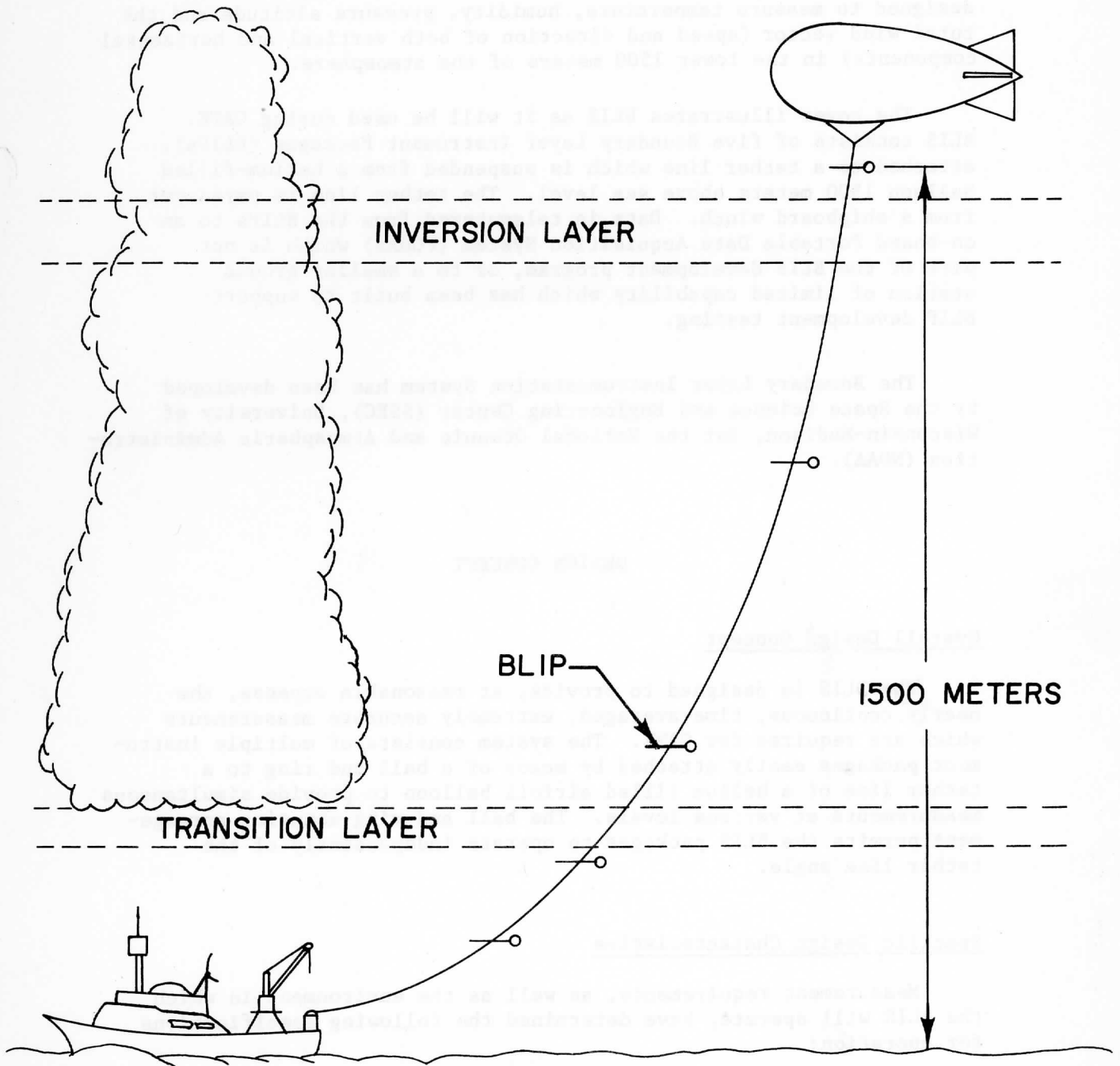


# BLIS

## THE BOUNDARY LAYER INSTRUMENTATION SYSTEM



## INTRODUCTION

The development of the Boundary Layer Instrumentation System (BLIS) is part of the Global Atmospheric Research Program (GARP) and it was designed specifically to meet the observational requirements of GARP's Atlantic Tropical Experiment (GATE). The system was designed to measure temperature, humidity, pressure altitude and the total wind vector (speed and direction of both vertical and horizontal components) in the lower 1500 meters of the atmosphere.

