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BLIP

BOUNDARY LAYER INSTRUMENTATION PACKAGE

"Measurands, Sensors, Configuration of the Subsystem, and Field Use Comments"

A Training Manual

prepared by

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BOUNDARY LAYER INSTRUMENTATION PACKAGE (BLIP)

A Training Manual

1.0 Introduction

The objective of this publication is to serve as a working outline for GATE trainees who will be working with or using the Boundary Layer Instrumentation Package (BLIP). You are encouraged to use this manual for notes as you work in the field these next two weeks. Feel free to ask questions of the personnel listed in Section 1.2.

Please remember that each BLIP is a precision $1800 meteorological instrument and should be treated with care.

1.1 General Subsystem Description

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

1.2 SSEC BLIS Personnel

There are six (6) personnel to whom either in pre-GATE or GATE activities you may address questions about the operation of the BLIP. Table I lists their names and probable GATE assignments.

TABLE I

Dr.Stanley G. Burns	BLIS Program Manager	Dakar(June,July,Aug) Oceanographer(Sept)
James A. Maynard	Principal Elec. Tech.	Dakar(June,July,Aug) Researcher (Sept)
Herb Hannam	Student Elec. Tech.	Researcher(June,July,Aug)
Dave Milke	Student Elec. Tech.	Ship and/or Dakar (June-September)
Gary Sutcliffe	Student Elec. Tech.	Dakar (June, July, Aug)
Larry Van Epps	Student Elec. Tech.	Oceanographer (June,July,Aug)

1.3 NOTES

2.0 BLIP Description

The BLIP is a wind vane with a 3-cup anemometer at the front, an instrumentation 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.

2.1 Performance

BLIS packages have been designed to operate in the environment specified in Table II.

TABLE II

- 0-50°C ambient temperature range
- 0-1500 meter altitude range
- 20%-100% relative humidity range
- 0-25 meters/second wind speed measurement and survival
- 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
- 48 hour continuous operation without servicing

2.2 Measured Performance

Table III is a summary of the measurement capability of each of the sensors.

TABLE III

Sensor Performance

Parameters	Absolute Accuracy	Relative Accuracy	Range
Wind speed	<.5 meter/second	.027 meters/second	0.5 → 25 meters/sec
Wind direction	within 1°	within 1°	0 - 360°
Pressure	<.5 mb	within .05 mb	850 - 1040 mb
Dry bulb temperature	within 0.1°C	within .03°C	0 - 50°C
Wet bulb temperature	within 0.1°C	within .03°C	0 - 50°C
Altitude	± 2 meters	within .5 meters	sea level-1500 meters
Package tilt angle	within 1/2°	within 1/2°	0 - 18°

2.3 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. 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.

The 16 words of a frame each represent a specific piece of information. The word assignment is as follows:

4 seconds {
- 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 - hygristor or another type of resistance sensor
- 13 - atmospheric pressure
- 14 - pressure reference capacitance
- 15 - rear electronics package temperature or another type of resistance sensor

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.

During this training program you will collect meteorological BLIP data which will yield representative decimal numbers for each of the above words. In a later section, "typical" numbers will be associated with each channel; however, in order to ascertain engineering units, one should refer to the baseline and calibration that will be performed during GATE and this training session.

2.4 NOTES

3.0 Brief Sensor Description

These descriptions are merely to give you an overview of how each meteorological parameter is measured. The scope of this document does not include

A. Original sensor calibration procedure

B. Field calibration and baseline procedures

C. Servicing and maintenance.

D. Conversion of the sensor signals to the telemetered binary data streams

Other segments of this training program will cover (A) and (B) while (C) is the delegated responsibility of the BLIS technician working with the BLIS team Chief. Information on (D) may be obtained from the SSEC BLIS personnel.

3.1 Temperature Sensor

Wet bulb and dry bulb temperatures are measured by thermistors mounted on a sensor board clipped onto the bottom of the rear electronics package. 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 (RO). 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.

These thermistors supply data for Channels 4, 5, and 15. Channels

6 and 7 are fixed precision resistors multiplexed in the circuit for ascertaining the RO calibration stability.

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

3.2 Pressure Sensor

Pressure is measured by an aneroid capsule located in the rear electronics package 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 (CO). 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.

The aneroid output is located in Channel 13. Channel 14 is a precision capacitor multiplexed in the circuit for ascertaining the CO calibration stability.

3.3 Hygristor

A VIZ Manufacturing Corporation Type 1163-50 precision grade hygristor is being used as the BLIP humidity element. These are identical to the units that are going to be used on the GATE radiosondes. Their 33% RH nominal resistance value is 10 KΩ. High RH values increase this value up to near 1 MΩ while low RH values result in resistance values of a few KΩ.

These units are clipped in a holder on the bottom sensor board.

