AVENTECH RESEARCH INC.

AIMMS-30

OPERATING MANUAL

Document-P/N: *AIMMS30-OM*

Aventech Research Inc.
756 Huronia Road, Unit 2
Barrie, Ontario, Canada L4N 6C6

Tel: (705) 722-4288
Fax: (705) 722-9077

Web: www.aventech.com

Issued

Date	Name	Signature	Function
03.09.2018	Sebastien Reid		IM

Checked

Date	Name	Signature	Function
04.09.2018	Sebastien Reid		IM

Approved

Date	Name	Signature	Function
06.09.2018	Bruce Woodcock		HD

Customer Approval (as required)

Date	Name	Signature	Function

Table of Functions

CUST	**Customer**
DE	**Design Engineer**
HD	**Head of Design Engineering**
IM	**IT Manager**

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RECORD OF REVISIONS

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06.09.2018	1.00		Initial Release
28.09.2018	1.10	33	Revised Table 6.1 (list of error codes)

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1 INTRODUCTION

The Aventech Research Inc. AIMMS-30 (**A**ircraft **I**ntegrated **M**eteorological **M**easurement **S**ystem) delivers high-quality three-dimensional wind data in real-time, plus temperature and humidity, while operating on a wide variety of airborne platforms. It achieves this as a system of measurement and processing modules that are integrated using a Controller Area Network (CAN) bus.

The system requires a minimum of two modules to operate:

- Vectrax module (GPS/inertial/processing module), which contains:
  - Two GPS processors
  - Six degree-of-freedom Inertial Measurement Unit (IMU)
  - Central Processing Subsystem (CPS)
  - USB-flash file system
- Air Data Probe (ADP)
  - 5-hole probe head (for resolving airflow angles, and pitot pressure)
  - Static ring
  - Reverse-flow housing for temperature, humidity sensors

The AIMMS-30 system also supports a third module, a touchscreen display called the MetTrack, to provide a general user interface that includes functions such as real-time data display (wind, atmospheric stability profiles), read/write system control parameters, flight calibration support among other features. See the MetTrack Operating Manual (Doc. P/N: MetTrack-OM) for more details.

The Vectrax collects velocity and differential carrier-phase information from two GPS antennas. This information is fused with IMU output (acceleration and angular rate data at 100Hz), using a custom designed Kalman filter. The result is high precision aircraft roll, pitch and heading attitude with an absolute accuracy of better than 0.25 degrees.

The externally mounted Air Data Probe (ADP) provides pressure, temperature and humidity information necessary to define the speed and direction of the aircraft-relative wind vector. Code running on the CPS takes this information applies various corrections based on the aerodynamics of the installation to correct for static-pressure position error, along with errors affecting sideslip and angle-of-attack measurements. The result is air-motion information accurate to within a fraction of 1 kt. in three dimensions. A special flight calibration procedure is necessary to determine position-error correction parameters in order to achieve full system accuracy (see Section 3.1).

Other features of the AIMMS-30 system include:

- Wide input voltage range (9-36VDC)
- Dual RS232 serial communications interface (COM1 for diagnostics, COM2 for host computer integration, eg. spray guidance system)
- USB interface supporting flash drives up to 32GB (FAT32)
- Automatic flight data recording based on GPS ground speed
- Updating of system setup parameters automatically from a file on a USB drive
- Updating of system firmware automatically from a file on a USB drive
- Optional switch input to record external on/off events (eg. spray booms on/off) using USB extension port
- Internal non-volatile data log sufficient to record last 40 hours of flight data
- Extensive set of self-diagnostic CBIT (Continuous Built-In Test) parameters that are recorded to both USB drive and internal data logs
- Extensive set of status LED lights on front panel to assist basic system troubleshooting
- Optional satellite communications module (internal to the Vectrax enclosure) for position tracking and meteorological data telemetry via the Iridium satellite network

2 QUICK START

One of the first things you will want to do with your AIMMS-30 is to become familiar with its external connections. This chapter will help you get familiar with basic setup and operation.

2.1 Verify the List of Supplied Items

The first thing you will want to do is verify that you have received the following items with your equipment:

- One Vectrax module
- One Air Data Probe
- One USB flash drive
- Two GPS antennas
- Two GPS signal cables
- CAN cable (to connect ADP to Vectrax)
- Dual port RS-232 (Y) cable
- Power cable

2.2 Vectrax External Features

Figure 2.1: Front label of Vectrax.

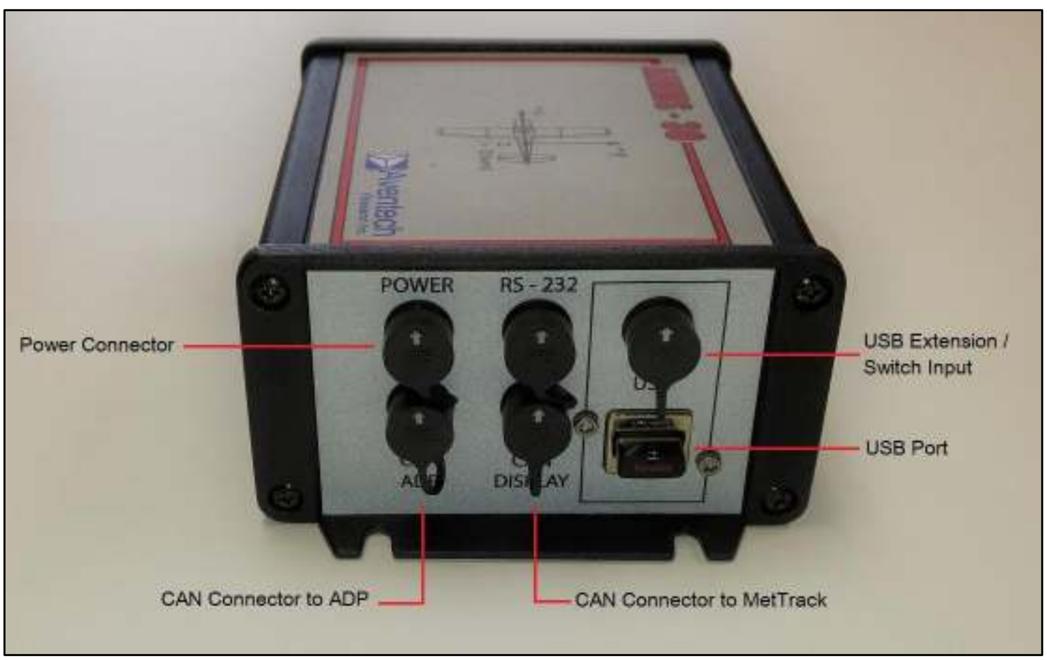

Figure 2.2: Back label of Vectrax.

2.3 Installing the Vectrax

The Vectrax is mounted securely to the airframe, usually inside the cockpit. Since it houses an Inertial Measurement Unit, *it must be properly oriented for the system to work properly*. The top label on the module indicates the correct orientation relative to the aircraft. The status LEDs face forward in the direction of the flight with the box sitting horizontally. As per the top label diagram shown in Figure 2.3, the forward (X), horizontal (Y-starboard) and vertical (Z-down) axes of the Vectrax should be parallel to the corresponding axes fixed to the aircraft. A high degree of accuracy is not required in aligning with the principal axes of the aircraft because any small angular offsets can be dealt with by the flight calibration process.

Figure 2.3: Top label of Vectrax.

In-service accessibility should be taken into consideration when choosing a mount location for the Vectrax. The front panel LEDs should be visible to aid with system diagnostics, and the USB port should be easily accessible so flash drives can be used without difficulty. If this is impossible, then the USB extension port can be used to connect a USB extension cable with an externally mounted receptacle placed in a more accessible location.

Two GPS antennas need to be mounted on the airframe with a minimum separation distance of 10 feet (3m). This is commonly achieved by a lateral antenna arrangement with one antenna on each wingtip. A longitudinal (or fore-aft) arrangement is also possible with two antennas mounted on the fuselage. GPS signal cables must then be routed from the antennas to the Vectrax, with port or fore antenna connected to the connector labelled **GPS 1** and the starboard or aft antenna connection to the connector labelled **GPS 2**.

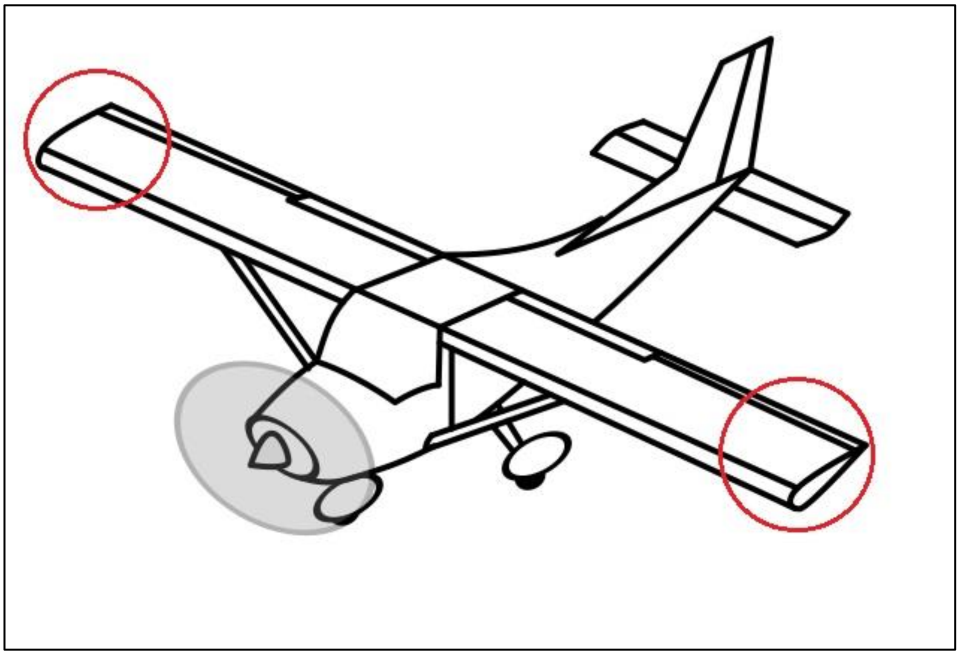

Figure 2.4: Typical locations for GPS Antennas.

