How to Test, Train, and Race with AeroPod®

May 2020

Firmware 7.14+

VELOCOMP

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Introduction

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.

This document will guide you through the basics of AeroPod CdA measurement and analysis, and how to use AeroPod to Test, Train, and Race with aerodynamics. We encourage you to take a few minutes to understand more about what CdA is, how AeroPod measures CdA, how to use CdA while on the road, how to use Isaac software to analyze CdA, and most importantly, how to use CdA to help you improve your cycling.

There are now two ways AeroPod 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 for both applications.

NOTE TO ORIGINAL AEROPOD OWNERS: Firmware 7.14+ contains A LOT of new features, important changes to CdA measurement procedures, and also a new, more accurate way to display CdA information in Isaac. Please review these instructions to learn about new "CdA Aero Testing" using profile 4, and new "Training/Racing CdA measurement" using profile 3!

YOU CAN CHECK/UPDATE THE FIRMWARE INSTALLED IN YOUR AEROPOD USING THE ISAAC COMMAND "DEVICE/CHECK ONLINE FOR FW UPDATE…"

For information regarding attaching AeroPod to your bike, and pairing AeroPod to your ANT+ sensors, please consult the **AeroPod Installation Instructions**, included with your AeroPod.

The Basics of Aerodynamics and CdA

Just as lower weight makes for faster climbing on hills, lower aerodynamic resistance 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 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.

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.

***New to firmware 714 and higher (714+), AeroPod has a "profile 4" mode for CdA Testing*.** When riding with AeroPod on closed-course loops or out-and-back routes, you'll be able to do CdA Tests with high-accuracy, repeatable CdA measurement of your ride position and equipment.

CdA for Training and Racing

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

New to firmware 714+, AeroPod has a "profile 3" mode for training and racing. When training and racing with AeroPod, you will get rapid, real-time CdA measurements *during your ride* that help you manage your riding for optimum aerodynamic performance.

In summary, aerodynamics in competitive cycling is really about two things: ***before racing***, testing your ride position and equipment to find the most aero setup for your racing, and ***during training and racing***, getting real-time aerodynamic feedback to help you minimize the effects of wind as much as possible.

AeroPod does BOTH of these things.

How AeroPod measures CdA

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

1. *AeroPod 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
- The cyclist's applied power counters the *opposing forces* caused by wind, hills, acceleration and friction. These opposing forces are measured by AeroPod's sensors:
    - The opposing force due to hills and bike acceleration are measured in real-time by AeroPod's accelerometer
    - Wind speed is measured in real time by AeroPod'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. AeroPod assumes C_{rr} is a constant value that does not change during the bike ride.

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

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

Determining the opposing aero force requires the conversion of AeroPod'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 will equal the applied force of the DFPM.*

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

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

New to Firmware 714+: two ways to measure CdA

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

Aero Testing (Profile 4)

In profile 4 mode (closed course aero testing), you'll test ride **on a closed course lap (loop or out-and-back),** ***in the same position, with the same equipment, for the entirety of each lap test***. These test conditions are comparable to those used in a wind tunnel or velodrome and *allow AeroPod to provide the most accurate and consistent measurement of CdA*. When set to profile 4 measurement, *AeroPod averages your CdA during each lap test and displays the cumulative average on your bike computer display*. At the end of each lap test, AeroPod displays on your bike computer the measured CdA for the just-completed lap, and records your lap CdA number in the ride file.

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.

Training/racing CdA (profile 3)

In profile 3 mode (Training/Racing), you are not restricted to test riding on closed courses, nor do you have to remain in the same ride position. Instead, AeroPod provides continuous measurement of your CdA, averaged over a 60 second time period. For example, if you go into a tuck on a downhill to become more aerodynamic, the AeroPod CdA number displayed on your bike computer display will drop quickly, over a period of about 60 seconds, to the CdA value that corresponds to your tucked aero position.

<u>In Profile 3 AeroPod 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>

Differences between CdA measurements in profile 4 (Aero Testing) and profile 3 (Training/Racing)

Aero Testing in profile 4 REQUIRES that you ride on a closed course, and ASSUMES that during each Aero Test, nothing is changing in your equipment or ride position. These two restrictions enable very precise calibration of AeroPod sensors, and allow AeroPod to gather the most possible data to use for each CdA measurement. Additionally, CdA data is recorded in the Isaac ride file HR field, in a new format that allows 0.001 resolution of CdA tests.

Training/Racing in profile 3 can be used on ANY course, open or closed, DOES NOT ASSUME your equipment and ride position are unchanging, and DOES NOT REQUIRE you to mark laps. In profile 3 you'll get much faster on-the-road feedback regarding your CdA, allowing you to evaluate quickly the implications of changing ride position. You'll also be able to use an exclusive AeroPod metric, Time Advantage, to quantify the time implications of your real-time aerodynamic changes. Because less data is used in Training/Racing CdA measurement, CdA measurement tends to be "jumpier" than CdA measured in Aero Testing, and real-time CdA resolution is not quite as good. CdA data is recorded in Isaac with a resolution of 0.004.

AeroPod Setup

See the "**AeroPod Installation Instructions**" to learn how to attach AeroPod to your bike, and pair AeroPod to your ANT+ sensors.

NOTE: AEROPOD REQUIRES USE OF ISAAC SOFTWARE FOR PC/MAC. HERE ARE ISAAC LINKS:

ISAAC SOFTWARE DOWNLOAD: https://velocomp.com/isaac-software-installation/

ISAAC SOFTWARE INSTALLATION: https://velocompforum.com/viewtopic.php?f=12&t=4774

ISAAC USER MANUAL: http://velocomp.com/wp-content/uploads/ ... 121219.pdf

SETUP STEPS

When first setting up AeroPod with Firmware 714 you'll need to do these things:

1) Use Isaac software to enter "profile 4" parameters for you and your bike
2) Make sure your speed and DFPM sensors are in good condition (fresh batteries, good calibration)
3) Pair your ANT+ speed, cadence, and DFPM sensors to AeroPod
4) Pair AeroPod to your bike computer display device
5) Perform AeroPod calibration ride
6) Use Isaac to transfer your profile 4 calibration results to profile 3
7) Use Isaac to set AeroPod 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

You'll use Isaac to enter AeroPod parameters for you and your bike. AeroPod (and Isaac) will store your entered parameters in profile 4.

