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STANDARD OUTPUT DATA PRODUCTS FROM THE NCAR RESEARCH AVIATION FACILITY

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I. *Foreword*

The *RAF Bulletin* series is intended to guide scientists in making effective use of NCAR aircraft. We recognize that some of the topics presented deserve more space than is available here; however, we have endeavored to make the material useful to those having little or no experience in the use of an aircraft as an observing system. We invite comments from our facility users on how we might improve this presentation.

II. *Introduction*

This document describes the standard data output products and formats furnished to each user. The specific contents of the standard output products vary as a function of the type of research program flown. The standard, final data package supplied to the user contains three items:

(1) written documentation,
(2) 35-mm microfilm or microfiche of computer-generated time-series plots and listings, and
(3) 1/2-inch magnetic tape containing processed project data.

The written documentation contains information on the magnetic tape format and the project data quality. An output tape log and a tape dump are included to aid the user in retrieving data from the magnetic tape. In addition, information on reading the magnetic tape is provided for various computers: 16-bit, 32-bit, and 64-bit machines. A copy of the calibration subroutine is also included with the written documentation. This subroutine details how various parameters are calculated.

III. *Data Processing Policy Statement*

The standard output product from a project is designed to provide as much readily usable information as possible to the investigator. The format and content of the output product are detailed in section VI of this bulletin. Examples from the standard output product are included in the appendices. (Appendix A contains a list of standard parameters found in the standard output product. Typically, a given project will contain a subset of this list as requested by the user scientist.) If the format and content of this standard product are insufficient for a given project, the investigator will have to make arrangements with RAF for additional or special processing. Requests for special processing may or may not be accommodated, depending upon their impact on the data processing facility at RAF. These requests are handled separately from the request for aircraft support.

The Data Management Group (DMG) at RAF has an established policy regarding requests for special processing and for changes to standard formats. These requests must be reviewed, finalized, and documented no later than two weeks prior to the start of a project. Thus, a lead time of three to four weeks prior to the start of a project is recommended for submitting such a request. Factors considered when reviewing requests for additional data processing include: the amount of new software to be written, the extent of requested changes to existing software, and the impact on computer resources and staff.

All requests for special data processing should initially go through the Project Manager. Simple requests, such as including an additional derived parameter or recording and processing inputs from user-supplied equipment, can be handled and approved by the Project Manager. More involved requests such as a significant change to the standard processing software will be routed to the DMG.

IV. Data Sets (Types of Processing) Available

All data sets provided by RAF contain basic meteorological and aircraft measurements averaged to 1-s values. These data sets are usually subsets of the parameters listed in Appendices A and D. In addition, investigators may require three-dimensional turbulence data (at either a high or low rate), data from PMS* cloud microphysics probes, or data obtained from user-supplied instrumentation.

Data sets collected from different projects can vary in several respects: the sample rates used, the type of wind data obtained, the research instrumentation used, etc. A project investigating fluxes in the boundary layer would require high-rate, three-dimensional wind, pressure, temperature, and moisture data. A project requiring less spatial or temporal resolution, such as a study of the flow in and around a developing cumulonimbus, could use lower rate data, but still require measurement of the three-dimensional wind components. An air chemistry sampling program might only require mean horizontal wind data with no vertical wind component. Thus, depending on the needs of a project, different types of data sets are obtained, and different processing is required.

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*PMS is an acronym for Particle Measuring Systems, Inc.

RAF data sets contain one of three different types of wind calculations: high-rate turbulence (HRT), low-rate turbulence (LRT), and non-turbulence inertial (NTI). A gust probe flow-angle sensor is used to obtain the three-dimensional wind field, $\overline{u} + u'$, $\overline{v} + v'$, and $\overline{w} + w'$, in turbulence measurements. Both the low-rate and high-rate turbulence data are suitable for flux and other turbulence calculations. Typically, when HRT wind data are collected, appropriate additional channels are also sampled at a high rate to measure fluxes of moisture or temperature. The NTI wind data contain only mean horizontal winds (no vertical wind component) and are not suitable for flux or turbulence calculations. (Please note that the type of turbulence processing has a significant impact on RAF resources.)

High-Rate and Low-Rate Data Output Format

With the exception of data obtained from PMS microphysics probes, data channels on RAF aircraft are sampled at either 5 samples per second (sps) or 50 sps. The high-rate analog data channels (HRT winds, etc.) are sampled at 50 sps and filtered at 10 Hz with electronic active filters on the aircraft to reduce possible aliasing error from higher frequency noise. The low-rate analog data channels (LRT and NTI winds, other 1-s averaged data) are sampled at 5 sps and filtered at 1 Hz. Both high-rate and low-rate digital data channels are recorded directly and not filtered on the aircraft.

In post-flight processing, all digital channels, both high-rate (50 sps) and low-rate (5 sps) are filtered with digital filters which simulate the on-board analog filter. All high-rate data are then interpolated from 50 sps to 20 sps. The low-rate data are 1-s averaged data obtained from a five-point block average over the 5 sps data centered at the start of each second. An output tape containing high-rate data (HRT wind calculations, etc.) will also contain parameters recorded and/or derived at low rate. A high-rate parameter is output to tape at 20 sps (10 Hz data) and a low-rate parameter is output to tape at 1 sps.

Very high-rate turbulence (VHRT) data and data processing (250 sps with a 50-Hz analog filter) are available from RAF. However, this data set is considered nonstandard and requires special processing. Arrangements must be made with RAF for this option.

PMS Data

In addition to the standard-parameter data set recorded, cloud microphysical data obtained from PMS probes are available. Both one- (1D) and two-dimensional (2D) probes are flown on RAF aircraft. Up to four different probes can be flown on a given aircraft at the same time. (Refer to Bulletin No. 24 for more detailed information regarding these probes.)

The 1D probes (ASASP, FSSP, 200X, 200Y, and 260X) can be sampled at three different rates: 1, 5, and 10 sps. The standard PMS 1D sampling rate is 1 sps. The 2D probes (2D-C, cloud probe, and 2D-P, precipitation probe) have a variable sample rate. That rate is only limited by the tape recording rate. The present on-board data system provides the capability for a combined rate of 7 samples per second. The RAF standard 2D recording rate is one record per second per probe. Recording 2D data at higher rates will require an advance request and justification. (Note that the 2D probes function asynchronously, that is, only when triggered by particles going through their beam. When triggered, the information is recorded on magnetic tape by the on-board data system.) Information regarding the parameters recorded from the PMS probes and the data output formats available is contained in the appendices and in section VI.

V. *Data Acquisition and In-Flight Display System*

Acquisition

Data acquisition and display aboard the aircraft are handled by the aircraft data system (ADS). The ADS configuration consists of two separate computers. A Motorola 68000 microprocessor controls the data acquisition (A/D conversion, digital signal interfaces, etc.) and data recording on 1/2-inch magnetic tape. A second component of the ADS, an HP 1000 minicomputer, provides on-board display and hard-copy capability. The HP 1000 also allows the user to control the entire system.

The data-acquisition system takes both analog and digital inputs from various sensors. The ADS system uses a custom-built analog and digital sampler that multiplexes both digital and analog input buses to the Motorola 68000. The analog signals from individual sensors are amplified, filtered (four-pole, low-pass, Butterworth, analog filter) and input to an analog-to-digital converter. Digital signals go directy into the sampler's digital bus. The 68000 runs an interrupt-driven sampling/logging program that interrogates the data bus at a predetermined frequency. All data sampled are then written to 1/2-inch magnetic tape. (Note: This is not the magnetic tape described as part of the RAF standard output product. The tape written on board the aircraft contains only raw (sampled) data. Further post flight/post project processing is required to produce the standard output product magnetic tape.)

Display

Data can be displayed in-flight on both TV monitors and a hard-copy output device. A separate CRT monitor is available for display of PMS 2D data. The data display is real-time. There is no data storage on disk or in memory for display of previously obtained data. The displays available consist of lists, statistics (the time interval is variable, set by the operator), x-y plots, track plots, and PMS 1D histograms. For further information refer to the Aircraft Data System (ADS) User's Manual 002-41ADS-002.

VI. *Output Formats Available - The Standard Output Product*

Written Documentation

In addition to information regarding magnetic tape format, the written documentation includes a report on data quality and limitations. This data quality report is prepared by the project staff and contains specific information regarding the data reduction as well as a flight-by-flight summary of the project data quality. Other documents are included with the final data package to aid the investigator: research flight reports, mission summaries, INS performance summary, calibration maneuver results, and tower flyby results.

Microfilm - Microfiche

The standard output product consists of both 35-mm microfilm (microfiche is an available option) and 1/2-inch magnetic tape. The microfilm contains time-series plots of each parameter and a tabular listing of second-by-second data. The microfilm of the time-series plots also contains both statistics for each parameter taken over the plot interval time period and a set of plotted calibration curves. The standard time-series plot interval is 20 minutes per frame. Examples of microfilm output products are shown in Appendix B.

A header data block is included at the start of the time-series plots in the microfilm output. This data block details all the parameters calculated for the time-series plot output. The header block lists all parameters used in the derivation of other parameters. For example, in the header block shown in Appendix B, page B.1, the parameter TASF (fuselage true airspeed) is derived from TTF (fuselage total temperature), QCFC (corrected fuselage dynamic pressure), and PSFDC (corrected fuselage digital static pressure). The header block also lists all parameters used in the derivation of the wind components. This is the parameter list associated with a reference to a subroutine named GUSTR in the example given.

Any functions or equations used in parameter calculation are also shown in the header block. The example includes equations for pressure defect corrections (PCOR), sensitivity functions (XGR), and vapor pressure (ESUBT).

In the microfilm output, PMS 1D probe data are available in several modes. The various parameters (number of particles counted, concentrations, probe status information, etc.) are available in both time-series plots and tabular listings. In addition, histograms can be plotted that depict the average concentration or total number of counted particles in each size bin. The histogram time interval is generally one minute but is selectable, and a histogram will be plotted only if the number of particles counted in this time interval exceeds a specified threshold value. An example of an FSSP histogram output is included in Appendix B.

The RAF standard output product contains PMS 1D information distributed to both the microfilm product and the magnetic tape. Unless altered by a specific request, the microfilm product will contain only derived parameters (CONCx, DBARx, PLWCx, etc.), housekeeping parameters (FRESET, FRANGE, FACT, AACT, etc.), and histograms of average particle concentrations calculated for 60-s intervals. The magnetic tape will contain all the parameters listed previously as well as the bin-by-bin- or cell-by-cell-counted particles and concentrations (Axxx01, etc. and Cxxx01, etc. listed in Appendix A).

Information obtained from the 2D probes is written to a separate microfilm product, which contains plotted images and calculated concentrations. Appendix F gives a description of the microfilm format. Additional information on the 2D probes can be obtained from RAF personnel or found in Bulletin No. 24. Currently, RAF is adding several options for 2D data output, including generation of 1-s data from the asynchronous 2D record as well as writing the 2D derived data to magnetic tape in addition to the microfilm. (Contact RAF for currently available options.)

Because general-purpose processing of 2D data is only one step in 2D data analysis, and because user-specific analysis of raw 2D data is often better suited to a particular processing requirement, RAF will provide processed and/or raw 2D data. RAF cautions that one should be familiar with 2D data and its format when requesting 2D data. It is strongly recommended that specific user requests for 2D data be made as soon as possible before the start of a project.

Magnetic Tape

The magnetic tape provided with the standard output product contains one header file and one data file per research flight. A printed listing of one header file accompanies the data tapes for each project. The header file contains 80 ASCII characters per record and describes the format of the information encoded in the data file. An example of a magnetic tape header file is shown in Appendix C.

The data file consists of 32-bit, scaled, integer words. Each 32-bit word is scaled to create a positive integer value while preserving the proper number of decimal places. (See Appendix C.) The standard word length is 32 bits. However, other packing options are available that include word lengths of 16, 20, or 24 bits. A request for a packing option other than into a 32-bit word length would constitute a special request and would be subject to the constraints listed previously. The user should be aware that too short a word length causes a loss of usable resolution.

Two magnetic tape density options are available: phase-encoded 1,600 bpi (bytes per inch), and 6,250 bpi, gcr (group coded recording). Both options are on nine-track tape. (The user is billed $20.00 per data tape by the Scientific Computing Division (SCD) of NCAR. If the data tapes remain at NCAR for subsequent analysis there is no charge.)

Both the raw and processed tapes are backed up on the NCAR TBM mass storage system, which has proven to be a reliable archive. However, we strongly urge the investigator to make an archival copy of his own data tapes to protect against damage or loss. RAF feels that this is consistent with proper data processing procedures and will save the extra RAF effort, cost, and delays that would result if it were necessary to recopy the tapes or reprocess the data. **The RAF tape archiving policy is presented in Appendix G.**

Multi-investigator Projects (Electra N308D)

In projects involving a single investigator or a single investigator and piggyback (adjunct) investigator, a copy of the data as described above is distributed to the principal investigator and to the adjunct investigator. This is usually the case on projects with the Queen Air, King Air, and Sabreliner. In projects conducted with the Electra, where many investigators are involved, the data dissemination is somewhat different.

In large, multifacility projects where a data office is maintained, a copy of the data is sent to that office. The investigator in such a project who was the initial requestor of the aircraft would also receive a copy. However, other adjunct investigators would have to obtain their data from the data office. The ALPEX and MONEX programs are examples of such situations.

In projects involving the Electra and many investigators, where no data office is maintained, a copy of the data is given to the principal investigator who initially requested the aircraft. Copies of the data will be supplied to the other adjunct investigators with the consent of the principal investigator. The adjunct investigator is directed to go through the principal investigator in order to obtain a copy of the data set. It is again noted that there is a charge to each investigator for tapes made at NCAR.

VII. GENPRO Processing Program

The final RAF data processing is usually carried out on the CRAY-1A mainframe computer at the NCAR Mesa Lab site. A software program developed jointly by RAF and SCD specifically for processing large data sets is used. This program (GENPRO) is written in FORTRAN and is composed of modules (subroutines) for performing functions normally used in data processing such as interpolation, filtering, calibration, plotting, parameter derivation, etc.

The modules are assembled and compiled for a specific project as required. They are configured through the use of data input files called "directive" files. The directives define the parameters to be used for processing a specific project, such as calibration coefficients, filter weights, time periods, plot axes and titles, and many others. While the processor is extremely versatile, RAF has adopted a policy of defining a standard processor and data format. Deviations from this standard must be requested with justification and approved well in advance of the project.

GENPRO processes the data in units called cycles, a cycle being a 1-s frame of data. Some modules require overlapping data such as filtering and interpolation. The main driver program, GENPRO, calculates the number of cycles to process based on the amount of overlap required, the raw data record size, and the amount of memory available (dimensioned arrays) in the computer.

The primary modules used in the order they are applied in processing a typical turbulence project data set are described below.

INPUT

Reads the digital aircraft tapes and arranges the data into an array in a format expected by subsequent modules. Flags data gaps, parity errors, etc.

DESPIKE

Detects and removes wild points, spikes, and gaps in data. After removal, the bad data are replaced with interpolated values. Information that determines the maximum width of a spike and the allowable point-to-point change is entered for each variable via directives. Specific information regarding the number of points removed, the time of occurrence, etc., is monitored by RAF personnel. Any resultant data problems will be addressed in the project data quality report.

FILTER

Allows for the application of different digital filters to the data. Choices include recursive and nonrecursive and even or odd weight filters. Filter weights and coefficients are entered via directives. In the standard processing, filters are configured to match the characteristics of the on-board electronic filters.

SHIFT

Changes the phase of dependent variables relative to the independent variable (usually time). Typically this module is used to adjust the phase shift of recursive filters and to synchronize data sets that have independent time bases. The shift is dynamic to account for drift between the independent clocks. (This technique is used to synchronize the INS serial, digital-data bus with the ADS clock using the variable TMLAG.)

INTERP

Changes the sample rate of the dependent variable relative to a specified increment of time. Rates can be increased or decreased through the options of block averaging, or linear, quadratic, or cubic interpolation.

RAF uses this process in HRT data processing to bring variables to a common rate of 20 sps before processing.

CALIBRATE

Applies calibration coefficients to raw data and calculates derived variables.

STATS

Calculates statistics on selected variables over a specified period (or number of samples). Statistics available are maximum value, minimum value, mean, standard deviation, skew, and kurtosis.

PLOT

Provides plots of any or all variables on microfilm or fiche. This module uses the NCAR System Plot Package and provides many different plotting options.

PRINT

Provides tabular output of any or all variables at a specified rate.

OUTPUT

Copies the values of selected or all variables to a magnetic tape or a device that emulates a magnetic tape, such as the NCAR mass storage device. This module also writes an associated descriptive header file prior to each data file.

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APPENDIX A

The following is a list of variables available in a standard RAF data set. For the most part, the list is in the order in which the variables will appear on the microfilm and magnetic tape output. An attempt has been made to group the variables into generic categories as specified.

Variable List

DESCRIPTOR	**UNITS**	**VARIABLE NAME**
AIRCRAFT POSITION VARIABLES		
INS LATITUDE	deg	ALAT
INS LONGITUDE	deg	ALON
LORAN C LATITUDE	deg	CLAT
LORAN C LONGITUDE	deg	CLON
DME DERIVED LATITUDE	deg	DLAT
DME DERIVED LONGITUDE	deg	DLON
DISTANCE EAST OF START	km	DEI
DISTANCE NORTH OF START	km	DNI
DME CHANNEL	MHz	DMECH
DME DISTANCE	km	DMEDI
ATMOSPHERIC STATE VARIABLES		
CORRECTED STATIC PRESSURE (FUSELAGE DI)	mb	PSFDC
CORRECTED STATIC PRESSURE (FUSELAGE)	mb	PSFC
CORRECTED STATIC PRESSURE (BOOM)	mb	PSBC
CORRECTED STATIC PRESSURE (WING)	mb	PSWC

DESCRIPTOR	UNITS	VARIABLE NAME
AMBIENT TEMPERATURE (BOOM)	°C	ATB
AMBIENT TEMPERATURE (BOOM HEATED)	°C	ATBH
AMBIENT TEMPERATURE (FUSELAGE)	°C	ATF
AMBIENT TEMPERATURE (FUSELAGE HEATED)	°C	ATFH
AMBIENT TEMPERATURE (WING)	°C	ATW
AMBIENT TEMPERATURE (WING HEATED)	°C	ATWH
AMBIENT TEMPERATURE (REVERSE FLOW)	°C	ATRF
AMBIENT TEMPERATURE (FAST RESPONSE)	°C	ATKP
DEW POINT TEMPERATURE (THERMOELEC) (TOP)	°C	DPTC
DEW POINT TEMPERATURE (THERMOELEC) (BOT)	°C	DPBC

WIND VARIABLES

HORIZONTAL WIND DIRECTION	deg	WD
HORIZONTAL WIND SPEED	m/s	WS
WIND EAST COMPONENT	m/s	UI
WIND NORTH COMPONENT	m/s	VI
WIND VERTICAL COMPONENT	m/s	WI
WIND LONGITUDINAL COMPONENT	m/s	UX
WIND LATERAL COMPONENT	m/s	VY

ALTITUDE VARIABLES

GEOMETRIC (RADIO) ALTITUDE	m	HGM
GEOMETRIC (RADAR) ALTITUDE (APN-159)	m	HGME
COARSE GEOMETRIC ALTITUDE (APN-159)	deg	CHGME
NACA PRESSURE ALTITUDE	m	PALT

DESCRIPTOR	UNITS	VARIABLE NAME
PRESSURE-DAMPED INERTIAL ALTITUDE	m	HI3
D-VALUE (HGME-PALT)	m	DVALU

THERMODYNAMIC VARIABLES

DESCRIPTOR	UNITS	VARIABLE NAME
SURFACE PRESSURE	mb	PSURF
POTENTIAL TEMPERATURE	K	THETA
EQUIVALENT POTENTIAL TEMPERATURE	K	THETAE
VIRTUAL POTENTIAL TEMPERATURE	K	THETAV
VIRTUAL TEMPERATURE	°C	TVIR
ABSOLUTE HUMIDITY (THERMOELEC) (TOP)	g/m^3	RHODT
ABSOLUTE HUMIDITY (THERMOELEC) (BOT)	g/m^3	RHODB
RELATIVE HUMIDITY	pct	RHUM
MIXING RATIO	g/kg	MR
SPECIFIC HUMIDITY	g/kg	SPHUM

LIQUID WATER VARIABLES

DESCRIPTOR	UNITS	VARIABLE NAME
CORRECTED PMS-KING LIQUID WATER CONTENT	g/m^3	PLWCC
CORRECTED C-T LIQUID WATER CONTENT	g/m^3	LWCC
SUPERCOOLED LIQUID WATER CONTENT	g/m^3	SCLWC

PMS PROBE VARIABLES

DESCRIPTOR	UNITS	VARIABLE NAME
PMS ASAS PROBE (TOTAL COUNTS)	cnts	ASASP
ASAS PROBE CONCENTRATION	n/cm^3	CONCA
ASASP MEAN DIAMETER	μm	DBARA

DESCRIPTOR	UNITS	VARIABLE NAME
ASASP DISPERSION (SIGMA/DBARA)	---	DISPA
ASASP RAW ACTIVITY COUNTS	---	AACT
PMS FSSP PROBE (TOTAL COUNTS)	cnts	FSSP
FSSP PROBE CONCENTRATION	n/cm^3	CONCF
FSSP MEAN DIAMETER	µm	DBARF
FSSP DISPERSION (SIGMA/DBARF)	---	DISPF
FSSP WATER/ICE CONTENT	g/m^3	PLWCF
FSSP CALCULATED ACTIVITY FRACTION	---	FACT
FSSP BEAM FRACTION (FSSP/FSTROB)	---	FBMFR
FSSP RANGE	---	FRANGE
FSSP FAST RESETS	cnts	FRESET
FSSP TOTAL STROBES	cnts	FSTROB
PMS 200X PROBE (TOTAL COUNTS)	cnts	X200
200X PROBE CONCENTRATION	n/l	CONCX
200X MEAN DIAMETER	µm	DBARX
200X DISPERSION (SIGMA/DBARX)	---	DISPX
200X WATER/ICE CONTENT	g/m^3	PLWCX
200X REFLECTIVITY FACTOR	dB(Z)	DBZX
PMS 260X PROBE (TOTAL COUNTS)	cnts	X260
260X PROBE CONCENTRATION	n/l	CONC6
260X MEAN DIAMETER	µm	DBAR6
260X DISPERSION (SIGMA/DBAR6)	---	DISP6
260X WATER/ICE CONTENT	g/m^3	PLWC6