2.4 ADP External Features

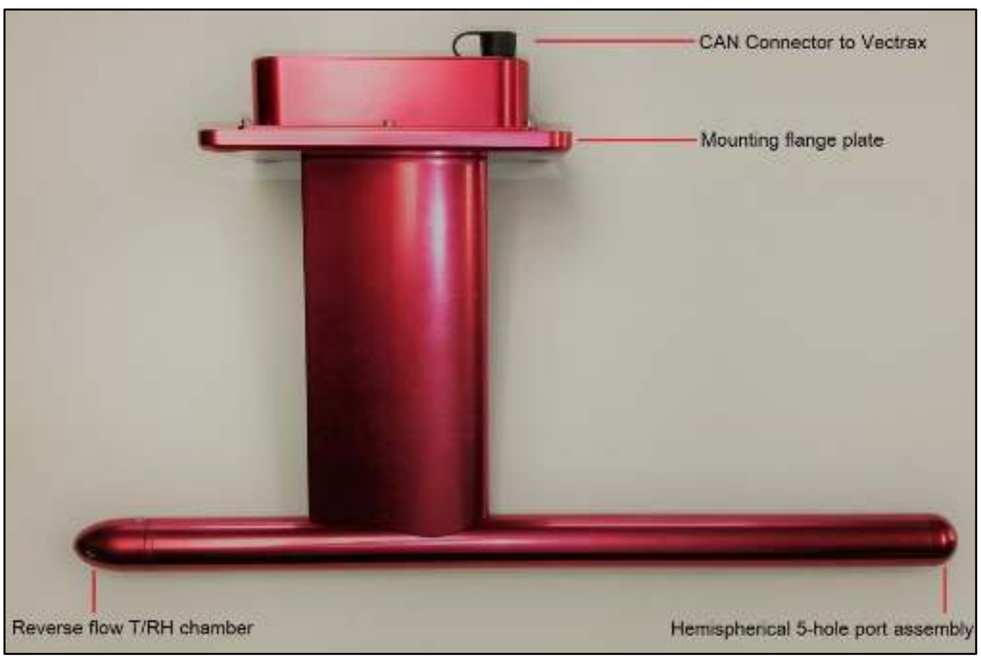

Figure 2.5: Side view of Air Data Probe.

2.5 Installing the Air Data Probe

The AIMMS-30 Air Data Probe (ADP) can be mounted anywhere on the exterior of the airframe, provided the airflow incident to the probe is approximately parallel to the probe-tube axis and that the flow is relatively "clean" and undisturbed. The lower wing surface is a common mounting location, at a point approximately ¾ wing span to ensure the probe is well removed from the propeller wake. It is also possible to mount the probe horizontally or vertically to the fuselage, provided the unit is operating free of propeller wake turbulence (such as on the forward fuselage sections of a twin-engine aircraft).

Position-error effects, due to aerodynamic modification of the flow by the airframe, are accounted for during data processing using flow-correction equations. These corrections are applied to angle-of-attack, angle-of-sideslip, and static / pitot-static pressure errors. The parameters governing these equations are determined by analysis of calibration flight data (see Section 3.1).

Angular precision, for attitude angles and flow angles alike, must be better than a few tenths of one degree. One implication of this strict requirement is that the probe must be rigidly attached. Any flexure of the skin, for example, can alter the pitch or roll orientation of the probe relative to the system reference frame attached to the IMU inside the Vectrax. Too much flexure will result in erratic system performance. Care must be taken ensure adequate stiffness of the hardpoint plate or any other means of fixture to the airframe.

For more installation detail, please see *AIMMS-30 Installation Quick-Start Manual* (Doc. P/N: AIMMS30-IQSM Rev. 1.01)

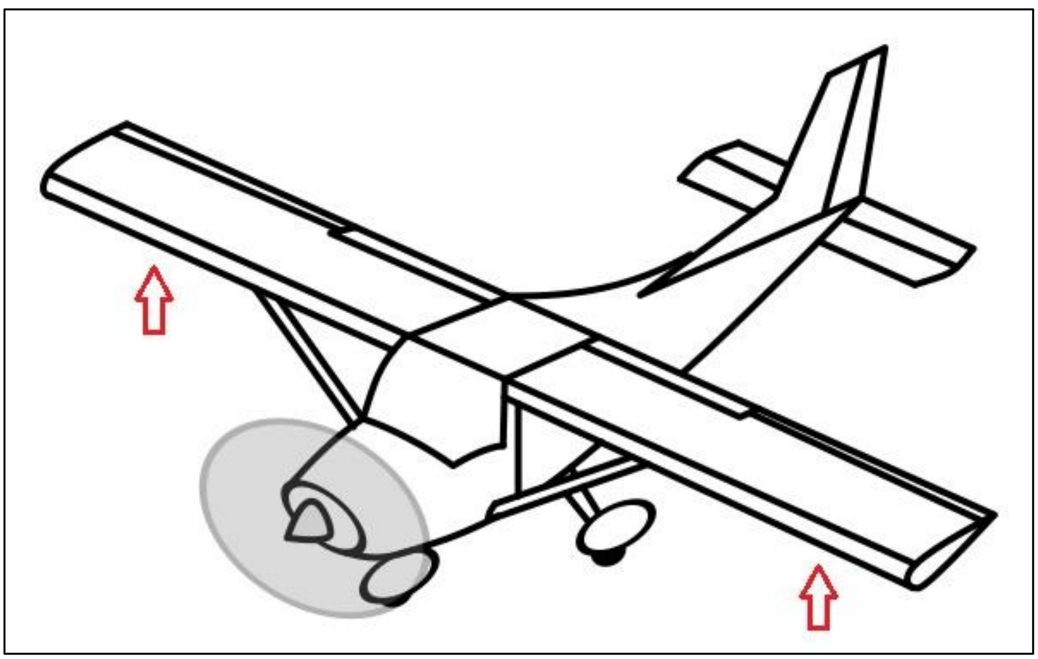

Figure 2.6: Typical locations for the ADP mount

2.6 Turning the Unit On

Power (9-36VDC) is input to the Vectrax. It contains a power filter and a DC-DC converter to supply conditioned 12VDC power that is distributed to other components of the AIMMS-30 system, such as the ADP or MetTrack. Once power is applied, the power LED on the Vectrax front panel will illuminate green and the unit will immediately boot up. The first task performed by the operating firmware is to index the section of non-volatile memory containing the flight data log. During this process, **STATUS 1** LED will be red while executing a continuous rapid flash sequence. After approximately 15s, **STATUS 1** will stop flashing and **STATUS 2** will commence the same rapid red flash sequence, which indicates the firmware is scanning the section of flash memory containing the CBIT status log. This log scan will be complete after approximately 5 seconds and **STATUS 2** will revert to a steady red. **STATUS 1** will turn steady green once **GPS 1** has a valid navigation solution. Likewise, **STATUS 2** will turn steady green to indicate **GPS 2** has a valid navigation solution. **STATUS 3** will normally be off unless a thumb drive is installed in the USB slot. It will turn solid green once a drive has been inserted and the volume has been successfully mounted (i.e. ready for access).

A red flash sequence will be displayed on **STATUS 1** or **STATUS 3** LEDs if any errors are detected within the system. See Section 6.1 for details.

It is recommended that a flash drive always reside in the USB port. If a drive is present and mounted successfully, a system data file will be created automatically whenever the ground speed reported by the GPS subsystem exceeds 20 kt (10 m/s). A file is automatically closed once the ground speed drops below 10 kt (5 m/s).

Important Note: turning off power to the unit before the file has been closed will result in complete loss of data on the USB drive.

Thumb drive data files, indicated by the **.raw** file extension, contain a facsimile of every byte transmitted across the CAN network. These files contain both raw sensor information and data that has been generated by the Central Processing Subsystem (CPS), including aircraft attitude and wind vector components. Because these files contain all system information, it is possible to reprocess data using PC-based software to derive the full meteorological data set. This is useful to the calibration process because fitness of a calibration parameter set can be assessed by reprocessing the same data set instead of loading new parameters into the AIMMS-30 and re-flying. Similarly, because the *.raw* file contains data generated by all subsystems, its contents are very useful for system troubleshooting. A PC-based file scan utility, called **CAN-Extract**, is employed to check the **.raw** binary file for errors and to generate a variety of files useful for examining system behavior.

Once all status LEDs are green, the system is ready for takeoff.

3 FLIGHT CALIBRATION

No matter where the ADP is installed, it is impossible to escape the aerodynamic influence of the airframe. This fact means we must account for such position-error effects in order to achieve a high degree of accuracy. This is accomplished by means of a special calibration flight, in which a specific set of manoeuvres are flown. The necessary correction parameters are obtained by subsequent flight data analysis using special custom analysis software.

The central concept behind the flight calibration method is that the real wind remains unaffected by changes in aircraft state, which is defined by airspeed, angles of attack and sideslip, and heading. Thus, as aircraft state parameters are purposely changed in flight, any coincident changes in the observed (computed) wind vector are implicitly conveying information about the behavior of the aerodynamic error. When airspeed, AoA and AoS are modulated along a pair of flight legs along reciprocal headings, enough information exists for a unique solution to be determined for the set of aerodynamic correction parameters. Included in this process is a determination of any fixed angular offsets of the probe, i.e. offset of ADP longitudinal axis relative to the X axis of the IMU inside the Vectrax.

A few 360 degree turns are included in the calibration process to provide varying angular rate and acceleration signals for the IMU, which upon subsequent analysis, can be used to estimate offset angles for the antenna baseline relative to the IMU.

3.1 Flight Calibration Details

Make sure a flash drive is inserted in the USB port of the Vectrax module. Start the aircraft and power up the AIMMS system. Wait for **STATUS 1** and **STATUS 2** LEDs to turn solid green, indicating that both GPS units are up with valid navigation solutions, and **STATUS 3** is solid green, indicating the flash drive has been successfully mounted and is ready for use. Takeoff and climb to an altitude high enough to be sure of operating in smooth air. This is important because turbulent variations in the wind add noise to the process that will reduce accuracy of the final results.

Note: the Vectrax will automatically create and record data at the start of the take-off roll, once groundspeed exceeds 20 knots.

1. Select an airspeed range, from just above aircraft stall (with reasonable margin) to maximum cruise. Select the minimum and maximum calibration speeds in consultation with the pilot flying the calibration flight to determine what they are comfortable with.

2. Start the calibration procedure by setting up on a true north heading at the lowest airspeed from step 1 above.

3. At this lowest airspeed, perform a yaw maneuver yawing the aircraft approximately 5-10 degrees to port followed by 5-10 degrees to starboard, or vice-versa, at a rate of approximately 5 seconds into the yaw and 5 seconds back out for a total of approximately 20 seconds for the complete maneuver.

4. Once the yaw maneuver is complete, maintain the lowest airspeed on a constant true north heading for approximately 10 seconds. Increase airspeed to the speed mid-way between minimum and maximum values while maintaining constant altitude.

