AeroWare

SOFTWARE MANUAL

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Proprietary Information

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Acronyms

Acronyms	Description
DAQ	Data Acquisition
in	Inch
MPS	Model Positioning System
NA	Not Applicable
NI	National Instruments
PC	Personal Computer
PTA	Pressure Transducer Array
V	Volt
VFD	Variable Frequency Drive
TBD	To Be Decided

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Document Version Control

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Software Version Control

Version	Description	Date
1.0	Aero-Ware	11/19/2016

Reference Documents

Version	Document	Date
1.0	CPT6100 Data Sheet.pdf	Jan 2015
1.0	ACS355-User Manual.pdf	Nov 2016
1.0	ACS355-03U-46A2-2.pdf	Nov 2016
1.0	NI 9171 Manual.pdf	Nov 2016
1.0	MDR-60-16 Datasheet.pdf	No 2016

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AEROWARE

Figure 1: AeroWare Loading Screen

1. Introduction

AeroWare is a lightweight, high-speed data acquisition and control program for use with Aerolab wind tunnels and equipment. You should use this software to acquire the sensor, environmental, VFD, traverse, balance, and all other signals pertaining to your application. AeroWare excels at logging simultaneous signals with microsecond precision and logging this data for post processing and analysis. For most applications, AeroWare can read and log data at a maximum rate of 25,000 samples/second/channel. For users with a fully integrated Aerolab tunnel control system, it will also control any physical hardware you also purchased such as variable frequency drives, traverse systems, motorized model positioning systems, and servos.

This manual is intended to be an introductory document to educate you on the capabilities, limitations, and suggested uses of AeroWare. Please read it thoroughly to familiarize yourself with the different control and acquisition modes within the program. Please refer to other documents you have received with your tunnel or other hardware for a more complete view of how AeroWare is intended to be used for your application.

1.1.   A Note to the End-User

Please keep in mind that this document likely is not the only documentation you have received as a customer of Aerolab. Being a consumer of highly technical and specialized instruments, a background in

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basic fluid mechanics, electronics, mechanics, and instrumentation will be useful in understanding your system. Please refer to all documentation you received when trying to answer questions for yourself. If you find the subject matter of this manual difficult to understand, we highly recommend learning more about the fundamentals behind the concepts discussed within this manual.

2. Installation

Installation of AeroWare follows the typical format of virtually every other software commercially available. To install AeroWare, simply run the "setup.exe" file located on the flash drive that was provided with your equipment and follow the prompts until the software completes. You will likely be asked to restart your computer to put into effect several software and registry changes that are made when installing AeroWare for the first time. Do not attempt to run the software after the initial installation until you have restarted your computer.

2.1.   File Read/Write Permissions

In some cases, installing software for PC users who do not have administrative access limits the Aeroware's ability to record data to the hard disk. If you find that your data is not properly being written to disk, open the folder properties for the directory in which Aeroware.exe was installed to and currently located in. Enable read/write permission for each of the user cases and save those settings. In most cases, this will solve any file writing issues you may encounter.

2.2.   Software Customization

Most of Aerolab's projects involve customized hardware and thus, the software must be altered from its base distribution to fit the needs of every customer. Therefore, the software you receive may deviate slightly in design, visual appearance, display organization, labeling, settings options, instruments, and control capabilities from what is shown in this manual. For that reason, we have gone to great lengths to attempt to make this manual generic enough to apply to all cases, yet specific enough to provide you with the level of detail required to easily navigate the software.

Know that even though you may see minor changes between your software and this manual, key topics such as data acquisition control, fan and servo control, and safety considerations are all standardized and will be generic to virtually all application instances.

3. User Interface

This section provides an overview of the different visual panes you will find in AeroWare. It is not intended to be a functional description, but rather an introduction to the basic components of the Human Machine Interface (HMI).

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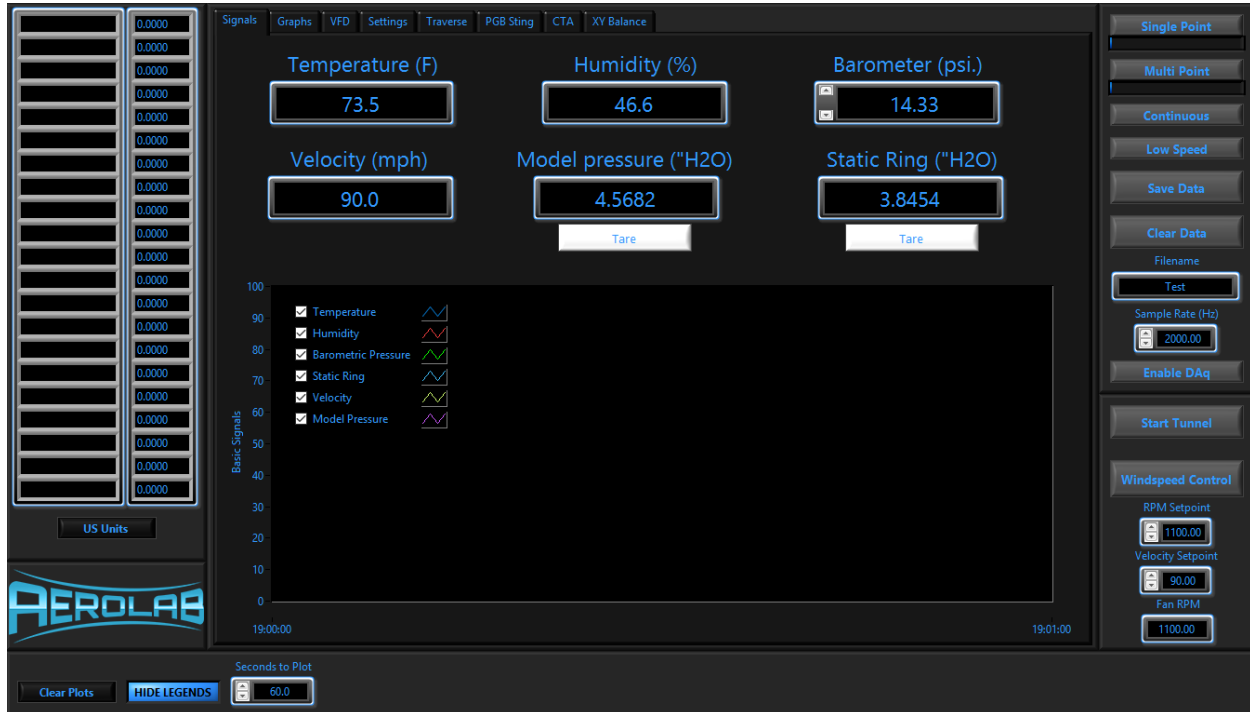
Figure 2: AeroWare GUI Overview

3.1. Plots

You will notice that most tabs have a mixture of digital readouts and plots. Digital readout show only the instantaneous value for any indicated signal, while each pot can show instantaneous data and its temporal history. Since all AeroWare plots are governed by the same functionality, they will be described as a group here and only unique details and suggested uses will be discussed for each individual section.

There are 3 controls on the User Interface which give you control over the visual arrangement of the display on each of the plots.
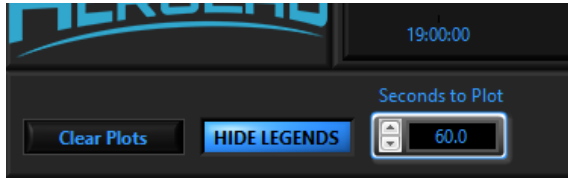
3.1.1. Clear Plots

This button, when pressed will erase all data from each of the plots and allow you to look at data moving forward without the past data visible. This control is useful when you encounter large fluctuations in signal magnitude and wish to reset the auto-sizing feature of the Y-axis of a plot. To re-size the plot scale, simply clear the plots using the "Clear Plots" control and each plot will immediately re-size to the current scale of the data

3.1.2. Hide Legends

This button toggles on and off and respectively, toggles the plot legends for all plots on an off. This can be useful when you want to customize a plot, but want to be sure of the color of the line representing the signals you are interested in. You can quickly toggle the legends on to verify the colors, then toggle them off to enjoy an un-obscured view of the plots.

