AIMMS-20

Aircraft Integrated Meteorological Measurement System

OPERATING MANUAL

Document-P/N: *AIMMS20-OM*

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22.11.2013	Bruce H. Woodcock		HD

Customer Approval (as required)

Date	Name	Signature	Function

Table of Functions

CUST	**Customer**
DE	**Design Engineer**
HD	**Head of Design Engineering**
PM	**Production Manager**
QM	**Quality Manager**

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RECORD OF REVISIONS

Date	Issue	Page	Paragraph	Firmware Revision	Comments
21.11.2013	1.00	All	All		Preliminary Draft
22.11.2013	1.00	All	All		Release

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1 INTRODUCTION

The Aventech Research Inc. AIMMS-20 (Aircraft Integrated Meteorological Measurement System) is an integrated, turn-key system for measuring accurate, real-time meteorological data on airborne platforms. The meteorological data set includes temperature, humidity, three-dimensional winds (speed, direction and vertical) and turbulence. The data generated by the system is broadcast in real-time via an RS-232 serial communications link to either a GPS navigation system or data acquisition system.

This document provides a step by step description on how to setup and calibrate the AIMMS-20 instrumentation for your aircraft or helicopter airframe. Section 2 provides an overall description of the components of the AIMMS-20 system. Section 3 provides detail on how to perform the initial setup of the system followed by a description of the flight manoeuvres that must be performed in order to calibrate the system. In order to set up and calibrate the system, the user will utilize Aventech's aimcfg PC-based software utility. A user's guide for the aimcfg software utility is provided in Section 4. Technical specifications for the system are provided in Section 5. If the end user wishes to integrate the AIMMS-20 serial broadcast data stream into their dedicated data acquisition system, details of the broadcast format can be found in Appendix A.

2 SYSTEM OVERVIEW

The AIMMS-20 system consists of four modules: an Air Data Probe (ADP) which is mounted external to the aircraft, an Inertial Measurement Unit (IMU), a GPS Phase Module (GPS) and a Central Processing Module (CPM). The following section of this manual describes each of the system components in order to familiarize you with the system.

2.1 Air Data Probe (ADP)

The Air Data Probe is mounted external to the aircraft and is the component of the AIMMS-20 which measures static pressure, the three-dimensional flow vector relative to the aircraft frame of reference, Outside Air Temperature (OAT), Relative Humidity (RH) and turbulence.

The three-dimensional flow vector is measured using a series of five pressure ports located on the hemispherical nose of the ADP’s measurement boom and a ring of static pressure ports slightly aft of the measurement boom nose. Using this set of pressure ports measurement of the barometric, pitot-static, differential angle-of-attack and differential side-slip pressure measurements can be obtained which define the three-dimensional flow vector.

OAT and RH measurements are made using a small 0.038” diameter bead thermistor and thermoset polymer RH sensor respectively. Both sensors are located in a reverse-flow chamber at the aft end of the probe to protect them from direct impact with particulates and larger objects in the free stream flow.

With your AIMMS-20 system you will have received one of two Air Data Probe types depending on the airframe for the planned installation, an under-wing version as shown in Figure 1 or a sting-mount version as shown in Figure 2.

The under-wing ADP is typically utilized for fixed-wing installations while the sting-mount ADP is typically utilized in rotary-wing installations. In some cases end users have also used the sting-mount probe for fixed-wing installations with their own mounting bracket design.

Figure 1: AIMMS-20 Under-Wing Air Data Probe Installation

Figure 2: AIMMS-20 Sting-Mount Air Data Probe Installation

2.2 Inertial Measurement Unit (IMU)

The IMU is a six-degree of freedom inertial measurement unit consisting of three MEMS accelerometers and three MEMS rate gyros. Utilizing inexpensive MEMS-based measurement devices provides a high-accuracy, low cost method of measuring the dynamic, high-frequency motion of an airborne platform. However, the compromise is that MEMS-based measurement devices have poorer long term DC stability. The AIMMS-20 system compensates for this DC instability using a single-axis GPS carrier-phase system which is described in Section 2.3.

Figure 3: AIMMS-20 Inertial Measurement Unit

2.3 GPS Phase Module (GPS)

The GPS Phase module is a two antenna, single baseline GPS carrier-phase subsystem. Accurate, DC-stable attitude of the baseline between two GPS antennae either mounted laterally (wingtip to wingtip) or longitudinally (wingtip to wingtip or fore / aft) on the airborne platform can be determined using the GPS carrier-phase measurements from the two GPS receivers located in the module. Lateral antennae configurations are typically used on fixed-wing aircraft while longitudinal antennae configurations can be utilized on fixed or rotary wing aircraft.

Although the attitude measurement performed using this technique is stable it possesses a fairly low frequency response (2.5 Hz). Higher frequency dynamic information is provided by the IMU described in Section 2.2. The mathematical algorithm used to optimally combine the two sets of data is called an Extended Kalman Filter (EKF) and runs in the firmware loaded in the CPM described in Section 2.4.

Figure 4: AIMMS-20 GPS Phase Module

2.4 Central Processing Module (CPM)

The CPM is essentially the main computational center for the AIMMS-20 system. CPM firmware utilizes acceleration and angular-rate information from the IMU and carrier-phase information from the GPS to compute the precise three-dimensional orientation of the aircraft using an Extended Kalman Filter (EKF) algorithm. In parallel, the three-dimensional winds relative to the aircraft are evaluated from air data provided by the ADP. These data, when combined with aircraft attitude and velocity, are transformed into the earth reference frame to provide the final three-dimensional wind output.

The CPM also acts as the main interface between the aircraft spray navigation system and the rest of the AIMMS-20.

Aircraft power is provided to the AIMMS-20 through the CPM module which steps the input voltage down +12 VDC and distributes it to power the balance of the modules through the Controller Area Network (CAN) cables.

The real-time aircraft state (attitude) and meteorological (temperature, humidity, wind speed, wind direction and turbulence) data provided by the AIMMS-20 is broadcast on the second serial port of the CPM as two unique aircraft state and meteorological packets which can be read by a host computing device such as a GPS navigation system or data acquisition system. Details of the format of these packets can be found in Appendix A.

Figure 5: AIMMS-20 Central Processing Module

2.5 Communications

The four AIMMS-20 modules communicate with each other via a high-speed, digital serial Controller Area Network (CAN) bus. The four conductor cable connected between the modules provides power to each of the modules and communication between them.

