Operating instructions for AeroPod 2® with FW 10+, and Velocomp Aero software for Mac/PC February 2025

Firmware 10.0+

VELOCOMP

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Introduction
NOTE: AEROPOD CDA MEASUREMENT DOES NOT WORK WITH EBIKES

In 2008 Velocomp introduced "iAero", the first-ever device for outdoor cycling aerodynamic CdA measurement. iAero's foundational principles—based on Velocomp patents issued just a few years prior—were not only sound, but superior to later-generation aero sensors based on "virtual elevation" calculations. That said, iAero was too far ahead of its time: its analog sensors weren't up to snuff, and the required direct force power meter sensors were extremely expensive.

In the sixteen years since introducing iAero, Velocomp has worked continuously on improving everything related to CdA measurement: digital sensors, faster electronics, computational algorithms, on-the-road device firmware, and post-ride analysis software have all improved significantly. And the cost of DFPMs has declined dramatically, making CdA an economically practical measurement.

Firmware 10.0+ and Velocomp Aero, introduced in June of 2024, together represent the pinnacle of Velocomp's advancements in CdA measurement and analysis. **Firmware 10.0+ and Velocomp Aero software are both completely new**—they have been written from the ground up—and together they take AeroPod CdA measurement to a level of accuracy, consistency, and simplicity that will delight mainstream cyclists, and provide competitive advantage insights for time trialist and triathlon competitors. And true to Velocomp's practice of "continuous improvement", ***when FW 10+ is loaded into your existing AeroPod, your AeroPod it becomes the "next generation" AeroPod 2***

If you already own an AeroPod we strongly suggest you upgrade to FW 10, and install Velocomp Aero on your Mac/PC to gain full AeroPod 2 performance. You'll find that Velocomp Aero (VA) operates very similarly to Isaac, so there is a only a short learning curve required.

If you're new to aerodynamics and CdA, we suggest you take a look at the Appendices, which explain the basics of aerodynamics and CdA measurement.

There are two ways AeroPod 2 can be used for improving your aerodynamic performance: 1) systematic CdA aero testing of ride position and equipment; and 2) on-the-road, training and racing measurement of CdA. Please follow these instructions to learn about using AeroPod 2 for both kinds of CdA measurement.

AeroPod 2 can also function as a stand-alone power meter. When used in this manner AeroPod 2 provides accurate cyclist power data but does NOT provide CdA measurements.

For comprehensive instructions for software installation, and AeroPod 2 setup and usage, please click on the following link**:**
https://velocompforum.com/viewtopic.php?f=98&t=6033

AeroPod 2 "Profile Setting" determines "aero sensor" or "power meter" mode

AeroPod 2 functions either as an aero sensor or as a stand-alone power meter. During setup you will select between AeroPod 2's "aero sensor" modes (profile 3 and 4) or "power" modes (profiles 1 and 2).

Each of AeroPod 2 "profiles" store bike and rider data, speed/cadence/HR sensor IDs, and calibration data, and configure the electronics for aero measurement or power measurement.

Each profile requires separate setup. To set up a profile, you use Velocomp Aero software for Mac/PC to activate (select) the desired profile, then enter bike/rider data; after that, you perform sensor pairing and calibration processes on the bike. Sensor ID and calibration data are stored permanently in the selected profile and does not need to be re-entered.

When used as an aero sensor (profile 3 or 4) AeroPod 2 measures aerodynamic CdA, based on data from your bike's direct-force power meter and from AeroPod 2's opposing-force sensors.

When used as a stand-alone power meter (profiles 1 or 2), AeroPod 2 data comes only from its opposing-force sensor measurements (a direct force power meter is not required). Note that when operated as a stand-alone power meter, AeroPod 2 does NOT measure CdA.

For using AeroPod 2 as a stand-alone power meter, download the "AeroPod2_Power_122822.pdf" document, available in the "Other AeroPod 2 Features" section linked here:

https://velocompforum.com/viewtopic.php?f=98&t=6033

USING AEROPOD 2 FOR CDA MEASUREMENT

NOTE: AEROPOD CDA MEASUREMENT DOES NOT WORK WITH EBIKES

<u>Testing (Profile 4)</u> and <u>Racing</u> (Profile 3) CdA: two AeroPod 2 modes for CdA measurement

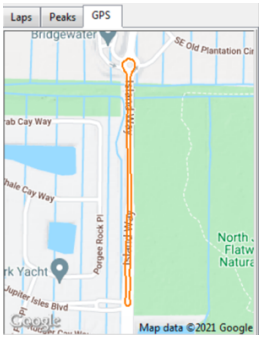
Aerodynamics in competitive cycling is really about two things: ***before racing***, finding the best aero ride position and equipment (CdA Testing), and ***while training and racing***, getting real-time CdA feedback to help you minimize the effects of wind as much as possible.

AeroPod 2 measures, displays and records CdA according to how you are using it: <u>Aero Testing (profile 4)</u>, or <u>Training/Racing (profile 3).</u>

Aero Testing: Profile 4 (factory default)

Profile 4 provides high-accuracy, repeatable CdA measurement of your ride position and equipment.

When riding in profile 4 mode, **you MUST ride on a closed course of 0.5 to 1.5 miles (loop or out-and-back route), *in the same position, with the same equipment, for the entirety of each lap test***.

CLOSED LOOP TESTING


OUT AND BACK TESTING

Closed course testing produces results comparable to wind tunnel or velodrome testing, and *allows AeroPod 2 to provide the most accurate and consistent measurement of CdA*. At the end of each lap test, your Garmin uses the "AeroPod 2.0" app to display the measured CdA for the just-completed lap, and records your lap CdA number in the ride file. After completing your testing, the Velocomp Aero app for Mac/PC further refines your CdA measurements, providing highest accuracy and consistency of CdA measurement.

<u>Aero testing in profile 4 is the best way to find the combination of ride position and equipment that will make you the most aerodynamic.</u>

Training/racing CdA (profile 3)

Profile 4 CdA Testing on closed courses is great, but cyclists train and compete on the open road where ride position, terrain, wind conditions, and fatigue are constant challenges. All of these changing conditions affect aerodynamics.

When AeroPod 2 is set to Profile 3 (Training/Racing), you will get real-time CdA measurements *during your ride* that help you manage your riding for optimum aerodynamic performance.

In profile 3 you are not restricted to test riding on closed courses, nor do you have to remain in the same ride position. When set to profile 3, Your Garmin will display continuous measurement of CdA, averaged over a 60 second time period. For example, if you go into a tuck on a downhill, the AeroPod 2.0 CdA number displayed on your Garmin display will drop quickly, over a period of about 60 seconds, to the CdA value that corresponds to your tucked aero position.

<u>When set to Profile 3, AeroPod 2 measures in real time, on your training and racing routes, how well you manage your riding to keep your CdA low and your aerodynamics as good as possible.</u>

SOFTWARE APPS FOR YOUR AEROPOD 2

Your AeroPod 2 interacts with four separate apps:

1. **Velocomp Aero** for Mac/PC—REQUIRED, used to set up AeroPod 2 and analyze CdA ride files
2. **AeroPod 2.0** *ConnectIQ app for Garmin*—REQUIRED, used to display CdA data on your Garmin bike computer
3. **Velocomp** app for iOS/Android—OPTIONAL, used to change AeroPod 2 profiles when away from your computer
4. **Velocomp Tracker** app for iOS/Android—OPTIONAL, used to record GPS information for merging into your CdA ride files

Apps 1) and 2) are required in order to operate your AeroPod 2; *apps 3) and 4) are optional* but make operation of AeroPod 2 more convenient.

Download and install apps 1) and 2), and optionally 3) and 4), before starting use of your AeroPod 2, available here:

1) Velocomp Aero for Macs:
https://velocompforum.com/viewtopic.php?p=32451

1) Velocomp Aero for Windows
https://velocompforum.com/viewtopic.php?p=32450

2) AeroPod 2.0 app for Garmin bike computers
https://apps.garmin.com/apps/41ca192f-24a7-4c52-bcf9-306c3c15496e

3) Velocomp app for iOS
Search for "Velocomp" in iOS App Store

3) Velocomp app for Android
Search for "Velocomp" in Google Play store

4) Velocomp Tracker app for iOS
Search for "Velocomp Tracker" in iOS App Store

4) Velocomp Tracker app for Android
Search for "Newton Tracker" in Google Play store

Comprehensive Instructions for AeroPod 2

NOTE: AEROPOD CDA MEASUREMENT DOES NOT WORK WITH EBIKES

AeroPod 2 is a very sophisticated device, and we have provided extensive instructions and videos for setup and use. Here is the link where you will find all AeroPod 2 instructions, as well as links to the required and optional apps:

https://velocompforum.com/viewtopic.php?f=98&t=6033

See the "**Getting Started: AeroPod 2 Setup and Calibration**" section of the Comprehensive Instructions for information and videos about setting up, mounting, and calibrating your AeroPod 2
NOTE: DO NOT MOUNT AEROPOD 2 TO AERO BAR EXTENSIONS

See the "**Installing and using Velocomp Aero software**" section of the Comprehensive Instructions for information about installing and using the Velocomp Aero app for Mac/PC to setup your AeroPod 2 profiles, and for downloading and analyzing your AeroPod 2 ride files

See the "**Installing and using AeroPod 2.0 ConnectIQ app for Garmin devices**" section of the Comprehensive Instructions for information about installing and using the AeroPod 2.0 app with your compatible Garmin bike computer, available here: http://bit.ly/4bcjGct

Before proceeding, please use the above instructions to attach your AeroPod 2 to your bike, *download and install the Velocomp Aero app on your computer, and download and install the AeroPod 2.0 app on your Garmin bike computer.*

NOTE: All instructions in the sections to follow assume you have completed the installation of the required Velocomp Aero and AeroPod 2.0 apps.

