Particle Analysis and Display System (PADS) 2.5.6

Operator Manual

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2545 Central Avenue
Boulder, CO 80301-5727 USA

2545 CENTRAL AVENUE
BOULDER, COLORADO, USA 80301-5727
TEL: +1 (303) 440-5576
FAX: +1 (303) 440-1965
WWW.DROPLETMEASUREMENT.COM

Trademark Information

Risks of Installing Additional Software

Instrument computers from DMT are configured to acquire data in a reliable, robust manner. Typically, such instruments are either not connected to a network or are connected to a small, local network that is isolated from the internet, reducing the risk of viruses. Since anti-virus programs can cause erratic behavior when run in the background on data acquisition computers, DMT does not install anti-virus, anti-spam, or anti-malware programs. If you choose to install these programs, you accept the risk associated with them in terms of potential performance degradation of the software installed by DMT.

For similar reasons, DMT recommends that you do not install or run other software on the dedicated instrument computer. Although the installation of some software may be unavoidable, it is particularly important not to run other software while the computer is acquiring data.

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1.0 Introduction

The Particle Analysis and Display System (PADS) is a software package that interfaces with all the instruments produced by Droplet Measurement Technologies (DMT) and other leading instruments used in the atmospheric sciences. The program is designed using LabVIEW, which facilitates instrument connectivity while providing powerful graphical displays. For more detailed information about PADS architecture, see *Appendix D: PADS System Architecture*.

PADS uses a tab-based structure to display information about individual instruments and the overall program. The system will sample real-time information from the instruments and record the data to files. During playback mode, it will also read and display data from previously created files. The output data files are in comma-delimited format, so that data can be imported into spreadsheet programs for additional analysis. The program is configurable to use any combination of instruments and has the ability to sample at speeds up to 10 Hz.

The figures below show typical PADS displays. Figure 1 is for a system with only the Cloud Imaging Probe (CIP) shown during acquisition mode. Figure 2 shows a system with multiple instruments in playback mode.

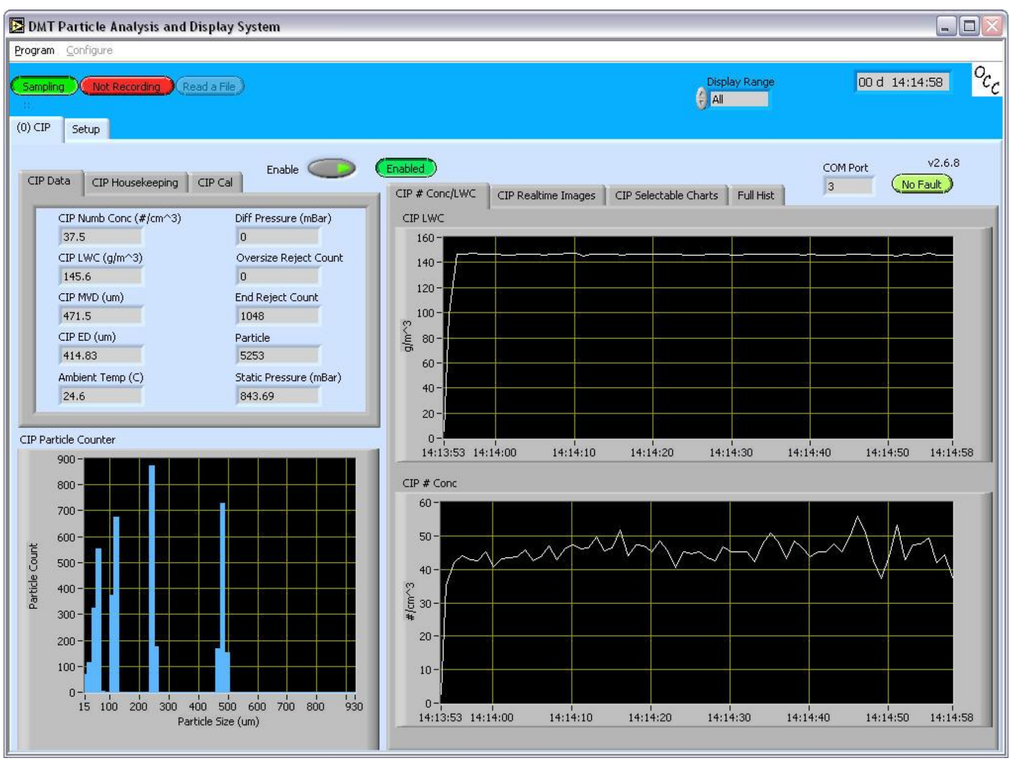

Figure 1: PADS Display Window during Acquisition Mode

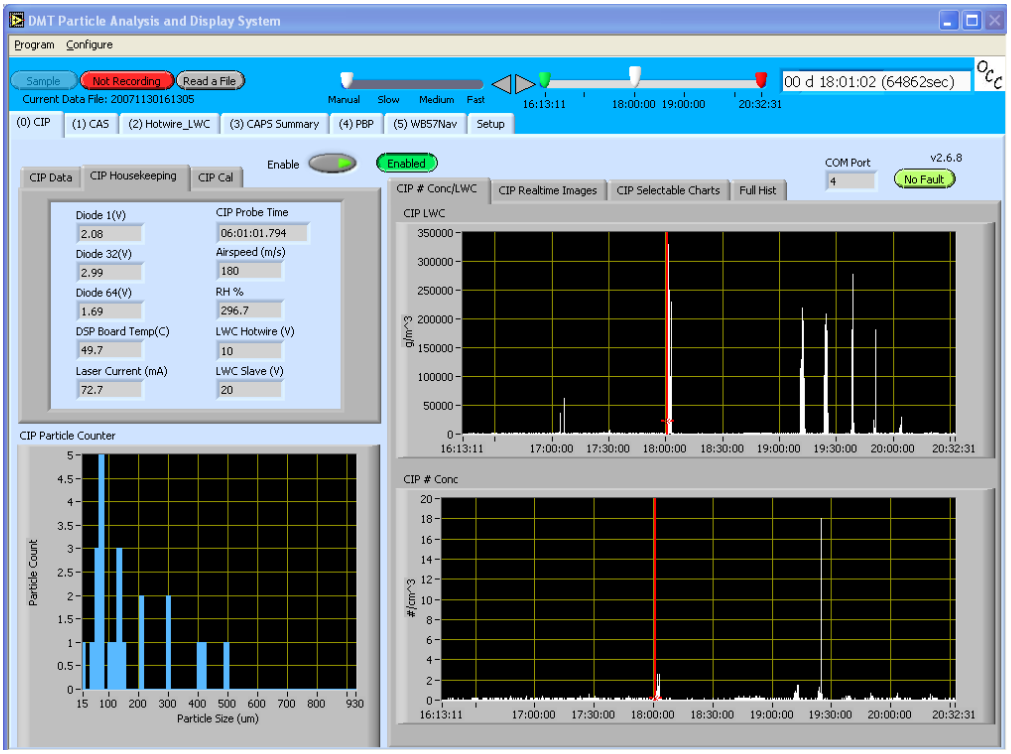

Figure 2: PADS Display Window during Playback Mode

Instruments Supported by PADS

PADS supports the following instruments and summary modules:

- AIMMS-20
- Air Data Probe (ADP)
- Anemometer with NI A2D Converter
- Cloud and Aerosol Spectrometer (CAS)
- Cloud and Aerosol Spectrometer with Particle by Particle (CAS-POL-PBP)
- Cloud Combination Probe (CCP)
- Cloud Condensation Nuclei Counter (CCN)
- Cloud Droplet Probe (CDP)
- Cloud Droplet Probe with Particle by Particle (CDP-PBP)
- Cloud Instrument Probe (CIP)
- Cloud Instrument Probe Grayscale (CIP GS)
- Cloud, Aerosol, and Precipitation Spectrometer (CAPS)
- Dewpoint
- Fog Monitor (FM-100)

- Fog Monitor Extinction Module
- Garmin GPS
- General Summary
- Hot-Wire Liquid Water Sensor (Hotwire LWC)
- Meteorological Particle Spectrometer (MPS)
- PCASP-100X / SPP-200
- PCASP-X2
- Precipitation Imaging Probe (PIP)
- SPP-100
- Telemetry

Advantages of PADS over the Particle Analysis and Collection Software (PACS) System

PADS offers many advantages over PACS, which was DMT's original particle-analysis system. These include the following:

- PACS only covers older instruments. In contrast, PADS covers recently released ones such as the Cloud Instrument Probe Grayscale (CIP GS), the Cloud Droplet Probe with Particle by Particle (CDP PBP), and the Cloud Aerosol Spectrometer Polarization Option with Particle by Particle (CAS POL PBP).
- Unlike PACS, PADS is currently supported by DMT. This means that if you encounter problems with the program, you can get help from our software engineers.
- PACS is an older system that is no longer being developed. PADS is constantly being improved and expanded to facilitate data collection and analysis.

2.0 Setting up PADS

The PADS software is preconfigured at DMT for a given suite of instruments. You can disable the instruments using the PADS user interface, but you cannot add instruments without DMT reconfiguring your software.

Hardware Requirements

PADS must be run on a Windows XP operating system. To use the program, you must also be authorized as an Administrator on your computer. You do not need to be authorized as an Administrator on the network.

If you are running PADS in data acquisition mode, the program also requires a USB key that DMT will supply you. In addition, data acquisition requires DMT-supplied hardware that interfaces your computer with your instruments. These include communication port cards and image port cards.

Note that you do not need the USB key to use PADS in playback mode with previously acquired data.

Software Requirements

To run PADS, you will need PADS software. This should either be pre-installed on your computer or arrive on a DMT-supplied disk. PADS also requires the National Instruments Run-time Engine deployment software for operation, which is provided on the same disk.

The same program configuration is used for both data acquisition and data playback. The use of the playback program is not restricted; you can install it on multiple computers without limitations. You can enable acquisition on another computer simply by moving the USB key to that computer. This is especially useful for bench testing and servicing of instruments. You can have a second computer off the aircraft that also has the necessary interface boards, which you can use for probe service or calibration by moving the USB key to this computer.

You should set your screen resolution to 1024 x 780 for the PADS display to fill the screen. If you do not want to fill the screen with the PADS display, you can use 1280 x 1024 resolution. During data acquisition, screen savers should be turned off, and the power monitor settings **Turn off monitor**, **Turn off hard disks** and **System Standby** should be set to “Never.”

Installation

When installing the USB Key or the data and image port cards, you should first install any necessary software. Then when you plug your cards into the motherboard, the computer will recognize them.

Installing the USB Hardware Key

In many cases, DMT will have installed your hardware key for you. However, if you are running PADS on a new computer, you may have to install the hardware key yourself. To do this, you will need to run the *KeyLock Install.exe* program from the PADS installation CD. The program must be run before installing the USB key.

Installing Image and Serial Cards

In most cases, DMT will have already installed the necessary image and serial cards on your computer, along with the PADS software. In some instances, however, you may want to install cards yourself. To do this, follow the steps listed in *Appendix C: Installation Instructions for DMT-Supplied Drivers and Computer Cards*.

Installing PADS Software from the DMT-Supplied CD

To install PADS itself, navigate to the Setup Installer on your CD. Double-click on this file and accept all license agreements. When the software has finished installing, copy any folders with instrument names into the `C:/Program Files/PADS` directory. Also copy any relevant configuration files and threshold tables.

Note that if you have installed anti-virus software, web browsers, or other software programs on the computer, you should avoid running these while PADS is acquiring data. Doing so can compromise data acquisition.

Macro-Level File Structure and Locations

The program's input and output macro-level file structures (i.e., where input and output files are located) are designed to make PADS easy to use. On the input end, files are arranged so that DMT can easily modify your system if you wish to change your instruments or configuration. On the output end, the system creates data directories in a structure that allows for easy data retrieval and troubleshooting. While you can modify these file structures to a certain extent by specifying an alternative output destination, it is recommended that you keep them as they are unless you have a specific reason to do otherwise.

Input File Structure

PADS uses a variety of input files to run. These are located in the C:/Program Files/PADS directory. They typically include the following:

a. A directory for each instrument being used for sampling
b. A threshold tables directory
c. A Config to Load file, "`Config to Load.ini`"
d. A Configuration file, "`[Customer].ini`," where [Customer] is the client name; this file gets copied to the output directory under the name `PADS.ini`

The executable file, `PADS.exe`, is also located in the `C:/Program Files/PADS directory`.

Note that you should not modify the file `PADS.ini` in this directory, and do not save your configuration under this name, as it is reserved by the program.

A diagram of the PADS input file structure appears in Figure 3.

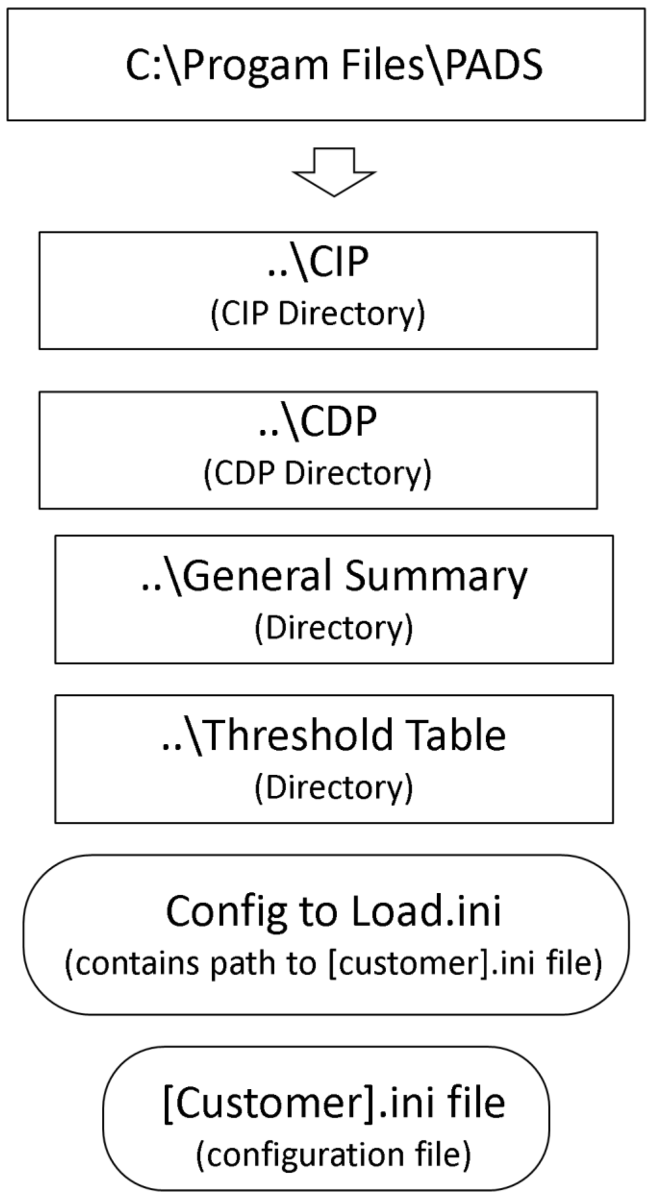

Figure 3: Macro-Level File Structure--Input Files and Directories

Output File Structure

PADS creates several different types of output files. Every time you click the "Recording" button, a new session will start; each session generates a log, output files for each instrument, and a copy of the configuration files the program has used to run. In addition to these session-specific output files, PADS generates a daily log for each day the program has been run. Unless you specify otherwise, PADS creates these output files in subdirectories of `C:\PADS Data`.

The first time that PADS is run on any given day, it will create a subdirectory within the PADS data directory. This subdirectory will be named after the current date in yyyymmdd format. Within this subdirectory, the program then creates additional subdirectories for each individual PADS session. These session directories are named to reflect both the date and the exact time that PADS was run; their names are in yyyymmddHHMMSS format. This time stamp marks the time when PADS started acquiring data, not the time when the program began recording data.

Within the directory for the day, there is a date-stamped log file showing the actions of the day. Additionally there is a file `PADS.ini` that contains the configuration information of the system when PADS was most recently started.

Within the directory for each session, the program will create a variety of output files. It will create a log file in plain text format and a PADS.ini file containing the configuration information when the system was run. It will also create output files for each instrument that collected data. These data files are named in the following way:

```
01CAS20060208154734test.csv
```

Where 01 is the instrument number, CAS is the instrument type, 20060208154734 is the time stamp, and "test" is the file suffix specified on the Setup screen. The files are comma-delimited and will open with Excel or any other spreadsheet program. They contain configuration parameters, which appear at the top of the file, and channel data, which appear below the configuration parameters. (Note that "parameters" in this document refer to PADS inputs, while "channels" refer to data outputs from the probe. Each probe has a set number of channels it tracks during each sampling instance.) See Figure 6 for an example output file.

Note that DMT strongly recommends you save your output files under a new name before opening them in Excel or any other program. Original output files should be kept archived in their original output data directories. This simplifies reading files during Playback mode and facilitates troubleshooting.

Figure 4 shows the file structure that results when PADS has been run under the following conditions:

- The first sampling session occurred at 9:12:02 a.m. on Oct. 23, 2008
- The second sampling session occurred at 10:15:17 a.m. on Oct. 23, 2008
- PADS sampled from two instruments, the CIP and CDP, during both sessions
- The user specified "test" as a file name suffix during the first session, and did not provide a suffix during the second session

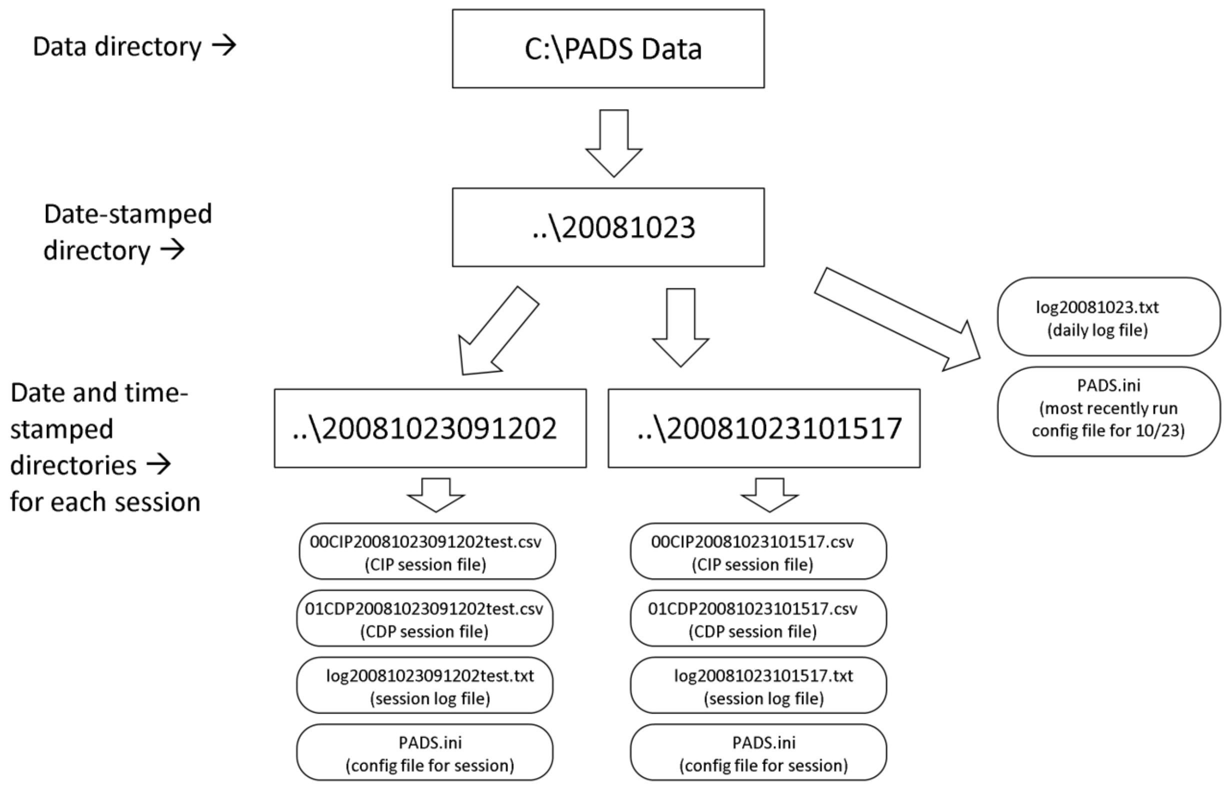

Figure 4: Macro-Level File Structure--Output Files

Micro-level File Structure and Locations

The internal file structure of PADS configuration and data files are discussed below.

Configuration Files

Configuration files tell PADS how to run—what instruments will be used during sampling, the default settings for these instruments, the default settings for PADS displays, and so on. An example configuration file for the CIP instrument is given below. On the right are explanations of what the different lines in the configuration file do.

[Main]	
Config Desc=""	Description of configuration (See "Setup")
Data Path=/C/PADS Data	Output data path (See "Setup")
File Suffix=""	Suffix appended to output files (See "Setup")
Acquire at Startup=FALSE	If TRUE, PADS samples instruments upon startup
Write at Startup=FALSE	If TRUE, PADS records data upon startup
Instr 0=CIP	
Display 0=CIP	Instrument assignations
Display Instr 0=0	
Sec to Buffer=3600	Specifies how far back PADS will remember data
Manual AS?=FALSE	in acquisition mode—see *Note 1 below*
Air Speed Value=25.000000	
Manual Temp?=FALSE	
Temp Value=25.000000	Default sources for common PADS parameters
Manual Press?=FALSE	(See "Setup")
Press Value=840.00000	
Manual Hotwire?=FALSE	
Hotwire Value=2.000000	
Display Range=0	*See Note 2 below*
Timed?=FALSE	If TRUE, PADS only samples for timed interval
Rec Time=0.000000	Length of timed interval (if applicable)
[Instrument 0]	Beginning of instrument-specific config settings
Instrument Type=CIP	
Cycle Time=1000	Instrument sampling interval in milliseconds
Enabled=TRUE	(e.g., here instrument will sample every second)
Port=1	
Baud Rate=57600	
Minimum Slice Count=0	
DOF Reject=FALSE	
N Value=1	
Divisor Flag=0	
End Diode Rej=TRUE	
Use Part. Width=TRUE	
TAS Source=TRUE	
Image Card #=0	
Use as Master TAS=TRUE	Default settings for instrument (See instrument
Arm Width=100	manual)
Probe Res=25	
Use as Master Ambient=TRUE	
Use as Master Press=TRUE	
Use as Master Hotwire=TRUE	
Static Slope=206.880005	
Static Yint=0.000000	
Dynamic Slope=68.900002	
Dynamic Yint=0.000000	
Temp Sensor=1.000000	
RH Slope=0.07876	
RH Offset=-25.806	

```
[Display 0]
Display Type=CIP
Cycle Time=1000
Chart 1=66
Chart 2=67
```

Settings for CIP Display in PADS

Channels used in selectable charts; *See Note 3*

Figure 5: Sample Config File

Note 1: **Sec to Buffer** is typically set to 3600, or one hour. See *Appendix D: PADS System Architecture* for more details.

Note 2: **Display Range** tells PADS how far back to display data during acquisition mode. (During playback mode, you can use the time-range controls to instruct the program how far back to display data.) The display range is constrained by the **Seconds to Buffer** parameter, which tells the program how far back to accumulate data in memory. So if **Seconds to Buffer** is 3600, meaning the program will commit the last hour's worth of data to memory, the maximum actual display range is also an hour, even if the **Display Range** parameter corresponds to four hours.

Display ranges in the config file are codes rather than actual times. Thus a display range of 0 does not mean PADS will not display any data; in fact, the code "0" tells PADS to display all the data that has been accumulated in memory. Display Range codes and their corresponding display range times are listed below.

Display Range Code	Actual Display Range
0	All data in memory
1	4 hours
2	2 hours
3	1 hour
4	30 minutes
5	10 minutes
6	5 minutes
7	2 minutes
8	1 minute

Table 1: Display Range Codes in Config File

Note 3: These parameters tell PADS which channels the instrument's selectable charts will display as defaults. For a complete list of instrument channels, see *Appendix A* in the instrument's PADS module.

PADS Data Files

Each instrument will generate its own data file in PADS. These data files are typically divided into two parts. The top section contains configuration information for that instrument, similar to what you will find in the configuration file. The bottom section contains the actual data that were collected. Files are in comma-delimited format. An example file generated by a CIP is shown below. In this case, the file has been pulled up in Excel, and in reality it extends far to the right of the page.

	A	B	C	D	E	F	G	H
1	[Instrument 0]							
2	Instrument Type=CIP							
3	Cycle Time=1000							
4	Enabled=TRUE							
5	Port=4							
6	Baud Rate=57600							
7	Minimum Slice Count=0							
8	DOF Reject=FALSE							
9	N Value=1							
10	Divisor Flag=0							
11	End Diode Rej=TRUE							
12	Use Part. Width=TRUE							
13	TAS Source=TRUE							
14	Image Card #=0							
15	Use as Master TAS=TRUE							
16	Arm Width=100							
17	Probe Res=2							
18	Use as Master Ambient=TRUE							
19	Use as Master Press=TRUE							
20	Use as Master Hotwire=TRUE							
21	MVD Calc=1							
22	Static Slope=206.880005							
23	Static Yint=0.000000							
24	Dynamic Slope=68.959999							
25	Dynamic Yint=0.000000							
26	Temp Sensor=1.000000							
27								
28	Notes:							
29	****							
30	Time	Over_rej_count	Bin_1	Bin_2	...Bin_62	DOF_rej_counts	End_rej_counts	Diode_1_Volts
31	31480.25	1	0	0	0	0	9	1.89
32	31480.63	3	2	0	0	0	9	1.88
33	31481.63	0	6	1	0	0	9	1.87
34	31482.63	0	4	1	0	0	7	1.89
35	31483.63	0	0	0	0	0	11	1.88
36	31484.64	1	0	1	0	0	12	1.9
37	31485.64	1	0	0	0	0	12	1.89

CIP Configuration Settings

Data gathered by CIP

Time (in seconds after midnight)

More data channels

Figure 6: Sample Output File

3.0 Operations

PADS Program Overview

When you start PADS, you will see a window similar to Figure 7. (The light blue tabs on your screen may look different, since your software will come configured for your specific set of instruments.) The PADS window consists of a menu bar on top, sample and recording buttons, and a window showing instrument tabs and the Setup tab. In acquisition mode, the PADS window shows a Display Range control. In playback mode, it shows time-range controls.

The number in parentheses on a tab corresponds to a unique instrument, so if there are two instruments of the same type you can distinguish them by their number. The Setup tab on the far right allows you to set system options.

You can configure the parameters for displays and instruments to suit your needs.