3.1.3. Seconds to Plot

This control simply changes the scale of the X-axis (time axis) to allow you to see a variable amount of time history per your preference. This can be useful in seeing details at small or large time scales that are otherwise invisible. For example, if you wished to get an idea of the steady state drift over time, you should increase the number of seconds to plot. If you want to see rapid oscillations in your signals more clearly, reduce this number to stretch out each individual data point. The limits for this input are 0.1 to 60.0 seconds.

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3.2.   Signal Viewer
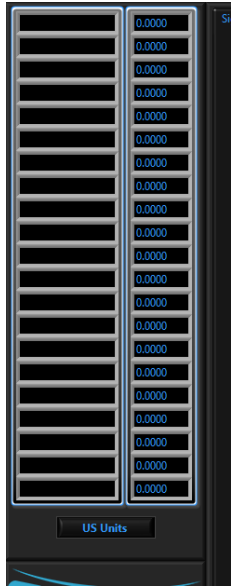
This pane shows all incoming signals and their corresponding values. These values are neither averages nor filtered, but the live stream from the different sensor sources and update at a rate of 10 Hz. They have been scaled to display in the proper units, which can be verified by looking in the Instrument Viewer pane. Depending on your specific hardware configuration, you could have as few as 4 signals here or as many as 100.

For applications with large channel counts (larger than about 25), a scroll bar is shown to allow you to view signals more easily. This pane is not intended to be the main window for viewing signals, but rather provides a 30,000-foot view of your system in its entirety. These signals are also visible in many other places on the User Interface as describes in other subsections. When no signals are being read or the data acquisition engine is idling, this pane appears grayed out and inactive.

3.3.   Instrument Viewer

This pane is the most obvious and provides the most organized view of the different signals AeroWare is capable of processing. It is organized into several tabs which organize and display data from different instruments for convenience and improved comprehension.

The subsequent subsections will explain each of the different tabs in tabs within the Instrument Viewer.

3.3.1. Signals

This tab shows the most generic signals relating to wind tunnel testing. Here, absolute environmental signals such as temperature, humidity, and barometric pressure are shown. In addition, the several differential pressure signals from pitot tubes and model pressure taps are displayed and a calculated wind-speed is also shown.

Depending on your hardware configuration, each environmental signal may show up as either an input or a display value. For configurations where sensors are used, signals will be shown as a display value, indicating that the sensor is reading in the environmental condition and providing the corresponding data to the wind-speed calculator and data logger. Where no such instruments are present, it is the responsibility of the user to independently look up or measure these values and input them into the user interface. In these cases, that measurement is static and will only vary if you change it yourself.

For signals such as dynamic pressure which are differential in nature, virtually all configurations will have corresponding sensors for which indicators in this tab are strictly used as display values. The user cannot change these signal values. You can however tare any instantaneous offset from these signals to "zero" their values. When you tare a signal, the zeroed value propagates throughout AeroWare and it becomes the value from which any calculations or logging are performed.

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Velocity is calculated as a function of temperature, humidity, barometric pressure, and dynamic pressure. Often, multiple dynamic pressure channels are provided and it can become ambiguous as to which one is being used to calculate speed. To clarify this, the channel that is marked "Dynamic Pressure (Units)" is the channel used to calculate velocity. This does not mean that other differential pressures are not also showing some form of dynamic pressure, but it does indicate that they are not being used to calculate wind velocity.

The plot for this tab shows a time history of each of the signals displayed on top of one another. This can be useful when you want to compare signals and visually process data in real time. One typical way to configure this plot is to show only velocity and dynamic pressure at the same time. This gives perspective on the quadratic relationship between dynamic pressure and velocity.

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3.3.2. Graphs
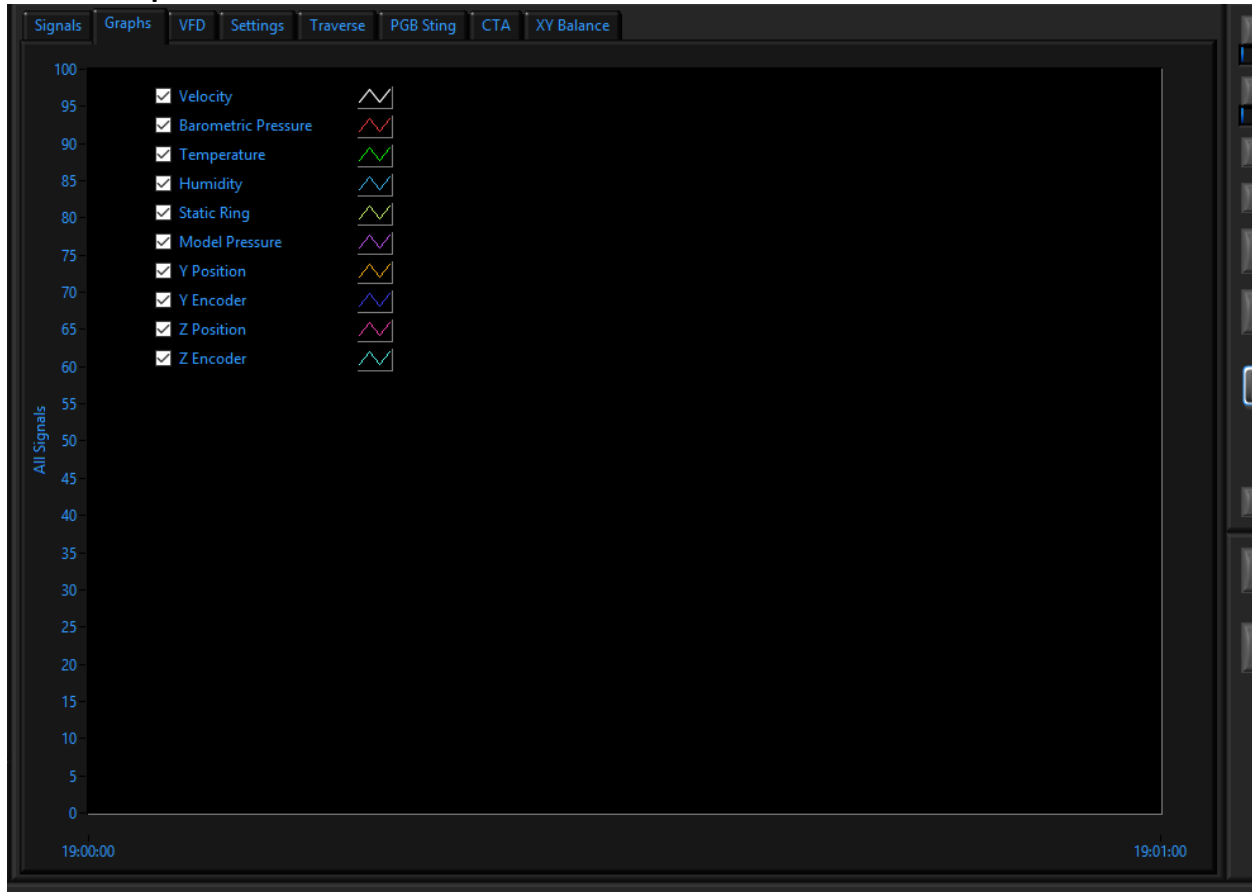
Figure 3: AeroWare- Graphs Panel

This tab allows you to chart any signal your system is acquiring on the same plot. A list of all available channels is shown in the legend with individual check boxes for each signal. Enable visibility by checking the box for each signal you wish to see. This can be useful for tracking trends between variable which are not commonly monitored together. For example, if you wished to do a study to see how humidity affects drag, you could plot humidity and drag on the same plot and observe their relationship easily.