Communication between the AIMMS-20 and a host computing device (GPS navigation or data acquisition system) is via a standard RS-232 serial port.

3 AIMMS-20 SETUP AND CALIBRATION

3.1 Preparation of Laptop / Computer

The first step in setting up your AIMMS-20 system is to install the aimcfg software utility provided with the system onto a laptop computer which will be used to interact with the system. The laptop will require an RS232 serial communications port, either built into the computer or as a PCMCIA or USB peripheral adapter. Instructions on installing the software are provided in Section 4.1.

Before proceeding further, you should first familiarize yourself with the aimcfg PC-based software utility. The aimcfg User's Manual is provided as Section 4 of this document.

3.2 Measurements

Two pieces of information will be required concerning the physical installation on your aircraft. First, the straight-line distance between the two GPS antennas, referred to as the antenna baseline, must be measured (see Fig. 6). This can be determined from known station information utilized for the unstallation, or measured directly using a plumb-bob first to mark the position on the ground directly below the each antenna, then measuring the distance between these two marks on the ground using a long tape measure. Similarly, the location of the ADP relative to the aircraft centreline needs to be determined, referred to as the ADP Offset. This is the straight-line distance from the centre of the probe to the centreline of the aircraft. The ADP Offset is positive if the ADP is located on the starboard wing and negative if located on the port wing. Retain these measurements for later input as part of AIMMS-20 configuration setup using the aimcfg software utility.

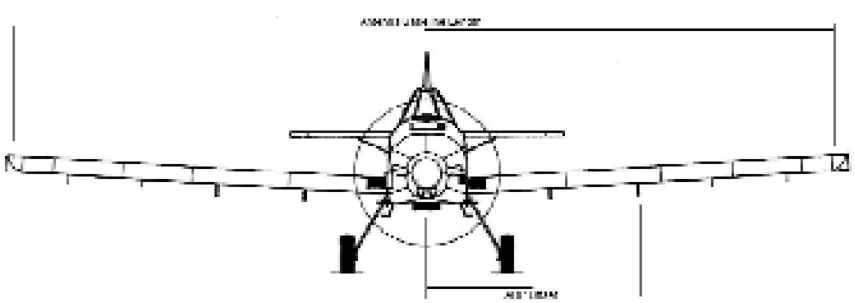


Figure 6: Definition of Antenna Baseline Length and ADP Offset

3.3 Calibration Flight Procedure

The following section describes the manoeuvres that are to be flown, while recording data, during the calibration flight. The resulting data file provides the required information so that the calibration coefficients that have to be programmed into the AIMMS-20 can be determined in order to provide a real-time wind solution.

Two different procedures exist for flight calibration. The first procedure is required to determine aerodynamic errors induced by the aircraft itself (see Section 3.3.2). The second procedure is required to capture small alignment errors (i.e. cross-axis error) between the gyros, accelerometers, GPS antenna baseline and the primary reference frame of the IMU (see Section 3.3.3). Data required for analysis of the aerodynamic calibration flight is automatically recorded in the FLASH memory on-board the CPM, which can be downloaded after landing using the *aimcfg* software utility (Section 4.4.1). However, data requirements for the GPS-IMU cross-axis calibration are such that all raw system data must be recorded. Raw data can be captured using the *aimcfg* utility (see Section 4.4.4).

Step by step instructions are provided followed by a graphical depiction of the flight segment.

3.3.1 Pre-Flight Procedure

i) Power up the AIMMS-20 system.

ii) Start aircraft, taxi and ascend to an altitude at which you will be insured smooth air with a constant wind field. Depending on the prevailing meteorological conditions this may be well above the temperature inversion and/or cloud top.

3.3.2 Aerodynamic Calibration Manoeuvres

i) Select three true air speeds (TAS) within a range from a comfortable margin above aircraft stall to a comfortable margin below maximum cruise. The mid-range TAS is typically selected at your spray release airspeed. Select the minimum and maximum calibration speeds in consultation with the operations manager and pilot flying the calibration flight.

ii) Start the calibration procedure by setting up on a true north heading at the lowest airspeed selected in step 3 above.

iii) At this lowest airspeed perform a yaw manoeuvre yawing the aircraft approximately 5 degrees to port followed by 5 degrees to starboard, or vice-versa, at a rate of approximately 5 to 10 seconds into the yaw and 5 to 10 seconds back out for a total of 20 to 40 seconds for the complete manoeuvre.

iv) Once the yaw manoeuvre is complete, hold the lowest airspeed on a constant true north heading for approximately 10 seconds and then increase the airspeed slowly to your mid-range or spray release airspeed. Once stabilized repeat the yaw manoeuvre at this airspeed.

v) Once again, when the yaw manoeuvre is complete, hold the operational airspeed on a constant true north heading for approximately 10 seconds and then increase the airspeed slowly to your maximum selected airspeed, determined in step 3.

vi) At the highest TAS repeat the yaw manoeuvre.

vii) Turn the aircraft around 180 degrees at a moderate bank angle (approx. 30 degrees) and set up on a true south heading at the highest airspeed.

viii) Repeat the yaw manoeuvre.

ix) Decrease the airspeed continuously to the mid-range airspeed.

x) Perform the yaw manoeuvre at the operational TAS setting.

xi) Decrease the airspeed once again continuously to the lowest airspeed.

xii) Perform one last set of yaw manoeuvres at the lowest airspeed.