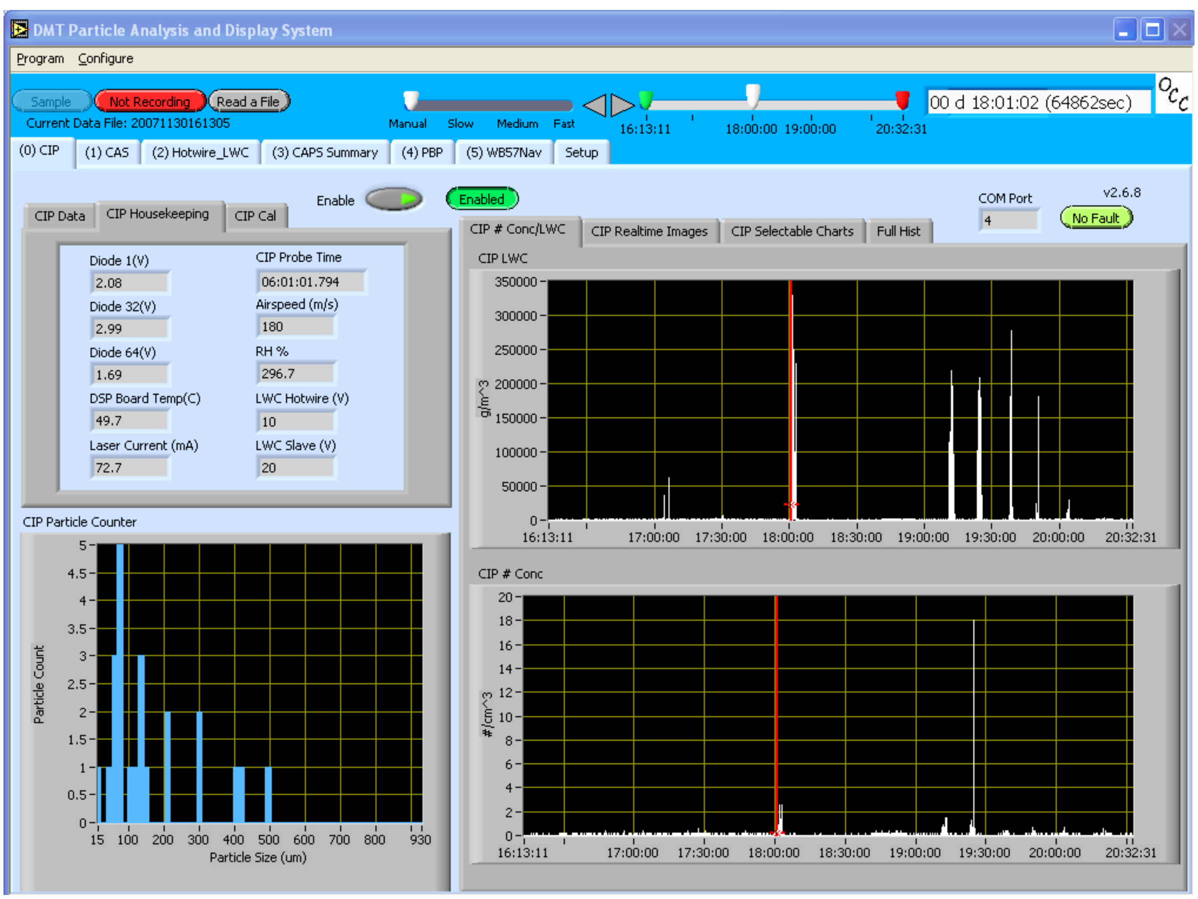

Figure 7: PADS Window

Menu Items

The menu bar at the top of the window controls the basic program functions. PADS gives you two menus, the **Program** menu and the **Configure** menu.

The **Program** menu at the top of the tool bar gives you three choices: **Print Screen, Save Screen to JPEG,** or **Exit**. The **Print Screen** sends your display data to the computer's default printer. This function is active only in the **Read a File** mode. **Save Screen to JPEG** will save an image of the screen in the current data directory. This file will be called PADSx.jpg, where x is an incremental number based on the number of images saved. The **Exit** button lets you quit the program. ***NOTE*****:** You can only stop the program by selecting **Exit**; you cannot quit by clicking the upper right of the window. **Exit** ensures proper instrument shutdown and safety when in a flight environment.

The **Configure** menu allows you to load previous instrument configurations (**Load Configuration**) or to save modified configurations (**Save Configuration**). The **Configure Instrument** and **Configure Display** menu options are instrument-specific. You can only use these menu options when a specific instrument tab is active. Once the **Configure** menu has been invoked, a green **Reset Program** button will appear on the control toolbar, and you must reset the program for the configuration changes to become active.

Buttons

The buttons just below the menu bar control the PADS recording and playback functions. The **Sample** button activates the program for instrument polling and data display. The button to the right is the **Recording** button. When it is red and set to **Not Recording**, clicking it will cause it to turn green and indicate data are being stored in a file. Although you will see data displayed when only the **Sample** button is on, these data will not be recorded unless the **Recording** button is also set to Recording**.**

If you turn the **Sample** button off, both sampling and recording will stop. If you turn **Recording** off, only recording will stop. If sampling is off the **Read a File** button will become active. You can then click on this button to read from an archived data file.

Note*:* Each recording session generates multiple data files. This is because each instrument generates its own data file. The files from any one recording session are all stored in the same directory, which is in turn stored in the **Current Data Directory** (see "Macro-level File Structure" for details). When you use **Read a File** to select a data file associated with an individual instrument, PADS automatically loads all of the data files from this recording session.

The green **Reset Program** button, depicted in Figure 8, appears when you have reconfigured a display or an instrument. You must press this button before changes will take effect.

Figure 8: The Reset Program Button

Note that pressing the **Reset Program** button will clear any data currently being displayed. PADS will then reload the current configuration file.

In Playback mode, PADS displays the current data file beneath the menu buttons, as shown above. This is the data directory that contains all the data files currently displayed.

Display Range Control (appears only during Acquisition)

In acquisition mode, a **Display Range** indicator and button appear to the right of the "Read a File" button. By clicking on the button, you can indicate the time interval for which you would like data displayed. For instance, if you select "10 minutes," at 9:10 a.m. you will see the data collected between 9:00 and 9:10 a.m., while at 9:15 a.m. you will see the data sampled between 9:05 and 9:15.

Note that the actual amount of data displayed will be limited to the lesser of the Display Range control, the Sec to Buffer parameter, and the amount of data actually available.

Time-Range Controls (appear only during Playback)

To the right of the "Read a File" button are the **Time-Range** controls. You will not see these when data are being acquired, but you will see them when you read a data file. The time-range controls are shown in Figure 9.

Figure 9: Time-Range Controls

The control on the left can be used advance the current time automatically. If this control is set to "Manual," the current time can be changed manually by using the arrows to the right.

In the middle is the **Time-Range Bar**, which has three controls—green, red, and white. You may not see the green control if the white control is covering it.

The green control indicates the start time of the data displayed in the time-series graphs, whereas the red shows the end. The white control shows the current time. Data specific to this time appear in the channel tabs and histograms.

On the time-series graphs, the current time is indicated by a red cursor through the graph (see below). The red “x” on the cursor marks the value on the y-axis for the current moment in time. Note that the chart data are compressed, so the graph may not display data values for all sampling instances. To see all the data, zoom in on the display.

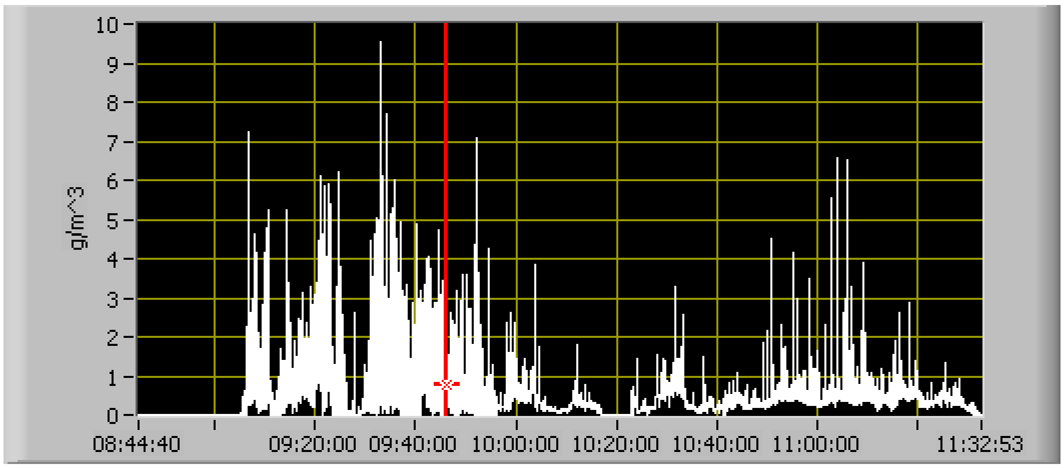

Figure 10: Time-Series Graph

You can move the white control around to view the data at different time points. When you set the time using the white control, you will see the exact time you've selected in the white box on the far right.

To zoom in on the data, move the green and red controls close to the white control, which will narrow the range of displayed data. To zoom out, move the two colored controls away from the white control.

The two arrows on the left of the time-range bar let you change the time position by one sample time. The control to the left of the arrows will set the PADS into automatic playback, which will advance time in various speeds (slow, medium, and fast).

The window on the right displays the current time in both *hours:minutes:seconds* format and in seconds after midnight on the day the program was started. This way of calculating seconds after midnight means that the values do not get reset to zero when a new day starts. For instance, if you start PADS at 11:59:59 p.m. on one day and stop the program at 12:00:01 a.m. the next, the seconds-after-midnight values are 86,399, 86,400, and 86,401 respectively. The seconds-after-midnight value appears in parentheses.

Setup Tab

Beneath the buttons and time-range controls are a series of tabs. The tab on the right is the setup tab, which allows you to control the global parameters of the system. These parameters include the following:

- The PADS configuration the system is running
- The directory where output data files are stored
- The sources that are being used for certain key parameters
- A log of recent program activity

Note that while you can change many of these parameters on the Setup window, the changes will not be saved under the current configuration unless you select **Save Configuration** from the Configuration menu.

The setup parameters are discussed in more detail in the following section. Below is a picture of the Setup window.

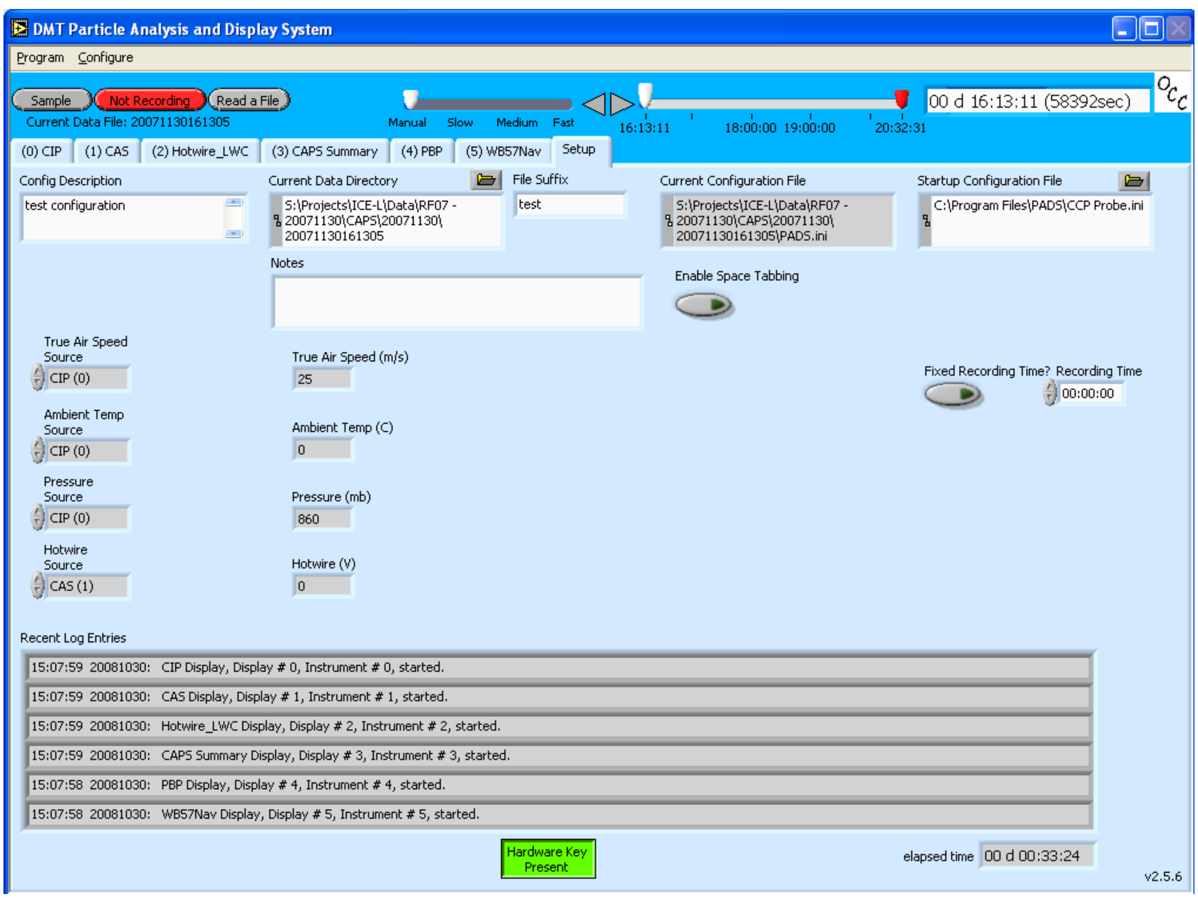

Figure 11: PADS Setup Window

Configuration files

When you run PADS, the program knows what instrument windows and other information to display based on a configuration file. The location of this file is displayed in the Setup window's **Current Configuration File** control. If the file has a description associated with it, this is listed in the **Configuration Description** control. You can specify a description by typing it into this control. The default configuration file that PADS uses on start-up is listed in the **Startup Configuration** control to the right.

Changing Configurations

If you want to change the configuration file for the rest of the session, use the "Load Configuration" option from the Configure menu up top. If you want to change the configuration file that is used as the default on start-up, do so from the Setup window. You can either specify a new file path in the control or browse files by clicking on the folder icon.

Data Output

The **Current Data Directory** lists the directory that all output files are sent to. The root directory for data files is normally `C:\PADS Data`. Within this directory is a subdirectory, which is labeled with a date-stamp in YYYYMMDD format. The Current Data Directory control specifies the entire path of this subdirectory (e.g., `C:\PADS Data\20081023`). You can change the current data directory either by typing a new path or by clicking the folder icon and navigating to the desired location. Using a directory with the date-stamp in its name is recommended. Each data-recording session will generate a separate subdirectory with data output files in it; see the "Macro-level File Structure" section for more detail.

The **File Suffix** control lets you specify a suffix you'd like included in each file name. For instance, if you're running an initial test of the system, you can select "test" as your suffix. Each data file that PADS generates will then have "test" appended to its name.

Other Setup Features

The **Notes** section allows you to enter comments about the session. You should enter them before you begin recording data. They will be saved in the comma-delimited data file that each instrument generates. These notes do not appear in PADS during playback mode, however.

The **Enable Space Tabbing** button allows you to use the space bar to toggle between the different PADS tabs. This can be convenient for situations where you do not want to use the mouse. *Warning:* If space-tabbing is enabled and you use the space bar for another purpose, such to type notes, you will toggle to another tab.

On the left side of the Setup window, you will see controls used to set the source for common variables. These controls are important in cases where more than one instrument may be supplying parameters like pressure, ambient temperature, true air speed, and hotwire LWC. The controls in the Setup window let you choose which instrument's measurements the system will use by clicking on the button to the left. You can also fix these parameters manually by selecting “Manual” and then typing in the appropriate value. This may be useful, for example, when doing ground-based testing with a spinning disk, for which the measured TAS would be zero. A manual value of 25 m/sec will enable accurate acquisition of particle images.

The **Recent Log Entries** listing will display the six most recent actions the system has performed. Log entries include things like starting and stopping the program, enabling the probes, and errors that may occur when communicating with the probe.

Log entries are listed in reverse chronological order, with the most recent items at the top. A complete log of system activity is recorded to the log file.

The **Fixed Recording Time** allows you to specify a length of time the recording will take place once the **Record** button is pushed. Once this time has been exceeded, recording will automatically stop and the Record button will indicate **Not Recording.**

The **Hardware Key Present** indicator at the bottom of the window indicates whether the USB hardware key is present. If the key is missing, this indicator turns brown, and you will get a message that data acquisition will not proceed. You will still be able to operate PADS in the playback mode, however.

The **Elapsed Time** indicator displays the time that has elapsed since the PADS session began.

Instrument Tabs

Most instruments will have their own tabs. Clicking on the tab will let you see the data being measured by that instrument.

The typical instrument display will have the graphical layout as shown in Figure 12. (Some instruments and summary displays differ considerably from the example instrument tab below, and the following explanations may not apply.) In the upper left of the display, you can see the tabular data for the instrument channels. In the lower left, you find the histogram data. The right half of the display are time traces of the data.

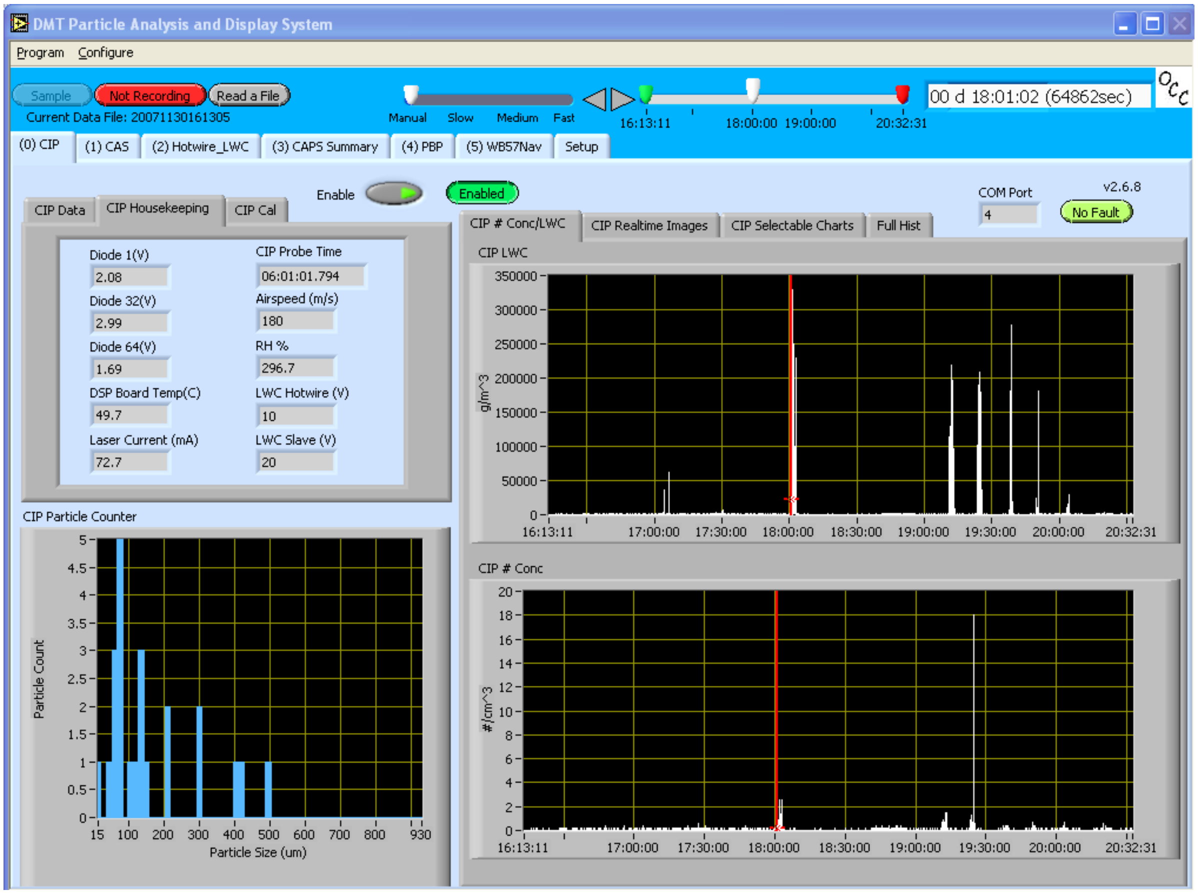

Figure 12: Typical Instrument Display

Time-series charts consist of both standard and selectable charts. You can move among the different charts by clicking on the tabs above them.

Standard charts plot the number and volume (or mass) concentration over time. Selectable charts allow you to display any channel the instrument measures over time. Left click on the controls above the charts to display a list of the available channels. You can also use the buttons on the left of the control to step up and down the channel list.

Instrument windows will generally have an **Enable** button and an **Enable Status** indicator that shows whether the instrument is currently enabled. When the Enable button is on and the indicator shows "Enabled," PADS will acquire data from that instrument whenever the **Acquire** button is pressed. Clicking the enable button when it is on will disable the instrument.

Many instrument windows will also have a **COM Port** Indicator, which displays the communications port on the computer's motherboard that the instrument is hooked up to.

Instrument windows also typically have a **Fault/No Fault** indicator. If this indicator displays “Fault,” there is a communication problem with the instrument that must be addressed before data can be acquired properly.

For more information on the specific instrument tabs, see the appropriate PADS modules for those instruments.

Data Acquisition: Taking Data for the First Time

The steps below will take you through acquiring data with PADS for the first time. Before beginning, make sure your software is properly installed and PADS is detecting your hardware key. You can check for the presence of the hardware key by going to the “Setup” tab and making sure the indicator at the bottom of the window says **Hardware Key Present**. For more details, consult *Appendix E: Troubleshooting*.

NOTE: If your configuration file is set to sample or record data upon start-up, you may not need to do steps 6 and 7 below. When you first open PADS, you may also get error messages if the instruments are not communicating properly with the program. In this case press **Sampling** to turn it to **Not Sampling**, fix the communications with the instruments, and then resume data acquisition by pressing **Not Sampling** so that it again says **Sampling**.

1) Open PADS.

2) You should see the instruments you want to use in the tabs across the top of the window. Each instrument will have its own tab, as in Figure 13. If you do not see all the instruments you want, or you see ones you do not want, you may be loading the wrong configuration file.

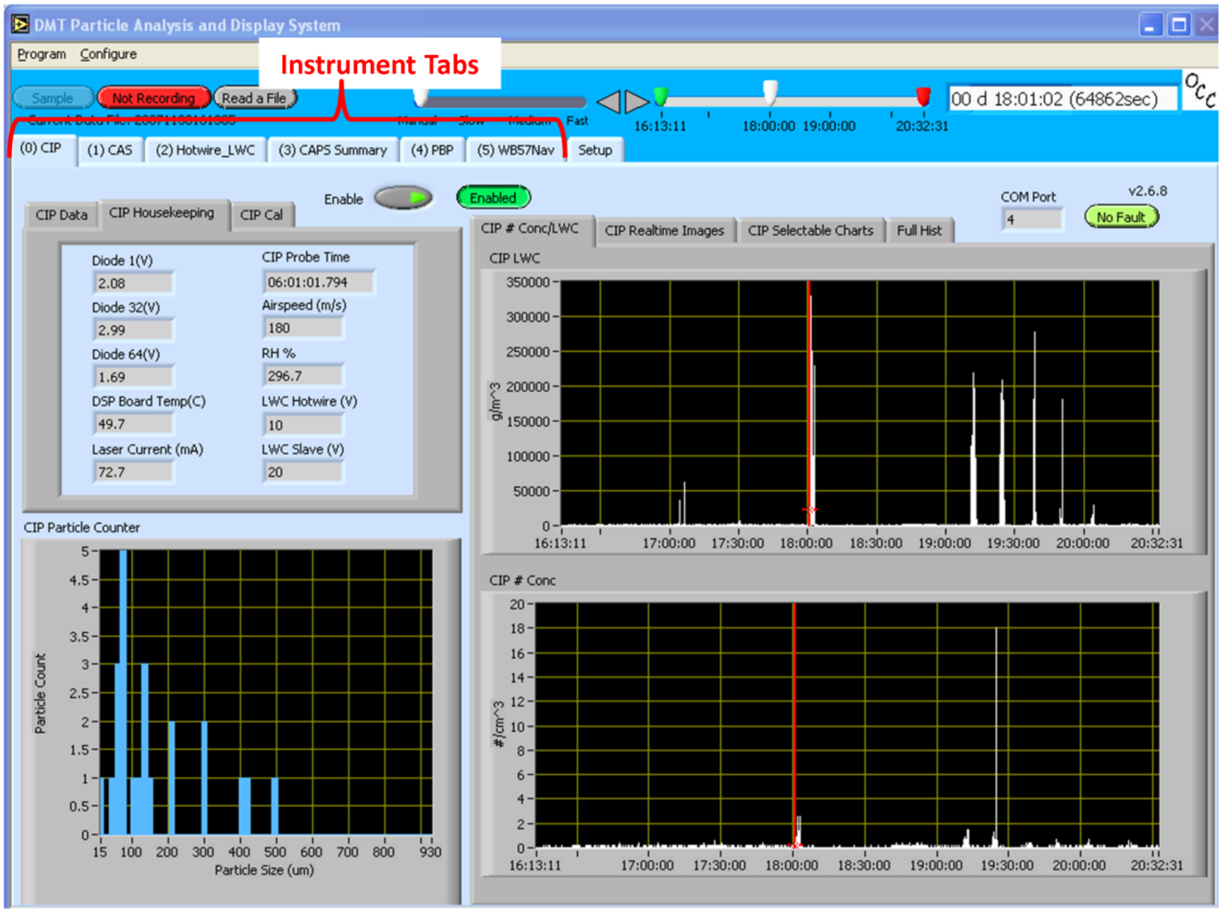

Figure 13: Instrument Tabs

3) Click on the Setup tab to the right of the instrument tabs.

a) Check the **Current Data Directory** to make sure data will be recorded in the desired directory. If you would like to add an identifying suffix to the output files your session will record, type this suffix (e.g., "test") in the relevant control.

b) If you would like to set a recording limit for your session, do so using the **Fixed Recording Time?** button and the control to its right.

c) Staying on the Setup window, set the source for any parameters (e.g., True Air Speed) that may have more than one instrument measuring them, or for parameters that you wish to set manually. These parameters are listed on the left side of the setup window. Normally they will be set to their correct values according to the configuration file.

4) If necessary, set the parameters for each instrument by clicking on the instrument's tab, then selecting "Configure Instrument" from the **Configure** menu. (If you cannot select "Configure Instrument," click on the Setup tab and then click the instrument's tab again; you should now be able to select "Configure Instrument.") After making any changes to the instrument configuration, click the green **Reset**

Program button. Note: setting instrument parameters is not necessary if the configuration is okay.

5) If you are particularly interested in measurements from one instrument and want to see the data real-time, click on the tab of that instrument.

6) When you are ready to start acquiring data, click on the **Sample** button in the upper left of the PADS window.

7) When you are ready to record the data being sampled, press **Not Recording**, which will change to **Recording** and indicate data is being recorded.

8) When you are done recording, press **Recording** again, which will change to **Not Recording**. If you are done sampling entirely, press **Sampling.** Repeat steps 6 and 7 until you no longer wish to acquire data.