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3.3.3. VFD
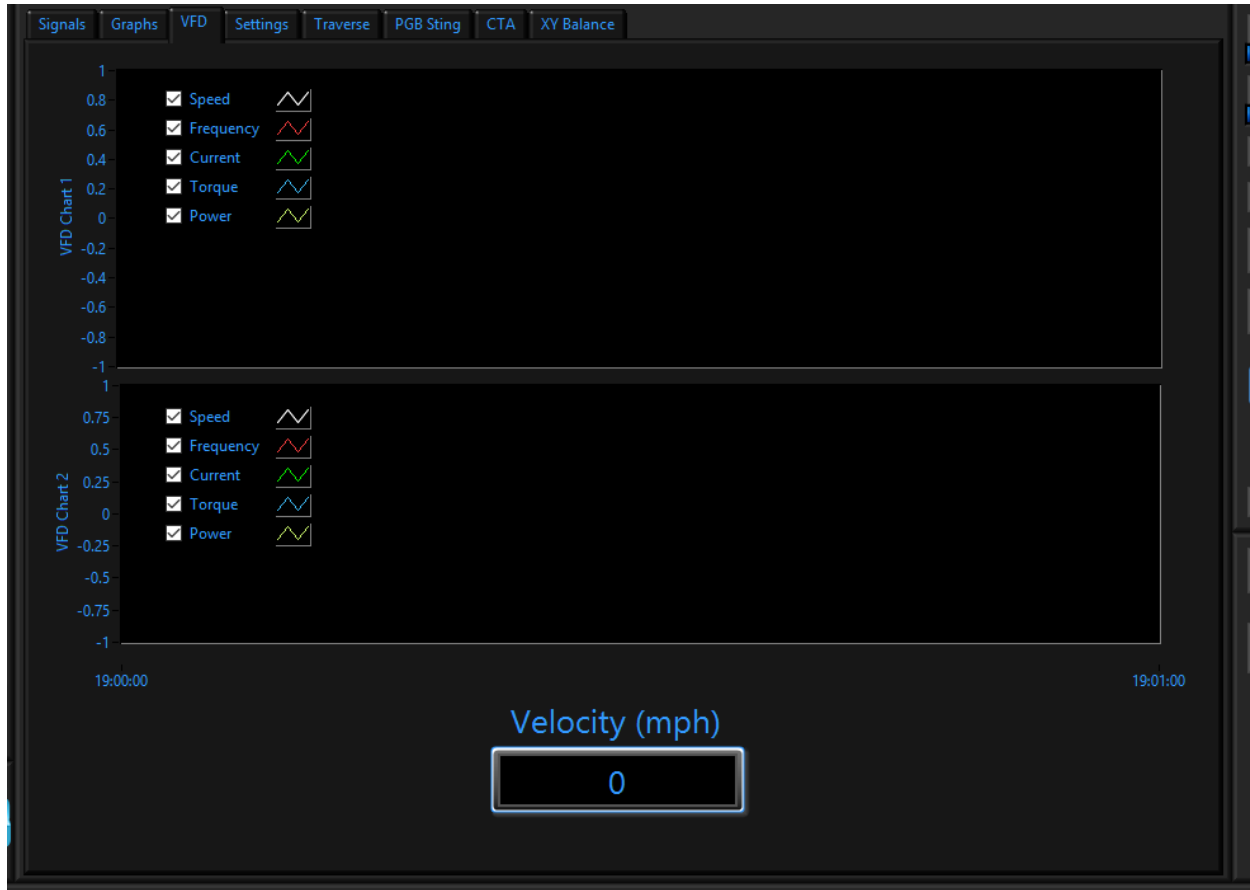
Figure 4: AeroWare- VFD Panel

This tab can be useful for observing different VFD parameters in real time. Two plots are provided because of the wide range of numerical magnitude for each signal. It is difficult to accurately see changes in performance when tracking VFD RPM and VFD Frequency. Since RPM and frequency are often 2 orders of magnitude apart in amplitude, it is easier to look at them both on plots with different scales.

This tab can also be useful in verifying tunnel performance and behavior. Being able to see actual RPM is sometimes more valuable than being able to see a calculated wind-speed in environments where large amounts of electrical noise might be interfering with pressure measurement sensors. The data displayed here is generally not useful for research purposes, but it is provided to allow you to use it however you wish.

3.3.3.1. VFD Control
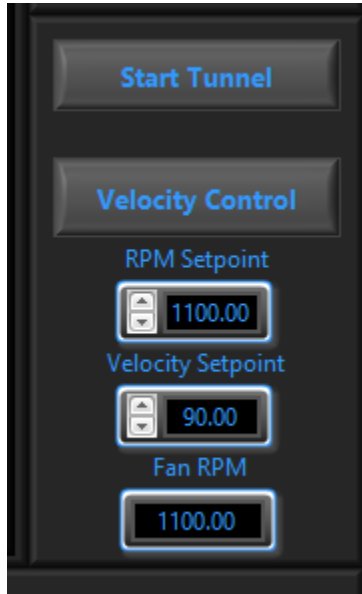
In addition to the plots available on the VFD Tab, the lower right hand corner of the User Interface displays various inputs which control the VFD that drives the fan for your tunnel. If your configuration does not include a VFD, these controls are hidden.

The VFD which came with your tunnel is manufactured by ABB and full documentation is available on the flash drive that came with your system. It would be wise to familiarize yourself with its specifications and operating principles before you begin using your new tunnel. For simplicity, controls have been added to the user interface to provide you with programmatic control over its basic functions. The VFD can be controlled in two basic modes via this button:

A full description of both modes proceeds this subsection.

RPM Control

This mode allows you to control the RPM of the VFD directly. You will know you are in RPM mode because the Button will display "RPM Control" text. When in this mode, the Fan RPM Input is active and will control the VFD's speed directly. This input accepts values that are safe for your hardware configuration. It is potentially harmful to the internal motor windings to run the fan at very low speeds, so there is generally a lower limit of about 25 RPM for most fans. Upper ranges are typically between 1000 and 3000 RPM. Enter the desired RPM into the control shown below.
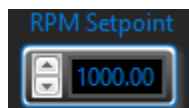
The VFD is equipped with an on-board controller which uses a closed control loop algorithm similar to PID to modulate the fan speed to match this value. You may see some overshoot and minor oscillations, but these are usually very small and reach steady state very quickly.

Velocity Control

This control mode allows you to specify a desired wind velocity for your tunnel to attempt to maintain. Internally, AeroWare uses a PID closed control loop algorithm to attempt to compensate for changes in wind-speed and maintain the test section velocity constant. AeroWare will modulate the RPM set point

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automatically and in real time to compensate for changes in blockage, pitch, roll, and yaw changes in your model, open test section panels, etc.

This control mode is much more difficult to achieve and thus is susceptible to larger overshoots, longer ramp times, and increased oscillation. Every possible effort is made to minimize this, but you should expect some variance in this control mode. In general, this control mode is less stable than RPM control mode and care should be taken when using it.