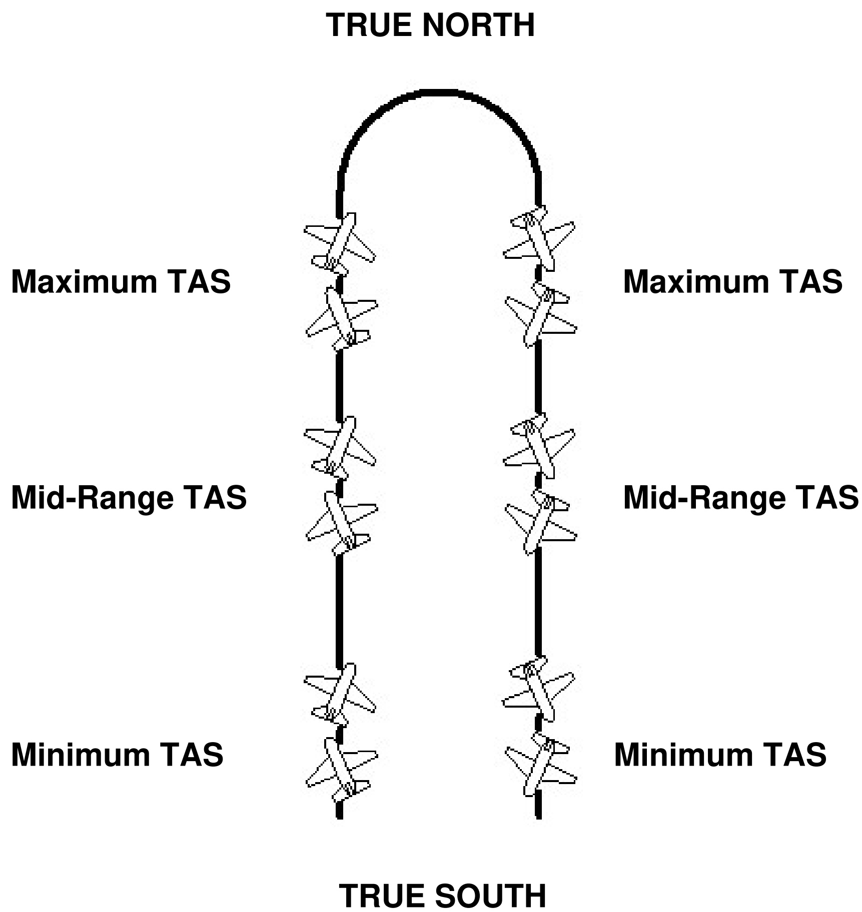


Figure 7: Aerodynamic Calibration Manoeuvres

3.3.3 Inertial System Calibration Manoeuvres

i) Select any heading which will locate the aircraft in low or no traffic airspace to perform the following manoeuvre.

ii) After stabilizing perform a 360 degree orbit to starboard at a bank angle of 15 degrees. When complete stabilize on the original heading for approximately 5 seconds.

iii) Repeat step ii) using an approximate bank angle of 30 degrees.

iv) Repeat step ii) again using an approximate bank angle of 45 degrees.

v) Repeat steps ii) to iv) to port which will be six orbits in total.

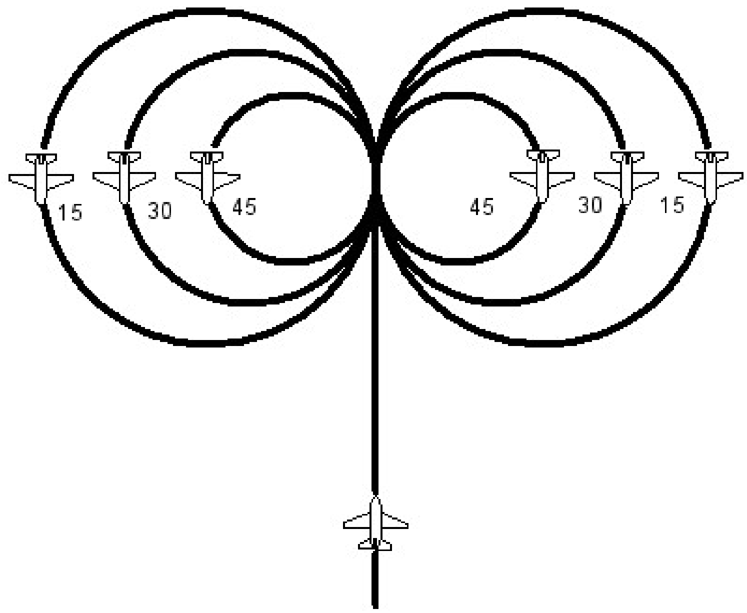


Figure 8: Inertial System Calibration Manoeuvres

3.3.4 Post Flight Procedure

i) Return to base and land.

ii) E-mail the log file on the USB FLASH memory device to support@aventech.com or the e-mail address of your dedicated Aventech support engineer for post-processing. The new calibration parameters will be e-mailed to you for programming into the AIMMS-20 system.

4 AIMMS CONFIGURATION UTILITY SOFTWARE USER'S MANUAL (*aimcfg.exe*)

4.1 Installing *aimcfg*

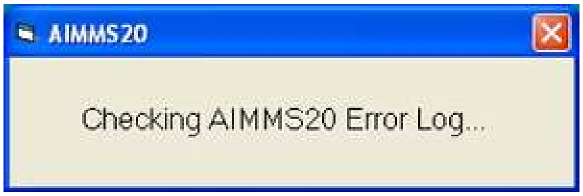
The installation software package is provided as a compressed file archive *aimcfgXXX.zip* where *XXX* is the version number. Unzip the file archive using standard Windows tools and place the files in a temporary destination folder. From the list of files within this folder you should see the program file *setup.exe*. Double click on this file to launch the installer and follow the subsequently provided instructions. Please make note of the directory to which the *aimcfg* files are installed.

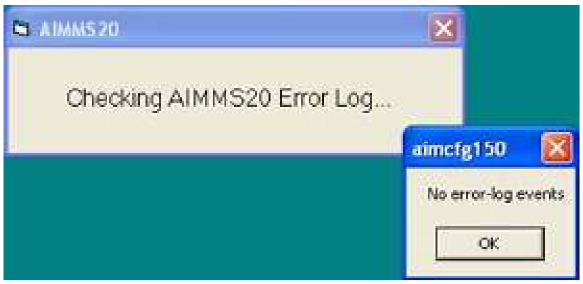
4.2 Starting *aimcfg*

Before starting the *aimcfg* utility program, make sure the serial cable provided with the system is connected between your PC and the RS-232 port of the CPM module. The serial cable has a 6-pin female circular connector on one end and two DSub-9 serial connectors on the other. Connect the DSub-9 connector labelled COM1 with a black hood to your computer at this point in order to communicate with, and setup, the AIMMS-20. Once the communications cable is connected, and the AIMMS system connected to power, turn on the AIMMS.

