NCAR
Research Aviation Facility

Bulletin No. 4

THE NCAR/NSF ELECTRA (N308D): OVERVIEW AND SUMMARY OF CAPABILITIES

The purpose of this Bulletin is to acquaint prospective users with the capabilities of the NCAR/NSF Electra aircraft (Tail Number N308D). The four-engine Electra aircraft (See Figure 1.) gives atmospheric scientists a long-range and large-payload capability which is particularly suitable for over-ocean research, mesoscale research, and for large-scale tropospheric chemistry studies.

Introduction

The Lockheed L-188C Electra is a pressurized, low-wing, turbo-propeller airplane that was designed as a medium-range airliner. It is powered by four Allison 501-D13 constant-speed, axial-flow, turbine engines which drive four-bladed, full-feathering, reversible-pitch, turbo propellers. Flight is approved in known icing conditions. However, external instrument installations may limit operations in icing conditions.

Figure 1. NCAR/NSF Electra shown with the ELDORA Rotodome on the tail section.

Basic specifications and performance figures for the NCAR/NSF Electra are given in Table 1. Detailed information about flight planning is available to Electra users in *Research Aviation Facility Bulletin No. 7*. This Bulletin provides the necessary information to formulate outlines of realistic research flight plans.

Aircraft Modifications

The Electra has been modified to accommodate a wide variety of instrumentation used for atmospheric research. (Figure 2 shows the external configuration of the Electra.) Modifications to the aircraft include:

- Nose Section--A radome differential-pressure gust-probe system is built into the radome. Around the radome several instrument-mounting pads are available for mounting sensors.

- Fuselage Section--Cabin-window hard points are located on both sides and on the top and bottom of the aircraft. These can be used as sensor view ports or for equipment exposure to the airstream. Two sensor pylons located on top of the fuselage near the front of the aircraft can be used for mounting various instruments. Up- and down-looking radiometer pods are available on the top and bottom of the fuselage.

- Wingtips--Pylons on each wingtip can be used for PMS probe and sensor mounting.

- Dispensing Chutes--Two chutes are available in the aft section of the aircraft to dispense meteorological and oceanographic dropsondes.

- Tail Section--The Electra's original tail assembly was replaced with one from a P-3 to allow mounting the Rotodome for the ELDORA radar.

- Electrical Power--A complete research electrical power system distributed through the aircraft provides 28 Vd.c. and 115 Va.c. at frequencies of 60 and 400 Hz.

- Vacuum Port--An engine-driven venturi vacuum port is available on the aircraft for air-sampling applications. (At an altitude of 6,500 ft, this source provides flow ranges from 45 SCFM at a pressure drop of 60 mm Hg to 0 SCFM at a pressure drop of 530 mm Hg.)

- Instrumentation Racks--Several instrumentation racks are available in the cabin for mounting RAF and user-supplied instruments.

