the microphone signal or the Vadic modem signal, before the signal is fed to the transmitter via a 500-ohm balanced pair of wires. In the receive mode, this amplifier amplifies the signal coming in on the same two wires, then feeds it to the speaker in the Deskon unit. There is a gain control (or volume control) at the upper part (center) of the Deskon unit, which controls the audio level coming through the speaker. This is the output of the narrow-band receiver. However, the amplifier in the Deskon unit can be used to amplify wide-band signals if the selector switch on the Deskon unit is switched to the wide-band receive only position. No transmit capability is available for this particular switch position. The data-mode position of the switch disconnects the microphone from the input amplifiers and the data signal is fed directly from the modem via a twisted pair of wires (phone line) to the GE Console for modulating the transmitter. During this mode of operation, the receive signal comes in on the second pair of twisted wires, from the wide-band receiver, and is fed through the Deskon directly to the Vadic modem. Thus, both receive and transmit signals are simultaneously handled by the Vadic modem in a full duplex manner. The Deskon unit also has an off-on switch, located on the lower part of the right-hand apron, for its 115-V supply.

### 1.2.5 Antennas and Antenna Controls<sup>1</sup>

The antennas that are used at both the Hawaii State Kamamalu Building and Ames Building 244 are crossed dipole arrays. There are separate four-bay transmit and four-bay receive-antennas. Each antenna array of four elements uses crossed dipoles, phased 90°, to produce right circular polarization with an ellipticity of approximately 1 dB. Separation between receive and transmit antennas should be of the order of 30 m (100 ft) to avoid interference.

Each antenna has an elevation rotor and rotor control and a horizontal (azimuth) rotor and rotor control. The elevation rotor is an Alliance antenna rotor; the azimuthal rotor is a CDF (Cornell Dublier Ham M) rotor.

### 1.2.6 Computer Terminal

The computer terminal in Hawaii is a Texas Instrument (TI) 725 Silent 700 terminal with an on-line/off-line button, an off-on switch, and a standard computer terminal keyboard. The Hawaii terminal has been modified so that the built-in acoustic coupler is bypassed and the terminal is hard-wired to a four-wire Vadic modem. This provides a noise-free data interface between the terminal and communication equipment.

The terminal output is in ASCII Code (American Standard Code for Information Interchange) with NRZL (non-return to zero level) format which is fed to the Vadic modem. The modem generates an 1,100 or a 2,200 Hz tone for producing either an originate-mode or a receive-mode. In the receive-mode, logical ones and zeros are made up by frequency-shift keying an 1,100 Hz signal. In the originate-mode, the modem generates ones and zeros by frequency-shift keying a 2,200 Hz signal. The frequency shift is about 100 to 150 Hz deviation about the center subcarrier frequency. Logical ones are shifted above and logical zeros are shifted below the center subcarrier frequency. With the Vadic modem hard-wired to the transmitter, as in Hawaii, the lights on the modem's front panel will indicate the presence of a received signal and a transmitted signal. The transmit-light will flicker as a signal is transmitted from the computer terminal to the transmitter and through the satellite link to the Ames receive-station and to the TENEX-ILLIAC computer at Ames. The green light for the acoustical coupler on the computer terminal in Hawaii will not function, since the Vadic modem is hard-wired to the computer terminal. No acoustic noise is picked up using this hard-wire configuration and the performance of this data system is far superior to that of an acoustically-coupled terminal (because the acoustic coupler will pick up any room noise). The computer

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<sup>1</sup>The complete station being used in Hawaii for this experiment was originally sent to the University of Hawaii for the ALOHA experiment. The receive-antenna was modified by the University so that its gain was approximately 6 dB lower than the original design. Actions to restore part of the antenna performance were completed in August, 1979. This was accomplished by reinstalling a standard feeding harness with UHF fittings and a phasing harness for proper phase shift and impedance match for the feeding elements of the crossed dipoles.

access at Ames is through a terminal interface processor (TIP). For this experiment the signal from Hawaii goes directly into the TIP via a dedicated input terminal through a four-wire Vadic modem (identical to the unit in Hawaii). The TIP then routes the signal into the interface message processor (IMP) in the TENEX, from which the actual software on TENEX-ILLIAC is accessed.

