Table 6.1
NSF/NCAR C-130Q Hercules (N130AR)
Aircraft Instrumentation Specifications
State Parameter Sensors

Variable Measured	Instrument Type	Manufacturer & Model No.	Range	Accuracy	Resolution
Aircraft Latitude (LAT) Aircraft Longitude (LON)	**Inertial Navigation System**	**Honeywell Laseref SM IRS**	**+-90 deg**	**+-0.164 deg (6hr)**	**0.00017 deg**
Aircraft Ground Speed (VEW, VNS)	**Inertial Navigation System**	**Honeywell Laseref SM IRS**	**0-400 M/s**	**+-4 M/s (6 hr)**	**0.002 M/s**
Aircraft Vertical Velocity (VSPD)	**Inertial Navigation System**	**Honeywell Laseref SM IRS**	**+-200 M/s**	**+-0.15 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**	**0.00017 deg**
Aircraft Pitch Angle (PITCH)	**Inertial Navigation System**	**Honeywell Laseref SM IRS**	**+-90 deg**	**+-0.05 deg**	**0.00017 deg**
Aircraft Roll Angle (ROLL)	**Inertial Navigation System**	**Honeywell Laseref SM IRS**	**+-180 deg**	**+-0.05 deg**	**0.00017 deg**

OPS Characteristics: There are several types of errors generally associated with RAF's IRS systems which affect the data after a successful alignment. The first one to consider, because it affects every flight, is the navigational position drift. Errors in both position (LAT,LON) and ground speed (VEW,VNS) vary in an oscillatory fashion in flight. These oscillations will vary in magnitude from flight to flight, will typically be out of phase, and maintain a period of roughly 84 minutes. This phenomenon is known as the Schuller oscillation and is caused by the fact that the earth is not a true inertial system. Overall performance is judged through final position errors noted upon the completion of each flight. Position errors of less than 1.0 nmi/hr are within normal operating specifications. Position comparisons against other navigational aids can be very useful. The Global Positioning System (GPS) is considered to be the most accurate position reference system and is used to correct the IRS data for use in the WIND calculations.

Variable Measured	Instrument Type	Manufacturer & Model No.	Range	Accuracy	Resolution
Aircraft Position & Gnd Speed (GGLAT, GGLON, GALT, GGVEW, GGVNS)	**GPS Navigation Sensor**	**Trimble Navigation Model TANS III**	**Global 0 to 400 M/s**	**+-100 M H +-10 M V +-0.1 M/s**	**<=0.5 M <=0.5 M <=0.05 M/s**

OPS Characteristics: Generally speaking the data from this unit is either there and accurate or it is not there at all. This fact is not always clear from a casual look at the on board display. Following ADS initiation, GPS position (GGLAT/GGLON) will be available. If the signal is lost, for any reason, the on board display will carry forward the last values in memory (ie fixed position) until signal lock is regained. Intermittent signals have been experienced on several projects. Typically the cause is an antennae problem. However, the unit status function (GGSTAT) will provide a diagnostic value that monitors all other problem sources (battery, etc). See the manual for more details on this process. Routine comparisons against the standard IRS data (LAT/LON, VEW/VNS) are strongly recommended. This unit provides the most accurate data on aircraft position and speed and provides the information needed to correct the IRS data that are used in the WIND calculations.

Variable Measured	Instrument Type	Manufacturer & Model No.	Range	Accuracy	Resolution
Aircraft Position & Gnd Speed (LATDG, LONDG, ALTDG, VEWDG, VNSDG)	**Differential GPS Navigation Sensor**	**NovAtel Model OEM 4 L1/L2**	**Global 0 to 400 M/s**	**+-0.3 M H +-0.2 M V +-0.1 M/s**	**<=0.01 M <=0.01 M <=0.01 M/s**

OPS Characteristics: The differential GPS system utilizes a L1/L2 antenna and receiver to acquire aircraft position data at a rate up to 10 sps. DGPS is capable of achieving sub-10 cm accuracy under favorable conditions. The system does not provide realtime high accuracy data during flight. High accuracy position information is obtained during post flight processing using concurrent data from stationary ground-based dual frequency receivers. The application of the system is limited by the availability of ground-based GPS recording stations along the flight track and can be improved by installing an EOL-supplied ground station at the OPS base. Accuracy of teh DGPS data degrade as the aircraft travels away from teh ground station. On long flights over teh ocean the accuracy can range from 20 to 60 cm OSSD. GPS constrellation and aircraft banking may further decrease the accuracy of the measurements or render the data useless if the number of concurrently observed satellites is less than five.

Table 6.1 State Parameters Sensors (cont.)