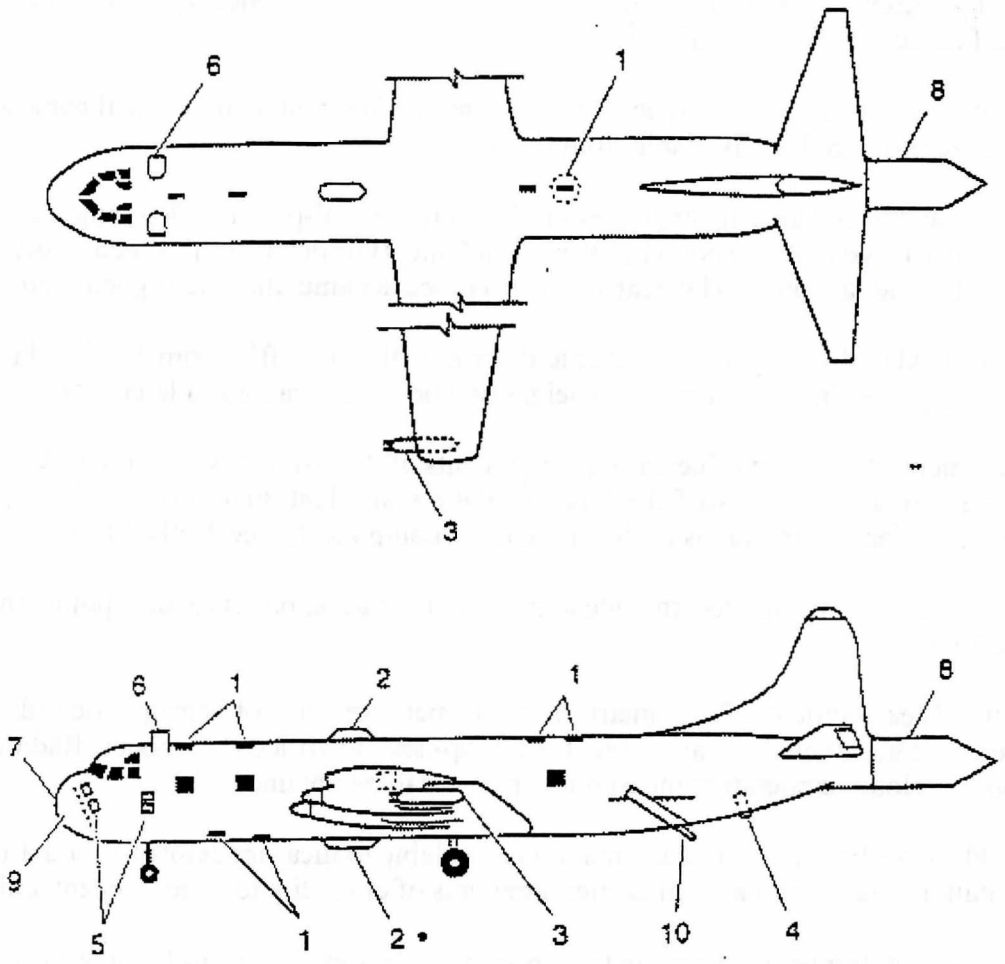

Figure 2. External Configuration of the NCAR/NSF Electra

1. Fuselage Apertures (15)
2. Radiometer Pods (2)
3. Pylon Wing Boom--PMS Probes (2)
4. Dropsonde Dispenser (1)
5. Sensor Mount Pods (8)
6. Sensor Pylons (2)
7. Radome Gustprobe
8. ELDORA (Doppler Radar)
9. Nose Radar (Collins WXR-700C)
10. Oceanographic Probe Dispensing (1)

Instrumentation

The standard research instrumentation aboard the aircraft is quite extensive. The specific set of instruments flown on a given project is generally a subset of the complete instrumentation list given in Table 2. Refer to other RAF Bulletins for details of the various instruments and equipment. RAF assumes responsibility for installing, calibrating, and maintaining the requested RAF-supplied instrumentation.

Measurement Systems

- Aircraft geographic position is available from an Inertial Reference System (IRS) and from a Global Positioning System (GPS) receiver.

- The aircraft attitude (pitch, roll, and heading) and the horizontal and vertical components of aircraft ground speed are available from the IRS.

- Angles of attack and sideslip are measured by a differential-pressure flow-angle sensor consisting of an array of five pressure ports in the nose radome. (For details of this technique, see Brown, et al., Ref. 1.) The radome can be heated to prevent ice accumulation during icing conditions.

- Radio and radar altimetry are available to determine the aircraft's geometric height above the surface. High-resolution vertical GPS height will be incorporated at a later date.

- Measurement of mean and fluctuating components of the wind (u, v, w, and u', v', w') are available with a resolution sufficient for calculating turbulent fluxes up to 10 Hz equivalent wavelength. For specifications of the air velocity components, see Table 3 below.

- Atmospheric State Parameters include ambient temperature, pressure, dew point, and water vapor fluctuations.

- Radiation Measurements--Radiometric airborne measurements of hemispheric radiation (visible, infrared, and ultraviolet) are available, both in up- and down-looking modes. Radiometric surface, sky, and in-cloud temperature measurements also can be obtained.

- Cloud Physics--Extensive instrumentation is available to measure aerosol, cloud droplet, and precipitation size spectra as well as measurements of cloud liquid water content and icing rate.

  Aerosol, cloud droplet and precipitation spectra can be obtained from Particle Measuring System's (PMS) probes (either 1D or 2D). The Electra typically can accommodate up to four different PMS probes. In limited applications, up to five PMS probes can be carried.

- Air Chemistry Measurements--A variety of chemical species can be measured on the aircraft. Instruments for routine sampling of condensation nuclei (CN), ozone (1 Hz), and carbon monoxide are available. Measurements of other chemical species (listed on Page 6 of Table 2) are available through special arrangements with RAF. (See Special Instruments.)

- Weather Avoidance Radar--The weather avoidance radar aboard the NCAR/NSF Electra is a Collins WXR-700C, a C-band Doppler radar that can display radar reflectivity, areas of turbulence or a combined reflectivity-turbulence display. The Doppler display only operates at ranges less than 90 km. The radar also has a ground-mapping mode. The C-band transmit frequency of this radar provides improved storm penetration capabilities than would an X-band radar, thus improving the ability of the Electra to penetrate storms while avoiding the more intense storm areas. Reflectivity and velocity data can be recorded and displayed on any on-board workstation. Plans are underway for developing a combined aircraft track and radar display in real time. This radar can be used to optimize the flight tracks around convective storms to help optmize the ELDORA radar's data sampling.