### 1.2.7 ATS Satellites

The ATS series of satellites includes ATS-1 through ATS-6. These satellites all have similar VHF capability; thus, if the ATS-1 VHF system is understood, the VHF systems of all the other satellites will be understood. The ATS-type satellites, with the exception of ATS-6, are large drum-like satellites with solar cells attached to the outside of the drums; they are spin-stabilized. At the belt line, a series of 16 antennas is equally spaced around the drum. Eight of the antennas extend radially from around the spacecraft and then are bent up at a 45° angle to the horizontal. The other eight are bent downward at 45° in the opposite sense, so that one antenna will transmit essentially at 45° to the right, and the receiving antennas will listen to signals that are propagating at 45° to the left. Essentially, we have a 90° difference between the polarization of the transmitting antennas and the polarization of the receiving antennas. The eight that are used for transmitting are each connected to a 5-W solid-state transmitter and to individual phase shifters that are electronically controlled by goniometer-type electronics. The goniometer uses a sun sensor strobe and a rate generator to generate the 360° pulses that are necessary for electronic beam steering of the antennas on the satellite. The receiving arrays utilize phase shifters and are electronically steered in the same way as the transmitting antennas, and by the same electronics.

The ATS series of satellites is in geostationary orbit about the Earth at an altitude of about 35,750 km (19,300 n. mi.). The ATS-1 satellite is positioned at long. 149°W and the ATS-3 satellite is positioned at approximately long. 105°W. The remaining ATS satellites have operational problems and thus, function only marginally. ATS-6 is no longer in service.

The tracking and control center for these satellites is located at NASA Goddard; it is called ATSOCC (ATS Operations Control Center). ATSOCC has telemetry readouts showing the status of the spacecraft. All scheduling and suspected problems associated with the spacecraft operational mode can be clarified by calling ATSOCC. The telephone number is (301) 344-5664 or (301) 344-5665. All contact with ATSOCC for this experiment must be cleared through Ames.

When the satellite is operated in the half-power mode, only half of the transmitting antennas and half the number of transmitting amplifiers are used. There is a loss of 3 dB when half the antennas are used. An additional 3 dB is lost by using only half the available transmitters. Further, when the beaming of the antenna occurs with only four elements spaced 90° apart from each other, an additional 1.5 to 1.75 dB is lost. The total power lost between half-power and full power thus turns out to be about 7.75 dB. This loss of available signal power during satellite operations with Hawaii will

compromise the signal received in Hawaii to an unacceptable level for the experiment.

The satellite operates in a broadcast mode, in which it simply retransmits the signal it receives within the 100 kHz bandwidth. It essentially translates the frequencies from the 149.22 MHz center channel up-link, to 135.600 MHz downlink center band. Since the satellite has a receiver that can receive a full 100 kHz bandwidth, any signals that are sent up to the satellite within that band will be retransmitted in a broadcast mode throughout the hemisphere of the Earth. Thus, the satellite retransmits any radio signals that it picks up throughout its hemisphere of coverage, including stray signals from police, ambulances, and fire trucks that operate on frequencies within its 100 kHz bandwidth.

The ATS-1 satellite has hard-limiting in the receiver that, in general, produces transmitted signals that are not proportional to their incoming amplitudes. The ATS-3 satellite uses a soft-limiting process in the receiver and produces signals that are suppressed proportionally to their amplitude differences. That is, if two signals differing by 5 dB are received by the ATS-3 satellite, the retransmission of those signals will exhibit a 5 dB difference. However, on ATS-1, for the same conditions, the signal that was originally 5 dB lower would be retransmitted essentially 15-20 dB lower because of the suppression factor used on that satellite.

The satellite transponder characteristics for the ATS-1 satellite are as follows: The measured ERP (Effective Radiated Power) was 48.0 dBm, receiver noise 4.0 dB and receiver bandwidth 100.0 kHz. The transmitter frequency, center band, is 135.6 MHz,  $\pm 50$  kHz, and the receiver center band is 149.22 MHz,  $\pm 50$  kHz. The translation error is less than  $\pm 50$  Hz. As mentioned earlier, Channel 3 is the center channel of the operating band. Channel 4 is at Channel 3 plus 25 kHz, and Channel 2 is at Channel 3 minus 25 kHz. Channel 1 is 20 kHz below Channel 2, and Channel 5 is 20 kHz above Channel 4. The transponder operates using the receiver elements adjusted in phase to compensate for the relevant position of each dipole around the spacecraft belt line. This signal is amplified in a low noise pre-amplifier and then mixed with a local oscillator signal to produce a 29.95 MHz IF signal. This signal is fed through a 100 kHz band-limiting crystal filter. The IF is then converted up by another mixer amplifier to 135.6 MHz, plus or minus the desired channel frequency offset. The signal is then fed to an eight-part power divider, then to each one of the phase shifters, and finally to each of the transmitters. The transmitters are solid-state units capable of producing 5-W outputs. In the full-power mode, 40 W are available, since there are eight transmitters. In the half-power mode, four transmitters are used to provide 20 W output. The goniometer electronics can be turned on to provide a beamed mode, or turned off for the omni mode. Both modes can be operated at full- or half-power. In every case, all eight receiving antenna elements and their associated circuitry always are employed for receiving. The receiving system can be operated in either an omni or a beamed mode, with all the antennas interconnected through appropriate switching networks.