Navigate to the installation folder and you should see the executable file named *aimcfgXXX.exe* where *XXX* is the version number. You can create a shortcut to the desktop for the *aimcfgXXX.exe* file for ease of access in the future. Double-click on this file to launch the AIMMS setup utility (Note: make sure the AIMMS has been powered up for at least 5 s before launching the program. This is the amount of time it takes for the AIMMS system software residing within the CPM to start). Immediately after the program launches, you will be presented with the small dialog box shown below confirming the baud rate at which the program will attempt to make a serial connection with the AIMMS-20.

After clicking OK, the AIMMS configuration utility will check for any system errors that might have been logged. The first dialog box shown below will then pop-up indicating that *aimcfg* is checking the Error Log. After a brief period of time (less than a few seconds), the second dialog box shown below will appear indicating the status of the log. If log events are noted, they will be downloaded to a file in the *aimcfg* installation directory.





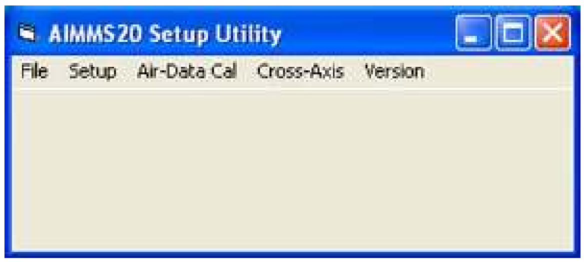
If a communications failure occurs, a dialog box will appear indicating a “timeout” condition. This error condition indicates that communications have not been established with the system. Additional action should be taken at this point to determine the cause of the communication failure:

1) Check all connections, including that you are connected to COM1 (black hood) on the serial cable.
2) Make sure the unit has power applied.
3) Check that the correct baud rate is set.

Click “OK” to continue.

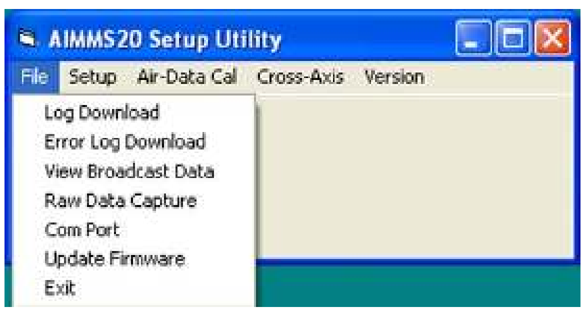
4.3 Main Program Window

Once communication has been successfully established and the error-log process complete, *aimcfg* will next display the main program window. The main window contains a number of pull-down menus that you will use to access the various features of the configuration utility.



4.4 File Menu

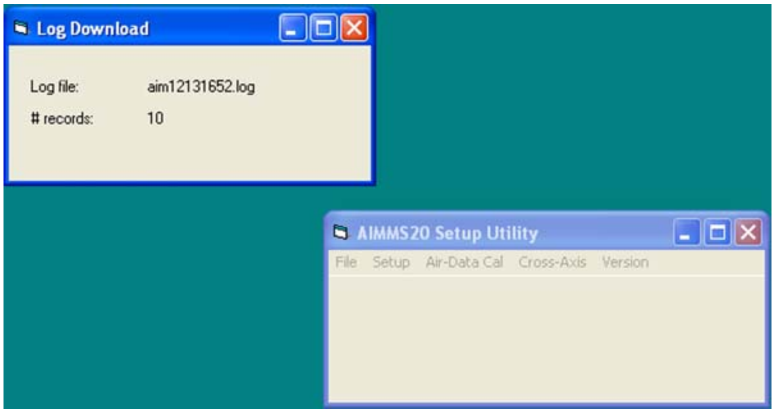
Clicking on the File menu will display a list of options you will use to perform basic functions such as downloading the internal AIMMS data log or changing the COM port assignment and baud rate of the computer. Each of the file menu items is described in Sections 4.4.1 to 4.4.6.



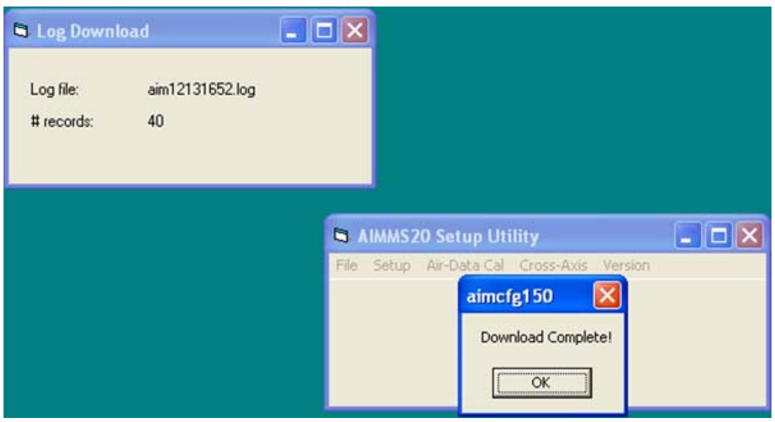
4.4.1 Log Download

Selecting Log Download will immediately start the process of transferring the contents of the internal flight data log to the hard disk of your computer.

When the Log Download menu item is selected, a dialog box appears indicating the file name used for storing the data log (generated based on date and time) and the number of records currently transferred to the data log file as shown below. The file will be located in the same directory as the *aimcfg* program installation.



Once the download has completed, a dialog box will pop up indicating "Download Complete". Press "OK" to return to the main form.



Note: The AIMMS CPM internal data log is reset when two conditions are met:

1) A GPS signal is available.
2) And the system has been powered up for more than one minute.

