NOAA-56 SCIENTIFIC INSTRUMENTATION

A NOAA Twin Otter (NOAA-56) was equipped with a purpose designed NOAA Aircraft Operations Center (AOC) instrumentation package to support atmosphere-ocean-ice research in Alaska and the Arctic. This was the first system of its kind installed on a NOAA Twin Otter and significantly expanded the capability of the platform.

The system consists of the following key components:

1. Advance Vertical Atmospheric Profiling System, 2 channel – Measures vertical atmosphere profiles
2. Up-looking Pyranometer- measures total solar energy
3. Down-looking Radiometer – accurately measures surface temperature when flying at low altitude
4. Radar Altimeter – measures height above the surface
5. AIMMS-30 Air Data System – in-situ temperature, pressure, humidity, 3-axis winds and wind fluxes
6. Garmin/Shadin Aircraft Data – captures navigation and air data generated by aircraft avionics systems
7. Airborne Expendable (AX) receiver system – ocean parameters by depth with expendable probes
8. Iridium Satellite Data modem
9. Project data system software package and data ingest computer (science computer)
10. Moving Map (TZ Navigator)
11. Expendables launch chute
12. GoPro High speed video and still picture camera

The external arrangement is shown in Drawing 730001A1.

DETAILED SYSTEM DESCRIPTION

1. Advanced Vertical Atmospheric Profiling System (AVAPS) System

The 2-channel AVAPS dropwindsonde system consists of a telemetry receiver system borrowed from the National Center for Atmospheric Research (NCAR), GPS receive antenna (existing aircraft scientific GPS antenna), a belly mounted telemetry receive antenna, a launch tube assembly, and the science computer executing AVAPS Drop Software V. 4.0.5. Real time data is not currently transmitted for weather model assimilation. AVAPS data may to be transmitted to NOAA/AOC for near real-time processing and quality control prior to being passed to the NOAA Data Gateway.

The AVAPS system ingests the IWG1 (International Working Group) aircraft flight level data generated by the Arctic Heat software package, and captures this data at time of launch for inclusion into the dropsonde data file.

2. Pyranometer

An Eppley PSP pyranometer (clear) is installed on the upper hatch plate. The associated amplifier is mounted to the underside of the plate. Analog output from the pyranometer (0 – 10 VDC) is routed to an AOC Analog to Digital converter (A-AD), with the digital output of the A-AD forwarded to the Arctic Heat data ingest program for data collection at rate of 100 Hz. This pyranometer measures solar and sky irradiance from 0.285 to 2.8 µm.

3. Radiometer

A Heitronics Model KT19.85 II radiometer is mounted on the belly of the aircraft to provide accurate surface temperature when the path between the aircraft and the surface is not blocked by clouds. The radiometer operates in the 9.6 to 11.5 µm range with a resolution of 0.03 degrees Celsius. In general, the aircraft is operated at 500 ft when collecting sea-surface temperature radiometry in order to reduce potential atmospheric interference.

4. RADAR Altimeter

The analog output of the aircraft radar altimeter (0 – 18 VDC) is tapped off and fed to a channel of the AOC-Analog to Digital converter. To reduce the voltage to be within range of the A-AD, a passive resistive voltage divider (100 KOhm resistors) is embedded in the wire harness which is isolated and protects against the failure of the science system from degrading the flight instrument signal levels. The aircraft radar altimeter reports altitude up to 2550 feet above the surface. Above this altitude, the Arctic Heat software reports “-98”.

5. AIMMS-30 Air Data System

The AIMMS-30 Air Data System consists of the ARIM200 Air Data Probe mounted on a pylon on the right wing (Fig. S1) the AIMMS-30 GPS/inertial/processing module with dual GPS antenna inputs, a AIMMS-30 display module, and the Arctic Heat software running on the

Fig. S1. ARIM200 Air Data Probe mounted on the pylon on the right wing of NOAA 56.

science computer. Data from the AIMMS-30 system (flight level meteorological and 3-axis aircraft motion) is collected by the Arctic Heat software at 5Hz. Up to 20 Hz may be available, but this has not yet been attempted due to the manufacturer's warning that this may not be a stable configuration.