AeroPod has four separate profiles. Profiles 4 and 3 are used for CdA measurement (profiles 1 and 2 are for power measurement using AeroPod as a stand-alone power meter).

At the factory your AeroPod is set to profile 4, so when you use the Isaac wizard, your parameter selections will be stored in profile 4 of AeroPod.

To enter your parameters, connect AeroPod to Isaac software and use the command "Device/Setup Device…" to launch the Isaac setup wizard. These are the parameters that you will enter with the 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 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 setup wizard.

2. Check your Speed and DFPM sensors

CdA measurements require correct operation of your ANT+ speed sensor and DFPM power sensor.

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

IMPORTANT: You MUST use a separate ANT+ speed sensor. ***AeroPod will not work unless it is paired to a separate ANT+ speed sensor.***

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!

SPECIAL NOTE: Calibrating an SRM with AeroPod

SRMs are calibrated very differently from other direct force power meters. When AeroPod is paired to an SRM direct force power meter or other "crank-torque-frequency" power meter, the SRM is automatically calibrated ("PCAL") by AeroPod, each time the SRM is "found" by AeroPod. **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 from sleep
E. When AeroPod detects that it is paired to a "crank-torque-frequency" power meter (i.e. SRM), AeroPod automatically starts the PCAL process

F. During the PCAL process, AeroPod light flashes green
G. If the AeroPod one-time calibration ride has not been completed (Step 5), when PCAL is successfully completed, AeroPod light turns solid YELLOW
H. If the AeroPod calibration ride HAS been completed, when PCAL is successfully completed, AeroPod 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)

3. Pair ANT+ sensors to AeroPod

Awaken your speed, DFPM, and (optional) cadence sensors. *Before starting AeroPod pairing we strongly recommend you use your bike computer to confirm proper operation of your sensors.*

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

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

The AeroPod 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 to your bike computer

NOTE: YOU MUST PAIR AEROPOD TO YOUR ANT+ SENSORS (Step 4) **BEFORE** PAIRING AEROPOD TO YOUR BIKE COMPUTER.

AeroPod is compatible with these bike computers:

- Garmin bike computers with Connect IQ compatibility: https://bit.ly/2eh9WFC
- Everysight Raptor AR glasses www.everysight.com

Garmin

1. Install the AeroPod CdA Connect IQ app, available here: https://bit.ly/2C7BLfD
2. Follow the ConnectIQ app installation instructions provided with the link
3. AFTER installing the app on your Garmin, wake up your speed sensor and after that wake up AeroPod.
4. AeroPod transmits data only when you see its light show solid yellow or green (If AeroPod shows solid RED, then AeroPod has not been paired successfully to your speed sensor. If AeroPod flashes green but never turns to a solid color, then perform a new sensor pairing process according to step 4).
5. After confirming that AeroPod light is solid yellow or green, pair AeroPod to your Garmin
6. When your Garmin is receiving AeroPod data, the "wind speed", "CdA", "slope", and "Time Advantage" fields will show as numbers.

Raptor

1. Wake up your speed sensor and then wake up AeroPod. AeroPod will be transmitting data after you see its solid yellow or green light.
2. Follow the instructions provided by the manufacturer to pair Raptor to AeroPod, and to set Raptor display to show CdA measurements

5. AeroPod calibration ride—Profile 4 only

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

IMPORTANT: Every time you perform a sensor pairing between AeroPod and any ANT+ sensors (Step 4 above), *even when you re-pair AeroPod to the same sensors,* AeroPod is "forced" into calibration ride mode.

We recommend calibrating AeroPod on a fairly flat road where there is little traffic and the wind is fairly calm.

At the factory your AeroPod is set to Profile 4. So, the calibration ride stores parameters in Profile 4 of your AeroPod.

PROFILE 4 CALIBRATION RIDE

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 70W when you pass by the starting point.

3) EXCLUSIVE TO AEROPOD PROFILE 4: After riding past the starting point, CONTINUE RIDING SOLO FOR ANOTHER 5 MINUTES, IN YOUR NORMAL RIDE POSITION AND NORMAL BIKE SPEED/POWER LEVEL. Watts rise to 100W, then revert to normal.

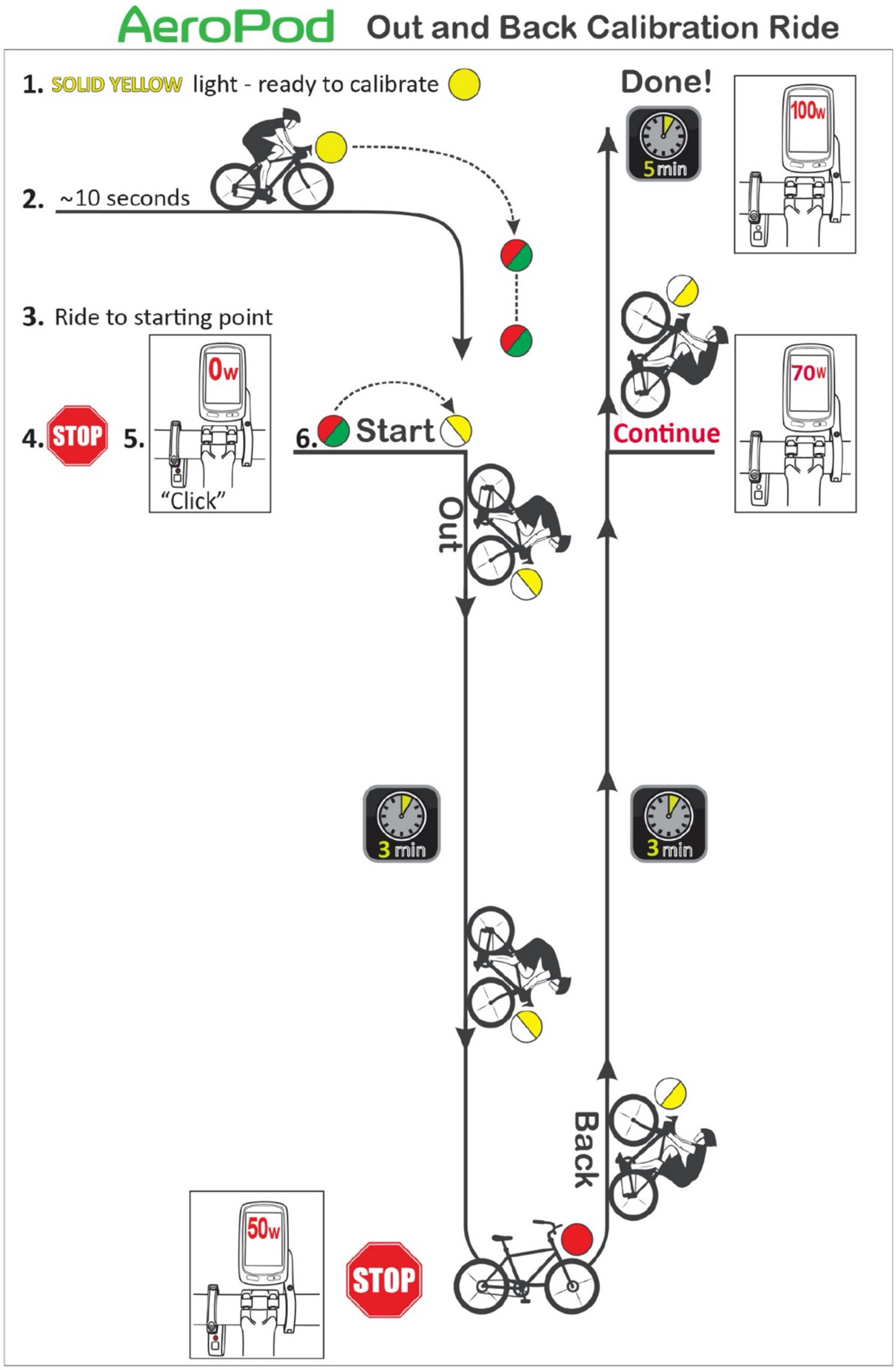
The next page shows the AeroPod calibration ride pictorially.