The cover illustrates BLIS as it will be used during GATE. BLIS consists of five Boundary Layer Instrument Packages (BLIPs), attached to a tether line which is suspended from a helium-filled balloon 1500 meters above sea level. The tether line is payed out from a shipboard winch. Data is telemetered from the BLIPs to an on-board Portable Data Acquisition System (PODAS) which is not part of the BLIS development program, or to a smaller ground station of limited capability which has been built to support BLIP development testing.

The Boundary Layer Instrumentation System has been developed by the Space Science and Engineering Center (SSEC), University of Wisconsin-Madison, for the National Oceanic and Atmospheric Administration (NOAA).

## DESIGN CONCEPT

### Overall Design Concept

The BLIS is designed to provide, at reasonable expense, the nearly continuous, time-averaged, extremely accurate measurements which are required for GATE. The system consists of multiple instrument packages easily attached by means of a ball and ring to a tether line of a helium filled airfoil balloon to provide simultaneous measurements at various levels. The ball and ring mounting arrangement permits the BLIS packages to operate independently of the tether line angle.

### Specific Design Characteristics

Measurement requirements, as well as the environment in which the BLIS will operate, have determined the following specifications for operation:

- 0-50°C ambient temperature range
- 0-1500 meter altitude range
- 20%-100% relative humidity range
- 0-15 m/s wind speed (will survive speeds up to 25 m/s)
- 48 hours of continuous rain
- 48 hours of continuous exposure to salt spray
- daily solar radiation exposure
- static electricity in the vicinity of the tether line and balloon, except for direct arcing
- mechanical shock resulting from crew handling; wind induced vibration of the tether line; and accelerations caused by balloon and ship motions.
- 48 hour continuous operation without servicing

#### Sensor Performance

<u>Parameter</u>	<u>Accuracy</u>	<u>Range</u>
Wind speed	$\pm 0.08$ meter/second	0.5->25 meter/second
Wind direction	$\pm 1^\circ$	0-360°
Pressure	$\pm 0.1$ millibar (relative)	850-1040 mb
Dry bulb temperature	$\pm 0.1^\circ\text{C}$	0-50°C
Wet bulb temperature	$\pm 0.1^\circ\text{C}$	0-50°C
Altitude	$\pm 2$ meters	200-1500 meters
Package tilt angle	$\pm 1/2^\circ$	0-18°

## SYSTEM DESCRIPTION

### Balloon

The carrier consists of an aerodynamically shaped balloon (U.S. Navy profile, Modified Class C, with a fineness ratio of 2.75:1) made of nylon coated with polyurethane. The balloon volume is 3500 cubic feet (130 cubic meters) with a length of 12 meters and a diameter of 4.36 meters. Either a rigid metal frame tail surface or an inflatable tail can be used. The balloon is equipped with expansion capability of 30% of volume. Balloon weight is 44 kg and it has 45 kg of static net lift at sea level. The balloon is designed to fly for 48 hours at 1500 meters without servicing, to hold altitude in winds up to 30 knots and to survive winds to 50 knots. Figure 1 is a picture of a prototype balloon which has demonstrated this performance.

### Tether Line

The tether line is made by the Colombia Rope Company with the brand name NOLARO. It is a polyethylene jacketed Dacron lay-flat fiber. The size used by BLIS has a rated breaking strength of 1005 pounds. The line is one continuous piece, 2200 meters long, and weighs less than 13.5 kg/km.