AeroWare uses the velocity displayed and logged on the User interface as the set point variable and VFD RPM as the process variable. This means that depending on your hardware configuration, this measurement may come from a non-obtrusive static ring differential pressure or a pitot probe. Since this velocity is calculated from the signal names "Dynamic Pressure (Units)", you will always be able to see the pressure which is ultimately being used to change this closed control loop. Remember that wind velocity is not constant through all sections of your wind tunnel and this mode controls the speed in the center of the test section if you have a static ring, or at the pitot probe if you do not.

Because of the less stable nature of this mode, be very careful when using it to control your wind tunnel. While unusual, some circumstances result in temporary overshoot velocities in excess of 130% of the set point value and thus can induce higher-than-expected aerodynamic forces on models, instruments, and probes. When fixturing and installing models and instruments, ensure that they will be able to tolerate these excess forces when using the velocity control mode.

Enter the desired velocity (using the current units) into the control shown below in conjunction with this control mode.
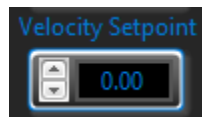
Start Tunnel

This button toggles the tunnel fan on and off. The "Start/Stop Tunnel" button, "Velocity/RPM Setpoint" inputs, and the "RPM/Velocity Control" button are the only control inputs for the VFD. They can all be changed at any time and independently from one another. AeroWare continually monitors each of these controls and takes appropriate steps to ensure that the fan operates in a safe mode regardless of what inputs you change. For example, changing from a high RPM control to a low Velocity control will not induce unsafe acceleration or deceleration, but rather AeroWare will apply the appropriate torque to change the motor speed safely.

This does not mean, however, that all speeds are always safe. For example, changing speeds drastically via the User Interface should never damage the fan, motor, or VFD, but could cause problems elsewhere. Be sure that any model you place into the test section is properly fixtured and can withstand any wind load your tunnel can produce. It is possible that your model could break free from your fixture and accelerate toward the power section or diffuser and damage components downstream. Heavy objects can break through the protective screens and be ejected out of the tunnel. Take measures to ensure this does not happen, and be sure that nothing fragile nor people are located directly behind the tunnel outlet.

4. Data Acquisition
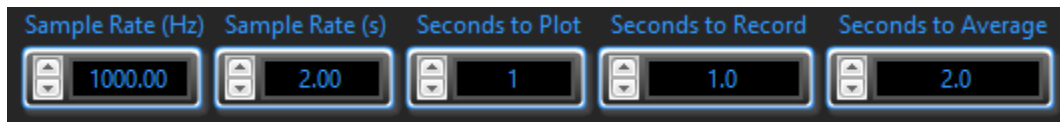
AeroWare provides a fully customized battery of data acquisition tasks to you, the end-user. An overview of the different software acquisition modes is outlined here. Small images are appended to each subsection showing the software button that enables the described activity where applicable.
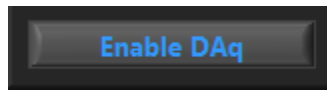
4.1.   DAq Enable

To conserve system resources and provide flexibility on acquiring data and connecting hardware, data acquisition can be enables and disabled at will. In general, most tasks require that the DAq be enabled to function. Simple tasks such as traverse moves, VFD RPM controls, etc. will still function while the DAq is disables, but complex functions like traverse matrix path motions and VFD wind-speed set point controls require that the DAq be enabled. This is the case because many complex functions require that real time data be inputted to many background functions that make such functionality possible.

Buttons which are grayed out on software start likely are so displayed because they require the DAq to be active. To enable these functions, simply enable the DAq by pushing the corresponding button and then proceed.

4.2.   Sample Rate
There are two separate Sample rate controls. They are explained below.

4.2.1.   Sample Rate (Hz)
This input allows the user to change the sample rate at which data is acquired and recorded to a data file. We recommend that the slowest possible data rate be use for your application that will not

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compromise your measurement integrity. Sampling at the slowest possible rate reduces the usage of system resources and allows for more processing time for other Windows operating system tasks to execute. This reduces the likelihood that AeroWare will become sluggish or unresponsive. This control accommodates rates between 10 and 25,000 Hz in most cases.

For example, if you are testing the steady state performance of an airfoil, sample rates on the order of 100 Hz are typically more than sufficient to capture and characterize its behavior. Sampling at 10,000 Hz is simply unnecessary and results in high system resource usage, excessively large data files, and increased software error risk. On the other hand, some instruments such as constant temperature anemometers are designed to characterize high speed signal fluctuations and can be sampled at higher rates.

4.2.2. Sample Rate (s)
This input allows the user to control the Low Speed data acquisition mode. It specifies the frequency with which long term data will be acquired in seconds. Its use will be explained more fully in the "Low Speed Mode" subsection later on in this "Data Acquisition" section.

4.3. Temporary Buffer File
All data you collect is first stored in a temporary buffer file. This data is physically written to the nonvolatile memory of your Hard Drive Disc or Solid State Drive as it is collected and as such is protected from unexpected computer shutdowns or other hardware issues. Data is stored in this temporary buffer until the used decides to either save or delete the buffered data. More on this will be discussed in later subsections.

4.4. Single Point
This control allows you to acquire a single point of data and record it to the temporary buffer file. Two other inputs affect the behavior of this control, namely the "Sample Rate (Hz)" and "Seconds to Average" inputs. When the Single Point button is clicked, the software will immediately rout the streaming signals to a volatile memory buffer, at the rate specified in "Sample Rate (Hz)" for the period of time specified in "Seconds to Average". Once all the data is collected, then all data will be average down to a single point for each channel. A single data point for each channel and a time stamp will then be written to the temporary buffer file until it is either recorded or cleared by the user. NOTE: Using this mode results in a single averaged point for each channel.

For example: If your software inputs were configured as shown here below,

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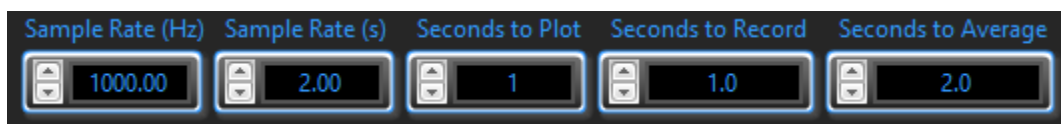
and you clicked the "Single Point" button, AeroWare would collect 2,000 samples over a duration of 2.0 seconds for each channel. It would average this data for each channel and save it to the temporary buffer file.
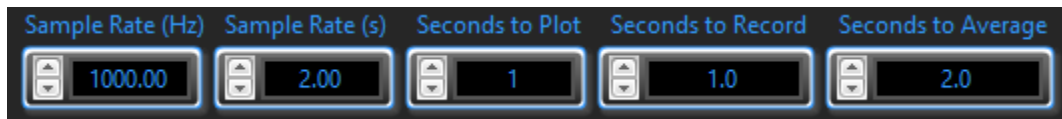
This acquisition mode is most useful when steady state data is required and any frequency domain data is unimportant. Typically, it is not necessary to sample data for this mode at rates exceeding 100 Hz because it is averaged into a single point anyway. In addition, averaging times are more repeatable when they extend over periods of time exceeding your longest transient variable. For example, if you were testing the steady state pressure conditions over an airfoil at low speeds, you may notice induced vortex shedding on the order of 2-3 Hz, or once every 1/2 to 1/3 seconds. In this case, an averaging time somewhere between 5-10 times (1.5 to 5 seconds) would be appropriate.