Data from the AIMMS-30 system is streamed not only to the science computer, but also the AIMMS-30 display module, which is be configured to automatically store all mission data on a USB drive. Capturing data on the USB drive provides a duplicate backup method for the AIMMS-30 system. The USB drive can only be installed or removed when the AIMMS system is powered off.

6. Garmin / Shadin Aircraft Data

The aircraft primary navigation system is a Garmin 530 avionics package. The Garmin navigation data and Garmin derived atmospheric data is fed into a Shadin data converter avionics box. The serial output of the Shadin box is used by the aircraft fuel management system, and this serial data stream is split and ingested by the Arctic Heat software running on the science computer. The Garmin / Shadin aircraft data is not of research quality, but it provides a good check data to compare with the AIMMS-30 Air Data System.

7. Airborne Expendable (AX) Receiver System

The AX receiver system consists of an antenna mounted to the bottom of the aircraft, a three channel MK10A receiver, a single channel MK21 Processor, a PMD560 audio recorder system, commercial data collection software running on the science computer, and the standard launch tube assembly. This system will work with any of the three channels available on the expendables; switching between channels requires moving coax cables on the back of the receiver.

8. Iridium Satellite Modem

A low-speed (2400 baud) satellite data link is provided via an Iridium modem and science computer. The primary function is to email dropsonde or AX data files in near real time for forecasting purposes.

9. Arctic Heat data system software package and data ingest computer

A single program running on the science computer captures and stores the analog and serial data (excluding data from the various expendables). This program "Arctic Heat" is written in Labview and maintained by NOAA/AOC.

In addition to capturing the live data, "Arctic Heat" parses and decodes the data for live display and capture, and generates an IWG1 data stream. Data files generated:

- **YYYYMMDD_HHMMSS_AIMMS_RAW.dat** This is a capture of all data transmitted from the AIMMS Air Data system. The file is in binary format, and can be decoded using a software package from the vendor, Aventech.
- **YYYYMMDD_HHMMSS_MET.txt** This is a comma delimited file containing the decoded AIMMS Air Data System 5 Hz "Met" data. Data fields provided are: *TIME,TEMP(C),RH(%),STATIC PRESSURE(mB),N WIND(m/s),E WIND(m/s),WS(m/s),WD(Deg),Wind Status Good(T/F),Purge Active(T/F),GPS Status*

Good(T/F),Checksum Good(T/F). Note that although the data is updated every 0.20 seconds, the time stamp assigned is updated on at the beginning of each second interval.

- **YYYYMMDD_HHMMSS_AC_STATE.txt** This is a comma delimited file containing the decoded AIMMS 5Hz "Aircraft State" data derived from the AIMM inertial unit and differential GPS unit. Data fields provided are: *TIME, Lat(DEG), LON(deg), GPS ALT(m), GPS N Velocity(m/s),GPS E Vel(m/s), Down Vel (m/s), Roll Angle(Deg), Pitch Angle(Deg), True Hdg(Deg), TAS(m/s), Vert wind(m/s),S Slip(Deg),AoA Diff Press,S Slip Diff Press,Checksum Good(T/F).).* Note that although the data is updated every 0.20 seconds, the time stamp assigned is updated on at the beginning of each second interval.

- **YYYYMMDD_HHMMSS_analog_raw.dat** This is a capture of the 8 channel, 100 Hz analog data collection module (A-AD). Channel assignments are as follows: Channel 0: Downlooking radiometer; Channel 1: Uplooking pyranometer; Channel 2: Aircraft radar altimeter; Channel 3: spare; Channel 4: spare; Channel 5: Precision 5.000 VDC; Channel 6: Precision 5.000 VDC; Channel 7: 0.000 VDC. For the Arctic Heat project, the A-AD is not precisely timed to operate at 100 Hz, it is free running and transmits a data packet of 100 samples (each sample contains 8 measurements). A data packet is generated approximately every 1.00 seconds. The only data time tag is the time stamp incorporated into the files name, which is the PC time the data collection was started. Calibration coefficients are not applied to the raw data.