9) To open data previously recorded in PADS, click **Read a File.** Go to the current data directory specified in step #3. You will see a subdirectory named after the time when the sample was taken. If you recorded data multiple times, you will see multiple subdirectories with different names. Click on the subdirectory you want, and you will see data files for each instrument you used during sampling. Select one of these files. Opening one instrument's file will load all of them; you will be able to see the output for different instruments by clicking on the instrument tabs at the top of the window.

10) To pull up the data in another program, e.g. Excel, first create copies of all the output files you want to view. Then start Excel and open the copied data file(s).

11) When you are done using PADS, go to the **Program** menu and select **Exit**.

Appendix A: Definitions

The definitions below cover output channels and input parameters for many different DMT instruments. Depending on your system, you may or may not see certain channels and parameters.

1D Sizing Threshold: A parameter on the CIP Grayscale that indicates the minimum grayscale threshold a particle must reach in order to be sized. For instance, if you set 1D Sizing Threshold to Level Three, particles registering Level One and Level Two will not get sized. PADS will only image particles that have Level Three segments. *Note:* It is recommended that you set this threshold to a level corresponding to a 50% grayscale setting, since standard practice in the atmospheric sciences is to size particles that obscure 50% or more of a diode's light.

1st Stage Mon / 1st Stage Monitor: A diagnostic channel that serves different purposes on different instruments. On the CCN, **1st Stage Mon** indicates whether the optical particle counter (OPC) is fogged or dirty. When **1st Stage Mon** exceeds its threshold for a sustained period, the CCN computer generates an **Alarm Code**; see the *CCN Software Manual* for details. On the BCP, **1st Stage Monitor (V)** increases if the instrument happens to point directly at the sun or if stray light increases for some reason. If **1st Stage Monitor** goes up significantly, the BCP instrument data are suspect.

8_Volts (V): A channel in the CIP GS output file that indicates how accurately the pressure transducers are calibrated. If transducers are calibrated properly, the 8_Volts (V) channel should read 8 volts. If this channel varies from 8 volts by more than 1%, the system's pressure readings will be inaccurate.

 # Conc: See **Num Conc.**

ABC: A Dewpoint channel that stores the status of the instrument's automatic balance (ABC) cycle. If ABC = 1, the instrument is in calibration mode rather than data acquisition mode, so the Dewpoint channel in the output file is set to NaN. If ABC = 0, Dewpoint stores the dew point value returned in the instrument data packet.

Abs Press: A CCN channel indicating the absolute pressure in the CCN column. The absolute pressure is one factor that determines the instrument's supersaturation.

ADC Threshold: A parameter on light-scattering instruments that indicates the smallest peak digital value a particle can have and still be sized by the instrument. Small digital peaks can occasionally occur in the absence of particles, and the ADC Threshold can be used to eliminate such noise.

ADC_overflow: A channel on light-scattering instruments that indicates how many particles have been detected but rejected for counting because they were oversized. Oversized particles send out a peak digital signal that exceeds that given in a threshold table as the upper boundary of the uppermost sizing bin. On the CCN, these particles are included in **CCN # Conc**, but PADS omits them from the histogram display and the bin channel counts.

age of diff correction (s): A Garmin GPS channel that indicates the age of the differential GPS data, i.e. the number of seconds since the last valid Radio Technical Commission for Maritime Services (RTCM) standard transmission occurred. If there isn't a valid RTCM differential GPS fix, this channel will be 0.

Air density (kg/m^3): A channel in the Hotwire LWC output file. For details on how PADS calculates air density, see Appendix B.

Air Speed (m/sec): See **True Air Speed**.

Alarm Code: A CCN channel that stores the sum of any current alarm codes the CCN computer has generated. Each alarm code is a unique 2^n number that reflects a specific issue with the CCN. For instance, an alarm code of 4 indicates a problem with the total flow or with the sample-sheath flow ratio. An alarm code of 16 indicates a problem with the sample temperature. Problems with both the flow and the sample temperature would result in an **Alarm Code** value of 20 (= 4 + 16), providing no other alarm codes have been generated. A negative alarm code indicates problems severe enough that the instrument has gone into safe mode. See the *CCN Software Manual* for details.

Altitude (m): An AIMMS-20 channel indicating the aircraft's altitude in meters.

Ambient Temp (C): The temperature of the air around the probe as measured by the probe. Note that ambient temperature sensors have a range of -50° to 50° C. Temperature sensors are calibrated by the sensor's manufacturer.

Warning*: PADS actually displays the measured temperature, not the ambient temperature, in the display fields marked Ambient Temperature. It also uses the measured temperature in certain calculations where it should use ambient temperature, such as the Hotwire LWC calculations for air density, dry air term, film temperature, LWC raw, and P Dry Calculated. These are known bugs that will be fixed in an upcoming version of PADS. However, PADS uses the correct ambient temperature when making calculations for true air speed*. See *Appendix B: Calculations for Derived Channels* for information on how to calculate ambient temperature from measured temperature. ***Exception****: The temperature reading generated by the AIMMS-20 has been corrected for dynamic heating, so it reflects ambient temperature rather than recovery temperature. To calculate ambient temperature, the AIMMS-20 uses a dynamic heating efficiency factor that users can specify. For details, see the AIMMS-20 manual supplied by Aventech.*

Ambient Temp Sensor: This control tells PADS what kind of temperature sensor is installed in the instrument. It is pre-configured to match the temperature sensor on your particular probe and should not be changed.

Angle of Attack (AoA) (deg) A channel on the AIMMS-20 that indicates the angle the relative wind flow vector makes with the principal / longitudinal axis of the aircraft in the vertical plane. A negative angle of attack indicates the plane's rotation is up relative to the wind flow vector. *Note: In standard aerodynamics convention, angle of attack increases when the flow makes a greater incidence angle with the lower surface of the wing, which is opposite to the convention used here. The convention used by the AIMMS-*

20, however, is mathematically consistent with the coordinate system and rotational transformations employed.[1]

Antenna altitude (m): A channel on the Garmin GPS indicating the height of the GPS antenna above or below mean sea level. This can range from -9999.9 to 9999.9 meters.

AoA pressure diff (mBar): A channel on the ADP and AIMMS-20 that is calculated as follows:

$$\text{AoA pressure diff} = p_t - p_b$$

where

p_t = the pressure in mBar at the top port on the hemispherical tip of air-data probe

p_b = the pressure in mBar at the bottom port on the hemispherical tip of air-data probe

and top and bottom are defined when probe aligned in its in-flight orientation.

APD: An avalanche photodiode. APDs are sensitive optical detectors that are used in DMT aerosol-sensing instruments.

APD 1st Stage (V): A PCASP-X2 channel that indicates the amount of background light scattered by the instrument optics. A typical reading is approximately 1 V; readings of 2-3 V or higher indicate the optical system needs to be cleaned.

APD Bias Voltage (V): A monitor voltage of the bias to the APD in the PCASP-X2. This voltage varies from APD to APD, typically between -250 to -325 VDC, but for any given

[1] Information obtained from Aventech Research Inc., which manufactures the AIMMS-20.

photodiode it should stay constant ±10 V. An unstable voltage will destabilize the gain on the APD.

APD Temp (C): A PCASP-X2 channel that monitors the temperature of the APD. The APD is a temperature-sensitive component. There is a thermal-electric cooler (TEC) to stabilize the temperature at around 25 ºC.

Arm Width (mm): On imaging probes, the distance between the probe's arms along which the laser travels. This value is used in calculating particle concentrations. (See the "Sample Volume" entry for details.) The arm width of your probe should not change. This parameter is only used in sample volume calculations.

At Startup Enabled / Disabled: If you want the instrument to acquire data when PADS begins sampling, make sure this parameter is in the "Enabled" mode. In some cases, such as if the instrument is inoperative, you may want to use this control to disable the probe. Disabling the instrument allows data to transmit from other instruments without interference.

Avg_Transit (µs): A channel that indicates the average time in microseconds that the laser illuminated a sized particle. On the CDP and BCP, Avg_Transit is averaged over 128 particles and has a resolution of 25 ns. The largest transit time allowed is 100 µs. On the SPP-200 / PCASP-100X, the user specifies the number of particles to use in the Avg_Transit calculation. This number is entered in the **Avg Transit Sample Number** field on the SPP-200 Config Editor Screen.

Avg Transit Sample Number: A control on the SPP-200 / PCASP-100X that allows you to specify the number of particle readings that are used to calculate Avg_Transit, which is the average time it takes for particles to pass through the beam.

Back : Fwd: A channel on the CAS_POL_PBP that stores the ratio of the average backward-scattered signal to the average forward-scattered signal. PADS calculates this as follows:

$$Back : Fwd = \frac{\sum_{i=1}^{n} B_i}{\sum_{i=1}^{n} F_i}$$

where

B_i = The adjusted backward count for particle number *i* in the current sampling instance

F_i = The adjusted forward count for particle number *i* in the current sampling instance

n = The number of particles observed during the current sampling instance's particle-by-particle analysis

For information on adjusted forward and backward counts, see *Appendix B: Adjusting PBP Size Count Channels so They Scale Linearly* in the CAS_POL_PBP module of the *PADS Operator Manual*.

Note that *n* must be <= 292 since PADS limits particle-by-particle observations to the first 292 particles detected in each sampling instance.

Warning: PADS currently includes overflow counts when calculating the **Back : Fwd** ratio. This is a known bug that will be fixed in an upcoming version of the program.

Back Block Temp (C): See **Backward_Block_T.**

Back_Heat_Sink_T / Back Heat Sink Temp: A channel on the CAS and CAS_POL_PBP that stores the temperature of the backward-scattering detector's heat sink. The heat sink is located just outside the detector itself, and it provides an extra indication of the health of the thermal electrical cooler inside the detector. (The cooler's temperature is also measured directly in the **Backward_TEC_T** channel.) The heat sink temperature should stay near 25° C.

Back_Hi_Gain_Volt / Back High Gain Baseline (V): A channel on the CAS and CAS_POL_PBP that stores the average voltage registered by the backward-scattering detector's high-gain signal. This voltage is the sum of voltage generated by any scattered particle light and the voltage offset that the system constantly adds to reduce noise. In situations where no particles are present, this channel should stay relatively constant and reflect only the voltage offset.

Back_Lo_Gain_Volt / Back Low Gain Baseline (V): A channel on the CAS and CAS_POL_PBP that stores the average voltage registered by the backward-scattering detector’s low-gain signal. This voltage is the sum of voltage generated by any scattered particle light and the voltage offset that the system constantly adds to reduce noise. In situations where no particles are present, this channel should stay relatively constant and reflect only the voltage offset.

Back_Mid_Gain_Volt / Back Mid Gain Baseline (V): A channel on the CAS and CAS_POL_PBP that stores the average voltage registered by the backward-scattering detector’s mid-gain signal. This voltage is the sum of voltage generated by any scattered particle light and the voltage offset that the system constantly adds to reduce noise. In situations where no particles are present, this channel should stay relatively constant and reflect only the voltage offset.

Back_Overflow: A channel on the CAS_POL_PBP that stores the number of particles whose back-scattering signals have saturated the back-scattering detector. This occurs when a particle’s peak backward-scattering signals exceed 3071 digital counts. If this happens with a particle that has been observed during the particle-by-particle analysis, the Back Size channel on the PBP file will be set to 4095.

Back Size (counts): A channel in the CAS_POL_PBP’s particle-by-particle output file. This channel stores the peak digital signal detected by the instrument’s backward-scattering optics. A value of 4095 indicates the detector has been saturated. Back Size counts are not linearly scaled, since they have been measured after different gain stages. See *Appendix B* of the CAS_POL_PBP Module of the *PADS Operator Manual* for information on how to adjust Back Size readings so they scale linearly.

Back TEC Temp: See **Backward_TEC_T.**

Backward_Block_T / Back Block Temp (C): A channel on the CAS and CAS_POL_PBP that stores the temperature of backward-scattering optics block. The temperature should stay near ambient temperature, so approximately 22 – 28 ºC. The backward block maintains the laser diode temperature, which must remain constant to obtain accurate particle readings. The block also shares the load of maintaining the optics and APD tech temperatures. Therefore, if the backward block overcools or overheats, it can cause problems for the CAS.

Backward_Overflow: A channel on the CAS that stores the number of particles with backward-scattering signals that have saturated the backward detector. This occurs when the peak back-scattering signal exceeds either 1.) the limit given in the backward thresholds table (for the CAS) or 2.) a digital count of 3071 (for the CAS_POL_PBP).

Backward_TEC_T / Back TEC Temp: A channel on the CAS and CAS_POL_PBP that stores the temperature of the backward-scattering detector's thermal electrical cooler. The TEC is internal to the detector and keeps the detector's temperature constant, ensuring accurate readings. Backward_TEC_T should stay near 25º C.

Backward Threshold Tables: A parameter on the CAS Config Editor screen that lists the path to the backward-scattering threshold table files. PADS uses these tables to classify particles that the instrument's backward-scattering optics have detected. The system uses two backward threshold tables, but PADS only lists one of these tables, `casb_t.csv`, in the Backward Threshold Tables field. The other file, `casb_p.csv`, should be located in the same directory. Note that the Backward Thresholds Tables field should always be set to the `casb_t.csv` file, and PADS finds the `casb_p.csv` file automatically using the same path.

`Casb_t.csv` tells PADS the correct sizing bin for a particle given the peak digital value from the particle's back-scattered light. `Cas_p.csv` tells PADS the upper boundary for each bin.

Baro Pressure (mBar) / Barometric Pres. (mBar): An output channel on the ADP and AIMMS-20 that stores the barometric / static pressure. On the ADP, this pressure is uncorrected for dynamic heating, and the output file channel corresponds to the barometric pressure in the "Uncorrected Values" column of the **ADP Parameters** box on the PADS screen. The corrected version can be found in the **Baro Pressure Dynamic (mBar)** channel. On the AIMMS-20, **Barometric Pres. (mBar)** has been corrected for dynamic heating and position error as a function of angle-of-attack.

Baro Pressure Dynamic (mBar): An output channel on the ADP that stores the barometric / static pressure corrected for dynamic heating and position error as a function of angle-of-attack.

Baseline Monitor (V): A BCP channel that stores an inverted representation of the actual negative baseline, with a gain of 10. Since the actual baseline signal is -.3V, **Baseline Monitor (V)** should be 3V ± .2V.

Baud Rate: The Baud rate for the probe is defined at manufacture, and you should not need to change it. PADS lists this parameter because some probes can run at different baud rates. So if you reconfigure your hardware, the baud rate may change. In general, a higher baud rate means that the probe can transmit data more quickly to the computer. However, higher baud rates may not work with some computers and can result in unreliable data transmission.

BCP_Inv_Bin_*i* : A BCP channel indicating the particle counts in bin *i,* which have been adjusted using the Inversion Matrix. These counts are what the PADS histograms display.

BCP_Raw_Bin_*i*: A BCP channel indicating the raw particle counts in bin *i*. Due to ambiguities in the back-scattered light signals, these may not reflect actual particle counts; the values in **BCP_Inv_Bin_*i*** are more indicative of actual particle-size distributions.

Bin Setting: A parameter on the CCN Config Editor screen that can be used to limit the **# Conc** calculation to reflect larger particles only. Bins lower than the **Bin Setting** do not have their particles included in this calculation. If all particles are to be included, **Bin Setting** should be 0.

Bins: Channels that store particle-size data used in the histogram displays. Different instruments have slightly different names for these channels, and the number and size range of channels varies. More information about the bins for particular instruments is given below.

CIP, CIP GS, MPS, and PIP: These instruments' bin channels are labeled Bin_[*i*], where *i* ranges from 1 to 62. Each bin sizes particles one probe resolution bigger than the previous bin. Particles in bin *i* are approximately of size [*i* * R], where R is the probe resolution. In practice, this size is a range, with a minimum boundary of

$$\frac{(i-1)R+(i)R}{2}$$

and the maximum boundary of

$$\frac{(i)R+(i+1)R}{2}$$

For instance, say you have a CIP probe with a resolution of 25 μm. Bin_1 will tell you the approximate number of particles that are between 12.5 and 37.5 μm. Particles smaller than 12.5 μm are too small to trigger even one diode, so the CIP does not recognize them. Particles larger than 37.5 μm will typically trigger more than one diode, so they fall into Bin 2's count.

Note that particles slightly larger than 37.5 μm can still trigger only one diode if they fall centered over a diode. For instance, if you have a particle that is 39 μm long, it could fall so that the 25 μm in the center of the particle cover one diode, while the 7 μm on the ends of the particle each cover only a small fraction of each of the neighboring diodes. In this case, neither of the neighboring diodes would get triggered, leading the instrument to undersize the particle. For more information on sizing issues, consult the *DMT Data Analysis Users' Guide*.

CDP: The CDP's bin channels are labeled CDP_Bin_[*i*], where *i* typically ranges from 1 to 30. The span of CDP bins varies; PADS uses the CDP threshold tables to find particle sizes for different bins. On most 30-bin CDPs, particles in bin 0 will be detectable particles under 1 μm; for all other bins, particles in bin *i* will be between *i* and (*i* + 1) μm in size if *i* <= 10, and between (2*i* - 12) and (2*i* - 10) μm in size if *i* > 12.

FM 100: The FM 100's bins are labeled FM_100_OPC_ch[*i*]. On a 20-bin FM 100, *i* ranges from 0 to 19. The span of FM 100 bins varies; PADS uses the threshold tables to find particle sizes for different bins. Standard FM 100 bins are two μm wide for particles up to 20 μm, and then are three μm wide to the upper limit of the FM 100 range of 50 μm.

Block Temperature (C): The temperature at the PCASP-X2 optics block. Ideally, this temperature is measured by the PCASP-X2 temperature sensor, although other sources can also provide this reading. The **Block Temperature** listed in the data window and in the instrument output file may differ from the temperature source used in the calculations to convert mass flows to volume flows. For details, see the *PADS PCASP-X2 Module Operator's Manual*.

Board_Temp (C): A CIP GS channel indicating the temperature at the power supply board. In flight situations, the board temperature will typically be considerably higher than the ambient temperature. This is because the electronics raise the board's temperature and because the board is encased in an insulating canister.

Calculated TAS: The probe air speed of the local instrument. This may differ from the Global TAS.

Calculated Dewpoint (C): A channel on the ADP that stores the temperature to which air must be cooled in order for its water vapor to condense into liquid water, assuming that static pressure stays constant. The Dew Point is the temperature at which water vapor (H_20_g) and liquid and solid water ($H_20_{l/s}$) are in equilibrium. PADS calculates dew point as follows:[2]

$$DP = \frac{\left[\frac{T \bullet 17.27}{T + 237.7} + \ln\left(\frac{RH}{100}\right)\right] \bullet 237.7}{17.27 - \left[\frac{T \bullet 17.27}{T + 237.7} + \ln\left(\frac{RH}{100}\right)\right]}$$

where

DP	=	Dew point
T	=	Ambient Temperature in °C (corrected for dynamic heating)
RH	=	Relative Humidity (corrected for dynamic heating and pressure change at the sensor housing)

[2] Sonntag D. "Important New Values of the Physical Constants of 1986, Vapour Pressure Formulations based on the IST-90 and Psychrometer Formulae." *Z. Meteorol.*, 70 (5), pp. 340-344, 1990.

CAS_Back_ch[*i*]: A channel on the CAS that stores the number of particles sampled by the backward-scattering optics that are in bin (*i* + 1).

CAS Conc (#/cm3): A CAPS summary channel that stores the **Number Conc** for the CAS.

CAS_ED: The **ED** for the CAS.

CAS For TEC Temp: See **Forward_TEC_Temp**.

CAS_Forw_ch[*i*] A channel on the CAS that stores the number of particles sampled by the forward-scattering optics that are in size bin (*i* + 1).

CAS_LWC, CAS_MVD, CAS_#_Conc: The **LWC, MVD,** and **Number Conc** for the CAS, respectively.

CAS_POL_PBP_Bin_[*i*]: A channel on the CAS_POL_PBP that stores the number of particles sampled by the forward-scattering optics that are in size bin *i*.

CAS_POL_PBP_IPT_Bin_[*i*]: These channels categorize observed particle inter-arrival times for particle-by-particle by length. Note that they have nothing to do with the particle size channels. Table 1 in the *CAS_POL_PBP Module* of the *PADS Operator Manual* shows the IPT time ranges for each CAS_POL_PBP_IPT_Bin. See the entry for **Inter-arrival Particle Time** for information on the resolution and maximum possible values for IPT measurements.

CAS Total Count: A CAPS summary channel that stores the **Particle Counter** for the CAS.

CCN Status: A Boolean parameter designed to store information on the communication between the CCN and PADS. Currently, PADS always sets CCN Status to 1. In a future version of PADS, a CCN Status value of 1 will indicate good communication and 0 will indicate poor communication.

CDP_Bin_[*i*]: See **Bins.**

CDP_ED, CDP_LWC, and **CDP_MVD:** The **ED, LWC,** and **MVD** for the CAS, respectively.

CDP Laser Monitor: See **Dump_Spot_Monitor.**

CDP_PBP_Bin_[*i*] Channels on the CDP_PBP that stores the number of particles that are in size bin *i* .

CDP_PBP_IPT_Bin_[*i*] Channels on the CDP_PBP that categorize observed inter-particle times for particle-by-particle by length. Note that they have nothing to do with the particle size channels. Table 1 in the CDP_PBP module of the *PADS Operator Manual* shows the IPT time ranges for each CDP_PBP_IPT_Bin. See the entry for **Inter-particle Time** for information on the resolution and maximum possible values for IPT measurements.

Channels: Data fields returned by a probe during each sampling instance. For example, LWC is a channel on many probes. A list of channels for each instrument appears in *Appendix A* of that instrument's PADS manual.

Channel Count: A parameter on scattering probes that indicates how many sizing bins the instrument uses to categorize particles. This number has been grayed out because it is preconfigured for your instrument and should not change.

Checksum: A Garmin GPS channel that is currently unused.

CIP Conc(#/cm3): A CAPS summary channel that stores the **Number Conc** for the CIP.

CIP_ED, CIP_LWC, CIP_MVD, CIP_Numb / CIP Conc: The **ED, LWC, MVD,** and **Number Conc** for the CIP, respectively. Note that these channels on the CAPS or CCP summaries may have different values than their counterparts on the CIP. This is because the CAPS and CCP parameter **CIP Max Size (um) / Max Size for CIP MVD** filters out large CIP-detected particles, so they are not included in CAPS and CCP calculations.

CIP_GS_ED, CIP_GS_LWC, CIP_GS_MVD, CIP_GS_Numb: The **ED, LWC, MVD,** and **Number Conc** for the CIP Grayscale, respectively.

CIP Max Size (µm): A parameter on CCP and CAPS summary screens. This parameter sets the maximum diameter that a CIP-detected particle can have and still be included in the summary's calculations for CIP MVD, CIP ED, CIP LWC and CIP # Conc. Particles exceeding this maximum size are still included in calculations displayed on the CIP display screen and in the CIP output file, but they are omitted from the summary module's calculations. As a result, the CIP MVD displayed on the CIP tab, for instance, may differ from CIP MVD displayed on the summary tab. Setting a maximum size for CIP MVD allows you to omit large outliers such as raindrops, which can dramatically alter the results of these calculations.

CIP Over Range: See **Over_rej_count.**

CIP Strut Temp: See **Ambient Temperature**.

COM Port: This is the serial communications port that the instrument uses to connect with the computer. This number should match the computer hardware configuration for the particular computer you are using. If you are not using multiple computers, this number should not be changed.

Concentration: See **Particle Concentration.**

Control Board Temp (C): An MPS channel indicating the temperature at the board that regulates the instrument's temperature, power, and laser drivers.

Count Method: This parameter is obsolete and you should not need to change it.

Dark_Current_[*i*]: A channel in the CIP GS output file that indicates the amount of light diode [*i*] registers when the laser is off. Dark_Current_[*i*] is measured at instrument start-up and remains constant throughout the sampling session. PADS measures light obscuration relative to this dark current initial value.

DAT entries: See **Dry Air Term.**

Default Manual Pressure: A PCASP-X2 parameter that specifies the default value for the manual pressure upon PADS start-up. If you want to change the manual pressure for the current session only, you can do so from the main PCASP-X2 window. Note: If Pressure Source is set to Global and the global source in turn is set to manual, the default manual pressure is the one specified on the Setup screen, not in this parameter.

Default Manual Temp: A PCASP-X2 parameter that specifies the default value for the manual temperature upon PADS start-up. If you want to change the manual temperature for the current session only, you can do so from the main PCASP-X2 window. *Note:* If

Temperature Source is set to global and the Global source in turn is set to manual, the default manual temperature is the one specified on the Setup screen, not in this parameter.

DePol Size (counts): A channel in the CAS_POL_PBP's particle-by-particle output file. This channel stores the peak digital signal detected by the instrument's depolarized detector. A value of 4095 indicates the detector has been saturated. DePol Size counts are linearly scaled, since the depolarized detector has only one gain stage.

Depth of Field: The distance along a laser beam in which a particle can fall and be sufficiently illuminated and in focus to be sized with an acceptable level of accuracy. More information about depth of field for particular instruments is given below.

Light-Scattering Instruments

In light-scattering instruments, depth of field is a constant that is set at the time of probe manufacture. Particles that fall outside this depth of field scatter light in ways that make particles difficult to size. In this case, the instrument's masked or qualifying detector will register a voltage that indicates the particle should be rejected for counting.

Imaging Probes

For imaging probes, particles outside the depth of field do not shadow the diodes properly. The darkness of a particle's image on the diode array is a function of the particle's distance from the center of focus. Particles at the center of focus cause a 100% change in the light level of the laser. Farther away, the change is less. Particles too far away from the center of focus change the light level by less than 50% and are rejected for counting. (The CIP is set up to accept particles whose image changes the light level of the laser on the diodes by 50% or more.)

Depth of field varies by particle. It is a function of the wavelength of the laser, λ, and the square of the particle radius, r.

The depth of field for larger particles will be the entire length between the probe arms. For smaller particles, it will be some subset of the beam's length, as shown below.

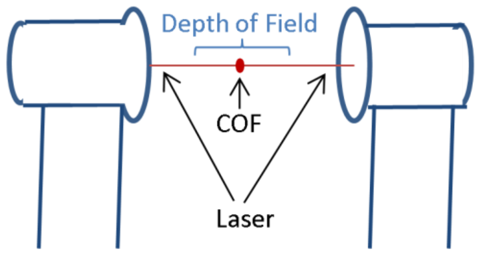

Figure 14: Depth of Field Range

Information on how PADS calculates DOF for imaging instruments is listed under **Sample Volume** in *Appendix B: Calculations for Derived Channels*.

Dewpoint: The temperature at which water vapor (H_20_g) and water in a liquid state ($H_20_{l/s}$) are in equilibrium.

Diff Pressure (mBar) (Differential Pressure): See "Pitot-Static Tube System" for details. Diff Pressure is also sometimes referred to as dynamic pressure or pitot pressure. This reading should correlate with the pressure measurements taken by the aircraft's on-board pitot system. If Diff Pressure is zero, or if Diff Pressure stays constant while air speed, temperature, or altitude is changing, this indicates a potential problem with the pressure transducer. Note that Diff Pressure readings between different instruments on the same aircraft can vary by up to 10%.