4.5.   Multi Point

This control allows you to acquire a single, finite length time series of data upon clicking it. Two other inputs affect the behavior of this control, namely the "Sample Rate (Hz)" and the "Seconds to Record" inputs. When the Multi Point button is clicked, the software will immediately rout the streaming signals to the temporary buffer file to be recorded to nonvolatile memory. Each channel is recorded at the rate specified in "Sample Rate (Hz)" for the duration of time shown in "Seconds to Record". The data recorded will be discrete and have associated time stamps for each data point.

For example: If your software inputs were configured as shown here below,

and you clicked the "Multi Point" button, AeroWare would collect 2,000 individual data points with discrete time stamps over the space of 2.0 seconds and save them to the temporary buffer file. This acquisition mode is useful when you want to characterize time dependent variables in your experiment. For example, if you wanted to observe and record a vibration phenomenon that you expect is oscillating at 150 Hz from a load balance, you could use the Multi point function to record data at 1,500Hz for a finite amount of time.

The duration you should record is typically a balance between desired file size and ability to properly characterize the time dependent variable. It is generally important to record the time dependent signal for at least 30 full cycles, but not too long that the file size becomes too large to process. If you are unsure how long you need to record, err on the side of having more data that you need.

4.6.   Continuous

This control will allow you to record a nearly infinite time series of data when activated. The only other control that affects its behavior is the "Sample Rate (Hz)" input. When clicked, "Continuous" will immediately rout the streaming signals to the data logger to be recorded to the temporary buffer file in

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real time until the button is clicked again. This works similarly to the Multi Point function, but you do not need to know beforehand how long you wish to record.

For example: If your software inputs were configured as shown here below,

Sample Rate (Hz)	Sample Rate (s)	Seconds to Plot	Seconds to Record	Seconds to Average
1000.00	2.00	1	1.0	2.0
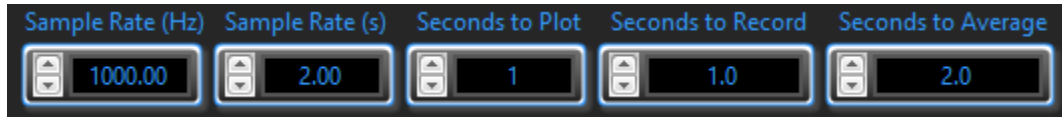
and you clicked the "Continuous" button, AeroWare would collect a single data sample for each channel every 1.0 milliseconds and save it to the temporary buffer file. This function is useful when you want to record the characteristics of an entire process, but do not know how long it will take. For example, if you wanted to observe and record the response of an anemometer as a function of wind-speed, but did not know its general behavior beforehand, you could begin recording continuously, change the wind-speed input variable, wait for the anemometer to reach steady state, then stop recording.

This would leave you with a custom length time series of data that captured the entire response of the anemometer without having to guess it's behavior beforehand. In general, use Continuous mode when you want time dependent data, but do not want to be constrained by a finite record duration. NOTE: Be careful not to record too many channels at too high a rate for too long of a duration. It is possible that you could fill a hard drive and crash Windows if you left this mode running unchecked.

4.7. Low Speed
This control allows you to record data over very long time frames. It is essentially a timed version of "Single Point" in that it records a single point of data -- in the exact same way the "Single Point" function operates -- every "Sample Rate (s)" seconds.

For example, If your software inputs were configured as shown here below,

Sample Rate (Hz)	Sample Rate (s)	Seconds to Plot	Seconds to Record	Seconds to Average
1000.00	2.00	1	1.0	2.0

and you clicked the "Low Speed" button, AeroWare would collect 2,000 samples over a duration of 2.0 seconds for each channel. It would average this data for each channel and save it to the temporary buffer file. This behavior would repeat every 2.00 seconds in perpetuity until the "Low Speed" button is clicked again. It is important to know that the 2.00 second delay between taking points is absolute and runs independently from the timer that governs how long data is recorded.

This means you get a data point with a time stamp every "Sample Rate (s)" seconds, not every "Sample Rate (s)" plus "Seconds to Average" seconds. So, to finalize the clarification, for the example above you would get a sample recorded every 2 seconds, not every 4 seconds. Knowing this, it is important to set

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"Sample Rate(s)" to be larger than or equal to "Seconds to Average", or you will experience erratic and inconsistent data acquisition.

4.8.   Save Data
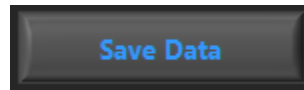
Save Data

This control allows you to save everything that has been thus stored in the temporary buffer file to a more permanent and presentable data file. Upon clicking "Save Data", all data points stored in the temporary buffer file are loaded into memory, copied to a new location, then the temporary buffer file is flushed and closed for continued recording.

Data is recorded to the same directory in which the AeroWare executable file is located and run from. Each data file includes two rows of headers. The first, or top row indicates the signal name while the second or lower header indicates units for generic signals. The text shown for the "Filename" input is appended to a date and time stamp for each file that is saved. This facilitates easy data tracking and prevents the possibility of accidentally overwriting data. A typical, sample data file is included on the flash drive given to you at project completion and/or tunnel commissioning.

Because of the limitation of many data processing software packages such as Matlab, Excel, and Mathcad, it is not advisable to let the temporary buffer file grow to sizes larger than 500 MB. This equates to about 40,000,000 (forty million) individual data points. This means that if you were recording 10 channels at a rate of 10,000 Hz, you should limit your recording time to less than 400 total seconds before saving the data (4,000,000 individual samples with 10 channels each).

Ignoring this recommendation can make it difficult to post-process data, make your operating system sluggish, and even cause AeroWare to fail and lock up. In general, keep file sizes as small as possible between saves.

4.9.   Clear Data

Clear Data
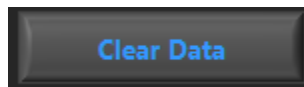
This control allows the user to flush the data stored in the temporary buffer file without saving it. This action is irreversible and will result in the loss of any data that has been accumulated in the buffer. Only click this button if you are sure you do not need or want the data that is stored in the buffer. If you are unsure of what is currently in the buffer, we advise saving the data and checking it before you delete it to be safe.

A dialogue appears when it is clicked giving you the opportunity to cancel the clear action in case it is accidentally clicked.

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5. Quick Start Guide

To simplify the initial process of taking data and shorten the learning curve, this Quick Start Guide is provided. This is not intended to be full training on how to use your Aerolab hardware, but rather an initial introduction to the steps required to begin taking your first measurements. Please read it carefully and be sure you understand this process.

5.1. Visual Inspection

Before enabling any software controls, do a thorough visual inspection of your entire system. Look at the test section, inlet, outlet, power section, and honeycomb. If you see anything that seems potentially hazardous, take steps to remedy the issue before proceeding. Also, look at the various connections. Is all hardware plugged in or connected to power? Are all USB, Ethernet, and other wire connections made and stable? If any hardware was unplugged before software start, you will likely need to restart AeroWare and possibly your PC before continuing.
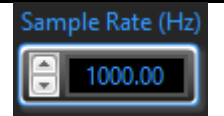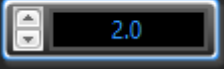
5.2. Open Software

Do this by double clicking the application names "AeroWare.exe". This file was created when you first installed this software and is by default found in the C:/Program Files/AeroWare directory.
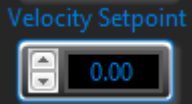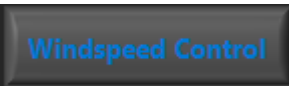
You will see a splash screen with a graphic, Aerolab's company logo, and a loading bar. Once the software has been loaded into RAM, the main screen will open.