- Documentation of the Weather Situation--Color video cameras are available to record weather

conditions during the research missions. Locations are: in the cockpit for forward view; inside the cabin for side-looking views.

- A Research Intercommunications System (ICS) is available for use by the project participants during research operations. During the preparation phase, an RAF Project Manager will inform and familiarize the requestor with the ICS system to ensure that it is used to its full potential.

Data Sampling and Recording

A second-generation Aircraft Data System (ADS2) has been developed using a distributed-sampling approach. Two Data System Modules (DSM) are located in the aircraft and communicate with each other and with display computers through a single-cable computer network.

Analog and digital inputs from the instrumentation are sampled, recorded, and displayed by a Sun SPARC-10 computer-controlled data system located at the Electra's operator station. The data are recorded on Exabyte (Model EXB-8505) 8mm tape cartridges (currently with 4.0 Gb capacity). Two drives are used for redundancy. Sampling rates available for all measurements are 5, 25, and 250 sps and 1K sps (higher for special requirements). All channels are simultaneously sampled and digitized at 10K sps. Each analog channel includes a single-pole, anti-alias filter at 5 KHz. The sampled data are decimated with FIR (finite impulse response) digital filters. Each DSM can sample up to 64 analog channels plus blocks from various serial devices, such as navigation systems, PMS 1-D and 2-D probes. This new system supports user-provided workstations (generic UNIX with TCP/IP protocol) aboard the Electra using the in-flight network.

Real-Time Data Display (WINDS)

Real-time data display is through the WINDS (WINdow Display System) software system. The system displays aircraft data in either real-time or post-processing mode. This interactive display system includes a variety of x-y plots, (e.g., time series, skew-t log-p, sounding, and track), fixed and scrolling alphanumeric lists, 1D-probe histograms and 2D probe images. Displays can be printed in color with on-board PostScript color printers. (See details of the WINDS system by Horton, 1994, Ref 2.)

One data system display station is located in the cockpit for the flight crew and mission scientist, and four display stations are in the main cabin. Displays can be printed in color with on-board PostScript color printers. Video cameras mounted in the cockpit and on the side of the aircraft can be viewed in real-time on any of the display stations. Video repeaters for ELDORA are also available.

Data Processing and Documentation

Extensive documentation is provided to the users following each project.

Data tapes generated during flights are processed and quality controlled by the RAF Project and Data Support Group to produce output files containing data (in engineering units) from measured and derived variables. The standard RAF data set consists of 1 sample-per-second (sps), averaged data from all measured variables. (See *Research Aviation Facility Bulletin No. 9.*) After the standard data processing is completed, high rate (25 sps) data may be provided by special request for certain flight segments.

Please note that flux calculations derived from high-rate scalar measurements can be affected by

measurement uncertainties associated with flow distortion around the aircraft. Investigators are encouraged to contact RAF to discuss any planned application of this technology. (See Ref. 3.)

Usually accompanying Electra field projects is a quick-look, post-flight, data-processing system. This computer system is used primarily for quality assurance but is also available for limited data processing.

Special Instruments

Several special instrument packages can be made available to Electra users on an "as needed" basis. These must be specifically requested, and their deployment (e.g., ELDORA and Dropwindsonde) depends upon resources provided by other ATD facilities.

- **Dropwindsonde**--A light-weight dropwindsonde can be launched from the Electra. This dropwindsonde system consists of a new aircraft data system and a new, light-weight, digital sonde (300 g) developed and supported by the Surface Sounding System Facility (SSSF) at NCAR. The sondes can provide temperature, humidity, and wind data profiles while descending to the surface.

  Information concerning dropwindsonde requests should be directed to Harold L. Cole, Acting Manager, Surface Sounding Systems Facility, Atmospheric Technology Division at (303) 497-8753, by FAX at (303) 497-8770, or via email: cole@ucar.edu.

- **Special Air Chemistry Measurements**--Measurements of O3 and CO2 (fast-response), hydroperoxides, formaldehyde, NOy, and SO2 require special arrangements with RAF before they can be made available for a given project.

  Information concerning these chemistry instruments should be directed to Gregory L. Kok, Research Aviation Facility, Atmospheric Technology Division at (303) 497-1070, by FAX at (303) 497-1092, or via email: kok@ucar.edu.

- **Airborne Doppler Radar**--Observations of large-scale storm systems and high-resolution observation of small-scale weather phenomena can be obtained with the Electra Doppler Radar System (ELDORA). ELDORA is an airborne, dual-beam, x-band, rapid-scanning radar system mounted on the tail of the Electra. This rapid-scanning, unique Doppler radar system allows making air-motion measurements while flying straight lines past weather events of interest. ELDORA is not a permanent part of the instrumentation payload. Installation of this facility requires separate funding approval for a given project. ELDORA is a separate facility within ATD's Remote Sensing Facility (RSF). RSF is responsible for its operation and for its data products.