AeroPod 2 Setup, Profiles 4 and 3 (CdA measurement)

NOTE: AEROPOD CDA MEASUREMENT DOES NOT WORK WITH EBIKES

After attaching AeroPod 2 to your bike you'll need to do these things:

0) Install VA software in your Mac or PC, and install "AeroPod 2.0" for iOS/Android app on your Garmin

1) Use Velocomp Aero (VA) software to enter "profile 4" parameters for you and your bike
2) Check your ANT+ speed and DFPM sensors (fresh batteries, good DFPM calibration)
3) Pair your ANT+ speed, optional cadence, and Direct Force Power Meter (DFPM) sensors to AeroPod 2
4) Pair AeroPod 2 to your Garmin display device
5) Perform a AeroPod 2 profile 4 calibration ride
6) Use VA (or the Velocomp app for iOS/Android) to set AeroPod 2 to profile 4 (aero testing) or profile 3 (training/racing)

These are one-time steps, and though the list may seem daunting, it's pretty fast and easy! ☺

1. Enter "Profile 4" parameters

At the factory your AeroPod 2 is set to profile 4, so when you use VA "Device/Setup Device…" wizard, your parameter selections will be stored in profile 4 of AeroPod 2.

To enter your parameters, connect AeroPod 2 to VA software and use the command "Device/Setup Device…" to launch the VA setup wizard. These are the parameters that you will enter with the VA setup wizard and which will be permanently stored in profile 4:

Body weight
Bike and gear weight
Normal ride position
Tire type and road surface

TIP: We strongly recommend you measure your body weight and the weight of your bike and gear. This will improve the accuracy of AeroPod 2 CdA calculations.

Once you have entered parameters into profile 4, you won't have to enter them again. Of course, later-on you can modify profile parameters as needed, using the Velocomp Aero setup wizard.

NEW TO FIRMWARE 10.0+: Parameters entered into profile 4 will be copied automatically into profile 3, making CdA measurements between the two profiles more consistent

2. Check your Speed and DFPM sensors

CdA measurements require correct operation of your ANT+ speed sensor and Direct Force Power Meter (DFPM) power sensor. *If using a "magnet-less" speed sensor, make sure it is attached to the front hub.*

We strongly recommend you replace the batteries in all of your sensors.

IMPORTANT: You MUST use an ANT+ speed sensor. *AeroPod 2 does not work with GPS-based speed readings from your Garmin*

Additionally, consult the instructions of your DFPM to make sure you know how to calibrate it. If your DFPM calibration is incorrect then you won't be able to achieve accurate or consistent CdA measurements!

NOTE: If you have an "old style" SRM crank power meter, see the Appendix for special calibration instructions

3. Pair ANT+ sensors to AeroPod 2

Awaken your speed, DFPM, and (optional) cadence sensors. *Before starting AeroPod 2 pairing we strongly recommend you use your Garmin to confirm proper operation of your other ANT+ sensors.*

To initiate AeroPod 2 sensor pairing process, *press-hold the AeroPod 2 button for 4 seconds, until its light flashes green*. Release the button when the light starts flashing green.

- During pairing, when AeroPod 2 "finds" your DFPM the AeroPod 2 status light will flash yellow three times.
- If AeroPod 2 finds a (separate) cadence sensor the light will flash red three times
    - NOTE: if your DFPM also measures *cadence*, AeroPod 2 "reads" the cadence signal from your DFPM, and the AeroPod 2 light won't flash red
- When AeroPod 2 finds your speed sensor the light will turn solid green, and then go out, indicating that **the pairing process is finished and has been completed properly**
    - NOTE: if your DFPM also measures *bike speed*, AeroPod 2 "reads" the speed signal from your DFPM. You won't need a separate speed sensor, and the AeroPod 2 light will show solid green at the end of the pairing process

- If pairing did not succeed the light will flash red. Make sure your sensors are awake, then initiate another pairing process

The AeroPod 2 pairing process can last up to 60 seconds, and the pairing process ends successfully when the light turns solid green, then goes out.

4. Pair AeroPod 2 to your Garmin

NOTE: YOU MUST PAIR AEROPOD 2 TO YOUR ANT+ SENSORS (Step 3) **BEFORE** PAIRING AEROPOD 2 TO YOUR GARMIN.

Awaken your Speed and DFPM sensors on your bike, then click your AeroPod 2 button to awaken it. *The AeroPod 2 light should show either solid Yellow or solid Green*.

Follow the setup instructions of your Particular Garmin device to pair the AeroPod 2 to your Garmin. AeroPod 2 will appear as a power sensor in your Garmin.

5. AeroPod 2 calibration ride

After pairing AeroPod 2 to your sensors and your Garmin, AeroPod 2 is ready for a profile 4 calibration ride.

IMPORTANT: Every time you perform a sensor pairing between AeroPod 2 and your ANT+ sensors (Step 3 above), AeroPod 2 is "forced" into calibration ride mode, *even when you re-pair AeroPod 2 to the same sensors*.

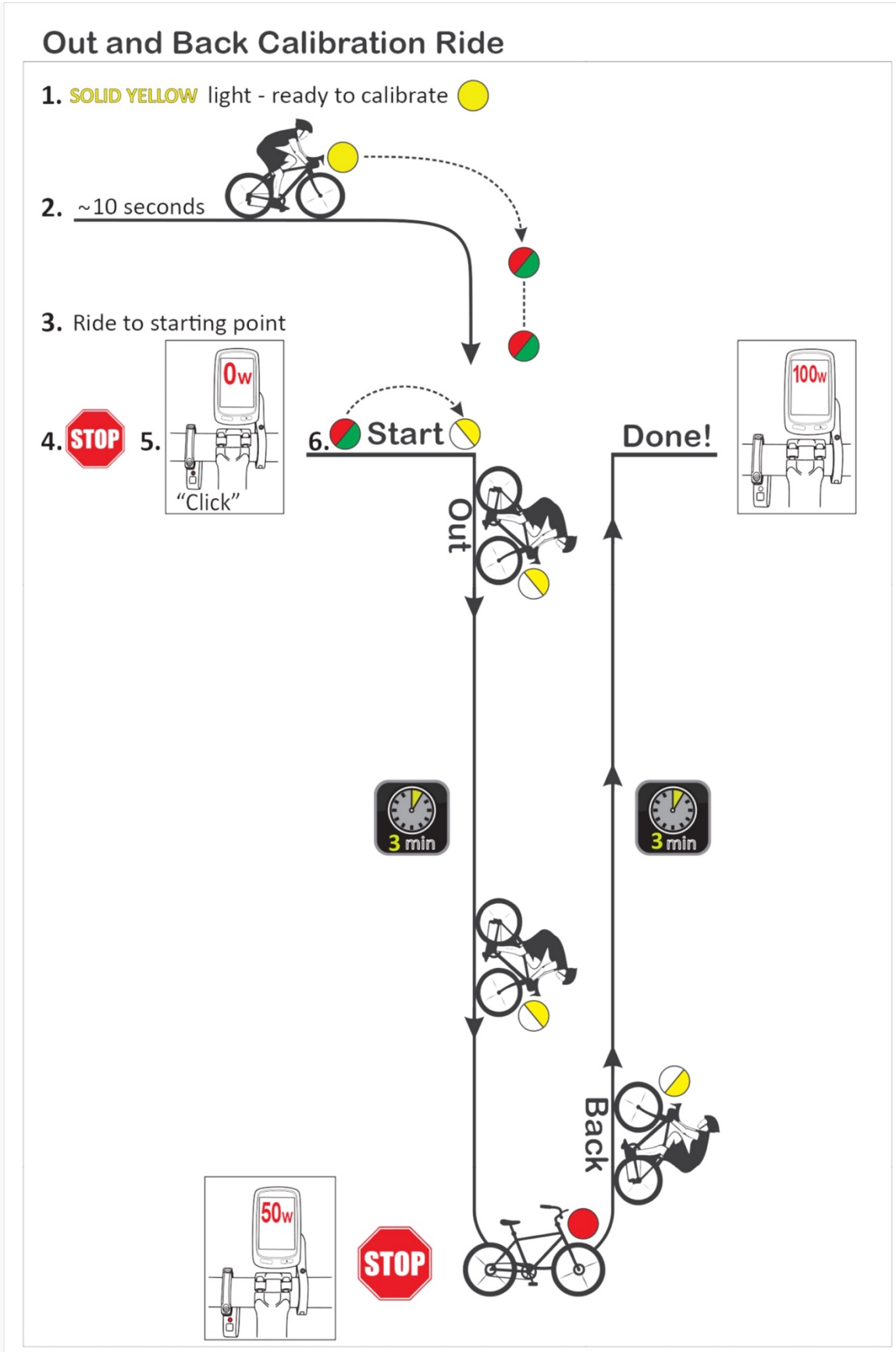
We recommend calibrating AeroPod 2 where there is little traffic and the wind is fairly calm.