### Full Balloon Indicator

A lightweight 390 MHz telemetry system has been developed which can be attached to the balloon so as to indicate the degree of balloon inflation without bringing the balloon to the surface. The system has self-contained batteries which will allow operation in excess of one month without servicing. This equipment is intended to be used at all times that the balloon is in flight. It can tell the balloon operator when the balloon has lost gas to such an extent that the balloon will become flaccid before being brought to the surface, thus avoiding the most dangerous situation which is likely to occur during BLIS operations.

## BOUNDARY LAYER INSTRUMENTATION PACKAGE (BLIP)

### Configuration

The BLIP is a wind vane with a 3-cup anemometer at the front, an instrument package at mid-section, and a cylindrical tail fin. The entire package rests on a plastic ball fastened to the tether line about which the package is free to turn in any direction. A damped pendulum measures the departure of the package from the horizontal; pointing direction is sensed relative to magnetic north. Atmospheric pressure, and wet and dry bulb temperatures are measured.

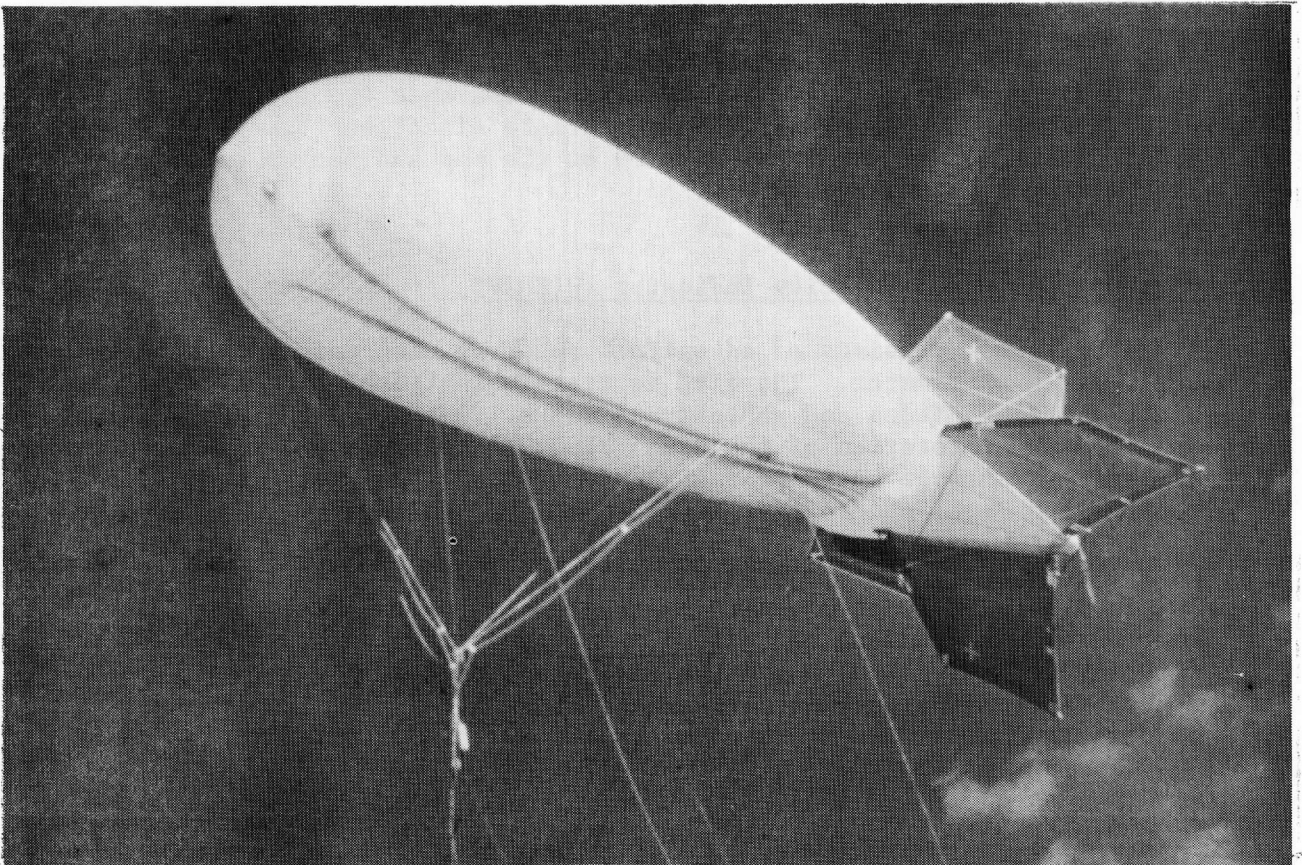


Figure 1. Prototype balloon with rigid frame tail surface

Figure 2 illustrates the BLIP configuration.

#### Dimensions

The overall length of the BLIP is approximately 70 cm. The circular diameter of the tail section is 20 cm.

#### Weight

The BLIP weighs 675 grams with a full water tank (50 cc of distilled water) and a replaceable lithium battery pack.