The above listing of specific characteristics applies to the ATS-1 satellite only, but the general operational characteristics are applicable to all ATS satellites.

The ATS-3 satellite has a measured ERP of 47.6 dBm. Receiver noise figures are the same, 4 dB, and the bandwidth is 100 kHz. The transmitter and receiver frequencies are exactly the same as those for ATS-1. However, the translation error of +800 Hz, ±100 Hz is considerably above that of ATS-1. The final power amplifier stages of the ATS-3 were designed for maximum power output capabilities of 10 W each, or a total of 80 W. However, the driver stages in the AGC circuits were designed to limit the maximum output power to 5 W for each transmitter element.

### 1.3 General Information

#### 1.3.1 Satellite Communication Frequencies

The communication frequencies for ATS-1 and ATS-3 are shown in table 1.

TABLE 1.- COMMUNICATION FREQUENCIES:  
ATS-1 AND ATS-3

Channel	Transmit, MHz	Receive, MHz
1	149.175	135.555
2 <sup>a</sup>	149.195	135.575
3 <sup>b</sup>	149.22	135.6
4 <sup>a</sup>	149.245	135.625
5	149.265	135.645

<sup>a</sup>Typical for ATS-3.

<sup>b</sup>Typical for ATS-1.

##### 1.3.1.1 Hawaii-Ames Satellite Link Frequencies

The Hawaii-Ames satellite link uses Channels 2 and 4 on the ATS-3 satellite. Transmit and receive frequencies for both Ames and Hawaii are shown in table 2.

TABLE 2.- HAWAII-AMES SATELLITE LINK FREQUENCIES

Site	Transmit:	Receive:
	channel and frequency	channel and frequency
Hawaii	Channel 2; 149.195 MHz	Channel 4; 135.625 MHz
Ames	Channel 4; 149.245 MHz	Channel 2; 135.575 MHz

### 1.3.2 Interferences

#### 1.3.2.1 Natural

The common interferences or performance degradation in the system result from three principal causes: (1) those inherent in the spacecraft design; (2) weather conditions at either or both sites, and (3) solar activity.

Basic design of the spacecraft leads to three possible sources of interference from the satellite: (1) the spacecraft, due to thermal conditions, generates extraneous signals at 11-15 kHz above the center frequency of 135.6 MHz; (2) the satellite is spin-stabilized and, even with the eight transmit antennas synchronized, the amplitude of the transmitted signal varies with spacecraft rotation at a frequency of approximately 1 Hz; and (3) low signal level when the satellite is operated at half-power.

Weather conditions at either location can affect the signal adversely. High moisture in the atmosphere in the form of rain or rain clouds will attenuate the signal and decrease the signal-to-noise ratio. High wind conditions at the site will cause the antennas to move and not be centered on the satellite, with the result that the signal fluctuates, thus degrading overall signal quality.

Solar activity produces electromagnetic radiation which includes radio-frequency radiation that interferes with normal radio communications.

#### 1.3.2.2 Artificial

This category of interference covers a wide range, including other experimenters inadvertently radiating and trying to use the satellite and out-of-tune mobile and stationary radio transceivers operating on frequencies within the satellite bands. Automobile ignition noise may at times cause interference. Another potential source of interference results from multi-use of the frequencies principally assigned for satellite communication. These frequencies are assigned to the government; the FAA has the authority to allow the airlines to use them on a noninterference basis. If this type of interference is experienced, as much detail as possible should be gathered (e.g., time, conversation, and type of aircraft) and the FAA coordinator contacted.

Others using the satellite for communications may come on the air and cause interference; however, this may result from an emergency requirement, in which case the scheduled user of the satellite should relinquish the satellite. All other cases of interference should be reported to ATSOCC (see sec. 1.2.7).

## 2.0 PROCEDURE FOR ACTIVATING STATION

### 2.1 Verify Schedule

Before turning on power to the transmitter, be sure to recheck the schedule sent by teletype from ATSOCC to insure that scheduled time on the satellite has not been changed (for the Hawaii-Ames link, the schedule will be monitored at Ames, since teletype facilities are not conveniently available to the Hawaii user).

## 2.2 Precheck

The following should be done routinely by the station operator before the power to the station is turned on.

### 2.2.1 Visual Inspection

#### WARNING

Be sure power is off before opening backside of cabinet and avoid high voltage areas where residual charge may be present.