5. Repeat the yaw maneuver (see step 3).

6. Increase airspeed to the maximum value. Remember to maintain constant altitude.

7. Repeat the yaw maneuver.

8. Turn the aircraft 180 degrees and set up on a true south heading at the maximum airspeed.

9. Repeat the yaw maneuver.

10. Decrease airspeed to the mid-range value (constant altitude).

11. Repeat the yaw maneuver.

12. Decrease airspeed to the minimum value (constant altitude).

13. Repeat the yaw maneuver.

14. Fly a 360 degree turn at 15 degree bank (right or left bank).

15. Fly a second 360 degree turn in the same direction, but at 30 degree bank.

16. Fly a third 360 degree turn in the same direction, but at 45 degree bank.

17. Roll the aircraft now to enter a 15 degree bank turn in the other direction and perform 4th orbit.

18. Increase bank to 30 degree, perform 5th orbit

19. Increase bank to 45 degree, perform 6th and final orbit

20. Return to base and land. Power down the AIMMS system **ONLY** after the aircraft has come to a complete stop. This is to guarantee that the file has been closed before power is cut to the system.

Figure 3.1 below illustrates the steps of the aerodynamic calibration (steps 1- 13), and Figure 3.2 illustrates the steps for the GPS-inertial alignment calibration (steps 14-19).

Remove the flash drive from the USB port and send the file to support@aventech.com for evaluation. We will return to you a set of calibration parameters that will have to be entered into the system using PC software with either a CAN or RS232 connection to the Vectrax (see Section 4), the MetTrack display unit, or using a special file (**PARAM.SET**) in the root directory of the USB flash drive (see Section 5.3).

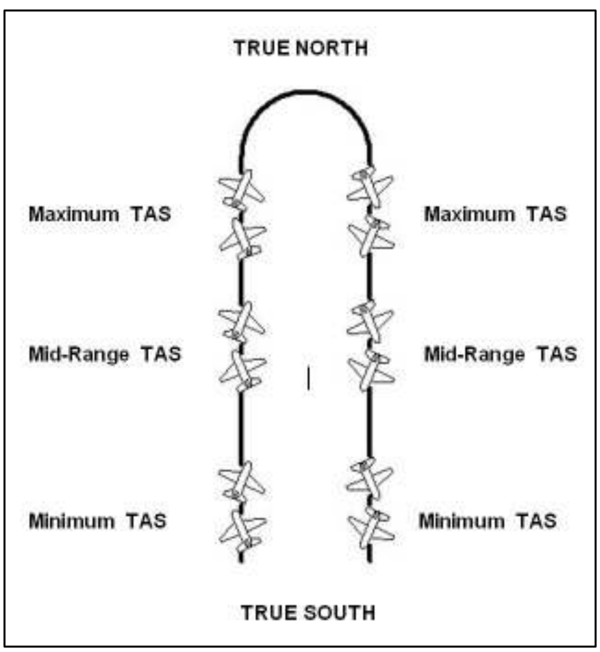

Figure 3.1: Aerodynamic Calibration

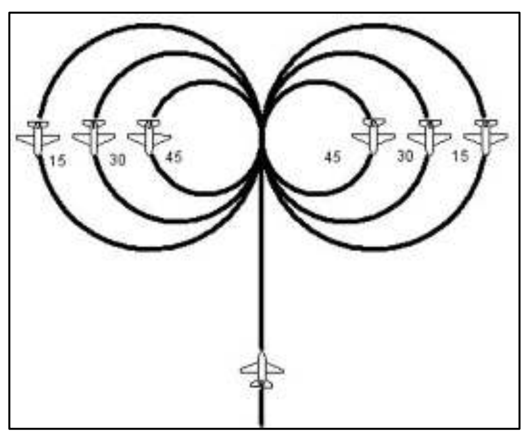

Figure 3.2: GPS-Inertial Calibration

4. AIMMS-30 Config

This section details the installation and use of PC-based utility software to configure the AIMMS-30 system.

4.1 Installation

This section describes how to install the AIMMS-30 Config program. Follow the steps below to complete the installation. The .zip file containing all installation components can be obtained by FTP (contact support@aventech.com for details).

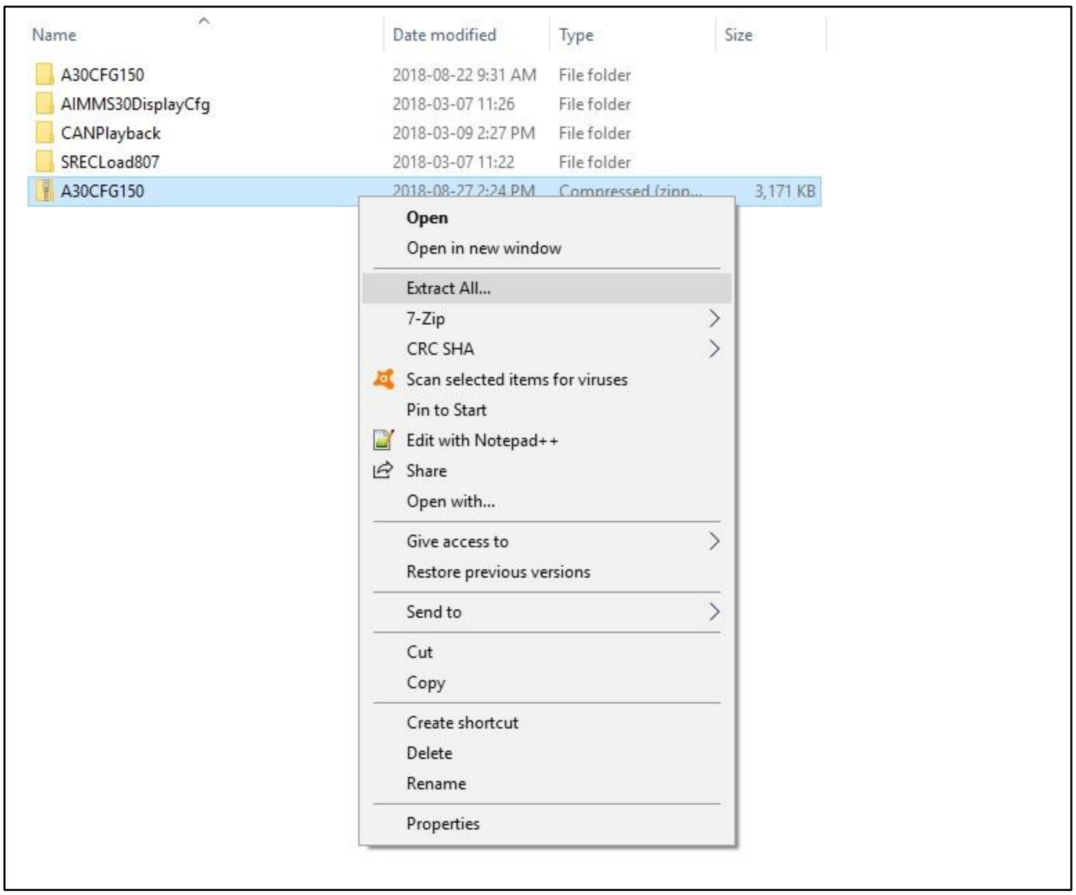

Figure 4.1: Find the downloaded zip file, then right-click and select "Extract All".

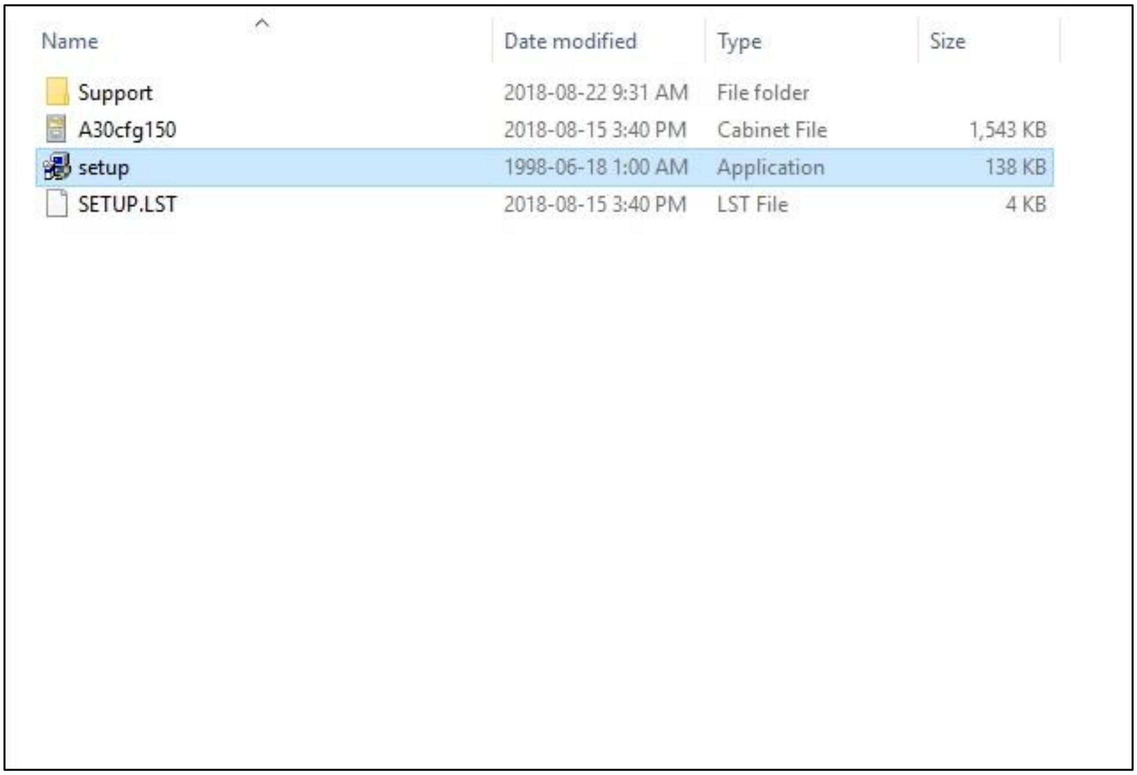

Figure 4.2: Go to the extracted folder, then run "setup.exe".