Variable Measured	Instrument Type	Manufacturer & Model No.	Range	Accuracy	Resolution
Fuselage Static Pressure (PSFD)	**DigiQuartz Transducer**	**Paroscientific 1000**	**50 to 1085 mb**	**+-0.3 mb**	**0.00001 mb**
OPS Characteristics: Instrument is generally not susceptible to outside interference and is typically used as the primary static pressure reference. The corrected value (PSFDC) is a derived variable, however, and can be influenced by errors in dynamic pressure (QCR) and vertical differencial pressure (ADIFR) which factor into the empirically derived PCOR.					
Fuselage Static Pressure (PSFRD)	**DigiQuartz Transducer**	**Paroscientific 1000**	**50 to 1085 mb**	**+-0.3 mb**	**0.00001 mb**
OPS Characteristics: Instrument is generally not susceptible to outside interference. The corrected value (PSFC) is a derived variable, however, and can be influenced by errors in dynamic pressure (QCFR). This system is plumbed independently from the reference pitot/static system.					
Cabin Static Pressure (PCAB)	**Variable Capacitance**	**Rosemount Inc. 1201**	**600 to 1035 mb**	**+-1 mb**	**0.07 mb**
OPS Characteristics: Instrument is sensitive to marked temperature changes. However, the relatively controlled environment within the aircraft cabin limit the impact of this effect.					
Dynamic Pressure (QCR, QCF)	**Variable Capacitance**	**Rosemount Inc. 1221**	**0 to 125 mb**	**+-0.7 mb**	**0.006 mb**
OPS Characteristics: Instruments are generally not susceptible to outside interference and either can be used as the primary dynamic pressure reference. The corrected values (QCRC, QCFCC) are derived variables, however, and can be influenced by errors in dynamic pressure (QCR) and vertical differencial pressure (ADIFR), which factor into the empirically derived PCOR.					
Dynamic Pressure (QCFR)	**Variable Capacitance**	**Rosemount Inc. 1221**	**0 to 125 mb**	**+-0.7 mb**	**0.006 mb**
OPS Characteristics: Instrument is generally not susceptible to outside interference. The corrected value (QCFRC) is a derived variable. This sytem is plumbed independently from the reference pitot/static system.					
Total Air Temperature (TTRL, TTRR)	**Platinum Resistance**	**Rosemount Inc. 102E2AL**	**-60 to +40 C**	**+-0.5 C**	**0.006 C**
OPS Characteristics: All ambient temperatures are derived parameters which are also dependent upon the reference dynamic pressure (QCX). This parameter must also be examined when troubleshooting atypical behavior. Most common problems are loss of flow due to icing of the sensor housing and the evaporative cooling of the sensing element resulting from cloud/precipitation penetrations. These errors in in-cloud temperatures can be as large as 0.5 to 1.0oC and will always appear as negative biases. There have been certain instances of radio frequency interference with this measurement system.					
Total Air Temperature (TTWH)	**De-iced Platinum Resistance**	**Rosemount Inc. 102E**	**-60 to +40 C**	**+-1.0 C**	**0.006 C**
OPS Characteristics: Basically the same instrument as TTRL except for the addition of deicing heaters to the sensor housing. Instrument response is slower than the unheated version.					
Geometric Altitude - AGL (HGM232)	**Radar Altimeter**	**Stewart-Warner APN-232**	**0 to 12,000 M**	**+-10 M**	**0.1 M**
OPS Characteristics: While on the ground or in certain low altitude applications the return signal can overload the detector. System output will oscillate between zero and full scale at these times. Accuracy of the output will be altitude dependent above 1000 m. Generally it will be 1% of the current altitude.					
Pressure Altitude - MSL (PALT, PALTF)	**NACA Standard Atmosphere**	**Paroscientific 1000**			
OPS Characteristics: This derived parameter represents an aircraft altitude above sea level based on the NACA Standard Atmosphere. A surface pressure of 1013 mb is used to define the sea level reference point. Normal fluctuations in surface pressure can therefore result in errors of +-200 m. Under certain high pressure conditions near sea level, PALT values can even be negative. In exotic tropical or arctic locations the local lapse rate can introduce significant errors as well.					

Table 6.1 State Parameter Sensors (cont.)