Look over the equipment, including the backside of the cabinet and observe any unusual conditions such as arcing, scorching (color changes), loose wires, frayed insulation and loose tubes.

### 2.2.2 Switch Settings

Figure 2 shows all the switches and their proper settings when the station is operating in the data mode. For voice, when using the microphone in the GE Console, the remote-disable switch should be in the disable position and the N200/TENEX-N240 switch<sup>2</sup> should be in the middle position (these switches are located between the receivers).

### 2.2.3 Unusual Odor

Immediately after the station power is turned on and throughout the period of operation be alert to any unusual odor, such as a sharp acrid smell or odor of scorched material.

## 2.3 Turning Power On

### 2.3.1 Sequence for Turning on Switches

The following sequence for turning on the switches is suggested.

1. Turn on main power to console at least 15 min before scheduled operations so that the transmitter and receiver power supplies can reach stable operating temperature.
2. Turn on power supplies for receivers.
3. Turn on transmitter power supply (switch labeled "Plate").

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<sup>2</sup>Note: This switch is on the Ames GE Console only.

4. Turn up volume for both narrow-band and wide-band receivers.
5. Set squelch so that most of the noise is suppressed.

### 2.3.2 Nominal Meter Readings — Check

The four meters at the top of the GE Console should nominally indicate from left to right:

1. Received signal strength — about 40 units if transmitter is on or 60-80 units if transmitter is off and signal is being received. If no one is transmitting, the background noise reading will be about 30 units. Note that these are readings when the receive antenna is properly aligned; see section 2.4 for aligning antenna.
2. Transmitter, high-power amplifier plate voltage — 2,000 V.
3. Transmitter, high-power amplifier plate current — 250 mA.
4. Transmitter, high-power amplifier output — 55 units. Note: See next section for adjusting power amplifier.

### 2.3.3 Adjustments to Transmitter High-Power Amplifier

If the transmitter high-power amplifier meter readings deviate from those in the previous section, the user should take the following actions:

1. If the deviations are very large (greater than 50 mA for plate current, 500 V for plate voltage, and 10 units for power output), turn power to transmitter off. Contact Ames via telephone for recommended course of action.
2. If the deviations are small, contact Ames on the voice link at the start of scheduled operation for instructions on adjusting the high power amplifier.

## 2.4 Tuning Antennas

### 2.4.1 Receive Antenna

Before any attempt is made to tune or align the antenna, be sure to double check that the station power and the transmitter and receivers have been turned on for at least 15 min to insure that the station equipment temperature has stabilized. Then check the receive-power strength meter to verify that the antennas are aligned from the previous session (generally, unless the antennas are moved or severe winds occur between operational sessions, the antennas should retain their alignment).

#### 2.4.1.1 Switch Settings on Transmitter and Receivers

The setting for switches are as shown in figure 2 for aligning the receive-antenna, except as specified in the next two sections.

#### 2.4.1.2 Alignment of Receive-Antenna Prior to Scheduled Operation

The receive-antenna can be tuned prior to scheduled operation by listening to the ATS-3 satellite. Turn on both the wide-band and narrow-band receivers and monitor the received signal strength. If the reading is high, as stated in section 2.3.2 (about 60-80 units), no adjustment to the antenna is required. If the reading signifies only background noise (about 30 units), as stated in section 2.3.2, turn the channel selector switch for the narrow-band receiver from channel to channel until a signal is detected and note signal strength. If necessary, proceed to align the antenna for the highest received signal strength (caution - verify visually that the antenna is pointed in general direction of ATS-3, long. 105°W, if there is any doubt that the received signal is from ATS-1 at long. 149°W). If no signal is detected on any of the narrow-band receiver channels, set the channel selector back to Channel 4 and repeat the procedure with the wide-band receiver. If no signal is detected on either receiver, wait for the regularly scheduled operational period and follow procedures in the next section.

#### 2.4.1.3 Sequence of Activities to Align Receive-Antenna

The Hawaii antenna can be aligned by listening to Channel 4 or listening to Hawaii's own transmitted signal on Channel 2.

The preferred method is to use Hawaii's transmitted signal. To do this, both the receiver and transmitter should be turned on and the exciter for the transmitter turned on (see fig. 2) so that the station will be transmitting a carrier signal. The receiving antenna should then be rotated using the rotor control while watching the received signal strength meter; the antenna is then positioned at the highest meter reading. With the receive-antenna aligned, the transmit-antenna can now be aligned (see sec. 2.4.2.2).