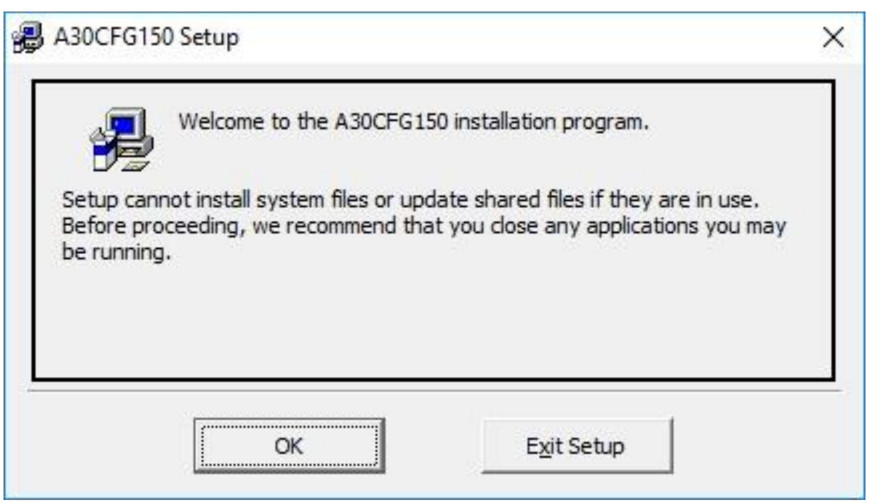

Figure 4.3: Click "OK" to continue.

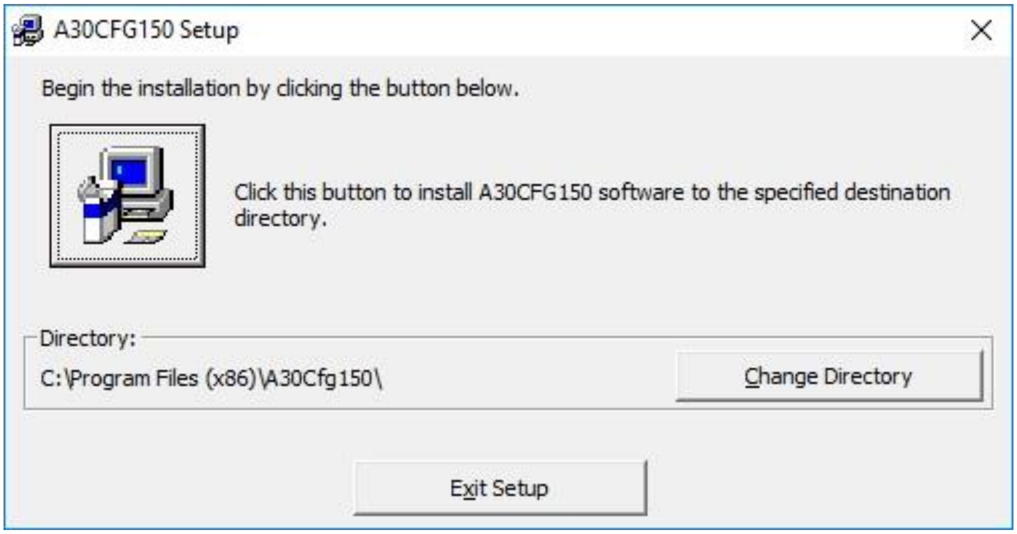

Figure 4.4: Click the computer icon button to install in the specified directory.

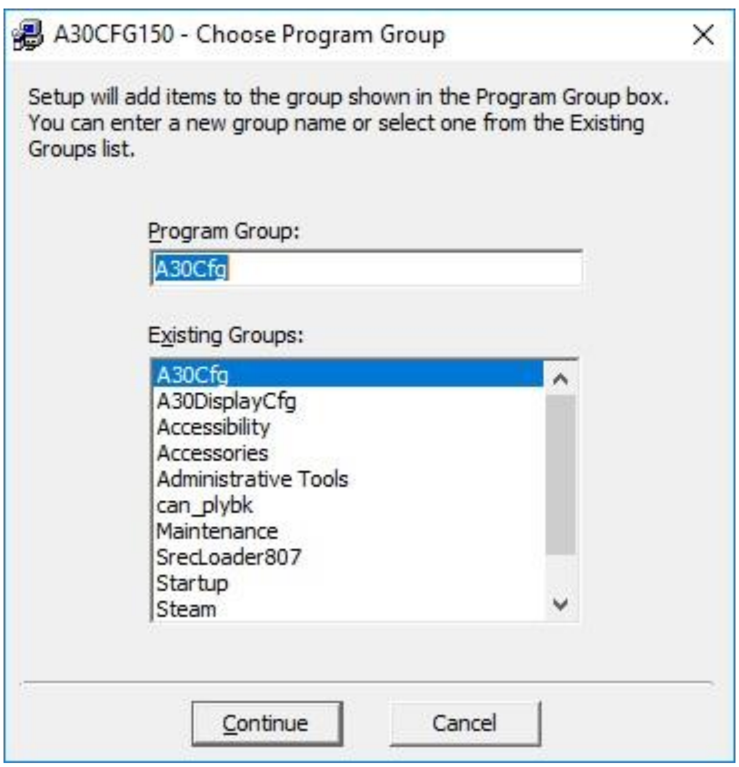

Figure 4.5: Click "Continue" to confirm the Program Group name for Windows.

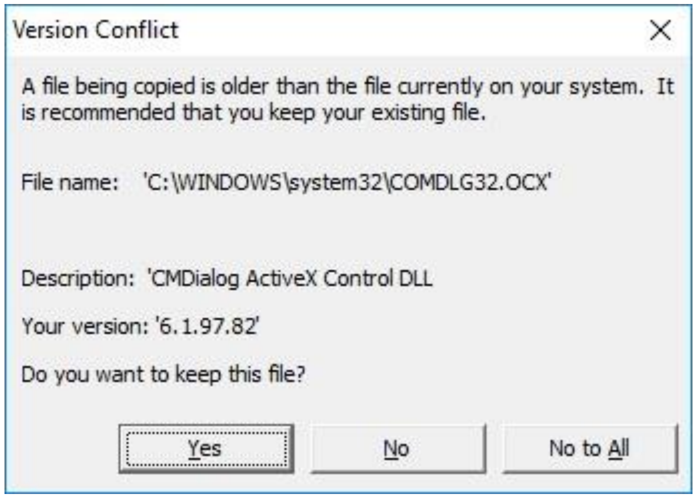

Figure 4.6: If you see this message, click “Yes” to keep your existing file.

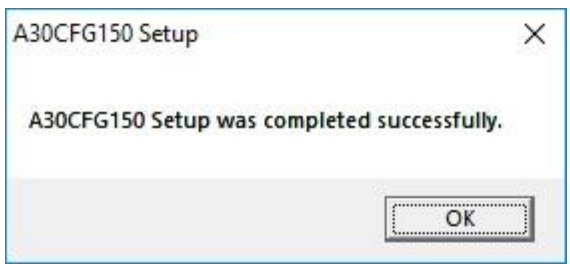

Figure 4.7: Once setup is complete, click “OK”.

4.2 Using AIM CONFIG

4.2.1 Making the Connection

Before starting the configuration setup program, make sure the Vectrax has been powered up for more than 30 seconds (rapid red flash sequences on **Status 1** and **Status 2** LEDs have ceased). Also, make sure the RS232 cable is connected using the DB-9 connector labelled COM1 (black) at the end of the Y-cable. Using your Windows File Explorer, navigate to the folder into which **A30Cfg150** was installed (C:\Program Files(x86)\A30Cfg150 in the example of Section 4.1). Locate the executable file **A30cfg150.exe** and double-click on it to launch the program. It will immediately attempt to open an RS232 (COM) port to communicate with the Vectrax. The default port number and baud rate are defined by the file **CFG.DAT** located in the same folder as **A30Cfg150.exe**. If the initial defaults are in conflict with your PC setup, the error message **Error: Invalid Port Number** will pop up. After clicking **OK**, the window **Comm Port and Baud Rate Select** will be displayed in this circumstance (see Figure 4.8).

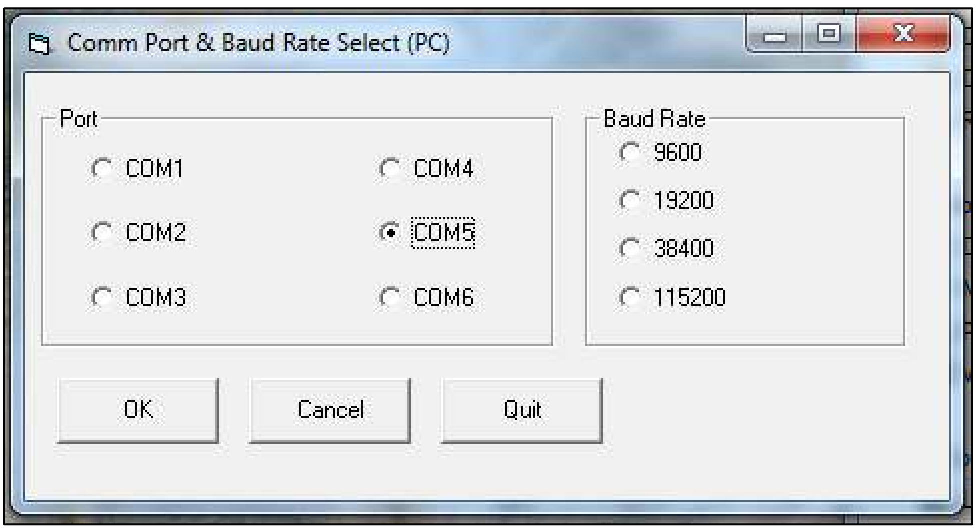

Figure 4.8: RS232 Parameter Selection

Select the correct **Port** number by clicking on the corresponding radio button. The baud rate to be used will depend on the configuration programmed at the factory. The defaults assumed are as follows based on the system to which the AIMMS-30 is expected to be paired:

System	Factory Set Baud Rate
AgNav	38400
Satloc	19200
All others	115200

Once the correct COM port has been selected and the correct baud rate set, click **OK**. The system will then attempt to communicate with the Vectrax. If the baud rate is incorrect, then the error message **NOT CONNECTED** will be displayed in a dialog box. Press **OK** to continue. If RS232 parameters are correct, a dialog box will display **CONNECTED**. In either event, the main program form, as shown in Figure 4.9 below, will be displayed next.

