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SEEDING OPERATIONS & ATMOSPHERIC RESEARCH

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Aircraft instrumentation

The SOAR Cheyenne II research aircraft is an airborne platform for atmospheric research consisting of instrumentation that has the capability of measuring in situ microphysical properties of clouds and their thermodynamic environment, documenting the composition of clouds and diagnosing the physical processes within them. This aircraft has been especially modified and equipped for atmospheric research together with the crew and infrastructure needed to support its use. The SOAR Cheyenne II research aircraft, entirely dedicated to atmospheric research, is a versatile flying laboratory offering several scientific configurations: basic meteorological instrumentation, turbulent flux equipment, microphysics sensors, and in-situ chemistry instruments. Access to the SOAR Cheyenne is offered to all research groups. The facility is offered with the configuration required, including infrastructural, logistical, technical and scientific support.

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The **DMT Cloud Imaging Probe (CIP)** is very similar in technical operation to the 2D-OAP developed by PMS. A linear array of laser beams is focused on a sampling area where the particles' shadows are optically magnified to provide the imaging data. The data output is distributed in 62 channels making the minimum detectable particle size at 12.5 µm and the largest particle at 1562.5 µm. Particles that shadow the two end diodes (1 and 64) are end rejected. The CIP incorporates a Liquid Water Content (LWC) detector.

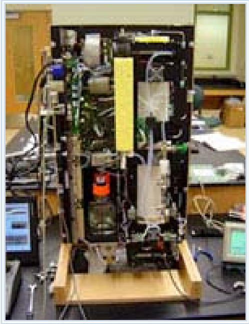
The **DMT Cloud Droplet Probe (CDP)** is similar in technical operation to the FSSP. The instrument counts and sizes individual droplets as they traverse a laser beam. Droplets that hit the laser beam within the sample volume scatter light and the forward scattered light is collected onto an optical beam splitter and then onto a pair of photo detectors, the sizing detector and the qualifying detector. The range of the CDP is fixed and the output is distributed in 30 size channels in the range of 2 µm to 50 µm.

The **Aircraft Integrated Meteorological Measurement System (AIMMS-20)** gives up-to-the-second real-time three-dimensional wind conditions evaluated using the Kalman Filter Digital Signal Processing (DSP) technique. The AIMMS-20 consists of four components: an Air Data Probe (ADP), a carrier-phase Geostationary Positioning Satellite (GPS) measurement module, an Inertial Measurement Unit (IMU) and Central Processing Module (CPM).

The **Passive Cavity Aerosol Spectrometer Probe (PCASP SPP-200)** counts and sizes particles present in any given volume of air within a specified size range. Light scattered by a particle entering the PCASP laser beam is collected and focused onto a photodetector where it undergoes 3 stages of amplification to cover the range between 0.1 and 3.0µm.

The **Forward Scattering Spectrometer Probe (FSSP SPP-100)** is also used to collect size distributions of airborne particulates ranging from 2 - 47µm. For ease of service and compatibility the probe mounts in the 7-inch OD cylinder as a plug-in assembly with two internal connectors at 90° to each other allowing the probe light tubes to be oriented either perpendicular or parallel to the mounting pad.

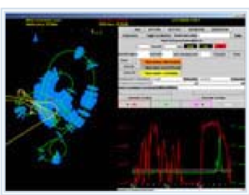
The **DMT CCN Counter** samples aerosols from outside the aircraft to measure their capability to act as cloud condensation nuclei. An air sample is introduced in the CCN chamber at the top center of a vertical cylindrical column and is surrounded by an aerosol-free humidified uniform supersaturation flow environment. As the air sample flows down through the chamber, CCN activate in response to the exposed supersaturation and grow to droplets. An optical particle counter at the base or outlet of the chamber detects all particles with diameters larger than 0.5µm. The heart of the instrument is the 50 cm long cylindrical column which provides the environment to activate and grow aerosol particles. The column is mounted vertically with the ambient aerosol entering at the top, and the increase in supersaturation takes place down the column. The unit operates at a single supersaturation. The supersaturation depends on the temperature difference between the top and bottom of the column as well as the flow rate in the column. The supersaturation can be varied between 0.07 % and 1.2 %. The column has three temperature control zones, for rapid shifting between supersaturation. Approximately 30 seconds are required for a shift from one supersaturation to



another, although operation in the field shows that shifting from a high supersaturation (1.2 %) to a low supersaturation (0.07 %) may take more than a minute since the temperature controllers are more efficient at warming the column than at cooling. The data output is distributed in 20 bins of resolution over the sizing range of 0.75 µm to 10 µm. The particle sizing data is updated at 1-second intervals. At a sample flow rate of 60 vccm, 6000 particles per cubic centimeter can be counted with a maximum of a 10 % coincidence.

In a **Differential Mobility Analyzer (DMA)**, an electric field of known magnitude is induced in order to separate particles within a narrow electrical mobility range. Size distribution of the particles ingested by the DMA can be determined by scanning the voltage applied to create the electric field, since particles possessing one elementary charge demonstrate a unique relationship between their electrical mobility and their size. The TDMA is actually two DMAs in series where the first DMA remains at a constant voltage and produces a mono-dispersed aerosol which is then subjected to a high relative humidity. If the aerosol is hygroscopic, it will take up water and grow while an aerosol that exhibits no hygroscopic properties will exhibit no growth. The second DMA is applied a voltage that is continuously scanned. Since the ingested aerosol will flow from the first DMA to the second, the known particle size separated by the first DMA with the final size distribution measured by the second DMA, the hygroscopic growth distribution of the aerosol can be determined. Texas A&M University owns and operates the TDMA.

The **Continuous Tracer (sulfur hexafluoride) Analyzer** allows for real-time, in-situ measurement of tracer gas concentrations. Ambient air is mixed with hydrogen and passed over a catalyst where oxygen and hydrogen form water. The water is then removed from the gas with a counter-current Nafion membrane drier and the dry gas passes through an electron capture detector (ECD). An HP 5890 gas chromatograph's ECD and associated electronics have been incorporated into the tracer analyzer flow system. The ECD is a variable frequency (pulse rate) which rises when an electron capturing compound is passing through the cell. The pulse rate is converted to a voltage, linearly related to amount of electron capturing material in the cell. The output is a 0-1 V analog signal.



This **Parcel Tracking Software (PTS)** was developed and tested for cloud parcel tracking. The capabilities of PTS are to:

1) accept the GPS coordinates of seeder aircraft in flight and presents their tracks in real time in the cockpit of the cloud physics aircraft,
2) marks the positions of the seeder and cloud physics aircraft and/or an event, such as the detected "hit" of SF6 gas and then repetitively navigates back to this point as it drifts with the ambient wind,
3) display of LWC along the track of the cloud physics aircraft when it was in cloud,
4) displays in real-time the plots of measured aircraft parameters and presents the aircraft navigation information in a form useful to the pilot.