  Information concerning the ELDORA facility should be directed to the Jeff Keeler, Acting Manager, Remote Sensing Facility, Atmospheric Technology Division at (303) 497-2031, by FAX at (303) 497-2044, or via email: keeler@ucar.edu.

User-Interface

Considerable freedom is permitted in mounting user-supplied instrumentation on the aircraft. Procedures and limitations are described in detail in *Research Aviation Facility Bulletin No. 12*. RAF will supervise

the installation of all user-supplied instrumentation to ensure compatibility with existing RAF instrumentation and the data system, and to satisfy aircraft safety requirements. The user-supplied equipment must be designed to satisfy the requirements of *Research Aviation Facility Bulletin No. 13*.

RAF can advise and, in some instances, assist users in the aeronautical, chemical, and electrical engineering design and fabrication of special equipment. Guidance in sampling and measurements can also be provided. RAF can help project scientists with experimental design and planning, including flight planning.

References

1. Brown, E.N., C.A. Friehe, and D.H. Lenschow (1983): The use of pressure fluctuations on the nose of aircraft for measuring air motion. *J. Climate and Appl. Met.*, **22**, 171-180.

2. Horton, G. (1994): A graphical user interface system for real-time and post-processing display and analysis of aircraft measurements. Preprint volume of the *Tenth International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology*, January 23-38, 1994, Nashville, TN. Published by the American Meteorological Society, Boston, MA.

3. Wyngaard, J.C. (1988): The effects of probe-induced flow distortion on atmospheric turbulence measurements: Extension to scalars. *J. Atmos. Sci.*, **45**, 3400-3412.

Investigators interested in discussing any use of the NCAR/NSF aircraft or its instrumentation, including questions on scheduling, may contact the Facility Liaison for Field Projects at (303) 497-1047, FAX (303) 497-1092, or via email: rbf@ucar.edu.

Table 1		
NCAR/NSF L-188C ELECTRA (N308D)		
Dimensions	Length	105 ft
	Wingspan	99 ft
	Cabin Floor Area:	628 sq ft
Weights	Gross Weight	116,000 lb max
	Payload	19,276 lb max
		5,592 lb with full fuel
Performance	Altitude	28,400 ft (max operating)
	Range	1,500 nmi (at 1,000 ft cruise)
		1,900 nmi (at 10,000 ft cruise)
		2,400 nmi (at 20,000 ft cruise)
	Endurance	8.5 hours max, with IFR reserve
	Speed	310 kt TAS (typical cruise)
	Acceleration Limit	2.5 G (flight load)
Flight Crew	Two pilots + flight engineer (Up to 16 seats available for project participants, depending on equipment payload)	
Engines	Four Allison 501-D13, 4,000 SHP each	
Electrical Power	59 kVA (available for research)	
Base	Jefferson County Airport, Broomfield, CO, USA **(BJC)**	

Please Note: The figures quoted for payload, range, altitude, and endurance are maxima that may be reduced due to high temperatures, extensive IFR weather conditions or other factors too numerous to list here. In some circumstances, these values may be increased based on experience, base-instrumented weights, inclusion of extra flight crew, etc. Each project is planned and executed according to the circumstances prevailing at the time. See *Research Aviation Facility Bulletin No. 7* for more details on Electra flight planning.

Due to insurance liability considerations, the crew must be limited to the necessary project participants. The maximum number of people on a given mission is 19.

ELECTRA CABIN PRESSURIZATION	
Aircraft Altitude	Cabin Pressure Differential (cabin pressure - outside pressure)
5,000 ft	0 to 5.1 inches Hg
10,000 ft	0 to 9.2 inches Hg
15,000 ft	5.3 to 13.0 inches Hg
20,000 ft	8.5 to 13.3 inches Hg
25,000 ft	11.0 to 13.3 inches Hg

Table 2

NCAR/NSF ELECTRA (N308D)

AIRCRAFT INSTRUMENTATION SPECIFICATIONS

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Variable Measured	Instrument Type	Manufacturer & Model No.	Combined Performance of Transducer, Signal Conditioning, and Recorder		
			Range	Accuracy	Resolution
Aircraft Latitude (LAT)	Inertial Navigation System	Honeywell Laseref SM IRS	+/- 90 deg	+/- 0.164 deg (6 hr)	0.00017 deg
Aircraft Longitude (LON)	Inertial Navigation System	Honeywell Laseref SM IRS	+/- 180 deg	+/- 0.164 deg (6 hr)	0.00017 deg
Aircraft Position & Ground Speed (GLAT, GLON, GALT & GVEW, GVNS)	GPS Navigation Sensor	Trimble Navigation Model TANS III	4-Satellite, 3-D pos. 3-Satellite, 2-D pos.	+/- 100 m (Horiz) +/- 156 m (Vertical) +/- 0.1 m/s (Velocity)	< = 0.5 m < = 0.5 m < = 0.05 m/s
Aircraft Ground Speed (VNS, VEW)	Inertial Navigation System	Honeywell Laseref SM IRS	0 to 400 m/s	+/- 4.115 m/s (6 hr)	0.0020 m/s