In the event the transmit-antenna is badly misaligned, the transmitted signal to the satellite will be poor and the reflected signal received in Hawaii may be unusable for aligning the receive-antenna. In this event, the receiver should be turned to Channel 4 so that the transmitted signal from Ames can be heard and used for aligning the receive-antenna. The procedure for aligning the antenna is the same as stated above.

#### 2.4.2 Transmit-Antenna

The statements made in section 2.4.1, Receive-Antenna, also apply here and can generally be followed.

#### 2.4.2.1 Switch Settings on Transmitter and Receivers

The required settings for the switches are as shown in figure 2, with the exceptions noted in the next section.

#### 2.4.2.2 Sequence of Activities to Align Transmit-Antenna

The transmit-antenna can be easily aligned once the receive-antenna has been properly aligned. The transmitter should be turned on and the exciter switched on. The narrow-band and wide-band receivers should be set to Channel 2 to receive the transmitted signal echoed from the ATS-3 satellite. The echoed signal should be monitored on the receive-signal strength meter as the transmit-antenna is rotated via its rotors. When the highest signal strength is registered on the meter, the antenna is properly aligned. It may be necessary to go past the peak reading and then backtrack to the highest reading.

With the transmit-antenna and the receive-antenna aligned, the receivers should be reset to Channel 4 to communicate with Ames.

### 2.5 Voice Communication Mode

With the station up and operating and the antennas aligned, the station is ready to communicate with Ames. The first step is to establish a voice communication link using the narrow-band receiver and discuss planned operations for the scheduled operational period.

#### 2.5.1 Switch Settings

The required switch settings for the transmitter, receivers, and Deskon for voice communication is detailed in the following two sections.

##### 2.5.1.1 Switch Settings for the Transmitter and Receivers

The switch settings for the voice or data-communication-via-Deskon mode of operation are shown in figure 2. The voice or data mode will be selected on the Deskon.

##### 2.5.1.2 Deskon

If the remote microphone is used, the mode control and transmitter control switches in the GE console should be set to "remote" and the Deskon switch set to "voice."

## 2.5.2 Procedure for Activating Transmitter and Deskon Microphones

With the station up and operating, voice communications can be conducted either from the GE Console transmitter microphone or from the Deskon microphone. The switching of control between either station is effected by the mode control and remote-remote disable switches. When they are set to off, the transmitter microphone controls transmissions; when the switches are set to remote settings, the Deskon microphone controls transmissions. When the exciter is turned on while using the GE Console microphone, the carrier will be on and the microphone, when keyed, only turns itself on to carry on a conversation. If the exciter is off, the microphone, when keyed, will turn the transmitter carrier and itself on so voice communication (the key can be held down even while listening) can be conducted.

## 2.6 Data Communication Mode

### 2.6.1 Switch Settings

The switch settings are the same as specified for voice communications from the Deskon with the following changes: the Ames unit requires that the N200/TENEX-N240 switch be set to N/TENEX position; the Deskon switch setting should be on data.

#### 2.6.1.1 Transmitter and Receiver

The switch settings for the transmitter and receiver are as specified in section 2.6.1. For data transmission the wide-band receiver should be used since the link is a full duplex link and the station is configured so that the wide-band receiver is always listening; on the other hand, the narrow-band receiver normally is automatically squelched off when the station is transmitting.

#### 2.6.1.2 Deskon

When the station is operating in the data mode, the Deskon acts as a switch between the Vadic modem and the transmitter. The switch on the Deskon unit should be in the data position.

#### 2.6.1.3 Computer Terminal

As stated earlier, the computer terminal is a Texas Instrument, Model 725, portable data terminal with a standard ASCII keyboard. Unfortunately, this unit does not provide the lower case characters that are sometimes required for this type of application.

The standard logging-in procedure is shown in table 3. The only non-standard commands required initially because of the unique method being used

to access the Ames TIP (Terminal Interface Processor), are commands (1) and (8) in table 3. Normally, it is not necessary to type in these commands.

TABLE 3.- PROCEDURE FOR LOGGING IN

1. @ ECHO REMOTES	Type in entire line only if no printout at remote
2. @0 15	Type in entire line - tells TIP which computer system to connect to; in this case, the TENEX-ILLIAC
3. TRYING . . .	Computer response
4. OPEN	Computer response
5. I4-TENEX	Computer response
6. @LOGIN AMESPNW	Computer prompts with "@" sign - type in entire line; will not print since this is password
7. JOB (No.) ON TTY165 (Date)	Computer response
8. @TE T17	Computer prompts with "@" sign - type in rest of line to alert computer to type of terminal used; can be typed in earlier by typing entire line including @ sign
9. @<IAC EDITOR>	Computer prompts with "@" sign - type in rest of line; provides access to EDITOR software
10. EDITOR VERSION 4.7	Computer response
11. ! Type in whatever Editor function to be used	

Note: Refer to Editor Users Handbook, Institute for Advanced Computation, Ames Research Center, July 1, 1978.