#### Suspension and Balance

The BLIP is mounted on the tether line with a plastic (Delrin) ball and ring swivel joint. Longitudinal imbalance is corrected by sliding the tail assembly in the appropriate direction through the eight screw-down spring clips located on the top and bottom of the rear electronics package.

#### Wind Direction and Velocity Indicator (WINDAV)

The WINDAV consists of an optical resolver disc mounted on the shaft of an anemometer. The disc is transilluminated by two pairs of light emitting diodes and photo transistors. One pair produces a pulse for each  $2^\circ$  of rotation of the disc (RESOLVER pulses). Therefore, transitions through zero occur at  $1^\circ$  intervals. The resolver circuit squares and level shifts the RESOLVER pulses. The second pair produces one pulse for each revolution of the disc (ONCE AROUND pulse). The once around pulse circuit squares and level shifts the ONCE AROUND pulses. A third sensor, a SONY magnetodiode, is built into the anemometer and produces an approximately sinusoidal signal resulting from the orientation of one anemometer arm loaded with a magnetic concentrator material with the earth's magnetic field. This signal is detected, amplified and squared by the SONY pulse detector.

#### Wind Direction Logic

The wind direction logic produces a pulse on each transition of the RESOLVER pulses. These pulses are applied to a counter beginning at the center of a SONY pulse. The counting continues until it is inhibited by the occurrence of a ONCE AROUND pulse. The accumulated count is a measure of the angle between the earth's magnetic field and the axis of the BLIP.