The final 6 minutes of your calibration ride measures and stores your "normal" value of CdA; that is, your measured CdA value for your normal ride position. When you download your ride files into Isaac, this measured value of 'normal CdA' will be used in your profile.

When the calibration is complete you are ready to start using AeroPod for CdA measurement.

NOTE THAT IF YOU CALIBRATE AEROPOD IN PROFILES 1-3, THE CALIBRATION RIDE ENDS WHEN YOU REACH THE STARTING POINT.

CALIBRATION RIDE, PROFILE 4



6. Copy Profile 4 data to Profile 3

After completing the calibration ride, your bike setup and calibration data is stored in profile 4, and your AeroPod is set up for CdA Testing in profile 4. However, as explained above, **AeroPod performs CdA measurements both in profile 4 *and* profile 3**. This step copies your profile 4 data into profile 3 of AeroPod, so that you can *also* use profile 3 for Training/Racing CdA measurement. Copying profile 4 data into profile 3 eliminates the need to perform another *sensor pairing and calibration ride for profile 3.*

1) Connect AeroPod to Isaac
2) Go to "Edit/Edit Profiles"
3) Click the "Extract from Device" button. Your profile 4 data will be transferred from AeroPod to Isaac
4) Click the "*Set Active Profile in Device" dropdown menu and select "Profile 3". You will get a confirming message
5) Click the "Send to Device*" button. You will get a confirming message.

Once this step is completed your AeroPod is calibrated with the same settings both for profile 4 (aero testing) and profile 3 (training/racing CdA). *When using profile 3 you won't have to repeat the sensor pairing and calibration ride steps.*

7. Select CdA measurement mode

AeroPod measures CdA in two different ways, depending on which profile you manually select.

PROFILE 3: **on-the-road, real-time CdA measurement**. Select profile 3 for training and racing. On your Garmin you will see display of continuously-updated CdA values.

PROFILE 4: **Aero testing on closed loops or out-and-back routes**. Select Profile 4 for ride position and equipment testing. CdA measurements do not change very much during each test; however, the precise CdA measurement value is displayed at the end of each marked lap.

Here's how to use Isaac to select the active profile in your AeroPod

1) Connect AeroPod to Isaac
2) Select "Device/Set Active Profile in Device…"
3) Select profile 3 (training/racing CdA) or profile 4 (Aero Testing). You will get a confirming message.

IMPORTANT: AEROPOD WILL REMAIN IN THE PROFILE YOU SET UNTIL YOU MANUALLY CHANGE IT USING ISAAC.

Using AeroPod for CdA Testing—profile 4

One of the very special things you can do with AeroPod is measure, improve, and optimize your ride position and equipment.

The idea in CdA testing is to perform a controlled set of tests, *on a closed loop or out-and-back route*, where you will measure the CdA of your equipment and ride positions, quantifying and comparing CdA data 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.

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-mile (or longer) loop without abrupt turns, or an out-and-back route at least one 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. Tire pressure. Make sure your tires are fully inflated. Different tire pressures on different days will cause CdA test measurements to vary
4. Warm up. Ride for 5-10 minutes before starting your tests. This will allow AeroPod internal calibrations to be checked, and allow the DFPM sensor to temperature stabilize
5. Do not remove AeroPod between bike rides. After completing the out-and-back calibration ride, we recommend that you leave your AeroPod attached to your bike between rides (download ride files with AeroPod attached to your bike). Leaving your AeroPod attached minimizes the possibility of its calibration factors changing between rides due small differences in mounting position (AeroPod can measure slope differences as small as 0.02%--that is a 1-foot elevation change over a distance of nearly one mile!)
6. Test time length. We recommend each CdA test should be 6-10 minutes.
7. Test Power/Speed: Ride at power levels/bike speeds similar to those used during your calibration ride. For example, if the average bike speed of your calibration ride was 19 mph, your testing should also be at bike speeds around 19mph.
8. Consistent road surface. For highest accuracy results the road surface must NOT change on your route (for example, patches of chip seal on an otherwise smooth road)
9. Ground wind speed. 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".
10. 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)

11. Temperature. Try to do your testing where temperatures remain reasonably constant. Remember: DFPMs are temperature sensitive…
12. Total Test Length. Try to complete your testing in a few hours.