DESCRIPTOR	UNITS	VARIABLE NAME
260X REFLECTIVITY FACTOR	dB(Z)	DBZ6
PMS 200Y PROBE (TOTAL COUNTS)	cnts	Y200
200Y PROBE CONCENTRATION	n/l	CONCY
200Y MEAN DIAMETER	m	DBARY
200Y DISPERSION (SIGMA/DBARY)	---	DISPY
200Y WATER/ICE CONTENT	g/m^3	PLWCY
200Y REFLECTIVITY FACTOR	dB(Z)	DBZY

RADIATION VARIABLES

RADIOMETRIC SKY TEMPERATURE	°C	RSTT
RADIOMETRIC SURFACE TEMPERATURE	°C	RSTB
TOP SHORTWAVE IRRADIANCE	W/m^2	SWT
BOTTOM SHORTWAVE IRRADIANCE	W/m^2	SWB
TOP INFRARED CORRECTED IRRADIANCE	W/m^2	IRTC
BOTTOM INFRARED CORRECTED IRRADIANCE	W/m^2	IRBC
TOP ULTRAVIOLET IRRADIANCE	W/m^2	UVT
BOTTOM ULTRAVIOLET IRRADIANCE	W/m^2	UVB

AIRCRAFT STATE VARIABLES

AIRCRAFT TRUE HEADING (ARINC)	deg	THI
AIRCRAFT TRUE HEADING	deg	THF

DESCRIPTOR	UNITS	VARIABLE NAME
AIRCRAFT ROLL ATTITUDE ANGLE	deg	ROLL
AIRCRAFT PITCH ATTITUDE ANGLE	deg	PITCH
AIRCRAFT INS ACCELERATION	m/s^2	ACINS
RAW INS VERTICAL VELOCITY	m/s	VZI
DAMPED AIRCRAFT VERTICAL VELOCITY	m/s	WP3
INS GROUND SPEED	m/s	GSF
INS GROUND SPEED EAST COMPONENT	m/s	VEW
INS GROUND SPEED NORTH COMPONENT	m/s	VNS
INS GROUND SPEED X COMPONENT	m/s	XVI
INS GROUND SPEED Y COMPONENT	m/s	YVI
AIRCRAFT TRUE AIRSPEED (FUSELAGE)	m/s	TASF
AIRCRAFT TRUE AIRSPEED (BOOM)	m/s	TASB
AIRCRAFT TRUE AIRSPEED (GUST)	m/s	TASG
AIRCRAFT TRUE AIRSPEED (WING)	m/s	TASW
AIRCRAFT TRUE AIRSPEED (RADOME)	m/s	TASR
CORRECTED DYNAMIC PRESSURE (FUSELAGE)	mb	QCFC
CORRECTED DYNAMIC PRESSURE (BOOM)	mb	QCBC
CORRECTED DYNAMIC PRESSURE (GUST)	mb	QCGC
CORRECTED DYNAMIC PRESSURE (WING)	mb	QCWC
CORRECTED DYNAMIC PRESSURE (RADOME)	mb	QCRC

DESCRIPTOR	UNITS	VARIABLE NAME
RAW DYNAMIC PRESSURE (FUSELAGE)	mb	QCF
RAW DYNAMIC PRESSURE (BOOM)	mb	QCB
RAW DYNAMIC PRESSURE (GUST)	mb	QCG
RAW DYNAMIC PRESSURE (WING)	mb	QCW
RAW DYNAMIC PRESSURE (RADOME)	mb	QCR
RADOME TOTAL PRESSURE	mb	PTR
CABIN STATIC PRESSURE	mb	PCAB
ATTACK ANGLE (DIFFERENTIAL PRESSURE)	deg	AKDF
ATTACK ANGLE (RADOME)	deg	AKRD
ATTACK ANGLE (FIXED VANE, LEFT)	deg	AKFXL
ATTACK ANGLE (FIXED VANE, RIGHT)	deg	AKFXR
SIDESLIP ANGLE (DIFFERENTIAL PRESSURE)	deg	SSDF
SIDESLIP ANGLE (RADOME)	deg	SSRD
SIDESLIP ANGLE (FIXED VANE) (TOP)	deg	SSFXT
SIDESLIP ANGLE (FIXED VANE) (BOT)	deg	SSFXB
ATTACK DIFFERENTIAL PRESSURE	mb	ADIF
ATTACK DIFFERENTIAL PRESSURE (RADOME)	mb	ADIFR
RAW ATTACK (FIXED VANE, LEFT)	g	AFIXL
RAW ATTACK (FIXED VANE, RIGHT)	g	AFIXR
SIDESLIP DIFFERENTIAL PRESSURE	mb	BDIF
SIDESLIP DIFFERENTIAL PRESSURE (RADOME)	mb	BDIFR
RAW SIDESLIP (FIXED VANE, TOP)	g	BFIXT
RAW SIDESLIP (FIXED VANE, BOTTOM)	g	BFIXB

MISCELLANEOUS UNCORRECTED "RAW" VARIABLES

RAW STATIC PRESSURE (FUSELAGE DI)	mb	PSFD

DESCRIPTOR	UNITS	VARIABLE NAME
RAW STATIC PRESSURE (FUSELAGE)	mb	PSF
RAW STATIC PRESSURE (BOOM)	mb	PSB
RAW STATIC PRESSURE (WING)	mb	PSW
TOTAL TEMPERATURE (BOOM)	°C	TTB
TOTAL TEMPERATURE (BOOM HEATED)	°C	TTBH
TOTAL TEMPERATURE (FUSELAGE)	°C	TTF
TOTAL TEMPERATURE (FUSELAGE HEATED)	°C	TTFH
TOTAL TEMPERATURE (WING)	°C	TTW
TOTAL TEMPERATURE (WING HEATED)	°C	TTWH
TOTAL TEMPERATURE (REVERSE FLOW)	°C	TTRF
TOTAL TEMPERATURE (FAST RESPONSE)	°C	TTKP
DEW/FROST POINT TEMP (THERMOELEC) (TOP)	°C	DPT
DEW/FROST POINT TEMP (THERMOELEC) (BOT)	°C	DPB
RAW LYMAN-ALPHA VOLTAGE	Vdc	VLA
RAW TOP INFRARED IRRADIANCE	W/m^2	IRT
RAW BOTTOM INFRARED IRRADIANCE	W/m^2	IRB
TOP PYRGEOMETER DOME TEMPERATURE	°C	DTT
TOP PYRGEOMETER SINK TEMPERATURE	°C	STT
BOTTOM PYRGEOMETER DOME TEMPERATURE	°C	DTB
BOTTOM PYRGEOMETER SINK TEMPERATURE	°C	STB
RAW PMS-KING LIQUID WATER CONTENT	W	PLWC
RAW C-T LIQUID WATER CONTENT	g/m^3	LWC
RAW ICING RATE INDICATOR	Vdc	RICE

HOUSEKEEPING VARIABLES

10-V REFERENCE	Vdc	V10
10-V REFERENCE THROUGH RESISTOR	Vdc	V10R

DESCRIPTOR	UNITS	VARIABLE NAME
AIR TEMP ADS INTERFACE	°C	TADS
TEMP OF VOLTAGE REFERENCE	°C	TV10
AIR TEMP FLOW MONITOR - ADS	°C	FLOADS
FIXED ZERO VOLTAGE	Vdc	FZV
FIXED ZERO VOLTAGE THRU RESISTOR	Vdc	FZVR
DIFFERENCE OF 10-V REFERENCES	Vdc	VDREF
COCKPIT EVENT (BITS 0-5)	---	CKEVP
EVENT PADS (1, 2, 3,.....)	---	EV1, EV2.....
UNALTERED TAPE TIME	hr	HR
UNALTERED TAPE TIME	min	MIN
UNALTERED TAPE TIME	s	SEC
PROCESSOR TIME	s	PTIME
RAW TAPE TIME	s	TPTIME
ARINC TIME LAG	s	TMLAG
TIME OF DAY IN SECONDS AFTER MIDNIGHT	s	TSEC

DIFFERENCE VARIABLES

AKFXL - AKFXR	deg	DFAKLR
ATB - ATKP	°C	DFATBK
ATF - ATFH	°C	DFATFH
DPTC - DPBC	°C	DFDPTB
PITCH - AKDF	deg	DFPHAK
PSBC - PSFC	mb	DFPSBF
PSWC - PSFDC	mb	DFPSWD
QCBC - QCFC	mb	DFQCBF
SSFXT - SSFXB	deg	DFSSTB

DESCRIPTOR	UNITS	VARIABLE NAME
TASB - TASW	m/s	DFTABW

PMS CELL-BY-CELL VARIABLES

DESCRIPTOR	UNITS	VARIABLE NAME
PMS PROBE ASAS RAW COUNT CELL 01	cnts	AASS01
PMS PROBE ASAS RAW COUNT CELL 02	cnts	AASS02
: : : : : :	:	:
PMS PROBE ASAS RAW COUNT CELL 15	cnts	AASS15
PMS PROBE FSSP RAW COUNT CELL 01	cnts	AFSP01
PMS PROBE FSSP RAW COUNT CELL 02	cnts	AFSP02
: : : : : :	:	:
PMS PROBE FSSP RAW COUNT CELL 15	cnts	AFSP15
PMS PROBE 200X RAW COUNT CELL 01	cnts	A20X01
PMS PROBE 200X RAW COUNT CELL 02	cnts	A20X02
: : : : : :	:	:
PMS PROBE 200X RAW COUNT CELL 15	cnts	A20X15
PMS PROBE 260X RAW COUNT CELL 01	cnts	A26X01
PMS PROBE 260X RAW COUNT CELL 02	cnts	A26X02
: : : : : :	:	:
PMS PROBE 260X RAW COUNT CELL 62	cnts	A26X62
PMS PROBE 200Y RAW COUNT CELL 01	cnts	A20Y01
PMS PROBE 200Y RAW COUNT CELL 02	cnts	A20Y02
: : : : : :	:	:
PMS PROBE 200Y RAW COUNT CELL 15	cnts	A20Y15
ASASP CORRECTED CONCENTRATION CELL 01	n/cm^3	CASS01
ASASP CORRECTED CONCENTRATION CELL 02	n/cm^3	CASS02
: : : :	:	:
ASASP CORRECTED CONCENTRATION CELL 15	n/cm^3	CASS15
FSSP CORRECTED CONCENTRATION CELL 01	n/cm^3	CFSP01
FSSP CORRECTED CONCENTRATION CELL 02	n/cm^3	CFSP02
: : : :	:	:
FSSP CORRECTED CONCENTRATION CELL 15	n/cm^3	CFSP15
200X CORRECTED CONCENTRATION CELL 01	n/l	C20X01
200X CORRECTED CONCENTRATION CELL 02	n/l	C20X02
: : : :	:	:
200X CORRECTED CONCENTRATION CELL 15	n/l	C20X15
260X CORRECTED CONCENTRATION CELL 01	n/l	C26X01
260X CORRECTED CONCENTRATION CELL 02	n/l	C26X02
: : : :	:	:
260X CORRECTED CONCENTRATION CELL 62	n/l	C26X62

DESCRIPTOR	UNITS	VARIABLE NAME
200Y CORRECTED CONCENTRATION CELL 01	n/l	C20Y01
200Y CORRECTED CONCENTRATION CELL 02	n/l	C20Y02
: : : :	:	:
200Y CORRECTED CONCENTRATION CELL 15	n/l	C20Y15

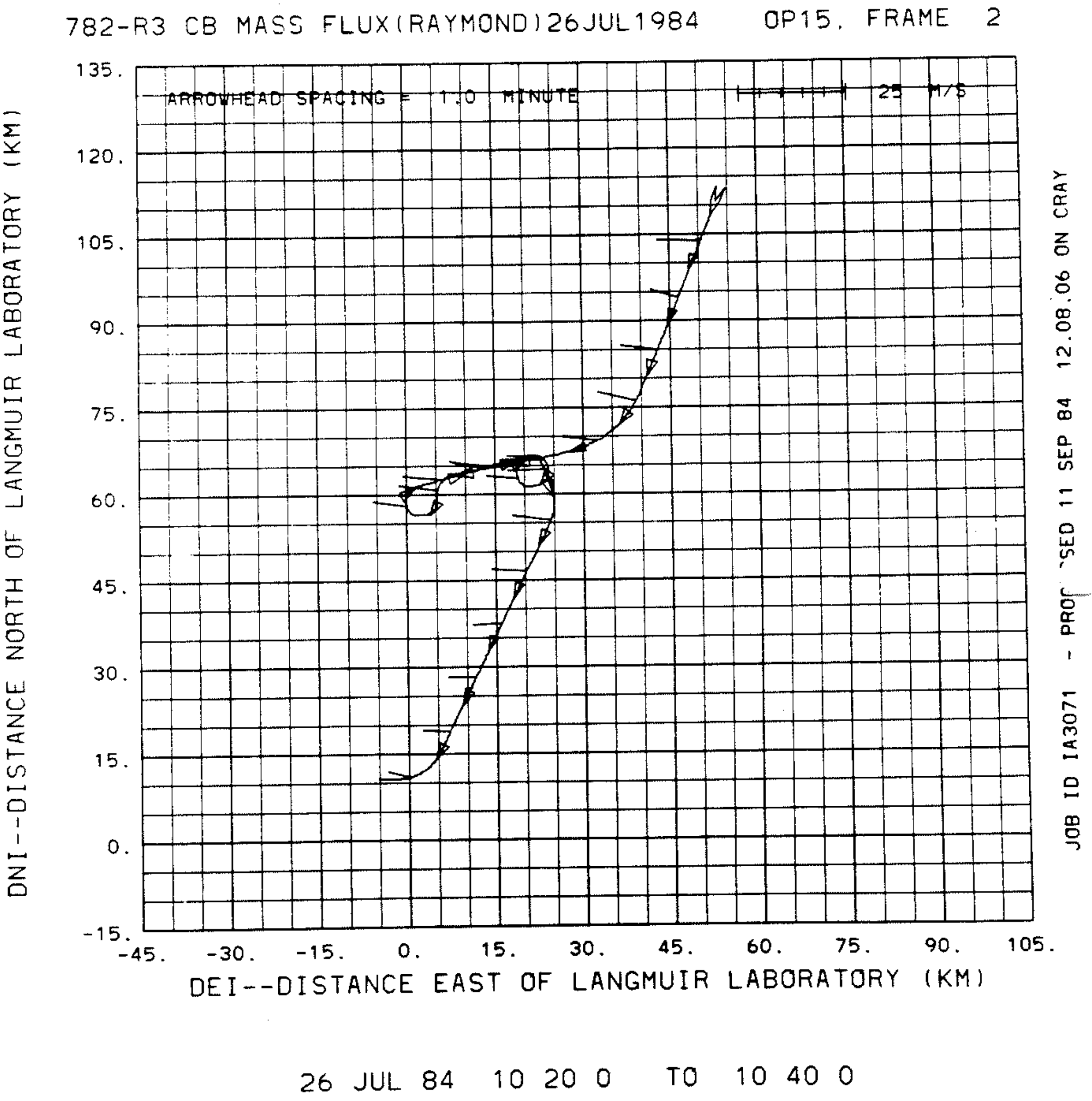
APPENDIX B

Examples of Microfilm Output

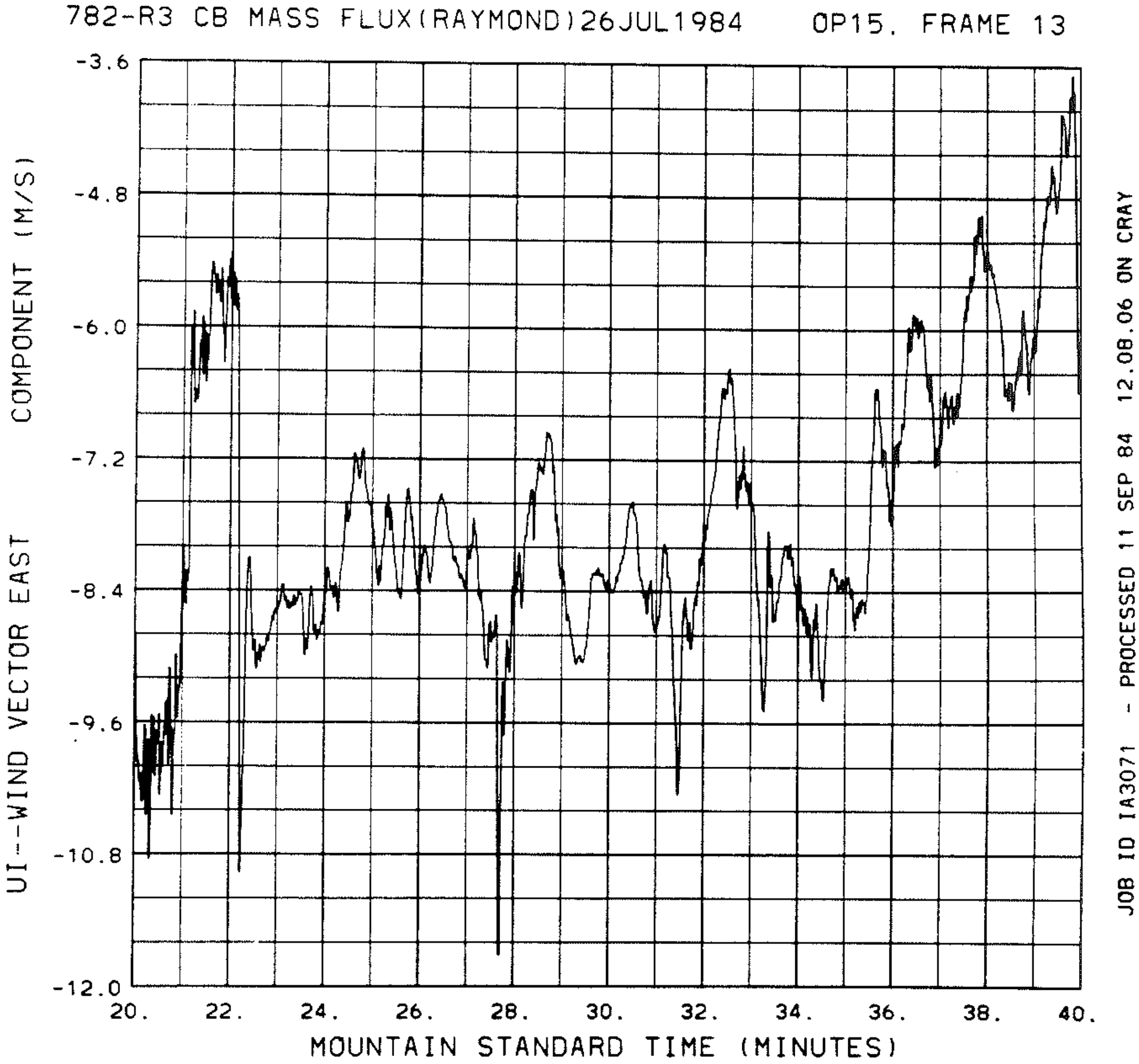
```
CALIB.ALAT    ALPHA   XVI     YVI     PITCH   CROLL   VZI     PALT     ARE USED IN COMP. OF GUST VARIABLES
CALIB. GUSTO    IS DERIVED FROM VARIABLES THF      TASB     TASB     AKDF     SSDF
CALIB.ALAT    ALPHA   XVI     YVI     PITCH   CROLL   VZI     PALT     ARE USED IN COMP. OF GUSTR VARIABLES
CALIB. GUSTR    IS DERIVED FROM VARIABLES THF      TASF     TASF     ATKR     SSLPR
CALIB. DNI      IS DERIVED FROM VARIABLES ALAT
CALIB. DEI      IS DERIVED FROM VARIABLES ALON     ALAT
CALIB. PSFDC    IS DERIVED FROM VARIABLES PSFD     QCF
CALIB. PSFC     IS DERIVED FROM VARIABLES PSF      QCF
CALIB. PSBC     IS DERIVED FROM VARIABLES PSB      QCB
CALIB. ATF      IS DERIVED FROM VARIABLES TTF      QCBC     PSFDC
CALIB. ATFH     IS DERIVED FROM VARIABLES TTFH     QCBC     PSFDC
CALIB. BDPC     IS DERIVED FROM VARIABLES DPRB
CALIB. TDPC     IS DERIVED FROM VARIABLES DPRT
CALIB. PALT     IS DERIVED FROM VARIABLES PSFDC
CALIB. THETA    IS DERIVED FROM VARIABLES ATF      PSFDC
CALIB. ETHETA   IS DERIVED FROM VARIABLES TDPC     ATF      PSFDC    RM
CALIB. VTHETA   IS DERIVED FROM VARIABLES ATF      RM       PSFDC
CALIB. TRHOTD   IS DERIVED FROM VARIABLES TDPC     ATF
CALIB. BRHOTD   IS DERIVED FROM VARIABLES BDPC     ATF
CALIB. RHUM     IS DERIVED FROM VARIABLES TDPC     ATF
CALIB. RM       IS DERIVED FROM VARIABLES TDPC     PSFDC
CALIB. SPHUM    IS DERIVED FROM VARIABLES TDPC     PSFDC
CALIB. DRICE    IS DERIVED FROM VARIABLES RICE     TASF
CALIB. TASB     IS DERIVED FROM VARIABLES TTF      QCBC     PSFDC
CALIB. TASF     IS DERIVED FROM VARIABLES TTF      QCFC     PSFDC
CALIB. QCBC     IS DERIVED FROM VARIABLES QCB
CALIB. QCFC     IS DERIVED FROM VARIABLES QCF
CALIB. AKDF     IS DERIVED FROM VARIABLES ADIF     QCBC     PSFDC    QCB
CALIB. SSDF     IS DERIVED FROM VARIABLES BDIF     QCBC     PSFDC    QCB
CALIB. GSF      IS DERIVED FROM VARIABLES XVI      YVI
CALIB. DFQCBF   IS DERIVED FROM VARIABLES QCBC     QCFC
CALIB. DFTABF   IS DERIVED FROM VARIABLES TASB     TASF
CALIB. DFATFH   IS DERIVED FROM VARIABLES ATFH     ATF
CALIB. DFDPTB   IS DERIVED FROM VARIABLES TDPC     BDPC
CALIB. DFPSBF   IS DERIVED FROM VARIABLES PSBC     PSFC
CALIB. DFPHAK   IS DERIVED FROM VARIABLES PITCH    AKDF
CALIB. DFH3     IS DERIVED FROM VARIABLES HI3      PALT
CALIB. TPTIME   IS DERIVED FROM VARIABLES HR       MIN      SEC
CALIB. QCRC     IS DERIVED FROM VARIABLES QCR      ADIFR    BDIFR
CALIB. QCR      IS DERIVED FROM VARIABLES PTR      PSFDC
CALIB. TASR     IS DERIVED FROM VARIABLES TTF      QCRC     PSFDC
CALIB. ATKR     IS DERIVED FROM VARIABLES ADIFR    QCRC     QCFC     PSFDC
CALIB. SSLPR    IS DERIVED FROM VARIABLES BDIFR    QCRC     QCFC     PSFDC
CALIB. GUSTO    USES CONSTANT BOOMLN    =      7.870 UNIT = M        IN THE COMPUTATION
CALIB. GUSTR    USES CONSTANT BOOMLN    =      4.830 UNIT = M        IN THE COMPUTATION
CALIB. DNI      USES CONSTANT INI-LAT   =     33.975 UNIT =  DEG     IN THE COMPUTATION
CALIB. DEI      USES CONSTANT INI-LON   =   -107.180 UNIT =  DEG     IN THE COMPUTATION
CALIB. ATF      USES CONSTANT REC-FACT  =      0.950 UNIT = ND       IN THE COMPUTATION
CALIB. ATFH     USES CONSTANT REC-FACT  =      0.980 UNIT = ND       IN THE COMPUTATION
CALIB. PALT     USES CONSTANT ASTG      =   1013.240 UNIT = MB       IN THE COMPUTATION
CALIB. TASB     USES CONSTANT REC-FACT  =      0.950 UNIT = ND       IN THE COMPUTATION
CALIB. TASF     USES CONSTANT REC-FACT  =      0.950 UNIT = ND       IN THE COMPUTATION
CALIB. AKDF     USES CONSTANT BIAS      =     -0.170 UNIT = DEG      IN THE COMPUTATION
CALIB. SSDF     USES CONSTANT OFFSET    =     -0.700 UNIT = DEG      IN THE COMPUTATION
CALIB. TASR     USES CONSTANT REC-FACT  =      0.950 UNIT = ND       IN THE COMPUTATION
CALIB. SSLPR    USES CONSTANT BIAS      =      0.250 UNIT = DEG      IN THE COMPUTATION
CALIB. QCF     QCB      ARE USED AS QC REFERENCE VARS.
CALIB. PSFDC    USES PCOR FUNCTION --  PCOR (QCX7) =-0.80179+QCX7*(0.03010+QCX7*0.0001744)
CALIB. PSFC     USES PCOR FUNCTION --  PCOR (QCX7) =-0.80179+QCX7*(0.03010+QCX7*0.0001744)
CALIB. PSBC     USES PCORG FUNCTION -- PCORG(QCX7)=-0.1746+QCX7*(-0.01988-QCX7*0.0001275)

CALIB. QCBC     USES PCORG FUNCTION -- PCORG(QCX7)=-0.1746+QCX7*(-0.01988-QCX7*0.0001275)
CALIB. QCFC     USES PCOR FUNCTION --  PCOR (QCX7) =-0.80179+QCX7*(0.03010+QCX7*0.0001744)
CALIB. RM       USES ESUBT FUNCTION -- ESUBT(T)=6.107799961+T*(.4436518521+T*(.01428945805+T*
(2.650648471E-4+T*(3.031240396E-6+T* (2.034080948E-8+T*6.136820929E-11)))))
CALIB. SPHUM    USES ESUBT FUNCTION -- ESUBT(T)=6.107799961+T*(.4436518521+T*(.01428945805+T*
(2.650648471E-4+T*(3.031240396E-6+T* (2.034080948E-8+T*6.136820929E-11)))))
CALIB. ATFH     USES TFHERR FUNCTION --  TFHERR(Z) = ((-.382943*Z+23.603347)*Z-14.912448)*Z+2.454213
CALIB. TRHOTD   USES ESUBT FUNCTION -- ESUBT(T)=6.107799961+T*(.4436518521+T*(.01428945805+T*
(2.650648471E-4+T*(3.031240396E-6+T* (2.034080948E-8+T*6.136820929E-11)))))
CALIB. BRHOTD   USES ESUBT FUNCTION -- ESUBT(T)=6.107799961+T*(.4436518521+T*(.01428945805+T*
(2.650648471E-4+T*(3.031240396E-6+T* (2.034080948E-8+T*6.136820929E-11)))))
CALIB. RHUM     USES ESUBT FUNCTION -- ESUBT(T)=6.107799961+T*(.4436518521+T*(.01428945805+T*
(2.650648471E-4+T*(3.031240396E-6+T* (2.034080948E-8+T*6.136820929E-11)))))
CALIB. AKDF     USES XGR   FUNCTION -- XGR(G) = .086577797-.03560256*G+.00006143*G*G        15DEC1982
CALIB. SSDF     USES XGR   FUNCTION -- XGR(G) = .086577797-.03560256*G+.00006143*G*G        15DEC1982
CALIB. ETHETA   USES ESUBT FUNCTION -- ESUBT(T)=6.107799961+T*(.4436518521+T*(.01428945805+T*
(2.650648471E-4+T*(3.031240396E-6+T* (2.034080948E-8+T*6.136820929E-11)))))
```