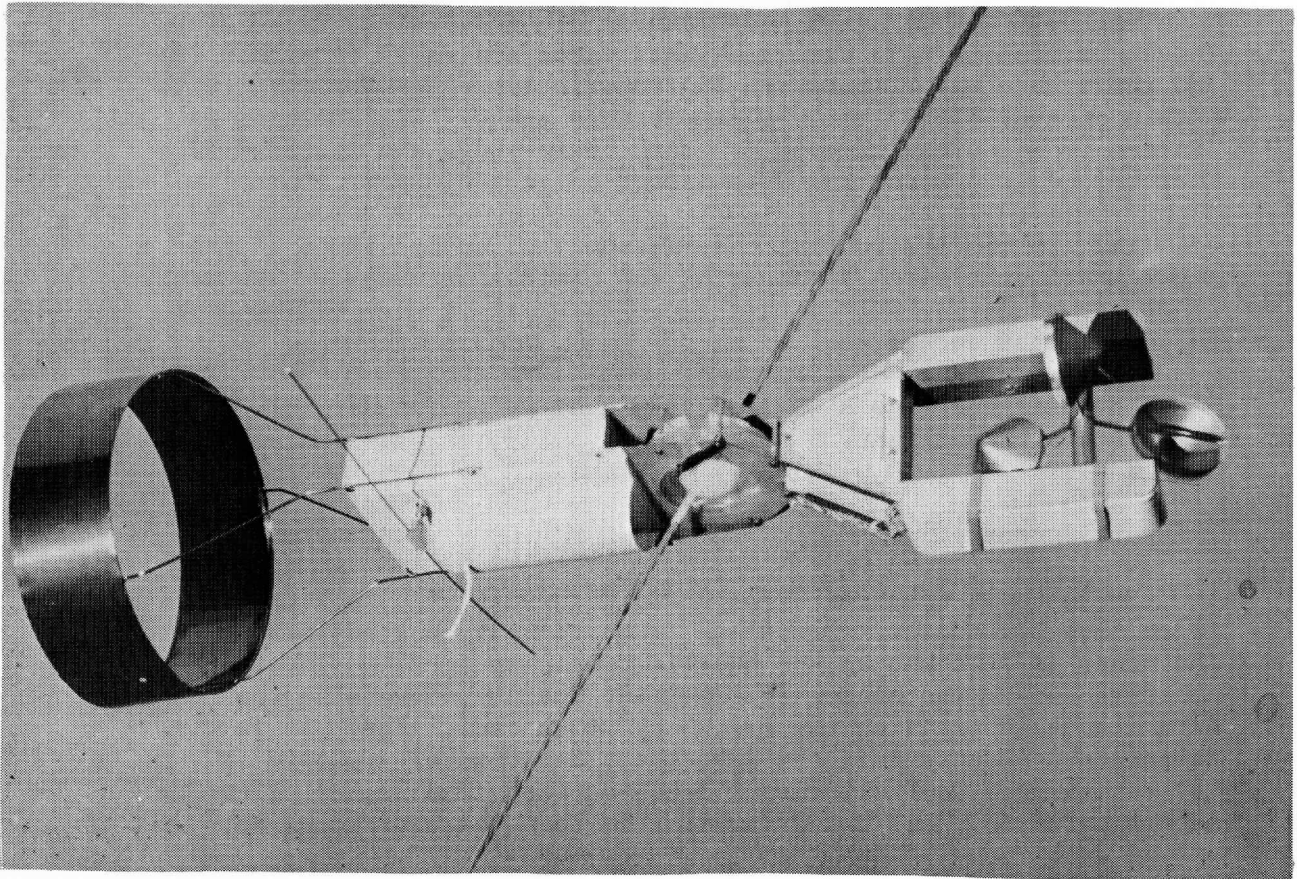


Figure 2. BLIP (Boundary Layer Instrumentation Package)

### Tilt Indicator

The Tilt Angle Indicator is a metallic sector suspended by the point and free to swing in its plane. Appropriate damping is provided to insure a critically damped pendulum response. The sector will remain nearly vertical when the BLIP tilts. Six concentric arcs near the circular edge of the sector each contain clear and opaque areas which are detected by phototransistors. The six bit Gray output code is a measure of the tilt angle of the BLIP.

### Temperature Sensor

Wet bulb and dry bulb temperatures are measured by thermistors. These thermistors have time constants which are equal to within 10% and resistance vs. temperature characteristics which are matched to within 5% over the 0° to 50°C temperature range. Self-heating is limited to a maximum of 0.01°C. Both thermistors are shielded from heat through the mount and from direct solar radiation.

The thermistors control the frequency of an oscillator. The subsequent logic gates a sample of the oscillator output. The number of counts occurring during this gated interval is then telemetered as part of the data frame.

The BLIP contains a 48 hour supply of water for wet bulb temperature measurement.

### Pressure Sensor

Pressure is measured by an aneroid capsule with an attached capacitive transducer. One plate is stationary, but adjustable, and the other is attached to the aneroid cell. An increase in air pressure causes the plates to separate, thereby decreasing the capacitance and raising the frequency of an oscillator. As in the temperature measurement, the subsequent logic gates a sample of the capacitance controlled oscillator output. The number of counts occurring during this gated interval is then telemetered as part of the data frame.