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

1) Attach AeroPod to Isaac, and use Isaac command "Edit/Edit Profiles/Set Active Profile in Device". Select "profile 4" to make profile 4 active
2) Ride to the place where you will do your closed loop or out-and-back testing.
3) Awaken AeroPod and then ride around your closed loop. Your loop should take at least 5 minutes to complete.
4) During the first 5 minutes of each new ride, AeroPod recalibrates itself. AeroPod CdA remains unchanged during the calibration period. At the end of the 5 minute period you'll see the CdA number change, VERY SLOWLY. In profile 4 this is normal!
5) Continue riding to the starting place of your CdA testing loop.
6) At the starting point of your loop testing, *click the lap button on your Garmin/Raptor*
7) You'll see AeroPod show a VERY SLOWLY CHANGING CdA number. The CdA number displayed is the cumulative average CdA for your current lap
8) During each test, ride at power levels/bike speeds similar to that you had during your calibration ride
9) Your total lap length should be at least 1 mile long
10) When you've completed each lap, use your bike computer lap marker to mark the completed lap. The measured CdA of your just-completed lap will be shown for 30 seconds on your display; then, CdA will go back to "live" values
11) *If you're doing out-and-back loop testing*, click the lap button at the end of the test. Your test result will be displayed for 30 seconds. Turn around and ride back to your starting point. Click the lap button again to start a new test
12) *If you're testing on a continuous 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; however, if you continue riding your new CdA measurement will begin immediately after clicking the lap button.

IMPORTANT: WHEN USING PROFILE 4 FOR AERO TESTING, MAKE SURE TO USE YOUR BIKE COMPUTER TO MARK THE BEGINNING AND END OF EACH LAP

TIP: For best results we recommend 2-3 lap tests for each configuration you're measuring

The above procedure will assure that you get accurate, repeatable CdA aero test measurements. Here are a few more hints that will help you get the most out of your profile 4 aero tests:

1. <u>Change only one variable per test</u>. 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 test with your helmet “A” and ride position “X”. For the next test, do NOT change to bike helmet “B” *and also* 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 is helmet “B” and ride position “X”).
2. <u>Do multiple laps per test configuration</u>. More data is better, and having 2-3 lap tests per configuration will provide higher levels of CdA accuracy and consistency.
3. <u>Be organized</u>! 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.
4. <u>Take notes</u>! 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)
5. <u>If you’re using a Garmin,</u> touch the 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 Isaac software.
6. <u>If you’re using Raptor glasses</u>, touch the temple at the end of each test. You will see the average CdA displayed for the just-finished lap. This action also places a lap marker in your AeroPod ride file, making it easier to analyze CdA later-on with Isaac software

After completing your tests, you can download your ride into Isaac software for more detailed analysis.

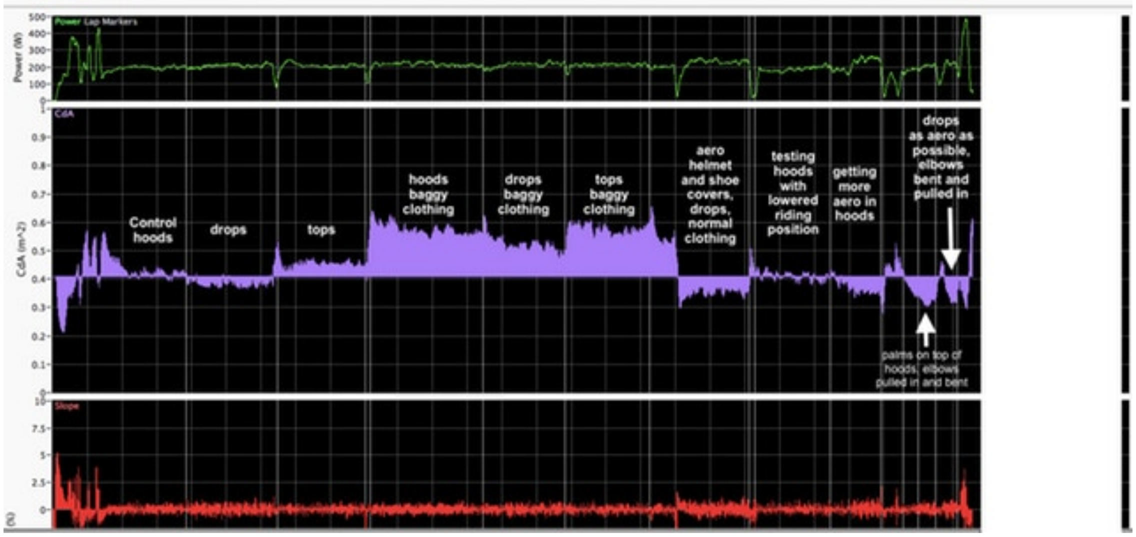
A Real-Life Example of CdA Testing

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."

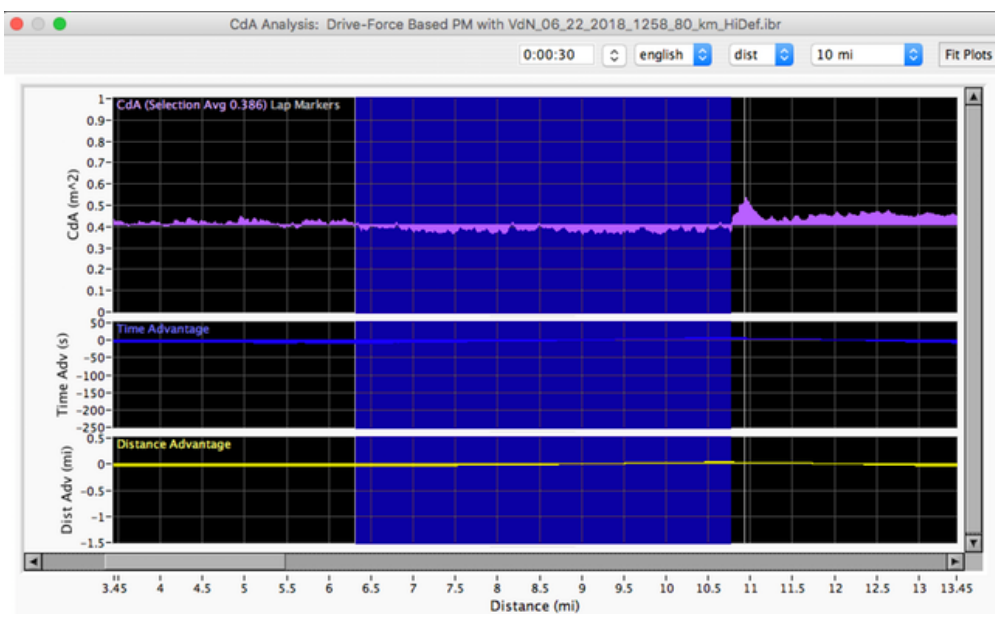
After completing his tests, he downloaded his data into Isaac (see next section for details about using Isaac), then used the "Tools/Analyze CdA" function in Isaac to display and quantify his measurements (remember: he saw these CdA numbers in the field, too!):



CdA Testing
Purple is CdA; "normal" CdA is about 0.4

In the graph above you see vertical lines. These are "lap markers" in the ride file, denoting where each test began. The data between any two lap markers is the test. The user inserted information stating what was being tested.