3.4 Tilt Indicator

The Tilt Angle Indicator is a metallic sector suspended by the point and free to swing in its plane. The tilt angle assembly is located in the trapezoidal shaped electronics package located in the frame. This electronics section is colloquially called "Blister Pack". 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. This coding can only be related to angle by using the conversion tables or, of course, the computer software. This data is telemetered back on Channels 1 and 9.

3.5 Wind Direction and Velocity Indicator (WINDAV)

The WINDAV consists of an optical position resolver disc mounted on the shaft of an anemometer. The disc is transluminated by two pairs of light emitting diodes and photo transistors. One pair produces a pulse for each 2° of rotation of the disc (RESOLVER pulses). Therefore, transitions through zero occur at 1° intervals. The second pair produces one pulse for each revolution of the disc (ONCE AROUND pulse). 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.

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.

Wind speed is measured by counting the number of RESOLVER pulses occurring during a digitally clocked gating interval.

Wind direction is telemetered on Channels 2 and 10. Wind speed is telemetered on Channels 3 and 11.

3.6 NOTES

4.0 Field Use Comments

At the request of the BLIS Team Chief or his designated representative BLIPS will be prepared for flight by the BLIS technician. The BLIS technician will initially check the units, replenish consumables and give them to the BLIS team members for baseline, calibration if necessary, and flight. Since some of you may work with the BLIS technician on these tasks, the following brief descriptions have been prepared.

4.1 Lithium Battery Pack

Each battery pack consists of 8 individual lithium cells arranged to provide 2 ampere hour series at $\pm$ 5.6 volts. This insures operation of a BLIP for 48 hours. You will note that each pack has a serial number. To maximize their use, the BLIS technician will initially check out and dispense batteries as required and record their serial number and approximate useage.

The battery pack is inserted in the bottom compartment of the front frame by carefully lining up the 3-snap clips and pressing the pack into position. Wide width rubber bands are then used to secure the assembly during operation.

Within 4 seconds after correct insertion, you will hear a "click-click" sound from the rear electronic package. This is the capacitor oscillator multiplexing relay and its operation serves as a very useful "pilot light".

Heavily used or "dead" battery packs should <u>not</u> be discarded overboard or in the trash barrels. Return them to the BLIS technician for appropriate documentation. In addition, many of the packs which may be partially dead or sufficiently used so that their use for more than several hours is not recommended can be partially salvaged for use in laboratory BLIP preparation.

DANGER: These battery packs have an extremely low internal resistance and as such, if the terminals are shorted , even for a few seconds, the cells could explosively extrude electrolyte. Never leave packs "lying around". Always, place a piece of tape over the terminals when not in use. This includes "dead" packs.

4.2 Wet Bulb Reservoir

The wet bulb reservoir, circular tank structure located between the front frame and rear electronics package, has a capacity of approximately 50 cm^3.

To fill the tank:

A. Place the BLIP in a vertical position tail down.

B. Remove the plastic plug located on the left side of the tank.

C. Using a hypodermic syringe filled with distilled water, carefully fill the tank. Rotating the BLIP from side to side as you fill the tank will help in the removal of air bubbles.

D. Replace the plastic filter plug. A thin layer of Dow Corning silicone grease on this plug will ensure a watertight fit.

E. After several minutes, capilliary action will guide water to the wet bulb wick located on the below package sensor board. You may be able to hasten the process by using the hypodermic syringe as a pump in the filter hole.

F. A small airhole is located in the top (white) forward part of the water tank. Should water not move freely along the wick this hole could have been plugged by dirt, etc. Avoid storing the BLIP upside down to minimize leakage through this hole

G. In order to function properly, the exposed wick material should be free of grease and dirt. Should the wick become clogged or for some other reason require replacement, return the BLIP to the BLIS technician for installation of a new wick.

4.3 Antenna and During Load Installation

A half-wave dipole (≈14") is supplied with each BLIP. To install the antenna, screw the miniature coaxial antenna fitting onto the coaxial connector located near the rear of the electronic package. Orient the antenna at right angles to the package. If you have trouble obtaining a snug finger tight fit, gently tighten the coaxial fitting with a pair of small needle-nosed pliers.

CAUTION: The antenna elements are insulated. Should the insulation wear off, do not allow the exposed metal elements to short circuit to the BLIP metal framework, i.e., by setting a unit on the steel deck of a ship. Such a short circuit could result in internal circuit board and/or battery damage.

A dummy load (miniature coaxial fitting with a 68 Ω resistor in place of the dipole antenna elements) should be attached in place of the antenna when you are using the calibration fixtures. This is to minimize interference with operating flight units and for reducing the BLIP physical dimension.

4.4 Package Balance

Package balance is adjusted by sliding the tail assembly along the clips attached to the rear electronic package. Rather than listing all possible adjustments to the package which can be done, the following check list may be used should gross package imbalance occur.