### Data System Logic

The data output from the BLIP is a pulse code frequency modulated carrier operating at one of six frequencies at 5 MHz intervals from 415 MHz to 440 MHz. The data output is grouped into frames four seconds in length. Each frame is subdivided into sixteen words, each one-fourth second in length and representing the value of one parameter measurement. Each word is subdivided into 16 bits, each bit one sixty-fourth second in length. A zero bit is represented by a negative voltage; a one bit as positive voltage. Each bit is at



zero voltage for one-half of one bit time, and at a positive or negative level the remaining one-half of one bit time. The leading and trailing bit of each data word is zero. The remaining 14 bits represent parameter values; the first of these 14 being the most significant bit. The 16 words of a frame each represent a specific piece of information. The word assignment is as follows:

- 0 - sync
- 1 - first tilt angle
- 2 - first wind direction
- 3 - first wind speed
- 4 - dry bulb temperature
- 5 - wet bulb temperature
- 6 - high reference resistance
- 7 - low reference resistance
- 8 - identification
- 9 - second tilt angle
- 10 - second wind direction
- 11 - second wind speed
- 12 - forward electronics package temperature
- 13 - atmospheric pressure
- 14 - pressure reference capacitance
- 15 - rear electronics package temperature

The sync-word consists of 16 one-bits to indicate the beginning of a frame. The identification word is an eight-bit pattern, unique for each BLIP, to identify the BLIP producing the data. The identification pattern is sent twice within one word.

### Transmitter

The transmitter consists of a crystal controlled oscillator operator at about 50 MHz with a buffer amplifier and a frequency multiplier stage to yield a 415 to 440 MHz, 2 milliwatt output. Data bits from the multiplexer frequency modulate the crystal oscillator through a voltage controlled capacitor. The crystal oscillator is then transformer coupled to an amplifier stage which increases the amplitude of the 50 MHz signal. The output from this buffer amplifier stage is transformer coupled to the frequency multiplier stage of the transmitter. In this stage, a varactor diode generates harmonics of the fundamental crystal oscillator. The output is inductively coupled to a stripline tank circuit which is then tuned to the eighth harmonic of the fundamental crystal frequency. Oscillator crystals are selected for output frequencies of either 415, 420, 425, 430, 435, or 440 MHz. The resultant narrow band frequency modulated signal is then coupled to an antenna.

### Antenna

The antenna is a horizontally polarized half-wave dipole aligned normal to the wind. Each has dimensions that permit optimum operation for the corresponding BLIP operating frequency. The antenna is attached perpendicular to the bottom of the rear electronics package.

### PODAS (PORTABLE DATA ACQUISITION SYSTEM)

The PODAS which is used in conjunction with BLIPs consists of six crystal controlled narrow band FM receivers, each centered at one of the BLIP frequencies. All receivers have automatic frequency control (AFC) and are connected to a bow tie corner reflector antenna through a single antenna mounted preamplifier with 30 dB of gain.

The data output of each receiver is decoded and displayed either as binary coded decimal (BCD) numbers for each of the 16 channels or by using a two point polynomial fit (straight line fit), as direct engineering units. Thus, a real time data check for each channel of each package can be obtained.

The above system is self-contained in a deck mounted cubicle (Figure 3).

The data obtained is then hard wired to a Digital Equipment Corporation PDP-11 computer system for storage on 9-track magnetic tape. In addition, software is available for obtaining extremely accurate engineering unit conversion by increasing the order of the polynomial fit.

Strip chart output can also be obtained either from the real time data or from previously stored data.

### Auxiliary Ground System

A ground system has also been developed for use by SSEC for BLIP testing and evaluation. The entire ground system package, as illustrated in Figure 4, consists of a six channel scanning UHF receiver modified for BLIP data reception, a ground station which is used to decode the BLIP data, and a paper tape printer. Provision is also made for direct magnetic tape recording for computer analysis. The ground station permits real time evaluation of the data as well.