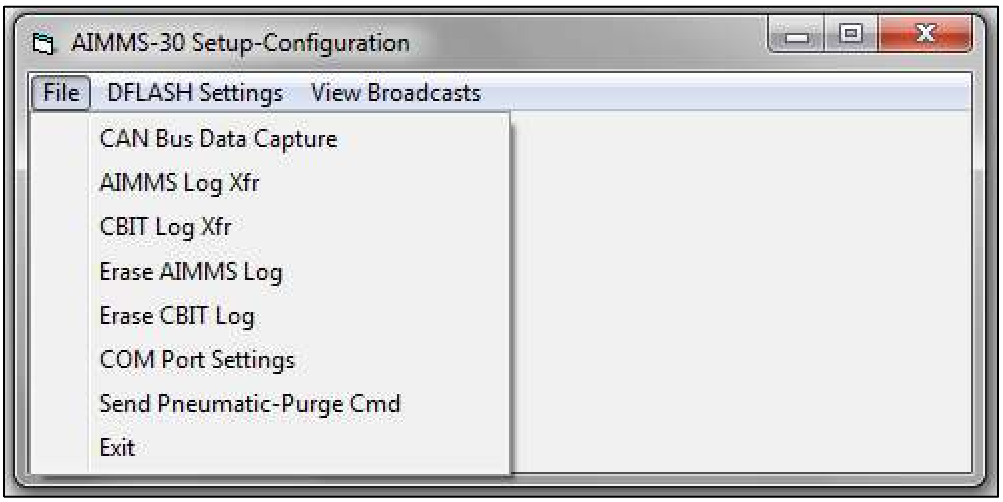

Figure 4.9: File Menu, Main Form

If previously **NOT CONNECTED**, select **COM Port Settings** from the **File** menu to re-enter the **COM Port and Baud Rate Select** form to try a different baud rate. If one cannot get a **CONNECTED** message after trying all baud rate combinations, the next step would be to examine cable connections and ensure the port number is in fact valid for your PC setup.

4.2.2 Editing System Parameters

Main system parameters are accessed under the **DFLASH Settings** menu. Select **CPS** from the menu to open the main parameter setup form (see Figure 4.10). You must first initialize the form by reading values stored in memory on the Vectrax. This is accomplished by clicking the **Read** button located on the bottom right of the form. After clicking the **Read** button, all fields in the **System Setup and Calibration Parameters** section should become populated. Note the **Protected Sector** is not accessible using the RS232 interface and can only be accessed using a valid Controller Area Network (CAN) connection. Each of the sections within the **System Setup and Calibration Parameters** section are briefly summarized below.

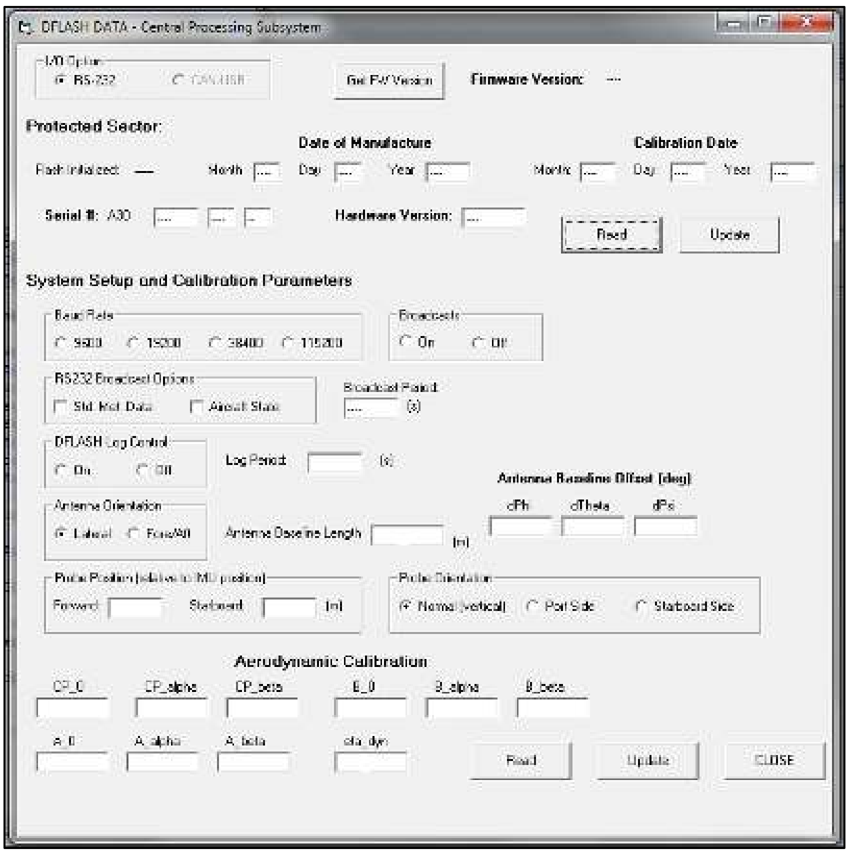

Figure 4.10: Main Parameter Setup

- Baud Rate and Broadcasts
    - Determines the baud rate at which the Vectrax will communicate after the next power reset.

  - **Broadcast On/Off** determines whether or not Standard Meteorological Data and/or Aircraft State data packets are output on a secondary RS232 port (COM2).
- RS232 Broadcast Options
  - Check boxes allow either Standard Meteorological Data and/or Aircraft State data packets to be broadcast on secondary RS232 port.
- Broadcast Period
  - Contains the period, expressed in seconds, between transmissions of broadcast data packets. Typical value for this parameter is 1s.
- DFLASH Log Control
  - Select whether or not information is stored internally in the 64Mbit serial data flash memory. This device stores only final processed data (*not* raw sensor data) and CBIT (Continuous Built-In Test) information at low frequency.
  - Recommended value for **Log Period** is 1s. With total capacity of 135000 records, this is sufficient to record more than 37 hours of data.
- Antenna Orientation
  - AIMMS-30 GPS-IMU attitude determining system relies on differences between signals received by two GPS antennas separated by a known distance. For the processing to be correct, it is important the system know whether the antenna pair is oriented parallel to the direction of flight (fore/aft) or perpendicular to it (lateral, i.e. wing-tip placement).
- Antenna Baseline Length
  - This is the straight-line distance between the two antennas, expressed in meters [Note: 1m = 3.281 ft.].
- Antenna Baseline Offset
  - The reference axes attached to the IMU are also the axes used by the AIMMS-30 system. The antenna baseline is ideally parallel to the IMU X-axis (in case of fore/aft) or parallel to the IMU Y-axis (in case of lateral placement). But, small non-zero differences in orientation will occur relative to this ideal. Kalman filter analysis of flight data during a series of turns, with different angles of bank and in two opposing directions, can be used to estimate angular offsets of the vector connecting the pair of antennas relative to the IMU. **dPhi** is the roll perturbation necessary to move from the IMU axis to this vector, **dTheta** is the pitch perturbation and **dPsi** is the yaw perturbation. For lateral antenna orientation, only roll and yaw are relevant; pitch and yaw are only relevant in the case of fore/aft antenna alignment.
- Probe Position
  - These two values are the distances forward and starboard (to the right) of the IMU. They are used to modify the IMU velocity to the velocity of the ADP, while taking into account the “lever arm” under non-zero rolling or yawing rates. The magnitude of this contribution is small and is only truly relevant where

turbulence-scale phenomena are of prime interest. Typically these values can be left at 0.

- Probe Orientation
  - This parameter modifies the ADP pressures used to describe angle-of-attack and angle-of-sideslip. When mounting the probe on the side of the fuselage, it will be rolled +90 deg. or -90 deg. depending on which side is used. The ports used to describe angle-of-attack and sideslip are swapped when the probe is rolled by +/-90 degrees. By selecting the correct orientation, proper adjustments are ensured.
- Aerodynamic Calibration
  - These coefficients are used in correction equations to compensate for "position error", i.e. distortions induced in the local flow by the aerodynamics of the aircraft itself at the ADP.
  - CP terms are used to describe behavior of static-pressure error offset (**CP_0** term), variation with angle-of-attack (**CP_alpha**) and variation with angle of sideslip (**CP_beta**).
  - B terms are used to describe true sideslip flow angle as a function of local flow angles at the probe. This represents orientation of the flow in the far-field relative to the IMU reference axes. **B_0** term will also account for any fixed physical yaw offset between the probe zero-axis and the IMU X-axis.
  - A terms are used to describe true angle-of-attack flow angle as a function of local flow angles at the probe. They represent orientation of the flow in the far-field relative to the IMU reference axes. **A_0** term will also account for any fixed physical pitch offset between the probe zero-axis and the IMU X-axis
- ETA_DYN
  - This parameter is used to correct for dynamic heating of the temperature sensor as a direct result of air flow velocity. It represents warming achieved at a given airspeed as a fraction of the ideal maximum, which occurs when the flow is brought to stagnation, i.e. when all kinetic energy has been converted to an increase in pressure. The approximate value of this parameter for the reverse-flow housing of the AIMMS-30 ADP is **0.9**. Note: at low speeds (< 50kt), this effect is negligible, but dynamic heating becomes important. At 100kt, the effect is 1.25C˚ of warming, and it increases with the square of airspeed, eg. +5C˚ at 200kt.

Analysis of a calibration flight will generate a set of new numbers for **Aerodynamic Calibration** factors and **Antenna Baseline Offset** values. These are the numbers that will have to be entered and programmed into the Vectrax. After new values have been generated and input, the Vectrax is updated by clicking the **Update** button on the bottom right of the form.

4.2.3 Inspecting Broadcast Data

The secondary serial communications port of the Vectrax, labelled **COM2** on the hood of the Y-cable DB-9 connector (tan colour vs. black for COM1 connector), should be connected in place of COM1 used previously. Click on menu **View Broadcasts** and then select **CPS/Vectrax** as shown below.

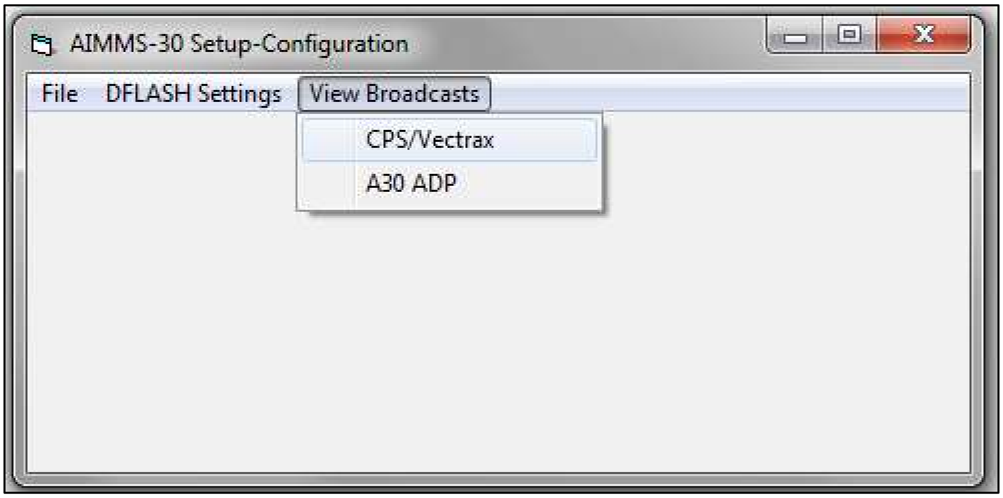

Figure 4.11: Broadcast Menu

This action will result in three data display forms being immediately generated (see Figure 4.12). The **Standard Meteorology Broadcast** form shows the contents of the latest broadcast message from the Vectrax. The wind data displayed for vector components are in instantaneous values, and the wind speed and direction are computed from 4s averages of 5Hz wind component data. The **Damped Wind Solution** form presents the same averaged wind data but in graphical form by using a polar diagram for the wind vector. The position on the outer ring denotes the direction the wind is blowing from, and the length of the inner line, which grows towards the center, represents increasing wind speed.