5.3. Choose settings

Your initial settings are trivial and can be changed at any point. For the purposes of this guide however, set the following controls to the indicated values:

Control	Value
Sample Rate (Hz) — 1000.00	1000
Sample Rate (s) — 5.00	5
Seconds to Plot — 60.0	60
Seconds to Record — 2.0	2

Seconds to Average 2.0	2
RPM Setpoint 1000.00	1000
Velocity Setpoint 0.00	0
RPM Control / Windspeed Control	RPM Control

5.4. Check connections

Be sure that all USB and Ethernet connections are properly made. If at any point these things become disconnected, you will need to re connect them and restart AeroWare.

5.5. Enable Data Acquisition

Start the data acquisition process by clicking the button below.

Enable DAq
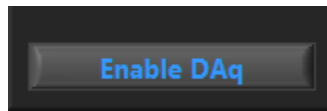
The National Instruments Hardware will begin collecting samples at 1000 Hz. Observe that the various plots are now showing measured sensor data and streaming this information to the digital and graphical displays.

5.6.   Collect and Save Data
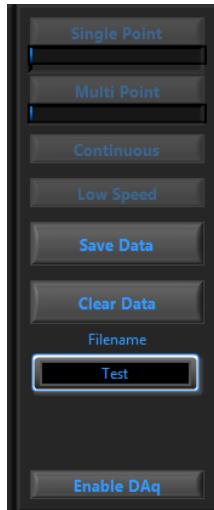
Take a single averaged point of data by clicking "Single Point".

Wait 5 seconds, then take a time series of data by clicking "Multi Point.

Wait 5 more seconds, then take continuous data for about 5 seconds by clicking "Continuous", waiting 5 seconds, then clicking "Continuous" again.

Take low speed data over a period of 30 seconds by clicking "Low Speed", waiting about 30 seconds, the clicking "Low Speed again.

Name the file by entering "Quick Start" into the "Filename" control.

Save the data by clicking "Save Data" and waiting for the process to complete. You will know it is done when the "Save Button" returns to it's original, lighter grey color after being initially clicked.

5.7.   Inspect Data

Find the data file in the save directory. The Default is C:/Program Files/ AeroWare. The data will appear as a .txt file with a long-form time stamp and "Quick Start" appended to the end. You can open this file in Notepad, but a spreadsheet application such as Microsoft Excel will make the data easier to visually process.

Once you have opened the data file; you should have the following data:

- 1 "Single" point
- 2000 "Multi" Points
- About 5000 "Continuous" Points, and
- About 6 "Low Speed" points

The numbers may vary slightly from these if your settings were slightly different from the recommended or your click timing was not exact.

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5.8. Test Fan
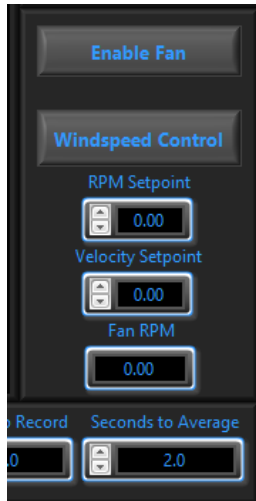
Enable the fan while in RPM mode by clicking "Enable Fan". NOTE: Be sure this is safe to do! Do not enable the fan if there are any loose items inside the test section or other parts of the tunnel. Also, be sure that no one is located downstream of the tunnel.

When the fan is up to speed, experiment with the different data acquisition settings and take data at multiple rates ad for multiple durations. This is not to test that AeroWare is functioning properly, but rather to familiarize yourself with the User Interface. Try changing RPM set points, switching back and forth between RPM and Wind speed control, changing these set points, and enabling/disabling the fan.

Take data intermittently while doing this and inspect the data. Notice how most processes work independently of each other and data acquisition settings can be modified without effecting VFD operation and visa-versa. If the Data Acquisition is enabled, Fan RPM will be displayed.

5.9. Experiment

AeroWare is generally robust and can tolerate many different settings changes at one. Experiment with different plot settings, enabling and disabling different signals, hiding legends, changing units, etc. Get to know AeroWare well, especially if you will be using it often.

Any signal that displays a "Tare" button below it can be zeroed at the current value for differential testing. Clicking this button once will remove the current offset from the signal, and clicking it again will return it to the untorn value. This action can be repeated for multiple torn measurements.

5.10. Close AeroWare

When you have finished taking data and trying everything you want to try, close the software by clicking the red "X" in the upper right hand corner. A dialogue will ask you if you are sure you want to quit. Choose "yes" if you are sure.

6. Traverse

This section explains details regarding an Aerolab 2-Axis traverse system. In general, a traverse is used to capture data in two dimensions, typically in the plane perpendicular to the airflow. This can be useful for performing flow quality analyses, spacial uniformity studies, mass/volume flow calculations, and flow angularity surveys. In addition, it allows precise control over probe and instrument placement within the test section.

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A typical traverse will be located outside the test section, with only a strut or probe that extends into the airflow to minimize aerodynamic drag and flow quality contamination. If you purchased a traverse with your system, refer to this section for guidelines and instructions on how to use it properly.

AeroWare Interface

At Aerolab, we integrate all our instruments seamlessly into a single software platform called AeroWare. Being a module located within AeroWare itself, the Traverse controls are in the "Traverse" tab located at the top of the screen. A screenshot of the user interface is shown here.

This tab shows all relevant data from the traverse and provides software controls to position the traverse and even automate its movements. Refer to the following subsections for specific instructions regarding each control.

6.1.   Special Installation Instructions

It is important to recognize that with the addition of a traverse system, additional installation instructions may apply. When AeroWare was installed, a configuration file was generated for your system. This file is found in the main directory you chose to install AeroWare under during the setup phase. The file is names "cDAQ Config.ini" and can be opened with any text editor. Check the following keys and verify that they are correctly called out:

6.1.1. Y Axis Port

This key instructs the software to communicate through the specified COM Port. The easiest way to tell which COM Port your traverse is communicating on is to open the Windows Device Manager and watch to see which ports populate when you plug in the USB that connects your traverse to the PC. If your traverse has a single VXM controller, only one extra COM Port will appear. If your system features 2 VXM controllers, two COM Ports will appear. By entering "COMX" after the Y Axis Port key, you can change the COM Port AeroWare looks on to communicate with the traverse.

NOTE: AeroWare can only communicate on ports 1-9, so you may need to rearrange your port allocations if you have many devices connected to your PC at once.

6.1.2. Z Axis Port

The setup process for this ort is the same is it is for Y Axis Port. Please refer to the previous sections on its use.

6.1.3. Y/Z Axis Baud

This key will specify the baud rate your VXM controller is communicating with. By default, it is set to 9600 for both axes and should not be changed.

6.1.4. VXM

This key specifies how many VXM controllers your system is equipped with. If your system has two controllers enter "2" here, otherwise, enter "1".

6.2.   Main Display

The Main display shows information and provides controls for the aspects of the tunnel which are universal. This includes the position indicators found at the top of the screen, homing and zeroing buttons, file formats, speed settings, chart controls, and Emergency Stop button.

A breakdown of each button's functionality is provided here.

6.2.1. Y/Z Position (in./mm)
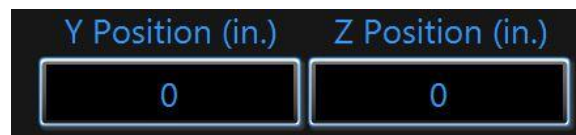
These indicators show the current relative position of the traverse expressed in either inches or millimeters. These indicators update to show the position as seem by the motor controllers. Each indicator updates independently after a move is made. You will not see this number changing while the traverse is moving, but rather only after a move has been completed. Updating the display in this way makes it easy to see position changes relative to each other and keep consistence between these

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indicators and the plot below them. NOTE: If that traverse slips while in motion, these numbers may not be correct. Always verify that these indicators match with the encoder positions displayed in the signal viewer.