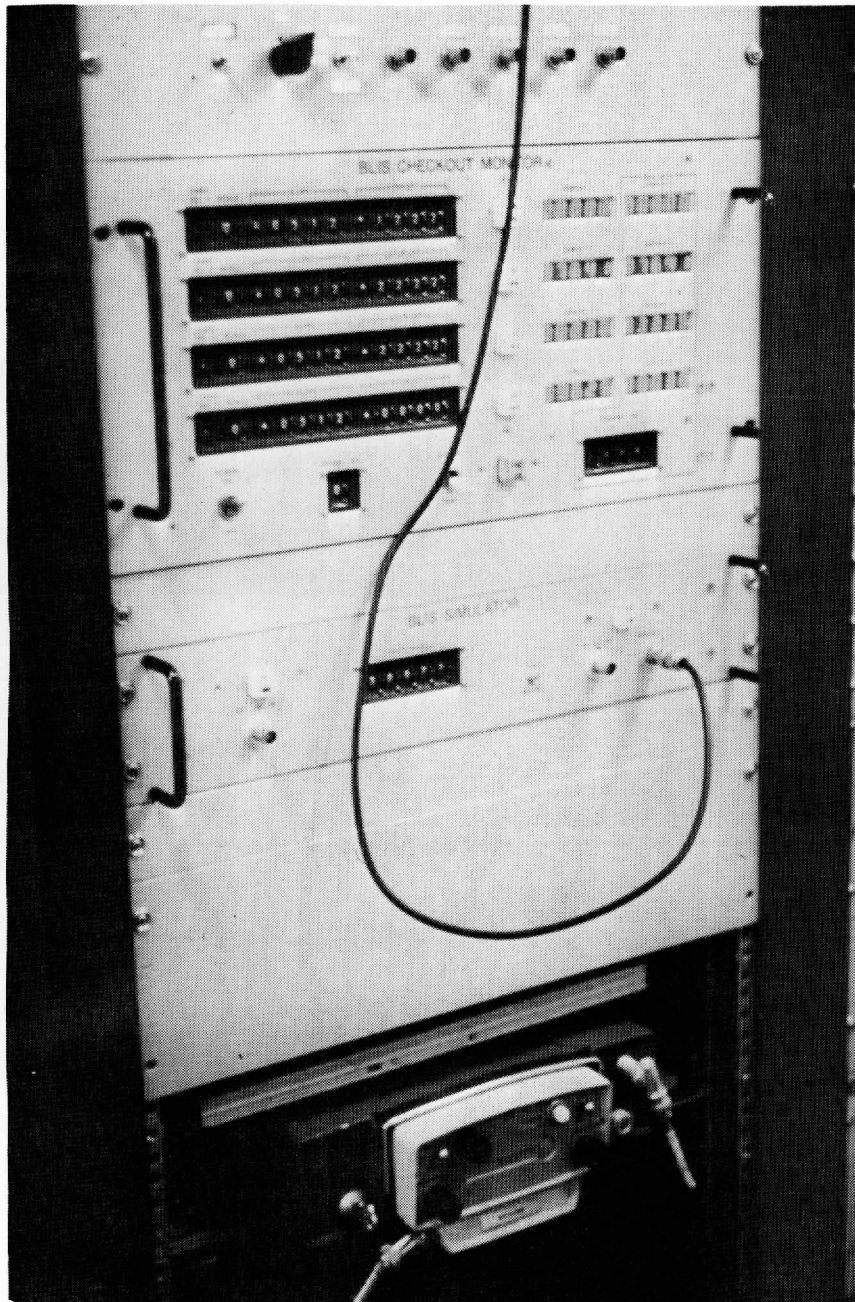


Figure 3. PODAS (Portable Data Acquisition System)