The final form, **Aircraft State Broadcast Data**, represents the contents of the latest aircraft-state packet, which provides:

- Position, speed and attitude (orientation) of the aircraft.
- U_i, V_i, W_i, which represent the North, East and Down inertial velocity components.
- Roll, Pitch and Yaw, which represent aircraft orientation in degrees.
- TAS, which is the true airspeed.
- W_w, which is the vertical wind component.
- P_alpha, P_beta, which represent the raw AoA and AoS pressure signals from the ADP non-dimensionalized by the pitot-static pressure.

- Flow, which is a field reserved for a different ADP variant used in some scientific research applications where this is the measured rate of purge-air flow used to drive any water out of the probe. [**Note**: Wind data will not be valid while on the ground. A minimum airspeed of 15-20 m/s (30-40 kt) is required before a valid wind solution will be generated. Below this speed, default values of 0 m/s and 90 deg. are output for wind speed and direction.]

The **A30 ADP** menu option is used to inspect data broadcasts directly from the ADP module itself, however this option requires a CAN connection between the PC and Vectrax CAN port.

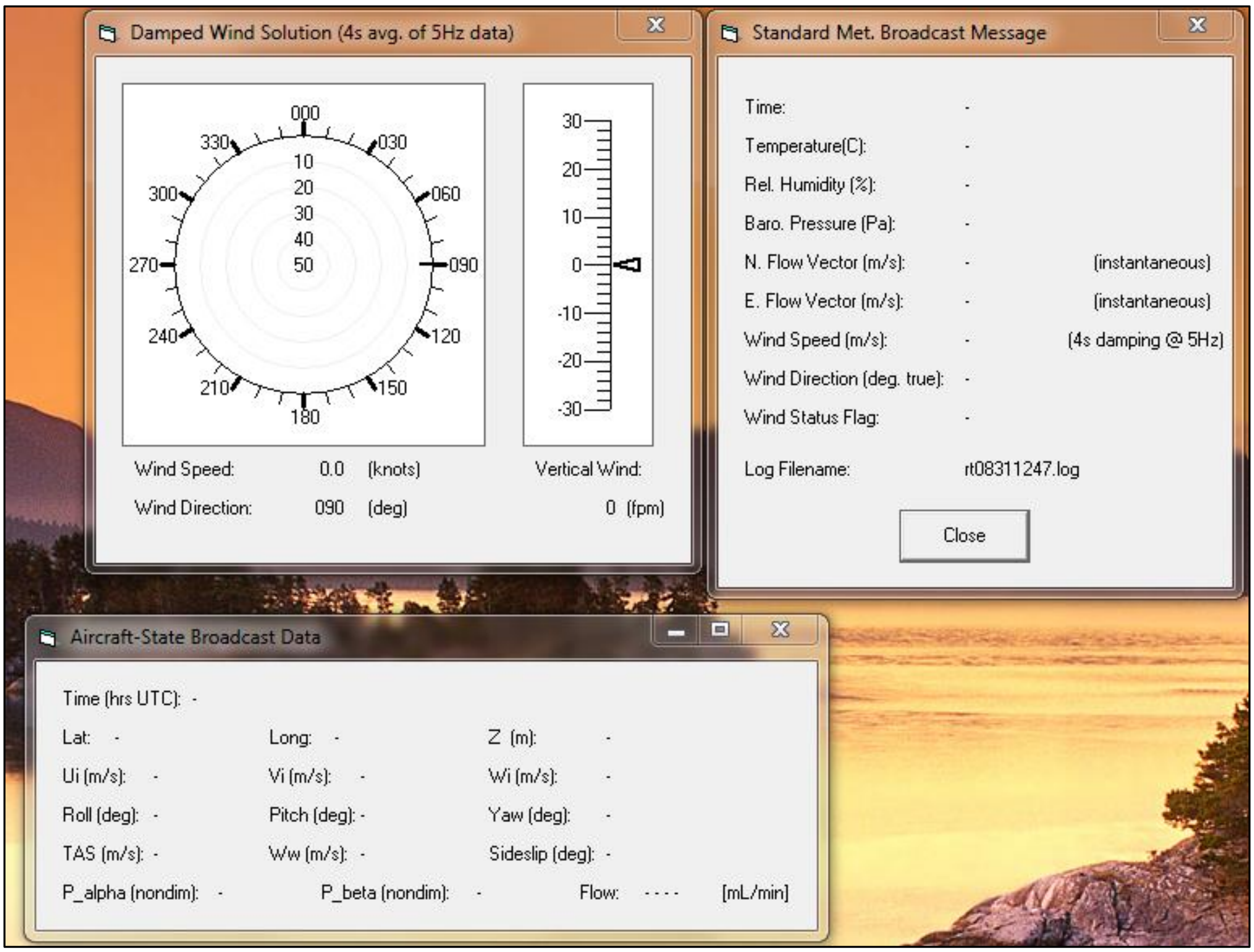

Figure 4.12 Broadcast Data Display

5.0 USB INTERFACE

The Vectrax includes a USB port intended for use with flash drives (see Figure 2.2). The key purpose of the drive interface is to offer a convenient means to record in-flight data. However, it also provides maintenance support functions such as updating system firmware and re-programming system setup parameters.

The system will automatically detect when a flash drive has been plugged in and will ready the drive to be used, a process called “mounting” the drive. It can take anywhere from a couple of seconds to as much as 10-15s to mount the drive. The system will indicate when the drive has been successfully mounted and ready to use by setting the **STATUS 3** LED to solid green (see Figure 2.1).

Note: the system supports only drives formatted according to **FAT32**.

5.1 Data Recording

File recording is automatically controlled using GPS speed as the means to determine when to open and close files. A file is opened once the GPS speed **exceeds 10 m/s (20kt)**, and closed once the speed **decreases below 5 m/s (10kt)**. [**Note**: it is important that at least one GPS processor has a valid solution for this to work.] The file open/close function also can be forced manually, which is ideal for system testing and diagnostics on the ground (see Section 6). Once opened, data is continuously written to the file, a fact that will be signalled by a slow (1Hz) on/off green sequence on the **STATUS 3** LED.

AIMMS-30 network traffic consists of short data packets (CAN messages) produced by all processors within the system. 10 CAN messages at a time are bundled for writing to the file as a single binary packet. As a result, the file contents represent an exact facsimile of all data produced by and shared between modules and sub-processors. The AIMMS-30 produces between 400-500 CAN messages per second, which translates into approximately 14-18 MB/hr written to the USB file.

The file name is generated automatically using the current date and time. Each file name is 8 characters long with the extension of **.RAW** eg. MMDDHHmm.RAW, where **MM** represents the month (01-12), **DD** represents the day (01-31), **HH** represents the hour UTC (00-23) and **mm** represents the minutes within the hour (00-59).

5.2 Firmware Updates

The USB file interface can be used as a means to update firmware on any of the processors within the AIMMS-30, with the exception of the processor responsible for the USB interface itself. A file is placed in the root directory of an **empty** flash drive (containing no other files or folders, including hidden files/folders). With the system already powered-up, place the flash drive into the USB receptacle. As soon as the drive is mounted, the firmware will scan for any firmware update files. If a file is found, then the firmware update process will begin immediately, a process that will typically begin within a few seconds of the flash drive being plugged in.

When the main processor of the Vectrax is targeted for the update, i.e. the Central Processing Subsystem (CPS), the status LEDs will go dark once the firmware reprogramming process has begun. The normal start-up LED sequence will begin immediately after the update is complete. The entire CPS reprogramming processing takes approximately 45s to complete.

Other processors are targeted according to the file name. All firmware update files have the file extension **.fw**. The first three letters of the file name indicate the target processor. Any remaining characters are ignored by this process, but are typically useful for denoting version number. The filenames and corresponding processors are summarized by Table 5.1 below:

Processor	Filename
Central Processing Subsystem	CPSxxx.FW
Inertial Reference Subsystem	IRSxxx.FW
Air-Data Probe Subsystem	ADPxxx.FW
Iridium Satcom Subsystem	TLMxxx.FW
MetTrack User Interface Main Processor	UIMxxx.FW
MetTrack User Interface File-Server Processor	UIFxxx.FW

Table 5.1: Firmware Filenames

Updating any other processors is done the same way. The difference is that progress of the update process will be indicated by the **STATUS 3** LED, which will perform a red strobe sequence during the process. Once the process is complete, **STATUS 3** will return to its regular solid green until the drive is removed.

If an error occurs during this process, a red error code sequence will be generated on the **STATUS 3** LED (see Section 6.1).

5.3 Programming System Parameters

The USB flash drive interface can be used to update key system parameters by simply placing the file named **PARAM.SET** into the root directory of an **empty** flash drive. The file system firmware will scan the root directory for **PARAM.SET** immediately after mounting the drive. If it is located, then the file is opened and the contents read, after which commands are sent to the main processor (CPS) to update all parameter values. This process will take no more than a few seconds. All status LEDs will flash on-off four times in unison to signal the successful completion of this process.

System parameters are stored in file **PARAM.SET** as scaled integers, i.e. if CP_0 has the value 0.1234, then the value stored in the file would become the integer value of 1234 when using a x10000 scale factor. Table 5.2 below gives the detailed file format, including the scale factors used for integer conversion. One parameter is assigned per line of the ASCII file.