Differ station ID: A Garmin GPS channel that indicates the differential reference station ID, which can range from 0000-1023. This value will be null in the absence of an Radio Technical Commission for Maritime Services (RTCM) Differential GPS fix.

Digital_Gnd (V): On the CDP, the ground voltage at the digital board (CDPE electronics). This should range from 0.0 to 0.3 volts. If Digital_Ground varies beyond this, there is likely a short or a problem in the power distribution.

Digital_V_Ref See **Laser_Driver_Ref**.

Diode Voltages 1, 32, and **64:** The representative power levels of the laser light illuminating the corresponding diode on the CIP's photodetector array. These indicators are used as a diagnostic. A very low or high voltage indicates a problem with the instrument, as does the appearance of one diode voltage being much higher or lower than the others. See the table below for acceptable values.

Type of Instrument	**Monoscale**			**Grayscale**		
Diode #	(1)	(32)	(64)	(1)	(32)	(64)
Ideal voltage reading when no particles are blocking the diode	1.5-2.5	2.0-3.2	1.5-2.5	1.5-5.0	1.5-5.0	1.5-5.0
Total voltage range for healthy instrument (includes times when particles are blocking the diode)	0.5-3.2	0.5-3.2	0.5-3.2	0.5-10.0	0.5-10.0	0.5-10.0

Table 2: Acceptable Values for Diode Voltages 1, 32, and 64

A chronic low voltage may indicate a blockage of photodetector array. Although much less likely, a low voltage may also indicate the laser is nearing end of its life. In this case, the instrument's laser current reading will likely be higher than usual.

Divisor Flag: This MPS parameter is obsolete.

DOF: See **Depth of Field.**

DOF Reject: On light-scattering instruments, the DOF reject button tells the instrument whether to reject particles that fall outside the instrument's depth of field. The default value is true, and you should not need to change it. During probe calibration and alignment, DMT sets DOF Reject to false, so that the probe will report all particles it detects.

DOF_rej_counts/DOF_Reject_Cnt: The number of particles rejected for counting during a given cycle because they fell outside the instrument's depth of field. See **Depth of Field** for more details.

Dpol : Back: A channel on the CAS_POL_PBP that stores the ratio of the average depolarized signal to the average backward-scattered signal. PADS calculates this as follows:

$$Dpol\ :Back\ = \frac{\sum_{i=1}^{n} D_i}{\sum_{i=1}^{n} B_i}$$

where

D_i = The depolarized count for particle number *i* in the current sampling instance

B_i = The adjusted backward count for particle number *i* in the current sampling instance

n = The number of particles observed during the current sampling instance's particle-by-particle analysis

For information on adjusted backward counts, see *Appendix B: Adjusting PBP Size Count Channels so They Scale Linearly* in the CAS_POL_PBP module of the *PADS Operator Manual*.

Note that *n* must be <= 292 since PADS limits particle-by-particle observations to the first 292 particles detected in each sampling instance.

Warning: PADS currently includes overflow counts when calculating the **Dpol : Back** ratio. This is a known bug that will be fixed in an upcoming version of the program.

Dpol_Baseline (V): A channel on the CAS_POL_PBP that stores the average voltage registered by the depolarized detector's signal. This voltage is the sum of voltage generated by any scattered particle light and the voltage offset that the system constantly adds to reduce noise. In situations where no particles are present, this channel should stay relatively constant and reflect only the voltage offset.

Dpol : Fwd: A channel on the CAS_POL_PBP that stores the ratio of the average depolarized signal to the average forward-scattered signal. PADS calculates this as follows:

$$Dpol : Fwd = \frac{\sum_{i=1}^{n} D_i}{\sum_{i=1}^{n} F_i}$$

where

D_i = The depolarized count for particle number *i* in the current sampling instance

F_i = The adjusted forward count for particle number *i* in the current sampling instance

n = The number of particles observed during the current sampling instance's particle-by-particle analysis

For information on adjusted forward counts, see *Appendix B: Adjusting PBP Size Count Channels so They Scale Linearly* in the CAS_POL_PBP module of the *PADS Operator Manual*.

Note that *n* must be <= 292 since PADS limits particle-by-particle observations to the first 292 particles detected in each sampling instance.

Warning: PADS currently includes overflow counts when calculating the **Dpol : Fwd** ratio. This is a known bug that will be fixed in an upcoming version of the program.

Dpol Heat Sink Temp (C): A channel on the CAS_POL_PBP that stores the temperature of the depolarized detector's heat sink. The heat sink is located just outside the detector itself, and it ensures that the thermal electrical cooler inside the detector hasn't failed. The heat sink temperature should stay near 25° C.

Dpol_Overflow: A channel on the CAS_POL_PBP that stores the number of particles detected by the depolarized detector because their peak depolarized signals exceed 3071 digital counts. If this occurs on a particle that has been observed during the particle-by-particle analysis, the DePol Size channel on the PBP file will be set to 4095.

Dpol TEC Temp (C): A channel on the CAS_POL_PBP that stores the temperature of the depolarized detector's thermal electrical cooler. The TEC is internal to the detector and keeps the detector's temperature constant, ensuring accurate readings. Dpol TEC Temp should stay near 25º C.

Droplet Speed Radio Button: A control on the MPS Config Editor window. The radio button allows you to select from two possible droplet speeds to be used in MPS concentration calculations, 25 meters/second or calculated terminal velocity. 25 meters/second is appropriate for spinning disk calibrations. For data acquisition, use the calculated terminal velocity. Note that the droplet speed used to determine the MPS image clock rate differs from that specified for concentration calculations; see *Appendix B* of the MPS Module of the *PADS Operator Manual*.

Dry Air Term (DAT): A channel on the Hotwire LWC indicating the amount of heat loss due to convection. The heat that is removed from the heated cylinder by the air flowing past the sensor is dependent on the ambient temperature, the wire temperature, the ambient pressure, the air velocity and the cross sectional area of the sensor. These losses have been parameterized from wind tunnel studies and depend on the Reynolds and Prandtl numbers (see **P Dry Calculated**).

Dry Air Term Calculated (g/m^3): A channel on the Hotwire LWC output file. This channel is identical to **P Dry Calculated (W)** *except the units are converted to g/m^3*. Dry Air Term Calculated (g/m^3) is the amount of cooling that is caused by air passing the sensor. In cloud-free air, this cooling is measured by the amount of power required to keep the sensor at a constant temperature. The power is normally given in units of watts but is also converted into units of g/m^3 of equivalent water content, i.e. the water concentration that would cause the equivalent amount of cooling by evaporation. When in clouds, the dry air term cannot be directly measured due to the presence of water, but it can be calculated using an empirical equation that has been derived from wind tunnel studies. See Zukauskas and Ziugzda, 1985, and the **LWC** and **P Dry Calculated (W)** entries in *Appendix B*.

Dry Air Term Observed (g/m^3): A channel on the Hotwire LWC output file. Dry Air Term Observed (g/m^3) gives the amount of liquid water content that would cause the same amount of latent heat loss as the heat loss currently being caused by convection (i.e., dry air term). PADS uses this channel in calculating actual liquid water content, because subtracting the dry air term from the raw liquid water content gives an estimate of actual LWC (See **LWC** in *Appendix B: Calculations for Derived Variables*). In contrast to the Dry Air Term Calculated channel, which calculates DAT from other variables, PADS derives the Dry Air Term Observed directly from the measured power in Watts (see **Dry Air Term Observed (W)**) by averaging dry air term readings when the **Get DAT Observed** button is pressed. Presumably, this button is pressed when no clouds are present, yielding accurate readings of heat dissipation due entirely to convection.

Dry Air Term Observed (W): A channel on the Hotwire LWC output file. It is identical to **Dry Air Term Observed (g/m^3)** but reports the DAT in units of watts, not g/m^3.

Dump_Spot_Monitor: A channel indicating the amount of focused, unobstructed laser light collected in the dump spot monitor. This channel can indicate overall system health. If the monitor reading goes down when there are no particles present, there may be a problem. (When particles are present, the laser light scatters, which reduces the focused light collected in the dump spot.) It is important to track the trend over a long period of time, for instance over several months, as this channel can change slowly. Overheated lasers or probe windows blocked by fog and/or ice could cause the laser monitor reading to go down even though no particles are present.

For the CDP: The dump spot monitor is a voltage reading that is averaged over the timing interval.

For the FM-100: The dump spot monitor is a raw A/D reading that may be stored in the **Optic Block Temp (C)** channel. A good reading is approximately 3,000 when no particles are present. For more information, see Appendix B of the *FM-100 Module for the PADS Operator Manual (DOC-0181)*.

DSP Board Temp (C): Temperature as measured on the digital signal processing board. In flight situations, the DSP Board Temperature will typically be considerably higher than the ambient temperature. This is because the power consumption of the electronics raises the board's temperature and because the board is encased in an insulating canister. A DSP Board temperature that is routinely above 50ºC will shorten the life of the laser.

Dynamic Pressure (mBar): See **Diff Pressure**.

Dynamic Press Slope: This is the slope used in the linear function to derive dynamic pressure from the voltage output of the dynamic pressure transducer, as follows:

*Dynamic Pressure = **(Dynamic Press Slope)** * (Voltage) + Dynamic Press Y-int*

Dynamic Press Slope is a calibration coefficient measured by DMT and specific to your transducer. It assumes a 5-volt sensor range that is electronically multiplied by 2 before going to a 0-10 volt analog-to-digital converter. Do not change this parameter without consulting DMT first.

Dynamic Press Y-int: This is the intercept term used in the linear function to derive dynamic pressure from the voltage output of the dynamic pressure transducer, as follows:

*Dynamic Pressure = (Dynamic Press Slope) * (Voltage) + **Dynamic Press Y-int***

Dynamic Press Y-int is a calibration coefficient measured by DMT and specific to your transducer. It assumes a 5-volt sensor range that is electronically multiplied by 2 before going to a 0-10 volt analog-to-digital converter. Do not change this parameter without consulting DMT first.

ED (µm) *(Effective Diameter)*: A channel proportional to the ratio of liquid water content to the optical cross sectional area of droplets.

Warning: Currently PADS does not take into account that imaging probes' sample space volumes vary with particle size, so their ED calculations are somewhat inaccurate. This issue does not affect scattering probes. The problem will be fixed in an upcoming version of the program. See *Appendix B: Calculations for Derived Channels* for details.

Elect. Temp (C): The electronics temperature, which should stay under 45° C.

Electronic Box Temp (C): A BCP channel indicating the temperature at the Electronic Box. This should stay under 60 ºC.

End Diode Reject: A button on the Config Editor window of imaging probes. When this button is enabled, the probe will reject any particles for sizing that obscure an end diode. (Particles that obscure both end diodes are always rejected.) The default setting for this control is enabled.

End Reject Count: The number of particles that are not sized because the droplet shadow obscures an end diode. Particles that obscure both diodes do not get counted in this channel; they are counted in **Over_rej_count**.

Ext_lambda[AAA]to[BBB]nm_km-1_ch[i]: FM-100 Extinction channels that store the extinction coefficients in km^{-1} for all particles in size bin i for spectral band AAA-BBB nm. For information on how PADS calculates extinction coefficients, see *Appendix B* of the *PADS Manual FM 100 Extinction Module*.

Ext_lambda[AAA]to[BBB]nm_km-1: FM-100 Extinction channels that store the extinction coefficients in km^{-1} for all particles of all measured sizes for spectral band AAA-BBB nm. For information on how PADS calculates extinction coefficients, see *Appendix B* of the *PADS Manual FM 100 Extinction Module*.

Extinction Table: A table on the FM 100 Extinction Configuration Editor screen. The table lists factors used in calculating extinction coefficients for the different spectral bands. You can modify the values in the table by typing in new numbers directly, by importing a new file, or by pressing the **Load Default Extinction Table** button to revert to the table's original default values. The factors listed in the table are the extinction efficiencies for different particle sizes multiplied by the cross sectional area of the particle cm^2. For more information, see *Appendix B*.

Fifo_Full A channel on the CAS that stores the total number of times the FIFO (first-in-first out) buffers filled up and were prematurely emptied. The FIFO buffers store particle information until it is sent to PADS, but if these buffers fill up before transmission occurs, the system empties them and the data are lost. Approximately 4,000 particles are lost each time the system prematurely empties the FIFO buffers. This will normally happen only in very high concentrations and corrections can be made for the lost particles by using the FIFO_Full number.

FM_100_OPC_ch[*i*]: See **Bins.**

Forward_Block_T / Fwd Block Temp (C): A channel on the CAS and CAS_POL_PBP that stores the temperature of forward-scattering optics block. The temperature should stay near ambient temperature, so approximately 22 – 28 °C. The forward block shares the load of maintaining the optics and APD tech temperatures. Thus if the block overcools or overheats, it can cause problems for the CAS.

Forward_Heat_Sink_T / Fwd Heat Sink Temp (C): A channel on the CAS and CAS_POL_PBP that stores the temperature of the forward-scattering detector's heat sink. The heat sink is located just outside the detector itself, and it provides an extra indication of the health of the thermal electrical cooler inside the detector. (The cooler's temperature is also measured directly in the **Forward_TEC_T** channel.) The heat sink temperature should stay near 25º C**.**

Forward_Overflow: A channel on the CAS that stores the number of particles detected by forward-scattering optics but rejected for classification because they are oversized (i.e., their peak signal is above the limit given in the forward thresholds table).

Forward Size (counts): A channel in the CAS_POL_PBP's particle-by-particle output file. This channel stores the peak digital signal detected by the instrument's forward-scattering optics. A value of 12287 indicates the detector has been saturated. Forward Size counts are not linearly scaled, since they have been measured after different gain stages. See *Appendix B* of the CAS_POL_PBP Module of the *PADS Operator Manual* for information on how to adjust Forward Size readings so they scale linearly.

Forward_TEC_Temp / Fwd TEC Temp (C): A channel on the CAS and CAS_POL_BPB that stores the temperature of the forward-scattering detector's thermal electrical cooler. The TEC is internal to the detector and keeps the detector's temperature constant, ensuring accurate readings. Forward_TEC_Temp should stay near 25º C**.**

Forward Threshold Tables: A parameter on the CAS Config Editor screen that lists the path to the forward-scattering threshold table files. PADS uses these tables to size particles that the instrument's forward-scattering optics have detected. The system uses two forward threshold tables, but PADS only lists one of these tables, `cas_t.csv`, in the Forward Threshold Tables field. The other file, `cas_p.csv`, should be located in the same directory. Note that the Forward Thresholds Tables field should always be set to the `cas_t.csv` file, and PADS finds the `cas_p.csv` file automatically using the same path.

`Cas_t.csv` tells PADS the correct sizing bin for a particle given the peak digital value from the light scattered by the particle. `Cas_p.csv` tells PADS the upper size boundary in microns for each sizing bin.

Frostpoint: The temperature at which water vapor (H_20_g) and water in a solid state ($H_20_{l/s}$) are in equilibrium.

Fwd Block Temp (C): See **Forward_Block_T**.

Fwd Heat Sink Temp (C): See **Forward_Heat_Sink_T.**

Fwd_Hi_Gain_Volt / Fwd High Gain Baseline (V): A channel on the CAS and CAS_POL_PBP that stores the average voltage registered by the forward detector's high-gain signal. This voltage is the sum of voltage generated by any scattered particle light and the voltage offset that the system constantly adds to reduce noise. In situations where no particles are present, this channel should stay relatively constant and reflect only the voltage offset.

Fwd_Lo_Gain_Volt / Fwd Low Gain Baseline (V): A channel on the CAS and CAS_POL_PBP that stores the average voltage registered by the forward detector's low-gain signal. This voltage is the sum of voltage generated by any scattered particle light and the voltage offset that the system constantly adds to reduce noise. In situations where no particles are present, this channel should stay relatively constant and reflect only the voltage offset.

Fwd_Mid_Gain_Volt / Fwd Mid Gain Baseline (V): A channel on the CAS that stores the average voltage registered by the forward detector's mid-gain signal. This voltage is the sum of voltage generated by any scattered particle light and the voltage offset that the system constantly adds to reduce noise. In situations where no particles are present, this channel should stay relatively constant and reflect only the voltage offset.

Fwd_Overflow: A channel on the CAS_POL_PBP that stores the number of particles rejected for classification because the peak signal detected by the forward detector exceeded 9216.

Fwd TEC Temp (C): See **Forward_TEC_Temp**.

Geoidal separation (m): A Garmin GPS channel that indicates geoidal height, which ranges from -999.9 to 9999.9 meters.

Global Ambient Temperature: The measured temperature provided by the ambient temperature source as listed on the Setup tab. This reading may differ from the ambient temperature provided by the local instrument.

Global Pressure: The static pressure provided by the static pressure source as listed on the Setup tab. This reading may differ from the static pressure provided by the local instrument.

Global TAS: The probe air speed provided by the True Air speed source as listed on the Setup tab. This air speed may differ from that provided by the local probe.

GPS Time: A channel on every instrument in a system in which one of the instruments in the system has GPS time available. **GPS Time** reflects the time captured by the GPS. If no instruments have GPS, there is no GPS channel in the output file. If the instrument with the GPS is not connected or enabled, GPS Time will be 0.

GND See **Wingboard_Gnd.**

GPS UTC time: A Garmin GPS channel indicating the Coordinated Universal Time (UTC) of the position fix. Older versions of the Garmin PADS software display UTC time in hhmmss format. Current versions convert this time to seconds since midnight of the current day.

Grayscale Level 1 – 3: Parameters on the Config Editor screen of the CIP Grayscale (GS). When a particle passes through the laser of the CIP GS and partially obscures one or more of the photodetectors in the diode array, Grayscale Level [*x*] determines what percentage decrease in the intensity of laser will be registered as an image shadow at a level x (1, 2 or 3). These thresholds are used in the display of the image and in subsequent data processing to determine how close a particle is to the center of focus. The greater percentage decrease in incident light level, the closer a particle is to the center of focus.

Hi_Gain_Baseline An SPP-200 channel that stores the average voltage registered by the high-gain signal. This voltage is the sum of voltage generated by any scattered particle light and the voltage offset that the system constantly adds to reduce noise. In situations where no particles are present, this channel should stay relatively constant and reflect only the voltage offset.

Hotwire LWC (V): A channel on the CAPS and CCP summaries that is taken from the Hotwire LWC instrument. It corresponds to the Hotwire LWC's **LWC hotwire (V)** channel.

Horiz precision: A Garmin GPS channel indicating the horizontal dilution of precision, which ranges from 0.5 to 99.9. For more details, consult Garmin International, Inc., which manufactures the Garmin GPS.

Host_Sync_Counter: This channel is reserved for internal use.

Hours: See **Time Channels.**

IAC_[*i*] These CAS channels currently do not have any functionality.

Image Card #: This is the communications port that the instrument uses to relay image data to the computer. The image card serial port differs from a standard serial port and can communicate data at higher speeds. If you have multiple instruments transmitting image data, the Image Card # tells you which port is being used by the current instrument. As with the Com Port parameter, you may need to change this if you are running PADS in data-acquisition mode on different computers.

Imaging Instruments: Probes that acquire particle data by imaging particles onto a photodiode array. Examples of imaging instruments include the CIP, CIP GS, PIP, and MPS.

Imaging Threshold: On the CIP Grayscale, the minimum grayscale threshold a particle must reach in order for that particle to be recorded as an image. For instance, if you set this threshold to Level Three, particles only registering at Levels One and Two will not be recorded. PADS will only image particles that include Level Three segments.

Include for [*Parameter*] Option: Controls on the ADP's Config Editor window that indicate whether the ADP is the master source for the parameter's value.

Inlet Temp (C): The temperature of the CCN's inlet manifold. When **Inlet Temp (C)** differs substantially from its set point for a sustained period, the CCN computer generates an **Alarm Code**. See the *CCN Software Manual* for details.

Instant_Illum_[*i*]: A channel in the CIP GS output file that indicates the peak illumination of diode [*i*]. This channel will be renamed Peak_Ilum_[*i*] in an upcoming version of PADS. The channel is a measurement that reflects probe health. While it is normal for peak illumination to fluctuate temporarily as particles pass, a constant decrease indicates a potential problem like dust blockage or optical issues. Note that since the channel's refresh rate is only 1 Hz, this channel is not useful in counting particles.

Inter-arrival Particle Time (IPT): For the CAS-POL-PBP, the instrument returns IPT times in the serial stream output. The maximum inter-particle time that the system registers is approximately 1677.72 msec. In the PBP output file, IPT (msec) readings of 1677.72 denote an overflow. IPT times are measured using 18 bits at a resolution of 6.4 μsec (2^{18} * .0064 msec = 1677.72 msec). Note that the PBP output file does not distinguish between inter-arrival particle times that exactly equal the maximum measurable value and those that exceeded it. However, you can assume that in most cases maximum IPT values represent overflows, since the chance of an IPT falling exactly on the maximum allowable time is extremely rare.

Unlike the CAS-POL-PBP, the CDP-PBP instrument does not return IPT times in the serial stream data. Rather, during each sampling instance, the CDP-PBP returns a 48-bit number indicating the time that elapsed from probe initialization to the observation of the first particle in the sampling instance. For each PBP particle in the sampling instance, the probe also returns a 20-bit number indicating the time between the first observed particle and the current particle. PADS then calculates IPT times from these times as follows. For each particle, the program first calculates the **Time** for each particle by adding three factors: 1.) the 20-bit particle time, 2.) the 48-bit time stamp of the first particle and 3.) the time in seconds after midnight at which the probe was initialized. (This **Time** channel is the one stored in the PBP file, not the one in the main output file.) **IPT Time** is then derived by subtracting the **Time** of the previous particle from that of the current particle.

Note that for the CDP-PBP, Sample Time should be set to one second or less to ensure IPT Time accuracy. Note also that IPT Times for the first particle in a PBP data packet may be NaN. For more information on both of these issues, see Appendix B in the CDP-PBP Module of the PADS Manual (DOC-0192).

Internal Temp (C): Temperature inside the instrument.

Instrument #: This lists the number corresponding to the instrument you are viewing. If your instrument has been assigned instrument number one, you will see "1" in this field. You should not need to modify the instrument number, and in fact you are unable to do so from within PADS.

Laser_Current (mA): The electrical current flowing through the instrument's laser diode. A sudden change in current could reflect a problem with the instrument. A reading of 60 – 120 mA indicates the instrument is functioning properly. If the laser current is weak and the laser begins pulsing, the laser has become overheated. A current reading of zero indicates a failure. However, a temporary drop in laser current is normal when anti-icing heaters are initially turned on. A high laser current can indicate the laser is nearing the end of its life. On the CCN, a sustained high Laser Current will generate an **Alarm Code.** See the *CCN Software Manual* for details.

Laser Current Monitor (V): A CAS and CAS_POL_PBP channel that indicates laser health. If a voltage of much less than 3.75V is seen, the laser power is not controlled. Failed lasers show 1 V or less.

Laser Current Slope: This is the laser current slope used in the linear function to determine laser current from a bit count, as follows:

*Laser Current = **(Laser Current Slope)** * (bits + Laser Current Y-int)*

Note that this function differs from the traditional slope-intercept formula in that the intercept term is added before multiplication occurs.

Laser Current Slope is a conversion coefficient related to the electronics. Do not change this parameter without consulting DMT first.

Laser Current Y-int: This is the laser current intercept used in the linear function to determine laser current from a bit count, as follows:

*Laser Current = (Laser Current Slope) * (bits + **Laser Current Y-int**)*

Note that this function differs from the traditional slope-intercept formula in that the intercept term is added before multiplication occurs.

Laser Current Y-int is a conversion coefficient related to the electronics. Do not change this parameter without consulting DMT first.

Laser_Driver_Ref (V): The power 5-volt reference for the control system on the CDP. This voltage is divided by two, digitized, and multiplied by two in PADS to allow an effective 0 – 10 volt range. Nominally it should be five volts, and if it varies by more than .2 volts, this may indicate a problem in the power distribution board.

Laser_Monitor (V): See Dump_Spot_Monitor (V).

Laser_Photodiode_Monitor (V): A CDP and CDP-PBP channel that stores the voltage from the photodiode that is inside the laser diode, which varies based on the light it has registered. This will range from 0 – 5 volts.

Laser Power (V): A CIP and MPS channel indicating relative laser power as measured by the laser onboard power monitor. PADS converts a digital count to volts to obtain this reading, which correlates to the optical power produced by the laser diode. This channel is useful for observing general trends, but currently it does not accurately indicate absolute laser power. However, the channel is still useful in diagnosing laser health. Laser power should stay stable ±20%; vacillation beyond this boundary indicates a problem with the laser.

Laser_Power_Mon / Laser Power Monitor (V) This CAS channel does not currently have any functionality.

Laser_Ref *(for the CDP or CDP-PBP)*: See **Laser_Photodiode_Monitor (V).**

Laser Ref (V) *(for the SPP_200 / PCASP-100X)*: A channel that measures the laser power. The probe does not attempt to control laser power; instead, it uses laser power measurements to compensate for slight declines in power over time. This insures accurate particle measurements. However, if Laser Ref (V) drops below 6 Volts, it is recommended you replace or realign the laser or clean the instrument windows.

Laser Reference (V) *(for the PCASP-X2)*: A channel that monitors the laser power in the optical cavity. A drop in this voltage indicates that either the instrument's reflective crystal oscillator mirror and/or the laser output lens are dirty or the laser is nearing the end of its life. Laser Reference should remain stable at approximately 4V. Although the PCASP-X2 can still make accurate measurements at a laser reference of 2-3 V, readings in this range indicate a need for optical cleaning, optical alignment, or laser replacement. The **APD 1st Stage (V)** channel is useful in determining if dirty windows are the source of the problem.

Laser_Temp (C): A channel that indicates the temperature of the laser heat sink. The Laser_Temp reading should be relatively stable. Healthy Laser_Temp readings are 20°-30° C.

Latitude (deg) An AIMMS-20 and Garmin GPS channel indicating the aircraft's latitude (north-south measurement) in degrees. On the AIMMS-20, a positive latitude indicates a location in the northern hemisphere. On the Garmin GPS, PADS displays latitude readings as absolute values.

Light-scattering Instruments: Probes that acquire particle data by illuminating particles with a laser and analyzing how the laser's light scatters. Examples of light-scattering instruments include CAS, CAS_POL_PBP, CCN, CDP, CDP_PBP, FM_100, SPP_100 and SPP_200.

Lo_Gain_Baseline (V) An SPP-200 / PCASP-100X channel that stores the average voltage registered by the low-gain signal. This voltage is the sum of voltage generated by any scattered particle light and the voltage offset that the system constantly adds to reduce noise. In situations where no particles are present, this channel should stay relatively constant and reflect only the voltage offset.

Longitude (deg) An AIMMS-20 and Garmin GPS channel indicating the aircraft's longitude (east-west measurement) in degrees. On the AIMMS-20, a positive longitude indicates a location east of the prime meridian in Greenwich. On the Garmin GPS, PADS displays latitude readings as absolute values.