- **YYYYMMDD_HHMMSS_analog.txt** This is a comma delimited file containing the 100 Hz (approximate) analog data. Calibration coefficients are applied prior to writing this file. Data fields provided are: *TIME, RAD ALT (FT), SST (C), SOLAR (W/m**2).* The time field is updated at the arrival of each new data packet (each data packet contains 100 samples collected at 100 Hz). Format of the time field is HHMM_SS.ssss. Note that the Radar Altimeter was disconnected for this project, which resulted in a constant value of -20 ft for this field.

- **YYYYMMDD_HHMMSSShadin_RAW.dat** This is a capture of the unmodified 9600 baud serial data streamed from the Aircraft navigation system data concentrator the, the Shadin. . The only data time tag is the time stamp incorporated into the files name, which is the PC time the data collection was started. Calibration coefficients are not applied to the raw data.

- **YYYYMMDD_HHMMSS_Shadin.txt** This is a capture of the decoded 1Hz Shadin serial output data stream. The data fields provided are: *TIME, AirSpeed(kts), TAS(kts), Mach, PressureAlt(ft), DensityAlt(ft),AmbientAirTemp(C),TrueAirTemp(C),WD(deg),WS(kts),TurnRate(deg/sec),Vert Velocity(ft/min),Heading(deg).*

- **YYYYMMDD_HHMMSS_IWG.dat** The IWG1 file is a text file with comma separated values recorded at once per second. The first group of data parameters in a line of the IWG data are defined by the IWG1 standard, parameters after this initial group are user defined. The data field parameters are as follows:
IWG1_NAMES,TIME,LAT,LON,ALTGPS,GPS_GEOIDHT,ALTPAFT,ALTRAFT,GS,TAS,IAS,MACH,GSZ,THDG,TRK,DA,PITCH,ROLL,SA,AA,TA,TD,TTM,PS,PQ,PCAB,WS,WD,UWZ,none,none,none,none,FLID,MISSIONID,STORMID,SST,PYRAUCLEAR,RH

Note that the IWG1 standard is not strictly adhered to, as every 30 seconds, there is an additional entry consisting of a listing of the data field parameters. Data included in the IWG file is acquired from the latest available sample from the AIMMS system, the most current Shadin data sample, and the mean of the last 100 analog samples from the A-AD analog collection system.

The IWG data is streamed in real time to other systems on the aircraft, used by AVAPS and available as a data source for the KARMA moving map program and the Mission Scientist's laptop.

10. Moving Map Tools

TZ Navigator is a full featured marine oriented moving map program available for mission planning and real time tracking of the mission progress. Vista moving map and KARMA mapping applications are also available. The aircraft is also equipped with an internal GPS signal radiator to support any navigation package used by the Mission Scientist.

11. Expendables Launch Chute

The launch chute (Fig. S2) was designed for launching AXBT size "A" or smaller expendables. The launch tube assembly includes a short sleeve secured to the aircraft, and a launch tube sleeve which slides inside the short sleeve and acts as an extension to ensure adequate separation between the expendable and the bottom of the aircraft (Drawing 1894-12-100). The launch tube is inserted only in flight, and removed prior to landing. Launch speed not to exceed 120 knots indicated airspeed. The aircraft is equipped with an external GoPro video camera to record launches, used to verify the proper deployment of the parachute (Video S3 and S4).

Fig. S2. Airborne Expendable (AX) launch chute on NOAA 56, during the deployment of an atmospheric dropsonde.

Further details and calibration information: https://seb.noaa.gov/pub/seb/TwinOtterSupportFiles/