Aircraft Vertical Velocity (IVSPD)	Inertial Navigation System	Honeywell Laseref SM IRS	+/- 200 m/s	+/- 0.1524 m/s (6 hr)	0.0095 m/s
Aircraft True Heading (THDG)	Inertial Navigation System	Honeywell Laseref SM IRS	0 to 360 deg	+/- 0.2 deg (6 hr)	0.00017 deg
Aircraft Pitch Angle (PITCH)	Inertial Navigation System	Honeywell Laseref SM IRS	+/- 90 deg	+/- 0.05 deg (6 hr)	0.00017 deg
Aircraft Roll Angle (ROLL)	Inertial Navigation System	Honeywell Laseref SM IRS	+/- 180 deg	+/- 0.05 deg (6 hr)	0.00017 deg

Table 2

NCAR/NSF ELECTRA (N308D)

AIRCRAFT INSTRUMENTATION SPECIFICATIONS

Variable Measured	Instrument Type	Manufacturer & Model No.	Combined Performance of Transducer, Signal Conditioning, and Recorder		
			Range	Accuracy	Resolution
Fuselage Static Pressure (PSFD)	Oscillation Frequency (digital output)	Rosemount, Inc. 1501	250 to 1035 mbar	+/- 1 mbar	0.034 mbar
Wing Static Pressure (PSW)	Variable Capacitance	Rosemount, Inc. 1201F	250 to 1035 mbar	+/- 1 mbar*	0.07 mbar
# Cabin Static Pressure (PCAB)	Variable Capacitance	Rosemount, Inc. 1201F	600 to 1035 mbar	+/- 1 mbar*	0.07 mbar
Indicated Airspeed Pressure (QCW, QCF, QCR)	Variable Capacitance	Rosemount, Inc. 1221	0 to 125 mbar	+/- 0.7 mbar	0.006 mbar

Total Air Temperature (TTB, TTF)	Platinum Resistance	Rosemount, Inc. 102E2AL	-60 to +40 C	+/- 0.5 C	0.006 C
Total Air Temperature (TTWH, TTFH)	Deiced Platinum Resistance	Rosemount, Inc. 102DB & 102CV	-60 to +40 C	+/- 1.0 C	0.006 C
# Ambient Air Temperature (OAT)	Infrared Thermometer @ 4.25 um	Ophir Corporation III	-40 to +40 C	----	0.05 C
Dew-Point Temperature (DPB)	Thermoelectric Hygrometer	EG&G Model 137-C3-S3	-50 to +50 C	+/- 0.5 C (> 0 C) ** +/- 1.0 C (< 0 C)	0.006 C
Dew-Point Temperature (DPT)	Thermoelectric Hygrometer	General Eastern Model 1011B	-65 to +50 C	+/- 0.5 C (> 0 C) +/- 1.0 C (< 0 C)	0.006 C
## Dew-Point Temperature (DPCRC)	Cryogenic Hygrometer	NCAR-developed	-85 to -15 C	+/- 0.5 C	0.01 C

* Assuming transducer is exposed to < 1 C/min rate of temperature change
** If relative humidity is > 11 %

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Table 2

NCAR/NSF ELECTRA (N308D)

AIRCRAFT INSTRUMENTATION SPECIFICATIONS

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Variable Measured	Instrument Type	Manufacturer & Model No.	Combined Performance of Transducer, Signal Conditioning, and Recorder		
			Range	Accuracy	Resolution
# Absolute Humidity (RHOLA) *	Lyman-alpha Hygrometer	NCAR Developed LA-3	0.1 to 25 g/m3	+/- 5 % **	0.2 %