NEW: At the factory your AeroPod 2 is set to Profile 4. The calibration ride stores parameters in Profile 4 of your AeroPod 2, and afterwards are copied automatically over to profile 3.

CALIBRATION RIDE

After performing the profile 4 calibration ride, you don't have to repeat the calibration ride each time you do a new profile testing sequence

1) Ride "out" for about 3 minutes, at the power levels/bike speeds where you normally train. Watts rise to 50W
2) At the 50W point you will STOP, turn around, and ride back to the starting point at a similar pace. Watts rise to 100W as you ride by the starting point then revert to normal. The cal ride is complete.
3) NEW TO FW 10: CAL RIDE DATA FROM PROFILE 4 (TESTING) IS COPIED TO PROFILE 3 (TRAINING/RACING). YOU DON'T HAVE TO DO A SEPARATE CAL RIDE FOR PROFILE 3

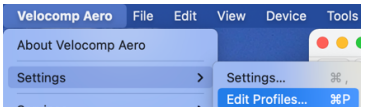


6. Select CdA measurement mode

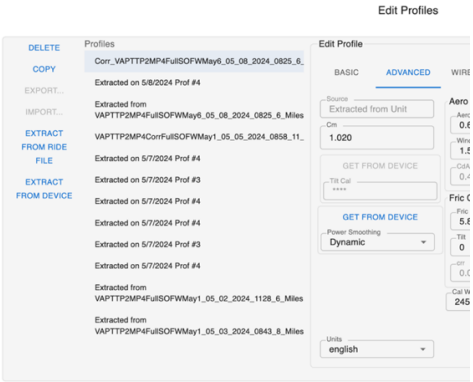
AeroPod 2 measures CdA in profile 4 and 3, depending on which profile you manually select. USE VA, "DEVICE/SETUP/SET ACTIVE PROFILE…" TO SELECT YOUR CDA MEASUREMENT MODE (PROFILE 4 OR PROFILE 3). [*Or, optionally, use the "Velocomp" app for iOS/Android to switch to your preferred profile*]

Here's how to use the Velocomp Aero app (VA) to select the active profile in your AeroPod 2

1) Connect AeroPod 2 to VA
2) Select "Velocomp Aero/Settings/Edit Profiles…"



3) In the bottom left corner of the Edit Profiles window, set the active profile to Profile 3 (training/racing CdA) or profile 4 (Aero Testing).



Click here to change active profile →

You will get a confirming message (in this example, AP has been set to profile 3):

TIP: YOU CAN USE THE "VELOCOMP" APP FOR IOS/ANDROID TO CHANGE PROFILES FROM YOUR SMARTPHONE. LAUNCH THE APP, TOUCH "RIDER, BIKE AND SENSOR SETUP", SELECT THE PROFILE YOU WANT TO USE, THEN CLICK THE "SAVE" BUTTON. YOU'LL GET A CONFIRMING MESSAGE SHOWING YOUR AEROPOD 2 IS ACTIVE IN THE PROFILE YOU HAVE SELECTED.

IMPORTANT: AEROPOD 2 REMAINS IN THE PROFILE YOU HAVE SELECTED, UNTIL YOU MANUALLY CHANGE IT USING VA or the VELOCOMP APP

Using AeroPod 2 for CdA Testing mode—profile 4

One of the very special things you can do with AeroPod 2 is measure, improve, and optimize your ride position and equipment, using AeroPod 2's profile 4 "CdA Testing" feature. You'll get highest accuracy and most consistent CdA measurement using profile 4, with measurements refined even more in post-ride analysis using the Velocomp Aero (VA) app for Mac/PC.

Quick Summary of profile 4 CdA Testing:

A. Profile 4 CdA testing REQUIRES a Garmin bike computer, using the free Velocomp AeroPod 2.0 ConnectIQ app, available here: http://bit.ly/4bcjGct
B. Profile 4 CdA testing REQUIRES a closed-loop or out-and-back lap route, 0.5 to 1.5 miles
C. Profile 4 CdA testing REQUIRES that you **click the Garmin lap button at the SAME start and stop location of each CdA test**
D. During testing your Garmin shows live, cumulative CdA measurement
E. You click the lap button of your Garmin at the start and stop point of each loop test. THE START AND STOP LOCATIONS MUST BE THE SAME PHYSICAL PLACE.
F. At the end of each test, when you click the lap button your Garmin shows, for 10 seconds, the measured CdA for the just-completed lap, then resumes "live" CdA display
G. Repeat the *same* test configuration 4-6 times, resulting in 4-6 separate measurements of your CdA

Detailed Instructions for profile 4 testing

For profile 4 CdA measurement you will perform a controlled set of rides, *on a closed loop or out-and-back route*. Each test measures the CdA of your equipment and ride positions. You'll do a series of measurement tests for each configuration, allowing you to quantify and compare CdA results from each of your tests. Your tests will help you figure out the best combination of equipment and ride positions for your style of riding and your cycling objectives.

NOTICE: IF YOU RIDE WITH PROFILE 4 ON ANYTHING OTHER THAN A CLOSED COURSE ROUTE, OR IF YOU CLICK THE LAP BUTTON ANYWHERE OTHER THAN THE SAME START/STOP OF YOUR ROUTE, YOU WILL GET VERY POOR CDA MEASUREMENTS.

When doing CdA testing you will be comparing *multiple* measurements from *multiple* tests. **Because you're doing comparisons, *and because CdA is sensitive measurement*, for best results you'll need to set up and perform aero tests in a careful manner:**

1. Test route. Ride the SAME route for each test. A one-half mile (or longer) closed loop without abrupt turns, or a reasonably straight course, out-and-back route at least one quarter mile long in each direction, works well. A reasonably level road is best, because it allows you to pedal with a fairly constant level of power during the entire test.

2. Solo ride. CdA testing does not work when riding in a group.
3. No traffic. When vehicles zoom by they create wind gusts, adversely affecting the accuracy of CdA measurement.
4. Tire pressure. Make sure your tires are fully inflated. ***Different tire pressures on different days will cause CdA test measurements to vary.***
5. Warm up. Before starting testing, ride one complete lap of your test route, at least 5 minutes long, *clicking the Garmin's lap button at the start and end of the warm-up lap*. This allows AeroPod 2 internal calibrations to be checked, and allows the DFPM sensor to temperature stabilize
6. Do not move AeroPod 2 during testing. Make sure AP is securely attached to your bike *and cannot rotate*.
7. Course length. *Route length must be at least 0.5 miles long*. A total route length of 1-2 miles is great.
8. Test Power/Speed: Ride at a reasonably uniform level of power. High speed is not essential, but should be at least 15 mph.
9. Consistent road surface. For highest accuracy results the road surface should NOT change on your route (for example, patches of chip seal on an otherwise smooth road)
10. Calm winds. Average ground wind speed should be less than 10 mph. If you're doing out-and-back testing, it's best if the winds are not "cross winds".
11. Avoid gusty winds. You want to test in conditions where winds are consistent. Do NOT test when winds are gusty. Do NOT test on roads where there is a lot of road traffic (cars cause wind gusts). Do NOT test in urban environments where wind blasts occur between buildings.
12. Temperature. Try to do your testing where temperatures remain reasonably constant. Remember: DFPMs are temperature sensitive…

On-the-Road Test Procedure

When you're ready to perform Aero Testing with profile 4, here is our recommended procedure:

1) Attach AeroPod 2 (AP) to VA, and use VA command "Velocomp Aero/Edit Profiles/Set Active Profile in Device". Select "profile 4" to make profile 4 active. (**TIP**: You can also use the "Velocomp" iOS/Android app to select profile 4, without attaching AeroPod 2 to your computer)
2) Awaken your ANT+ sensors (DFPM, speed) on your bike
3) Click AP button to awaken it. When AP is paired your ANT+ sensors its light will turn solid green, then off (this assumes you have already completed a cal ride). TIP; you do NOT need to do a new cal ride for each test.
4) *After* AP is awake and paired, turn on your Garmin. If everything is working you'll see live AP slope data in the "AeroPod 2.0" app you've previously installed.
5) Ride to the place where you will do your closed loop or out-and-back testing.
6) Click the Garmin lap button, then do a warm-up lap of your complete closed route. Your warm-up should take at least 5 minutes to complete; if your route is shorter than 5

minutes then slow down or do multiple circuits of your route. At the end of your warm-up closed-route lap click the Garmin lap button, *at the place where you started your warm-up*. This will appear as "lap 1" in the AeroPod 2.0 app screen.