In Isaac, CdA is quantified simply by highlighting the relevant test lap. For example, the CdA of the "drops" section is 0.386 (shown in upper left corner of window of the graph below)



Measured CdA of drops position (0.386)

Here are the measured CdAs of all tests:

- 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... ☺

Using AeroPod CdA on training/racing rides—profile 3

On your everyday rides, AeroPod helps you understand your aerodynamics as they change, and quantifies the time advantage implications of your aerodynamic changes. 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. If you're doing a Time Trial, make Time Advantage work for you. The more positive the Time Advantage number is, the more aero you are!
4. 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 and Time Advantage measurements are meaningful ONLY when you are riding solo, <u>and</u> you are riding on road surfaces whose roughness is not changing.

How to use Training/Racing CdA (Profile 3)

1) Attach AeroPod to Isaac, and use Isaac command "Edit/Edit Profiles/Set Active Profile in Device". Select "profile 3" to make profile 3 active
2) Make sure AeroPod is attached to your bike and is awake.
3) Start riding. For the first 5 minutes of each new ride, AeroPod 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 your calibration ride.

> 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. *This variation is normal*; see pages 30 to 31 for a practical example.

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
- 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 in profile 3 you will get a very good idea of your CdA, and its natural variation as you ride.

Another feature with profile 3: Time Advantage

Time Advantage™ is an exclusive measurement related to CdA that is enabled in Profile 3.

What is Time Advantage?

When you ride a bike, most of the time you're riding in your "normal" riding position.

DEFINITION: YOUR "NORMAL RIDING POSITION" IS THE POSITION YOU HELD DURING YOUR AEROPOD CALIBRATION RIDE

As long as you stay in your normal riding position, the total amount of time it takes to complete your ride is unaffected by your riding position; that is, a "normal" riding position results in a "normal" ride time.

Now, suppose you're on a ride and you deviate from your normal riding position; for example, you go into a tuck. If you ride in a tuck with the same level of power, you will go faster because of your more aero ride position. And the faster speed you achieve by riding in a more aero position means it will take you less time to get to your current position, compared to riding at the same power to the same place, in your normal ride position. *But how much less time*?

Here's another situation: you attack on a hill and stand up to get more power. You know that "standing up" is aerodynamically less efficient, and therefore costs you some time to get to the top of the hill, compared to riding in your normal ride position. *How much extra time did it take to climb the hill due to aerodynamic inefficiencies?*

A final situation: you've perfected your "normal" ride position using AeroPod. During a long ride, however, you get tired and your ride position becomes a bit sloppy. *How much longer did it take you to complete your ride because your ride position became worse?*

Time Advantage answers all these questions, and more.

DEFINITION: AT ANY POINT OF YOUR RIDE, “TIME ADVANTAGE” IS THE CUMULATIVE AMOUNT OF TIME YOU HAVE GAIN (OR LOSE), DUE ONLY TO DEVIATIONS FROM YOUR NORMAL RIDE POSITION.

Time advantage is measured in seconds. Suppose you look at your Garmin or Raptor CdA screen at mile 6.2 of your ride and Time Advantage reads +30 seconds. This means that, at mile 6.2 of your ride, you have been more aero than normal, and you have ***gained*** 30 seconds of time, *compared to riding the same distance in your “normal” ride position, with the same amount of power*. If, alternatively, your Time Advantage reads -15 seconds, you have changed ride positions in a way that has caused you to be *less aero* than normal, and you’ve *lost* fifteen seconds compared to staying in your normal riding position.

How are CdA and Time Advantage related?

If your real-time value of CdA is higher than your normal CdA, you are less aerodynamic compared to your normal riding position. Therefore, for the same amount of applied power, you’re less aerodynamic and it takes more time to cover the same distance. Conversely, when your real-time CdA is lower than your normal value you are MORE aerodynamic, and watt-for-watt you’ll cover the same distance in less time.

Time Advantage compares your real-time value of CdA to your baseline, “normal” CdA, moment-by-moment. Using the comparative CdA values between your baseline CdA and your current CdA, AeroPod computes the cumulative amount of time you gain or lose, moment-by-moment, due to deviations from your baseline CdA.