Angle of Attack (ADIFR)	Flow Angle Sensor, Radome	Rosemount, Inc. 1221F	+/- 10 deg	+/- 0.134 deg	0.002 deg
Angle of Sideslip (BDIFR)	Flow Angle Sensor, Radome	Rosemount, Inc. 1221F	+/- 5 deg	+/- 0.096 deg	0.002 deg
Radiometric Surface Temperature (RSTB)	Bolometric Radiometer (spectral range 9.5 to 11.5 um)	Heimann Infrared Model KT19.85	-50 to +50 C	+/- 0.5 C (plus 0.7 % of difference between housing and object temperature)	0.1 C
# Radiometric Sky Temperature (RSTT)	Bolometric Radiometer (spectral range 9.5 to 11.5 um)	Heimann Infrared Model KT19.85	-50 to +50 C	+/- 0.5 C (plus 0.7 % of difference between housing and object temperature)	0.1 C
Infrared Radiation (IRT, IRB)	Pyrgeometer 3.5 to 50 um (Silicon Dome)	Eppley PIR (NCAR modified)	0 to 600 W/m2	----	0.12 W/m2
Visible Radiation (SWT, SWB)	Pyranometer .285 to 2.8 um (Clear Dome WG7)	Eppley PSP (NCAR modified)	0 to 1400 W/m2	----	0.12 W/m2
Ultraviolet Radiation (UVT, UVB)	Photometer .295 to .385 um	Eppley TUVR (NCAR modified)	0 to 60 W/m2	----	0.12 W/m2
## Spectral Vegetation Radiometer (WV650, WV862)	Two-wavelength device (650 & 862 nm)	NCAR Developed 1992	Suitable for characterizing Normalized Difference Vegetation Index (See NCAR Technical Note NCAR/TN-370+STR.)		

* Stub or crossflow type (Available only for high-rate projects)
** Long-term accuracy is slaved to measurement from a thermoelectric hygrometer.

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Table 2

NCAR/NSF ELECTRA (N308D)

AIRCRAFT INSTRUMENTATION SPECIFICATIONS

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Variable Measured	Instrument Type	Manufacturer & Model No.	Combined Performance of Transducer, Signal Conditioning, and Recorder		
			Range	Accuracy	Resolution
Geometric Altitude (HGM)	Radio Altimeter	Collins ALT-55	0 to 780 m	+/- 0.6 or 2 % (0 to 152 m) +/- 3 % (152 to 780 m)	0.1 m
Geometric Altitude (HGME)	Radar Altimeter	Stewart Warner APN-159	500 to 10,000 m	+/- 9.7 m	0.1 m
Cloud Liquid Water Content (PLWC)	Heated-wire	PMS Model KLWC-5	0 to 5 g/m3	0.02 g/m3	0.001 g/m3
Icing Rate Detector (RICE)	Accretion of Cloud Droplets	Rosemount, Inc. 871F	0 to 0.5 mm increments	----	0.0005 mm
# Photography	VHS Video Cameras: ● Forward Looking, Minolta color camera with JVC recorder ● Left side, color, GE camera Model 1CVK 5032A with GE Model 1CVK 5022X VCR		Up to 6 hours of recording per cassette (w/wo voice)		

Available from RAF upon request--must choose location(s) and direction(s)

Table 2

NCAR/NSF ELECTRA (N308D)

AIRCRAFT INSTRUMENTATION SPECIFICATIONS

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Variable Measured	Instrument Type	Manufacturer & Model No.	Combined Performance of Transducer, Signal Conditioning, and Recorder		
			Range	Accuracy	Resolution
# Aerosol Spectrum (PCASP)	Laser Spectrometer	Particle Measuring Systems, Inc.	0.12 to 3.12 um	----	0.025 to 0.375 um (progressively weighted)
# Cloud Droplet Spectrum (FSSP-100)	Laser Spectrometer	Particle Measuring Systems, Inc.	0.5 to 47 um	----	Selectable 0.5, 1, 2, 3 um
# Cloud Droplet Spectrum (FSSP-300)	Laser Spectrometer	Particle Measuring Systems, Inc.	0.3 to 20 um	----	0.05 to 2.0 um (progressively weighted)
# Cloud Droplet Spectrum (260X)	Laser Spectrometer	Particle Measuring Systems, Inc.	40 to 620 um	----	10 um
# Hydrometeor Spectrum (200Y)	Laser Spectrometer	Particle Measuring Systems, Inc.	300 to 4,500 um	----	300 um
# Cloud Particle Spectrum - 2D (2D-C)	Laser Spectrometer	Particle Measuring Systems, Inc.	25 to 800 um	----	25 um
# Hydrometeor Spectrum - 2D (2D-P)	Laser Spectrometer	Particle Measuring Systems, Inc.	200 to 6,400 um	----	200 um

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Table 2

NCAR/NSF ELECTRA (N308D)