7) When you're ready to start testing and you are at the starting point of your test route, *click the lap button on your Garmin to start the test*
8) Riding along the test route you'll see AeroPod 2.0 show a VERY SLOWLY CHANGING CdA number. The CdA number displayed is the cumulative average CdA for your current lap
9) During the test, ride at consistent power levels/bike speeds
10) Total closed route length must be at least 0.5 miles long—1 to 2 miles total is best
11) *To end the CdA measurement test*, click the lap button on your Garmin *at the same place where you clicked the lap button to start the test*. Your CdA test result will be displayed for 30 seconds in the CdA window of your Garmin; then, CdA will go back to "live" values. Also, the CdA test result will also be recorded in the table of AeroPod 2.0 app.
12) If you're doing an out and back route, turn around and ride back to your starting point. Click the lap button again to start a new test
13) *If you're testing on a closed loop*, such as an outdoor velodrome, click the lap button at the end of each test. Your previous-lap CdA will be shown for 30 seconds; then, CdA will go back to "live" values. Note that if continue riding, your new CdA measurement will begin immediately after clicking the lap button. KEEP RIDING to continue your next test.

NOTICE: IF YOU RIDE WITH PROFILE 4 ON ANYTHING OTHER THAN A CLOSED COURSE LOOP, YOU WILL GET VERY POOR/INCONSISTENT CDA MEASUREMENTS.

IMPORTANT: WHEN USING PROFILE 4 FOR AERO TESTING, MAKE SURE TO USE YOUR GARMIN'S LAP BUTTON TO MARK THE BEGINNING AND END OF EACH LAP. **NOTE**: **IF YOU CLICK THE LAP BUTTON AT ANY PLACE OTHER THAN THE START AND END OF THE LOOP, YOU WILL GET VERY INACCURATE AND INCONSISTENT RESULTS.**

TIP: For best results we recommend 3-5 lap tests for each configuration you're measuring

The above procedure will assure that you get accurate, repeatable CdA aero test measurements.

HOW TO GET THE MOST OUT OF PROFILE 4 AERO TESTING

Aero Testing works best when you follow standard protocols for scientific measurements. Here are some suggestions that will help you get the most out of your profile 4 aero tests:

1. Change only one variable per test sequence. For example, you want to compare the CdA differences between bike helmets "A" and "B", and ride positions "X" and "Y". You decide to do the first CdA testing with your helmet "A" and ride position "X". For the next sequence of testing, do NOT change to bike helmet "B" *and also change* to ride position "Y"! Likely you'll get a different CdA, but you won't know how much of the CdA change was due to helmet "B", and how much was due to ride position "Y"! (The correct second test sequence is helmet "B" and ride position "X").
2. Do multiple laps per test sequence. More data is better, and having 3-5 lap tests per sequence will provide higher levels of CdA accuracy and consistency.
3. When you're finished testing a sequence (say, three laps of "A" and "X", *click the stop button of your Garmin*. On your AeroPod 2.0 app screen your tests will all be marked with the same sequence "S" number. When you're ready click the start button of your Garmin to start the next set of tests, which will have the next higher S number.
4. Be organized! If you're doing equipment testing, have your gear laid-out at your starting point, so you can easily swap equipment at the end of each test.
5. When you're ready to begin a new test sequence, click the start button of your Garmin.
6. Take notes! It's super-easy to forget what exactly it is you tested. Write down your test variables at the end of each test, and any test notes (such as: a big truck created a wind gust half-way through my last test)
7. Make sure to touch the Garmin's Lap button at the end of each test. You will see the average CdA displayed for the just-finished lap, and later-on, when you download the ride file, you will see lap markers placed in the ride file, making it easier to analyze CdA later-on with VA software.

After completing your tests, you will download your ride into VA software for more detailed analysis using the "Analyzed CdA" feature of VA.

A Real-Life Example of CdA Testing

One of our CdA users performed a very interesting set of tests, comparing clothing, equipment, and ride position, quantifying the effects of each on aerodynamics.

He did his riding on an outdoor track, methodically performing each of his tests.

He liked seeing his CdA while riding: "It was great being able to see the list CdA results as I rode. I was able to tweak positions while riding...[it helped me learn] more intuitively."

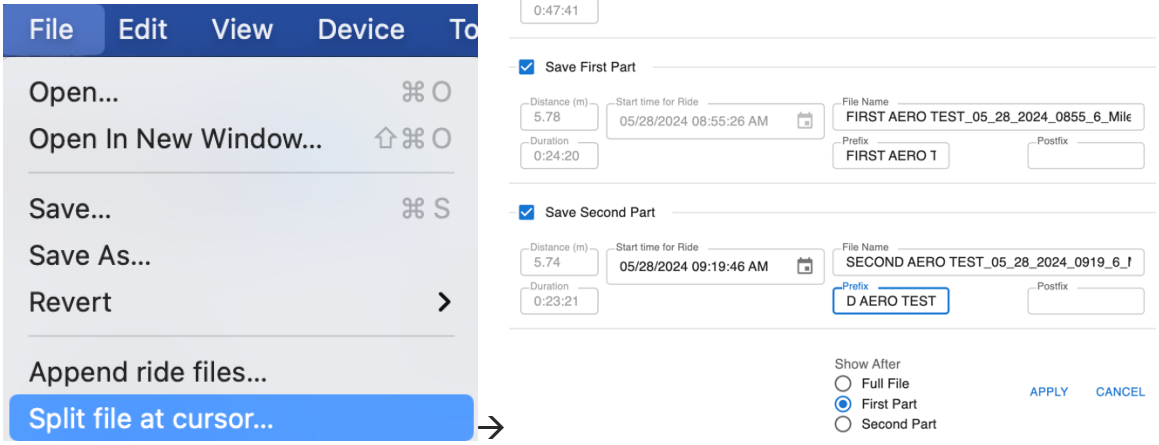
- Control, hoods .419
- drops, normal clothing .386

- tops .452
- hoods, baggy clothing .568
- drops, baggy clothing .516
- tops, baggy clothing .572
- drops, normal clothing, aero helmet, shoe covers .354
- hoods, lowered riding position .408 hoods,
- more aero position .371 hoods,
- elbows pulled in .321
- drops, aero as possible, elbows bent and pulled in .326

Our rider was able to optimize, on-the-road, his aerodynamics, and to quantify some of the benefits of different equipment. For example, when holding the "drops" riding position, by adding an aero helmet and shoe covers, he improved his aerodynamics by about 0.032 = (0.386 – 0.354); that is, his aero helmet and shoe covers LOWERED his CdA by 0.032

It's also obvious that baggy clothing is BAD NEWS for aerodynamic performance... ☺

TIP: IF YOU TEST MORE THAN ONE SEQUENCE, YOUR SINGLE VA RIDE FILE WILL SHOW ALL OF YOUR DIFFERENT SEQUENCES IN A SINGLE RIDE FILE. YOU CAN SPLIT YOUR SINGLE RIDE FILE INTO MULTIPLE RIDE FILES, SAY ONE RIDE FILE PER SEQUENCE, BY DOING THIS: OPEN YOUR RIDE FILE IN VA, CLICK THE CURSOR IN THE GRAPH WHERE YOU WISH TO SPLIT THE FILE, THEN USE THE COMMAND "FILE/SPLIT FILE AT CURSOR…" TO DIVIDE THE FILE. IN THE "PREFIX" SECTION OF THE WINDOW YOU CAN NAME EACH OF THE SPLIT FILE PORTIONS.



Using AeroPod 2 CdA on training/racing rides—profile 3

On your everyday training/racing rides, AeroPod 2 helps you understand your aerodynamics as they change. Here are some things you can do with profile 3 CdA measurement:

1. Find a ride position that allows you to keep high power output but reduces CdA. Watch both your power output and your CdA.
2. On longer rides, watch the trend of your CdA, to see if it becomes higher as you become more fatigued
3. On hills your CdA doesn't matter as much. Pay more attention to CdA when you're riding on the flats

It's important to remember that CdA measurements are meaningful ONLY when you are riding solo, and you are riding on road surfaces whose roughness is not changing.

How to use Training/Racing CdA (Profile 3)

1) Attach AeroPod 2 to VA, and use Velocomp Aero command "Velocomp Aero/Settings/Edit Profiles/ Active Profile in Device". Select "profile 3" to make profile 3 active (you can also use the Velocomp app for iOS/Android to select profile 3)
2) Make sure AeroPod 2 is attached to your bike and is awake.
3) Start riding. (***NOTE****: if you've previously completed a profile 4 calibration ride, you don't have to do a new cal ride prior to profile 3 measurement*). For the first 5 minutes of each new ride, AeroPod 2 internal calibration measurements will be made. During the first 5 minutes try to ride at a constant power level, and avoid sharp turns.
4) After 5 minutes, your CdA measurement will go "live".
5) If you ride in the position you used during your calibration, the live CdA number you see will be close to the number measured during setup.