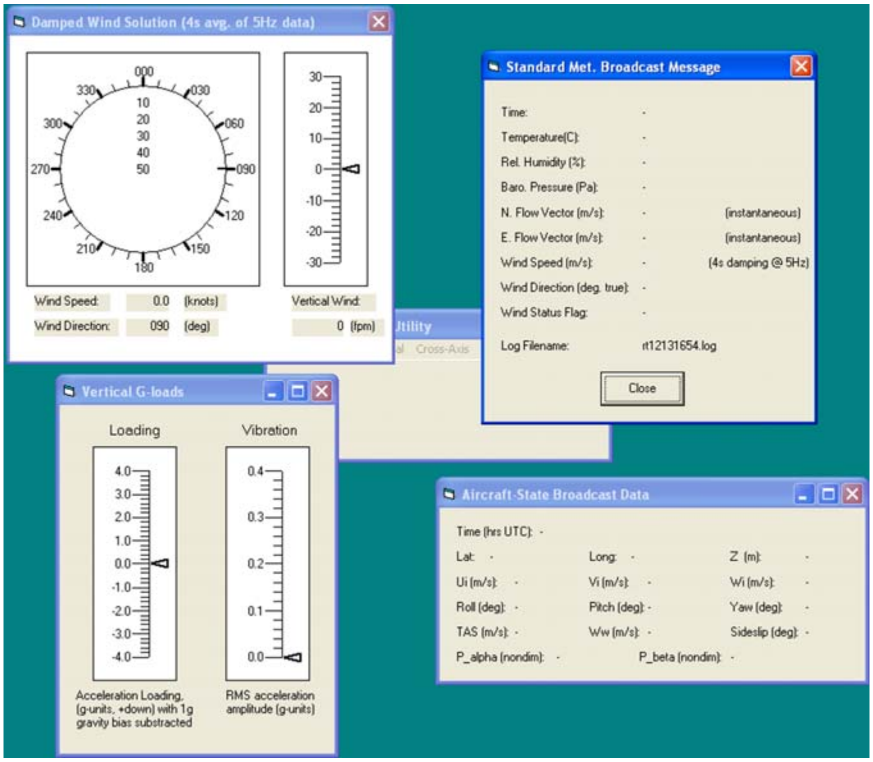
This allows the log to automatically clear itself and prepare to record a new flight without any user actions beyond turning on the system. If the user is unsuccessful on the first or subsequent download attempts, the system can be powered down and another download attempt made provided the unit is powered for no more than one minute (60 s.).

4.4.2 Error Log Download

The error-log download menu item offers an alternative way to initiate the same log transfer process that normally starts automatically when *aimcfg* is launched (see Section 4.2).

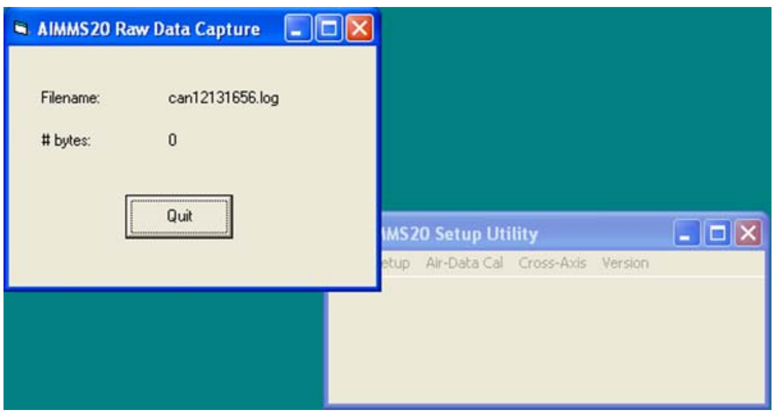
4.4.3 View Broadcast Data

Aircraft state and meteorological data is computed in real-time by the AIMMS-20 and broadcast out the COM2 port of the CPM (grey hooded DSub-9 connector on the provided serial cable. If this serial port is connected to your computer, it is possible to view this information directly in real-time as shown below, e.g. by using a laptop in-flight.



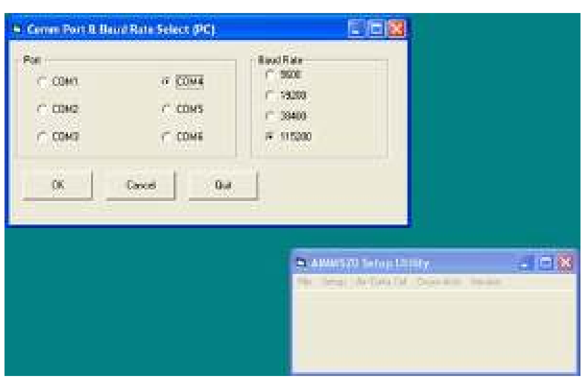
4.4.4 Raw Data Capture

Low-level system diagnostics and advanced flight-calibration data analysis are aided by the collection of "raw" data. Selecting this menu item starts the collection of all sensor information that is passed between the four modules of the AIMMS-20 system via the COM2 serial port of the CPM connected to your computer. A dialog box will be displayed showing the filename being used to record the data, and the number of bytes currently transferred. Information should accumulate at a rate of a little more than 20 MB / hour. Simply click the "Quit" button to close the file and terminate the raw-data collection process.



4.4.5 COM Port

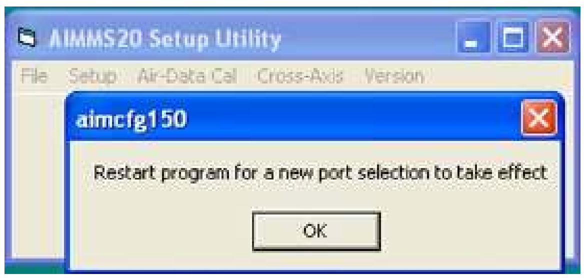
The COM port and baud rate used by your computer to communicate with the AIMMS CPM is modified using this menu item. This should not be confused with the communication settings used internally by the AIMMS-20 (see Section 4.5)



The baud rate setting utilized by different GPS navigation systems are provided below:

ADAPCO Wingman GX	19,200 baud
AGNAV Accuair / Flight Master	38,400 baud
Satloc G4	38,400 baud

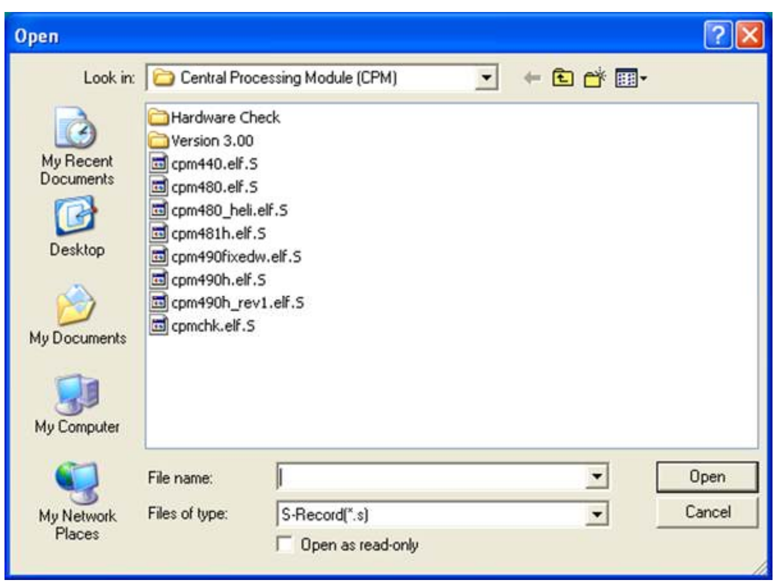
When a COM port or baud rate setting change is performed, the *aimcfg* program must be restarted for the change to take effect.