Line #	Parameter	Scale Factor
1	Broadcast Period [s]	1000
2	CP_0	10000
3	CP_alpha	10000
4	CP_beta	10000
5	B_0	1000
6	B_alpha	1000
7	B_beta	1000
8	A_0	1000
9	A_alpha	1000
10	A_beta	1000
11	Antenna baseline length [m]	1000
12	Antenna orientation [1 = fore/aft, 2 = lateral]	N/A
13	Antenna baseline offset, roll [deg]	100
14	Antenna baseline offset, pitch [deg]	100
15	Antenna baseline offset, yaw [deg]	100
16	Air-data probe orientation [1 = normal, 2 = port, 3 = starboard]	N/A

Table 5.2: Definition of PARAM.SET contents

6.0 DIAGNOSTICS

Several options are available to determine whether or not your AIMMS-30 system is functioning properly and, if not, to determine where the problem lies. Information suitable for diagnostic purposes can be obtained by one of three ways:

- LED colour codes and flash sequences.
- Information routinely broadcast on the primary RS232 serial port.
- Analysis of data recorded by the USB file system.

6.1 LED Error-Code Sequences

Status LEDs residing on the front of the main panel (see Figure 2.1) provide the easiest way to confirm the operating state of the AIMMS-30 system. The power LED function is, of course, reserved to indicate that sufficient input power is being applied. It will light with a steady green colour when the unit is adequately powered up. The other LEDS, labeled **STATUS 1**, **STATUS 2** and **STATUS 3,** use a combination of either red or green lights in a variety of sequences in order to signal system status or events. Table 6.1 summarizes the meaning of these indicator sequences [**Note**: colours are R = Red, G = Green, O = Off].

LED #	Colour	Sequence	Description
1	R	on/off (continuous)	Indexing internal flight data log
1	R	solid	Acquiring signal, GPS 1
1	G	solid	Signal acquired, navigation solution good, GPS 1
1	R	1 blink – pause	Air data probe not online
1	R	2 blinks – pause	Inertial subsystem not online
1	R	3 blinks – pause	GPS subsystem not online
1	R	4 blinks – pause	CAN bus warning or reset
2	R	on/off (continuous)	Indexing internal CBIT error log
2	R	solid	Acquiring signal, GPS 2
2	G	solid	Signal acquired, navigation solution good, GPS 2
1,2,3	G	on/off x 4	System parameter update successful from PARM.DAT
3	O	n/a	No drive in USB slot
3	G	solid	Flash drive mounted
3	G	on/off (cont)	File-write process active
3	R	solid	ALFAT I/O error while accessing the device
3	R	fast on/off (cont)	Firmware update process active (except for CPS)
3	R	1 blink – pause	Error mounting the drive
3	R	2 blinks – pause	Error reading directory
3	R	3 blinks – pause	Error opening file
3	R	4 blinks – pause	Error firmware update

Table 6.1: Error Code Sequences

6.2 Serial Data Output, Primary RS-232 Port (COM1)

Starting immediately after a power-reset, various pieces of system data are output on the primary serial port during the boot process. An initial baud rate of 115200 is always assumed for the CAN-based bootloader to announce its version number [**Note**: the bootloader is the small application that starts first upon a reset that permits new firmware to be loaded if necessary]. Once the main application code starts, which is only a fraction of a second after the bootloader starts, it will present the software version number and key options (update rate for GPS, type of air-data probe to be used). If a different baud rate had been programmed in flash (eg. 9600, 19200 or 38400), it will announce at this point the new baud rate before switching to it. This is done so that one can be certain of the baud rate, and you will be notified of the value if it is something other than 115200 for operation.

The boot process continues by scanning internal data flash memory (not to be confused with USB flash drive) for the purposes of indexing. It will determine the number of flights contained in the log, first for the flight data log, then secondly for the Continuous Built-In Test (CBIT) error log. Once this is complete, taking approximately 20s, the system sends out a poll request to all system modules to report their respective firmware version numbers. A standard AIMMS-30 system will contain an IRS module (Inertial Reference Subsystem), a GPS/USB control module and an ADP module. The IRS and GPS/USB modules are managed by additional processors also housed within the Vectrax module. This allows one to determine the current revision status of all firmware operating within the system without need for any special tools.

If system time is valid, i.e. real-time clock is reporting OK or GPS solution is valid, and the internal data logging option is on, the system will next announce the initialization of the internal data log for this session to confirm the log process is now active [**Note**: data will be appended after the end of the previous session].

Immediately after the firmware versions have been reported, the system goes into a continuous state of writing system status messages once every second. These messages, one record per line of ASCII text, are divided into several fields:

1. System time (hours)
2. CBIT word #1 (32 bits, hexadecimal format)
3. CBIT word #2 (32 bits, hexadecimal format)
4. Air-data probe CBIT (32 bits, hexadecimal format)
5. GPS 1 status
6. GPS 2 status

Appendix B details the meaning of each individual bit for the CBIT1, CBIT2 and ADS CBIT words. Each bit that is set represents a specific system state that is being flagged.

If the ADS is not visible to the system, the ADS CBIT field is replaced by "***********" to indicate no information is being received from the module.

GPS status consists of a sequence of four numbers:

1. Position Type
   a. No solution = 0
   b. Standard solution = 1 or 16
   c. WAAS correction solution = 18
2. Solution Status
   a. 1 = acquiring
   b. 0 = solution acquired
3. # satellites tracked / reporting for raw data (carrier-phase)
4. # satellites used in the navigation solution (position, velocity, time)

Figure 6.2 below shows a terminal screen capture of typical output after reset.

```
Aventech AIMMS30 CPS Firmware
version 2.1.0 B1
Options:
  GPS PVT Rate: 1 Hz
  AIMMS-30 ADP
DFLASH initialized!

SPI FLASH TYPE: 1
FILE SERVICE RESULT CODE: 0
# blank = 2206 not wrapped,  ipage = 4566 irec = 0 n_file = 21
# blank = 88 not wrapped,  ipage = 8103 irec = 0 n_file = 18
POLL MODULE FIRMWARE VERSIONS:
   MODULE   VERSION BUILD#
    IRS      1.3.0   1
  GPS/USB    2.0.0   1
    ADP      2.3.0   1

TIME UTC, CBIT1, CBIT2, ADP, GPS1: POS_TYPE, SOL_STAT, #SAT.ICP/PVT; GPS2: SAME
  17.63222  -CBIT: 0x00000000 CBIT2: 0x00000000 ADS CBIT: 0x00000000 GPS1: 0 0 0 0 GPS2: 0 0 0 0
AIMMS LOG INIT!
CBIT LOG INIT!
  17.63249  -CBIT: 0x82400000 CBIT2: 0x000C0400 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63277  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63305  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63333  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63361  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63388  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63416  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63444  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63472  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63500  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63527  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63555  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63583  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63611  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63638  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63666  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63694  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63722  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63750  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63777  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63805  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63833  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63861  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63888  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 0 0 GPS2: 0 1 0 0
  17.63916  -CBIT: 0x82400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 0 1 5 0 GPS2: 0 1 6 0
  17.63944  -CBIT: 0x00400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 16 0 6 6 GPS2: 16 0 6 6
  17.63972  -CBIT: 0x00400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 16 0 6 6 GPS2: 16 0 6 6
  17.63999  -CBIT: 0x00400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 16 0 6 6 GPS2: 16 0 6 6
  17.64027  -CBIT: 0x00400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 16 0 6 6 GPS2: 16 0 6 6
  17.64055  -CBIT: 0x00400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 16 0 6 6 GPS2: 16 0 7 6
  17.64083  -CBIT: 0x00400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 16 0 6 6 GPS2: 16 0 7 6
  17.64111  -CBIT: 0x00400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 16 0 6 6 GPS2: 16 0 8 6
  17.64138  -CBIT: 0x00400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 16 0 6 6 GPS2: 16 0 8 7
  17.64166  -CBIT: 0x00400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 16 0 6 6 GPS2: 16 0 8 7
  17.64194  -CBIT: 0x00400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 16 0 6 6 GPS2: 16 0 8 7
  17.64222  -CBIT: 0x00400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 16 0 6 6 GPS2: 16 0 8 7
  17.64249  -CBIT: 0x00400000 CBIT2: 0x000C0000 ADS CBIT: 0x00000000 GPS1: 16 0 6 6 GPS2: 16 0 8 7
```

Figure 6.1: Typical Output after Reset on COM1

6.3 System Data Files

The **.RAW** data file that is created by the USB flash file system contains a copy of every network data packet sent across the CAN bus. Not only can this data be re-processed, but it also represents a wealth of information available for system diagnostics. A **.RAW** file can be obtained by inserting a flash drive into the USB slot prior to take-off, to be retrieved after landing. However, a file can also be acquired on the ground if one has access to the primary serial port as discussed on Section 6.2. Two “hot keys” are available to spoof the system into opening a file as if it were flying, or closing a file as if landing. Pressing the ‘**g**’ key will automatically force the file-open / file-write process to start, and pressing the ‘**s**’ key will cause the process to stop and close the file. With this “cheat” it is possible to obtain a file record of all system network traffic on the ground. If any issue is suspected, emailing such a file to support@aventech.com will allow our technicians to efficiently diagnose any system issue.