NOTE: If the starting portion of your ride includes lots of turns, speed changes, and stopping, it can take up to 10 minutes for the CdA number to stabilize.

IMPORTANT: When riding with profile 3, variation of CdA numbers is normal

When riding the same ride position for an extended period of time, it is normal for profile 3 "live CdA" to vary somewhat below and above an average value.

What can cause CdA value to vary, even when you don't change anything about your ride position or equipment?

- Small, natural variations in power measurements, both from your DFPM and from AeroPod 2
- Surging/coasting. When focusing on CdA, try to pedal at an even level of power, and minimize coasting
- Changes in hill slope, for example when on rolling hills
- Drafting/group riding
- Braking
- Sharp turns
- Significant changes in road roughness

After riding some with AeroPod 2 in profile 3 you will get a very good idea of your CdA, and its natural variation as you ride. In the example profile 3 ride shown below, the CdA line (cyan) "hovers", +/-, around an average value of 0.4

Ride with profile 3

Using Velocomp Aero (VA) Software to Analyze CdA Data

NOTE: THIS SECTION ASSUMES YOU HAVE INSTALLED VA SOFTWARE AND ARE FAMILIAR WITH ITS OPERATION. SEE HERE FOR VA INSTRUCTIONS:

https://velocompforum.com/viewtopic.php?p=32452

Once you've finished your on-the-road CdA testing, you can download your AeroPod 2 ride file to VA for more detailed analysis.

IMPORTANT: FIRMWARE 10.0+ AND VELOCOMP AERO (VA) ARE COMPLETELY NEW. THEY OPERATE SIMILARLY TO PREVIOUS VERSIONS OF FW AND VELOCOMP AERO, BUT USING THEM WITH AEROPOD 2 IT IS MUCH EASIER TO OBTAIN ACCURATE, CONSISTENT CDA MEASUREMENT. PLEASE READ THIS SECTION TO FIND OUT HOW TO USE VA WITH FW 10+.

Using Velocomp Aero and Firmware 10.0+ with Profile 4, Aero Test

IN FW 10+, SIGNIFICANT CHANGES HAVE BEEN MADE TO THE WAY AEROPOD 2 RIDE FILES ARE RECORDED IN PROFILE 4: A SINGLE RIDE FILE RECORDS ALL TESTS MADE.

Here is an aero test of a cyclist riding on the hoods around a closed 1.2 mile loop, for 8 closed-loop tests total (laps 2-9), in profile 4. The cyclist traveled around a 1.1 mile loop road, clicking the Garmin's lap marker at the end of each completed lap. The lap markers were recorded in the ride file. The course is basically flat, with one small bump (slope change in red) on the route.

Below is the AeroPod 2.0 Garmin screen from the same ride. Notice that the Garmin lap CdA numbers line-up with the corresponding lap numbers in VA (cyan graph) (lap 8 in VA corresponds to lap 9 of Garmin screen)

LAPS PEAKS

Lap	Start		Duration				
	Time	Dist	Time	Dist	CdA	DFPM	Power
1	0:00:00	0.0	0:00:42	0.1	0.499	19.762	17.476
2	0:00:42	0.1	0:05:08	1.2	0.441	106.006	117.961
3	0:05:50	1.3	0:04:36	1.2	0.413	124.688	127.725
4	0:10:26	2.5	0:04:30	1.2	0.409	127.448	121.696
5	0:14:56	3.7	0:09:02	2.4	0.438	133.642	127.779
6	0:23:58	6.1	0:04:35	1.2	0.430	132.116	131.524
7	0:28:33	7.2	0:04:36	1.2	0.423	129.076	127.986
8	0:33:09	8.4	0:04:42	1.2	0.419	120.883	119.986
9	0:37:51	9.6	0:04:35	1.2	0.423	132.116	125.313
10	0:42:26	10.8	0:01:45	0.3	0.420	15.962	16.019

Using the Velocomp Aero app to analyze profile 4 CdA lap test results

During your testing you may have noticed that CdA test numbers from individual lap tests can vary somewhat. This variance is normal (CdA is a very sensitive measurement), and is the reason that multiple lap tests are conducted. *Multiple lap tests allow the variance to be minimized, allowing for high accuracy and consistent measurement of CdA*.

The new Velocomp Aero app reads the raw sensor data from your AeroPod 2 tests, then automatically analyzes it to give you a high-accuracy, high-consistency measurement of CdA based on the results of *all* of your individual lap tests.

QUICK SUMMARY OF "ANALYZED CDA" INSTRUCTIONS

1) Open in Velocomp Aero (VA) the profile 4 ride file you want to analyze
2) In the Lap box to the left of the main graph, select the full laps from your multiple tests that you want to analyze. More laps are better.
3) Above the lap stats you'll see the "Analyzed CdA" value for the laps selected. Click the APPLY button to apply the corrections to the file and to read your best-fit CdA value for the multiple lap tests you selected.

DETAILED "ANALYZED CDA" INSTRUCTIONS WITH EXAMPLE

We will use the above ride file to illustrate how the VA "Analyzed CdA" process works in detail:

1) Download/open in VA the ride file with the test you want to analyze
2) To the left of the graph you will see the laps of your test ride. In this example there were 10 total laps; lap one was from the starting point of the ride to the starting point of the test; laps 2-9 were closed circuit laps of 1.2 miles each, with the Garmin "lap" button being pressed at the end of each closed-loop lap, and lap 10 was from the end of the final lap to the end point of the ride.

LAPS PEAKS

Lap	Start		Duration				
	Time	Dist	Time	Dist	CdA	DFPM	Power
1	0:00:00	0.0	0:00:42	0.1	0.499	19.762	18.247
2	0:00:42	0.1	0:05:08	1.2	0.420	106.006	118.163
3	0:05:50	1.3	0:04:36	1.2	0.396	124.688	125.554
4	0:10:26	2.5	0:04:30	1.2	0.398	127.448	119.529
5	0:14:56	3.7	0:09:02	2.4	0.431	133.642	127.013
6	0:23:58	6.1	0:04:35	1.2	0.421	132.116	131.402
7	0:28:33	7.2	0:04:36	1.2	0.419	129.076	126.787
8	0:33:09	8.4	0:04:42	1.2	0.415	120.883	119.149
9	0:37:51	9.6	0:04:35	1.2	0.423	132.116	125.764
10	0:42:26	10.8	0:01:45	0.3	0.411	15.962	15.947

3) Above the lap stat box is another box with the overall results from the tests. *Note that the average wind speed for the entire test (blue: 14.6 mph) is lower than the average bike speed for the test (15.1 mph). Also note that the uncorrected CdA value of these test results is CdA = 0.430*

	Min	Avg	Max	
Power	0.0	119.2	237.0	W
DFPM Pow	0.0	120.3	250.0	W
Aero	0.0	77.3	196.2	W
Rolling	6.6	39.6	46.3	W
Gravity	-274.7	0.0	261.0	W
Speed	2.5	15.1	17.6	mi/h
Wind	0.0	14.6	23.9	mi/h
WSB	-8.5	-0.5	8.4	mi/h
Elev	-143.0	-137.2	-130.0	ft
Slope	-4.6	0.0	3.8	%
Cadence	4.0	69.0	84.0	rpm
HR	0.0	0.0	0.0	bpm

N P: 127 W	N DFPM: 129 W
CdA: 0.430 m^2	Crr: 0.0054
245 lb	5/5/24, 8:58 AM
77 F	1013 mbar

4) Because this was a closed loop profile 4 test, a "perfect" calibration of the AeroPod 2 wind sensor would show an average wind speed of 15.1, nearly identical to average bike speed of 15.1, *higher than the measured 14.6 mph*. Thus, and because the wind as reported is lower than bike speed, this causes the reported, uncorrected CdA to be higher than "actual".
5) Note that laps 2-9 each have a distance of 1.2 miles (lap 5 has a length of 2.4 miles, or two complete laps)
6) Click on lap 2, the first closed lap of 1.2 miles length. It will be highlighted in blue:

Lap	Start		Duration				
	Time	Dist	Time	Dist	CdA	DFPM	Power
1	0:00:00	0.0	0:00:42	0.1	0.499	19.762	18.247
2	0:00:42	0.1	0:05:08	1.2	0.420	106.006	118.163
3	0:05:50	1.3	0:04:36	1.2	0.396	124.688	125.554
4	0:10:26	2.5	0:04:30	1.2	0.398	127.448	119.529
5	0:14:56	3.7	0:09:02	2.4	0.431	133.642	127.013
6	0:23:58	6.1	0:04:35	1.2	0.421	132.116	131.402
7	0:28:33	7.2	0:04:36	1.2	0.419	129.076	126.787
8	0:33:09	8.4	0:04:42	1.2	0.415	120.883	119.149
9	0:37:51	9.6	0:04:35	1.2	0.423	132.116	125.764
10	0:42:26	10.8	0:01:45	0.3	0.411	15.962	15.947