4.4.6 Update Firmware

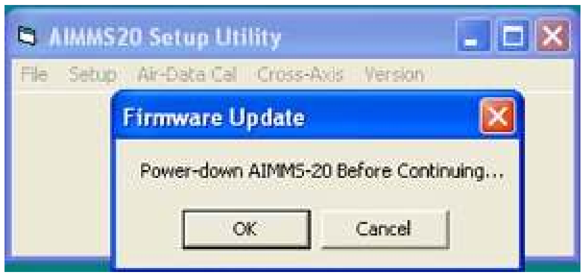
The AIMMS-20 CPM firmware is field upgradable. Updating the CPM's internal firmware is performed using the "Update Firmware" menu item and is described below. Simply follow the instructions provided by the *aimcfg* software.

Select the firmware file for the update.



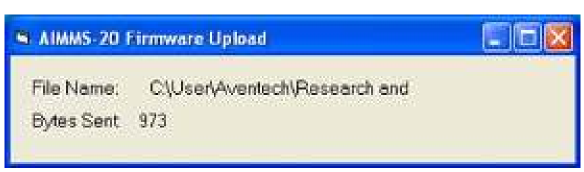
Note: The firmware update file will have the extension ".elf.S".

Once the user has selected the firmware update file using the "Open" button, a dialog box will be displayed instructing the user to insure the AIMMS-20 is powered down. Press OK once you have verified that the system is OFF.

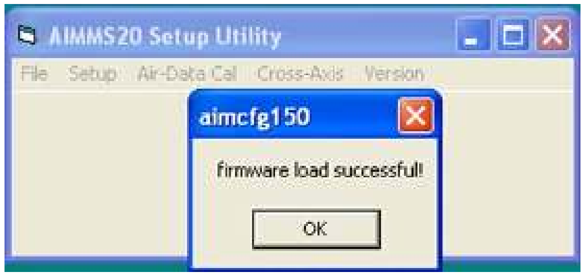


Click "OK". The *aimcfg* utility will now wait for the AIMMS to be powered-up. (Note: that it is only upon a power reset that a special message is sent from the processor that permits the firmware update process to begin).

The firmware load process should begin immediately after power has been applied to the system. The "Firmware Upload" window should continuously update the number of bytes sent to the module as shown below.



The user will be presented with a message indicating that the firmware load was successful.



The process from power reset to completion should take a few minutes.

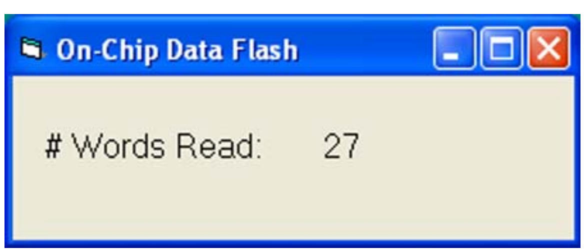
4.5 Setup

The "Setup" menu item displays a window which allows the user to enter and program general operational parameters for the AIMMS-20 system. These parameters include:

1) Internal data log status and period
2) Antenna Baseline Length
3) ADP Offset distance
4) Baud Rate
5) Data broadcast type and period
6) Local geomagnetic declination

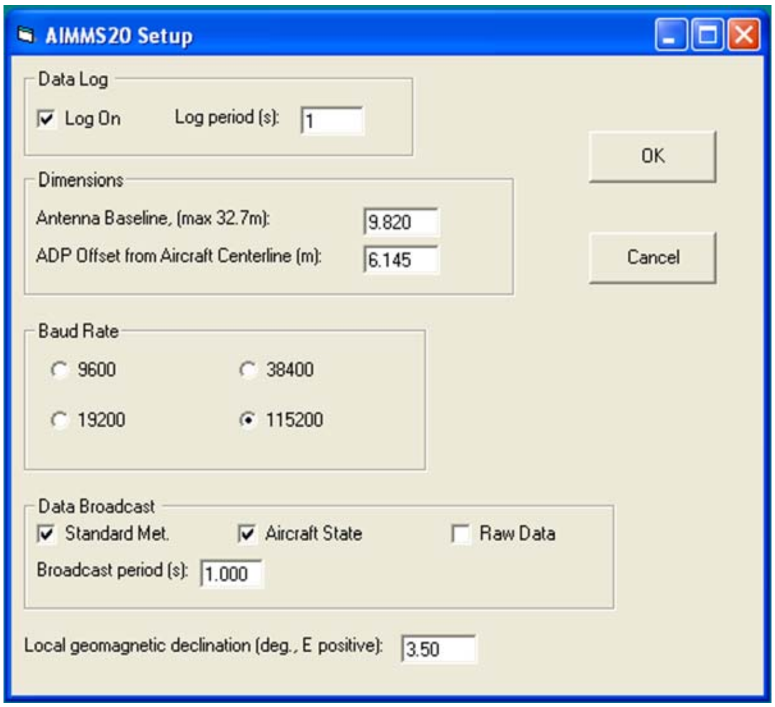
The latter item 6), the local geomagnetic declination is a legacy item and no longer required to be entered.

After selecting the "Setup" menu item, *aimcfg* will respond by loading an image of the setup data stored in the FLASH memory of the CPM. Progress of the data transfer is indicated by a pop-up window that displays the number of data words downloaded. This process should only take a few seconds to complete.



After the data is downloaded, an AIMMS-20 Setup Form is displayed showing the setup parameters currently stored in the system. When the setup information is downloaded for the first time, it will consist of factory defaults settings which were programmed into the system at time of manufacture.