LWC (g/m^3) *(Liquid Water Content)*: A channel on many instruments indicating the mass of liquid water per unit volume of air. Particle-counting instruments measure LWC by calculating total particle mass and then dividing this number by the sample volume. There is also an instrument called the LWC Hotwire, which estimates LWC using a sensor (see the entry for LWC Hotwire). *Appendix B: Calculations for Derived Channels* provides details on how PADS computes LWC and gives an example calculation.

Note that the CIP Cal and CIP GS windows display a channel named LWC (V). This channel should really be labeled LWC Hotwire (V) and will be fixed in an upcoming version of PADS. See the definition of LWC Hotwire (V) for details on this channel.

LWC – DAT Calc (g/m^3): A channel on the Hotwire LWC. This channel indicates the liquid water content estimate that PADS derives by subtracting the DAT Calc (g/m^3) estimate for dry air term from raw LWC (g/m^3). It gives an accurate estimate of the actual LWC in the air. For calculation details, see the entry "LWC (Liquid Water Content) in g/m^3 – *For the Hotwire LWC*" in *Appendix B*.

LWC – DAT Observed (g/m^3): On the Hotwire LWC, the liquid water content estimate that PADS derives by subtracting the DAT Observed (g/m^3) estimate for dry air term from raw LWC (g/m^3). This channel gives an accurate estimate of the actual LWC in the air. This is identical to the **LWC – DAT Calc (g/m^3)** except P_d is taken from the averaged, observed power measured when out of cloud and when the button is depressed to average these values.

LWC Hotwire (g/m^3): A channel on the CAPS and CCP summaries that is taken from the Hotwire LWC instrument. It corresponds to the Hotwire LWC's **LWC-DAT Calc (g/m^3)** channel.

LWC Hotwire (V): The voltage that is proportional to the power required to maintain the fixed temperature of the Hotwire Liquid Water Content Sensor. This voltage will vary depending on the water content in the air and the air density, viscosity, and velocity. In theory, the LWC Hotwire (V) reading reflects power needed to offset convective, radiative, and latent heat of vaporization losses. In practice, radiative losses are negligible, and the LWC Hotwire (V) reading reflects only convective losses and those due to vaporization. By calculating the power required to offset convective losses and subtracting this from the LWC Hotwire (V) total, PADS can determine the amount of power necessary to offset heat losses due solely to vaporization, and then derive an estimate of LWC (g/m^3).

The LWC reading for some probes, such as the CIP, is in fact calculated using another method (see "LWC" entry in *Appendix B: Calculations for Derived Channels*). However, the LWC Hotwire's reading can also be useful, as the hotwire measures LWC for a different range of particle sizes using a different mechanism. To see the LWC derived from the hotwire, click on the "Hotwire_LWC" tab and look at the "LWC raw" indicator. (If no Hotwire_LWC tab exists, then your instrument does not have a hotwire.)

The LWC Hotwire (V) reading for individual instruments may stay set to zero in the following circumstances:

- No hotwire is present
- The hotwire is wired to a different instrument (see **Hotwire Source** on the Setup tab to see your hotwire reading source)

For example, say you have a CIP and a CAS, and your instrument is configured so that the hotwire data are sent to the CAS. The CAS tab will show the voltage reading for the LWC hotwire, and the Hotwire_LWC tab will give specifics on hotwire data. However, the LWC Hotwire (V) indicator on the CIP screens may be zero, since the CIP is not reporting hotwire data.

Note that if a CIP and CAS are both present, the CAS's version of LWC Hotwire should take precedence. This preference should be indicated on the Setup tab.

In general, LWC Hotwire (V) readings fall between 0.0 - 1.5 V when no clouds are present and increase in clouds. A constant LWC Hotwire reading of 10 (the maximum value) indicates a potential problem with the LWC hotwire element, which is a consumable product that occasionally needs replacement. If an instrument that supports an LWC Hotwire does not have a hotwire wired to it, the voltage reading is irrelevant and can be ignored.

LWC raw (g/m^3): A channel on the Hotwire LWC. This channel indicates the liquid water content that would be present if all of the LWC Hotwire (V) power were dedicated to offsetting latent heat loss due to vaporization. In practice, some of this power is dedicated to offsetting convective heat losses as well. However, by calculating LWC raw (g/m^3) and then subtracting either the calculated or the observed LWC DAT (g/m^3), PADS derives an accurate estimate of actual LWC (g/m^3). See *Appendix B* for details on how PADS calculates LWC raw, see the entry "LWC (Liquid Water Content) in g/m^3 – *For the Hotwire LWC*" in *Appendix B.*

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LWC Slave (V) / LWC_Slave_Monitor (V): A voltage proportional to the power used by the end sections or "slaves" of the LWC Hotwire, which are used as active insulators. The slave voltage is not used in calculating LWC; rather, the slaves maintain a constant temperature for the measurement section of the LWC hotwire, which makes the device more accurate. An LWC Slave reading of more than five volts reflects a problem with the device. If the slave coils are not functioning properly, the master coil will lose heat transversely out of its ends and the subsequent derived LWC will be an underestimate of the actual LWC. On the CAPS and CCP summaries, this channel is taken from the Hotwire LWC instrument.

Masked Baseline (V): See **Qualifier Baseline (V).**

Max CIP Size for MVD: See **CIP Max Size (µm).**

Median Volume Diameter (MVD) (µm): The droplet diameter which divides the total water volume in the droplet spectrum such that half the water volume is in smaller drops and half is in larger drops. See *Appendix B: Calculations for Derived Channels* for more details and an example calculation.

Mid_Gain_Baseline (V) An SPP-200 / PCASP-100X that stores the average voltage registered by the mid-gain signal. This voltage is the sum of voltage generated by any scattered particle light and the voltage offset that the system constantly adds to reduce noise. In situations where no particles are present, this channel should stay relatively constant and reflect only the voltage offset.

Min Slice Count: By setting the minimum slice count parameter, you can instruct PADS to store images only of larger particles. The probe will not retain any images of particles smaller than the minimum slice count. Each slice has a width of the probe resolution, so a minimum slice count of four on a instrument with 25 µm-resolution means that particles smaller than 100 µm will not be saved as images. Setting the value to zero means that all images will be recorded. Raising the minimum slice count helps conserve storage space on the computer disk and in very high concentrations will also prevent losing information due to limitations related to transmission bandwidth. Note that particles that are not saved as images will still be sized and used to create the 1D size distributions that are transmitted at a constant rate to the computer from the probe. It is recommended that this parameter be set to zero in most cases unless you are operating the system in an environment where concentrations are extremely high, such as in sprays, where the number concentration can exceed several thousand per liter.

On the MPS, it is difficult to estimate particle size using slice counts, since smaller particles may have a slower speed than the MPS attributes to them (see *Appendix B* of the *PADS MPS Module*). As a result, it is recommended that you set the MPS's minimum slice count to zero and not use this parameter to try to eliminate smaller particles from imaging.

Minutes: See **Time Channels**

MPS ED, MPS LWC, MPS MVD, MPS Numb Conc, MPS Vol: The **ED, LWC, MVD, Number Conc** and **Volume Conc** for the MPS, respectively.

MVD (µm): See **Median Volume Diameter.**

N Value: This parameter determines what fraction of particle images get saved. Its default is one, meaning that all images are saved. Increasing the value decreases the number of images by a factor of N. So if N = 3, PADS will only save every third image. Raising the N value helps conserve disk storage space and limits transmission losses. Unless disk space is an issue, it is recommended that all images are saved.

Nafion Temp (C): A CCN channel indicating the temperature at the Nafion humidifier. When **Nafion Temp (C)** differs substantially from its set point for a sustained period, the CCN computer generates an **Alarm Code**. See the *CCN Software Manual* for details.

Num Conc or **Number Conc (#/cm^3)** *(Number Concentration)*: The **Particle Number Concentration** in sized particles per cubic centimeter of air. On the CCN, number concentration is calculated as follows:

 # Conc = [(Sum of qualifying Bin Counts) + (ADC Overflow)] / Sample Flow • 60

The 60 is a unit conversion factor, since **Bin Counts** and **ADC Overflow** are given in particles per second while **Sample flow** is in cm^3/min. The CCN's **# Conc** includes oversized particles but does not include particles in bins smaller than the **Bin Setting.** When **# Conc** falls below its threshold for a sustained period, the CCN computer generates an **Alarm Code.** See the *CCN Software Manual* for details.

OPC Temp (C): The temperature of the CCN's optical particle counter. When **OPC Temp (C)** differs substantially from its set point for a sustained period, the CCN computer generates an **Alarm Code**. See the *CCN Software Manual* for details.

Optic Block Temp (C): The temperature at the optical block that houses the receiving optics. On the BCP, this temperature should not exceed 45 ºC. ***NOTE for FM-100 Customers:*** FM-100s manufactured after June 2009 store the **Dump Spot Monitor** in the housekeeping channel that was formerly the **Optic Block Temp**. If you have an FM-100 manufactured after this date, the Optic Block Temp will actually store the raw A/D count from the dump spot monitor. If you have an earlier version of the FM-100 but an updated version of PADS (2.8.1 or later, but earlier than 3.5), you will need to apply a conversion formula to the **Optic Block Temp (C)** reading to obtain a temperature in °C. For more information, see Appendix B of the *FM-100 Module for the PADS Operator Manual (DOC-0181*).

Optional_temp_*i*, Optional (X Position), Optional (Y Position), Optional (Pressure 1-3), Optional (Temperature), Optional (Flow), and **Optional (Density):** These channels are reserved for internal use.

Over Range: A BCP channel that stores the number of detected particles that are oversized. The BCP does not bin these particles.

Over_rej_count / Oversize Reject Count: A channel on imaging probes indicating how many particles were rejected for counting because they obscured both end diodes.

P Dry Calculated (W): A channel in the Hotwire LWC output file that tracks the power that the hotwire sensor dissipates due to calculated dry air term. This channel is identical to **Dry Air Term Calculated (g/m^3)** *except the units are kept in Watts.* **P Dry Calculated** is the amount of cooling that is caused by air passing the sensor. In cloud-free air, this cooling is measured by the amount of power required to keep the sensor at a constant temperature. When in clouds, the dry air term cannot be directly measured due to the presence of water, but it can be calculated using an empirical equation. See the entry for **P Dry Calculated (W)** in *Appendix B.*

P Total (W): A channel in the Hotwire LWC output file. P Total is the total power required to keep the hotwire sensor coil at the target temperature specified on the instrument configuration editor screen. This power is the sum of the power the sensing wire dissipates through losses of convective heat (i.e., dry air term) and latent heat of vaporization. In theory, radiative heat losses also contribute to P Total, but these are so negligible that PADS ignores them.

PADS Time: A channel in the PBP output file of the CDP-PGP. **PADS Time** is the time at which PADS receives the PBP data. This will be identical for all the particles that were received by PADS in a single data packet.

Parameters: Data inputs that PADS requires. These are stored in the configuration files. For instance, "Display Range" is a parameter that tells PADS how far back it should display data.

Particle: An indicator on the CIP Data screen; see **Particle Counter**.

Particle Concentration: The measured particle number concentration—physically, the number of sized particles in a unit volume of air.

Particle Count: A field on the CIP Realtime Images tab that indicates the total number of particles detected during the entire session. This number rolls over at approximately 65,000.

Particle Counter: The number of particles of all sizes the instrument has detected during the current sampling instance. This number includes sized particles but also particles rejected for sizing because they fell outside the depth of field or because they obscured one or more end diodes on imaging instruments.

PBP Avg IPT (msec): A CAS_POL_PBP channel that stores the average inter-arrival particle time for particles observed in the particle-by-particle analysis.

PBP IPT Std Dev (msec): A CAS_POL_PBP and CDP_PBP channel that stores the population standard deviation from the mean inter-arrival particle time. The sample includes all particles observed in the particle-by-particle analysis during the current sampling instance. For information on how PADS calculates PBP IPT Std, see *Appendix B*.

Peak Max Width (usec): A parameter on the PCASP-X2 Configuration Editor screen that sets the maximum length of time that a particle can be illuminated in order for it to be sized by the instrument. Resolution is to 0.1 µs, and a value of 100 is recommended. The Peak Max Width parameter helps ensure data accuracy by rejecting signals that most likely have been generated by particles outside the sample area.

Peak Min Width (usec): A parameter on the PCASP-X2 Configuration Editor screen that sets the minimum length of time that a particle must be illuminated in order for it to be sized by the instrument. Resolution is to 0.1 µs, and a starting value of 1 is recommended for this parameter. If bin 1 shows too much noise, increase this time. If bin 1 seems empty, decrease the Peak Min Width. The Peak Min Width parameter helps ensure data accuracy by rejecting signals that most likely have been generated by electronic noise or particles that pass through the edge of the beam and should not be counted.

Peak Width Threshold: A control on the SPP-200 / PCASP-100X that sets the minimum length of time that a particle must be illuminated in order for it to be sized by the instrument. Peak Width Threshold is measured in clock ticks, and a value of 20 is recommended. (20 clock ticks = 1 μs.) The Peak Width Threshold parameter helps insure data accuracy by rejecting signals that most likely have been generated by electronic noise or particles that pass through the edge of the beam and should not be counted.

Photodiode_[1-4] These CAS and CAS_POL_PBP channels do not currently have any functionality.

PIP_ED, PIP_LWC, PIP_MVD, PIP_Numb: The **ED, LWC, MVD,** and **Number Conc** for the PIP, respectively.

Pitch angle (deg) An AIMMS-20 channel that stores the bank angle of the aircraft, with zero degrees indicating that the plane's nose and tail are level with the local horizontal plane. Pitch is positive when the aircraft's nose is up. For more information, see en.wikipedia.org/wiki/Flight_dynamics.

Pitot Pressure: See **Diff Pressure. Pitot Pressure (mB)** is a channel on CAPS and CCP summaries derived from the **CIP Diff_Press** channel. **Pitot-static Pressure (mBar)** is also a channel on the ADP that stores the dynamic pressure uncorrected for dynamic heating.

Pitot-Static Tube System: A device mounted on aircraft and DMT instruments to measure static and total pressure. Pitot tubes have an open port pointing directly into the airflow, which measures the stagnation (total) pressure. They also have ports on their sides that measure static pressure. Dynamic pressure can then be calculated by subtracting the static pressure from the stagnation pressure.

The Pitot-Static tube system measures pressure using transducers, which output a voltage. PADS then converts these voltage readings to pressure (mBar) measurements using the following formula:

*Pressure = (Press Slope) * (Voltage) + Press Y-int*

Where *Press Slope* and *Press Y-int* are constants that depend both on the probe and on the type of pressure being measured.

Static pressure reflects the altitude at which the aircraft is flying, while the dynamic pressure is proportional to the air speed. For more on how PADS calculates air speed, see **True Air Speed**.

Prandtl Num Dry: A channel on the Hotwire LWC output file. The Prandtl number is the viscosity divided by the thermal conductivity. PADS calculates **Prandtl Num Dry,** Pr_d, as follows:

$$Pr_d = \frac{v_d}{k_d}$$

where

v_d = Viscosity Dry (g/sec-cm) = $f(T_{flm})$

k_d = Thermal Cond Dry (sec-cm-K) = $f(T_{flm})$

Prandtl Num Wet: A channel on the Hotwire LWC output file. The Prandtl number is the viscosity divided by the thermal conductivity. PADS calculates **Prandtl Num Wet,** Pr_w, as follows:

$$Pr_w = \frac{v_w}{k_w}$$

where

v_w = Viscosity Wet (g/sec-cm)

k_w = Thermal Cond Wet (sec-cm-K)

Press_Temp (C): A channel in the CIP GS output file that measures the temperature near the pressure transducer. The pressure transducer sits on top of a heating element that regulates its temperature to be near 25° C. In practice, the actual temperature moves through a cycle where it dips slightly below and then rises slightly above 25° C. If the Press_Temp falls dramatically, this indicates a problem with the system.

Pressure Offset: See **Static Press Y-int.** Note that the PCASP-X2's pressure sensor reading is converted from bits rather than volts.

Pressure Slope: See **Static Press Slope.** Note that the PCASP-X2's pressure sensor reading is converted from bits rather than volts.

Pressure Source: A PCASP-X2 parameter that sets the pressure source used in calculating volumetric flows from mass flows. There are three possible options for this setting:

1.) *Local* – This instructs PADS to use the output from the PCASP-X2's pressure sensor for calculations. Local is the default option. It typically results in the most accurate conversion calculation, since it measures pressure at the point where air is flowing into the instrument.

2.) *Manual* – This instructs PADS to use a pressure value that the user has entered manually. The default manual value is listed to the right of the Pressure Source parameter on the Configuration Editor screen. The manual option can be useful if the PCASP-X2's sensor is not functioning properly. In this case, the manual value is written to the Pressure channel in the data file so that there is a permanent record of the value that was used in the calculation.

3.) *Global* – This instructs PADS to use the global pressure from the master source specified on the Setup Screen. This setting is rarely used. Note that the global source can be set to PCASP-X2, in which case the pressure values used will be the same as in setting 1. The global source can also be set to manual, which is different than when the Pressure Source parameter is directly set to manual. In the former case, the default manual setting is listed on the Setup tab, not in the PCASP-X2 Configuration Editor screen. The global source can also be another instrument if the system has other instruments besides the PCASP-X2.

Probe Resolution: This parameter indicates your probe's resolution in microns (μm). Because this was set at the time of manufacturing, you should not need to modify this parameter. In fact, doing so may compromise your data. This is because PADS uses the Probe Resolution number specified on the instrument Config Editor window to determine particle size and sample volume.

Prop Valve (V): A CCN channel that stores the voltage the computer sends to the proportional valve to keep the CCN's air flow constant.

Pump Control: A control on some instruments with pumps that specifies whether the instrument's pump should turn on when PADS starts acquiring data. The default setting is on. In some cases, such as if the instrument is being calibrated, the technician may want to use this control to turn off the pump.

Qual_Heat_Sink_T / Qual Heat Sink Temp (C): A channel on the CAS and CAS_POL_PBP that stores the temperature of the qualifying detector's heat sink. The heat sink is located just outside the detector itself, and it ensures that the thermal electrical cooler inside the detector hasn't failed. The heat sink temperature should stay near 25° C.

Qual_Hi_Gain_Volt / Qual High Gain Baseline (V): A channel on the CAS and CAS_POL_PBP that stores the average voltage registered by the qualifying detector's high-gain signal. This voltage is the sum of voltage generated by any scattered particle light and the voltage offset that the system constantly adds to reduce noise. In situations where no particles are present, this channel should stay relatively constant and reflect only the voltage offset.

Qual_Lo_Gain_Volt / Qual Low Gain Baseline (V): A channel on the CAS and CAS_POL_PBP that stores the average voltage registered by the qualifying detector's low-gain signal. This voltage is the sum of voltage generated by any scattered particle light and the voltage offset that the system constantly adds to reduce noise. In situations where no particles are present, this channel should stay relatively constant and reflect only the voltage offset.

Qual_Mid_Gain_Volt / Qual Mid Gain Baseline (V): A channel on the CAS and CAS_POL_PBP that stores the average voltage registered by the qualifying detector's mid-gain signal. This voltage is the sum of voltage generated by any scattered particle light and the voltage offset that the system constantly adds to reduce noise. In situations where no particles are present, this channel should stay relatively constant and reflect only the voltage offset.

Qual TEC Temp (C): See **Qualifier_TEC_Temp.**

Qualifier Baseline (V): The instantaneous voltage registered by the qualifier detector. This voltage will vary considerably based on whether particles are present at the time of the reading. When no particles are present, the signal baseline should range from .29 - .33 volts.

Qualifier_TEC_Temp / Qual TEC Temp (C): A channel on the CAS and CAS_POL_PBP that stores the temperature of the qualifying detector's thermal electrical cooler. The TEC is internal to the detector and keeps the detector's temperature constant, ensuring accurate readings. Qualifier_TEC_Temp should stay near 25° C.

Quality: A channel on the Garmin GPS that indicates the quality of the GPS reading. A value of 0 indicates a fix is not available. A value of 1 indicates a fix is available. The hardware supports other codes, but they should never appear in system. For more details, consult Garmin's *GPS 15H & 15L Technical Specifications* document.

Rain Rate (mm/hr): An MPS channel indicating the depth of water that would accumulate over a unit area during the period of an hour. See *Appendix B* for information on how PADS calculates Rain Rate.

Recovery Temperature (C): The temperature of the air immediately in contact with the probe. For further information see Appendix B, Section 7 of Bulletin #9 from the National Center for Atmospheric Research's Research Aviation Facility (RAF), available online at http://www.eol.ucar.edu/raf/Bulletins/b9appdx_B.html#THERMO

Refresh Time: An input parameter on the Telemetry Config Editor screen that specifies 1.) the interval at which data will get refreshed in the PADS display and 2.) the interval at which telemetry data is sent over the COM port.

Rej_DOF: See entry for **DOF_Rej_Counts**.

Rej_Transit: A CDP channel indicating the number of particles the probe rejected for sizing because their transit time was too long. A long transit time indicates that the laser light scattering may have been caused by something other than the detected particle, such as water on one of the probe's windows. Omitting these cases thus gives more accurate estimates of particle sizes. Particles with transit times that exceed 100 µs are rejected for counting.

Relative Humidity% (RH%): A measurement of the water vapor that exists in a mixture of air and water vapor. It is calculated as follows:

$$RH\,\% = \frac{p(H_2O)}{p^s(H_2O)} * 100\,\%$$

where $p(H_2O)$ = the partial pressure of the water vapor

and $p^s(H_2O)$ = the vapor pressure when the air is saturated at a prescribed temperature

Reset_Flag: A channel reserved for internal use.

Resolution: See **Probe Resolution.**

Reynolds Number: A channel on the Hotwire LWC output file used in LWC Calculations. See *Appendix B* for details.

RH: An output channel on the ADP that stores the percent relative humidity, uncorrected for dynamic heating.

RH Dynamic: An output channel on the ADP that stores the relative humidity corrected for dynamic heating and pressure change at the sensor housing.

RH Slope: This is the relative humidity (RH) slope used in the linear function to derive relative humidity from a relative humidity sensor, as follows:

*RH = **(RH Slope)** * (bits) + RH Offset*

RH Slope is a calibration coefficient measured by the sensor's manufacturer. Do not change this parameter without consulting DMT first.

RH Offset (called **RH Y-int** on some instrument screens)**:** This is the intercept term used in the linear function to derive relative humidity from a relative humidity sensor, as follows:

*RH = (RH Slope) * (bits) + **RH Offset***

RH Offset is a calibration coefficient measured by the sensor's manufacturer. Do not change this parameter without consulting DMT first.

Roll Angle (deg) An AIMMS-20 channel that stores the bank angle of an aircraft, with zero degrees indicating that the wings on a fixed-wing aircraft are level with the local horizontal plane. The roll angle indicates rotation about the aircraft's longitudinal axis and is positive when the right wing is down. For more information, see en.wikipedia.org/wiki/Flight_dynamics.

Sample Area: A parameter on light-scattering probes that indicates the physical area in which particles are detected. On light-scattering instruments, sample area is a constant regardless of particle size. This value is preconfigured to match your instrument, so do not change it.

Sample Flow: Sample Flow is a channel on several instruments, as described below.

CCN:

On the CCN, **Sample Flow (cm^3/min)** stores the volumetric sample flow rate. The sample flow is not calculated by PADS but rather read in directly from the CCN data packet. Typically the ratio of sample flow to sheath flow should be about 1:10, since the volume of sheath air should be about ten times more than that of the sample air. If the observed ratio diverges significantly from the set-point ratio for a prolonged period, the CCN computer generates an **Alarm Code**. See the *CCN Software Manual* for details.

SPP-200 / PCASP-100X

On the SPP-200 / PCASP-100X, **Sample_Flow (std cm^3/s)** stores the mass flow rate of the sample gas at standard pressure and temperature conditions, usually 1013.25 mBar and 0º C. The instrument measures mass flow and converts it to volumetric flow for concentration calculations.

Also on the SPP-200 / PCASP-100X, **Sample Flow(vol cm^3/s)** stores the sample volume flow rate, i.e. the volumetric flow at ambient pressure and temperature. This flow is usually set at the factory during calibration to a value of 1 cm^3/sec for standard pressure and temperature. Since volumetric flow nominally stays constant regardless of ambient conditions, this channel should stay constant during flight at around 1 cm^3/sec if the pump is operating correctly, there are no leaks in the system, and the mass flow is being correctly converted to volumetric flow rate.

PADS calculates volumetric sample flow from the sample mass flow rate, **Sample_Flow (std cm^3/s)**. The combination of two gas laws, Boyle's Law and Charles's Law, yields the following relationship between gas volumes under standard and ambient conditions:[3]

$$F_a = F_{std} \bullet \frac{P_{std}}{P_a} \bullet \frac{T_a}{T_{std}} \qquad (1)$$

where

F_a = Sample_Flow (vol cm^3/s)

F_{std} = Sample_Flow (std cm^3/s)

T_a = Ambient temperature (K)

T_{std} = Standard temperature, or 273.15 K

[3] Technically these laws are applied to static volumes of gas, but they can also be applied to flow rates.

P_a = Ambient Pressure (mBar)

P_{std} = Standard sea-level pressure, or 1013.25 mBar

The calculation of particle concentration requires the number of particle counts to be divided by the flow volume for the sample interval. To convert the volume flow rate to a volume, and keep it consistent with the sample time, the flow rate needs to be multiplied by the particle sample rate in terms of seconds/sample or the inverse of the sample frequency:

$$V_a = F_a \bullet t \qquad (2)$$

Where V = volume and t = sample rate. The result is the volume of gas in which the particles were sampled. Dividing this into the number of particle counts will give the concentration in particles/cm^3:

Number_Conc(cts/cm^3) = *Particle Counts* / V_a

The derivation of the sheath flow rates is done in the same way, but this value does not enter into the concentration calculations. It is only used to monitor the quality of the flow, since the ratio of the sheath to sample flow should remain constant.

Sample Temp (C): A CCN channel indicating the temperature of the sample air. When **Sample Temp (C)** exceeds its range for a sustained period, the CCN computer generates an **Alarm Code**. See the *CCN Software Manual* for details.

Sample Time: This parameter shows the time interval you'd like between samples. For some instruments, sample time should always be set to one second / one Hertz; see individual instrument manuals for details. Note that if you increase the sample time, you will still collect data for the same number of particles. This is because the probe collects data continuously and relays cumulative data at each sampling interval. For example, say you have the sample time set to .5 seconds. You might see four particles of size 25 µm during the first sample, and five particles of this size during the second sample. If you had set your sample time to one second instead of .5 seconds, you would instead get one sample that showed nine particles of size 25 µm.

Satellites: A channel on the Garmin GPS that indicates the number of satellites in use. This can range from 0 – 12. For more details, consult Garmin International, Inc., which manufactures the Garmin GPS.