7) Hold down the "shift" button on your keyboard, then click on lap 9, the final closed-loop lap of the test. Laps 2-9 will be highlighted:

Analyzed CdA: 0.407 APPLY

Lap	Start		Duration				
	Time	Dist	Time	Dist	CdA	DFPM	Power
1	0:00:00	0.0	0:00:42	0.1	0.499	19.762	17.476
2	0:00:42	0.1	0:05:08	1.2	0.441	106.006	117.961
3	0:05:50	1.3	0:04:36	1.2	0.413	124.688	127.725
4	0:10:26	2.5	0:04:30	1.2	0.409	127.448	121.696
5	0:14:56	3.7	0:09:02	2.4	0.438	133.642	127.779
6	0:23:58	6.1	0:04:35	1.2	0.430	132.116	131.524
7	0:28:33	7.2	0:04:36	1.2	0.423	129.076	127.986
8	0:33:09	8.4	0:04:42	1.2	0.419	120.883	119.986
9	0:37:51	9.6	0:04:35	1.2	0.423	132.116	125.313
10	0:42:26	10.8	0:01:45	0.3	0.420	15.962	16.019

8) Notice that, above the lap stats box, a message appears saying “Analyzed CdA: 0.407 APPLY”. **0.407 is the Analyzed CdA result for all individual tests**. What is corrected? Click the APPLY button to find out: wind speed is corrected so that average wind speed is nearly the same as average bike speed. Note that CdA drops down from its uncorrected value of 0.430 to its final value of 0.407

Analyzed CdA: 0.407 APPLY

Lap	Start		Duration				
	Time	Dist	Time	Dist	CdA	DFPM	Power
1	0:00:00	0.0	0:00:42	0.1	0.499	19.762	17.476
2	0:00:42	0.1	0:05:08	1.2	0.441	106.006	117.961
3	0:05:50	1.3	0:04:36	1.2	0.413	124.688	127.725
4	0:10:26	2.5	0:04:30	1.2	0.409	127.448	121.696
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8	0:33:09	8.4	0:04:42	1.2	0.419	120.883	119.986
9	0:37:51	9.6	0:04:35	1.2	0.423	132.116	125.313
10	0:42:26	10.8	0:01:45	0.3	0.420	15.962	16.019

→

	Min	Avg	Max	
Power	0.0	124.8	236.3	W
DFPM Pow	0.0	126.3	250.0	W
Aero	14.2	80.5	194.2	W
Rolling	16.8	40.6	46.3	W
Gravity	-275.2	0.4	260.9	W
Speed	6.4	15.4	17.6	mi/h
Wind	8.3	15.5	24.7	mi/h
WSB	-8.3	0.0	9.2	mi/h
Elev	-143.0	-137.1	-130.0	ft
Slope	-3.4	0.0	3.8	%
Cadence	4.0	69.4	84.0	rpm
HR	0.0	0.0	0.0	bpm

N P: 128 W	N DFPM: 130 W
CdA: 0.407 m^2	Crr: 0.0054
245 lb	5/5/24, 8:59 AM
77 F	1013 mbar

→CdA = 0.407

Why does wind speed need correction?

One of the purposes of closed loop testing is to satisfy the condition that bike speed and wind speed balance. When the wind sensor is calibrated correctly this condition is satisfied.

Minor changes in AeroPod 2 location on the bike, or day-to-day variations in wind direction and magnitude can cause measured wind readings to vary somewhat. *However, by using the "Analyzed CdA" feature of VA, these variations can be corrected after the ride, making it possible to have both accurate and consistent measurement of CdA from ride to ride.*

PROFILE 4 ACCURACY AND CONSISTENCY WITH "ANALYZED CDA"

Here is CdA data from 3 rides using the same equipment and ride position; from two different AeroPod 2s, mounted in two different locations; on two different types of rides (closed loop and out-and-back); on 3 different days; with 3 different numbers of test laps. You can see the effect that "Analyzed CdA" has on the raw data out of AeroPod 2, resulting in *accurate and consistent measurements*:

date	route type	AP location	# laps	Unanalyzed CdA	Analyzed CdA
5-May	loop	1	8	0.433	0.407
8-May	loop	2	5	0.472	0.404
9-May	out and back	1	3	0.383	0.405

Using Velocomp Aero in Profile 3

You can download profile 3 files into VA. Looking at the "CdA" graph you can see places where your CdA varies—perhaps because of changing ride positions, perhaps because of fatigue.

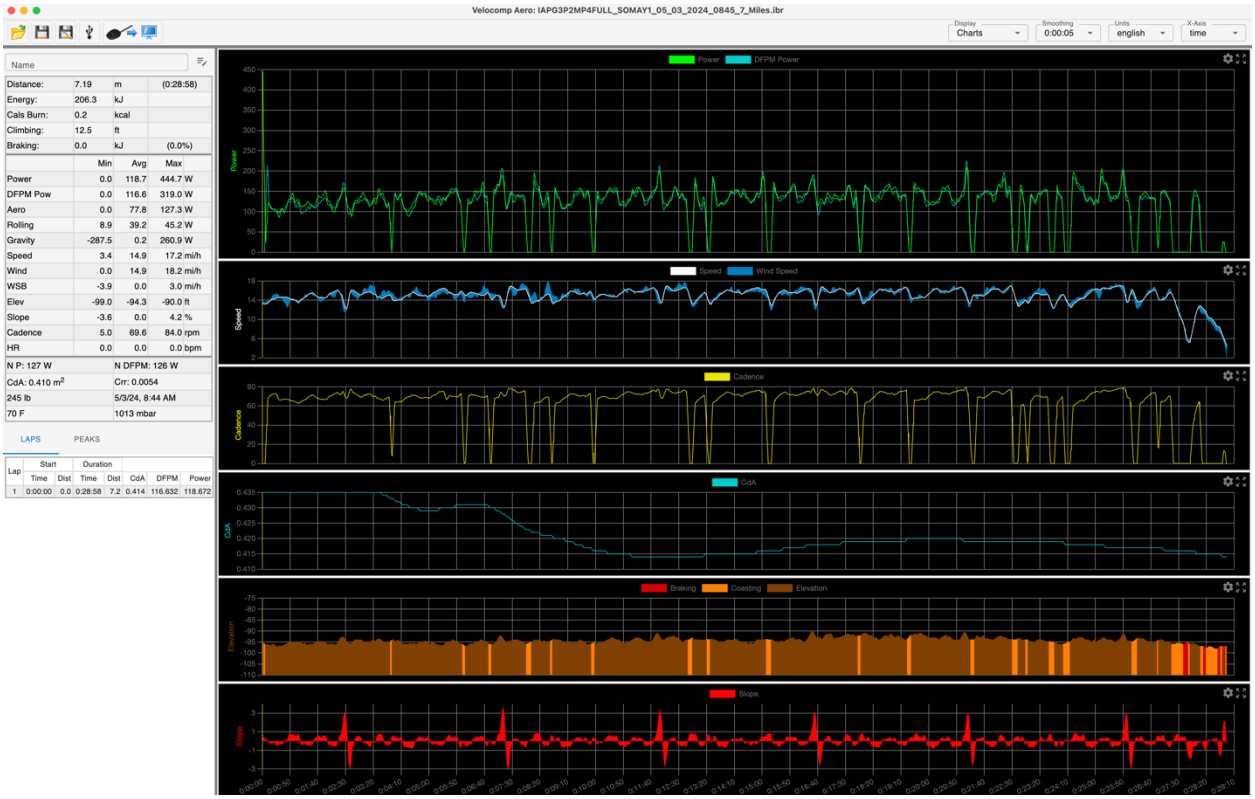
You do not need to use the lap button in profile 3, but if you do a marker will be placed in your ride file showing the average CdA between the last marker and the one just made.

Note that the "Analyzed CdA" button functions, though with less precision than available in a profile 4 file.

Here is a comparison between two ride files, recorded on two different AeroPod 2s, mounted on the same bike. One of the AeroPod 2s was set to profile 3; the other, to profile 4.