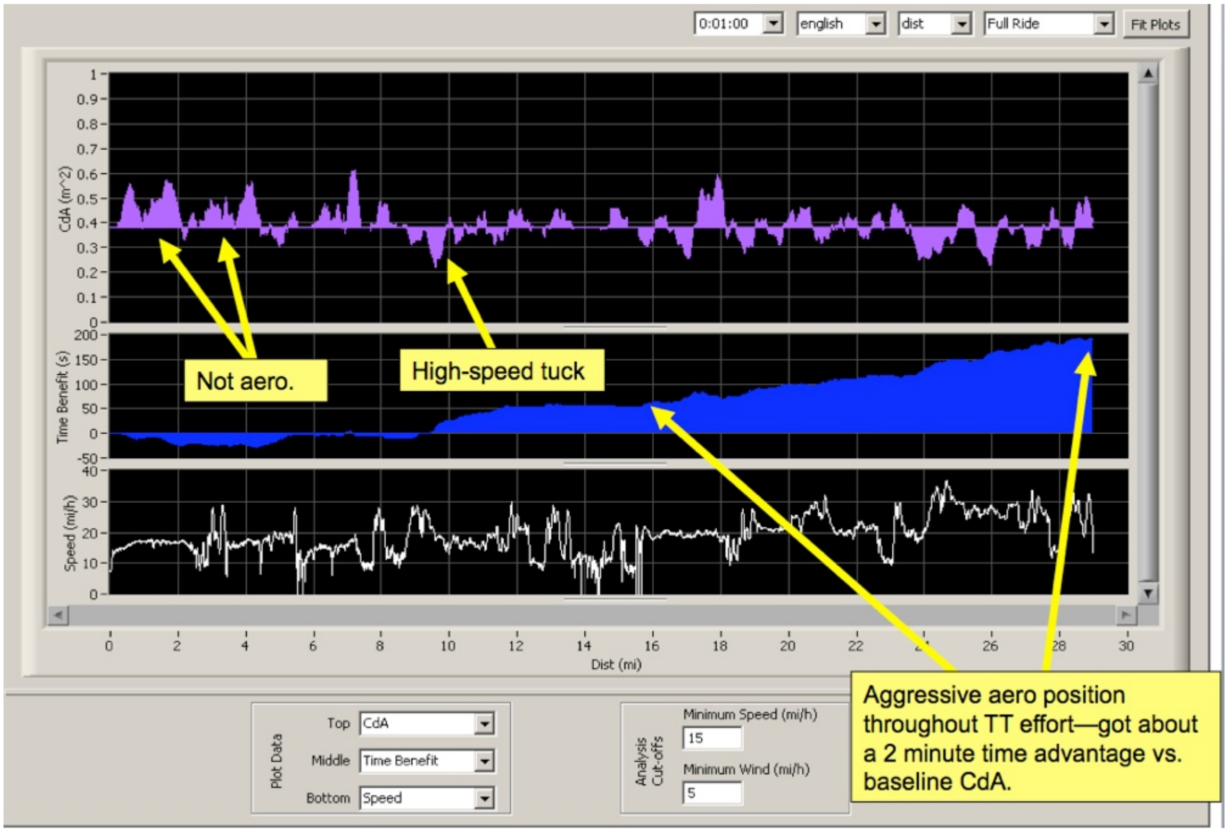
- If you spend most of your time in your “normal” ride position, Time Advantage will be approximately zero
- A positive Time Advantage means you’ve picked up time due to improved aerodynamics
- A negative Time Advantage means you’ve lost time due to worse aerodynamics

AeroPod reports the cumulative, net Time Advantage effect of better-and-worse ride positions. Time Advantage is displayed on your Garmin or Raptor screen.

You can view CdA and Time Advantage data on your bike computer, during your ride and also, after the ride, when you download your ride to Isaac.

Time Advantage Graphical Example

Here is a graphical depiction of an actual AeroPod ride with a DFPM, using the “Tools/CdA Analysis…” feature of Isaac (discussed below).



The top graph shows CdA versus distance. The middle graph shows Time Advantage vs. distance, and the bottom graph shows speed vs. distance

This ride was about 29 miles long. In the top window, you see in purple the rider's CdA vs distance. <u>Note that an imaginary horizontal line can be drawn through the purple graph at about CdA = 0.39</u>. **The value CdA = 0.39 is this rider's "normal" CdA value as measured by the AeroPod O&B calibration ride.**

For the first 4.4 miles of this ride the rider had CdA measurements that, most often, were above the normal value of 0.39. *A higher-than-normal CdA means the rider was relatively less aerodynamic, and that time was lost due to the relatively poor riding position*. <u>How much time did the high CdA cost</u>? According to the graph, the time lost peaked at -42 seconds at mile 4.4. What does negative 42 seconds mean? It means that if the rider had pedaled equally hard, *but had always stayed in the normal ride position*, then the rider would have arrived at mile 4.4 <u>about 42 seconds sooner</u>. Said differently: at mile 4.4, aerodynamic riding inefficiencies have cost this rider about 42 seconds, as compared to biking in a normal riding position.

At mile 4.4 the rider improves riding position (becoming more "aero") and CdA drops <u>below</u> his baseline value. *Riding in a more aero position improves the Time Advantage trend; Time Advantage becomes less negative*. In fact, by mile 5.2 the rider is nearly back to zero Time Advantage—meaning the rider at mile 5.2 has neither gained nor lost time due compared to riding the same distance in a normal ride position.

Between miles 6 and 8 there are some high CdA spikes. A high CdA should cause Time Advantage to go more negative, *but Time Advantage curve does <u>not</u> change*. Why? *Time Advantage measurements become less accurate as bike speed and wind speed drop*. Accordingly, <u>AeroPod does not record changes in Time Advantage when bike speed is below 15 mph or when net opposing wind speed is below 5 mph (caused typically by tailwinds)</u>. In this example, the rider is just below the 15 mph threshold between miles 6 and 8, so Time Advantage does NOT change.

Just after mile 8 the rider goes into a tuck and his bike speed increases to nearly 30 mph. The rider gains a tremendous amount of Time Advantage: between mile 9.5 and 10 the gain is about 35 seconds*! The faster you're riding, the more Time Advantage you get from a more "aero" riding position.*

The rider continues the tuck until about mile 11.5. At this point Time Advantage is 50 seconds overall since the beginning of the ride.

Between mile 11.5 and 16 Time Advantage remains flat at about 50 seconds. This is due to low bike speeds of around 10 mph, a result of hill climbs. *At low bike speeds aerodynamic forces don't affect Time Advantage significantly.*

At mile 16 the rider goes into an aggressive tuck and really picks up the pace, too. Between mile 16 and 29 Time Advantage increases by an ADDITIONAL 150 seconds, so that, by the end of the ride, total Time Advantage is about 200 seconds.

What does 200 seconds of Time Advantage mean? **It means that, by becoming more aero, the rider finished 200 seconds (3 minutes, 20 seconds) faster than riding in the "normal" riding position for the entire ride!**

AeroPod gave this rider feedback about the quality of riding position, AND quantified the Time Advantage of aerodynamic improvements.