Save Binary Data: A box on the AIMMS-20 Config Editor screen. When this box is checked, PADS creates an extra output file that stores the AIMMS-20's data stream in binary format as it comes across the serial port. There is no tool for viewing this data in an accessible format. It is intended solely as a diagnostic to be sent to Aventech, the AIMMS-20's manufacturer, as necessary. The default setting for this parameter is off.

Seconds: See **Time Channels**

Sec to Buffer: The number of seconds that PADS stores data acquired by the instrument in its memory. One hour has been chosen as the default setting because this is the maximum length of time that data can be stored without taxing computer memory.

Sheath Flow: Sheath Flow is a channel on several instruments, as described below.

CCN

On the CCN, **Sheath Flow (cm^3/min)** stores the volumetric flow rate of the sheath air. The sheath flow is not calculated by PADS but rather read in directly from the CCN data packet. Typically the ratio of sheath flow to sample flow should be about 10:1, since the volume of sheath air should be about ten times more than that of the sample air. If the observed ratio diverges significantly from the set-point ratio for a prolonged period, the CCN computer generates an **Alarm Code**. See the *CCN Software Manual* for details.

SPP-200 / PCASP-100X

On the SPP-200 / PCASP-100X, **Sheath Flow (vol cm^3/s)** stores the volumetric flow of the sheath gas at ambient pressure and temperature. Using two gas laws (see the entry for **Sample_Flow(vol cm^3/s)**), PADS uses equation 1 to calculate this value from the mass sheath flow rate, **Sheath_Flow(std cm^3/s).**

Also on the SPP-200 / PCASP-100X, **Sheath_Flow(std cm^3/s)** stores the mass flow of the sheath gas at standard pressure and temperature, usually 1013.25 mBar and 0º C. The instrument measures mass sheath flow and converts it to volumetric flow. The sheath is the volume of air around the sample volume that serves as a buffer to keep the sample volume from dispersing inside the instrument. It ensures that the entire sample flow passes through the laser.

Sideslip angle (deg) A channel on the AIMMS-20 that stores the angle the relative wind flow vector makes with the principal / longitudinal axis of the aircraft in the horizontal plane. The sideslip is positive when the relative wind flows such that it falls to right of the aircraft's centerline.

Sideslip Differential / Sideslip Pressure Diff (mBar): A channel on the AIMMS-20 and ADP that is calculated as follows:

$$\text{Sideslip Differential} = p_r - p_l$$

where

p_r = the pressure in mBar at the right port on the hemispherical tip of air-data probe

p_l = the pressure in mBar at the left port on the hemispherical tip of air-data probe

and right and left are defined when facing the direction of flight.

Signal Baseline (V): The instantaneous voltage registered by the sizing detector. This voltage will vary considerably based on whether particles are present at the time of the reading. When no particles are present, the signal baseline should range from .29 - .33 volts.

Size (counts) A channel in the CDP_PBP's particle-by-particle output file. This channel stores the peak digital signal detected by the instrument's optics. This value is not linearly proportional a particle's size, but rather to the particle's optical-scattering cross-section. PADS then determines particle size from this value. A Size (counts) value of 4095 indicates the detector has been saturated.

Spare or **Spare_analog_*i*:** An instrument channel reserved for internal use.

SSP200_ED, SSP200_MVD: The **ED** and **MVD**, respectively, reported by the SPP200 / PCASP-100X.

SPP_200_OPC_ch[*i*]: The SPP-200 / PCASP-100X channels that hold particle size data. On a 30-bin PCASP-100X, *i* ranges from 0 to 29. The widths of the PCASP-100X bins vary; PADS uses the threshold tables to find particle sizes for different bins. Standard PCASP-100X bins are 0.01 µm wide for particles up to 0.18 µm, and then are 0.02 µm wide to the upper limit of the SPP_200 range of 3 µm.

SS setting: A CCN channel that stores the instrument's supersaturation setting. A higher **SS setting** means that more particles will be detected. See the *CCN Software Manual* for details.

Static Pressure (mBar): See **Pitot-Static Tube System** for details. Static pressure should correlate with the pressure measurements taken by the aircraft's on-board pitot system. If Static Pressure is zero, or if it stays constant while air speed, temperature, or altitude is changing, this indicates a potential problem with the pressure transducer. Note that Static Pressure readings between different instruments can vary by up to 10%. The CAPS and CCP summaries take their static pressure readings from the CIP. On the PCASP-X2, the static pressure listed in the data window and in the **Pressure** channel in the instrument output file may differ from that used in the calculations to convert mass flows to volume flows. For more details, see the *PADS PCASP-X2 Module Operator's Manual*.

Static Press Slope: This is the slope used in the linear function to derive static pressure from the voltage output of the static pressure transducer, as follows:

*Static Pressure = **(Static Press Slope)** * (Voltage) + Static Press Y-int*

Static Press Slope is a calibration coefficient measured by DMT and specific to your transducer. It assumes a 5-volt sensor range that is electronically multiplied by 2 before going to a 0-10 volt analog-to-digital converter. Do not change this parameter without consulting DMT first.

Static Press Y-int: This is the intercept term used in the linear function to derive static pressure from the voltage output of the static pressure transducer, as follows:

*Static Pressure = (Static Press Slope) * (Voltage) +* ***Static Press Y-int***

Static Press Y-int is a calibration coefficient measured by DMT and specific to your transducer. It assumes a 5-volt sensor range that is electronically multiplied by 2 before going to a 0-10 volt analog-to-digital converter. Do not change this parameter without consulting DMT first.

Status: An indicator that shows whether the probe and PADS had good communication with each other. On some probes, status is currently always set to 1; see individual instrument manuals for details.

Sum_of_DOF: A CAS_POL_PBP channel that stores the sum of particles rejected for counting because they fell outside the instrument's depth of field.

Sum_of_Particles: This CAS channel currently does not have any functionality.

Sum_of_Transit A channel on the CAS and CAS_POL_PBP that stores the total number of sample clocks (currently at 20 MHz) during which a particle was detected in the forward block during the current poll period. This includes all samples, whether correctly qualified or not.

T1 Read (C): The temperature in the CCN's top control zone.
T2 Read (C): The temperature in the CCN's middle control zone.
T3 Read (C): The temperature in the CCN's bottom control zone.

When any of the **T Read (C)** channels differ significantly from their set points, **Temp Stable?** is set to 0. See the *CCN Software Manual* for details.

TAS Source: A switch on the CIP and CIP GS Config Editor windows. This switch sets the source for true air speed that is used for controlling the rate at which images are sampled. The optimum rate will be one sample taken each time a particle moves across the array by one resolution step. For example, for a 25-µm resolution instrument, if the air is moving at a velocity of 100 m/sec, the image would be sampled once every 250 nanoseconds, or 25 x 10^{-8} seconds. This insures that the recorded images are not artificially elongated (over-sampled) or truncated (under-sampled).

Setting the value to "Use Host Control Air Speed" tells the probe to use the host computer's version of TAS. (The host computer's source for the TAS reading is in turn set in the Setup tab.) Setting the slide control to "Use On-Board True Air Speed" tells the probe to use its own internal measurement of air speed for clocking. Normally, the "Use Host Control Air Speed" is selected, since this is the airspeed computed from the pitot measurements of one of the probes and is most representative of the particle velocity at the point of measurement.

Note that the TAS source set in the instrument Config Editor window is only used to clock the probe. For calculations that use TAS, PADS uses the source set in the Setup window.

For on-the-ground data collection, TAS Source should be set to "Use Host Control Air Speed." On the Setup window, the TAS source should then be set to "Manual" and an appropriate value chosen, e.g. 25 m/sec if the instrument is using spinning glass disks.

Telemetry Channels: User-specified channels that the PADS Telemetry module will send to a COM port. For more information, see the *Telemetry Module Operator Manual*.

Temp (C): An output channel on the ADP that stores the recovery temperature, i.e. the temperature uncorrected for dynamic heating. This value is labeled "Ambient Temp" in the "Uncorrected Values" column of the **ADP Parameters** box.

Temp (C) Dynamic: An output channel on the ADP that stores the ambient temperature, or temperature corrected for dynamic heating.

Temp Gradient: A CCN channel that stores the temperature gradient along the CCN's wetted walls, i.e. **T3 Read (C)** – **T1 Read (C)**. The gradient is the controlling factor that determines the instrument's supersaturation.

Temp Sensor: See **Ambient Temp Sensor.**

Temperature Source: A PCASP-X2 parameter that sets the temperature source used in calculating volumetric flows from mass flows. There are three possible options for this setting:

1.) *Local* – This instructs PADS to use the output from the PCASP-X2's temperature sensor for calculations. Local is the default option. It typically results in the most accurate conversion calculation, since it measures temperature at the point where air is flowing into the instrument.

2.) *Manual* – This instructs PADS to use a temperature value that the user has entered manually. The default manual value is listed to the right of the Temperature Source parameter on the Configuration Editor screen. The manual option can be useful if the PCASP-X2's sensor is not functioning properly. In this case, the manual value is written to the Block Temp channel in the data file so that there is a permanent record of the value that was used in the calculation.

3.) *Global* – This instructs PADS to use the global temperature from the master source specified on the Setup Screen. This setting is rarely used. Note that the global source can be set to PCASP-X2, in which case the temperature values used will be the same as in setting 1. The global source can also be set to manual, which is different than when the Temperature Source parameter is directly set to manual. In the former case, the default manual setting is listed on the Setup tab, not in the PCASP-X2 Configuration Editor screen. The global source can also be another instrument if the system has other instruments besides the PCASP-X2.

Temp Stable?: A Boolean parameter on the CCN indicating when **T1**, **T2**, or **T3 Reads** differ significantly from their set points. A value of 1 indicates all three channels are close to their set points. If **Temp Stable?** is 0 for a sustained period, the CCN computer generates an **Alarm Code**. See the *CCN Software Manual* for details. Note that **Temp Stable?** indicates temperature stability but does not necessarily indicate data stability, which also depends on other factors.

Terminal Velocity: The velocity of a rain drop in m/sec when it passes through the sample volume of the probe. This velocity varies with particle size, as larger particles have more mass and fall faster.

Thermal Cond Dry (cal/sec-cm-K): A channel on the Hotwire LWC output file. It indicates the thermal conductivity of the air as a function of film temperature, T_{flm}.

Thermal Cond Wet (cal/sec-cm-K): A channel on the Hotwire LWC output file. It indicates the thermal conductivity as a function of sensor temperature, T_s.

Threshold Tables: A parameter in light-scattering instruments that lists the path to the threshold table files. These files are used in sizing particles, and the instrument has two threshold tables associated with it. (PADS only lists one of these tables in the Threshold Tables field, but both are in the directory.) `[Instrument]_t.csv` tells PADS the correct sizing bin for a particle given the peak digital value converted from the light scattered by the particle. `[Instrument]_p.csv` tells PADS the upper size boundary in microns for each sizing bin. Note that the Thresholds Tables field should always be set to the `[Instrument]_t.csv` file, and PADS finds the `[Instrument]_p.csv` file automatically using the same path.

Time: For the **Time** channel in standard output files, see **Time Channels**. For the **Time** channel in the PBP output file of the CDP-PBP, see **Time (in CDP-PBP PBP file).**

Time Channels: Channels that store time data. **Time** is generated by the PADS clock and is the time when PADS receives the instrument's data. The time stamp for a given sampling instance thus equals the time at the end of that sampling instance plus the small time it took for the probe to send the data to PADS. Note that PADS uses the computer clock as its main time source, so the computer clock must be accurate for PADS times to be accurate. It is good practice to synchronize the computer clock to an accurate reference before starting PADS. **Time** is measured in seconds after midnight on the day the program was started. **Hours, minutes, seconds,** and **milliseconds** are channels on imaging probes that reflect the time when the probe gathered the data. Because this time may differ from the time when PADS received the data, the time in **Time** and that given by **hours, minutes, seconds** and **milliseconds** may vary slightly. **GPS**

Time is included in every instrument's list of channels whenever a GPS is included as one of the PADS instruments. Note that time channels may vary by instrument. The AIMMS-20, for instance, transmits two data packets to PADS; Hours, Minutes and Seconds describe the time the first data packet was sent, while Hours 2, Minutes 2, and Seconds 2 describe the time the second data packet was sent.

Time (in CDP-PBP PBP file): The time when the CDP-PBP detects a PBP particle, given in seconds after midnight on the day the program was started. Note that these PADS channels differ from the per-particle times in the CDP-PBP serial stream data. The latter are 20-bit numbers indicating the time between the first observed particle in the sampling instance and the current particle. The **Time** channels PADS generates are the sum of three factors: 1.) the 20-bit particle time, 2.) the 48-bit time stamp of the first particle, which is the time between probe initialization and the first particle in the sampling instance (this time stamp is sent as a header to the PBP data), and 3.) the time in seconds after midnight at which the probe was initialized.

Total Flow (cm^3/min): A CCN channel that stores the sum of the **Sample Flow** and the **Sheath Flow.** When the **Total Flow** deviates from its set point for a prolonged period, the CCN computer generates an **Alarm Code.** See the *CCN Software Manual* for details.

True Air Speed: The speed of the probe relative to the air it's flying in. For information on how this is calculated, see *Appendix B: Calculations for Derived Channels*. Note that True Air Speed often does not measure the aircraft's speed, which differs from the air speed at the probe. Due to flow distortions caused by the structure of the aircraft and the instrument, the flow velocity at the probe will not be that of the free stream. However, PADS needs to know the air speed at the probe in order to calculate sample space volume accurately.

Use as Master [*Parameter*]: Controls on an instrument's Config Editor window that indicate whether that instrument is the master source for the parameter's value.

Use Part. Width: A parameter on imaging probes that indicates whether to use particle width, rather than particle length, to size particles. The default and recommended setting is enabled. **Use Part. Width** should always be enabled on the MPS, which can only size particles based on width.

V_ref_1.24 (V): A channel in the CIP GS output file that indicates how accurately the ambient temperature sensor is calibrated. The sensor is calibrated so that the V_ref_1.24 (V) channel should read 1.24 volts. If this channel varies from 1.24 volts by more than 1%, the system's ambient temperature readings will be inaccurate.

Velocity D (m/s): An AIMMS-20 channel indicating the aircraft's downward velocity given in m/sec.

Velocity E (m/s): An AIMMS-20 channel indicating the aircraft's velocity in the easterly direction given in m/sec.

Velocity N (m/s): An AIMMS-20 channel indicating the aircraft's velocity in the northerly direction given in m/sec.

Vertical Wind (m/s) : An AIMMS-20 channel indicating the downward directional velocity of the wind.

Vis_lambda[AAA]to[BBB]nm_km: FM-100 Extinction channels that store the visibility in km for all particles of all measured sizes for spectral band AAA-BBB nm. For information on how PADS calculates visibility, see *Appendix B* of the *PADS Manual FM 100 Extinction Module*.

Viscosity Dry (g/sec-cm): A channel on the Hotwire LWC output file that is used in calculating the Prandtl and Reynolds number and ultimately the LWC. Viscosity measures a fluid's resistance when the fluid is being subjected to shear stress or extensional stress. Viscosity Dry (g/sec-cm), v_d, is a function of the film temperature, T_{flm} . For details on calculations, see the entry for **Viscosity** in *Appendix B.*

Viscosity Wet (g/sec-cm): A channel on the Hotwire LWC output file that is used in calculating the Prandtl and Reynolds number and ultimately the LWC. Viscosity measures a fluid's resistance when the fluid is being subjected to shear stress or extensional stress. Viscosity Wet (g/sec-cm), v_w, is a function of the sensor wire temperature, T_w. For details on calculations, see the entry for **Viscosity** in *Appendix B*.

Vol Conc/Volume Conc (µm^3/cm^3) *(Volume Concentration)*: The summed volume of sized particles in unit volume of air. See "Sample Volume" in *Appendix B: Calculations for Derived Channels* for information on how PADS calculates sample volume.

Voltage (V): A channel on the Anemometer_NI that records the device's raw voltage output. PADS converts this measurement into a TAS reading using the conversion equation specified in the Anemometer_NI's **Config Editor** screen.

Wind Direction (deg): An AIMMS-20 channel indicating the direction that the wind is coming *from*. This reading is based on 20 of the latest 5-Hz North and East wind component updates with valid wind solutions. Specifically, it is the direction of the four-second mean flow vector, with direction flipped 180º to accommodate the meteorological convention of reporting the direction the wind is flowing *from*.

Wind Flow E Comp. (m/s): An AIMMS-20 channel indicating the vector component of the wind that is going *to* the east in m/sec. A negative reading indicates the wind is flowing to the west.

Wind Flow N Comp. (m/s): An AIMMS-20 channel indicating the vector component of the wind that is going *to* the north in m/sec. A negative reading indicates the wind is flowing to the south.

Wind Solution An AIMMS-20 channel that indicates valid wind data readings. A value of 1 indicates a valid wind solution, which depends on three conditions: [4]

1.) The attitude solution is running. The attitude solution provides roll, pitch, heading and inertial velocity components of the aircraft. To generate this data, the AIMMS-20 requires valid navigation solutions from both GPS processors and a minimum of four matched satellite pairs (i.e., the two GPS processors can see at least four satellites in common).
2.) The pitot-static pressure reported from the air-data probe is above a threshold of 200 Pa / 2 mBar (for fixed-wing aircraft), and 50 Pa / .5 mBar (for helicopter setups).
3.) The purge-valve sequence is not in effect. (This condition is applicable to canister models that have this option installed.)

Wind Speed (m/s) An AIMMS-20 channel indicating the total wind speed in m/sec. This reading is based on 20 of the latest updates with valid wind solutions. Specifically, it is a four-second average of 5 Hz North and East wind component data. (The vertical component is not included.) There are typically differences between the instantaneous component values and the slightly smoothed wind speed channel.

Window Temp (C) / Window Temp (V): The temperature recorded at one of the MPS windows. This temperature reading controls the temperature at both windows; if it drops too low, the heaters start up. Healthy window temperature readings range between 25° – 30° C. *Note:* on the options for MPS selectable charts, window temperature is listed in volts. In fact, the chart displays temperature in degrees, as it should. The incorrect label is a bug that will be fixed in an upcoming version of PADS.

Wingboard_Gnd (V): A CDP channel that indicates the ground current for the wingboard or chassis, which is separate from the digital circuit. Wingboard_Ground should be 0.0 - 0.3 volts.

[4] Information obtained from Aventech Research Inc., which manufactures the AIMMS-20.

Wingboard_Temp_(C): A channel on the CDP that indicates temperature at the CDP's signal and power distribution board. This temperature gives an idea of the average temperature of the probe body. Wing_Board_Temp should be a few degrees higher than ambient outside temp, since the board is enclosed in the probe canister and since electronics heat it up.

Yaw angle (deg) An AIMMS-20 channel indicating the angle between the aircraft's longitudinal axis and true north when looking down onto the horizontal plane. Positive sense for yaw rotation is nose to the right—clockwise when looking down—resulting in increasing true heading.

Appendix B: Calculations for Derived Channels

Calculations for derived channels can vary by instrument. In cases where different instruments have different calculations to derive the same channels, the explanations indicate which instrument(s) they are referring to.

Air density (kg/m^3): PADS calculates air density, ρ_a, according to the formula below.

$$\rho_a = \frac{P}{T_a} \bullet 0.348388$$

where

P = Static pressure (mBar)

T_a = Ambient temperature[5] (K)

This air density reading, which depends on ambient temperature, differs from the air density used in calculating the Hotwire LWC's Reynolds number. The latter air density, ρ_d, depends on film temperature and is calculated as follows:

$$\rho_d = \frac{P}{T_{flm}} \bullet 0.348388$$

where

P = Static pressure (mBar)

T_{flm} = Film temperature (K) = $(T_{wire} + T_a)/2$

T_{wire} = Wire temperature

[5] PADS currently use the measured temperature rather than the ambient temperature in this calculation. This is a known bug that will be fixed in an upcoming version of the program.

Ambient Temperature: As stated in the definitions appendix, PADS actually displays the measured temperature in the display fields marked as ambient temperature. The measured temperature is higher than the ambient temperature because the air warms by compressional heating near the temperature sensor. This additional heating is a function of the air velocity and can be calculated using Bernoulli's equation. PADS applies this correction to derive ambient temperature for calculating other temperature-dependent channels, such as true air speed, and the corrected ambient temperature will be reported correctly in future versions of PADS. To convert measured temperature to ambient temperature, the program uses the following standard formula derived from Bernoulli's equation:[i]

$$T_a = \frac{T_m}{1 + M^2 r \frac{\gamma - 1}{2}}$$

Where

T_a	=	Ambient Temperature (°K)
T_m	=	Measured Temperature (°K)
M	=	Mach number (see **Mach Number** entry for calculations)
r	=	Recovery factor, which PADS currently sets to 1 but is probe-dependent and will be adjustable in future versions of PADS
γ	=	1.403509, the ratio of specific heat for dry air at a constant pressure (0.24 cal/gK) to specific heat for dry air at constant volume (0.171 cal/gK)

This formula is taken from Appendix B, Section 7 of Bulletin #9 from the National Center for Atmospheric Research's Research Aviation Facility (RAF). The bulletin is available online at http://www.eol.ucar.edu/raf/Bulletins/b9appdx_B.html#THERMO

After PADS calculates T_a in °K, it converts the result to °C.

Depth of Field: Calculation of depth of field varies by instrument. For depth of field calculations for the CIP and CIP GS, see entry for **Sample Volume**. For the CDP and FM 100, Depth of Field is constant for the instrument and is calculated at DMT to match the instrument's specific calibration.

Effective Diameter in μm

Effective diameter is calculated according to the following definition:[ii]

$$ED = \frac{3LWC}{4G\rho_w} \bullet 2$$

Where

LWC	=	Liquid Water Content
G	=	The geometric cross-sectional area of water drops per unit volume
ρ_w	=	The density of water

In practice, PADS calculates the Effective Diameter (ED) in µm of a sample droplet spectrum as follows:

$$ED = \frac{\sum_{i=1}^{n} p_i \bullet r_i^3}{\sum_{i=1}^{n} p_i \bullet r_i^2} \bullet 2$$

where

n	=	the number of sizing bins
p_i	=	the particle count for bin *i*
r_i	=	the mean radius in µm of bin *i*

Example: You have a CIP with a resolution of 25 µm. Say you want to calculate the effective diameter for particles in bins 1-4, which have counts of 100, 200, 300 and 200 respectively. Your data and preliminary calculations are as follows:

Bin #	*Radius*	*Particle count p_i*	*Radius ^ 3*	*Radius ^ 2*	*p_i * Radius ^3*	*p_i * Radius ^2*
1	12.5	100	1,953	156	195,313	15,625
2	37.5	200	52,734	1,406	10,546,875	281,250
3	62.5	300	244,140	3,906	73,242,188	1,171,875
4	87.5	200	669,921	7,656	133,984,375	1,531,250
				SUM:	*217,968,750*	*3,000,000*

Table 3: Calculating Effective Diameter

and then

$$ED = \frac{217{,}968{,}75\ \ 0}{3{,}000{,}000} \bullet 2 \quad = \quad 145.3\ \mu m$$

Warning: Imaging probes currently calculate the effective diameter using the raw particle counts, assuming equal sample volume for all sizes. However, as described in the **Sample Volume** entry, in these instruments sample volume is a function of particle size. PADS does not currently adjust ED to reflect these varying sample volumes. Future versions of PADS will address this issue to give a more accurate ED.

Film Temperature: On a hotwire sensor instrument, the film temperature is the arithmetic average of the sensor temperature and the ambient air temperature. PADS thus calculates film temperature, T_{flm}, as follows:

$$T_{flm} = \frac{T_a + T_w}{2}$$

where

T_a = Ambient temperature[6] (K)

[6] PADS currently uses the measured temperature rather than the ambient temperature in this calculation. This is a known bug that will be fixed in an upcoming version of the program.

T_w = Sensor temperature

PADS uses film temperature in calculating air density, viscosity, and thermal conductivity. The film temperature is also used when calculating Reynolds number because of the air density and viscosity that are temperature-dependent.

Latent Heat of Vaporization: A variable used in Hotwire LWC calculations for LWC. PADS calculates the latent heat of vaporization, L_v, as a function of the boiling temperature of water, T_b, as follows:

$$L_v = 597.3 \bullet \left[\frac{273.16}{T_b} \right]^{T_b \bullet 0.000367 + 0.167}$$

LWC (Liquid Water Content) in g/m^3 – *For Particle-Measuring Instruments*

The following section describes how particle-measuring instruments calculate LWC. For information on how the Hotwire LWC instrument calculates LWC, see the following section. *Most of the information in this section has been copied with permission from the FAA's* Electronic Aircraft Icing Handbook. *The relevant section of the handbook is available online by clicking on the cldpar.doc link at airportaircraftsafetyrd.tc.faa.gov/Programs/FlightSafety/icing/eaihbk.htm.*

Assume a sample droplet spectrum from an icing cloud for a given time interval is available in the following form: n sizing bins are defined by the bin boundaries b_1, b_2, b_3, …, b_n, b_{n+1}, (in µm) so that bin 1 is from b_1 to b_2, bin 2 is from b_2 to b_3, …, bin n is from b_n to b_{n+1}. The bin droplet concentrations for the icing interval have been determined to be c_i droplets per m^3 for i = 1, …, n.

Let m_i be the midpoint of the ith bin, i = 1, 2, …, n.

$$m_i = \frac{b_i + b_{i+1}}{2}$$

The liquid water content LWC_i for the droplets in the ith bin in g/m^3 can be approximated by using the bin midpoint:

$$LWC_i = c_i \bullet 10^{-12} \bullet \frac{\pi}{6} \bullet m_i^3$$

The $\frac{\pi}{6} \bullet m_i^3$ factor approximates the volume for a sphere with radius .5 m_i. The volume of a sphere equals $\frac{4\pi r^3}{3}$, so:

$$\frac{4\pi r^3}{3} = \frac{4\pi(.5)^3 m_i^3}{3} = \frac{4\pi m_i^3}{3 \bullet 8} = \frac{\pi \bullet m_i^3}{6}$$

It is also assumed that water has a density of 1 gram (g) per cubic centimeter (cm^3). 10^{-12} is a conversion factor from cubic microns (μm^3) to cm^3. The units in the equation thus reduce as follows:

$$LWC = 1\frac{g}{\cancel{cm^3}} \bullet \frac{[const]}{m^3} \bullet \frac{\cancel{cm^3}}{\cancel{um^3}} \bullet [const] \bullet \cancel{um^3} = \frac{g}{m^3}$$

Then the LWC for the spectrum can be computed by:

$$LWC = \sum_{i=1}^{n} LWC_i$$

Table 4 illustrates the computation of LWC for a hypothetical instrument.