6.2.2. Traverse Chart

The chart on the main display shows a relative history of where the traverse has been. It records each position as the traverse moves and includes it with connecting lines to this display. The scale of this chart updates with the current units selected for viewing.

At any time, this chart can be cleared and the data points reset to make the data shown here more meaningful. Because the chart axes auto scale as data of larger magnitudes is displayed, it can become difficult to seem smaller movements. If you are having this problem, simply clear the chart by clicking the button labeled "Clear Chart". Be careful though that you do not forget that these positions shown are relative to the current zero. DO NOT RELY ON THIS DISPLAY FOR TRAVERSE POSITIONING unless you are sure you have it zeroed appropriately for the work you are doing. In general, it is always better to use visual feedback to position the traverse manually.

6.2.3. Homing Controls

These controls here allow you to easily find absolute coordinate positions within the traversable space and zero your instrument accordingly. By clicking the "Find Y/Z Center" buttons, you position the traverse at the exact center of each axis respectively. In execution, the traverse will jog the full length of the axis until one limit switch is tripped then jog back until the other is tripped. The traverse will then move to the midpoint between those two locations and stop. By then clicking the "Zero Y/Z Axis" button, you can zero the relative coordinates at that location.

You can also choose to move the traverse to any other traversable position before zeroing to shift the home coordinates away from the center point. This function can be useful when you wish to perform an analysis in the plan perpendicular to the airflow. For example, if you wanted to center the traverse behind a model that is offset from the centerline of the test section, you could find the center of each

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axis, move the traverse by the offset amounts in each axis, then zero the traverse at that location. All control and data logging will then be done relative to the model and not the test section walls.

6.2.4. Y/Z Speed Controls
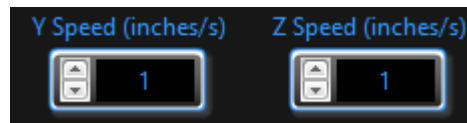
These controls a very straightforward. They control the speed at which the traverse moves in all modes. Each axis is controlled independently to allow for different speeds in each axis. As speed is decreased, motor torque is increased, and thus this feature can be used in the case that a large, unexpected load interferes with the traverse movement and extra torque is needed. The maximum speed is set to one inch per second and is appropriate for most applications.

6.2.5. Emergency Stop

The emergency stop button will perform a software stop of the traverse in any mode. NOTE: This button only controls the state of the traverse! Clicking this button will not stop the fan or other model positioning systems. After clicking this button, you will need to wait about 20 seconds, then click it gain to reset the fault states.

6.3. Motion Control Tabs

On the left-hand side of the main display are a series of tabbed pages which house controls for different traverse movement types. Each tab is described in detail here.

6.3.1. Manual

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This tab provides controls for manual movements. From here, the traverse can be arbitrarily jogged, stepped by discrete distances, or moved to an absolute location.

To jog, use the inner green arrow controls in the top section of the tab. By clicking and holding these inner arrows, the traverse will jog indefinitely (or at most until a limit is tripped) until you unclick the button. You can also "long-jog" by clicking the mouse down, moving the pointer off the control, and then releasing the button. This will jog the traverse – even though the mouse is no longer clicked down - until the button is clicked again. This can be useful when you need to jog long, indeterminant lengths and do not want to hold down the button for long periods of time. Be careful thought that you do not use this feature while not paying attention. It can be easy to forget what to do to stop the traverse and mentally seize up when you are under pressure to stop the traverse quickly.

To step the traverse a predetermined distance, use the outer green arrows in the top section of this tab in conjunction with the step length control. Clicking one of these outer arrows will move the traverse the distance shown in "Step Length". These clicks are not buffered, meaning that clicking this button several times in rapid succession will result in only one move.

To move to an exact location, use the Y/Z Position controls and the "Move to Absolute" button together. The coordinates here move the traverse to the exact location shown in Y/Z Position about the current zeroed position. For example, if the current location displays Y: -2 inches and Z: -3 inches and you move the traverse to (2,3), the traverse will step a total of 4 inches to the right, and 6 inches up.

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6.3.2. Sweep

This tab gives automation instructions to a motion driver which converts simple inputs into complex instructions synchronized with data acquisition tasks. It takes YZ limits and stop inputs to move the traverse in a grid pattern to perform planar surveys in the two axes of the traverse.

About the current zeroed position for both axes, using the sweep function will traverse back and forth between the Start Y/Z and End Y/Z coordinates, making Y/Z stops as it moves evenly spaced between the start and end points. To clarify this, you can look at the example below.

For inputs as follows:

Control	Input Value
Start Y	0
Start Z	0
End Y	1
End Z	1
Y Stops	3
Z Stops	3
Record Time	1

The traverse will move to the following points:

Y	Z
0	0
0	0.3333
0	0.6667
0	1
.3333	0
.3333	.3333
.3333	.6667
.3333	1
.6667	0
.6667	.3333
.6667	.6667
.6667	1
1	0

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1	.3333
1	.6667
1	1

This behavior is consistent between units and directions. Because the "Record Time" input is set to 1, the traverse will stop at each location (including (0,0) and (1,1)) for one second are record data at that point. Movements made in sweep mode are absolute about the currently zeroed position.

Sweep Mode will work with either Multi Point acquisition or Single Point acquisition, and can record each point to a separate file, or save them all in one single file depending on the configuration of the controls shown here. With these controls, the text displayed indicated the current recording mode. You can think of it as "what you see is what you get" if that helps you to remember how these controls are read by AeroWare.

Multi Point will record a time series of data at the current sampling rate for the time specified in "Record Time". Single Point will average all data collected at the current sample rate for the time specified in "Record Time".

Multiple Files will record data from each sweep location into a different file, while Single File will record data from each traverse location and append it to the data from each previous traverse location. In general, it is best to use Multiple File in conjunction with Multi Point to avoid excessively large file sizes and parsing difficulties. Equally, Single File is generally used with Single Point to avoid unnecessarily numerous files that can be difficult to post process together. This is not true for all situations though, be sure to use the file and acquisition settings that are optimized for your application and post processing needs.

In general, the sweep function excels at easily and quickly taking data within a plane perpendicular to the airstream. For example, if you wanted to analyze the wake characteristics of a model jet, you could position the traverse downstream from your model and collect data points across the test section in both directions. Collecting multi point data to multiple files makes it easy to calculate average speeds, turbulence intensity and even wake propagation behind the model.

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6.3.3. Matrix Mode

Matrix Mode allows you to import a .csv file of predetermined positions which the traverse will follow in successive order. Use the file control to select a 3-columned file formatted like the one shown here:

> Y,Z,Dwell
> 0,1,1
> 0,2,1
> 0,3,1
> 0,4,1
> 1,1,1
> . . .

The first row are simple headers. They do not need to be names as shown but they must be included, as AeroWare expects them and deletes the first row of the file automatically. After that, the first column indicated the desired Y positions, the second indicates the desired Z positions, and the third column indicated the amount to time (in seconds) to record data. At that location.

Once a file is loaded, it is automatically shown in the large table at the top of the tab. You can scroll up and down to see all the loaded points and verify that the file has imported correctly. The numbers shown will be interpreted and processed in the units you currently have selected. Changing between units during traverse sweeps will not affect the movement once the matrix has been started.

Once the points have been loaded and verified, clicking "Matrix" will begin the traverse movement. Once this button is clicked, changes to the import file will have no effect. Movements read by the matrix mode are absolute about the currently zeroed position.