Using Isaac Software to Analyze CdA Data

NOTE: THIS SECTION ASSUMES YOU HAVE INSTALLED ISAAC SOFTWARE AND ARE FAMILIAR WITH ISAAC OPERATION. YOU CAN FIND ISAAC INSTRUCTIONS HERE:

NOTE: AEROPOD REQUIRES USE OF ISAAC SOFTWARE FOR PC/MAC. HERE ARE ISAAC LINKS:

ISAAC SOFTWARE DOWNLOAD:
https://velocomp.com/isaac-software-installation/

ISAAC SOFTWARE INSTALLATION:
https://velocompforum.com/viewtopic.php?f=12&t=4774

ISAAC USER MANUAL: http://velocomp.com/wp-content/uploads/ ... 121219.pdf

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

Example

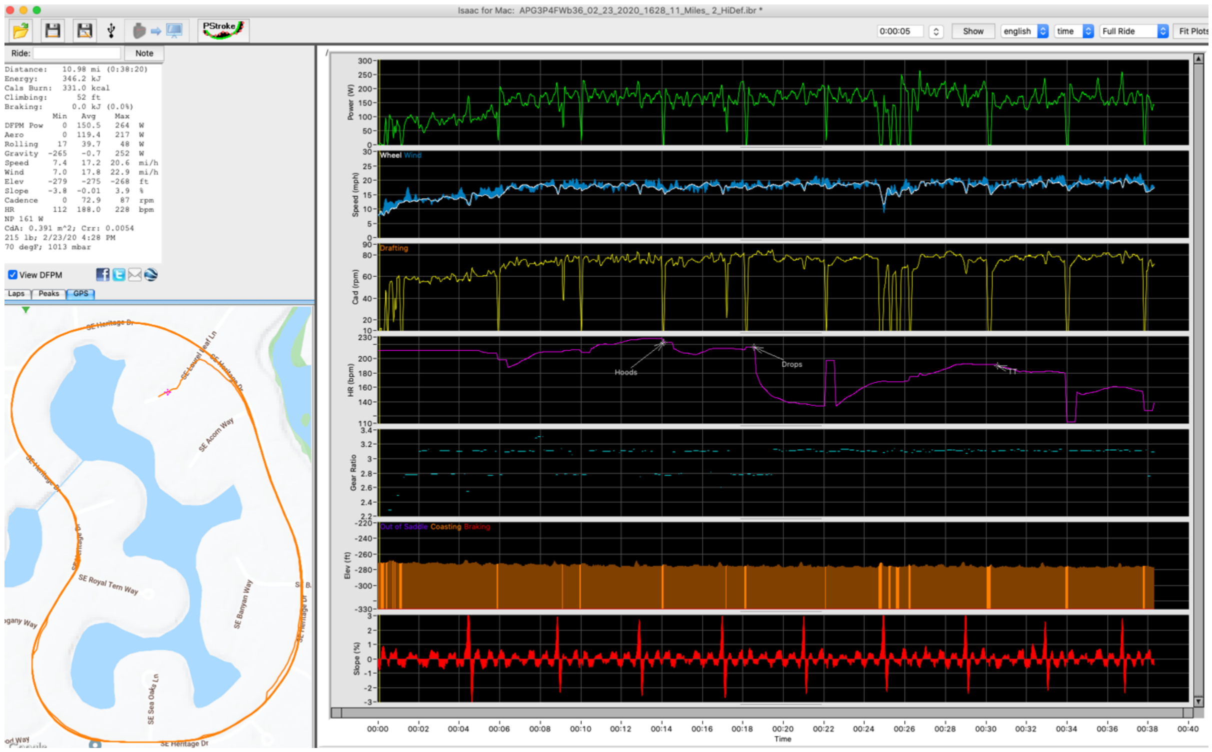
This section illustrates the differences between profile 4 and profile 3, using data from a ride recorded with TWO AeroPods, both mounted on the same bike. *One AeroPod is set to profile 4 (CdA Test) and the other AeroPod is set to profile 3 (Training/Racing).*

On this particular ride a 1.1 mile closed-loop route was chosen (so that profile 4 could be used), and over the course of 11 laps the cyclist rode in three different positions: 4 laps on the hoods, followed by 3 laps in the drops, followed by 2 laps in a TT position, followed by 2 laps on the hoods.

Using Isaac with Profile 4 Ride, Aero Test

The cyclist traveled around a 1.1 mile loop road, clicking the bike computer'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) on the route.

The Isaac command "Edit/Edit Annotation…" was used to add descriptions in the CdA/HR field of different ride positions. The first 4 laps (including the 5 minute warm-up lap) were on the hoods (minute 0 to 18). Drops riding occurred for 3 laps, beginning at minute 18 to minute 31, followed by two laps of TT riding starting at minute 31



How to analyze Profile 4 CdA in Isaac

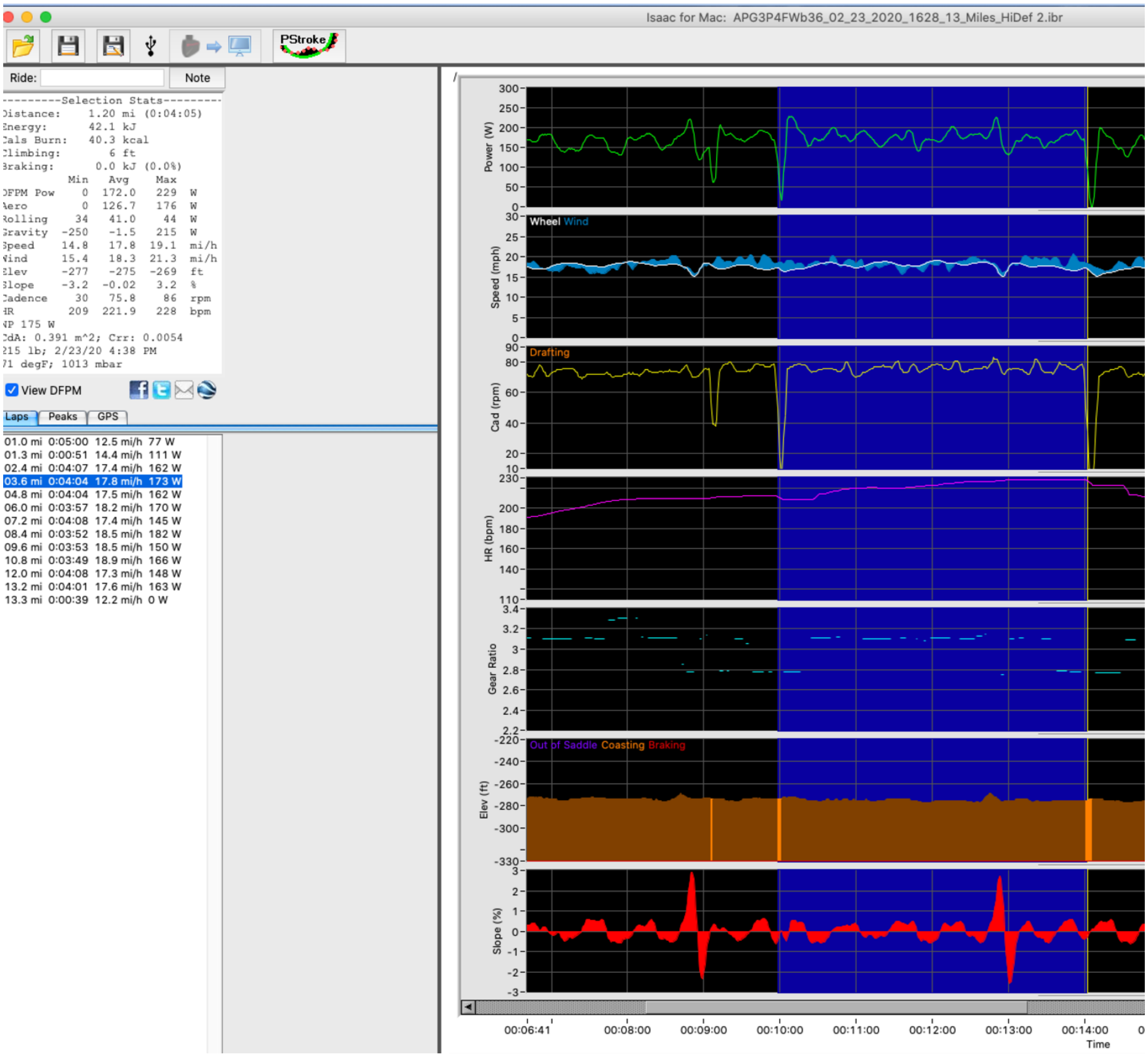
1) The CdA shown on your bike computer screen is the value actually measured in the ride file. For example, while riding, if your measured CdA is 0.380, then your bike computer will show 0.380 on the display.
2) AeroPod records CdA information in the ride file, in the Heart Rate channel. The CdA data for the ride is recorded in the HR (bpm) channel. IN PROFILE 4 **ONLY** THE CONVERSION FORMULA IS