It is recommended that until you work with someone who is experienced in balancing the BLIP, you return the unit to the BLIS Technician for this adjustment.

A. Check to be sure the battery, antenna, and sensor board are attached. The water tank fill level will not materially effect package balance due to its symmetrical location about the pivot point.

B. Visually line up the package to ensure the front frame or tail has not been knocked askew.

C. Because of ball stiction, the package when just allowed to rest on the ball mount may look out of balance. To obtain a situation more closely, approximating flight operation, vibrate the ball mount line. In normal flight operation, line vibration is such that the ball virtually "floats" on the Delrin ring mount.

4.5 Mounting on the Tether Line

In order to avoid tether line chaffing, a line protector is used. The following procedure in attaching the system is given below.

A. The tygon tubing line protector (11" long plastic tubing) is pressed around the Nolaro 0.193" diameter line. There is no preferred direction.

B. The two plastic ball halves are then snapped around the center cut-away section of the tygon tubing.

C. Disengage the captive screw located on the bottom plastic rig which attaches to the bottom circuit board. Gently fold down the lower hinged plastic ring about 45°.

D. Place the BLIP on the ball by carefully maneuvering the BLIP above the tygon section so that the tether line passes through the water tank and circuit board slot on the right side.

E. Lower the BLIP onto the ball, maneuvering the lower ring section to clear the ball.

F. Raise the lower ring so that the captive screw can be rotated and engaged onto the lower circuit board. The captive screw ring should then be flipped down to rest against the package.

G. Place two spring clips in the grooved-out sections of the tygon tubing.

H. Check to be sure the tether line is not entangled in any of the BLIP parts.

4.6 NOTES

5.0 Typical Numbers

The following information is being supplied only to give you a feel for the decoded decimal numbers that one can expect from the various channels of the BLIP binary data stream. This information is not to be construed as calibration information. Such information for each BLIP sonde such as appropriate operational limits, engineering unit conversions and calibration curves will be supplied to the Data Manager.

As you gain familiarity with the BLIP, you will be able to almost intuitively determine what the data numbers represent.

5.1 Tilt Angle Channels 1 and 9

As one can observe in Table IV, the binary gray code as used in the BLIP and translated to a decimal number, does not permit quick look angle identification. Hwever, if engineering unit conversion is not available, you will be able to at least have this look-up table.

5.2 Wind Speed Channels 3 and 11

A PODAS count of 37.2 is equivalent to 1 meter/second = 2.25 miles/hour.

5.3 Wind Direction Channels 2 and 10

Wind direction is readout directly in 1° increments with respect to magnetic north with the following exceptions.

A. As a result of the techniques used in the BLIP electronic processing, the lowest angle number you would usually see will lie between 60° and 120°. Numbers lower than this will read as 360° plus the number; i.e., a wind direction of 42° will read out as 360° + 42° = 402°. Thus if you observe a number larger than 360°, subtract 360° from this number to obtain the desired result.

B. It is possible that due to rough handling that the anemometer cups assembly may be twisted from its calibrated alignment. Should this occur, the wind direction will exhibit a linear bias equivalent to the angular twist. This sort of problem should be minimized by pre and post calibration and baseline checks. The BLIS Technician will be able to realign the cup assembly should this happen.

C. A number of 0 does not mean due north. This number which is not valid can be the result of very slow wind speeds or a malfunctioning WINDAV. If the wind speed is low, 0° is deliberately telemetered until the anemometer has rotated enough to provide a correct wind direction number.

5.4. Temperature (RO) Channels 4, 5, and 15

The BLIP is calibrated from 5°C to 40°. This is equivalent to counts from about 350 to 1400. Room temperature is equivalent to about 650. These will vary ± 10% between BLIPS and individual thermistors. Calibration data has been furnished to the Data Manager for each sensor. A count change of 1 is equivalent to approximately 0.03°C - 0.05°C.

5.5 Temperature Reference (RO) Channels 6 and 7

The temperature reference channels contain multiplexed fixed precision resistors. Channel 6 will read around 450-500 while Channel 7 will read around 1500-1650.

5.6 Pressure (CO) Channel 13

The BLIP is calibrated from sea level (1020 mb) to 850 mb. This yields numbers from 9000+ to 4500-5000 counts. A count change of 1 is equivalent to 0.03 - 0.05 mb. (Or 10 meters/mb means an altitude change of from .3 to .5 meters).

5.7 Pressure Reference (CO) Channel 14

The fixed multiplexed precision capacitor will give a count of between 9000 and 9500.

5.8 Identification Number (ID) Channel 8

You will observe three identifier serial numbers associated with each BLIP.