Appendix A: Typical values for aerodynamic calibration parameters

Parameter	Description	Typical Range
Cp_0	Offset of static pressure error	0 to 0.2
Cp_alpha	Variation of static pressure error with AoA signal	-0.5 to 0.5
Cp_beta	Variation of static pressure error of AoS signal	-0.1 to 0.1
b_0	Offset of sideslip angle	-5 to 5
b_alpha	Variation of sideslip error with AoA signal	-3 to 3
b_beta	Variation of sideslip error with AoS signal	6 to 14
a_0	Offset of angle of attack	-5 to 5
a_alpha	Variation of AoA error with AoA signal	6 to 14
a_beta	Variation of AoA error with AoS signal	-3 to 3

Table A-1: Aerodynamic Calibration Parameters

Parameter	Description	Typical Range
Antenna Baseline	Straight-line distance between GPS antennas	3m to 20m
Antenna Orientation	Selects either fore-aft or side-side alignment of GPS	1 or 2
Antenna Offsets	Adjustments to the alignment of GPS antenna baseline relative to the IMU reference axes (d_phi, d_theta, d_psi)	-5 to 5
Gyro Offsets[1]	Adjustments to the gyro signal to correct for small internal misalignments (roll, pitch, yaw)	-5 to 5
Probe Orientation[2]	Accommodates different probe installation orientations i.e. vertical (normal), side-mount (port or starboard)	

Table A-2: Non-Aerodynamic Calibration Parameters

[1] AIMMS-20 systems only
[2] AIMMS-30 systems only

Appendix B: Built-In Test Binary Flag Definitions

Bit #	Hexadecimal Value	Description
0	0x00000001	COP Reset Event
1	0x00000002	Static pressure sensor range error
2	0x00000004	AoA pressure sensor range error
3	0x00000008	AoS pressure sensor range error
4	0x00000010	Pitot-static pressure sensor range error
5	0x00000020	External temperature range error
6	0x00000040	Relative humidity range error
7	0x00000080	ADP internal temperature range error
8	0x00000100	Missing Processor on Network
9	0x00000200	ADP data rate warning
10	0x00000400	Sensor fault, static pressure
11	0x00000800	Sensor fault, AoA pressure
12	0x00001000	Sensor fault, AoS pressure
13	0x00002000	Sensor fault, pitot-static pressure
14	0x00004000	CAN bus warning
15	0x00008000	COP reset, ADS processor
16	0x00010000	COP reset, IRS processor
17	0x00020000	Data rate error, IRS subsystem
18	0x00040000	I/O error, RH sensor
19	0x00080000	Gyro range error
20	0x00100000	Accelerometer range error
21	0x00200000	Orion I/O error
22	0x00400000	Orion Message Count sequence
23	0x00800000	Orion self-test failure
24	0x01000000	GPS1 data stale
25	0x02000000	GPS1 navigation status bad
26	0x04000000	CAN bus rx overflow (controller)
27	0x08000000	CAN bus rx overflow (software buffer)
28	0x10000000	CAN bus tx overflow
29	0x20000000	CAN bus-off reset
30	0x40000000	GPS2 data stale
31	0x80000000	GPS2 navigation status bad

Table B-1: Continuous Built-In Test (CBIT) Flag Definitions, Group 1

Bit #	Hexadecimal Value	Description
0	0x00000001	Real-time clock status warn
1	0x00000002	ALFAT I/O error
2	0x00000004	ALFAT drive mount error
3	0x00000008	ALFAT directory list error
4	0x00000010	ALFAT file open error
5	0x00000020	Firmware update error
6	0x00000040	ALFAT file-write error
7	0x00000080	ALFAT close file error
8	0x00000100	GPS1 I/O error
9	0x00000200	GPS2 I/O error
10	0x00000400	Serial number fault, IMU data
11	0x00000800	Serial number fault, ADP data
12	0x00001000	Data flash I/O error
13	0x00002000	GPS1, buffer overflow error
14	0x00004000	GPS2, buffer overflow error
15	0x00008000	ADS not reporting
16	0x00010000	IRS not reporting
17	0x00020000	GPS-USB not reporting
18	0x00040000	IMU rate integration not active
19	0x00080000	GPS-IMU Kalman filter not running
20	0x00100000	Reserved
21	0x00200000	Kalman filter reset

Table B-2: Continuous Built-In Test (CBIT) Flag Definitions, Group 2

Bit #	Hexadecimal Value	Description
0	0x00000001	Range error, static pressure
1	0x00000002	Range error, AoA pressure
2	0x00000004	Range error, AoS pressure
3	0x00000008	Range error, pitot-static pressure
4	0x00000010	Range error, internal temperature
5	0x00000020	Range error, data refresh frequency
6	0x00000040	Sensor fault, static pressure
7	0x00000080	Sensor fault, AoA pressure
8	0x00000100	Sensor fault, AoS pressure
9	0x00000200	Sensor fault, pitot-static pressure
10	0x00000400	Range error, RH
11	0x00000800	Range error, thermistor
12	0x00001000	I/O error, RH sensor

Table B-3: Continuous Built-In Test (CBIT) Flag Definitions, Air-Data Subsystem

Appendix C: Technical Specifications

C-1 Air Data Probe (ADP)

Processor: Freescale MC56F8322

Internal Sampling Rate: 200Hz
Low-pass filter frequencies 6, 12 or 28Hz (3 dB corner frequency)
Data Output Rate: 0.2 - 20 Hz

Measurement	Range	Accuracy
Static Pressure	0-110000 Pa	100Pa + 0.05%
Pitot-Static Differential	0-7000 Pa	25 Pa + 0.05%
AOA / AOS Differential	+/- 7000 Pa	25 Pa + 0.05%

C-2 Inertial / GPS / Processing Module (IGPM)

Processors: Freescale DSP56F807 (X1)
Freescale MC56F8322 (X2)

Internal Sampling Rate: 250 Hz
Digital Low Pass Frequency: 1-40 Hz (3 dB corner frequency)
Data Output Rate: 100 Hz

Measurement	Range	Accuracy
3-axis accelerations	+/- 10 g	0.002 g
3-axis angular rates	+/- 150 deg/s	0.025 deg/s

C-3 Meteorological

Temperature

Resolution:	0.01 C˚
Accuracy:	0.30 C˚

Relative Humidity

Resolution:	0.05 %RH
Accuracy	2% RH

Three-Dimensional Wind

North and East Components:	0.50 m/s (1.0 knot) @ 150 knot TAS
Vertical:	0.50 m/s (1.0 knot) @ 150 knot TAS

C-4 Electrical

Operating Voltage:	9 - 36 VDC Input
Operating Current:	
Vectrax	155 mA @ 28 VDC
With ADP	200 mA @ 28 VDC
Digital Interfaces:	Controller Area Network (CAN2A) (500 kbps) 2 x RS-232 Serial Port (programmable baud rate: 9600-115200)

C-5 Environmental

Operating Temperature:	-40 C to 50 C˚
Storage Temperature:	-40 C to 90 C˚

C-6 Weight

Air Data Probe (ADP):	0.65 kg (1.44 lb)
Inertial/GPS/Processing Module (IGPM):	0.49 kg (1.06 lb)

Appendix D: Serial Communication Format (Broadcast Messages)

D-1 Introduction

The AIMMS-30 offers bi-directional RS-232 communications using a binary packet format. The default broadcast packet is called the Standard Meteorology Data Packet, which is output at a user-defined rate up to 20Hz. An optional Aircraft-State Data Packet is also available, which includes aircraft position, velocity, attitude and aircraft-relative flow (TAS) vector, each in three dimensions. This packet is also available at a user-defined output rate. For systems that include pneumatic purge-flow data feedback, a Purge Flow Data Packet is transmitted at the same rate as the aircraft-state packet, with flow-rate data refreshed internally at a rate of approximately 12Hz.

D-2 Hardware Configuration

The RS-232 serial interface utilizes only three lines: receive, transmit, and ground. The default baud rate is 19200. The system operates with no parity, 8 data bits, 1 stop bit.

D-3 Packet Format

Each packet consists of a four-byte header, a data block from 0 to 255 bytes in length, and a 16-bit checksum.

Byte	Description
1	Start of header = 1
2	Packet ID: 0 for standard met. packet, 1 for aircraft-state packet
3	Bitwise complement of ID (255, 254 respectively) used to further validate packet frame-lock
4	Number of bytes in data block (N)
5	First byte of data block
5+N	16-bit unsigned checksum, least significant byte
6+N	16-bit unsigned checksum, most significant byte

Note: The checksum includes the leading SOH character but not the two checksum-bytes themselves.

Byte #	Description	Var. Type	Scale
5	Time (UTC), hours	Char.	1
6	Time (UTC), minutes	Char.	1
7	Time (UTC), seconds	Char.	1
8	Temperature (deg. C) – lsb		
9	Temperature – msb	Signed int.	100
10	Relative humidity (fraction from 0 to 1) – lsb		
11	Relative humidity –msb	Unsigned int.	1000
12	Barometric pressure (Pa) – lsb		
13	Barometric pressure – msb	Unsigned int.	0.5
14	Wind flow vector N component (m/s) – lsb		
15	Wind flow vector N component – msb	Int.	100
16	Wind flow vector E component (m/s) – lsb		
17	Wind flow vector E component – msb	Int.	100
18	Wind speed (m/s) - lsb		
19	Wind speed (m/s) - msb	Int.	100
20	Wind direction (deg. true) – lsb		
21	Wind direction (deg. true) – msb	Unsigned int.	100
22	Status flag: bit 0 (wind status) 0 = not valid 1 = valid	Char.	1
	Status flag: bit 1 (purge status) 0 = purge off, 1 = purge ON	Char.	1
	Status flag: bit 2 (GPS solution status) 0 = GPS solution bad, 1 = GPS solution good	Char.	1

Table D-1: Binary Data Block, Standard Meteorological Data Packet

Notes:

- Wind flow vector points in the direction to which the wind is blowing.
- Wind direction is reported in accordance with standard meteorological convention, i.e. direction wind is blowing from.
- The following conditions must be met for a valid wind solution: a) wind measurement system must be calibrated; b) airspeed must exceed a threshold value of 30 m/s (~60 knots); c) valid navigation solutions available from both GPS processors; d) a minimum number of four matched satellite pairs must be visible.
- Wind speed and wind direction output are damped by a 20-point moving average (20 of the latest wind solution updates, eg. 5Hz update = 4 s damping).

Byte #	Description	Var. Type	Scale
5	Time (UTC) – hour	Char	1
6	Time (UTC) – minute	Char	1
7	Time (UTC) – second	Char	1
8	Latitude (deg.) - byte 1 (lowest byte)		
9	Latitude – byte 2		
10	Latitude – byte 3		
11	Latitude – byte 4 (highest byte)	Float	1
12	Longitude (deg.) – byte 1 (lowest byte)		
13	Longitude – byte 2		
14	Longitude – byte 3		
15	Longitude – byte 4 (highest byte)	Float	1
16	Altitude (m above geoid) – lsb		
17	Altitude – msb	Int	1
18	Velocity, north component (m/s) – lsb		
19	Velocity, north component – msb	Int	100
20	Velocity, east component (m/s) – lsb		
21	Velocity, east component – msb	Int	100
22	Velocity, down component (m/s) – lsb		
23	Velocity, down component – msb	Int	100
24	Roll angle (deg) – lsb		
25	Roll angle – msb	Int	100
26	Pitch angle (deg) – lsb		
27	Pitch angle – msb	Int	100
28	Yaw angle (heading) (deg. true) – lsb		
29	Yaw angle – msb	Int	50
30	True airspeed (m/s) – lsb		
31	True airspeed – msb	Int	100
32	Vertical wind – lsb		
33	Vertical wind – msb	Int	100
34	Sideslip angle (deg) – lsb		
35	Sideslip angle - msb	Int	100
36	AOA pres. differential (dimensionless)-lsb		
37	AOA pres. differential – msb	Int	10000
38	Sideslip differential (dimensionless) – lsb		
39	Sideslip differential – msb	Int	10000

Table D-2: Binary Data Block, Aircraft State Data Packet