AIRCRAFT INSTRUMENTATION SPECIFICATIONS

Variable Measured	Instrument Type	Manufacturer & Model No.	Combined Performance of Transducer, Signal Conditioning, and Recorder		
			Range	Accuracy	Detection Limit
## Cloud Droplet Nuclei (CVCNO, CVLA)	Counter Flow Virtual Impactor (CVI)	NCAR laboratory constructed	0 to 1,000 cm-3 0 to 20 gm-3	----	1 cm-3 0.1 gm-3
# Aerosol Concentrations (CONCN)	Butanol Condensation Nuclei	TSI Model 3760	0 to 10,000 ct cm-3	+/- 6 % (reading)	1 ct cm-3 (Selectable)
# Ozone Monitor (TEO3C)	UV Photometer	Thermo Electron Model 49	0 to 1 ppm	+/- 4 ppb	1 ppb
# Carbon Monoxide (COCAL)	Gas Correlation Filter	NCAR Developed 1989	0 to 5 ppm	+/- 20 ppb	10 ppb
## Formaldehyde (XFORS)	Fluorescence	NCAR laboratory constructed	0 to 10 ppbv	+/- 20 %	0.2 ppbv
## Hydroperoxides (PERSA, PERSB)	Fluorescence	NCAR laboratory constructed	0 to 10 ppbv	+/- 15 %	0.1 ppbv
## NOy (NOYC)	NO Chemiluminescence with gold converter	NCAR laboratory constructed	0 to 100 ppbv	+/- 10 %	0.05 ppbv
## Sulfur Dioxide (S02C)	Pulsed fluorescent fluorescence	TECO 43A	0 to 100 ppbv	+/- 10 %	1 ppbv
## Fast-Response Ozone (03FSC)	Chemiluminescence	NCAR laboratory constructed	0 to 300 ppbv	+/- 10 %	0.1 ppbv

## Fast-Response CO2/H2O	Infrared absorption	LiCor 6262	0-500 ppm (CO2) 0-20,000 ppm (H2O)	+/- 5 %	0.5 ppm (CO2) 100 ppm (H2O)

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Available from RAF via special arrangement

Table 3

NCAR/NSF ELECTRA

SPECIFICATIONS FOR AIR VELOCITY COMPONENTS

Variable Measured	Instrument Type	Range	Accuracy (m/s)		Resolution	Upper Limit Frequency Response (Hz)
			Relative, Short-term (< 10 min)	Absolute, Long-term (t in hours)		
* Wind vector horizontal component (UI, VI)	Input from radome gust probe and INS	0 to 100 m/s	+/- 0.1	+/- (1.0 + 0.5t) **	0.012 m/s	10
* Wind vector vertical component (WI)	Input from radome gust probe and INS	+/- 15 m/s	+/- 0.1	----	0.012 m/s	10
Horizontal wind direction (WD)	Input from radome gust probe and INS	0 to 360 deg	+/- COT-1 (UI/VI)	----	0.001 deg	10

* RAF-computed winds are a combination of the mean and fluctuating components (i.e., UI = UI + UI').
** With GPS corrections, long-term absolute accuracy improves to +/- 1. m/s.

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Last update: Wed Jan 22 16:10:20 MST 1997

Table 4

STANDARD OUTPUT PARAMETER LIST - ELECTRA

VARIABLES	SYMBOL	DATA OUTPUT sps	UNITS
AIRCRAFT POSITION VARIABLES			
Inertial Latitude	LAT	1	deg
GPS-Corrected Inertial Latitude	XLATC	1	deg
Inertial Longitude	LON	1	deg
GPS-Corrected Inertial Longitude	XLONC	1	deg
GPS Latitude	GLAT	1	deg
GPS Longitude	GLON	1	deg
ATMOSPHERIC STATE VARIABLES			
Corrected Static Pressure, Fuse.(DI)	PSFDC	1	mbar
Corrected Static Pressure, Wing	PSWC	1	mbar
Ambient Temperature, Radome	ATB	1, 25	C
Ambient Temperature, Reverse Flow	ATRF	1, 25	C
Dew Point Temperature, T-Electric - top	DPTC	1	C
Dew Point Temperature, T-Electric - bottom	DPBC	1	C
WIND VARIABLES			
Horizontal Wind Speed	WS	1, 25	m/s
Horizontal Wind Direction	WD	1, 25	deg
Wind Vector, East Component	UI	1, 25	m/s
Wind Vector, North Component	VI	1, 25	m/s
Wind Vector, Vertical Gust Component	WI	1, 25	m/s
Wind Vector, Longitudinal Component	UX	1, 25	m/s
Wind Vector, Lateral Component	VY	1, 25	m/s
GPS CORRECTED WINDS			
GPS Corrected Horizontal Wind Speed	XWSC	1, 25	m/s
GPS Corrected Horizontal Wind Direction	XWDC	1, 25	deg
GPS Corrected Wind Vector, East Component	XUIC	1, 25	m/s
GPS Corrected Wind Vector, North Component	XVIC	1, 25	m/s
GPS Corrected Wind Vector, Vertical Gust Comp.	XWIC	1, 25	m/s
GPS Corrected Wind Vector, Longitudinal Comp.	XUXC	1, 25	m/s
GPS Corrected Wind Vector, Lateral Comp.	XVYC	1, 25	m/s
GPS Corrected IRS Ground Speed, North Comp.	XVNSC	1, 25	m/s
GPS Corrected IRS Ground Speed, East Comp.	XVEWC	1, 25	m/s
ALTITUDE VARIABLES			
Geometric (Radio) Altitude	HGM	1	deg
NACA Pressure Altitude	PALT	1	m
Geometric (Radar) Altitude (APN - 232)	HGM 232	1	m
THERMODYNAMIC VARIABLES			
Potential Temperature	THETA	1, 25	K
Equivalent Potential Temperature	THETAE	1, 25	K
Absolute Humidity: T-Electric, Top	RHODT	1	g/m^3
Absolute Humidity: T-Electric, Bot	RHODB	1	g/m^3
Absolute Humidity (Lyman Alpha)	RHOLA	1, 25	g/m^3
Mixing Ratio: T-Electric	MR	1	g/kg
Relative Humidity	RHUM	1	per/cent
CLOUD PHYSICS VARIABLES			
Corrected PMS-King Liquid Water Content	PLWCC	1	g/m^3