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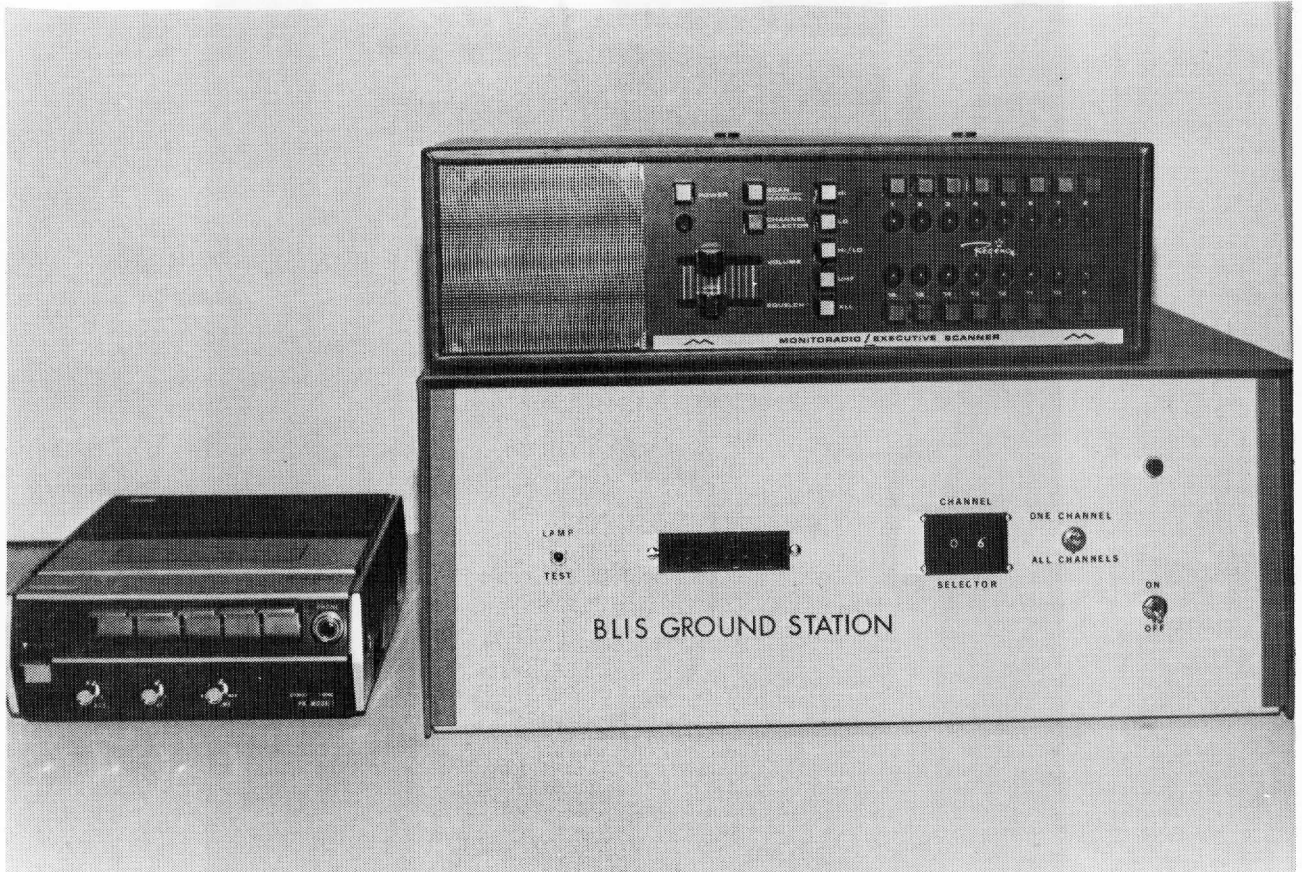


Figure 4. BLIP Auxiliary Ground System

This brief description has been prepared to assist persons engaged in planning for the Global Atmospheric Research Program's Atlantic Tropical Experiment (GATE).

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