Header Block


782-R3 CB MASS FLUX(RAYMOND)26JUL1984 OP15, FRAME 2
ARROWHEAD SPACING = 1.0 MINUTE
25 M/S
135.
120.
105.
90.
75.
60.
45.
30.
15.
0.
-15.
-45.
-30.
-15.
0.
15.
30.
45.
60.
75.
90.
105.
DNI--DISTANCE NORTH OF LANGMUIR LABORATORY (KM)
DEI--DISTANCE EAST OF LANGMUIR LABORATORY (KM)
JOB ID IA3071 - PROC SED 11 SEP 84 12.08.06 ON CRAY
26 JUL 84 10 20 0 TO 10 40 0

X-Y Track



26 JUL 84 10 20 0 TO 10 40 0

Time Series Plot

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                                         782-R3 CB MASS FLUX(RAYMOND)26JUL1984                                                   PAGE   225
HR  MI  SEC       ALAT     ALON       DEI      DNI     PSFDC    PSFC     PSBC      ATF       ATFH      BDPC     TDPC      WDIR     WSPD
 (OP13)           DEG      DEG        KM       KM      MB       MB       MB        C         C         C        C         DEG      M/S

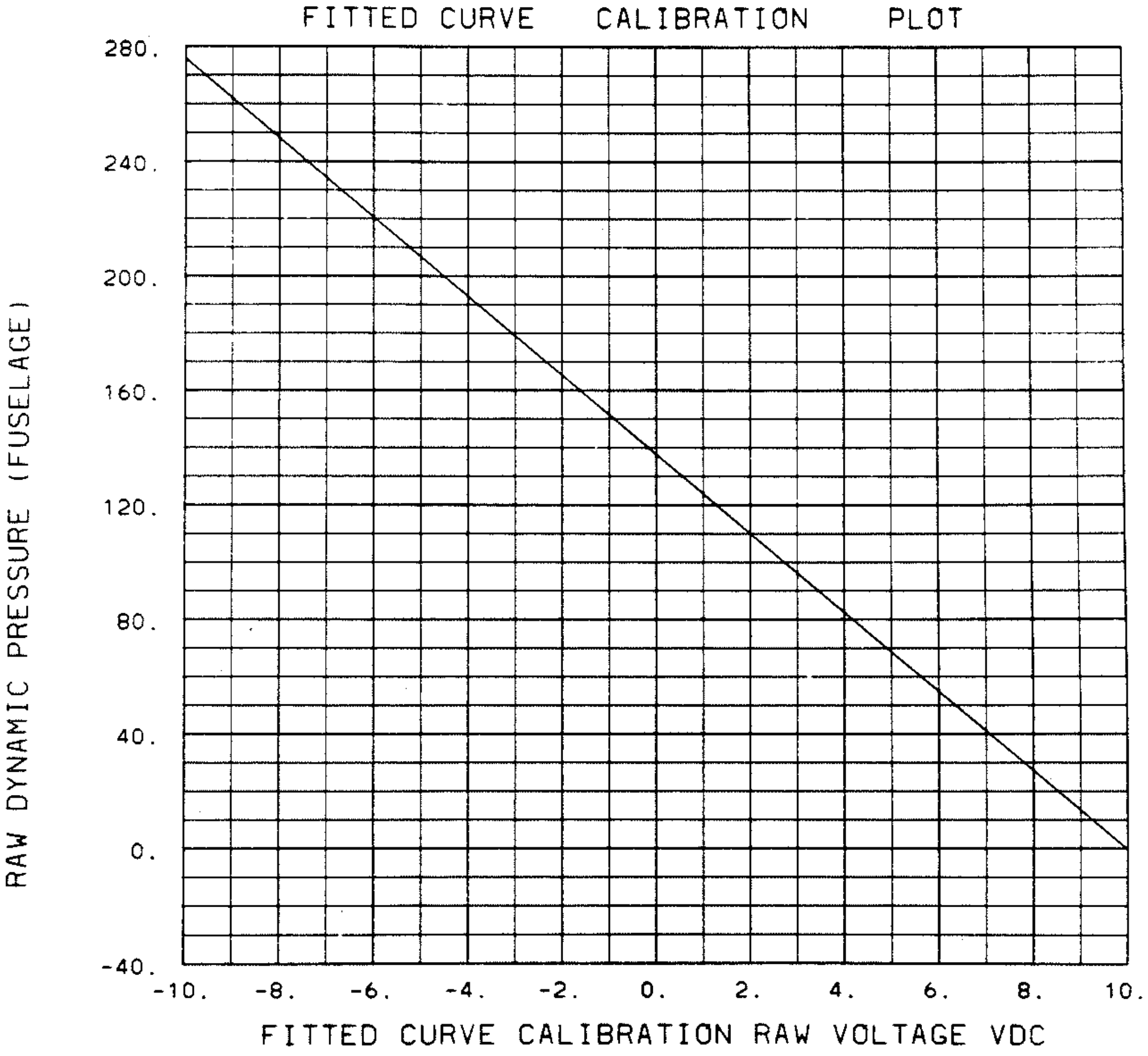
10. 35.  0.     34.412 -106.948     22.45    51.19   544.73   544.91   546.12    -2.50     -2.88    -12.87   -14.56     97.52     8.37
10. 35.  1.     34.409 -106.949     22.31    50.87   544.76   544.97   546.12    -2.53     -2.88    -12.84   -14.73     97.13     8.44
10. 35.  2.     34.409 -106.949     22.31    50.87   544.81   544.99   546.18    -2.50     -2.89    -12.82   -14.85     97.35     8.36
10. 35.  3.     34.406 -106.951     22.18    50.55   544.83   545.04   546.18    -2.48     -2.86    -12.81   -14.88     96.00     8.33
10. 35.  4.     34.406 -106.951     22.18    50.55   544.89   545.07   546.23    -2.51     -2.89    -12.82   -14.84     97.74     8.34
10. 35.  5.     34.404 -106.952     22.05    50.23   544.90   545.07   546.29    -2.50     -2.90    -12.84   -14.75     97.25     8.37
10. 35.  6.     34.404 -106.952     22.05    50.23   544.94   545.15   546.29    -2.53     -2.90    -12.87   -14.71     97.79     8.47
10. 35.  7.     34.402 -106.953     21.92    50.07   544.99   545.22   546.28    -2.55     -2.92    -12.92   -14.78     98.50     8.54
10. 35.  8.     34.400 -106.953     21.92    49.75   544.99   545.23   546.34    -2.54     -2.91    -12.98   -14.90     98.40     8.45
10. 35.  9.     34.400 -106.955     21.78    49.75   544.99   545.22   546.34    -2.55     -2.91    -13.05   -15.01     97.74     8.47
10. 35. 10.     34.398 -106.956     21.65    49.58   545.01   545.21   546.35    -2.58     -2.91    -13.12   -14.97     96.54     8.71
10. 35. 11.     34.397 -106.956     21.65    49.42   545.02   545.28   546.34    -2.57     -2.93    -13.17   -14.67     96.39     8.67
10. 35. 12.     34.395 -106.957     21.52    49.26   545.00   545.26   546.36    -2.56     -2.91    -13.19   -14.23     94.78     8.78
10. 35. 13.     34.394 -106.957     21.52    49.10   545.01   545.21   546.35    -2.59     -2.96    -13.19   -13.92     94.74     8.64
10. 35. 14.     34.394 -106.959     21.39    49.10   544.98   545.22   546.34    -2.61     -2.99    -13.17   -13.82     95.54     8.66
10  35. 15.     34.391 -106.959     21.39    48.78   544.99   545.23   546.34    -2.61     -2.98    -13.12   -13.98     95.05     8.56
10. 35  16.     34.391 -106.959     21.39    48.78   544.93   545.17   546.27    -2.63     -2.99    -13.05   -14.27     95.45     8.67
10. 35  17.     34 390 -106.962     21.12    48.62   544.94   545.18   546.27    -2.64     -3.01    -12.96   -14.53     95.52     8.58
10. 35. 18.     34.389 -106.962     21.12    48.46   544.91   545.05   546.27    -2.65     -3.02    -12.88   -14.61     95.67     8.52
10. 35. 19.     34.386 -106.962     21.12    48.14   544.84   545.05   546.20    -2.67     -3.01    -12.79   -14.50     95.50     8.62
10. 35. 20.     34.384 -106.963     20.99    47.98   544.81   545.00   546.14    -2.67     -3.02    -12.71   -14.31     95.73     8.59
10. 35. 21.     34.384 -106.964     20.86    47.98   544.75   544.94   546.19    -2.70     -3.05    -12.64   -14.13     96.45     8.51
10. 35. 22.     34.384 -106.964     20.86    47.98   544.73   544.89   546.12    -2.71     -3.06    -12.58   -14.13     96.77     8.55
10  35. 23.     34.383 -106.966     20.73    47.81   544.70   544.83   546.06    -2.71     -3.06    -12.54   -14.38     96.64     8.55
10. 35. 24.     34.380 -106.966     20.73    47.49   544.66   544.83   546.00    -2.72     -3.06    -12.55   -14.81     96.54     8.57
10. 35. 25.     34.380 -106.967     20.60    47.49   544.60   544.77   545.99    -2.75     -3.09    -12.58   -15.15     96.44     8.65
10  35. 26.     34.378 -106.967     20.60    47.17   544.57   544.71   545.99    -2.71     -3.11    -12.64   -15.25     96.32     8.53
10. 35. 27.     34.378 -106.968     20.46    47.17   544.51   544.71   545.92    -2.73     -3.11    -12.72   -15.11     96.45     8.52
10. 35. 28.     34.376 -106.970     20.33    47.01   544.55   544.72   545.92    -2.71     -3.10    -12.83   -14.94     96.09     8.28
10. 35. 29.     34.375 -106.970     20.33    46.85   544.55   544.66   545.92    -2.69     -3.09    -12.96   -14.88     95.31     8.20
10. 35. 30.     34.373 -106.971     20.20    46.69   544.56   544.73   545.85    -2.66     -3.06    -13.11   -15.03     95.12     8.02
10. 35. 31.     34.372 -106.973     20.07    46.53   544.53   544.74   545.85    -2.64     -3.05    -13.27   -15.37     94.83     7.90
10. 35. 32.     34.371 -106.973     20.07    46.37   544.50   544.68   545.91    -2.63     -3.04    -13.46   -15.83     94.66     7.59
10. 35. 33.     34.369 -106.973     20.07    46.21   544.52   544.70   545.90    -2.62     -3.03    -13.67   -16.29     95.17     7.35
10. 35. 34.     34.368 -106.974     19.93    46.05   544.52   544.64   545.96    -2.58     -2.97    -13.91   -16.77     94.44     7.19
10. 35. 35.     34.368 -106.974     19.93    46.04   544.56   544.64   545.96    -2.54     -2.94    -14.18   -17.26     93.80     7.08
10. 35. 36.     34.365 -106.975     19.80    45.72   544.64   544.78   545.95    -2.52     -2.92    -14.46   -17.73     94.14     7.00
10. 35. 37.     34.365 -106.977     19.67    45.72   544.72   544.85   546.00    -2.50     -2.90    -14.79   -18.13     93.81     6.68
10. 35. 38.     34.362 -106.977     19.67    45.40   544.73   544.93   546.06    -2.46     -2.87    -15.14   -18.47     94.16     6.56
10. 35. 39.     34.362 -106.977     19.67    45.40   544.80   544.93   546.12    -2.48     -2.82    -15.51   -18.79     93.24     6.63
10. 35. 40.     34.361 -106.978     19.54    45.24   544.84   545.00   546.12    -2.51     -2.82    -15.88   -19.15     92.80     6.54
10. 35. 41.     34.360 -106.978     19.54    45.08   544.88   545.00   546.11    -2.53     -2.83    -16.28   -19.44     92.76     6.62
10. 35. 42.     34.358 -106.979     19.41    44.92   544.88   545.07   546.11    -2.58     -2.85    -16.65   -19.57     92.93     6.67
10. 35. 43.     34.357 -106.979     19.40    44.76   544.84   545.00   546.18    -2.57     -2.86    -17.02   -19.22     91.47     6.85
10. 35. 44.     34.356 -106.982     19.14    44.60   544.78   545.00   546.18    -2.61     -2.90    -17.34   -18.44     91.68     6.87
10. 35. 45.     34.354 -106.982     19.14    44.44   544.78   544.94   546.18    -2.61     -2.91    -17.59   -17.55     91.25     6.94
10. 35. 46.     34.353 -106.982     19.14    44.27   544.85   544.95   546.18    -2.65     -2.92    -17.79   -17.00     91.27     7.08
10. 35. 47.     34.350 -106.983     19.01    43.95   544.84   545.00   546.18    -2.66     -2.92    -17.88   -16.91     89.66     7.25
10. 35. 48.     34.350 -106.984     19.01    43.95   544.88   545.01   546.24    -2.64     -2.97    -17.85   -16.97     89.83     7.15
10. 35. 49.     34.350 -106.985     18.88    43.95   544.92   545.08   546.24    -2.61     -2.96    -17.69   -17.07     89.56     7.09
10. 35. 50.     34.347 -106.986     18.74    43.63   544.97   545.09   546.29    -2.61     -2.95    -17.48   -17.25     89 83     7.10
10. 35. 51.     34.346 -106.986     18.74    43.47   544.97   545.09   546.29    -2.67     -2.96    -17.25   -17.47     89.36     7.12
10. 35. 52.     34.345 -106.986     18.74    43.31   545.01   545.16   546.35    -2.70     -2.98    -16.95   -17.55     89.78     7.33
10. 35. 53.     34.343 -106.988     18.61    43.15   545.05   545.17   546.34    -2.73     -3.03    -16.59   -17.22     90.75     7.43
10. 35. 54.     34.342 -106.988     18.61    42.99   545.12   545.24   546.41    -2.72     -3.03    -16.17   -16.58     89.84     7.43
10. 35. 55.     34.341 -106.988     18.61    42.83   545.13   545.24   546.47    -2.74     -3.06    -15.70   -15.93     90.15     7.52
10. 35. 56.     34.341 -106.990     18.35    42.83   545.20   545.31   546.46    -2.71     -3.05    -15.21   -15.56     90.89     7.75
10. 35. 57.     34.339 -106.990     18.35    42.67   545.24   545.32   546.52    -2.72     -3.07    -14.75   -15.70     90.95     7.56
10. 35. 58.     34.338 -106.992     18.21    42.51   545.23   545.37   546.53    -2.78     -3.06    -14.30   -16.15     89.94     7.79
10. 35. 59.     34.336 -106.992     18.21    42.34   545.31   545.44   546.59    -2.73     -3.07    -13.89   -16.49     89.33     7.71
```

Tabular Listing

B.4