### 3.0 PROCEDURE FOR SHUTTING DOWN STATION

#### 3.1 Precheck

Go to voice communication mode and discuss day's activity and logistics for next session; also verify schedule. Announce the station identification and that the station is going off the air.

##### 3.1.1 Switch Settings

Glance over switches and verify that they are on normal settings (see fig. 2).

### 3.1.2 Meter Readings

Verify that meter readings are nominal (specified in sec. 2.3.2).

## 3.2 Shutting Down Station

The preferred mode for station operation is to turn off only the switch for the high voltage to the plate of the transmitter tube with all other power switches left on. If for some reason it is necessary to turn off the power to the entire console, follow the sequence outlined in the next section.

### 3.2.1 Sequence for Turning Off Switches

For complete station shutdown the following sequence is preferred.

1. Turn switches from remote to local and from remote to remote disable, so that microphone at GE Console controls voice transmission.
2. Turn off high-voltage switch for transmitter plate voltage (see fig. 2).
3. Turn off switch labeled "cabinet power" (see fig. 2). This will shut-down power to the entire console.

## 3.3 Postshutdown Checks

### 3.3.1 Switch Settings

Double-check switch settings to insure that station is secure.

### 3.3.2 Visual Inspection

#### WARNING

Beware of residual electrical charges on high-voltage components.

Open rear door of console and look over wires and other components (see sec. 2.2.1).

### 3.3.3 Unusual Odor

Note any unusual odor (see sec. 2.2.3) and inform Ames. Contact GE Mobile Service for equipment check.

### 3.4 Secure Station

Replace microphone and close console doors when set has cooled down (1-2 hr).

## 4.0 TROUBLESHOOTING COMMON PROBLEMS

### WARNING

High-voltage hazardous to life is in this equipment. Exercise extreme caution at all times.

Before attempting any troubleshooting of the equipment, contact Ames personnel at telephone numbers provided in section 5.0.

### 4.1 No Electrical Power

#### 4.1.1 Check Fuses and Circuit Breakers

Check circuit breakers for building and outlets first; then check the main console fuse located immediately to the left of the cabinet power switch (see fig. 2). If power failure is localized check the appropriate fuses shown in figure 2.

#### 4.1.2 No Power to Transmitter — Check Procedure

Check the 115-V main power. If this is not the problem, consult with Ames or contact GE Mobile Service.

### 4.2 Weak Transmitted Signal

#### 4.2.1 Verify Transmit Power is at Rated Level

Transmit power should read about 50 units. This reading is on the meter at the extreme right on the top of the console.

#### 4.2.2 Check Antenna Pointing, Antenna, Cables, and Connections

Use the procedures outlined in section 2.4.2.2 to align the transmit-antenna. Inspect cables to insure they are not broken. Inspect connections for looseness and determine whether moisture has entered and caused corrosion. Correct any problems found. Consult with Ames for procedure if uncertain as to corrective action to be taken.

#### 4.2.3 Check and Adjust Transmit Frequency

If problem is determined, through operational checks with Ames, to be drift in the transmit frequency, the preferred course of action is to call GE Mobile Service and have them adjust the frequency. An alternative is to perform the necessary adjustments with step-by-step verbal guidance provided by telephone from Ames.

#### 4.2.4 Check GE Console and Deskon Microphones

Depending on whether the problem is with voice or data, or with both modes of communication, the connections on the GE Console and Deskon microphones and on the Deskon itself should be checked. If the problem is isolated, either correct it in consultation with Ames or have GE Mobile Service correct the problem.

#### 4.2.5 Check if Satellite on Half-Power

If equipment checks out but problem persists, call Ames and have Ames check with ATSOCC to determine whether satellite is on half-power.

### 4.3 Weak Received Signal

#### 4.3.1 Verify Received Signal Strength

Check signal strength on meter at the extreme left on the top portion of the GE Console. If the meter shows lower than normal reading, proceed to the next section.

#### 4.3.2 Check Antenna Pointing, Antenna Cable, and Connections

Use procedure outlined in section 2.4.1.3 to realign receive-antenna. Follow procedures stated in section 4.2.2.1 to check antenna cable and connections.

#### 4.3.3 Check and Adjust Receiver(s) Frequency

If verified with Ames that receiver(s) frequency has drifted, contact GE Mobile Service to adjust frequency. Alternative would be to make adjustments with step-by-step instructions from Ames, using other receiver, or via telephone link.