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<tr><th>Variable Measured</th><th>Instrument Type</th><th>Manufacturer & Model No.</th><th>Range</th><th>Accuracy</th><th>Resolution</th></tr>
<tr><td>Altitude - MSL (GGALT)</td><td>GPS Navigation Sensor</td><td>Trimble Navigation Model TANS III</td><td>0 to 12,000 M</td><td>+-10 M</td><td>0.1 M</td></tr>
<tr><td colspan="6">OPS Characteristics: This measurement is a direct output of the GPS position system. It takes a minimum of 4 satellites to provide the data needed to resolve the GPS altitude (GGALT). In the event that 4 satellites are not in range, the value of GGALT is set equal to the pressure altitude (PALT). In comparing GGALT and PALT in flight, it is important to remember that PALT is derived using the NACA Standard Atmosphere. Local conditions (surface pressure & lapse rate) will account for some of the differences noted. Over long distances the trends in PALT and GGALT can differ with changes in surface pressure. Irregular oscillations of up to 10 m in GGALT can be expected, even on the ground. Note that the aircraft auto-pilot is tied into a pressure altitude reference.</td></tr>
<tr><td>Ambient Air Temperature (OAT)</td><td>Infrared Thermometer @ 4.25 uM</td><td>Ophir Corporation III</td><td>-40 to +40 C</td><td>----</td><td>0.05 C</td></tr>
<tr><td colspan="6">OPS Charateristics: The Ophir-III thermometer measures the ambient temperature radiometrically by sensing the spectral radiance of CO_2 and determining the corresponding temperature of the emitting gas. Nominally, the sensed volume is a column extending about 10 m from the aircraft. However, the viewing depth of the sensor has increased over time. In sharp turns, the unit can view the earth's surface – thus biasing the data to higher temperatures. This effect can result in errors as large as 0.5 C. Once the aircraft is in flight, a comparison between OAT and ATX should be made routinely. In-cloud temperature measurements will be of interest since the Ophir output is unaffected by the presence of liquid water in the sample volume. For clear air measurements, however, the standard reference temperature sensor is still the best source of data. For detailed analyses of short, cloud penetration flight segments, Users may want to apply a separate reference baseline from near cloud clear air measurements.</td></tr>
<tr><td>Dew-Point Temperature (DPT, DPB)</td><td>Thermoelectric Hygrometer</td><td>Buck Research 1011C</td><td>"-75 to +40 C</td><td>+-0.5 C W
+-1.0 C F</td><td>0.006 C</td></tr>
<tr><td colspan="6">OPS Characteristics: This is an updated version of the GE 1011B sensor with added cooling capacity and improved electronics. Chilled mirror dew point sensors are relatively slow and primarily limited by their cooling and optical trigger components. Random drift or rapid oscillations in the signal can be indicators of a balance problem - readjust in flight. The inlet housing is unheated and susceptible to flow restrictions caused by icing conditions. Large dew point depressions (ATX - DPTC) >20 cause extreme forcing of the peltier cooling system in this unit and can result in instrument lag times as great as 10 seconds. This can be very important during rapid soundings. A nominal response time in moist conditions (RH > 50%) should be around 0.2 seconds. In-cloud conditions should result in dew point depressions on the order of 0 < (ATX - DPBC) < 1°C. Negative in cloud depressions indicate either poor calibration or possible element wetting of the reference temperature sensor.</td></tr>
<tr><td>Fast Response Water Vapor Density (RHOLA, DPLA)</td><td>Lyman-alpha absorption</td><td>NCAR</td><td>0.1 to 25 g/M3</td><td>+-5%</td><td>0.20%</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td>Water Vapor Density (MRLH)</td><td>TDL Open Path absorption</td><td>SpectraSensors</td><td>0.1 to 25 g/M3</td><td></td><td></td></tr>
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<tr><th>Variable Measured</th><th>Instrument Type</th><th>Manufacturer & Model No.</th><th>Range</th><th>Accuracy</th><th>Resolution</th></tr>
<tr><td>Angle of Attack (ADIFR, AKRD)</td><td>Flow Angle Sensor, Radome</td><td>Rosemount Inc 1221F</td><td>+-10 deg</td><td>+-0.134 deg</td><td>0.002 deg</td></tr>
<tr><td>Angle of Sideslip (BDIFR, SSRD)</td><td>Flow Angle Sensor, Radome</td><td>Rosemount Inc 1221F</td><td>+-5 deg</td><td>+-0.096 deg</td><td>0.002 deg</td></tr>
<tr><td colspan="6">OPS Characteristics: Measures differential pressures above/below (attack) or left/right (sideslip), which arise from off-axis flow. Most common problems are icing (radome). An unheated radome is also susceptible to blockage by ice particles from passage through fairly dense cold clouds. Such blockages can generally not be cleared until the aircraft descends to an altitude where the ambient temperature is above freezing. Since this is a primary sensor for a number of derived variables, such occurrences could impact those calculations as well. Due to its importance as a reference parameter, redundant sensors are normally flown on each aircraft. The fuselage pitot installations have good anti-ice capabilities but the radome units will provide the most accurate values for the WIND calculations. Comparisons should be made with corrected values (QCXC) only and differences should remain less than +- 0.5 mb. If the radome values appear to be low, check the integrity of the radome anti-ice system.</td></tr>
<tr><td>Horizontal Wind Vector components (UIC, VIC)</td><td>Radome gust probe, IRS, GPS</td><td>Various</td><td>0 to 100 M/s</td><td>+-0.5 M/s</td><td>0.012 M/s</td></tr>
<tr><td>Vertical Wind Vector component (WIC)</td><td>Radome gust probe, IRS, GPS</td><td>Various</td><td>+-15 M/s</td><td>+-0.2 M/s</td><td>0.012 M/s</td></tr>
<tr><td colspan="6">OPS Characteristics: One of the primary sources of error in the WIND calculations is the drift errors in the IRS position (LAT/LON) and ground speed (VEW/VNS) inputs. With the addition of the GPS to the instrument package, it is now possible to improve these inputs. A complex algorithm is used to smoothly link the two data sets with a resulting improvement in the horizontal winds. The vertical winds are unaffected by this process. A regular comparison of the basic and corrected wind data is useful as it provides a check on all of the WIND input systems. In the event of a GPS failure, the corrected wind values will revert to the basic values. In the event of an IRS failure, all wind data are lost. The GPS cannot provide the necessary redundancy on aircraft attitude data to complete the calculations.</td></tr>
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