```
      THE FOLLOWING STATISTICS COVER INTERVAL FROM   11.0 HRS     0.0 MNS     0.0 SEC     TO    11.0 HRS   20.0 MNS     0.0 SEC
VAR #  NAMVAR              RATE  UNITS            NPTOT   XMEAN        XMAX        XMIN          SIGMA       SKEW         KURTOSIS
   1   ALAT                10.     DEG            1200.  41.230      41.565      40.784        0.22403     551.75      0.20295E+06
   2   ALON                10.     DEG            1200. -106.53     -105.87     -106.92        0.29350    -1088.4      0.78969E+06
   3   DEI                 10.     KM             1200. -124.08     -66.451     -157.99         25.510    -14.069       133.91
   4   DNI                 10.     KM             1200.  154.35      193.61      102.05         26.249     17.261       200.55
   5   PSFDC               10.     MB             1200.  592.94      751.81      497.63         99.984     18.630       232.72
   6   PSFC                10.     MB             1200.  592.85      751.31      497.72         99.853     18.649       233.20
   7   PSBC                10.     MB             1200.  592.91      750.53      498.65         99.539     18.708       234.66
   8   ATF                 10.     C              1200. -7.7329      8.5577     -17.792         9.7874    -1.5388       2.9539
   9   ATFH                10.     C              1200. -8.1684      8.2322     -18.138         9.9139    -1.6417       3.1694
  10   BDPC                10.      C             1200. -22.212     -2.6417     -33.736         11.254    -5.4087       20.842
  11   TDPC                10.     C              1200. -23.307     -1.3006     -37.973         11.821    -5.3451       20.429
  12   WDIR                10.     DEG            1200.  275.58      308.07      243.47         7.9339     103.92       7203.1
  13   WSPD                10.     M/S            1200.  19.643      27.729      6.4250         4.4541     12.571       107.09
  14   UI                  10.     M/S            1200.  19.354      26.665      5.0581         4.3458     12.647       108.38
  15   VI                  10.     M/S            1200. -2.1518      6.3953     -9.4786         2.7551    -2.5372       7.1786
  16   WI                  10.     M/S            1200. 0.24709      5.7533     -3.1074         1.3432     1.2371       4.6455
  17   PALT                10.     M              1200.  4376.6      5607.1      2446.0         1224.5     9.9027       66.702
  18   HI3                 10.     M              1200.  4376.6      5601.5      2449.1         1224.5     9.9028       66.702
  19   THETA               10.     K              1200.  309.15      315.91      302.94         3.2174     288.05       55316.
  20   ETHETA              10.     K              1200.  313.87      318.18      310.51         1.7381     541.84      0.19573E+06
  21   VTHETA              10.     K              1200.  309.42      316.00      303.66         3.0249     306.73       62723.
  22   TRHOTD              10.      G/M3          1200.  1.1986      4.2951     0.19397         1.1815     3.9472       12.068
  23   BRHOTD              10.    G/M3            1200.  1.2525      3.8935     0.29424         1.1539     4.0819       12.707
  24   RHUM                10.    PERCENT         1200.  32.578      75.708      13.188         14.977     7.7046       42.352
  25   RM                  10.      G/KG          1200.  1.4789      4.2109     0.41876         1.2108     4.4363       14.745
  26   SPHUM               10.      G/KG          1200.  1.4752      4.1933     0.41858         1.2061     4.4400       14.764
  27   DRICE               10.      G/M3          1200. 0.75228E-03 0.12993E-01 0.00000      0.16911E-02  4.0732       18.665
  28   THI                 10.      DEG           1200.  198.13      358.69     0.22615         89.747     7.1606       35.719
  29   THF                 10.     DEG            1200.  198.11      358.02     0.34936E-01     89.763     7.1571       35.688
  30   ALPHA               10.     DEG            1200.  204.18      204.61      203.92        0.19302     3173.9      0.67160E+07
  31   ROLL                10.     DEG            1200.  2.5031      48.262     -34.142         9.8689     2.3362       11.525
  32   CROLL               10.     DEG            1200.  2.4406      48.098     -33.992         9.8563     2.3243       11.486
  33   PITCH               10.     DEG            1200.  5.0447      15.449     -5.5352         2.9761     6.5609       33.383
  34   ACINS               10.     M/S2           1200.-0.37975E-03  4.0949     -4.3221        0.77679    -0.81256      8.3937
  35   WP3                 10.     M/S            1200.  2.2302      31.332     -22.538         7.6708     2.6740       9.6479
  36   VZI                 10.     M/S            1200. -337.58     -301.31     -362.19         11.112    -89.969       5399.8
  37   TASB                10.     M/S            1200.  143.20      178.53      119.70         9.4324     46.468       1442.7
  38   TASF                10.     M/S            1200.  143.24      178.13      120.19         9.3925     46.673       1455.4
  39   QCBC                10.     MB             1200.  83.334      123.10      49.995         12.789     19.694       261.51
  40   QCFC                10.     MB             1200.  83.368      122.48      50.330         12.669     19.872       266.20
  41   QCB                 10.    MB              1200.  80.705      118.76      48.554         12.289     19.838       265.32
  42   QCF                 10.    MB              1200.  86.507      128.42      51.543         13.486     19.388       253.55
  43   AKDF                10.     DEG            1200.  4.2945      6.9376      2.0984        0.66009     19.936       268.20
  44   SSDF                10.     DEG            1200. 0.28280      2.7984     -2.7674        0.43864     1.8807       11.368
  45   ADIF                10.     MB             1200.  24.127      36.104      12.997         2.2708     31.958       687.18
  46   BDIF                10.     MB             1200.  5.6065      26.352     -16.654         2.8318     6.4021       39.510
  47   GSF                 10.     M/S            1200.  151.37      194.91      124.73         16.853     26.971       487.06
  48   VEW                 10.     M/S            1200.  50.524      173.59     -91.793         88.444     1.1643       2.3680
  49   VNS                 10.     M/S            1200. -34.178      144.71     -155.46         107.96    -0.41128      1.3612
  50   XVI                 10.     M/S            1200.  10.230      110.12     -148.38         70.335   0.15711E-01   1.7311
  51   YVI                 10.     M/S            1200.  60.229      194.74     -126.14         120.49    0.85277       1.7253
  52   PSFD                10.     MB             1200.  589.80      748.26      496.41         99.568     18.611       232.24
  53   PSF                 10.     MB             1200.  589.71      747.76      496.51         99.436     18.630       232.72
  54   PSB                 10.     MB             1200.  595.54      753.72      500.09         99.798     18.740       235.45
  55   TTF                 10.     C              1200.  2.0090      17.829     -10.363         9.4219     1.4350       2.7636
  56   TTFH                10.     C              1200.  1.8641      17.504     -10.056         9.5421     1.3802       2.6563
  57   DPRB                10.     C              1200. -20.059     -2.3425     -30.614         10.251    -5.3650       20.526
  58   DPRT                10.     C              1200. -21.073     -1.1561     -34.588         10.780    -5.3032       20.132
  59   VLA                 10.     VDC            1200. -5.2626     -3.6237     -5.9572        0.68838    -22.075       326.49
  60   UX                  10.     M/S            1200.  7.7475      25.185     -14.046         12.009     1.5274       3.1013
  61   VY                  10.     M/S            1200.  5.4298      21.908     -22.338         13.114    0.82829       1.8989
  62   RICE                10.     VDC            1200.  1.3380      1.4334      1.3037      0.30286E-01   134.20       12010.
```

Statistics



QCF MB 29AUG84

CALIBRATION CURVE COEFFICIENTS

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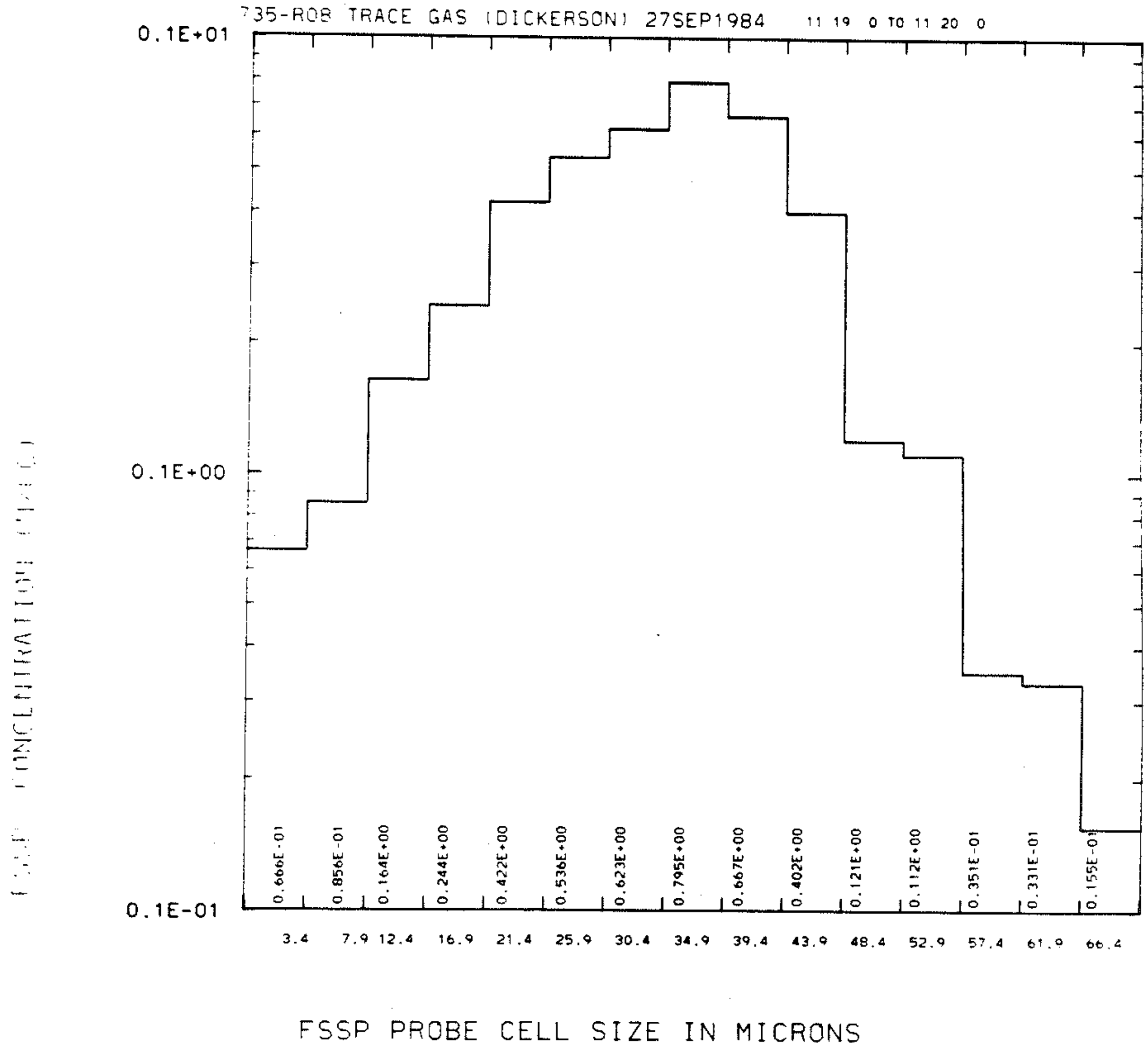
Calibration Curve



FSSP Histogram

APPENDIX C

Magnetic Tape Header File

This appendix contains an example of a processed magnetic tape header file. The header file completely describes the format of the RAF magnetic tape output and provides instruction on how to unpack the data encoded on the magnetic tape. Typically, each logical record contains 1-s of data, one GENPRO cycle.

Although the attached example does not show this, in most cases the first two variables will be processor time, PTIME, and raw tape time, TPTIME. (In the attached example the first two variables are latitude, ALAT, and longitude, ALON. Raw tape time, TPTIME is in the example, but in a different position.) The processor time is calculated from the start time of a tape and the number and size of raw data tape records. The processor time and the raw tape time should agree. Disagreement between these two times indicates a time gap problem on the raw data tape.

```
 BEGINHD                          /GENPRO OUTPUT HEADER
/HDROPT = (HEADER,NOSPAN,ASCII)   /HEADER RECORD OPTIONS
/HDRLOG =   10                    /LOGICAL HEADER RECORDS PER PHYSICAL RECORD
/HDRSIZ =     6400                /PHYSICAL HEADER RECORD SIZE (BITS)
/PROJECT= "812P-F03 EMEX (FERRY) 08JAN1987          "
/PRDATE = ("08","JAN","87")       /PROJECT DATE
/PRTIME = ("18H","01M","09S")     /PROJECT TIME
/BEGSNP = (  18.000    ,  1.0000    ,  9.0000     )
/ENDSNP = (  21.000    ,  46.000    ,  42.000     )
/COMMENT= "            NCAR RAF MAGNETIC TAPE FORMATS                        ".
/          "  THE CALIBRATED MAGNETIC TAPES ARE PRODUCED BY THE NCAR RAF DATA ".
/          " MANAGEMENT GROUP, WITH THE GENPRO-II DATA PROCESSING SOFTWARE.   ".
/          " THE FORMAT OF THESE TAPES INCLUDES A HEADER FILE AND A DATA FILE ".
/          " WHICH CORRESPONDS TO ALL OR PART OF A PARTICULAR AIRCRAFT FLIGHT ".
/          " - HEADER FILE DESCRIPTION                                        ".
/          " THE HEADER FILE DESCRIBING THE DATA FORMATS IS IN ASCII          ".
/          " CHARACTER FORMAT, 80 CHARACTERS TO A LOGICAL RECORD AND 10       ".
/          " LOGICAL RECORDS TO A PHYSICAL RECORD.                            ".
/          " THE HEADER FILE IS DIVIDED INTO THE FOLLOWING FIVE SECTIONS:     ".
/          " 1. THE GENERAL INFORMATION SECTION CONSISTS OF THREE PARTS:      ".
/          "    A) THE TITLE LINE IS (BEGINHD).  THIS PART CONTAINS THE       ".
/          "       INFORMATION PERTAINING TO HEADER FILE: HEADER RECORD OP-   ".
/          "       TIONS(HDRDPT), LOGICAL HEADER RECORDS PER PHYSICAL RECORD  ".
/          "       (HDRLOG), PHYSICAL HEADER RECORD SIZE IN BITS(HORSIZ),     ".
/          "       RESEARCH FLIGHT PROJECT TITLE(PROJECT), RESEARCH FLIGHT    ".
/          "       DATE(PRDATE), RESEARCH FLIGHT TIME(PRTIME), BEGINNING TIME ".
/          "       (BEGSNP), AND ENDING TIME(ENDSNP).                         ".
/          "     B) THE TITLE LINE IS (COMMENT= NCAR RAF MAGNETIC TAPE        ".
/          "        FORMATS).  THIS PART DESCRIBES THE DATA FORMAT OF         ".
/          "        GENPRO-II GENERATED DATA SETS.                            ".
/          "     C) THIS PART CONTAINS INFORMATION PERTAINING TO DATA SET     ".
/          "        GENERATION AND THE DATA FILE: PRODUCTION JOB EXECUTION    ".
/          "        DATE(EXDATE), EXECUTION TIME(EXTIME), COMPUTER USED FOR   ".
/          "        THE JOB(MACHINE), JOB IDENTIFICATION(JOBID), MEDIA NUMBER ".
/          "        (MEDIA), DATA RECORD OPTIONS(DATOPT), BITS PER LOGICAL    ".
/          "        DATA RECORD(LOGBIT), LOGICAL DATA RECORDS PER PHYSICAL    ".
/          "        RECORD(DATLOG) AND PHYSICAL DATA RECORD SIZE IN BITS      ".
/          "        (DATSIZ).                                                 ".
/          "  2. THE TITLE LINE OF THE VARIABLE NAME LIST SECTION IS          ".
/          "     (/VARIABLE WRITTEN FOR THIS SNAPSHOT PERIOD).  VARIABLE      ".
/          "     NAMES ARE LISTED ON THE FOLLOWING LINES THAT BEGIN WITH      ".
/          "     (APPVAR=). THIS SECTION CONTAINS ALL THE VARIABLE NAMES THAT ".
/          "     ARE ON THE DATA FILE.  A BRIEF DESCRIPTION OF EACH VARIABLE  ".
/          "     IS GIVEN IN SECTION 3.                                       ".
/          "  3. THE TITLE LINE OF THIS SECTION IS (ORDVAR  = TITLE).  EACH   ".
/          "     LINE FOLLOWING WILL BEGIN WITH (LETVAR=) AND BE FOLLOWED BY  ".
/          "     THE VARIABLE TITLE.  AT THE END OF THAT LINE, (%FOR,) IS     ".
/          "     FOLLOWED BY THE VARIABLE NAME.                               ".
/          "  4. THE TITLE LINE OF THIS SECTION IS (ORDVAR  = UNITS, SAMPLE,  ".
/          "     RATE, BITS, FSTBIT, SKIP).  EACH LINE FOLLOWING WILL BEGIN   ".
/          "     WITH (LETVAR =), AND BE FOLLOWED BY THE VARIABLE UNITS       ".
/          "     (UNITS),SAMPLING RATE(SAMPLE), OUTPUT RATE(RATE), BIT        ".
/          "     LENGTH OF EACH DATA VALUE(BITS), FIRST BIT LOCATION OF EACH  ".
/          "     VARIABLE(FSTBIT) AND NUMBER OF BITS BETWEEN TWO SEQUENTIAL   ".
/          "     DATA VALUES FOR THE SAME VARIABLE(SKIP).  AT THE END OF      ".
/          "     THAT LINE, (%FOR,) IS FOLLOWED BY THE VARIABLE NAME.         ".
/          "  5. THE TITLE LINE OF THIS SECTION IS (ORDVAR = CONKEY, SCLKEY,  ".
/          "     TERM, FACTOR).  EACH LINE FOLLOWING WILL BEGIN WITH          ".
/          "     (LETVAR =) AND BE FOLLOWED BY THE CONVERSION CODE USED BY    ".
/          "     GENPRO(CONKEY), THE SCALING ALGORITHM SELECTION(SCLKEY),     ".
/          "     THE VALUE OF THE SCALING TERM(TERM), AND THE SCALING FACTOR  ".
/          "     (FACTOR).  AT THE END OF THAT LINE, (%FOR,) IS FOLLOWED BY   ".
/          "     THE VARIABLE NAME.                                           ".
/          " - DATA FILE DESCRIPTION                                          ".
/          "   THE DATA FILE CONTAINS DATA VALUES OF VARIABLES OVER A         ".
```

```
/          " SPECIFIED TIME PERIOD (FROM BEGSNP TO ENDSNP) OF A PROJECT      ".
/          " PRODUCTION FLIGHT.  A GENPRO CYCLE INTERVAL OF DATA IS OUTPUT AS ".
/          " A DATA LOGICAL RECORD, WHERE ONE GENPRO CYCLE INTERVAL IS 1     ".
/          " SECOND(S) FOR THIS PROJECT.  BEFORE THE DATA ARE WRITTEN TO THE  ".
/          " OUTPUT DESTINATION, EACH DATA VALUE IS SCALED AND TRUNCATED TO A ".
/          " SPECIFIED NUMBER OF BINARY BITS ("BITS") AND THEN WRITTEN AS A   ".
/          " POSITIVE INTEGER. (I.E. A "TERM" IS ADDED TO EACH VALUE OF      ".
/          " VARIABLE AND THE RESULT IS MULTIPLED BY A "FACTOR".)            ".
/          "   EACH VARIABLE IN THE DATA FILE HAS A CORRESPONDING "FSTBIT",  ".
/          " "BITS","RATE","TERM", AND "FACTOR".  A GIVEN VARIABLE CAN BE    ".
/          " CONVERTED FROM A PACKED INTEGER VALUE TO AN UNPACKED REAL VALUE ".
/          " BY FOLLOWING THIS PROCEDURE:                                    ".
/          "       TAKE "BITS" NUMBER OF BITS STARTING AT "FSTBIT" .         ".
/          "       FROM THIS INTEGER VALUE DIVIDE BY THE "FACTOR"            ".
/          "       AND THEN SUBTRACT THE BIAS "TERM" FROM THE RESULT.        ".
/          "   IF THE VARIABLE HAS MORE THAN ONE SAMPLE PER GENPRO CYCLE     ".
/          " INTERVAL IN A LOGICAL RECORD, THE PROCEDURE MUST BE REPEATED    ".
/          " "RATE" TIMES IN A LOOP WHERE I=1 TO "RATE". THE STARTING BIT    ".
/          " NUMBER FOR EACH SEPARATE ITERATION IS THEN:                     ".
/          "       FSTBIT + BITS*(I-1)                                       ".
/          "   IF ALL PACKED VALUES ARE UNPACKED AND PLACED IN AN ARRAY,     ".
/          " THE FOLLOWING EQUATION MAY BE USED TO OBTAIN THE STARTING       ".
/          " INDEX OF A GIVEN VARIABLE (IVAR) WITHIN THE UNPACKED ARRAY:     ".
/          "       INDEX(IVAR) = ((FSTBIT(IVAR)-1)/BITS)+1                   "
/EXDATE = ("30","MAR","87")       /EXECUTION DATE
/EXTIME = ("17H","43M","08S")     /EXECUTION TIME
/MACHINE= "CRAY"                  /EXECUTION MACHINE
/JOBID  = "SI06475                                  " /JOB IDENTIFICATION
 MEDIA  =  1                      /MEDIA NUMBER
 DATOPT = (AUTO,NOSPAN)           /DATA RECORD OPTIONS
 LOGBIT =    42688                /BITS PER LOGICAL DATA RECORD
 DATLOG =    2                    /LOGICAL DATA RECORDS PER PHYSICAL RECORD
 DATSIZ =    85376                /PHYSICAL DATA RECORD SIZE (BITS)
/VARIABLES WRITTEN FOR THIS SNAPSHOT PERIOD
 APPVAR = HR          , MIN       , SEC       , PTIME     , TPTIME    , TMLAG
 APPVAR = ALAT        , ALON      , DEI       , DNI       , PSFDC     , PSBC
 APPVAR = PSWC        , ATFH      , DPTC      , DPBC      , HGM       , HGME
 APPVAR = PALT        , DVALU     , PSURF     , TVIR      , RHODT     , RHODB
 APPVAR = RHUM        , MR        , SPHUM     , LWCC      , SUM15F    , CONCF
 APPVAR = DBARF       , DISPF     , PLWCF     , FACT      , FBMFR     , FRANGE
 APPVAR = FRESET      , FSTROB    , SUMX6     , CONC6     , DBAR6     , DISP6
 APPVAR = PLWC6       , DBZ6      , CONC2C    , CONC2P    , RSTT      , RSTB
 APPVAR = SWT         , SWB       , IRTC      , IRBC      , THI       , ALPHA
 APPVAR = PCAB        , PSFD      , PSB       , PSW       , TTFH      , DPT
 APPVAR = DPB         , IRB       , IRT       , DTT       , STT       , DTB
 APPVAR = STB         , LWC       , SDWRC     , SDWRP     , XV10      , XV10R
 APPVAR = XTV10       , XTADS     , XFLOAD    , XFZV      , XFZVR     , XVDREF
 APPVAR = V10         , V10R      , TADS      , TV10      , FLOADS    , FZV
 APPVAR = FZVR        , VDREF     , AFSP01    , AFSP02    , AFSP03    , AFSP04
 APPVAR = AFSP05      , AFSP06    , AFSP07    , AFSP08    , AFSP09    , AFSP10
 APPVAR = AFSP11      , AFSP12    , AFSP13    , AFSP14    , AFSP15    , CFSP01
 APPVAR = CFSP02      , CFSP03    , CFSP04    , CFSP05    , CFSP06    , CFSP07
 APPVAR = CFSP08      , CFSP09    , CFSP10    , CFSP11    , CFSP12    , CFSP13
 APPVAR = CFSP14      , CFSP15    , RADON     , PB210     , VIFMT     , FMT
 APPVAR = SFMT        , VIFMB     , FMB       , SFMB      , PER1      , PER2
 APPVAR = HCHO1       , HCHO2     , STATP     , STATS     , LAMPP     , LAMPF
 APPVAR = O3          , FLOW1     , FLOW2     , FLOW3     , TRAP1     , TRAP2
 APPVAR = CAL1        , CAL2      , FMANS     , ZEROS     , RUN1      , RUN2
 APPVAR = CALG        , SAMP1     , SAMP2     , FMANG     , ZEROG     , STAT1
 APPVAR = ATB         , ATRF      , ATKP      , WD        , WS        , UI
 APPVAR = VI          , WI        , UX        , VY        , HI3       , THETA
 APPVAR = THETAE      , THETAV    , RHOLA1    , RFLAG     , PLWCC     , THF
 APPVAR = ROLL        , PITCH     , ACINS     , VZI       , WP3       , GSF
 APPVAR = VEW         , VNS       , XVI       , YVI       , TRKI      , TASB
 APPVAR = TASG        , TASW      , QCBC      , QCGC      , QCWC      , QCB
 APPVAR = QCG         , QCW       , AKFXL     , AKFXR     , SSFXT     , SSFXB
```