#### 4.3.4 Check Volume Control and Deskon

Check volume control on speakers located at bottom of console and, if using Deskon, check volume control. Also check squelch controls to insure

that signal is not over squelched. If problem persists, call GE Mobile Service for service or consult with Ames.

#### 4.3.5 Check if Satellite is on Half-Power

See section 4.2.5 for procedure.

#### 4.4 Interference and Noise

Covered in section 1.3.2; refer to that section for additional definitions or procedures.

##### 4.4.1 Characterize Interference or Noise

Try to determine the type and source of interference or noise; note whether the source is natural or artificial. Consult with Ames.

###### 4.4.1.1 Check Switches

Check switch settings to insure they are set properly (see fig. 2 and sec. 2.6.1) for the mode of communication being used; also check that proper receiver is being used. Check that the channels being used are correct as specified in section 1.3.1.1. Check the squelch controls.

###### 4.4.1.2 Check Weather Conditions

Check to see if weather conditions may be the source of the interference or noise — heavy rain or lightning can cause interference and noise.

###### 4.4.1.3 Interference by Unauthorized User

Broadcast that you are the authorized user of the satellite and ask that the unauthorized user desist unless he has an emergency. If it is an emergency, have user identify himself and declare an emergency. If he does, relinquish satellite. If emergency is not declared and interference persists, contact ATSOCC via Ames.

##### 4.4.2 Noise in Data

The problem of noise in the data may result from the interference or noise conditions discussed previously.

#### 4.4.2.1 Check Gain Controls at Transmitter and Deskon

Have Ames monitor the deviation in the signal and adjust the peak deviation to nominal value (about 20 kHz).

#### 4.4.2.2 Check all Lines and Connections

Inspect lines to GE Console from computer terminal and the antenna leads (both transmit and receive) to verify they are in good working order and that they are not loose, corroded, or contaminated with moisture.

#### 4.4.2.3 Check Computer Terminal

If the problem appears to be in the terminal, consult with Ames so that a test of the terminal via the link can be arranged and conducted.

#### 4.4.2.4 Check Vadic Modem

Check to see that the Vadic modem is properly configured and that no one has inadvertently pressed any of the buttons. Call Ames and double-check on the button settings. Institute test with Ames if problem persists.

### 5.0 AMES RESEARCH CENTER CONTACTS

#### 5.1 Ground Station

(415) 965-6519 or (415) 965-6525

#### 5.2 Hardware

Skip Gross: (415) 965-6440

Al Ross: (415) 965-6519 or (415) 965-6525

#### 5.3 Satellite Schedule

Brad Gibbs: (415) 965-5001 or (415) 965-6440

ATSOCC: (301) 344-5664 or (301) 344-5665, Goddard Spaceflight Center,  
Greenbelt, Maryland

#### 5.4 Remote Sensing, Computer Access, General

Kenji Nishioka: (415) 965-5897

David Morse: (415) 965-5897

## 6.0 MANUALS

### 6.1 GE Console

#### 6.1.1 GE Manuals

The set of manuals listed below was provided to Hawaii. They are published by the General Electric Company.

1. Power Amplifier LBI 3615D
2. EP38 Driver Supply LBI 4323H
3. High Power Supply LBI 3610H
4. Driver LBI 3869E
5. VHF Receiver LBI 3867
6. High Power Stations LBI 4148

### 6.2 EDITOR Users Manual

(see table 3)

### 6.3 Dictionaries of Electronic Terms

Many dictionaries of electronic terms are available. A readily available example is one by Allied Radio, now called Radio Shack, entitled "Dictionary of Electronics."

## 7.0 GLOSSARY

AGC Circuit — Abbreviation for automatic gain control circuit.

A self-acting compensation circuit that maintains the output of a system constant within narrow limits in the face of wide variations in the input to the system.

Ampere — A unit of electrical current; abbreviated A.

ASCII — USA standard for Information Interchange; an eight-bit character code.

Audio amplifier — A device designed to amplify signals within a frequency range of about 15 to 20,000 Hz.

Beamed mode — The electromagnetic radiation is focused into a desired pattern in a definite direction.

Belt line — The circumference of the satellite formed by the intersection of a plane perpendicular to the longitudinal axis of the cylinder and the cylindrical surface; thus, the circumference that separates the cylinder into two equal parts.

Circular polarization - Polarization such that the vector representing the wave has a constant magnitude and rotates continuously about an axis of propagation, thus describing a helix in space.

Decibel, dB - The standard unit for expressing transmission gain or loss and relative power levels;  $dB = 10 \log_{10} (P_1/P_2)$  where  $P = \text{power}$ .

Decibel, dBm - Term used when a power of 1 mW (0.001 W) is the reference level.