A. The three digit numbers ending in 15, 20, 25, 30, 35, or 40. This gives a quick check of the operating frequency since the BLIPS are set up on 4<u>15</u>, 4<u>20</u>, 4<u>25</u>, 4<u>30</u>, 4<u>35</u>, or 4<u>40</u> MHz.

The first digit is the production serial number of that frequency sequence, i.e., BLIP 335 is the third BLIP on 435 MHz.

This number is predominately displayed on the front frame.

B. Channel 8 ID word as decoded on the SSEC ground station. This is a hard wired digital sequence associated with the particular BLIP wiring. It may be identified by using a look-up table.

C. Channel 8 ID word as decoded on the PODAS (shelter) ground station. In about 2/3 of the cases this ID word will agree with the SSEC ground station. The remaining units will have this decoded differently as a result of differencesbetween the SSEC and PODAS ground stations. You should only be concerned with the ID word as read on the PODAS. This number is marked on the bottom of the rear electronic package.

5.9 Hygristor (RO) Channel 12

A nominal 33% RH will result in a count of around 1600-1700. High RH will result in numbers less than 100 while lower RH values will result in numbers of 2000+.

5.10 NOTES

MODIFIED BLIP TILT ANGLE CONVERSION CODE

Position	Tilt Angle (Wind Up)	Sine of Angle	Code 8192 4096 2048 1024 512 256	Decimal Conversion
1	18° 4'	.31	00 11 11	3840
2	17° 28'	.30	00 11 10	3584
3	16° 51'	.29	00 11 00	3072
4	16° 16'	.28	00 11 01	3328
5	15° 40'	.27	00 10 01	2304
6	15° 4'	.26	00 10 00	2048
7	14° 29'	.25	00 10 10	2560
8	13° 53'	.24	00 10 11	2816
9	13° 18'	.23	00 00 11	768
10	12° 43'	.22	00 00 10	512
11	12° 7'	.21	00 00 00	0
12	11° 32'	.20	00 00 01	256
13	10° 57'	.19	00 01 01	1280
14	10° 22'	.18	00 01 00	1024
15	9° 47'	.17	00 01 10	1536
16	9° 12'	.16	00 01 11	1792
17	8° 38'	.15	01 01 11	5888
18	8° 3'	.14	01 01 10	5632
19	7° 28'	.13	01 01 00	5120
20	6° 54'	.12	01 01 01	5376
21	6° 19'	.11	01 00 01	4352
22	5° 44'	.10	01 00 00	4096
23	5° 10'	.09	01 00 10	4608
24	4° 35'	.08	01 00 11	4864
25	4° 1'	.07	01 10 11	6912
26	3° 26'	.06	01 10 10	6656
27	2° 52'	.05	01 10 00	6144
28	2° 18'	.04	01 10 01	6400
29	1° 43'	.03	01 11 01	7424
30	1° 9'	.02	01 11 00	7168
31	0° 35'	.01	01 11 10	7680
32	0° 0'	.00	01 11 11	7936

TABLE IV

BLIP TILT ANGLE CONVERSION CODE

Position	Tilt Angle (Wind Down)	Sine of Angle	Code 8192 4096 2048 1024 512 256	Decimal Conversion
33	0° 0'	-.00	11 11 11	16128
34	0° 35'	-.01	11 11 10	15872
35	1° 9'	-.02	11 11 00	15360
36	1° 43'	-.03	11 11 01	15616
37	2° 18'	-.04	11 10 01	14592
38	2° 52'	-.05	11 10 00	14336
39	3° 26'	-.06	11 10 10	14848
40	4° 1'	-.07	11 10 11	15104
41	4° 35'	-.08	11 00 11	13056
42	5° 10'	-.09	11 00 10	12800
43	5° 44'	-.10	11 00 00	12288
44	6° 19'	-.11	11 00 01	12544
45	6° 54'	-.12	11 01 01	13568
46	7° 28'	-.13	11 01 00	13312
47	8° 31'	-.14	11 01 10	13824
48	8° 38'	-.15	11 01 11	14080
49	9° 12'	-.16	10 01 11	9984
50	9° 47'	-.17	10 01 10	9728
51	10° 22'	-.18	10 01 00	9216
52	10° 57'	-.19	10 01 01	9472
53	11° 32'	-.20	10 00 01	8448
54	12° 7'	-.21	10 00 00	8192
55	12° 43'	-.22	10 00 10	8704
56	13° 18'	-.23	10 00 11	8960
57	13° 53'	-.24	10 10 11	11008
58	14° 29'	-.25	10 10 10	10752
59	15° 4'	-.26	10 10 00	10240
60	15° 40'	-.27	10 10 01	10496
61	16° 16'	-.28	10 11 01	11520
62	16° 51'	-.29	10 11 00	11264
63	17° 28'	-.30	10 11 10	11776
64	18° 4'	-.31	10 11 11	12032

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