```
APPVAR = AFIXL     , AFIXR     , BFIXT     , BFIXB     , TTB       , TTRF
APPVAR = TTKP      , VLA       , PLWC      , DET       , DET5X     , ACCUMX6
APPVAR = CONCX6
ORDVAR = TITLE
LETVAR = "UNALTERED TAPE TIME                         ", %FOR, HR
LETVAR = "UNALTERED TAPE TIME                         ", %FOR, MIN
LETVAR = "UNALTERED TAPE TIME                         ", %FOR, SEC
LETVAR = "PROCESSOR TIME                              ", %FOR, PTIME
LETVAR = "RAW TAPE  TIME                              ", %FOR, TPTIME
LETVAR = "LTN-51 ARINC TIME LAG                       ", %FOR, TMLAG
LETVAR = "INS LATITUDE                                ", %FOR, ALAT
LETVAR = "INS LONGITUDE                               ", %FOR, ALON
LETVAR = "DISTANCE EAST OF START                      ", %FOR, DEI
LETVAR = "DISTANCE NORTH OF START                     ", %FOR, DNI
LETVAR = "CORRECTED STATIC PRESR (FUSELAGE DI)        ", %FOR, PSFDC
LETVAR = "CORRECTED STATIC PRESR ( BOOM    )          ", %FOR, PSBC
LETVAR = "CORRECTED STATIC PRESR (WING)               ", %FOR, PSWC
LETVAR = "AMBIENT TEMPERATURE (FUSELAGE HEATED)       ", %FOR, ATFH
LETVAR = "DEWPOINT TEMP. TOP    (THERMOELEC)          ", %FOR, DPTC
LETVAR = "DEWPOINT TEMP. BOTTOM(THERMOELEC)           ", %FOR, DPBC
LETVAR = "GEOMETRIC (RADIO) ALTITUDE                  ", %FOR, HGM
LETVAR = "GEOMETRIC (RADAR) ALTITUDE (APN-159)        ", %FOR, HGME
LETVAR = "NACA PRESSURE  ALTITUDE                     ", %FOR, PALT
LETVAR = "D-VALUE (HGME-PALT)                         ", %FOR, DVALU
LETVAR = "SURFACE PRESSURE                            ", %FOR, PSURF
LETVAR = "VIRTUAL TEMPERATURE                         ", %FOR, TVIR
LETVAR = "ABSOLUTE HUMIDITY (THERMOELEC TOP)          ", %FOR, RHODT
LETVAR = "ABSOLUTE HUMIDITY (THERMOELEC BOTTOM)       ", %FOR, RHODB
LETVAR = "RELATIVE HUMIDITY                           ", %FOR, RHUM
LETVAR = "MIXING RATIO                                ", %FOR, MR
LETVAR = "SPECIFIC HUMIDITY                           ", %FOR, SPHUM
LETVAR = "CORRECTED C-T LIQUID WATER CONTENT          ", %FOR, LWCC
LETVAR = "PMS PROBE FSSP TOTAL COUNTS                 ", %FOR, SUM15F
LETVAR = " FSSP PROBE CONCENTRATION                   ", %FOR, CONCF
LETVAR = " FSSP MEAN DIAMETER                         ", %FOR, DBARF
LETVAR = " FSSP DISPERSION (SIGMA/FDBAR)              ", %FOR, DISPF
LETVAR = " FSSP LIQUID WATER CONTENT                  ", %FOR, PLWCF
LETVAR = " FSSP CALCULATED ACTIVITY                   ", %FOR, FACT
LETVAR = " FSSP BEAM FRACTION (SUM15F/FSTROB)         ", %FOR, FBMFR
LETVAR = " FSSP RANGE (1=3-45 MICRONS)                ", %FOR, FRANGE
LETVAR = " FSSP FAST RESETS                           ", %FOR, FRESET
LETVAR = " FSSP TOTAL STROBE                          ", %FOR, FSTROB
LETVAR = "PMS PROBE 260X TOTAL COUNTS                 ", %FOR, SUMX6
LETVAR = " 260X PROBE CONCENTRATION                   ", %FOR, CONC6
LETVAR = " 260X MEAN DIAMETER                         ", %FOR, DBAR6
LETVAR = " 260X DISPERSION (SIGMA/FDBAR)              ", %FOR, DISP6
LETVAR = " 260X LIQUID WATER CONTENT                  ", %FOR, PLWC6
LETVAR = " 260X REFLECTIVITY FACTOR                   ", %FOR, DBZ6
LETVAR = " PMS 2-DC CONCENTRATION FROM SHADOW-OR      ", %FOR, CONC2C
LETVAR = " PMS 2-DP CONCENTRATION FROM SHADOW-OR      ", %FOR, CONC2P
LETVAR = "RADIOMETRIC SKY TEMPERATURE                 ", %FOR, RSTT
LETVAR = "RADIOMETRIC SURFACE TEMPERATURE             ", %FOR, RSTB
LETVAR = "TOP SHORTWAVE IRRADIANCE                    ", %FOR, SWT
LETVAR = "BOTTOM SHORTWAVE IRRADIANCE                 ", %FOR, SWB
LETVAR = "TOP    INFRARED CORRECTED IRRADIANCE        ", %FOR, IRTC
LETVAR = "BOTTOM INFRARED CORRECTED IRRADIANCE        ", %FOR, IRBC
LETVAR = "AIRCRAFT TRUE HEADING (ARINC)               ", %FOR, THI
LETVAR = "INS WANDER ANGLE                            ", %FOR, ALPHA
LETVAR = "CABIN STATIC PRESSURE                       ", %FOR, PCAB
LETVAR = "RAW STATIC PRESSURE (FUSELAGE DI)           ", %FOR, PSFD
LETVAR = "RAW STATIC PRESSURE (BOOM)                  ", %FOR, PSB
LETVAR = "RAW STATIC PRESSURE (WING)                  ", %FOR, PSW
LETVAR = "TOTAL TEMPERATURE (FUSELAGE HEATED)         ", %FOR, TTFH
LETVAR = "DEW/FROST POINT TEMP (THERMOELEC) (TOP)     ", %FOR, DPT
LETVAR = "DEW/FROST POINT TEMP (THERMOELEC) (BOT)     ", %FOR, DPB
LETVAR = "RAW BOTTOM INFRARED IRRADIANCE              ", %FOR, IRB
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LETVAR = "RAW TOP INFRARED IRRADIANCE             ", %FOR, IRT
LETVAR = "TOP PYRGEOMETER DOME TEMPERATURE        ", %FOR, DTT
LETVAR = "TOP PYRGEOMETER SINK TEMPERATURE        ", %FOR, STT
LETVAR = "BOTTOM PYRGEOMETER DOME TEMPERATURE     ", %FOR, DTB
LETVAR = "BOTTOM PYRGEOMETER SINK TEMPERATURE     ", %FOR, STB
LETVAR = "RAW C-T LIQUID WATER CONTENT            ", %FOR, LWC
LETVAR = " PMS 2DC PROBE (COUNTS)                 ", %FOR, SDWRC
LETVAR = "2D-P SHADOW-OR SIGNAL                   ", %FOR, SDWRP
LETVAR = "10V REFERENCE (EXT. CHASSIS)            ", %FOR, XV10
LETVAR = "TEN VOLT REF / RESISTOR                 ", %FOR, XV10R
LETVAR = "TEMP OF VOLTAGE REFERENCE(ADS EXTENSION)", %FOR, XTV10
LETVAR = "AIR TEMP ADS INTERFACE (EXT. CHASSIS)   ", %FOR, XTADS
LETVAR = "AIR TEMP-FLOW MONITOR    (ADS EXTENSION)", %FOR, XFLOAD
LETVAR = "FIXED ZERO VOLTAGE (EXT. CHASSIS)       ", %FOR, XFZV
LETVAR = "FIXED ZERO VOLTAGE / RESISTOR           ", %FOR, XFZVR
LETVAR = "DIFFERENCE OF 10-V REFS (EXT. CHASSIS)  ", %FOR, XVDREF
LETVAR = "10-V REFERENCE                          ", %FOR, V10
LETVAR = "10-V REFERENCE THROUGH RESISTOR         ", %FOR, V10R
LETVAR = "AIR TEMP ADS INTERFACE                  ", %FOR, TADS
LETVAR = "TEMP OF VOLTAGE REFERENCE               ", %FOR, TV10
LETVAR = "AIR TEMP FLOW MONITOR - ADS             ", %FOR, FLOADS
LETVAR = "FIXED ZERO VOLTAGE                      ", %FOR, FZV
LETVAR = "FIXED ZERO VOLTAGE THRU RESISTOR        ", %FOR, FZVR
LETVAR = "DIFFERENCE OF 10-V REFERENCES           ", %FOR, VDREF
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 01       ", %FOR, AFSP01
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 02       ", %FOR, AFSP02
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 03       ", %FOR, AFSP03
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 04       ", %FOR, AFSP04
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 05       ", %FOR, AFSP05
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 06       ", %FOR, AFSP06
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 07       ", %FOR, AFSP07
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 08       ", %FOR, AFSP08
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 09       ", %FOR, AFSP09
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 10       ", %FOR, AFSP10
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 11       ", %FOR, AFSP11
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 12       ", %FOR, AFSP12
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 13       ", %FOR, AFSP13
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 14       ", %FOR, AFSP14
LETVAR = " PMS PROBE FSSP RAW COUNT CELL 15       ", %FOR, AFSP15
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 01   ", %FOR, CFSP01
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 02   ", %FOR, CFSP02
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 03   ", %FOR, CFSP03
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 04   ", %FOR, CFSP04
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 05   ", %FOR, CFSP05
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 06   ", %FOR, CFSP06
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 07   ", %FOR, CFSP07
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 08   ", %FOR, CFSP08
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 09   ", %FOR, CFSP09
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 10   ", %FOR, CFSP10
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 11   ", %FOR, CFSP11
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 12   ", %FOR, CFSP12
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 13   ", %FOR, CFSP13
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 14   ", %FOR, CFSP14
LETVAR = " PMS PROBE FSSP CONCENTRATION CELL 15   ", %FOR, CFSP15
LETVAR = "RADON SAMPLE FLOW RATE                  ", %FOR, RADON
LETVAR = "LEAD-210 SAMPLE FLOW RATE               ", %FOR, PB210
LETVAR = "VERY INSENSITIVE FIELD MILL (TOP)       ", %FOR, VIFMT
LETVAR = "INSENSITIVE FIELD MILL (TOP)            ", %FOR, FMT
LETVAR = "SENSITIVE FIELD MILL (TOP)              ", %FOR, SFMT
LETVAR = "VERY INSENSITIVE FIELD MILL (BOTTOM)    ", %FOR, VIFMB
LETVAR = "INSENSITIVE FIELD MILL (BOTTOM)         ", %FOR, FMB
LETVAR = "SENSITIVE FIELD MILL (BOTTOM)           ", %FOR, SFMB
LETVAR = "HYDROGEN PEROXIDE CHANNEL 1             ", %FOR, PER1
LETVAR = "HYDROGEN PEROXIDE CHANNEL 2             ", %FOR, PER2
LETVAR = "FORMALDEHYDE CHANNEL 1                  ", %FOR, HCHO1
LETVAR = "FORMALDEHYDE CHANNEL 2                  ", %FOR, HCHO2
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LETVAR = "STATUS - PEROXIDE                       ", %FOR, STATP
LETVAR = "STATUS - FORMALDEHYDE                   ", %FOR, STATS
LETVAR = "LAMP VOLTAGE - PEROXIDE                 ", %FOR, LAMPP
LETVAR = "LAMP VOLTAGE - FORMALDEHYDE             ", %FOR, LAMPF
LETVAR = "OZONE SIGNAL                            ", %FOR, O3
LETVAR = "PEROXIDE FLOW 1                         ", %FOR, FLOW1
LETVAR = "PEROXIDE FLOW 2                         ", %FOR, FLOW2
LETVAR = "FORMALDEHYDE FLOW                       ", %FOR, FLOW3
LETVAR = "SGC TRAP 1 FLOW                         ", %FOR, TRAP1
LETVAR = "SGC TRAP 2 FLOW                         ", %FOR, TRAP2
LETVAR = "SGC CALIBRATION GAS FLOW 1              ", %FOR, CAL1
LETVAR = "SGC CALIBRATION GAS FLOW 2              ", %FOR, CAL2
LETVAR = "SGC MANIFOLD FLOW                       ", %FOR, FMANS
LETVAR = "SGC ZERO AIR FLOW                       ", %FOR, ZEROS
LETVAR = "SGC SAMPLE 1 STATE                      ", %FOR, RUN1
LETVAR = "SGC SAMPLE 2 STATE                      ", %FOR, RUN2
LETVAR = "GCMS CALIBRATION GAS FLOW               ", %FOR, CALG
LETVAR = "GCMS SAMPLE 1 FLOW                      ", %FOR, SAMP1
LETVAR = "GCMS SAMPLE 2 FLOW                      ", %FOR, SAMP2
LETVAR = "GCMS MANIFOLD FLOW                      ", %FOR, FMANG
LETVAR = "GCMS ZERO AIR FLOW                      ", %FOR, ZEROG
LETVAR = "GCMS SAMPLE 1 STATE                     ", %FOR, STAT1
LETVAR = "AMBIENT TEMPERATURE (  BOOM    )        ", %FOR, ATB
LETVAR = "AMBIENT TEMPERATURE (REVERSE FLOW)      ", %FOR, ATRF
LETVAR = "AMBIENT TEMPERATURE (FAST RESPONSE )    ", %FOR, ATKP
LETVAR = "HORIZONTAL WIND DIRECTION               ", %FOR, WD
LETVAR = "HORIZONTAL WIND SPEED                   ", %FOR, WS
LETVAR = "WIND VECTOR EAST GUST COMPONENT         ", %FOR, UI
LETVAR = "WIND VECTOR NORTH GUST COMPONENT        ", %FOR, VI
LETVAR = "WIND VECTOR VERTICAL GUST COMP          ", %FOR, WI
LETVAR = "WIND VECTOR LNGTDNL GUST COMPONENT      ", %FOR, UX
LETVAR = "WIND VECTOR LATERAL GUST COMPONENT      ", %FOR, VY
LETVAR = "PRESSURE-DAMPED INERTIAL ALTITUDE       ", %FOR, HI3
LETVAR = "POTENTIAL TEMPERATURE                   ", %FOR, THETA
LETVAR = "EQUIVALENT POTENTIAL TEMPERATURE        ", %FOR, THETAE
LETVAR = "VIRTUAL POTENTIAL TEMPREATURE           ", %FOR, THETAV
LETVAR = "ABSOLUTE HUMIDITY (LYMAN ALPHA - VLA)   ", %FOR, RHOLA1
LETVAR = " FLAG=-1.0,((RHOLA1-RHOTD)/RHOTD) > .15 ", %FOR, RFLAG
LETVAR = "CORRECTED PMS-KING LIQUID WATER CONTENT ", %FOR, PLWCC
LETVAR = "AIRCRAFT TRUE HEADING (YAW)             ", %FOR, THF
LETVAR = "AIRCRAFT ROLL ATTITUDE ANGLE            ", %FOR, ROLL
LETVAR = "AIRCRAFT PITCH ATTITUDE ANGLE           ", %FOR, PITCH
LETVAR = "AIRCRAFT INS VERTICAL ACCELERATION      ", %FOR, ACINS
LETVAR = "RAW INS VERTICAL VELOCITY               ", %FOR, VZI
LETVAR = "DAMPED AIRCRAFT VERT VELOCITY           ", %FOR, WP3
LETVAR = " GROUND SPEED  (INS)                    ", %FOR, GSF
LETVAR = "RAW INS GROUND SPEED EAST COMP          ", %FOR, VEW
LETVAR = "RAW INS GROUND SPEED NORTH COMP         ", %FOR, VNS
LETVAR = "RAW INS GROUND SPEED X COMPONENT        ", %FOR, XVI
LETVAR = "RAW INS GROUND SPEED Y COMPONENT        ", %FOR, YVI
LETVAR = " TRACK ANGLE                            ", %FOR, TRKI
LETVAR = "AIRCRAFT TRUE AIRSPEED (  BOOM  )       ", %FOR, TASB
LETVAR = "AIRCRAFT TRUE AIRSPEED (  GUST  )       ", %FOR, TASG
LETVAR = "AIRCRAFT TRUE AIRSPEED (  WING  )       ", %FOR, TASW
LETVAR = "CORRECTED DYNAMIC PRESSURE (BOOM)       ", %FOR, QCBC
LETVAR = "CORRECTED DYNAMIC PRESSURE (GUST)       ", %FOR, QCGC
LETVAR = "CORRECTED DYNAMIC PRESSURE (WING)       ", %FOR, QCWC
LETVAR = "RAW DYNAMIC PRESSURE (BOOM)             ", %FOR, QCB
LETVAR = "RAW DYNAMIC PRESSURE (GUST)             ", %FOR, QCG
LETVAR = "RAW DYNAMIC PRESSURE (WING)             ", %FOR, QCW
LETVAR = "ATTACK ANGLE (FIXED VANE,LEFT)          ", %FOR, AKFXL
LETVAR = "ATTACK ANGLE (FIXED VANE,RIGHT)         ", %FOR, AKFXR
LETVAR = "SIDESLIP ANGLE  (FIXED TOP    VANE)     ", %FOR, SSFXT
LETVAR = "SIDESLIP ANGLE  (FIXED BOTTOM VANE)     ", %FOR, SSFXB
LETVAR = "RAW ATTACK (FIXED VANE, LEFT)           ", %FOR, AFIXL
LETVAR = "RAW ATTACK (FIXED VANE, RIGHT)          ", %FOR, AFIXR
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LETVAR = "RAW SIDESLIP (FIXED VANE, TOP)              ", %FOR, BFIXT
LETVAR = "RAW SIDESLIP (FIXED VANE, BOTTOM)           ", %FOR, BFIXB
LETVAR = "TOTAL TEMPERATURE (BOOM)                    ", %FOR, TTB
LETVAR = "TOTAL TEMPERATURE (REVERSE FLOW)            ", %FOR, TTRF
LETVAR = "TOTAL TEMPERATURE (FAST RESPONSE)           ", %FOR, TTKP
LETVAR = "RAW LYMAN-ALPHA VOLTAGE                     ", %FOR, VLA
LETVAR = "RAW PMS-KING LIQUID WATER CONTENT           ", %FOR, PLWC
LETVAR = "SGC DETECTOR SIGNAL                         ", %FOR, DET
LETVAR = "SGC DETECTOR SIGNAL X5                      ", %FOR, DET5X
LETVAR = " PMS PROBE 260X RAW COUNT CELL 01-62        ", %FOR, ACCUMX6
LETVAR = " PMS 260X CONCENTRATIONS CELL 01-62         ", %FOR, CONCX6
ORDVAR = UNITS, SAMPLE, RATE, BITS, FSTBIT, SKIP
LETVAR = " HR      ",      1,        1, 32,        1,     0, %FOR, HR
LETVAR = " MIN     ",      1,        1, 32,       33,     0, %FOR, MIN
LETVAR = " S       ",      1,        1, 32,       65,     0, %FOR, SEC
LETVAR = " SEC     ",      1,        1, 32,       97,     0, %FOR, PTIME
LETVAR = " SEC     ",      1,        1, 32,      129,     0, %FOR, TPTIME
LETVAR = " SEC     ",      1,        1, 32,      161,     0, %FOR, TMLAG
LETVAR = " DEG     ",      1,        1, 32,      193,     0, %FOR, ALAT
LETVAR = " DEG     ",      1,        1, 32,      225,     0, %FOR, ALON
LETVAR = " KM      ",      1,        1, 32,      257,     0, %FOR, DEI
LETVAR = " KM      ",      1,        1, 32,      289,     0, %FOR, DNI
LETVAR = " MB      ",      1,        1, 32,      321,     0, %FOR, PSFDC
LETVAR = " MB      ",      1,        1, 32,      353,     0, %FOR, PSBC
LETVAR = " MB      ",      1,        1, 32,      385,     0, %FOR, PSWC
LETVAR = " C       ",      1,        1, 32,      417,     0, %FOR, ATFH
LETVAR = "  C      ",      1,        1, 32,      449,     0, %FOR, DPTC
LETVAR = "  C      ",      1,        1, 32,      481,     0, %FOR, DPBC
LETVAR = " M       ",      1,        1, 32,      513,     0, %FOR, HGM
LETVAR = " M       ",      1,        1, 32,      545,     0, %FOR, HGME
LETVAR = " M       ",      1,        1, 32,      577,     0, %FOR, PALT
LETVAR = " M       ",      1,        1, 32,      609,     0, %FOR, DVALU
LETVAR = " MB      ",      1,        1, 32,      641,     0, %FOR, PSURF
LETVAR = " C       ",      1,        1, 32,      673,     0, %FOR, TVIR
LETVAR = "G/M3     ",      1,        1, 32,      705,     0, %FOR, RHODT
LETVAR = "G/M3     ",      1,        1, 32,      737,     0, %FOR, RHODB
LETVAR = "PERCENT  ",      1,        1, 32,      769,     0, %FOR, RHUM
LETVAR = " G/KG    ",      1,        1, 32,      801,     0, %FOR, MR
LETVAR = " G/KG    ",      1,        1, 32,      833,     0, %FOR, SPHUM
LETVAR = " G/M3    ",      1,        1, 32,      865,     0, %FOR, LWCC
LETVAR = "COUNTS   ",      1,        1, 32,      897,     0, %FOR, SUM15F
LETVAR = " N/CC    ",      1,        1, 32,      929,     0, %FOR, CONCF
LETVAR = "MICRON   ",      1,        1, 32,      961,     0, %FOR, DBARF
LETVAR = "         ",      1,        1, 32,      993,     0, %FOR, DISPF
LETVAR = "G/M3     ",      1,        1, 32,     1025,     0, %FOR, PLWCF
LETVAR = "PERCENT  ",      1,        1, 32,     1057,     0, %FOR, FACT
LETVAR = "         ",      1,        1, 32,     1089,     0, %FOR, FBMFR
LETVAR = "R=1-4    ",      1,        1, 32,     1121,     0, %FOR, FRANGE
LETVAR = "COUNTS   ",      1,        1, 32,     1153,     0, %FOR, FRESET
LETVAR = "COUNTS   ",      1,        1, 32,     1185,     0, %FOR, FSTROB
LETVAR = "COUNTS   ",      1,        1, 32,     1217,     0, %FOR, SUMX6
LETVAR = " N/LTR   ",      1,        1, 32,     1249,     0, %FOR, CONC6
LETVAR = "MICRON   ",      1,        1, 32,     1281,     0, %FOR, DBAR6
LETVAR = "         ",      1,        1, 32,     1313,     0, %FOR, DISP6
LETVAR = "G/M3     ",      1,        1, 32,     1345,     0, %FOR, PLWC6
LETVAR = "MM6/M3   ",      1,        1, 32,     1377,     0, %FOR, DBZ6
LETVAR = " N/LTR   ",      1,        1, 32,     1409,     0, %FOR, CONC2C
LETVAR = " N/LTR   ",      1,        1, 32,     1441,     0, %FOR, CONC2P
LETVAR = " C       ",      1,        1, 32,     1473,     0, %FOR, RSTT
LETVAR = " C       ",      1,        1, 32,     1505,     0, %FOR, RSTB
LETVAR = " W/M2    ",      1,        1, 32,     1537,     0, %FOR, SWT
LETVAR = " W/M2    ",      1,        1, 32,     1569,     0, %FOR, SWB
LETVAR = " W/M2    ",      1,        1, 32,     1601,     0, %FOR, IRTC
LETVAR = " W/M2    ",      1,        1, 32,     1633,     0, %FOR, IRBC
LETVAR = " DEG     ",      1,        1, 32,     1665,     0, %FOR, THI
LETVAR = " DEG     ",      1,        1, 32,     1697,     0, %FOR, ALPHA
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LETVAR = " MB      ",     1,      1, 32,    1729,     0, %FOR, PCAB
LETVAR = " MB      ",     1,      1, 32,    1761,     0, %FOR, PSFD
LETVAR = " MB      ",     1,      1, 32,    1793,     0, %FOR, PSB
LETVAR = " MB      ",     1,      1, 32,    1825,     0, %FOR, PSW
LETVAR = " C       ",     1,      1, 32,    1857,     0, %FOR, TTFH
LETVAR = " C       ",     1,      1, 32,    1889,     0, %FOR, DPT
LETVAR = " C       ",     1,      1, 32,    1921,     0, %FOR, DPB
LETVAR = " W/M2    ",     1,      1, 32,    1953,     0, %FOR, IRB
LETVAR = " W/M2    ",     1,      1, 32,    1985,     0, %FOR, IRT
LETVAR = " C       ",     1,      1, 32,    2017,     0, %FOR, DTT
LETVAR = " C       ",     1,      1, 32,    2049,     0, %FOR, STT
LETVAR = " C       ",     1,      1, 32,    2081,     0, %FOR, DTB
LETVAR = " C       ",     1,      1, 32,    2113,     0, %FOR, STB
LETVAR = " G/M3    ",     1,      1, 32,    2145,     0, %FOR, LWC
LETVAR = " CNTS    ",     1,      1, 32,    2177,     0, %FOR, SDWRC
LETVAR = " CNTS    ",     1,      1, 32,    2209,     0, %FOR, SDWRP
LETVAR = " VDC     ",     1,      1, 32,    2241,     0, %FOR, XV10