Bin Number	Bin Boundaries	Droplet Conc	Midpoint	LWC_i
i	b_i	c_i	m_i	
	(microns)	(per m^3)	(microns)	(g/m^3)
1	10 - 20	100000	15	0.00018
2	20 - 30	200000	25	0.00164
3	30 - 40	300000	35	0.00673
4	40 - 50	400000	45	0.01909
5	50 - 60	500000	55	0.04356
6	60 - 70	400000	65	0.05752
7	70 - 80	300000	75	0.06627
8	80 - 90	200000	85	0.06431
9	90 - 100	100000	95	0.04489
10	100 - 110	0	105	0

LWC = 0.3 g/m^3

Table 4: Calculating LWC for a Hypothetical Instrument

$b_1 = 10$, $b_2 = 20$, …, $b_{11} = 110$

$c_1 = 100{,}000/m^3$, $c_2 = 200{,}000/m^3$, …, $c_{10} = 0$

$m_1 = 15$, $m_2 = 25$, …, $m_{10} = 95$

$LWC_1 = .00018\ g/m^3$, $LWC_2 = .00164\ g/m^3$, …, $LWC_{10} = 0\ g/m^3$

Figure 15 shows the LWC plotted against the bin right endpoint on the horizontal axis: i.e., LWC_1 vs. d_2, LWC_2 vs. d_3, …, LWC_{10} vs. d_{11}.

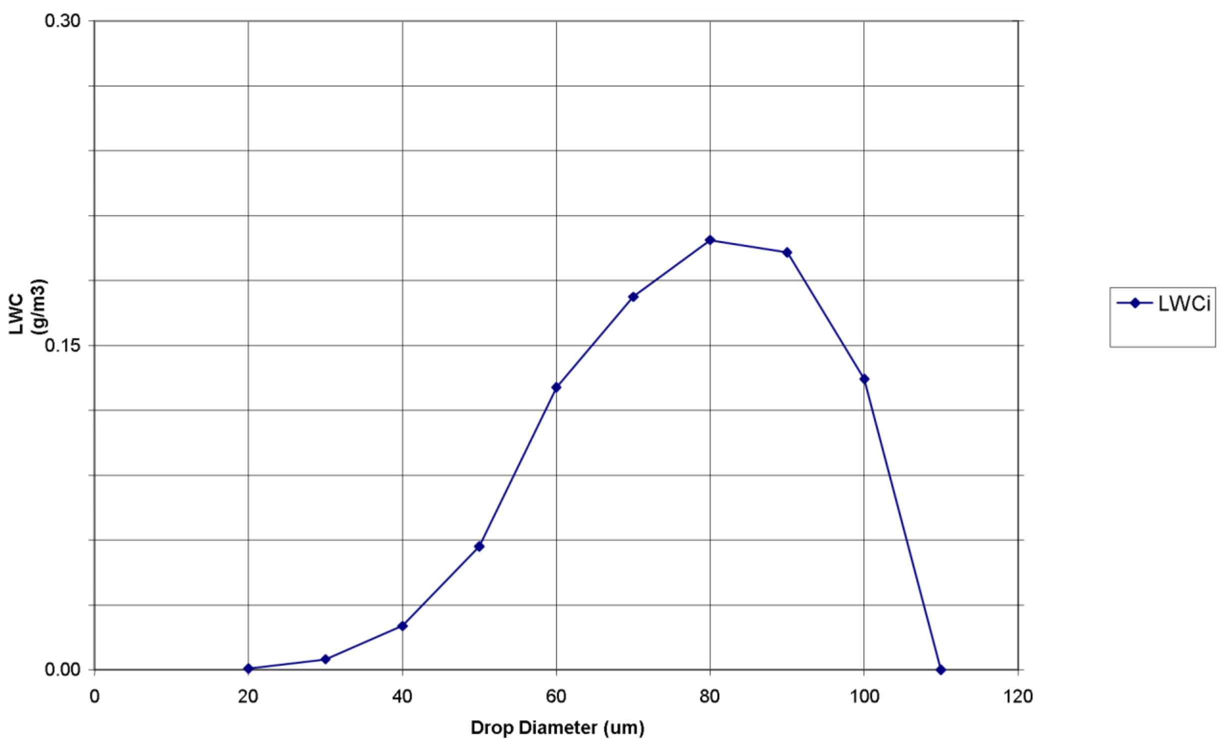

Figure 15: Hypothetical LWC Data

Note that PADS calculates concentration (c_i) in droplets per cm^3 rather than droplets per m^3. In order to calculate LWC using the proper units, PADS multiplies droplet concentration by 10^6. Since the equation already has a conversion factor of 10^{-12}, the program combines these two factors to get a conversion factor of 10^{-6}.

LWC for Imaging Instruments

Calculating the LWC from imaging instruments like the CIP and CIP GS is different than calculating it from light-scattering instruments like the CDP and CAS. This is because the sample volume used to derive particle concentration (c_i), a variable in LWC calculations described above, depends on the particle size in imaging instruments whereas it is constant in scattering probes. For more details, see the calculations for **particle concentration** and **sample volume.**

LWC (Liquid Water Content) in g/m^3 – *For the Hotwire LWC*

The hotwire LWC instrument measures LWC by examining the power required to keep the hotwire LWC sensor at a constant 125 °C temperature. The higher the LWC, the more power required. However, power is also required to offset heat losses due to convection (called "dry air term"). So the system must account for these power losses in order to get an accurate estimate of LWC.[7]

It does so as follows. First, it converts the total amount of heat loss to the wire into an LWC (g/m^3) estimate. The result, called **LWC raw (g/m^3),** reflects the amount of liquid water content in the air *if all the power losses were due to LWC, and none to dry air term*. PADS calculates **LWC raw (g/m^3)** as follows:

$$\text{LWC raw} = \frac{P_t \bullet 238850}{l \bullet d \bullet TAS \bullet 100 \bullet (L_v + T_b - T_a)}$$

where

P_t = P Total (W), the total the total power required to keep the hotwire sensor coil at the target temperature

l = Length of sensor (cm)

d = Diameter of sensor (cm)

TAS = True air speed (m/sec)

L_v = Latent heat of vaporization

T_b = Boiling temperature of water (K)

---

[7] For additional details on the operation of the Hotwire LWC, see Appendix B of the PADS Hotwire LWC Operator Manual DOC-0174).

T_a = Ambient air temperature[8] (K)

Next, PADS estimates how much of **LWC raw (g/m^3)** is due to dry air term and subtracts this amount from the total **LWC raw (g/m^3)** reading. This yields an estimate of true LWC.

PADS has two ways of estimating dry air term, and thus two ways of calculating LWC. The first way is to take empirical readings of dry air term when no clouds are present. The resulting LWC estimate is stored in the **LWC - DAT Observed (g/m^3)** channel. The second method is to calculate the dry air term and convert this result into in equivalent g/m^3 of LWC. It stores the result of this LWC estimate in **LWC - DAT Calc (g/m^3).** PADS calculates **DAT Calc (g/m^3)** as follows:

$$\text{DAT Calc} = \frac{(P_t - P_d) \bullet 238850}{l \bullet d \bullet TAS \bullet 100 \bullet (L_v + T_b - T_a)}$$

where

P_t = P Total (W), the total power dissipated by the hotwire sensor coil

P_d = **P Dry Calculated (W),** the power that the hotwire sensor dissipates due to calculated dry air term

l = Length of sensor (cm)

d = Diameter of sensor (cm)

TAS = True air speed (m/sec)

L_v = Latent heat of vaporization

T_b = Boiling temperature of water (K)

T_a = Ambient air temperature[9] (K)

---

[8] PADS currently uses the measured temperature rather than the ambient temperature in this calculation. This is a known bug that will be fixed in an upcoming version of the program.

[9] PADS currently uses the measured temperature rather than the ambient temperature in this calculation. This is a known bug that will be fixed in an upcoming version of the program.

Mach Number: PADS uses the following formula to calculate Mach Number:[iii]

$$M = \sqrt{2\frac{C_v}{R} \bullet \left(\left(\frac{Q_c}{P_s} + 1 \right)^{R/C_p} - 1 \right)}$$

where

M	=	Mach number
Q_c	=	Dynamic pressure (mBar)
P_s	=	Static pressure (mBar)
R	=	Gas constant for dry air, 0.068557 cal/gK
C_v	=	Specific heat for dry air at a constant volume, 0.171 cal/gK
C_p	=	Specific heat for dry air at a constant pressure, 0.24 cal/gK

MVD (Median Volume Diameter) in µm

Most of the information in this section has been copied with permission from the FAA's Electronic Aircraft Icing Handbook. *The relevant section of the handbook is available online by clicking on the cldpar.doc link at airportaircraftsafetyrd.tc.faa.gov/Programs/FlightSafety/icing/eaihbk.htm.*

Assume a sample droplet spectrum from an icing cloud for a given time interval is available in the following form: n sizing bins are defined by the bin boundaries b_1, b_2, b_3, …, b_n, b_{n+1}, (in µm) so that bin 1 is from b_1 to b_2, bin 2 is from b_2 to b_3, …, bin n is from b_n to b_{n+1}. The bin droplet concentrations for the icing interval have been determined to be c_i droplets per m^3 for i = 1, …, n.

Let m_i be the midpoint of the ith bin, i = 1, 2, …, n.

$$m_i = \frac{b_i + b_{i+1}}{2}$$

Let LWC be the total liquid water content for the sample, and LWC_i be the liquid water content for the droplets in the ith bin. (See **LWC** entry for details.)

Let pro_i = the proportion of the spectrum LWC that falls in the ith bin.

$$pro_i = \frac{LWC_i}{LWC}$$

Let cum_i = the cumulative proportion of the spectrum LWC that falls in the first i bins.

$$cum_i = pro_1 + \ldots + pro_i$$

The median volume diameter (MVD) is defined as the droplet diameter which divides the total water volume in the droplet spectrum such that half the water volume (or liquid water content) is in smaller drops and half is in larger drops. It can be approximated by a linear interpolation with respect to the liquid water content in the (i+1)st bin as follows:

Let i* = the smallest value of i such that $cum_{i*} > .5$. Then:

$$MVD = b_{i*} + \left(\frac{.5 - cum_{i*-1}}{pro_{i*}} \right)(b_{i*+1} - b_{i*})$$

Note that this interpolation gives a more accurate estimate of the median diameter than you would get by simply taking the halfway point between b_{i*} and b_{i*+1}. The second component of the equation, $\left(\frac{.5 - cum_{i*-1}}{pro_{i*}} \right)(b_{i*+1} - b_{i*})$, scales the amount being summed to b_{i*} according to how close b_{i*} and b_{i*+1} each were to .5. If b_{i*} was much closer to .5, for instance, then MVD will be much closer to the median diameter of the *ith* bin than to that of the *(i+1)th* bin.

Table 5 illustrates the computation of the LWC and MVD for a hypothetical instrument.

Bin Number i	Bin Boundaries b_i (microns)	Droplet Conc c_i (per m^3)	Midpoint m_i (microns)	LWC_i (g/m^3)	pro_i	cum_i
1	10	100000	15	0.00018	0.00058	0.00058
2	20	200000	25	0.00164	0.00538	0.00596
3	30	300000	35	0.00673	0.02214	0.02810
4	40	400000	45	0.01909	0.06274	0.09084
5	50	500000	55	0.04356	0.14320	0.23404
6	60	400000	65	0.05752	0.18909	0.42313
7	70	300000	75	0.06627	0.21786	0.64099
8	80	200000	85	0.06431	0.21143	0.85242
9	90	100000	95	0.04489	0.14758	1.00000
10	100	0	105	0.00000	0.00000	1.00000
	110		**LWC =**	**0.30 g/m³**		
					MVD =	**73.5µm**

Table 5: Calculating LWC and MVD

$b_1 = 10$, $b_2 = 20$, …, $b_{11} = 110$

$c_1 = 100{,}000/m^3$, $c_2 = 200{,}000/m^3$, …, $c_{10} = 0$

$m_1 = 15$, $m_2 = 25$, …, $m_{10} = 95$

$LWC_1 = .00018\ g/m^3$, $LWC_2 = .00164\ g/m^3$, …, $LWC_{10} = 0\ g/m^3$

$Pro_1 = .000581$, $Pro_2 = .000538$, …, $Pro_{10} = 0$

$Cum_1 = .00058$, $Cum_2 = .00596$, …, $Cum_{10} = 1.00000$

For this example, i* = 7 and

$$MVD = 70 + \left(\frac{.5 - .42313}{.21786}\right)(80 - 70)$$

Figure 16 shows the LWC (on the left vertical axis) and the cumulative proportion of LWC (on the right vertical axis) plotted against the bin right endpoint on the horizontal axis: i.e., LWC_1 and cum_1 vs. d_2, LWC_2 and cum_2 vs. d_3, …, LWC_{10} and cum_{10} vs. d_{11}.

When plotted in this way, the MVD is the point in the diameter on the horizontal axis where the cumulative LWC on the right vertical axis reaches 50 percent of the total.

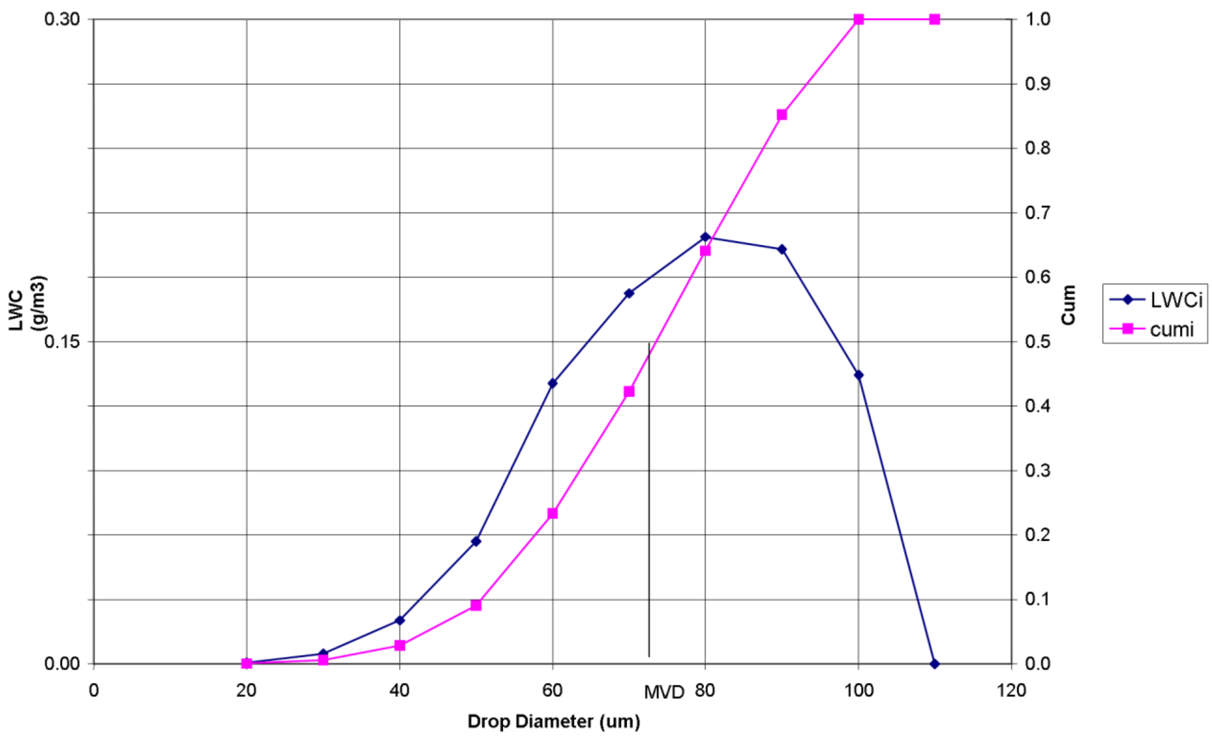

Figure 16: Hypothetical LWC and cum(i) Data

MVD for Imaging Instruments

Calculating MVD for the CIP and CIP GS is more complex than calculating MVD for light-scattering instruments like the CDP and CAS. This is because calculating particle concentration (c_i), which is a variable in MVD calculations, is more complicated for the imaging instruments than for other instruments. Specifically, particle concentration is inversely related to sample volume, which varies by particle size. For more details, see the calculations for **particle concentration** and **sample volume.**

P Dry Calculated (W): On the LWC Hotwire, the hotwire sensor dissipates heat due to dry air term (convection). This heat loss can be calculated using an empirical equation that has been derived from wind tunnel studies (see Zukauskas and Ziugzda, 1985[10]). Specifically, the heat loss P_d, the dry air term, is expressed by the equation

$$P_d = A_0 \bullet \pi \bullet k \bullet (T_s - T_a) \bullet Re^x \bullet Pr^y$$

where

k = Thermal conductivity of the air (g/sec-cm-K)

T_s = Sensor temperature (K)

T_a = Ambient air temperature (K)

Re = Reynolds number

Pr = Prandtl number

A_0, x, y = constants for a heated cylinder at a high Reynolds number

Using this formula, PADS calculates **P Dry Calculated (W)**, P_d, as follows:

$$P_d = \frac{0.26 \bullet \pi \bullet k_d \bullet (T_s - T_a) \bullet Re^{0.6} \bullet Pr_d^{0.37} \bullet \left(Pr_d / Pr_w \right)^{0.25} \bullet l}{0.23885}$$

where

Re = Reynolds number

Pr_d = Prandtl number dry

Pr_w = Prandtl number wet

k_d = Thermal Cond Dry (cal/sec-cm-K), the thermal conductivity of the air

[10] Zukauskas, A. and Ziugzda, J., 1985, *Heat Transfer of a Cylinder in Crossflow,* Hemisphere Publishing Corporation.

T_s = Sensor temperature (K)

T_a = Ambient air temperature[11] (K)

l = sensor wire length (cm)

Particle Concentration: Particle concentration (c_i) is measured in particles per cubic centimeters. It is defined as follows:

$$c_i = p_i / Vol_i$$

where

p_i = the number of particles in bin *i*

Vol_i = the sample volume in cm^3 for particles in bin *i*

Sample volume stays constant for light-scattering probes. For imaging probes, sample volume varies by particle size. This is due to two factors: 1.) the depth of the sample volume increases with the square of the particle radius, and 2.) the width of the sample volume decreases linearly with particle size. For more specific information on how PADS calculates imaging probe sample volumes for different particle sizes, see **Sample Volume.**

PBP IPT Std Dev (msec): PADS calculates PBP IPT Std Dev as follows:

$$\text{PBP IPT Std Dev} = \sqrt{\frac{\sum (t_i - \mu)^2}{n}}$$

where

[11] PADS currently uses the measured temperature rather than the ambient temperature in this calculation. This is a known bug that will be fixed in an upcoming version of the program.

t_i = Inter-particle time (msec) for particle number *i* in the current sampling instance

μ = Mean inter-particle time (msec) for the first *n* particles in the current sampling instance

n = The number of particles observed during the current sampling instance's particle-by-particle analysis

Note on the CAS_POL_PBP, *n* must be <= 256 since PADS limits particle-by-particle observations to the first 292 particles detected in each sampling instance. On the CDP_PBP, *n* must be <= 256 since for this instrument PADS limits observations to the first 256 particles detected in each sampling instance.

Rain Rate (mm/hr) PADS calculates rain rate using the function below:

$$\text{Rain Rate} = \sum_{i=1}^{n} A \bullet c_i \bullet vt_i \bullet d_i^{\,3} \bullet \pi/6$$

where

A = $3.6 \bullet 10^{-6}$, a scale factor to convert units to mm/hour

c_i = particle concentration of bin *i* in particles/cm^3

vt_i = mean calculated terminal velocity in m/sec of particles in bin *i*

d_i = mean diameter in μm of bin *i* particles

n = the total number of sizing bins for the instrument

1. Note on Scaling Factor:

The scaling factor of 3.6×10^{-6} is computed as follows. The rain rate should be in mm/hour, whereas the units in the equation are as follows:

$\#/cm^3 * m/sec * \mu m^3$

Thus, we need the scaling factors in the square brackets below in order to convert all distances to mm and to convert seconds to hours:

$\#/cm^3 * [10^{-3}\ cm^3/mm^3] * m/sec * [10^3\ mm/m * 3600\ sec/hour] * \mu m^3 * [10^{-9}\ mm^3/\mu m^3]$

These scaling factors then reduce to 3.6 x 10^{-6}.

2. Note on Sample Volume:

The sample volume used to calculate the particle concentration varies with particle size. For more details, see the **Sample Volume** entry.

3. Note on Uncertainties

The above formula assumes particles are liquid water and does not hold for snow, sleet, hail, graupel, etc. For more information on rain rate uncertainties, see the *MPS Operator Manual (DOC-0072)*.

Reynolds Number: A channel on the Hotwire LWC output file. A Reynolds number measures the ratio of inertial forces to viscous forces and thus indicates the relative importance of these two forces under given flow conditions (wikipedia.org). The Reynolds number, Re, is generally expressed as

$$Re = \frac{\rho \bullet V \bullet d}{v}$$

where

ρ = Air density (kg/m^3) for the film temperature

V = Velocity (m/sec)

v = Viscosity (g/sec-cm) = $f(T_{flm})$

d = Diameter (mm)

PADS calculates the Reynolds number for the LWC hotwire sensor as follows:

$$Re = \frac{\rho_d \bullet TAS \bullet d \bullet 100}{v}$$

where

ρ_d = Air density (kg/m^3) for the film temperature

TAS = True air speed (m/sec)

v_d = Viscosity Dry (g/sec-cm)= $f(T_{flm})$

d = Diameter of sensor (cm)

Sample Volume: Calculations for sample volume vary by instrument.

Imaging Instruments:

A volume of air is equal to length • depth • width. On the imaging instruments, the depth of the sample volume equates to the depth of field, which is the distance along the probe arms in which particles are accurately detected. The length of the sample volume corresponds to either 1.) the distance traveled (TAS • time) on airborne instruments, or 2.) a particle's **terminal velocity** on the ground-based MPS. The width corresponds to the width of the diode array, as shown in the diagram below.

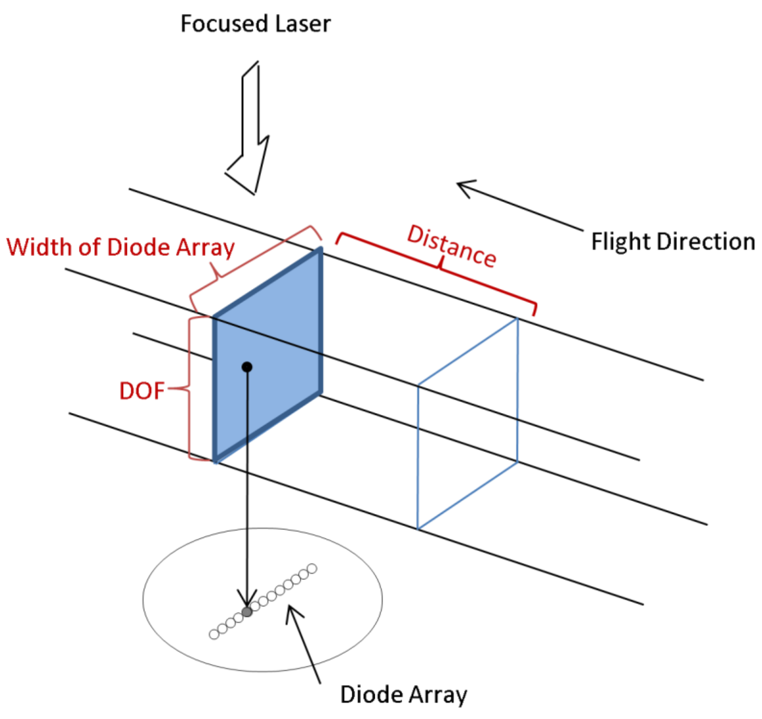

Figure 17: Imaging Probe Sample Volume

In the diagram above, a small particle image is on a diode in the middle of the array. As mentioned earlier, however, large particles are more likely to obscure one of the end diodes in the array and hence get rejected for counting. This effectively decreases the available sample volume width for increasing particle diameters.

Imaging probes have 64 diodes, but particles that block either of the outer two diodes get rejected for counting. Thus counted particles can span anywhere from 1-62 diodes. A one-diode-wide particle, i.e. a particle in size bin 1, has 62 spots in which it can fall and be counted. However, a particle 62 diodes wide can only be counted if it falls in one spot—the middle 62 diodes of the array, so that it still leaves the end diodes open. Thus, the width of the sample volume for a particle in bin 1 is effectively 62 times the width of the sample volume for a particle in bin 62. As a result, we adjust the sample volume width to be dependent on particle size, and define this width to be $(63 - i) \bullet$ [probe resolution], where *i* is the particle bin number and the probe resolution is the length in µm of one diode.

So our final calculation for sample volume is as follows:

$$Vol_i = DOF_i \text{ (mm)} \bullet \text{TAS (m/sec)} \bullet \text{Time (sec)} \bullet (63 - i) \bullet \text{[probe resolution (mm)]}$$

Calculating Depth of Field:

For imaging probes, PADS calculates the Depth of Field for particles of size *i* bins as follows:

DOF_i = the smaller of the arm width of the probe and $\frac{F_i \bullet r_i^2}{\lambda}$,

where

r_i = the mean radius (mm) of particles of size *i* bins

λ = the incident wavelength, which is 658 nanometers

and

F_i = an adjustment factor, as described below.

The adjustment factor takes into account the response time of the electronics and the 50% shadow threshold criterion. A particle crossing the diode array may physically change the light level by 50%, but if it crosses with high velocity and is on the array for a very short time, the response of the electronics may truncate the amplitude and register less than 50%. This means that a particle may need to be closer to the center of focus to create a darker shadow than 50% so that after truncation, the change will be registered as 50% or greater. The adjustment factor accounts for this with an empirical relation established by laboratory tests.

The electronic response is modeled with the first order equation[iv]

$$G = 1 - e^{-\Delta t/\tau}$$

where

Δt	=	the transit time of the particle across the array = $d_i/(TAS)$
d_i	=	mean diameter in μm of a particle of size i bins; e.g., 25 μm for a particle that falls in the first bin of a 25- μm resolution probe
τ	=	electronic response time of the diode array and electronics

and

TAS	=	True Air Speed (m/sec)

Then, if $0.5/G > 1$,

$$F_i = 30.46 - 0.628 \bullet 100 + .003246 \bullet (100)^2 = 0.12$$

otherwise,

$$F_i = 30.46 - 0.628(.5/G \bullet 100) + .003246(.5/G \bullet 100)^2$$

Light-Scattering Probes:

For light-scattering probes, sample volume is calculated as follows:

$$\text{Sample volume} = \text{TAS (m/sec)} \bullet \text{sample area (mm}^2\text{)}$$

where

TAS	=	True air speed (m/sec)

and

Sample area = height of the laser (mm) • length of the laser within the depth of field (mm)

The sample area for light-scattering instruments is given in the instrument's configuration editor window. It stays constant regardless of particle size.

The depth of field for light-scattering instruments does not change with particle size. Rather, DMT determined the depth of field for the probe when it was manufactured, and the probe was calibrated so that only particles that fell within this depth of field would be detected by the instrument's masked qualifying detector. See the instrument manual for details.