This form is used to enter the length of the antenna baseline and the distance the ADP is offset from the aircraft centerline (see Section 3.2) amongst the other parameters listed at the beginning of this section. The units for distance measurements is meters [divide by 3.281 to convert distance measured in feet to meters].



Once new settings have been entered into the window, click OK to upload and program these settings into the CPM Data FLASH. The new parameters will take effect on the next power cycle of the instrumentation.

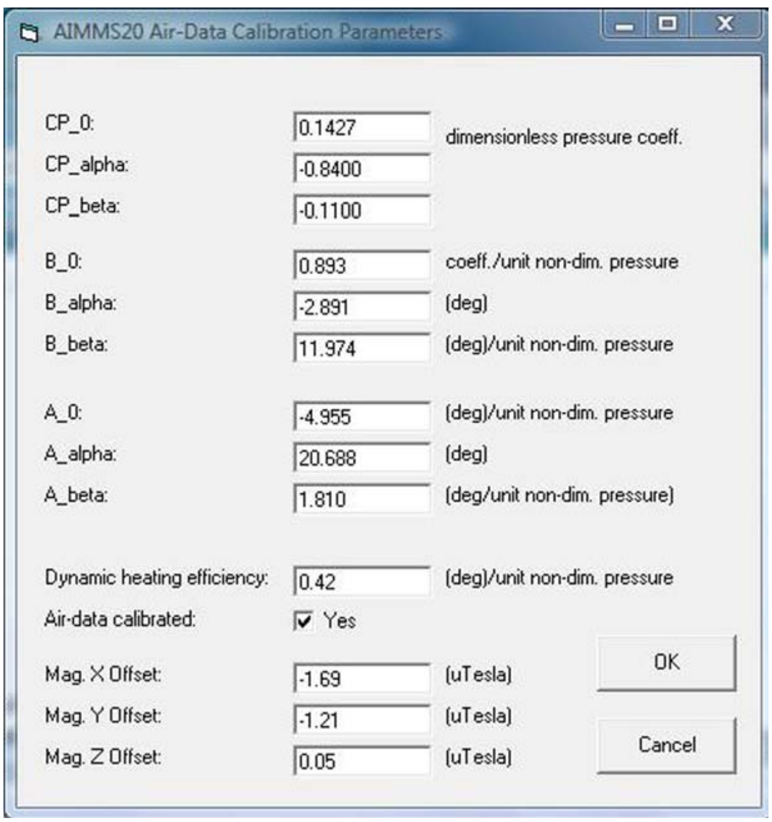
4.6 Air Data Calibration Parameters

The “Air Data Cal” menu item displays a window which allows the user to enter and program the Air Data Calibration parameters, dynamic heating efficiency and magnetic sensor offsets. The latter is a legacy item and no longer required.

Three sets of three calibration parameters are necessary to correct for the influence of the aircraft itself on air-data measurements (e.g. pitot-static pressure, angle of sideslip, and angle of attack). These parameters are obtained by analysis of flight data obtained during special calibration maneuvers (see Section 3.3) and will be provided to the end user by Aventech Research Inc.

The dynamic heating efficiency parameter should always be set to 0.42 as this is a function of the air-data probe design and not subject to change.

Although magnetic sensor data is no longer utilized by the CPM firmware, these calibration factors have been included for backwards compatibility.

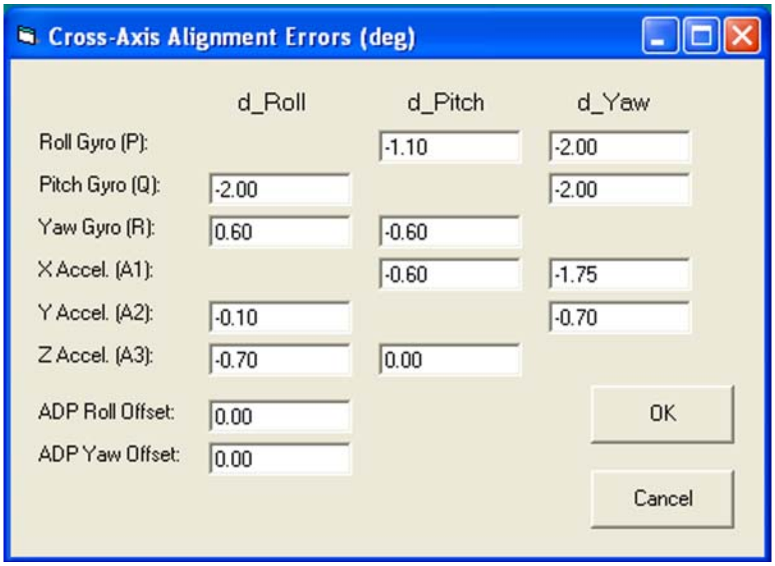


Once the new values have been entered into the window, click OK to upload and program these settings into the CPM Data FLASH. The new parameters will take effect on the next power cycle of the instrumentation.

4.7 Cross-Axis Alignment Errors

The “Cross-Axis” menu item displays a window which allows the user to enter and program the cross-axis alignment errors.

Cross-axis errors represent fine-tuning calibration factors that are used to correct measured angular rates (gyro output) and accelerations (accelerometer output) to optimize the performance of the IMU-GPS integration. These are determined upon special analysis of calibration-flight data by Aventech.



Once the new values have been entered into the window, click OK to upload and program these settings into the CPM Data FLASH. The new parameters will take effect on the next power cycle of the instrumentation.

4.8 Version

The "Version" menu item displays the version number of the aimcfg software currently installed on your computer. Click "OK" to continue.