LETVAR = " V       ",     1,      1, 32,    2273,     0, %FOR, XV10R
LETVAR = " C       ",     1,      1, 32,    2305,     0, %FOR, XTV10
LETVAR = " C       ",     1,      1, 32,    2337,     0, %FOR, XTADS
LETVAR = " C       ",     1,      1, 32,    2369,     0, %FOR, XFLOAD
LETVAR = " VDC     ",     1,      1, 32,    2401,     0, %FOR, XFZV
LETVAR = " V       ",     1,      1, 32,    2433,     0, %FOR, XFZVR
LETVAR = " VDC     ",     1,      1, 32,    2465,     0, %FOR, XVDREF
LETVAR = " VDC     ",     1,      1, 32,    2497,     0, %FOR, V10
LETVAR = " VDC     ",     1,      1, 32,    2529,     0, %FOR, V10R
LETVAR = " C       ",     1,      1, 32,    2561,     0, %FOR, TADS
LETVAR = " C       ",     1,      1, 32,    2593,     0, %FOR, TV10
LETVAR = " C       ",     1,      1, 32,    2625,     0, %FOR, FLOADS
LETVAR = " VDC     ",     1,      1, 32,    2657,     0, %FOR, FZV
LETVAR = " VDC     ",     1,      1, 32,    2689,     0, %FOR, FZVR
LETVAR = " VDC     ",     1,      1, 32,    2721,     0, %FOR, VDREF
LETVAR = "COUNTS   ",     1,      1, 32,    2753,     0, %FOR, AFSP01
LETVAR = "COUNTS   ",     1,      1, 32,    2785,     0, %FOR, AFSP02
LETVAR = "COUNTS   ",     1,      1, 32,    2817,     0, %FOR, AFSP03
LETVAR = "COUNTS   ",     1,      1, 32,    2849,     0, %FOR, AFSP04
LETVAR = "COUNTS   ",     1,      1, 32,    2881,     0, %FOR, AFSP05
LETVAR = "COUNTS   ",     1,      1, 32,    2913,     0, %FOR, AFSP06
LETVAR = "COUNTS   ",     1,      1, 32,    2945,     0, %FOR, AFSP07
LETVAR = "COUNTS   ",     1,      1, 32,    2977,     0, %FOR, AFSP08
LETVAR = "COUNTS   ",     1,      1, 32,    3009,     0, %FOR, AFSP09
LETVAR = "COUNTS   ",     1,      1, 32,    3041,     0, %FOR, AFSP10
LETVAR = "COUNTS   ",     1,      1, 32,    3073,     0, %FOR, AFSP11
LETVAR = "COUNTS   ",     1,      1, 32,    3105,     0, %FOR, AFSP12
LETVAR = "COUNTS   ",     1,      1, 32,    3137,     0, %FOR, AFSP13
LETVAR = "COUNTS   ",     1,      1, 32,    3169,     0, %FOR, AFSP14
LETVAR = "COUNTS   ",     1,      1, 32,    3201,     0, %FOR, AFSP15
LETVAR = "N/CC     ",     1,      1, 32,    3233,     0, %FOR, CFSP01
LETVAR = "N/CC     ",     1,      1, 32,    3265,     0, %FOR, CFSP02
LETVAR = "N/CC     ",     1,      1, 32,    3297,     0, %FOR, CFSP03
LETVAR = "N/CC     ",     1,      1, 32,    3329,     0, %FOR, CFSP04
LETVAR = "N/CC     ",     1,      1, 32,    3361,     0, %FOR, CFSP05
LETVAR = "N/CC     ",     1,      1, 32,    3393,     0, %FOR, CFSP06
LETVAR = "N/CC     ",     1,      1, 32,    3425,     0, %FOR, CFSP07
LETVAR = "N/CC     ",     1,      1, 32,    3457,     0, %FOR, CFSP08
LETVAR = "N/CC     ",     1,      1, 32,    3489,     0, %FOR, CFSP09
LETVAR = "N/CC     ",     1,      1, 32,    3521,     0, %FOR, CFSP10
LETVAR = "N/CC     ",     1,      1, 32,    3553,     0, %FOR, CFSP11
LETVAR = "N/CC     ",     1,      1, 32,    3585,     0, %FOR, CFSP12
LETVAR = "N/CC     ",     1,      1, 32,    3617,     0, %FOR, CFSP13
LETVAR = "N/CC     ",     1,      1, 32,    3649,     0, %FOR, CFSP14
LETVAR = "N/CC     ",     1,      1, 32,    3681,     0, %FOR, CFSP15
LETVAR = "  VDC    ",     1,      1, 32,    3713,     0, %FOR, RADON
LETVAR = "  VDC    ",     1,      1, 32,    3745,     0, %FOR, PB210
LETVAR = "  VDC    ",     1,      1, 32,    3777,     0, %FOR, VIFMT
LETVAR = "  VDC    ",     1,      1, 32,    3809,     0, %FOR, FMT
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LETVAR = " VDC     ".     1.     1. 32.    3841.     0. %FOR. SFMT
LETVAR = " VDC     ".     1.     1. 32.    3873.     0. %FOR. VIFMB
LETVAR = " VDC     ".     1.     1. 32.    3905.     0. %FOR. FMB
LETVAR = " VDC     ".     1.     1. 32.    3937.     0. %FOR. SFMB
LETVAR = " VDC     ".     1.     1. 32.    3969.     0. %FOR. PER1
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LETVAR = " VDC     ".     1.     1. 32.    4033.     0. %FOR. HCHO1
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LETVAR = " VDC     ".     1.     1. 32.    4097.     0. %FOR. STATP
LETVAR = " VDC     ".     1.     1. 32.    4129.     0. %FOR. STATS
LETVAR = " VDC     ".     1.     1. 32.    4161.     0. %FOR. LAMPP
LETVAR = " VDC     ".     1.     1. 32.    4193.     0. %FOR. LAMPF
LETVAR = " VDC     ".     1.     1. 32.    4225.     0. %FOR. O3
LETVAR = " VDC     ".     1.     1. 32.    4257.     0. %FOR. FLOW1
LETVAR = " VDC     ".     1.     1. 32.    4289.     0. %FOR. FLOW2
LETVAR = " VDC     ".     1.     1. 32.    4321.     0. %FOR. FLOW3
LETVAR = "L/MIN    ".     1.     1. 32.    4353.     0. %FOR. TRAP1
LETVAR = "L/MIN    ".     1.     1. 32.    4385.     0. %FOR. TRAP2
LETVAR = "L/MIN    ".     1.     1. 32.    4417.     0. %FOR. CAL1
LETVAR = "L/MIN    ".     1.     1. 32.    4449.     0. %FOR. CAL2
LETVAR = "L/MIN    ".     1.     1. 32.    4481.     0. %FOR. FMANS
LETVAR = "L/MIN    ".     1.     1. 32.    4513.     0. %FOR. ZEROS
LETVAR = " VDC     ".     1.     1. 32.    4545.     0. %FOR. RUN1
LETVAR = " VDC     ".     1.     1. 32.    4577.     0. %FOR. RUN2
LETVAR = "L/MIN    ".     1.     1. 32.    4609.     0. %FOR. CALG
LETVAR = "L/MIN    ".     1.     1. 32.    4641.     0. %FOR. SAMP1
LETVAR = "L/MIN    ".     1.     1. 32.    4673.     0. %FOR. SAMP2
LETVAR = "L/MIN    ".     1.     1. 32.    4705.     0. %FOR. FMANG
LETVAR = "L/MIN    ".     1.     1. 32.    4737.     0. %FOR. ZEROG
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LETVAR = " C       ".    20.    20. 32.    6081.     0. %FOR. ATKP
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LETVAR = " M/S     ".    20.    20. 32.    7361.     0. %FOR. WS
LETVAR = " M/S     ".    20.    20. 32.    8001.     0. %FOR. UI
LETVAR = " M/S     ".    20.    20. 32.    8641.     0. %FOR. VI
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LETVAR = " M/S     ".    20.    20. 32.    9921.     0. %FOR. UX
LETVAR = " M/S     ".    20.    20. 32.   10561.     0. %FOR. VY
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LETVAR = " K       ".    20.    20. 32.   11841.     0. %FOR. THETA
LETVAR = " K       ".    20.    20. 32.   12481.     0. %FOR. THETAE
LETVAR = " K       ".    20.    20. 32.   13121.     0. %FOR. THETAV
LETVAR = " G/M3    ".    20.    20. 32.   13761.     0. %FOR. RHOLA1
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LETVAR = " G/M3    ".    20.    20. 32.   15041.     0. %FOR. PLWCC
LETVAR = " DEG     ".    20.    20. 32.   15681.     0. %FOR. THF
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LETVAR = " DEG     ".    20.    20. 32.   16961.     0. %FOR. PITCH
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LETVAR = " M/S     ".    20.    20. 32.   18881.     0. %FOR. WP3
LETVAR = " M/S     ".    20.    20. 32.   19521.     0. %FOR. GSF
LETVAR = " M/S     ".    20.    20. 32.   20161.     0. %FOR. VEW
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LETVAR = " MB      ".    20.    20. 32.   27201.     0. %FOR. QCB
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LETVAR = " C        ",     20,      20, 32,    35521,       O, %FOR, TTKP
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LETVAR = " W        ",     20,      20, 32,    36801,       O, %FOR, PLWC
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LETVAR = "N/LTR     ",     62,      62, 32,    40705,       O, %FOR, CONCX6
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LETVAR =  1, 2,  1000.0000  , 1000.0000  , %FOR, TASG
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LETVAR =  1, 2,  1000.0000  , 1000.0000  , %FOR, QCWC
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LETVAR =  1, 2,  1000.0000  , 1000.0000  , %FOR, TTRF
LETVAR =  1, 2,  1000.0000  , 1000.0000  , %FOR, TTKP
LETVAR =  1, 2,  1000.0000  , 1000.0000  , %FOR, VLA
LETVAR =  1, 2,  1000.0000  , 1000.0000  , %FOR, PLWC
LETVAR =  1, 2,  1000.0000  , 1000.0000  , %FOR, DET
LETVAR =  1, 2,  1000.0000  , 1000.0000  , %FOR, DETSX
LETVAR =  1, 2,  1000.0000  , 1000.0000  , %FOR, ACCUMX6
LETVAR =  1, 2,  1000.0000  , 1000.0000  , %FOR, CONCX6
ENDHD
```

APPENDIX D

Brief Description of Variables and Algorithms

Some useful constants used in the following algorithms:

c_p = specific heat at constant pressure, 0.24 cal g^{-1} k^{-1}

c_v = specific heat at constant volume, 0.171 cal g^{-1} k^{-1}

R = gas constant for dry air, 6.8557×10^{-2} cal g^{-1} k^{-1}

σ = Boltzmann's Constant 1.38×10^{-23} joule-molecule^{-1}°K^{-1}

I. PARAMETERS OBTAINED FROM THE INERTIAL NAVIGATION SYSTEM (INS)

A Litton LTN-51 inertial navigation system is used to obtain aircraft position and attitude information. Three types of signals are input to the ADS data system from the INS. The first signal type is a serial digital data stream containing the variables ALAT, ALON, XVI, YVI, THI, and ALPHA. Because the INS reference time is not synchronized to the data system clock, these variables are shifted in subsequent processing to be synchronized with that clock. (See variable TMLAG.) A second signal type is a two-speed resolver output containing aircraft attitude information. The resolver outputs are converted to digital signals in the ADS hardware. Resolver output variables are PITCH, ROLL, CROLL, and PHDG. The third signal is a digital pulse stream recorded from the INS vertical accelerometer. This is used to obtain aircraft vertical velocity (VZI) and vertical acceleration (ACINS).

Raw INS Parameters

INS - Data System Time Lag (seconds) - TMLAG

This is the amount of time between the reference time of the Litton LTN-51 and the data-system clock in seconds. The time lag is always less than 2 s.

INS Latitude (deg) - ALAT

Aircraft latitude output from the INS at one sample per second (sps). Positive values are north. The resolution is 5 arc seconds (0.0014°).

INS Longitude (deg) - ALON

Aircraft longitude output from the INS at 1 sps. Positive values are east. The resolution is 5 arc seconds (0.0014°).

Raw INS Ground Speed X Component (m/s) - XVI

This is an output from the INS (10 sps) of the ground speed component along the x-axis of the INS platform. (During alignment of the INS, the x-axis is parallel to the longitudinal axis of the aircraft.) The resolution is 0.012 m/s.

Raw INS Ground Speed Y Component (m/s) - YVI

This is an output from the INS (10 sps) of the ground speed component along the y-axis of the INS platform. (During alignment of the INS, the y-axis is normal to the longitudinal axis of the aircraft.) The resolution is 0.012 m/s.

Raw INS True Heading (deg) - THI

This is an output from the INS (5 sps) giving the true heading of the aircraft. The resolution is 5 arc seconds (0.0014°).

INS Wander Angle (deg) - ALPHA

This is an output from the INS (5 sps) giving the difference between the platform heading x-axis and true north. ALPHA wanders slowly depending upon the east-west velocity of the aircraft. The resolution is 5 arc seconds (0.0014°).

Aircraft Pitch Attitude Angle (deg) - PITCH

This is an output from an 8:1 pitch-axis resolver. The range is ±22.5°. The resolution is 10 arc seconds (0.0028°).

Aircraft Roll Attitude Angle (deg) - ROLL

This is an output from an 8:1 roll-axis resolver. The output is synchronized with CROLL. The resolution is 10 arc seconds (0.0028°).

Aircraft Coarse Roll Attitude Angle (deg) - CROLL

This is an output from coarse roll-axis resolver. The resolution is ≈80 arc seconds (0.0228°).

INS Platform Heading (deg) - PHDG

This is an output from an 8:1 platform heading axis resolver. The resolution is 10 arc seconds (0.0028°).

Aircraft Vertical Velocity (m/s) - VZI

This is an integrated output from an up/down binary counter connected to the INS vertical accelerometer. Resolution is 0.012 m/s. Due to changes in local gravity, this is not an absolute quantity but drifts from zero considerably.

Parameters Derived from Raw INS Parameters

Vertical Acceleration of the Aircraft (m/s^2) - ACINS

This is the derivative of VZI.

Aircraft True Heading (deg) - THF

This a derived output of the horizontal projection of the aircraft centerline with reference to true north, calculated from PHDG and ALPHA. Resolution is 10 arc seconds (0.0028°)

$$\mathrm{THF} = \mathrm{PHDG} + \mathrm{ALPHA}$$

Aircraft Ground Speed (m/s) - GSF

This is a derived output from XVI and YVI giving the scalar magnitude of the INS ground speed.

$$\mathrm{GSF} = (\mathrm{XVI}^2 + \mathrm{YVI}^2)^{1/2}$$

Aircraft Ground Speed East Component (m/s) - VEW

This is a derived output using XVI, YVI, and ALPHA that rotates the horizontal ground speed components to a geographic reference frame. Positive values are toward the east.

Aircraft Ground Speed North Component (m/s) - VNS

This is a derived output using XVI, YVI, and ALPHA that rotates the horizontal ground speed components to a geographic reference frame. Positive values are toward the north.

Pressure-Damped Aircraft Vertical Velocity (m/s) - WP3

This is a derived output incorporating a third-order damping feedback loop to remove the drift from VZI using PALT as a long-term stable reference. Positive values are up.

Distance East (North) of a Reference (km) - DEI (DNI) or DEIxxx (DNIxxx)

This is a derived output obtained by subtracting the current position (ALAT and ALON) from a reference position. The reference position can be either the start of the flight (DEI, DNI) or some reference point, xxx (DEIxxx, DNIxxx). These values are then converted to kilometers.

$$\mathrm{DEI(xxx)} = (\mathrm{ALON} - \text{Reference Longitude}) \times (111.17) \times \cos(\mathrm{ALAT})$$
$$\mathrm{DNI(xxx)} = (\mathrm{ALAT} - \text{Reference Latitude}) \times (111.17)$$

The accuracy of these values is dependent on the accuracy of the INS; thus the accuracy degrades with time during the flight. (Refer to other Bulletins.)

II. AIRCRAFT AND METEOROLOGICAL STATE PARAMETERS

Meteorological and aircraft state parameters are measured at various locations on the aircraft. Generally, the location is part of the variable name in the output product. In this appendix, locations will be represented by x. In measurements from RAF aircraft, x may represent the following:

x = B measurement on the boom
x = G measurement on the gust probe
x = F measurement on the fuselage
x = W measurement on a wing

Note that the boom and gust probe are the same structure. The difference in these two measurements is the transducer used and its location. In the gust probe dynamic pressure measurement the transducer (Rosemount Model 1332 differential pressure transducer) is located closer to the sensor in the gust probe itself, whereas in the boom measurement, the transducer (Rosemount Model 1221 pressure transducer) is typically located in the aircraft nose.

Static Pressure (mb) - PSx, PSxC

These values are obtained from a calibrated pressure transducer at location x. The PSx values are measured static pressures that are affected by local flow-field distortion. The PSxC values are static pressures corrected for local flow field distortion. (See Bulletin No. 21.) The type of pressure transducer used is indicated in output variables PSFD and PSFDC. Here a Rosemount Model 1501 digital absolute pressure transducer is used. In other measurements the Rosemount Model 1201 absolute pressure transducer is used.

Dynamic Pressure (mb) - QCx, QCxC

These values are obtained from a calibrated differential pressure transducer. The measurement is the difference between a pitot pressure at location x and a static pressure. The QCxC value is corrected for local flow field distortion. The Rosemount Model 1221 differential pressure transducer is used for all direct dynamic differential pressure measurements, except in the case of QCG where a Rosemount Model 1332 differential pressure transducer is used.

Total Temperature (C) - TTx, TTxx

This is the output of the recovery temperature from a calibrated temperature sensor at location x. (For Rosemount temperature probes, the recovery temperature is a close approximation to the total temperature.) In the standard output, the total temperature (and ambient temperature) variable name also conveys the sensor type. The variable named TTx is obtained with a Rosemount Model 102 non-deiced temperature sensor. The variable named TTxH is obtained with a Rosemount Model 102 deiced (heated) temperature sensor. TTRF is obtained from the NCAR reverse-flow temperature sensor, and TTKP is obtained from the NCAR fast-response (K-probe) temperature sensor.

Ambient Temperature (C) - ATx, ATxx

The ambient temperature variable name, ATx, conveys the same information regarding sensor type and location as the variable name used with total (recovery) temperature.

The ambient temperature is calculated from the total temperature and dynamic heating considerations using conservation of energy for a perfect gas undergoing an adiabatic (in this case, deceleration) process.

From conservation of energy:

$$U_a^2/2 + c_p T_a = U_t^2/2 + c_p T_t$$

where

U_a = aircraft velocity, m/s

U_t = 0 for a perfect adiabatic deceleration at the sensing element.

T_a = the ambient temperature or the static air temperature, i.e., the temperature of the air at rest, K.

T_t = the total temperature, i.e., the temperature of the air at rest plus the temperature increase due to an adiabatic deceleration of the air at the temperature sensing element, K.

c_p = specific heat at constant pressure for dry air.

The above equation becomes:

$$T_a = T_t - U_a^2/(2c_p)$$

In general, most aircraft temperature sensors do not measure the value T_t, the total temperature, exactly but measure the temperature of the air immediately in contact with the sensing element. This air will not have undergone an adiabatic deceleration to zero velocity and, hence, will have a temperature somewhat less than T_t. This temperature is the measured or "recovery" temperature T_r. The ratio of the actual temperature difference attained, $T_r - T_t$, to the adiabatic temperature difference $U_a^2/2c_p$ is the recovery factor, r:

$$r = \frac{T_r - T_a}{U_a^2/2c_p} = \frac{T_r - T_a}{T_t - T_a}$$

where T_r is the measured (recovery) temperature, K.

Thus, the ambient temperature becomes:

$$T_a = T_r - rU_a^2/(2c_p)$$

The recovery factor can also be expressed in terms of the "fraction of the airspeed" in thermal contact with the sensing element. By substituting fU_a for U_t and T_r for T_t in the energy conservation equation above, the following result is obtained:

$$r = (1-f^2) = \frac{T_r - T_a}{U_a^2/2c_p} = \frac{T_r - T_a}{T_t - T_a}$$

where f = the "fraction of the airspeed" in direct contact with the sensing element.

The Rosemount temperature sensors used on RAF aircraft are designed to decelerate the air adiabatically to zero velocity. In fact they do not, but they come very close. Recovery factors determined from wind tunnel testing for the Rosemount sensors are 0.95 (non-deiced model) and 0.98 (deiced model). The recovery factor determined for the NCAR reverse-flow sensor is 0.6. The recovery factor for the NCAR fast-response (K-probe) temperature sensor is 0.8.