Terminal Velocity (m/sec): PADS uses the following empirical equation to determine calculated terminal velocity based on a particle's diameter, *d*, in µm:[v]

If $d < 100$ µm,

$$\text{Terminal velocity} = -0.015727 + 0.00097297d + 1.6739 \times 10^{-5}\, d^2$$

else

$$\text{Terminal velocity} = -0.19305 + 0.0049631\, d - 9.0457 \times 10^{-7}\, d^2 + 5.6597 \times 10^{-11}\, d^3$$

Thermal Cond (cal/sec-cm-K): PADS calculates the Thermal Conductivity, k, as follows:

$$k = \frac{T^{1.5} \bullet 0.00264638}{418.68 \bullet \left(T + 245.4 \bullet 10^{-12/T} \right)}$$

For **Thermal Cond Wet (cal/sec-cm-K),** $T = T_w$, the sensor wire temperature. For **Thermal Cond Dry (cal/sec-cm-K),** $T = T_{flm}$, the film temperature.

True Air Speed (m/sec): PADS calculates True Air Speed according to the formula below:[vi]

$$U_a = M \sqrt{T_a \bullet \gamma \bullet R}$$

where

U_a = Air speed at the probe in m/sec

γ = 1.403509, the ratio of specific heat for dry air at a constant pressure (0.24 cal/gK) to specific heat for dry air at constant volume (0.171 cal/gK)

R = Gas constant for dry air, 286.9 J/kgK

T_a = Ambient temperature (K)

M = Mach number

Note: Instruments that are not manufactured by DMT but that interface with PADS may use different methods for calculating TAS. For instance, AvenTech's ADP computes TAS using an incompressible relation for true airspeed reduction. The TAS calculation uses a corrected pitot-static pressure factor (corrected for static pressure error vs. angle-of-attack) and a density factor derived using corrected barometric pressure, corrected temperature, and an allowance for the effect of water vapor content. On the Anemometer_NI, PADS calculates air speed using the raw **Voltage (V)** measurement and a conversion equation specified in the Anemometer_NI's **Config Editor** screen.

Viscosity: PADS uses the following formula to calculate viscosity, v, in g/sec-cm:

$$v = 0.0001718 \bullet \frac{393.16}{120 + T_w} \bullet \left[\frac{T}{273.16}\right]^{1.5}$$

For **Viscosity Wet (g/sec-cm),** T = T_w, the sensor wire temperature. For **Viscosity Dry (g/sec-cm)**, T = T_{flm}, the film temperature.

Appendix C: Installation Instructions for DMT-Supplied Drivers and Computer Cards

To install DMT-supplied drivers, image port cards, and serial cards, follow the instructions below.

Install the Drivers

1. Turn on your PC.
2. If you are installing a Sealevel image port card, find the driver for the card. This is an executable file that can be found on your DMT-supplied disk. For instance, the installation file for card 5104 is `v04020102.exe`. If you are not installing an image port card, skip to step 4.
3. Run the file and press "Run" if you see a warning about running software from unrecognized sources.
4. Find and run the driver for your Sealevel serial card. This is another executable file on your disk. For example, the file for card 7201 is `SeaCOM_v030304.exe`. Again, press "Run" if a warning window pops up.
5. Install your USB key driver by running the file called `Keylock Install.exe`. Make sure the key is not plugged into the computer while you are installing the software.
6. Install any LabVIEW Runtime Engines supplied on your disk.

Install the Cards

7. Insert hardware key and click through the windows as the computer recognizes it.
8. Turn off and unplug your PC.
9. Observe standard rules for dealing with static-sensitive devices by grounding yourself.
10. Physically install your Sealevel image port card to the motherboard.
11. Physically install your Sealevel serial card to the motherboard.

12. Turn on your PC.

13. Windows should automatically detect the two Sealevel cards and bring up the "Found New Hardware" wizard. Follow the prompts for adding the cards and ports. Click "No" if the wizard asks you to search the Web for drivers, and select "automatic" as your installation option. If the wizard gives you a warning about logo testing, proceed with the installation.

14. Repeat step 12 until all the new hardware is installed.

Check that the Cards have Installed Properly:

15. Bring up the device manager by right-clicking on "My Computer," selecting "Manage," and then selecting 'Device Manager' under the System Tools dropdown menu.

    You will see a window like Figure 18. You should see the devices you just installed under "Multi-port serial adapters," "Ports," and "SeaMAC Device." You may need to press the + button to the left of the heading for the Device Manager to list all of the contents.

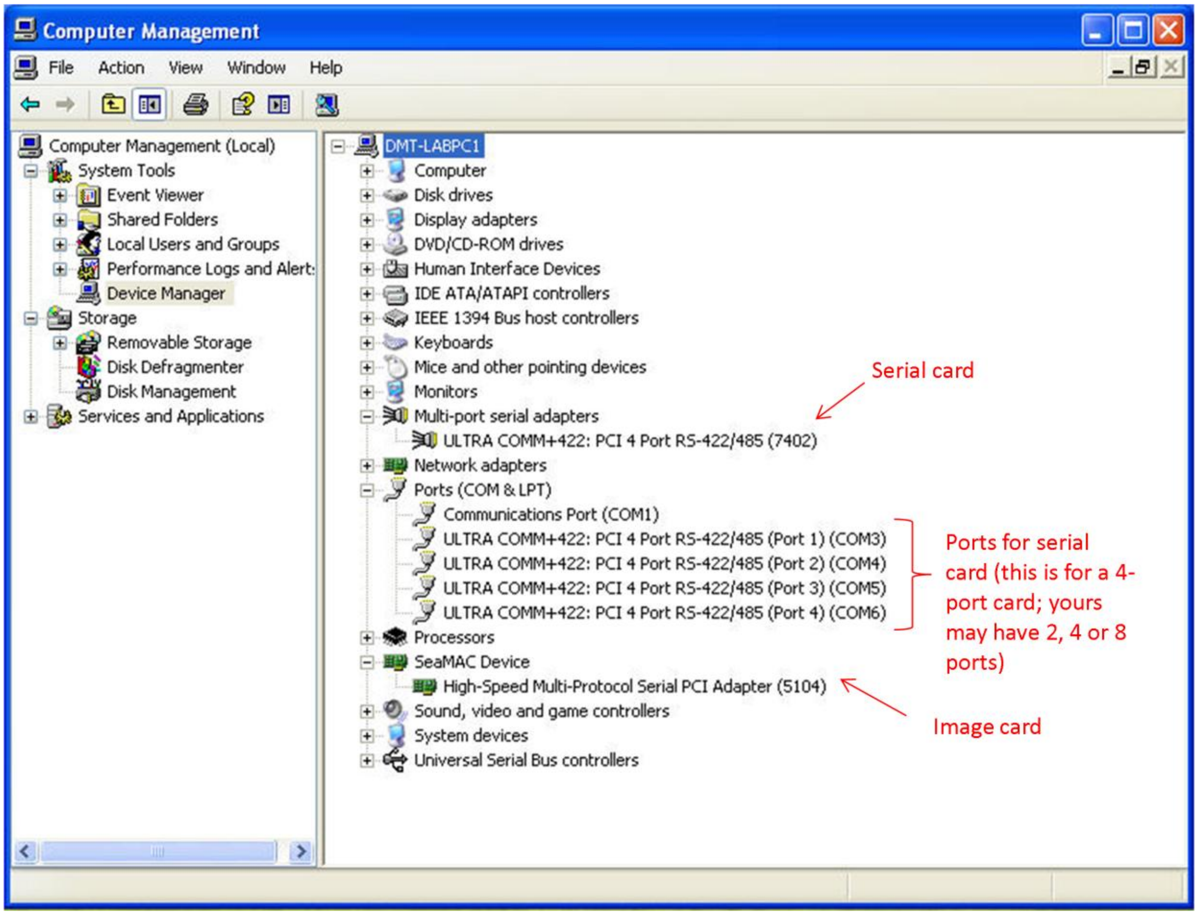

Figure 18: Device Manager Window after Successful Hardware Installation

16. If any of your device icons have an exclamation point on them like this: , they have not installed properly. In this case, contact Sealevel (http://sealevel.com/) or Droplet Measurement Technologies (http://www.dropletmeasurement.com/).

17. Staying in the Windows Device Manager, right-click on the image port card and select “Properties”

18. Click on the “Resources” tab

19. On the “Resource Settings” window, scroll down until you see the “IRQ” setting:

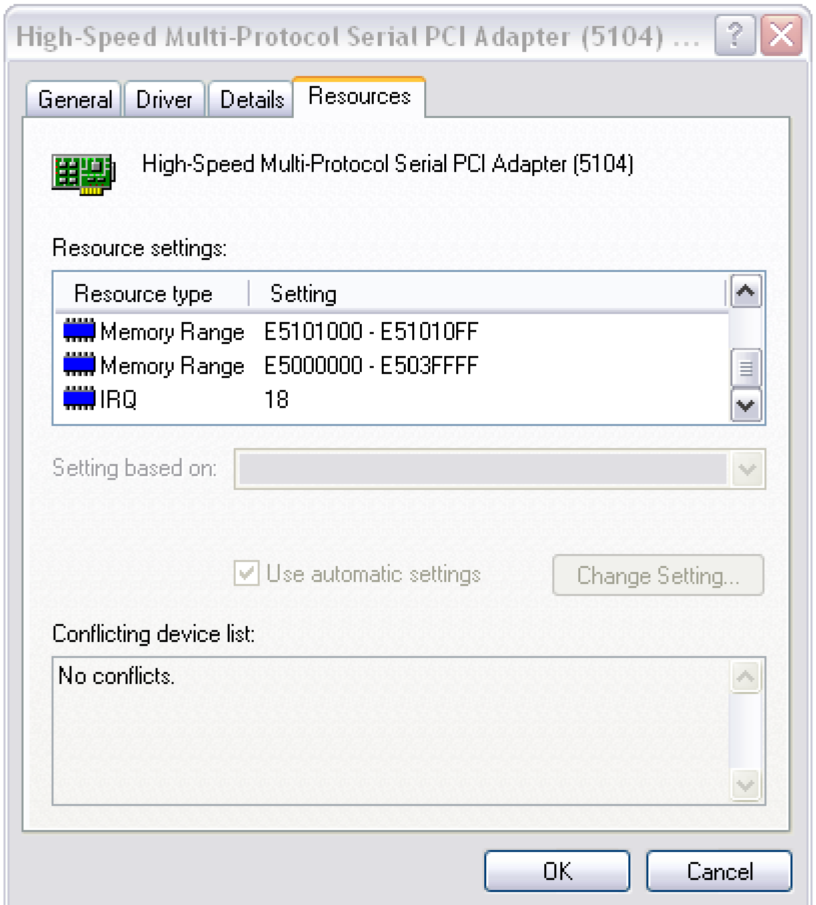

Figure 19: IRQ Settings in the Resources Window

20. Note the IRQ value for the image port card.

21. Select "Cancel" to exit the Properties Window.

22. In the Windows Device Manager, right-click on the serial card and select "Properties"

23. Click on the "Resources" tab

24. On the "Resource Settings" window, scroll down until you see the "IRQ" setting.

25. Note the IRQ value for the serial card.

26. Select "Cancel" to exit the Properties Window.

27. The IRQ for the Sealevel image port card should be greater than that for the Sealevel serial card. If it is, go to step 28.

28. If the Sealevel image port card IRQ is less than the Sealevel serial card IRQ, then do the following:

    a. In the Windows Device Manager, right click on the serial card and select "Uninstall."

    b. In the Windows Device Manager, under "Ports," right click on "Port 1" of the Sealevel serial card and select "Uninstall."

    c. Repeat step b to uninstall all of the remaining ports for the serial card.

    d. In the Windows Device Manager, right click on the image port card and select "Uninstall."

    e. Turn off PC.

    f. Switch the image port card and serial card locations on the motherboard.

    g. Turn on PC.

    h. Follow steps 12 thru 25.

Add Information to Registry

29. Find the file "`High Speed Card 1.reg`" on your CD. Double-click on it and select "Yes" to add the information to the registry.

Appendix D: PADS System Architecture

The PADS system is architected as a main control program, `PADS.exe`, and an arbitrary number of additional top-level programs that handle acquisition and display for each instrument.

The PADS system is flexible and dynamic, and its setup is determined by the configuration file being used. The configuration file is a `.ini` file, and is human readable text. Normally, the configuration file is only changed by DMT or through the configuration windows in PADS.

The window for the main PADS program, `PADS.vi`, is designed to fill a 1024 x 768 screen. This window provides up to 15 tabs of information. One tab, usually the right-most one, is the setup tab and contains control parameters for the PADS system. From 1 to 14 tabs can be displayed before the setup tab, depending on the configuration. Each of these tabs displays instrument data.

Top-Level Programs for Instruments and Displays

The main PADS program orchestrates the PADS system, but does not acquire or record any data on its own. This is left to the Instrument programs, which are described below. (When Display and Instrument are capitalized in this discussion, they refer to programs. In contrast, “display” refers to a tab or window, and “instrument” refers to an actual probe.)

Each of instrument tabs in PADS contains a display, which is run by a Display. Displays are top-level programs that run in parallel to the PADS program itself. Typically, each Display talks to a single Instrument, though Summary Displays can present data from multiple Instruments.

An Instrument is also a top-level program that runs in parallel to the PADS program and the Displays. An Instrument program typically talks to a single real-world instrument, acquires data, and stores the data to a file. As noted above, each Instrument has a Display associated with it.

Because different instruments are run by different Instrument programs, data from instruments are not synchronized with each other. The different Instrument programs also mean that instruments can collect data at different sampling intervals.

By default, PADS stores acquired data in memory for an hour. This is time is set in the program’s **Sec to Buffer** parameter in the PADS configuration file. One hour has been chosen as the default setting because this is the maximum time data can be stored without taxing computer memory.

Appendix E: Troubleshooting

I'm getting error messages when I first open PADS. How can I fix the problem?

Several problems may cause PADS to display error messages upon startup. The first step is to determine whether the problem happens any time you run PADS or only when you try to acquire data. If you turn instrument sampling off and you still have problems, then you may not have the proper authorization to run the program. If you get an error message like the one here:

> Error 1026 occurred at Call By Reference Node in CCP Summary Display 9.vi Possible reason(s): LabVIEW: VI Reference is invalid.

then check with your IT expert to make sure you are authorized as an administrator on your computer. It is also possible that the PADS installation has become corrupt. Reinstalling PADS will resolve this issue.

Problems with instrument sampling can have several causes. One potential issue is that the image and serial cards are not properly installed. If you have an image card, check to make sure its IRQ is less than the serial card IRQ. For details, see *Appendix C: Installation Instructions for DMT-Supplied Drivers and Computer Cards*. Also check your COM port settings to make sure they accurately reflect how your hardware is connected.

Another potential problem is that your USB hardware key is not hooked up correctly. If the "Sample" button is grayed out or your Setup screen displays a "Hardware Key Not Detected message," you will need to install a key before you can acquire data.

If the program is trying to sample data and some of your instruments are not connected or not working properly, you will get a series of error messages. In some cases, you may want to proceed with data acquisition using the remaining functional instruments. To turn off sampling for the probes you do not want to use, go to the instrument-specific tabs and click the Enable button so it turns off. This will stop sampling for the current session only. You can also permanently disable particular instruments upon startup by editing their section of the configuration file so that their "Enabled=TRUE" line reads "Enabled=FALSE."

If you want to use PADS in playback mode only, you should also turn off all sampling. You can do this in several ways. To turn off all sampling during the current session, press the green Sample button, which will turn red. To turn off all sampling permanently upon start-up, edit your program configuration file (whose location can be found on the Setup tab) so that the line that reads "Acquire at Startup=TRUE" now reads "Acquire at Startup=FALSE."

I'm trying to read an output file in playback mode, but the data isn't loading and I'm getting an error message. What's going on?

If you're having trouble reading a file in playback mode, make sure the file isn't open in another program (e.g., Excel). Also make sure that the output files haven't been modified since PADS originally created them. If you modified, moved, or deleted files from the output data directory, PADS will have trouble loading them in playback mode. All files, including the configuration file, must be present and have their original names. This is also true of the output data directory.

I'm trying to read an output file in playback mode, but one instrument tab is only displaying zeros. The other tabs show the data as they should. What's happening?

Make sure the file in question isn't open in another program (e.g., Excel). Also make sure that it hasn't been modified since PADS originally created it. If you modified, moved, or deleted a file from the output data directory, PADS will have trouble loading it in playback mode. All files, including the configuration file, must be present and have their original names.

When I view time-series data in playback mode, the charted data for the current time, indicated by the horizontal line, does not seem to match the numeric data in the channel displays. Why is this?

When you display a large range of time-series data, the chart display does not have sufficient resolution to display each individual time point. Thus it may appear that the cursor is centered over a data point when in fact it is only near that data point. However, the cursor will always display an "x" along its axis that marks the exact y-axis value for the current time point. By increasing and decreasing the time periods incrementally, you can see data values for all the nearby sampling instances. Another option is to zoom in on the data in the chart display until you can see data points for each sampling instance.

I'm trying to configure an instrument, but I cannot select the Config Instrument option on the Config menu because it's disabled. How can I fix this?

Click on another instrument tab or the Setup tab. Then click on the tab of the instrument you would like to configure. The Config Instrument option should now be available.

I'm getting strange results for channels like Numb Conc and Vol Conc. What could be causing this?

PADS calculations (except for MPS) always assume that the sample time is one Hertz, regardless of the sample time the instrument is set to. This is a bug that will be fixed in an upcoming version of the program. Currently, however, particle volume and rate channels that rely on time as an input variable can be inaccurate whenever the sample time is not set to one Hertz. To fix the problem, go to the Instrument Configuration window by selecting Configure > Configure Instrument, and then set the Sample Time to one Hertz.

The probe doesn't seem to be detecting particles. What's wrong?

One possibility is that the probe's windows have iced or fogged over, which impedes particle readings. Make sure the aircraft's anti-icing devices are turned on.

My laser current reading is bouncing around – what should I do?

Call DMT. A sudden change in the laser current can indicate a problem with the laser.

I have data from multiple instruments, and the data do not match up when I look at the entire data set for one moment in time. Why is this?

Because PADS runs each instrument using a separate Instrument program, data collected from different instruments may not be perfectly synchronized. For more details on how PADS works, see *Appendix D: PADS System Architecture*.

I'm seeing gaps in my data or problems with the data during a specific time interval. What could be causing this issue?

One possibility is that a screensaver, anti-viral program or other software has begun running in the background and is diverting necessary power from PADS. Another possibility is that power settings are set so that the computer goes into standby mode after periods of mouse or keyboard inactivity. Turn off all applications and set power option properties to "Never." (To access power option properties, right-click on the desktop and select `Properties > Screen Saver > Power`.)

I have a GPS as part of my PADS system. My cursor is jumping erratically around the screen, and PADS is not talking to the GPS serial port. What should I do?

The problem is that Windows attempts recognize serial as a serial mouse, and will assign the GPS port to a mouse. This might also happen with other serial devices that stream data as opposed to being query-response-based devices. To fix this problem, you will need to edit your Windows registry. Contact DMT for details on how to do this.

I'm having a problem with my output data, and I need DMT to look at it. What should I do?

If you need to send DMT your data for troubleshooting, make sure to include the entire contents of the output data directory. In order for DMT to load your data and replicate problems, we need all the output files as well as the configuration and log file.

Appendix F: Revisions to Manual

Rev. Date	Rev No.	Summary	Section
3-19-10	H-4	Added definitions and relevant calculations for LWC Module	Appendices A and B

Appendix G: PADS Release Notes – Version 2.8

Improvements to the Overall Program

PADS 2.8 offers several major enhancements over version 2.5:

1.) The program is written in LabVIEW 8.6, an upgraded version of the program.

2.) New modules such as the FM-100 Scattering and the PCASP-X2 been added to the system.

3.) Existing modules such as the CDP-PBP have been modified to improve accuracy or reflect improved instrument hardware. (See individual instrument sections below.)

4.) The PADS Image Playback Program has been incorporated into main PADS program, so that images can be seen during normal PADS playback and thus easily correlated to other PADS data.

5.) Graphs and charts are more user-friendly:

   a. Graphs have a white rather than black background, making them more readable than earlier versions.

   b. In graphs, clicking on “Log scale,” “Normalized,” or “Autoscale” updates the display immediately. In PADS 2.5, users had to change the current time before the display updated. In addition, more of the graphs have the Log Scale, Normalized, and Autoscale options available than in version 2.5

   c. Improved display timing reduces lags when the displays load.

Enhancements to Individual Instrument Modules

CAS:

- There is now a channel for Relative Humidity, **RH%**. This channel was formerly a spare analog channel.
- The CAS Configuration Editor window now includes **RH slope** and **offset** parameters.

- The Configuration Editor window also includes a **Use as Master Press** option so the CAS pressure can be set as the default global pressure on the **Setup** tab.

Note that most CAS instruments do not include the hardware sensors required to take advantage of the RH and Pressure channels.

CAS-POL-PBP:

- The default value for the **ADC Threshold** on the CAS-POL-PBP Configuration Editor has been set to 60.
- The default value for **Sample Area** on the CAS-POL-PBP Configuration Editor has been set to 0.24 mm.
- A larger version of the histogram now appears on a new chart tab, **Fwd Scatter.** This chart allows users to normalize, autoscale and log-scale data using control buttons at the top of the display.

CDP-PBP:

PADS has been updated to reflect upgrades to instrument firmware, specifically:

- New IPT calculations allow PADS to accurately record IPTs for particles much farther apart.
- Resolution on IPT time is now 1 µsec.
- The old **Time** channel in the PBP file is now named **PADS Time**, and is the time that PADS received the PBP data. This time will be the same for all particles observed during a single sampling instance.
- The new **Time** channel in the PBP data stores the time when the CDP-PBP detected the PBP particle. It is given in seconds after midnight on the day the program was started. This channel differs for different particles in a given sampling instance.

Note: These improvements require users to limit their sample time to 1 or 2 Hz (1 or 0.5 seconds) for accurate PBP results. 1 Hz/1 Sec is the ideal setting, as it ensures time-dependent calculations such as concentration will also be accurate. See the *PADS CDP-PBP Manual* (DOC-0192) for details.

CIP:

- CIP images are now viewable from the main PADS program.

- The data channel that used to be spare_analog_3 now stores **Laser Power.** The units on this channel are arbitrary, but it does correlate to the optical power produced by the CIP laser diode.
- PADS now records the RH slope and offset coefficients in config (PADS.ini) file.
- The calculation for MVD has been refined so that when TAS=0 (and thus the sample volume is also zero) MVD will be listed as 0 rather than the upper boundary of lowest bin.
- The label and axis of the LWC graph have been corrected.
- PADS calculations for probes with 100um resolution have been improved.

CIP-GS:

- PADS now records the RH slope and offset coefficients in config (PADS.ini) file
- The probe now gets automatically reset when the user presses the **Enable** or **Acquire** buttons.
- The scaling for the **Laser Temp** channel has been changed to use a 10K Thermistor
- The scaling has been improved for **Press_Temp(C)**, the channel that stores the pressure sensor's temperature.
- The calculation for MVD has been refined so that when TAS=0 (and thus the sample volume is also zero) MVD will be listed as 0 rather than the upper boundary of lowest bin.
- The label and axis of the LWC graph have been corrected.
- PADS calculations for probes with 100um resolution have been improved.

FM-100:

- The FM-100 is now set so that it never uses global air speed, although it can be a source for global air speed.
- The FM-100 display window now allows the user to control of air speed parameter. Specifically, a radio button appears above the FM-100 data window that allows the user to select Manual or Measured TAS. If Manual is selected, an input field appears for the user enter in a manual TAS value.
- The FM-100 channel that was formerly **Optic Block Temp** is now **Optional Output 1.** For FM-100s manufactured after June 2009, this channel will be a Dump Spot Monitor (V) that offers an indication of overall instrument health. For FM-100s manufactured prior to June 2009, the channel will store Optic Block Temp in arbitrary units (i.e., the channel will correlate to the optical block temperature but not report an accurate reading in °C). For more details, see the DMT Technical Note *FM-100 Housekeeping Channel Modification*.

FM-100 Scattering:

This is a new module added since PADS 2.5. It is a calculation module that relates specifically to the Fog Monitor (FM_100) module. The Scattering module acquires its data directly from the FM_100 module and calculates visibility and light extinction coefficients based on the FM_100 data. The Scattering module, therefore, is never run in PADS without the FM_100 module also present. The Scattering module's calculations are stored in a separate Scattering data file. For more information, see the PADS FM-100 Scattering Manual (DOC-0217).

Garmin GPS:

Latitude and Longitude readings are no longer displayed as absolute values. PADS now reports positive latitudes for locations in the northern hemisphere and negative ones locations in the Southern hemisphere. Meanwhile, positive longitudes reading indicate a location east of the Prime Meridian in Greenwich, whereas negative longitudes indicate a location west of the Prime Meridian.

MPS:

- MPS images are now viewable from the main PADS program.
- The scaling has been fixed on two MPS temperature channels.

PCASP-X2:

This is a new PADS module designed to interface with a new DMT instrument, the PCASP-X2. For more details, see the *PADS PCASP-X2 Manual* (DOC-0207).

PIP:

- PIP images are now viewable from the main PADS program.
- PADS calculations for probes with 100um resolution have been improved.

SPP-200 / PCASP-100X:

- The normalization calculation has been improved.
- A new **Relay On** light in the upper left of the display window indicates if PADS thinks the pump relay is on or off.

The following PADS instrument modules have had no significant changes made to them in version 2.8:

- ADP
- AIMMS-20
- Anemometer_NI
- CAPS Summary
- CCN
- CCP Summary
- CDP
- Dewpoint
- General Summary
- Telemetry

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[i] Appendix B, Section 7 of Bulletin #9 from the National Center for Atmospheric Research's Research Aviation Facility (RAF). www.eol.ucar.edu/raf/Bulletins/b9appdx_B.html#THERMO.

[ii] McFarquhar, Greg M. and Andrew J. Heymsfield. "The Definition and Significance of an Effective Radius for Ice Clouds." *Journal of the Atmospheric Sciences Vol. 55* (June 1998): 2039-2052. See Equation 4 in Section 2.

[iii] Appendix B, Section 7 of Bulletin #9 from the National Center for Atmospheric Research's Research Aviation Facility (RAF). www.eol.ucar.edu/raf/Bulletins/b9appdx_B.html#THERMO.

[iv] Baumgardner, D. *Corrections for the Response Times of Particle Measuring Probes*. Proceedings of the 6th Symposium on Meteorological Observations and Instrumentation, New Orleans, 1987

[v] DMT derived these polynomial equations to estimate terminal velocity using empirical data from two papers. The data for large droplets are from Gunn, Ross and Kinzer, Gilbert, "The Terminal Velocity of Fall for Water Droplets in Stagnant Air." *Journal of Meteorology* Vol 6. August 1949: 243 – 248. 2.) Data for smaller droplets are from Beard, K.V. and Pruppacher, H.R., "A Determination of the Terminal Velocity and Drag of Small Water Drops by Means of a Wind Tunnel." *Journal of Atmospheric Sciences* Vol 26, p. 1066-1072.

[vi] Appendix B, Section 7 of Bulletin #9 from the National Center for Atmospheric Research's Research Aviation Facility (RAF). www.eol.ucar.edu/raf/Bulletins/b9appdx_B.html#THERMO.