Table 4

STANDARD OUTPUT PARAMETER LIST - ELECTRA

VARIABLES	SYMBOL	DATA OUTPUT sps	UNITS
RADIATION VARIABLES			
Shortwave Irradiance, Top	SWT	1	W/m^2
Shortwave Irradiance, Bot	SWB	1	W/m^2
Corrected Infrared Irradiance, Top	IRTC	1	W/m^2
Corrected Infrared Irradiance, Bot	IRBC	1	W/m^2
Ultraviolet Irradiance, Top	UVT	1	W/m^2
Ultraviolet Irradiance, Bottom	UVB	1	W/m^2
Radiometric Surface Temperature	RSTB	1	C
AIRCRAFT STATE VARIABLES			
Aircraft True Heading Angle	THDG	1, 25	deg
Aircraft Roll Angle	ROLL	1, 25	deg
Aircraft Pitch Angle	PITCH	1, 25	deg
Aircraft Vertical Acceleration	ACINS	1, 25	m/s^2
Aircraft Ground Speed (IRS)	GSF	1, 10	m/s
IRS Ground Speed Vector, East Comp.	VEW	1, 10	m/s
IRS Ground Speed Vector, North Comp.	VNS	1, 10	m/s
GPS Ground Speed Vector, East Comp.	GVEW	1	m/s
GPS Ground Speed Vector, North Comp.	GVNS	1	m/s
Damped Aircraft Vertical Velocity, IRS	WP3, VSPD	1, 25	m/s
Aircraft True Airspeed, Fuselage	TASF	1, 25	m/s
Aircraft True Airspeed, Wing	TASW	1, 25	m/s
Aircraft True Airspeed, Radome	TASR	1, 25	m/s
Corrected Dynamic Pressure, Fuse.	QCFC	1, 25	mbar
Corrected Dynamic Pressure, Wing	QCWC	1, 25	mbar
Corrected Dynamic Pressure, Radome	QCRC	1, 25	mbar
Attack Angle, Radome Diff. Press.	AKRD	1, 25	deg
Sideslip Angle, Radome Diff. Press.	SSRD	1, 25	deg
MISCELLANEOUS SOURCE VARIABLES			
Raw Static Pressure Fuselage (Digital)	PSFD	1, 25	mbar
Cabin Pressure	PCAB	1	mbar
Raw Static Pressure, Wing	PSW	1, 25	mbar
Raw Dynamic Pressure, Fuselage	QCF	1, 25	mbar
Raw Dynamic Pressure, Wing	QCW	1, 25	mbar
Raw Dynamic Pressure, Radome	QCR	1, 25	mbar
Vertical Differential Press, Radome	ADIFR	1, 25	mbar
Horizontal Differential Press, Radome	BDIFR	1, 25	mbar
Total Temperature, Radome	TTRF	1, 25	C
Total Temperature, Reverse Flow	TTRF	1, 25	C
Dew/Frost Point Temperature, Fuse. Top	DPT	1	C
Dew/Frost Point Temperature, Fuse. Bot	DPB	1	C
Raw Lyman-alpha Output	VLA	1, 25	Vdc
Raw Infrared Irradiance, Top	IRT	1	W/m^2
Raw Infrared Irradiance, Bottom	IRB	1	W/m^2
Top Pyrgeometer Dome Temperature	DTT	1	C
Top Pyrgeometer Sink Temperature	STT	1	C
Bottom Pyrgeometer Dome Temperature	DTB	1	C
Bottom Pyrgeometer Sink Temperature	STB	1	C
Raw PMS-King Liquid Water Content	PLWC	1	W
Raw Icing Rate Indicator	RICE	1	Vdc

Note: Output from other RAF sensors, including PMS-Probes (if requested), are part of the standard output. See Table 2 for details or contact RAF.