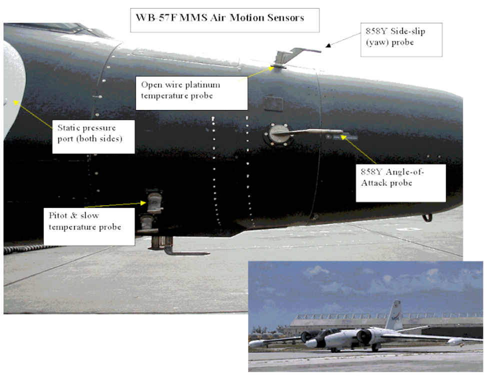
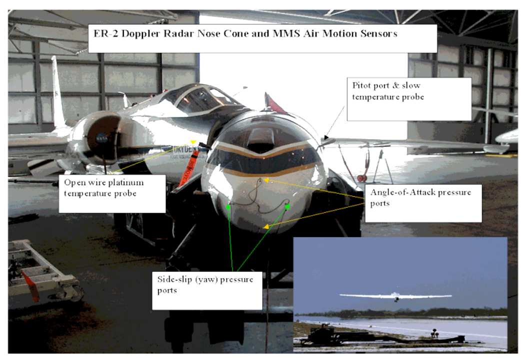
Meteorological Measurement Systems (MMS)

The Meteorological Measurement System (MMS) is a state-of-the-art instrument for measuring accurate, high resolution in situ airborne state parameters (pressure, temperature, turbulence index, and the 3-dimensional wind vector). These key measurements enable our understanding of atmospheric dynamics, chemistry and microphysical processes.

The MMS is used to investigate atmospheric mesoscale (gravity and mountain lee waves) and microscale (turbulence) phenomena. An accurate characterization of the turbulence phenomenon is important for the understanding of dynamic processes in the atmosphere, such as the behavior of buoyant plumes within cirrus clouds, diffusions of chemical species within wake vortices generated by jet aircraft, and microphysical processes in breaking gravity waves. Accurate temperature and pressure data are needed to evaluate chemical reaction rates as well as to determine accurate mixing ratios. Accurate wind field data establish a detailed relationship with the various constituents and the measured wind also verifies numerical models used to evaluate air mass origin. Since the MMS provides quality information on atmospheric state variables, MMS data have been extensively used by many investigators to process and interpret the in situ experiments aboard the same aircraft. In addition to the original development on the high-altitude ER-2 aircraft, MMS systems had flown successfully on the NASA DC-8 and WB-57 aircraft. An MMS is currently under development for the Altair unmanned aerial systems (UAS). Because of its unique capabilities, the MMS has been competitively selected to fly on numerous NASA airborne atmospheric science campaigns in the last 10 years. These international experiments have spanned the globe, from the North Pole to Antarctica and from the western Pacific to Scandinavia. Recent field campaigns included SOLVE, CAMEX-3/4, CRYSTAL-FACE, MidCix, AURA Validation Experiment, and NAMMA.





Primary Products @ 20 Hz:

	Typical value	Precision	Accuracy
Pressure	~ 60 mb	0.1 mb	± 0.3 mb ~ 0.5%
Temperature	~180 K	0.1 K	± 0.3 k ~ 0.2%
Horizontal Wind	~ 30 ms^{-1}	0.1 ms^{-1}	±1 ms^{-1} ~3.3%
Vertical Wind	< 1 ms^{-1}	0.1 ms^{-1}	time averaged ~ 0.0 ms^{-1}

Derived Parameter:

Potential Temperature, True-Air-Speed, Turbulence,

Measured Parameters:

DGPS Positions, Velocities, Accelerations, Pitch, Roll, Heading, Angle-of-Attack, Angle-of-Sideslip, Dynamic Total Pressures, Total Temperatures

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Instrument Description:

The MMS instrumentation consists of three major systems:

1. An air motion sensing system to measure the velocity of the air with respect to the aircraft, i.e., the true air speed.
2. An inertial navigation system to measure the velocity of the aircraft with respect to the earth, i.e., the ground speed.
3. A data acquisition system to sample, process and record the measured quantities.

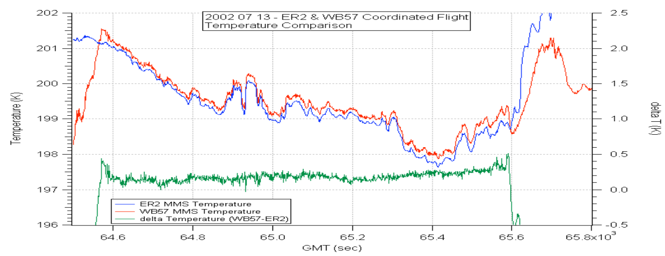
The air motion sensing system consists of sensors, which measure temperature, pressures, and airflow angles (angle of attack and yaw angle). The Litton LN-100G Embedded GPS Inertial Navigation System (INS) provides the aircraft attitude, position, velocity, and acceleration data. The Data Acquisition System samples the independent variables simultaneously and provides control over all system hardware.

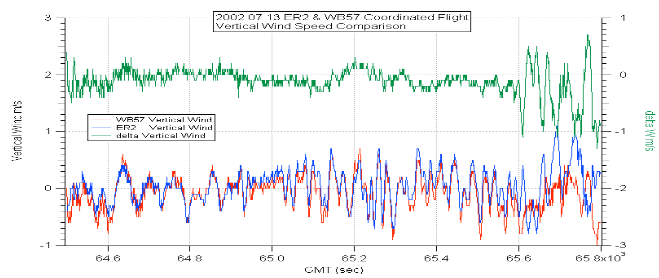
The true airspeed vector depends on air data measurements, including static pressure, static temperature, pitot pressure, and air flow with respect to the fuselage. Accurate measurements of these quantities require judicious choices of sensor locations, repeated laboratory calibrations, and proper corrections for compressibility, adiabatic heating and flow distortion. The ground speed vector is derived from the integration of acceleration data using the appropriate numerical constraints and compensation. For example, the vertical acceleration data includes the compensation for distance above the surface ($1/R^2$), centrifugal effects, and non-spherical earth effects. The integration is constrained by an altitude derived from the hydrostatic equation.

The system calibration of the MMS consists of:

1. Individual sensor calibrations.
2. Sensor dynamical response tests.
3. Laboratory determination of the dynamic behavior of the inertial navigation system.
4. In-flight calibration.
5. Comparison with radiosonde and radar-tracked balloons.

Sample Data:
Wing-tip intercomparison between ER-2 and WB-57





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