As can be seen in the above equation, the true airspeed, U_a, is required in order to calculate the ambient temperature. Conversely, the ambient temperature is required in order to calculate the true airspeed. (See page D.7.) The Mach number is used along with the recovery temperature to effectively solve two equations with two unknowns to obtain both the ambient temperature and the true airspeed. The Mach number is a dimensionless quantity that is not dependent upon temperature, but is a function of measured dynamic and static pressure.

The above expression can be expressed in terms of Mach number as follows:

$$a = (\gamma R T_a)^{1/2}$$

$$U_a^2 = M^2 a^2 = (\gamma R T_a) M^2$$

where

a = speed of sound, m/s
M = Mach number (see page D.8 for Mach number calculation)
γ = ratio of specific heat at constant pressure to specific heat at constant volume $= c_p/c_v$
R = gas constant for dry air
T_a = ambient temperature, K

thus:

$$T_a = T_r - r(\gamma R T_a M^2)/2c_p$$

solving for T_a:

$$T_a = T_r/(1+M^2(\frac{\gamma -1}{2}))$$

thus:

$$ATx = T_a - 273.16$$

Dew/Frost Point (C) - DPx

This variable is output from an EG&G Model 137 dew-point hygrometer. Below 0°C the instrument is assumed to be measuring the frost point.

Corrected Dew Point (C) - DPxC

This value is the frost point value adjusted to dew point. The difference between the dew point and the frost point is derived from the Goff-Gratch equations for water vapor pressure over plane surfaces of water and ice. The final adjusted dew point is with respect to a plane water surface. The accuracy of the conversion (one sigma) is 0.02°C over a range of 0 to -80°C.

$$xDPC = 0.009109+DPx(1.134055+0.001038DPx)$$

Voltage Output From the Lyman-alpha Sensor (VDC) - VLA

The Lyman-alpha sensor is an absorption hygrometer designed and built at NCAR to provide fast-response, high-resolution water vapor density measurements. At present, the user is supplied with the output voltage only, since processing of this output is still in the developmental stage. Algorithms are available for deducing specific humidity from the Lyman-alpha voltage. Interested investigators should contact RAF for assistance.

Aircraft True Airspeed (m/s) - TASx

This is a derived variable based upon a Mach number calculated from both the dynamic pressure at location x and static pressure. As in the case with ambient temperature, this expression is obtained from conservation of energy for a perfect gas undergoing an adiabatic process.

For a perfect gas:

$$a = (\gamma RT_a)^{1/2}$$

where

a = speed of sound, m/s
γ = c_p/c_v, the ratio of specific heat at constant pressure to that at constant volume
R = gas constant for dry air
T_a = ambient temperature, K

thus:

$$TASx = U_a = (\gamma R T_a)^{1/2} M$$

where M is the Mach number:

$$M = [2(c_v/R)((Q_c/P_s + 1)^{R/c_p} - 1)]^{1/2}$$

where

Q_c = dynamic pressure, mb
P_s = static pressure, mb

Substituting the recovery temperature for the ambient temperature (see section on ambient temperature) yields the following:

$$U_a^2 = \left[\gamma R \frac{T_r}{(1 + M^2 r (\frac{\gamma - 1}{2}))} \right] M^2$$

where

U_a = the true airspeed, TASx, m/s
T_r = the "recovery" temperature K
r = the recovery factor

Simplifying the above yields:

$$U_a = \left[\frac{\gamma R T_r}{(\frac{1}{M^2} + r \frac{(\gamma - 1)}{2})} \right]^{1/2}$$

Cabin Pressure (mb) - PCAB

Output of a Rosemount Model 1201 absolute pressure tansducer open to the interior of the aircraft cabin.

III. WINDS

Appendix E details the manner in which the wind components both with respect to the earth (UI, VI, and WI) and with respect to the aircraft (UX and VY) are obtained. In the data processing, a separate subroutine (GUSTO) is used to derive these wind components. That subroutine requires input of the INS parameters as well as true airspeed, aircraft attack angle, and aircraft sideslip angle. The wind components calculated in GUSTO are used to derive two additional components: the wind speed and wind direction.

Wind Speed (m/s) - WS
Wind Direction (deg) - WD

These variables are obtained in a straightforward manner from both UI and VI.

$$WS = (UI^2+VI^2)^{1/2}$$
WD = arc tangent function of the ratio UI/VI+180°

where

UI = easterly component of the horizontal wind measurement with respect to the earth. Positive values are toward the east.
VI = northerly component of the horizontal wind measurement with respect to the earth. Positive values are toward the north.

Vertical Wind Component with Respect to the Earth (m/s) - WI

This is the vertical wind component with respect to the earth obtained as specified in Appendix E. Positive values are up.

Wind Components with Respect to the Aircraft (m/s) - UX, VY

The variable UX is the component of the horizontal wind measurement parallel to the longitudinal axis of the aircraft. Positive is toward the nose of the aircraft. The variable VY is the component of the horizontal wind measurement normal to the longitudinal axis of the aircraft. Positive is toward the left wing of the aircraft.

Attack Differential Pressure (mb) - ADIF, ADIFR

This is the differential pressure in the vertical plane of the gust probe flow-angle sensor (aircraft vertical plane). The gust probe flow-angle sensor is either a Rosemount Model 858 flow-angle sensor (ADIF) or a nose radome (ADIFR). The differential pressure is measured with a Rosemount Model 1221 differential pressure transducer.

Sideslip Differential Pressure (mb) - BDIF, BDIFR

This is the differential pressure in the horizontal plane of the gust probe flow-angle sensor (aircraft horizontal plane). The gust probe flow-angle sensor is either a Rosemount Model 858 (BDIF) or a nose radome (BDIFR). The differential pressure is measured with a Rosemount Model 1221 differential pressure transducer.

Attack Angle (Differential Pressure) (deg) - AKDF, AKRD

This is a derived output of the attack angle obtained from either ADIF or ADIFR, a dynamic pressure, and a sensitivity function. For the Rosemount 858 flow-angle sensor, the sensitivity function is a constant 0.079 for Mach numbers less than 0.515. For Mach numbers greater than 0.515 the sensitivity decreases (a function of Mach number). For the nose radome gust probe, the sensitivity function has been empirically determined.

$$\text{ADKF (858)} = \frac{\text{ADIF}}{\text{GR*QCB}}$$

where GR is the sensitivity function.

Sideslip Angle (Differential Pressure) (deg) - SSDF, SSRD

This is a derived output of the sideslip angle obtained from either BDIF or BDIFR, a dynamic pressure, and a sensitivity function. For the Rosemount 858 flow-angle sensor, the sensitivity function is a constant 0.079 for Mach numbers less than 0.515. For Mach numbers greater than 0.515 the sensitivity decreases (a function of Mach number). For the nose radome gust probe, the sensitivity function has been empirically determined.

$$\text{SSDF (858)} = \frac{\text{BDIF}}{\text{GR*QCB}}$$

where GR is the sensitivity function.

Raw Attack (Fixed Vane) (g) - AFIXx

This is an amplified output from a strain-gage, fixed-vane sensor mounted in the horizontal plane of the aircraft at the end of the gust boom. The "force" on the vane (calibrated in "equivalent grams" at Jefferson County Airport gravity) varies as a function of the aircraft attack angle and dynamic presure. Here x refers to left or right.

Raw Sideslip (Fixed Vane) (g) - BFIXx

This is an amplified output from a strain-gage, fixed-vane sensor mounted in the vertical plane of the aircraft at the end of the gust boom. The "force" on the vane (calibrated in "equivalent grams" at Jefferson County Airport gravity) varies as a function of the aircraft sideslip angle and dynamic pressure. Here x refers to top or bottom.

Attack Angle (Fixed Vane) (deg) - AKFXx

This is a derived output of the attack angle computed from AFIXx, and QCx (either boom or gust dynamic pressure). An empirically derived function, HSSATK, is used to determine the attack angle based upon wind tunnel test data.

Sideslip Angle (Fixed Vane) (deg) - SSFXx

This is a derived output of the sideslip angle computed from BFIXx, and QCx (either boom or gust dynamic pressure). An empirically derived function, HSSATK, is used to determine the sideslip angle based upon wind tunnel test data.

IV. THERMODYNAMIC PARAMETERS

Water Vapor Pressure (mb) - ESUBW(T), ESUBI(T)

This is a derived intermediate parameter used in the calculation of several thermodynamic parameters. The vapor pressure is obtained according to the Goff-Gratch Formulation. Since this formulation is for pure water, and not moist air, an "enhancement factor" is also incorporated into this calculation. (See Buck (1981).) The formulation for vapor pressure, with respect to a plane water surface and with respect to an ice surface, and the enhancement factors used follow. (Which function applied, water vapor over water or over ice, is dependent upon temperature.)

A. $T \geq 273.15K$ (vapor pressure with respect to a plane water surface)

$$\log_{10} e_w = 23.832241 - 5.02808\log_{10}(T) - 1.3816x10^{-7}(10^A) + 8.1328x10^{-3}(10^B) + C$$

$$A = 11.334 - 0.0303998(T)$$

$$B = 3.49149 - 1302.8844/T$$

$$C = -2949.076/T$$

B. $T < 273.15K$ (vapor pressure with respect to a plane ice surface)

$$\log_{10} e_i = 10^A;\ A = 3.56654\log_{10}(T) - 0.0032098(T) - 2484.956/T + 2.0702294$$

Note: T (in Kelvins) is either the ambient temperature (saturation vapor pressure) or the dew/frost point temperature.

Enhancement Factors*

A. f_w = enhancement factor for calculation of the water vapor pressure of moist air with respect to a plane water surface

$$f_w = 1.0007 + (3.46x10^{-6}p)$$

p = pressure, mb

B. f_i = enhancement factor for calculation of the water vapor pressure of moist air with respect to a plane ice surface

$$f_i = 1.0003 + (4.18x10^{-6}p)$$

p = pressure, mb

Thus, water vapor pressures for moist air are calculated as follows:

$$e_{wc} = f_w e_w$$

$$e_{ic} = f_i e_i$$

where

e_{wc}, e_{ic} = water vapor pressure for "moist" air

f_w, f_i = enhancement factors

e_w, e_i = water vapor pressure as calculated by Goff-Gratch

*As recommended by Buck 1981.

Potential Temperature (k) - THETA

This is a derived parameter from the definition of potential temperature.

$$\theta = T_a \left(\frac{1000}{P_s}\right)^{R/c_p}$$

Θ = potential temperature

where

T_a = ambient temperature, K

P_s = static pressure, mb

c_p = specific heat at constant pressure for dry air

R = gas constant for dry air

Equivalent Potential Temperature (K) - THETAE

This is a derived parameter obtained by the method of Bolton (1980).

$$\Theta_e = \Theta\exp[((3.376/T_{lcl})-.00254)(r(1+(0.81\times10^{-3}r)))]$$

where

Θ = potential temperature, K

T_{lcl} = temperature at the lifting condensation level, K

$T_{lcl} = [(2840/(3.5 \ln T_k - \ln e - 4.805))+55]$

T_k = Ambient temperature, K

e = water vapor pressure, mb

r = mixing ratio, g/kg

Virtual Temperature (°C) - TVIR

The virtual temperature is the temperature of dry air having the same pressure and density as the air being sampled. It is a measure of the effect of water vapor on air density. The calculation of virtual temperature in RAF output products is taken from page 295 of the Smithsonian Meteorological Tables (1958).

$$T_{vir} = \left\{(T+273.16)\ \frac{1.0+1.6078q)}{(1.0 + q)}\right\} - 273.16$$

where

T_{vir} = virtual temperature, °C

T = ambient temperature, °C

q = specific humidity, g/g

1.6078 = the ratio of the molecular weight of dry air to that of water vapor

Virtual Potential Temperature (K) - THETAV

Derived output of potential temperature using virtual temperature as a reference, otherwise the same as the derivation of THETA.

$$\Theta_{vir} = (T_{vir} + 273.16)\left(\frac{1000}{P_s}\right)^{R/c_p}$$

where

T_{vir} = virtual temperature, °C

P_s = static pressure, mb

R = gas constant for dry air

c_p = specific heat at constant pressure for dry air

Absolute Humidity (Vapor Density) (g/m^3) - RHODx

Absolute humidity (water vapor density) computed from its standard definition (equation of state).

$$\rho_w = \frac{10^6 e M_w}{R_o T} \qquad \text{(multiplied by } 10^6 \text{ to give } g/m^3\text{)}$$

where

e = water vapor pressure over a plane water or ice surface = ESUBW (T_d) or ESUBI (T_d), mb

M_w = molecular weight of water

R_o = universal gas constant

T_d = dew-point temperature, K

T = ambient temperature, K

Relative Humidity (percent) - RHUM

Derived output of relative humidity from definition:

$$RHUM = \frac{e}{e_s} \times 100$$

where

e = atmospheric water vapor pressure = ESUBW(T_d) or ESUBI(T_d), mb

e_s = saturation water vapor pressure = ESUBW(T_a) or ESUBI(T_a), mb

T_a = ambient temperature, K

T_d = dew-point temperature, K

Specific Humidity (g/kg) - SPHUM

Derived output of specific humidity from definition:

$$SPHUM = 622e/(P_s-0.378e)$$

where

e = atmospheric water vapor pressure, = ESUBW(T_d) or ESUBI(T_d), mb

P_s = static pressure

T_d = dew-point temperature, K

622 = 1,000 times the ratio of the molecular weight of water vapor to that of dry air.

Mixing Ratio (g/kg) - MR

A derived parameter that is expressed in terms of grams of water vapor per kilogram of dry air. It differs from specific humidity in that it is related to dry air mass rather than the total of dry air plus water vapor.

$$RM = 622 \frac{e}{P_s - e}$$

where

e = water vapor pressure = ESUBW(T_d) or ESUBI(T_d), mb

P_s = static pressure, mb

T_d = dew-point temperature, K

622 = 1,000 times the ratio of the molecular weight of water vapor to that of dry air.

V. RADIATION PARAMETERS

Radiometric (surface or sky) Temperature (C) - RSTx

This is the output of equivalent black body temperature obtained from a narrow bandwidth, narrow field of view (2°) Barnes Engineering Model PRT-5 precision radiation thermometer. The bandwidth available is either 8 to 14 µm or 9.5 to 11.5 µm. The instrument is calibrated with a black body source manufactured by Eppley. x is either bottom or top.

Raw Pyranometer Output (W/m^2) - SWx

This is a calibrated thermopile output of shortwave radiation from pyranometers manufactured by Eppley Laboratory, Inc. Typically the pyranometer uses UG295 glass hemispheres which give the widest coverage of the solar spectrum - 0.285 µm to 2.8 µm. (Different bandwidths are obtainable by use of different glass domes available from RAF upon request. See Bulletin #25.) The pyranometers are flown in pairs, one up-looking and one down-looking. The pyranometers are calibrated periodically at the NOAA Solar Radiation Facility in Boulder, Colorado.

Raw Pyrgeometer Output (W/m^2) - IRx

This is a calibrated thermopile output of longwave terrestrial radiation from pyrgeometers manufactured by Eppley. The pyrgeometer uses a coated glass hemisphere that transmits radiation in a bandwidth from 3.5 µm to 50 µm. As with the pyranometers, they are usually flown in pairs. The pyrgeometers are calibrated at RAF according to procedures specified by Albrecht and Cox.

Corrected Infrared Irradiance (W/m^2) - IRxC

This is a derived output using measured pyrgeometer dome and sink temperatures, DTx and STx, Boltzmann's constant, the emissivity of the thermopile, and a pyrgeometer-dependent derived constant.

$$\text{IRxC} = \text{IRx} - \text{DSCOR} + \text{TCOR}$$

where

DSCOR is the difference in the dome and sink radiation and

TCOR is the radiation from the thermopile

$$DSCOR = x_k\ (\sigma(T_d{}^4 - T_s{}^4)$$

$$TCOR = \varepsilon\sigma T_s{}^4$$

x_k = empirically derived constant dependent on the dome type

ε = emissivity of the thermopile

σ = Boltzmann's constant

T_s = sink temperature, K

T_d = dome temperature, K

Raw Ultraviolet Radiometer Output (W/m^2) - UVx

This is the calibrated output from an Eppley Laboratories UV radiometer/photometer. The bandwidth of the instruments available from RAF is from 0.295 μm to 0.385 μm. The units are periodically returned to the Eppley Laboratories for calibration.

VI. ALTITUDE PARAMETERS

Radar Altitude (m) - HGM

This is an output from a radio altimeter corrected to altitude in meters above ground. The maximum range is 762 m (≈ 2,500 ft). The instrument changes in accuracy at an altitude of 152 m. The estimated accuracy from 152 m to 762 m is 7% while the estimated accuracy for altitudes below 152 m is 1.5 m or 5%, whichever is greater.

Geometric (Radar) Altitude (Extended Range) (APN-159) (m) - HGME

There are two outputs from the APN-159, one (CHGME) with coarse resolution and one (HGME) with fine resolution. Both are outputs cycling through the range 0-360 degrees, where one cycle corresponds to 4,000 ft for HGME and to 100,000 ft for CHGME. To resolve the ambiguity that arises from these cycles, 4,000 ft increments are added to HGME to maintain agreement with CHGME. This preserves the fine resolution of HGME (1.86 m) throughout the altitude range of the APN-159.

Calculated Surface Pressure (mb) - PSURF

This value is a calculated surface pressure obtained from HGM, TVIR, PSFDC, and RM using the thickness equation. The average temperature for the layer is obtained by using HGM and a dry adiabatic lapse rate. Due to the assumptions made in the calculation of this parameter, the result is only valid for flight in a well-mixed surface layer or in other conditions in which the temperature lapse rate matches the dry adiabatic lapse rate.

$$\mathrm{PSURF} = P_s \exp\left(g/R(\mathrm{HGM}/\bar{T})\right)$$

where

$\bar{T}$ = mean temperature of the layer, K

$= (T_{vir} + 273.16) + 0.5\ (g/c_p)(\mathrm{HGM})$

T_{vir} = virtual temperature, °C

HGM = radio altitude, m

P_s = static pressure, mb

NACA Pressure Altitude (m) - PALT

This is the pressure altitude obtained from the static pressure measurement using a NACA standard atmosphere. An altimeter setting of 1013.246 mb is used in the calculation of PALT.

$$\mathrm{PALT} = (T_r/\gamma)[1-(P/P_r)^x]$$

where

$x = R_o\gamma/M_w g = R\gamma/g$

P_r, T_r = reference pressure and temperature for the standard atmosphere (1013.246 mb and 288.15 K)

γ = assumed standard lapse rate

R_o = universal gas constant

M_w = molecular weight of air

g = acceleration due to gravity

R = universal gas constant for dry air

Pressure-Damped Inertial Altitude (m) - HI3

This is the aircraft altitude obtained from the twice-integrated INS acceleration (ACINS), damped to obtain long-term agreement with PALT.

VII. CLOUD PHYSICS PARAMETERS

Raw Output Cloud Technology (Johnson-Williams) Liquid Water Content (g/m^3) - LWC

This is the output of a Johnson-Williams liquid water content sensor in grams per cubic meter. The Johnson-Williams indicator measures the evaporative cooling caused by the latent heat of vaporization of droplets contacting the sensing element by sensing changes in the resistance through the heated element as it cools. Through calibration this resistance is converted to a liquid water content. A "compensation" wire is also mounted in the JW probe, parallel to the droplet stream to compensate for cooling effects sensed due to convection. Typically the instrument is set for an air speed of 200 knots (King Air). The instrument must be zeroed in "cloud-free air."

Corrected Cloud Technology (Johnson-Williams) Liquid Water Content (g/m^3) - LWCC

This is the corrected liquid water content obtained by using the aircraft true air speed and removing the zero offset.

$$\text{XLWCC} = \text{XLWC} \left(\frac{\text{true airspeed dial setting*}}{\text{TASx}}\right)$$