5 TECHNICAL SPECIFICATIONS

5.1 AIR DATA PROBE (ADP)

Internal Sampling Rate 200Hz

Low-pass filter frequency range 1 – 20 Hz (3 dB corner frequency)

Data Output Rate: 1 - 20 Hz

Measurement	Range	Accuracy
Static Pressure	0-110000 Pa	100Pa + 0.05%
Pitot-Static Differential	0-14000 Pa	20 Pa + 0.05%
AOA / AOS Differential	+/- 7000 Pa	20 Pa + 0.05%
Acceleration	+/- 5g	0.005g

5.2 INERTIAL MEASUREMENT UNIT (IMU)

Internal Sampling Rate: 200 Hz
Digital Low Pass Frequency: 20 Hz (3 dB corner frequency)
Data Output Rate: 40 Hz

Measurement	Range	Accuracy
3-axis accelerations	+/- 5g	0.005g
3-axis angular rates	+/- 60 deg/s	0.03 deg/s

5.3 CENTRAL PROCESSING MODULE (CPM)

Processor: Motorola DSP56F807

Internal FLASH Memory: 16 Mbit

5.4 METEOROLOGICAL

5.4.1 Temperature

Resolution:	0.01 C
Calibrated Accuracy:	0.05 C
Including Dynamic Heating Error:	0.30 C
Time Constant (63% Step Response) :	5 sec

5.4.2 Relative Humidity

Resolution:	0.1 %RH
Accuracy	2% RH

5.4.3 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
Broadcast / Log Update Rate:	1 - 10 Hz
Log Capacity:	45000 Records (12.5 hours @ 1Hz)

5.5 ELECTRICAL

Operating Voltage:	12.5 - 37 VDC Input
Max. Operating Current:	900 mA @ 12.5 VDC
Digital Interfaces:	Controller Area Network (CAN2A) 500 kbps RS-232 Serial Ports (default 19.2 kbps)

5.6 ENVIRONMENTAL

Operating Temperature:	-20 C to 50 C (standard) -40 C to 50 C (special order)
Storage Temperature:	-40 C to 90 C

5.7 WEIGHT

Air Data Probe (ADP):	3.36 kg (7.38 lb)
Inertial Measurement Unit (IMU):	0.74 kg (1.63 lb)
GPS Module (GPS):	0.80 kg (1.76 lb)
Central Processing Module:	0.60 kg (1.32 lb)

APPENDIX A: AIMMS-20 SERIAL COMMUNICATION FORMAT

A.1 Introduction

The AIMMS-20 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.

A.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.

A.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.

A.3.1 Data Block, Standard Meteorology Packet (ID = 0)

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

Notes:

1) Wind flow vector points in the direction to which the wind is blowing.

2) Wind direction is reported in accordance with standard meteorological convention, i.e. direction wind is blowing from.

3) 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.

4) 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).

A.3.2 Data Block, Aircraft-State Data Packet (ID = 1)

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

A.3.3 Data Block, Purge Flow Packet (ID = 4)

Byte #	Description	Var. Type	Scale
5	Flow rate, mL/min – lsb	Int	1
6	Flow rate, mL/min – msb	Int	1

A.3.4 Data Block, Internal Probe Temperature Packet (ID = 5)

Byte #	Description	Var. Type	Scale
5	Heater block temp. [C], fwd – lsb	Int	10
6	Heater block temp.[C], fwd – msb	Int	10
7	Heater block temp. [C], aft – lsb	Int	10
8	Heater block temp. [C], aft – msb	Int	10
9	Low-temp. threshold [C], lsb	Int	10
10	Low-temp. threshold [C], msb	int	10

Note: Low temperature threshold setting is the temperature below which the internal probe block heaters are engaged. The high threshold, i.e. temperature above which heaters are turned off, is always set to the low threshold + 10 Celsius.

A.3.5 Data Block, CAN Message Forwarding (Raw Data) Packet (ID = 22)

Byte #	Description	Var. Type	Scale
5	Message 0, CAN 2.0A ID, low byte (bits b.7 – b.0)	Int	1
6	Message 0, CAN 2.0A ID, high byte (bits b.10 – b.8) Length of CAN msg. data segment, value 0 – 8 (bits b.14 – b.11)	Int	1
7	Message 0, CAN data byte 1	u/s short int	1
8	Message 0, CAN data byte 2	u/s short int	1
9	…	u/s short int	1
$6+m_0$	Message 0, CAN data byte m_0 ($0 <= m_0 <= 8$)	u/s short int	1
$7+m_0$	Message 1, CAN 2.0A ID, low byte (bits b.7 – b.0)	Int	1
$8 + m_0$	Message1, CAN 2.0A ID, high byte (bits b.10 – b.8) Length of CAN msg. data segment, value 0 – 8 (bits b.14 – b.11)	Int	1
	Message 1, CAN data byte 1	u/s short int	1
$8 + m_0 + m_1$	Message 1, CAN data byte m_1 ($0 <= m_1 <= 8$)	u/s short int	1
…	…	…	…
$23 +\sum_{0}^{8} m_i$	Message 9, CAN 2.0A ID, low byte (bits b.7 – b.0)	Int	1
$24 +\sum_{0}^{8} m_i$	Message9, CAN 2.0A ID, high byte (bits b.10 – b.8) Length of CAN msg. data segment, value 0 – 8 (bits b.14 – b.11)	Int	1
$25 +\sum_{0}^{8} m_i$	Message 9, CAN data byte 1	u/s short int	1
$24 +\sum_{0}^{9} m_i$	Message 9, CAN data byte m_9	u/s short int	1

A.4 Packet-Based Command Input to AIMMS-20 CPM

A.4.1 5-Hole Probe Purge Initiation

Packet ID: 28
bytes, data block 3

Byte #	Description	Var. Type	Scale
5	Purge period (ms) – lsb	Int	1
6	Purge period (ms) – msb	Int	1
7	Valve sequence #	Unsigned short	1

Valve Sequence #	Ports Affected
0	Purge off, all ports closed
1	Pitot port only for time period input
2	Sideslip port pair only for time period input
3	Angle-of-attack port pair only for time period input
4	Automatically step through port purge sequence #s 3,2,1
255	Purge on, all ports open, indefinite period (must be followed by sequence 0 for off)

Command Acknowledgement:

Packet ID: NONE
bytes, data block 0

Description: No data is sent in reply. Purge command activity is signaled by bit 1 of the status byte of the std. meteorology data packet. Air-data should be considered invalid while this bit is set.

A.4.2 Change Probe Internal Block-Heater Set-Point

Packet ID: 29
bytes, data block 2

Byte #	Description	Var. Type	Scale
5	Low-temp. threshold [C] – lsb	Int	10
6	Low-temp. threshold [C] – msb	Int	10

Command Acknowledgement:

Packet ID: NONE
bytes, data block N/A

Description: No explicit acknowledgement is sent. However, the new set-point can be readily verified by the value sent in the next broadcast of packet ID5 (Internal Probe Temperature). The high threshold, i.e. temperature above which heaters are turned off, is always set to the low threshold + 10 Celsius.