Matrix Mode will work with either Multi Point acquisition or Single Point acquisition, and can record each point to a separate file, or save them all in one single file depending on the configuration of the controls shown here. With these controls, the text displayed indicated the current recording mode. You can think of it as "what you see is what you get" if that helps you to remember how these controls are read by AeroWare.

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Multi Point will record a time series of data at the current sampling rate for the time specified in "Record Time". Single Point will average all data collected at the current sample rate for the time specified in "Record Time".

Multiple Files will record data from each sweep location into a different file, while Single File will record data from each traverse location and append it to the data from each previous traverse location. In general, it is best to use Multiple File in conjunction with Multi Point to avoid excessively large file sizes and parsing difficulties. Equally, Single File is generally used with Single Point to avoid unnecessarily numerous files that can be difficult to post process together. This is not true for all situations though, be sure to use the file and acquisition settings that are optimized for your application and post processing needs.

This mode is useful when you need to record data from several precisely located positions. For example, suppose you wanted to analyze effects of a symmetric model on downstream wind conditions and were willing to make symmetry assumptions to make data collection quicker. For a spherical model, you could assume a polar coordinate system and simply traverse to several points in a radial line starting from the center of your model and propagating outward. By then extrapolating the collected data around the radial axis to gather planar information quickly while only acquiring data from a single line.

6.3.4.   COMS

The stepper motor controllers used to communicate between AeroWare and the traverse system accept a wide array of useful and customizable inputs via a string data serial input. With you traverse, you should have received a reference to all the different motion control commands you can send. You can use these controls to write custom programs to fit your exact needs. Data acquisition, however cannot be synchronized in this mode. If you want to collect data while using this feature you should use the continuous acquisition mode to be sure you do not miss any important information. Refer to [RD.3] for the full list of available commands.

6.3.4.1.   Axis Direction Switching
Depending on your physical perspective in reference to the traverse, you may want to reverse the positive direction on one or more of the axes. This is possible and only requires a simple text command through the COMS tab. If your traverse features 1 VXM controller, entering the following command into the "Command" input and pressing "Send" will flip the Y Axis:

F,C,setDM3,I1M1,R

And this command will flip the Z axis:

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F,C,setDM7,I1M1,R

For systems which feature 2 VXM controllers,

F,C,setDM3,I1M1,R

Will switch the Z axis if entered into the "Command Z" input and will flip the Y axis if entered into the "Command Y" axis. When only flipping 1 axis in the 2 VXM configuration, it is important that you do not leave the other command input window empty, but rather enter into it

F,C,I1M1,R

Before sending the command.

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7. 2-Axis Floor Balance

Aerolab's two axis floor balance is the most basic measurement tool available with our tunnels. Each floor balance measures load in two principal directions, namely axial and side. In general, these load measurements correspond to drag and side force respectively and can give a wide spread of aerodynamic information. Each balance is calibrated in house and includes compensation for non-linear coupling between the two axes. As an option, motorized yaw plates are available to perform systematic motion sweeps to shorten testing and setup time as well as add increased flexibility to your tunnel. AeroWare integrates fully both the measurement and control of a floor balance and motorized model positioning system. In the subsequent sections, these features will be covered in depth.

7.1. Main Display

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7.1.1. Measurement Indicators

The main display features both control and sensor reading features and provides an all-inclusive view of everything relating to the balance. Along the top of the screen, relevant measurements are displayed; namely Z Load, Y Load, Yaw Position (this display feature will either be an indicator- if you have the motorized yaw plate option - or a control - If you have the manual version), and wind Velocity. Below each of the balance related indicators and controls, a simple tare button is shown. Bu clocking these buttons, offsets can be applied and measurements can be "zeroed" to compensate for your model's initial conditions.

7.1.2. Raw Load Safety

As an important feature, a "Raw Load" indicator is shown below each of the axes tare buttons. This indicator gives a relative display of the balance's maximum loads. As the balance is loaded, these indicators will fill to the proportion of current load relative to the maximum safe load. When 75% safe load is reached, the fill will turn yellow and at 90% safe load, the indicator fill will turn red. The loads displayed here are true loads on the load cells and represent the maximum allowable load at any time.

If you have tared signals, it can become ambiguous as to what the true load is on the balance, so these indicators will always show you that information. NEVER load the balance with a higher load than it is rated. Doing so can shift the calibration and invalidate your measurements. If you believe the balance has been overloaded, you should perform some measurements with known loads and check them against the calibration to be sure no shift or nonlinearities have been introduced. If you find that the balance is not performing properly or is out of calibration, an overload is likely and it will need to be recalibrated or possibly repaired and reverified.

7.1.3. Graph

The graph shown here gives time relative indication of the relevant signals for a floor balance instrument. It shows both principal loads, yaw position, and tunnel velocity with respect to time.

7.1.4. File and Save Settings

In the lower left hand corner are two black indictors with blue text. They indicate the current file structure that will be saved during sweep and matrix operations. Since these attributes are universal to AeroWare and affect other instruments as well, these are indicators only and cannot be changed on this page. To change the file settings, navigate to the settings page where you will find the controls that modify file save settings for the motorized yaw plate motion settings.

7.1.5. Emergency Stop

Clicking this button will stop the motorized yaw plate ONLY. It will not affect other motion or power in the tunnel such as a traverse or VFD. This button will stop motion of any kind, regardless of the move our automated control used to move it. It must be manually reset.

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7.1.6. Motion Control Tabs

The bulk of the motorized yaw plate functionality resides here within these three tabs. Since their function is quite intricate, they will each be described here.

7.1.6.1. Manual

The manual motion controls are found here. In the top frame are incremental controls. The outer arrows will "step" the yaw plate in either direction by the distance (in degrees) show in "Step Size". The inner arrows will jog the yaw plate in either direction for as long as they are depressed. Moving the yaw plate in this way is the simplest way to position the plate where you need it.

Only slightly more complex is the "Move to Absolute" control, found in the lower pane. When clicked, the yaw plate will move to the absolute position shown.

Keep in mind that the yaw place can rotate in excess of 360 degrees so it is possible to give the motor commands that will rotate it more than one full revolution. If this happens unnecessarily, the Emergency Stop can be used to reset the motion and change can be made to avoid wasted motion.

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7.1.6.2. Sweep

Sweep controls allow you to quickly and easily execute coordinated motion and data logging actions with minimal human involvement. To execute a sweep, simply fill out the parameters, make sure the DAq is enabled, and click sweep. Keep in mind that after "Sweep" is clicked, the yaw plate will begin motion profiles that may seem erratic, so be sure that your model is in a safe position that can tolerate motion in any direction and to any degree.

The yaw plate will initially move to "Yaw Start" position and take "Yaw Steps" discrete steps to arrive at "Yaw End". Between each movement position, the data logger will record measurements for "Yaw Record Time (s)" seconds. The kind of data it logs depends on the indicated displays shown in the **File and Save Settings** indicators. Remember, that these can be changed in the "Settings" tab.

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7.1.6.3. Matrix

The matrix tab allows you to import a custom motion profile and record data accordingly. Simply click the folder open button below the file path indicator and navigate to the .csv file that contains the desires motion path. Matrix .csv files should be formatted as follows:

Yaw,Dwell
0,2
1,2
2,2
3,2
4,3
. . .

These files require a header of "Yaw" and "Dwell, separated by a comma. The subsequent rows show the desired yaw position (In degrees from the absolute zeroed position) followed by the amount of time you wish to record at the position. When you have loaded a valid file, it will be shown in the indicator above the file path display.

Check the file using the scroll bar on the right-hand side of the selected profile and click "Matrix" when ready. The yaw plate will position itself to each of the positions, in order, and then record data for the amount of time specified and according to the **File and Save Settings** selected.

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