Profile 3 AeroPod 2:

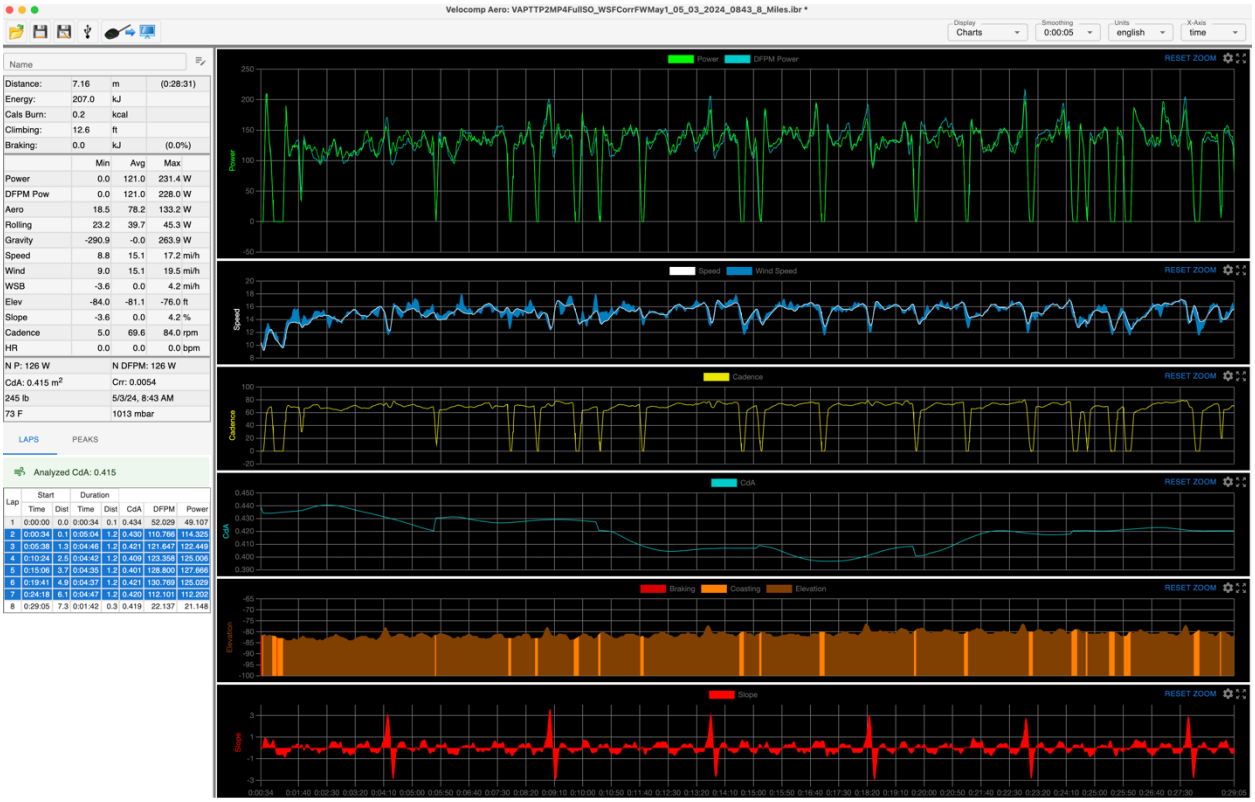
The AeroPod 2 started at an initial CdA of 0.435 (the default value stored in profile 3). After a recalibration period of about 6 minutes, CdA began to drop. The actual value of CdA is value below 0.435, settling about 5 minutes later to a value around 0.415. The CdA remained around 0.415 for the remainder of the ride. Note that, due to filtering in profile 3, it takes some time for the correct value of CdA to lock-in.



AeroPod 2, profile 3 ride

Profile 4 ride

Here is the same ride, recorded in profile 4, with 8 laps total. For the marked laps, the Analyzed CdA was 0.415



AeroPod 2, profile 4 ride

Notice that the profile 4 ride "locks-in" more quickly to the actual CdA value. However, this benefit is true ONLY when riding in closed loops!

USING AEROPOD 2 AS A STAND-ALONE POWER METER (PROFILES 1 OR 2)

AeroPod 2 functions as a stand-alone power meter when used in profiles 1 or 2.

For detailed instructions, download the "AeroPod 2_Power_122822.pdf" document, available in the "Other AeroPod 2 Features" section linked here:

https://velocompforum.com/viewtopic.php?f=98&t=6033

NOTE: CDA MEASUREMENTS ARE NOT POSSIBLE IN PROFILES 1 OR 2

NOTE: A DIRECT FORCE POWER METER IS NOT REQUIRED WHEN USING PROFILES 1 OR 2

When using profiles 1 and 2 with the Velocomp AeroPod 2.0 ConnectIQ app, instantaneous power, slope, and wind speed information is shown. *A CdA number is displayed but does not change.*

OTHER AEROPOD 2 FEATURES

AeroPod 2 and AeroPod 2+ includes Velocomp's GPS Tracker function. AeroPod 2+ also includes Velocomp's PowerStroke feature.

For detailed instructions, download the appropriate documents from the "Other AeroPod 2 Features" section linked here:

https://velocompforum.com/viewtopic.php?f=98&t=6033

TIPS AND TROUBLESHOOTING

Here are some things that you might want to check, especially as you get to know more about AeroPod 2 and CdA measurements

- I'm not getting consistent CdA measurements
  1. Make sure AP is attached to a place on your bike where there is no flex; DO NOT ATTACH AP TO AERO BARS. Questions? Email technicalsupport@velocomp.com
  2. Make sure you're riding on a closed loop of at least one mile length (profile 4)
  3. Mark laps (on your Garmin) at exactly the same start/stop point (PROFILE 4)
- I don't see CdA data on my Garmin; I see dashes (---) in the power/CdA/wind speed/slope fields
  1. Make sure you've downloaded and installed the AeroPod 2.0 CdA app on to your Garmin
  2. Make sure DFPM is working
  3. Make sure AeroPod 2 is paired to your bike's speed sensor (solid green light when button is pushed)
  4. Wait to turn-on Garmin until AFTER your AeroPod 2 is awake and paired (solid green→off).
  5. Ride for a few seconds; this often causes normal readings to begin (--- go to numerical readings)
- When I change ride positions, my CdA values don't change immediately
  1. Make sure you're riding in Profile 3. *When AeroPod 2 is set to Profile 4 you won't see any rapid changes in CdA*
  2. PROFILE 3: CdA measurements are smoothed over a period of 60 seconds. When you do something that causes you to become more (or less) aero, the CdA value will begin to change in a few seconds, but the full extent of the CdA change won't be evident until about 90 seconds has elapsed
- My CdA values vary in Profile 3, even when I stay in the same ride position
  1. This is normal. Some CdA variation around the "correct" value is expected
  2. Riding at a constant level of power reduces CdA variation
  3. Sharp turns, braking, drafting, strong acceleration/deceleration can cause CdA to vary
- My CdA number changes some when I ride on different road surfaces
  1. This is normal. CdA reported by AeroPod 2 will change when road surface type changes, because road surface changes cause rolling resistance (Crr) to change. AeroPod 2 *assumes* Crr does not change

- My CdA number changes when I ride the same roads on different days
  1. **Make sure to inflate your tires to the same pressure prior to every ride**. Different tire pressures cause Crr (and, consequently, measured CdA) to vary
  2. PROFILE 3: Make sure you ride at a constant pace during the first 5 minutes of your ride, without braking or sharp turns, so that the accelerometer properly recalibrates itself. In some cases, it can take up to 10 minutes for AeroPod 2 to fully calibrate itself.
  3. PROFILE 4: make sure you mark each completed lap on your Garmin, **in exactly the same location.**
  4. Make sure you have "warmed up" your DFPM and have re-calibrated it.
  5. Temperature variations from day to day can cause CdA measurements to change
  6. Make sure air movement over the pitot tube is not obstructed or blocked
- When testing, I don't see significant changes in CdA when I change "x" ("x" means changing to a different piece of equipment, or to a different ride position)
  1. Make sure you're using Profile 4 for CdA Testing.
  2. It's easier to measure small CdA changes when you test at higher speeds—18 mph or more
  3. Make sure AeroPod 2 and your DFPM have been calibrated correctly
  4. Especially when measuring minor changes to your aero setup, quantify CdA differences with Profile 4 CdA Testing, and the "Analyzed CdA" feature in VA
  5. In profile 4 testing, small differences are more easily detected over longer testing laps—1-2 mile laps, *and multiple test laps per test condition*.
  6. A "rule of thumb" is that a CdA change of .001 reflects a 1 watt difference between applied and opposing power readings. This is a small difference in power readings.
- My CdA numbers seem way too high (or low)
  1. Make sure your DFPM is properly calibrated. AeroPod 2 assumes your DFPM is working properly and that its wattage numbers are "correct".
     a. If your DFPM is reading high, then AeroPod 2 will report CdA numbers that are too high.
     b. If your DFPM is reading low, then AeroPod 2 will report CdA numbers that are too low.
  2. Make sure AeroPod 2 is attached to a place on your bike where there is no flex; DO NOT ATTACH AeroPod 2 TO AERO BARS.

The Basics of Bicycling Aerodynamics and CdA

Aerodynamics is important in cycling. Very simply put, for the same amount of power, the more "aero" you are, the faster you will go. So, improving the aerodynamics of your ride position and equipment is like adding more power and speed to your ride, *without pedaling any harder!*

A measurement called CdA quantifies how "aero" you are. The better you understand what CdA is, how to measure it, and how to improve it, the better you will be able to get the most out of your bike, your equipment, and your riding.