*as mentioned above, 200 knots

The Johnson-Williams liquid water probe is designed for the cloud droplet spectrum. There is some evidence to indicate that droplets larger than 30 µm tend to be shed before completely vaporizing on the probe element. This tends to underestimate the liquid water content.

Raw Output PMS/CSIRO (KING) Liquid Water Content (W) - PLWC

This is the output of a PMS/CSIRO (KING) liquid water probe in watts. The KING probe is a constant temperature probe. The probe measures the power required to maintain a constant temperature through a heated element as that element is cooled by convection and evaporation of impinging liquid water. The convective heat losses are determined by calibration in dry air over a range of air speeds and temperatures.

Corrected PMS/CSIRO (KING) Liquid Water Content (g/m^3) - PLWCC

This is the corrected liquid water content in grams per cubic meter obtained from relating power consumption (required to maintain a constant temperature) to liquid water content taking into account the effect of convective heat losses.

$$\begin{aligned} P &= P_{DRY}+P_{WET} \\ &= Nu\ \pi l\ k\ (T_S - T_A) \\ &\quad + l\ d\ [L + c(T_S - T_A)]\ v\ (LWC) \end{aligned}$$

where

Nu = Nusselt Number (relating conduction heat loss to the total heat loss, for dry air; and a function of velocity and density of the air)

k = thermal conductivity of the dry air

$T_S - T_A$ = difference between sensor and ambient temperatures

l, d = length and diameter of the master coil

v = true airspeed

L, c = latent heat of vaporization and specific heat, of water

LWC = liquid water content

P_{DRY} = power dissipated by the cooling effect of dry air alone flowing over probe coil

P_{WET} = power needed to heat and vaporize the liquid water that hits the probe

Raw Output Rosemount Icing Detector (VDC) - RICE

This is the output from a Rosemount 871F ice-accretion probe. The probe consists of a rod set in vibration by a piezoelectric crystal. The oscillation frequency of the probe changes with ice loading. When the probe loads to a certain point, the rod is heated to remove the ice. The probe output voltage is related to the mass of the accreted ice.

Derived Supercooled Liquid Water Content (g/m^3) - SCLWC

This parameter is the supercooled liquid water content obtained from the change in accreted mass on the probe over 1.0 s.

Note that the output is not valid during the probe deicing cycle. This cycle is apparent in the RICE output (a spike, followed by a decrease to near zero). To determine supercooled liquid water content, a water drop impingement rate is calculated for the Rosemount icing probe. This impingement rate is a function of the effective surface area, the collection efficiency, the true airspeed, and the supercooled liquid water content. The impingement rate obtained is equated to the accreted mass of ice collected by the probe in 1 s (empirical voltage/mass relationship). Solving the resulting equation for supercooled water yields:

$$\mathrm{SCLWC} = k \frac{\Delta m}{\Delta t}/U_a$$

where

k is dependent on the effective surface area of the probe, units are m^2

Δ m is the mass of ice accreted on the probe, units are g

Δ t is 1 s

U_a is the true airspeed, units are m/s.

VIII. CLOUD PHYSICS PARAMETERS OBTAINED FROM PMS PROBES (NOT INCLUDING 2D PROBES)

A. PMS Probe Total Counts (cnts) - ASASP, FSSP, X200, X260, Y200

This value is the total number of particles detected per unit time by a PMS probe. The counts can also be obtained on a bin-by-bin basis. (See Appendix A for variable names.)

B. PMS Probe Concentration (N/cm^3) - CONCA, CONCF
(N/L) - CONCX, CONC6, CONCY

This value is the particle concentration in either number per cubic centimeter (ASASP and FSSP) or number per liter (1D optical array probes - 200X, 260X and 200Y). In the scattering spectrometer ASASP and FSSP probes, the concentration value obtained is modified by the probe activity. The activity is a measure of the probe dead time, i.e., that time in which the probe electronics are busy processing and miss particles. The The concentration is obtained from the total number of counts and a calculated probe-dependent sample volume. Details of the concentration calculations are found in Bulletin No. 24.

C. PMS Probe Mean Diameter (μm) - DBARA, DBARF, DBARX, DBAR6, DBARY

The mean diameter is the arithmetic average of all particle diameters. It is calculated as follows:

$$\bar{D} = \sum_{i=1}^{m} \frac{(n_i d_i)}{N_t}$$

where

m is the number of cells

i = the $_i$th cell

n_i = the number of particles accummulated in channel i

d_i = the particle diameter for channel i

N_t = the total number of sized particles = $\Sigma\, n_i$

D. PMS Probe Dispersion (Standard Deviation/Mean Diameter) - DISPA, DISPF, DISPX, DISP6, DISPY

The dispersion is the ratio of the standard deviation of particle diameters to the mean particle diameter.

E. PMS Liquid Ice Water Content (g/m^3) - PLWCF, PLWCX, PLWC6, PLWCY

This variable is a derived calculation of the liquid water content and is calculated as follows:

$$LWC/IWC = \rho_w \sum_{i=1}^{m} N_i d_{ie}^3$$

where,

ρ_w = density of water

N_i = concentration of particles in size channel i

d_{ie} = equivalent melted diameter - the user must decide on method to be used to determine this - the equivalent melted diameter would be strongly dependent upon habit.

F. PMS Probe Reflectivity Factor - DBZX, DBZ6, DBZY (Optical Array Probes Only)

The radar reflectivity is defined as the amount of reflectivity a measured distribution of particles would have if detected by a radar.

The reflectivity is calculated with dimensions of decibels (dBZ) and is dependent upon the wavelength of the radar and the density of the particles. This reflectivity is calculated as follows:

$$dBZ = LOG_{10}(\sum_{i=1}^{m} (N_i d_i^6))$$

where,

dBZ = decibels reflectivity

N_i and d_{ie} are as defined for calculating liquid ice water content.

G. PMS Probe Function Variables

FSSP Range - FRANGE

This is a variable which indicates the size range used for the FSSP.

Range	Nominal Size Range	Bin Width
0	2 µm - 47 µm diameter	3.0 µm
1	2 µm - 32 µm diameter	2.0 µm
2	1 µm - 15 µm diameter	1.0 µm
3	0.5 µm - 7.5 µm diameter	0.5 µm

FSSP Fast Resets (cnts) - FRESET

This variable records the number of fast resets that occur during the FSSP sampling. A fast reset occurs when a particle traverses the beam outside the depth-of-field. When this occurs, the probe electronics determine that the particle will not be accepted and further delay is avoided. This generates the fast reset. This variable is required to account for the probe's total dead time. The fast reset time is a measured circuit characteristic determined in the laboratory.

FSSP Total Strobes (cnts) - FSTROB

This variable records the number of particles detected within the depth-of-field both inside and outside the "effective beam diameter." The effective beam diameter is that portion of the beam defined by velocity averaging circuitry (within the FSSP). That velocity averaging circuitry is designed to reject particles passing through the outer portions of the beam to provide a more accurate sizing within this effective beam diameter. The velocity averaging circuitry keeps track of particle transit times and rejects those below a certain, probe-dependent threshold.

FSSP Beam Fraction - FBMFR

This is a derived parameter that is the ratio of the number of velocity-accepted particles (particles that pass through the effective beam diameter) to the total number of particles detected in the depth-of-field of the beam.

$$\text{FBMFR} = \text{FSSP/FSTROB}$$

where

FSSP = Σn_i, the total number of particles counted by the FSSP.

FSSP Calculated Activity Fraction - FACT

This is the calculated FSSP probe activity. It represents the probe dead time, the time the probe electronics are busy processing particle data. The probe activity is calculated from fast resets, total strobes, and both slow and fast reset times (determined in the laboratory).

$$\text{FACT} = \text{FSTROB}*\lambda_1 + \text{FRESET}*\lambda_2$$

where

λ_1 = slow reset time

λ_2 = fast reset time

ASASP Raw Activity - AACT

This is a measurement of the ASASP probe dead time, the time that the probe electronics are busy processing particle data. The raw activity obtained from the probe is corrected with a factor supplied by the manufacturer (0.52).

$$\text{Activity} = \left(\frac{\text{raw activity*sample rate}}{1024.}\right) 0.52$$

(The value 1024 corresponds to 100% dead time.)

APPENDIX E

Wind Measurement on NCAR Aircraft

Air motion relative to the earth is obtained from the vector sum of the velocity of the aircraft with respect to the earth and the velocity of the air with respect to the aircraft:

$$\vec{V} = \vec{V}_p + \vec{V}_a$$

Here, $\vec{V}_p$ is the velocity of the aircraft with respect to the earth and $\vec{V}_a$ is the velocity of the airstream with respect to the aircraft. Fig. E.1 shows these vector relationships.

The components of the velocity of the airstream with respect to the aircraft are determined, in the aircraft frame of reference, by the measured angle of attack (α) and the sideslip angle (β). These components in vector notation are:

$$\vec{V}_a = -U_a\ D^{-1}\ (\vec{i}\,' + \vec{j}\,'\ \tan\beta + \vec{k}\,'\ \tan\alpha)$$

Here, the prime denotes the aircraft reference frame. The components of the aircraft velocity with respect to the earth are obtained from both integrated accelerometer outputs and aircraft attitude information obtained from an inertial navigation system.

The measured velocity components are rotated, with the proper angular transformations, to the local earth coordinate system. The resulting components of the air motion relative to the earth are:

$$\begin{aligned} U = {} & -U_a\ D^{-1}\ [\mathrm{SIN}\ \Psi\ \mathrm{COS}\ \Theta + \mathrm{TAN}\ \beta\ (\mathrm{COS}\ \Psi\ \mathrm{COS}\ \phi + \mathrm{SIN}\ \Psi\ \mathrm{SIN}\ \Theta\ \mathrm{SIN}\ \phi) \\ & +\mathrm{TAN}\ \alpha\ (\mathrm{SIN}\ \Psi\ \mathrm{SIN}\ \Theta\ \mathrm{COS}\ \phi - \mathrm{COS}\ \Psi\ \mathrm{SIN}\ \phi)] + U_p - L\ (\dot{\Theta}\ \mathrm{SIN}\ \Theta \\ & \mathrm{SIN}\ \Psi - \dot{\Psi}\ \mathrm{COS}\ \Psi\ \mathrm{COS}\ \Theta) \end{aligned}$$

$$\begin{aligned} V = {} & -U_a\ D^{-1}\ [\mathrm{COS}\ \Psi\ \mathrm{COS}\ \Theta - \mathrm{TAN}\ \beta\ (\mathrm{SIN}\ \Psi\ \mathrm{COS}\ \phi - \mathrm{COS}\ \Psi\ \mathrm{SIN}\ \Theta\ \mathrm{SIN}\ \phi) \\ & +\mathrm{TAN}\ \alpha\ (\mathrm{COS}\ \Psi\ \mathrm{SIN}\ \Theta\ \mathrm{COS}\ \phi + \mathrm{SIN}\ \Psi\ \mathrm{SIN}\ \phi)] + V_p - L\ (\dot{\Psi}\ \mathrm{SIN}\ \Psi \\ & \mathrm{COS}\ \Theta + \dot{\Theta}\ \mathrm{COS}\ \Psi\ \mathrm{SIN}\ \Theta) \end{aligned}$$

$$\begin{aligned} W = {} & -U_a\ D^{-1}\ [\mathrm{SIN}\ \Theta - \mathrm{TAN}\ \beta\ \mathrm{COS}\ \Theta\ \mathrm{SIN}\ \phi - \mathrm{TAN}\ \alpha\ \mathrm{COS}\ \Theta\ \mathrm{COS}\ \phi] + W_p \\ & + L\ \dot{\Theta}\ \mathrm{COS}\ \Theta \end{aligned}$$

In the preceding equations the term involving L is included to account for the separation between the inertial platform and the gust probe sensor on the aircraft. This is an angular velocity term resulting from that separation. Other terms in the equation are:

$$D = (1 + \tan^2 \alpha + \tan^2 \beta)^{1/2}$$

α = angle of attack

β = sideslip angle

Ψ = true heading

Θ = aircraft pitch

ϕ = aircraft roll

U_p, V_p, and W_p = aircraft velocity components

U_a = aircraft true airspeed (V_{tas} in Figure E.1)

The above equations are incorporated into the standard data processing at RAF to generate wind components relative to the earth. These are included in a subroutine referenced as GUSTO in examples from Appendix B.

For further information regarding aircraft wind measurements the reader is referred to Lenschow, 1981, and to Lenschow, 1986 (publication forthcoming, see "References").

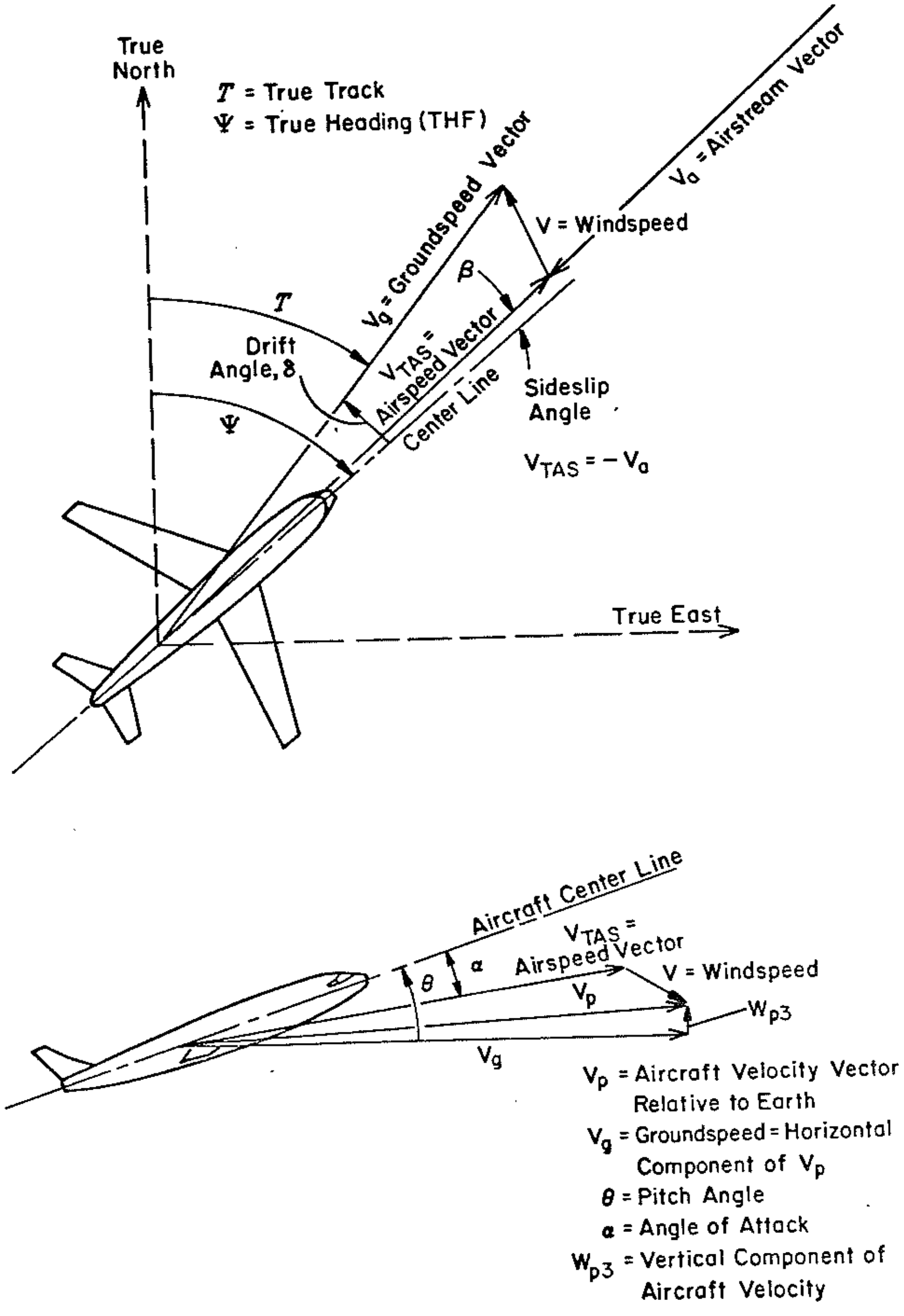

Figure E.1 Schematic of vectors associated with the derivation of the wind components.

APPENDIX F

PMS 2D Data Processing

Due to the subjective nature of 2D information and algorithm dependency upon varied specific conditions, no compilation of parameter algorithms will be attempted herein. The investigator is encouraged to provide algorithms specific to his/her particular application when requesting use of the 2D PMS probes. RAF urges inexperienced 2D data users to consult RAF staff members for assistance. Some useful guidance can be obtained from both Heymsfield and Baumgardner (1985) and an "NCAR Technical Note" forthcoming authored by Darrel Baumgardner addressing 2D processing.

The user must make the following choices before processing begins:

(1) Output to microfilm by record or by second?
(2) What rejection algorithms will be used, i.e., which spurious particles does the user wish to reject?
(3) What empirical relationships should be used for estimating the fall velocities, reflectivities, rain rates, and liquid water contents of ice particles?
(4) Is tape output desired? If yes, what parameters?

Microfilm Output

The PMS 2D (either the "precipitation" probe, 2D-P resolution 200 μm, or the "cloud" probe, 2D-C resolution 25 μm) data can be processed and output to microfilm. The microfilm contains two pages of processing information followed by frames containing the 2D images and information pertaining to those images. That information is displayed in two lines of print below the displayed images.

The first line of print available contains the following information:

Probe ID - C for the cloud probe, P for the precipitation probe.
Start and stop time of the record.
The total number of particles accepted after application of spurious particle rejection algorithms.
The number of particles classified as spherical (water or graupel).
The total number of particles rejected as spurious. (Refer to Bulletin No. 24.)
The number of particles triggering a fixed depolarization detection level.
The adjusted number of accepted and spherical particles, after weighting by size. The 2D sample volume is adjusted by increasing the effective sample width with increasing particle size. Instead of actually changing the sample width for each particle, each particle is weighted according to size so that the larger particle are weighted less, effectively increasing the sample volume. (Refer to Bulletin No. 24.)

The concentration of accepted and spherical particles in number per liter. (This uses the adjusted number weighted by size and divided by the fixed sample volume.)
The reflectivities in (dBZ), assuming low-density ice particles, graupel, and water drops, respectively.
The rain rates in mm/h, assuming all particles are graupel and assuming they are water drops.
The liquid water contents in grams per cubic meter assuming low-density ice, graupel, and water drops, respectively.
The elapsed time of the record in seconds.
The true airspeed in m/s using the setting of the 2D TAS clock.
The sampling volume in liters.
A flag indicating whether the probe went into the overload conditions while filling this record.

The second printed line contains size distribution information. There are 40 values printed on this line. The first thirty values show how many particles were classified into each of 30 different size categories. The bin width of each size category is fixed and corresponds to the probe resolution or one diode width. Thus, any particles which shadow "n" diodes are sized into bin "n" and the total number of those particles encountered in the selected sample interval is printed as the "nth" number on the second line. The last 10 values on the second line contain size information for particles greater than the 30 diode sizes. Each of the last 10 numbers is the particle size in number of diodes shadowed for each larger particle encountered. These values are printed in the order that the larger particles were encountered during a selected sample interval. (The particle size used is obtained along the direction of flight, i.e., perpendicular to the diode array.)

Output to Magnetic Tape

The following is a list of 2D variables proposed to be output to magnetic tape. The user should select those desired from this list. For this option the data are calculated for 1 s intervals.

2D VARIABLES

VARIABLE NAME	DESCRIPTOR
YYMMDD	Date.
HHMMSS	Start time of data.
ETIME	Actual elapsed time of this data segment (needed because of problems with overloads and parsing of records into fixed time segments.)
TOTC(P)	Total number of accepted particles from C probe or P probe (P).
WATC(P)	Total number of particles classified as spherical.
NDEPOL	Total number of particles causing depolarization.
CONCTC(P)	Average concentration of all particles.
DCNCTC(P)	Standard error of concentration within this period.
CONCWC(P)	Average concentration of all particles classified as spherical.
DCNCWC(P)	Standard error of concentration of spherical particles.
CONCD	Concentration of particles causing depolarization (C probe only).
DCONCD	Standard error of concentration of depolarizing particles.
DBZGP	Derived radar reflectivity assuming graupel (P probe only).
DBZWP	Derived radar reflectivity assuming water (P probe only).
DBZXP	Derived radar reflectivity, investigator specific (P probe only).
RRGP	Derived rain rate assuming graupel (P probe only).
RRWP	Derived rain rate assuming water (P probe only).
RRXP	Derived rain rate, investigator specific (P probe only).
AGWCC(P)	Derived ice water content assuming graupel.
ARWCC(P)	Derived rain water content.
AXWCC(P)	Derived ice water content from investigator. specifications.
SVOLC(P)	Sample volume for this period in liters.
TASC(P)	Average airspeed for this period.
REJC(P)	Total number of particles rejected.
STREKC(P)	Total number of particles rejected as streakers.
SHRTC(P)	Total number of particles with arrival times less than minimum.
BLNKC(P)	Total number of zero area images.
HLLWC(P)	Total number of particles rejected for hollow area criteria.
GAPC(P)	Total number of gapped images rejected.
D2DC(P)01- D2DC(P)20	Number of particles in this period of size D2DC(P)01 through D2DC(P)20.

APPENDIX G

RAF TAPE ARCHIVAL POLICY

The following establishes the formal RAF tape archival policy:

It is the Research Aviation Facility's (RAF) policy to recycle aircraft raw data tapes and processed tapes five years after the completion of the project. After five years, RAF will notify the original investigator(s) and the community before recycling. These data are in the public domain and may be claimed by interested investigators for the cost of the tape and its shipping and handling charges.

Responsibility for data sets from large multi-institutional and/or multi-aircraft projects having formal data management and archiving offices will be transferred to the NCAR Scientific Computing Division (SCD) Data Archive Facility after five years and/or will be transferred to the specific project designated archive.

RAF, realizing that some specialized data sets are of unique interest, will submit a brief description of projects whose data sets are targeted for recycling to the RAF panel for advisement before any action is taken.

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