Effective radiated power (ERP) - The product of antenna gain and input power, expressed in watts.

Exciter - A crystal or self-excited oscillator that generates the carrier frequency of a transmitter.

Gain - Any increase in power when a signal is amplified by an active circuit. For example, a larger antenna has more gain than a smaller antenna because it captures more energy. Usually expressed in decibels.

Goniometer - A device for electrically shifting the directional characteristics of an antenna.

Hard-limiting - The restriction of the amplitude of a signal so that interfering noise can be kept to a minimum. In hard-limiting the signals are compressed (amplitude decreased) in ratio to their strength; that is, the weaker the signal, the more it is compressed.

Hertz - A unit of frequency equal to 1 cycle/sec; abbreviated Hz.

Impedance - The total opposition (that is resistance and reactance), a circuit offers to the flow of alternating current at a given frequency; measured in ohms.

Intermodulation distortion - Nonlinearity characterized by the appearance of frequencies in the output equal to the sums and differences of integral multiples of the input frequencies (harmonics are usually not included).

Kilohertz - 1000 hertz; abbreviated kHz.

Kilovolts - 1000 volts; abbreviated kV.

Line-levelers - Device that automatically keeps the signal energy being transmitted over wires (lines) at a constant level.

Linear amplifier - An amplifier whose output signal is always an amplified replica of the input signal.

Linear final (amplifier) — The amplifier stage that feeds the antenna. An amplifier with operating characteristics of always outputting a signal that is an amplified replica of the input signal.

Megahertz — 1,000,000 Hz; abbreviated MHz.

NRZL — Nonreturn to zero level.

Ohm — The unit of electrical resistance; one ohm is the value of resistance through which a potential difference of 1 V will maintain a current of 1 A.

Omni mode — Radiation of the transmitted signal is nondirectional, that is, the same strength in all directions.

Phase modulator — A circuit that modulates the phase of a carrier signal with intelligence.

Phase shifter — A device in which the output voltage (or current) may be adjusted to have some desired phase relationship with the input voltage (or current).

Soft-limiting process — In soft-limiting, the entire spectrum of input signals (all frequency and power levels) are compressed or limited so that the output signals retain the same ratio as the input signals.

TENEX-ILLIAC IV Computer — One of several computers at Ames Research Center being used for analysis of digital remote sensing data; the primary computer used in this satellite-link experiment.

Translation error — In the case of the AST-1 or 3, the received frequency (center frequency, Channel 3) at 149.2 MHz is translated to the transmitted frequency (center frequency Channel 3) at 135.6 MHz. The error in translating the received to transmitted frequency is referred to as translation error.

Vadic modem — A modem manufactured by the Racal-Vadic Corporation in Sunnyvale, California. Modem is an acronym for modulator-demodulator. It is a device that translates a typical two-level computer signal into a form suitable for transmission over the telephone network.

Varactor diode — A two terminal solid-state device that utilizes the voltage-variable capacitance of a pn-junction; adjustment of the reverse bias level on the diode causes a capacitance change.

Volt — The unit of measurement of electromotive force. It is equivalent to the force required to produce a current of 1 A through a resistance of 1 ohm.

Watt — A unit of electric power required to do work at the rate of 1 J/sec. It is the power expended when 1 A of direct current flows through a resistance of 1 ohm;  $P = I^2R$ , where  $P$  = power (W),  $I$  = current (A), and  $R$  = resistance (ohm). Abbreviated W.

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16. Abstract <p>The process of transferring remote sensing technology to state and local governments in the Western Regional Applications Program (WRAP) region would be enhanced especially for remote areas if good data communications can be provided. This will enable participants in WRAP access to Ames Research Center computers to gain experience in conducting digital analysis of Landsat data. An experimental voice and data communication link using the ATS-3 satellite between Hawaii and Ames was implemented to determine if such links were feasible for the above purpose. The initial experience gained in training the Hawaii participants in satellite communication station operations indicated the need for a reference document on the operational procedures for such stations. This document provides these procedures.</p> <p>This document describes the overall communication network and its operational procedures along with the hardware used. But the primary utility of this document is in the detailed step-by-step operational procedures provided in sections 2, 3, and 4 to help newly initiated personnel to operate the satellite communication station (in Hawaii). Provided in section 1.3.1.1 are the transmit and receive channels used and their frequencies. Details such as switch settings for activating the station to the sequence of turning switches on are provided. Like details for shutting down the station is also provided. Methods and procedures for troubleshooting common problems encountered with communication stations are similarly provided. Basically, this document will provide anyone with a short one or two day training in station operation, the capability to operate the satellite communication equipment.</p>			
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