Just as lower weight makes for faster climbing on hills, lower aerodynamic resistance (lower CdA) enables faster riding on the flats.

A quantitative measure of aerodynamic drag is a single number called "CdA" (see Appendix for a more detailed discussion of CdA). The lower your CdA number is, the more aero you are. *The more "aero" you are, the less impact wind has when riding on the flats and, watt-for-watt, the faster you will go.*

Weight is measured easily with a scale, but aerodynamic CdA measurement is not so easy. Traditionally, CdA has been measured in the lab conditions of wind tunnel or velodrome environments, where the cyclist experiments with different ride positions, bike setups, and aero equipment such as wheels and helmets. The testing objective is to find those changes that optimally reduce CdA.

Of course, lab CdA measurements are valid *in the lab*. But what happens to your aerodynamics in the real-world, in time trials or daily training? Until now, that question has been basically impossible to answer.

AeroPod 2 makes it possible for you to measure CdA with lab-like accuracy and consistency, and additionally, to get on-the-road CdA data, in real time, when training and racing.

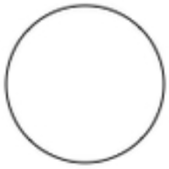
What is "CdA"?

The single number "CdA" is actually comprised of two components: your "frontal surface area (A)"—that is, the surface area your body and bike present to the wind in the direction of travel; and the "coefficient of drag (Cd)", a number quantifying the benefit you get from making the wind flow more smoothly around you and the bike.

In fact, CdA is the product of these two numbers:

CdA = Cd x A

To show how these two factors interrelate, here is a simple example. Suppose you put a round, flat disk in a wind tunnel, exposed to the wind. Viewed from the front the disk looks like this:



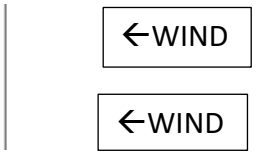
Round disk, frontal surface area A = 1

Let's suppose we set the diameter of the round disk so that it has a frontal surface area of "1". So, for this disk its frontal surface area A = 1

Wind is now blown against the disk. The "frontal surface area" the wind encounters when hitting the disk is "1".

But to know how much force the wind actually exerts on the disk, we also need to know its coefficient of drag.

What is the Cd of a round, flat disk? From a side view, flat disk has no depth, so it looks like a thin sliver:



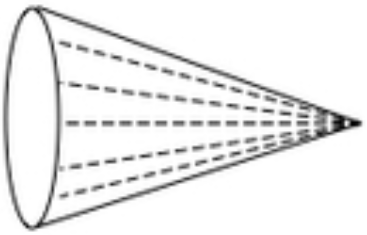
As it turns out, the Cd of a round, flat disk is 1.17. So, the CdA of our round, flat disk is

$CdA_{flatdisk}$ = Cd x A = 1 x 1.17 = 1.17

"1.17" is the CdA that will be measured in a wind tunnel of a flat disk with area "1".

How can we make a round disk, with a frontal surface area of "1", more aerodynamic?

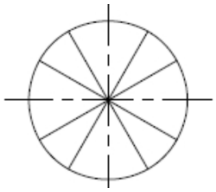
One way is to add depth to the disk, making it into a cone that points into the wind (like a rocket's nose cone).



← WIND

← WIND

Note that, looking at the cone directly from its front, *it still looks like a round disk with frontal surface area = 1*



CONE VIEWED FROM THE FRONT—FRONTAL SURFACE AREA IS STILL "1"

However, ***the conical shape makes it easier for the wind to flow around the disk, reducing Cd***.

In fact, if the "angle" of the cone is 60 degrees, the Cd is reduced from 1.17 to 0.50.

So, $\boldsymbol{CdA_{cone} = Cd \times A = 0.50 \times 1 = 0.50.}$

An angled 60 degree cone with a frontal surface area of "1" has a CdA more than 50% lower than a round, flat disk of the same area!

So, a round, flat disk becomes more "aero" by adding a conical aero shape in front of it!

Summary

CdA encompasses two factors: frontal surface area, and coefficient of drag. Lower CdA is "better". Cyclists can alter their ride position to reduce frontal surface area, and use aero-optimized equipment to reduce their coefficient of drag.

CdA Testing

Reducing aerodynamic drag (CdA) is an important objective for improved cycling performance, particularly on the flats. When you see cyclists riding in a TT position with deep-dish wheels, pointy-shaped aero helmets and skin suits, you know that the cyclist's objective is low CdA.

Here are just a couple of examples of how cyclists lower aerodynamic CdA (see the Appendix for a more detailed discussion of CdA):

- Reduce the frontal area exposed to the wind (make "A" smaller). For example, make your frontal surface area smaller by riding in a tuck:
    - Hoods (riding more upright→more exposed area): typical CdA is 0.36 to 0.40
    - TT (riding more aero→ less exposed area): typical CdA is .21 to 0.26
- Use "aero" bike equipment (make "C_d" smaller). For example, wearing a tighter-fitting cycling bib/jersey reduces CdA substantially:
    - Hoods, t-short and casual shorts: typical CdA is 0.50 to 0.70
    - Hoods, cycling bib and jersey: typical CdA is 0.36 to 0.40

Competitive cyclists work to reduce frontal surface area *and* reduce drag, and *CdA is a single number that encompasses the net effect of these changes*. In fact, a major purpose of CdA testing is to find the optimum *combination* of ride position and equipment that reduces your CdA, without sacrificing your power output.

How AeroPod 2 measures CdA

Understanding how AeroPod 2 measures CdA will help you obtain more consistent, accurate results for your CdA testing, and how to make best use of AeroPod 2's "live" CdA measurements.

1. *AeroPod 2 uses both applied and opposing force measurements*

- Applied forces are measured by the direct force power meter (DFPM) on your bike. DFPM *applied force* measurements are transmitted wirelessly to AeroPod 2
- The cyclist's applied power counters the *opposing forces* caused by wind, hills, acceleration and friction. These opposing forces are measured by AeroPod 2's sensors:
    - The opposing force due to hills and bike acceleration are measured in real-time by AeroPod 2's accelerometer
    - Wind speed is measured in real time by AeroPod 2's pitot tube and wind sensor.
    - The opposing force of friction is determined from the Coefficient of Rolling Resistance (C_{rr}). C_{rr} is determined from tire type, tire inflation, and road type,

which are user inputted during first setup of AeroPod 2. AeroPod 2 assumes C_{rr} is a constant value that does not change during the bike ride.

- The opposing forces measured by AeroPod 2 should equal to the applied forces measured by the DFPM (this is one way to express Newton's 3rd Law).

2. *AeroPod 2 CdA converts wind speed measurements into wind force measurements*

Determining the opposing aero force requires the conversion of AeroPod 2's wind *speed* measurements into wind *force* measurements. The conversion formula is well known, but actually doing the conversion requires a value of CdA. *When the correct value of CdA is used in converting wind speed measurements into wind force measurements, the total opposing forces measured by AeroPod 2 will equal the applied force of the DFPM.*

AeroPod 2 compares the real-time applied force readings measured by the DFPM, to AeroPod 2's real-time opposing force readings. AeroPod 2 calculates, in real-time, at each second of the ride, the value of CdA that makes AeroPod 2's measured opposing forces equal to the measured, applied forces of the DFPM.

AeroPod 2 measures CdA every second. So, whenever the rider does something that causes CdA to change (for example, by altering ride position), AeroPod 2 updates its calculations and recomputes the CdA value that keeps opposing forces equal to applied forces.

Calibrating an SRM with AeroPod 2

Old-style SRM crank power meters are calibrated very differently from other direct force power meters. When AeroPod 2 is paired to an SRM direct force power meter or other "crank-torque-frequency" power meter, the SRM is automatically calibrated ("PCAL") by AeroPod 2, each time the SRM is "found" by AeroPod 2. **MAKE SURE TO FOLLOW THIS "WAKE UP" PROCESS EVERY TIME YOU RIDE WITH AN SRM:**

A. Spin the crank to awaken the SRM
B. Spin the wheel to awaken the speed sensor
C. Let the bike crank sit motionless for 5 seconds
D. Awaken AeroPod 2 from sleep
E. When AeroPod 2 detects that it is paired to a "crank-torque-frequency" power meter (i.e. SRM), AeroPod 2 automatically starts the PCAL process
F. During the PCAL process, AeroPod 2 light flashes green
G. If the AeroPod 2 one-time calibration ride has not been completed (Step 5), when PCAL is successfully completed, AeroPod 2 light turns solid YELLOW
H. If the AeroPod 2 calibration ride HAS been completed, when PCAL is successfully completed, AeroPod 2 light turns solid green (assuming speed sensor is found), then turns off.
I. If PCAL is unsuccessful, light turns solid RED, then unit turns off (to rearm PP/AP for auto PCAL)