$$CdA_{profile4} = (HR + 180) / 1000$$

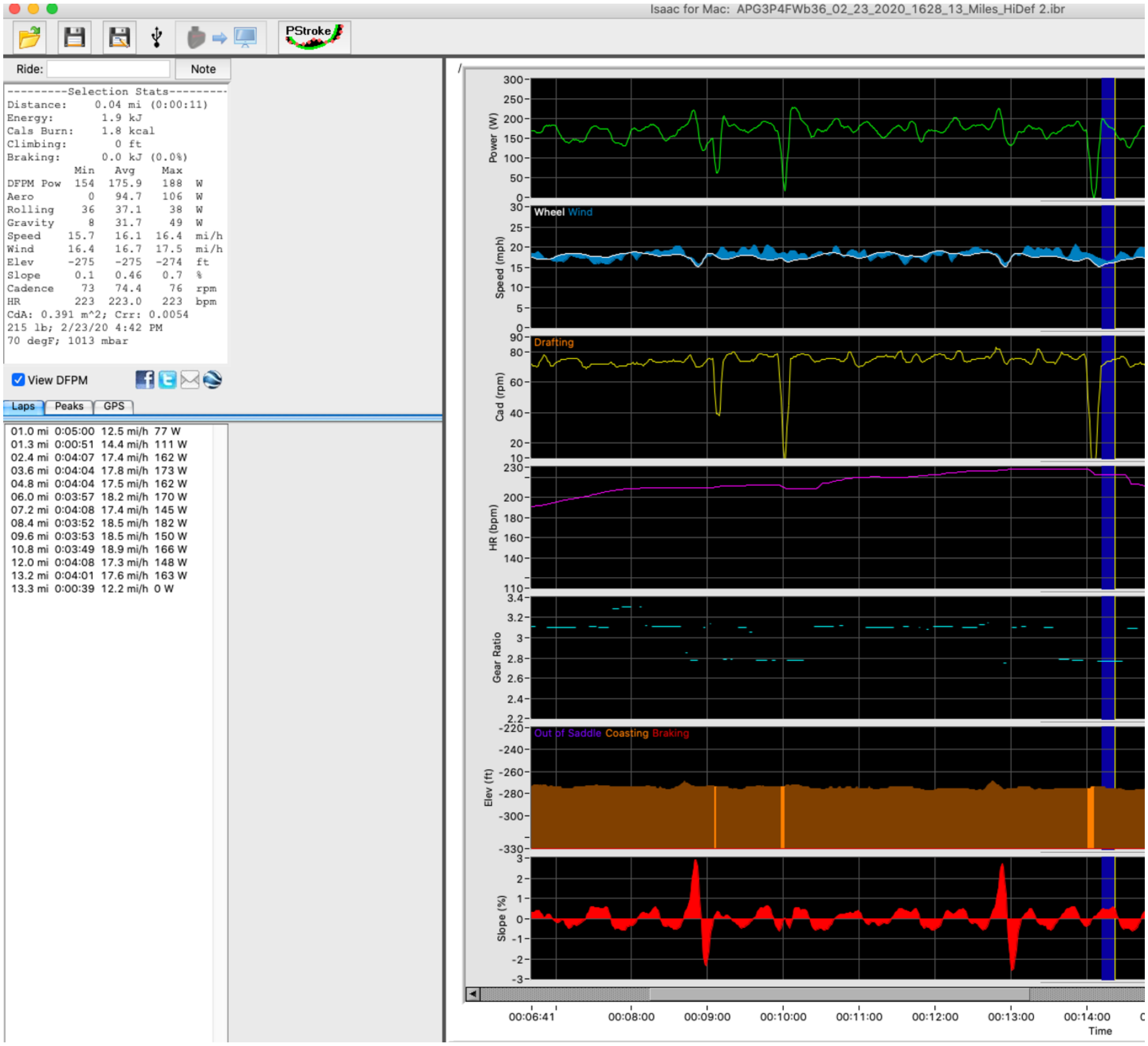
The range of recordable CdAs is from 0.180 to 0.435. As an example, in profile 4 a HR reading of 200 corresponds to a CdA of 0.380.

Note that the profile 4 conversion formula provides CdA resolution of 0.001—better than the profile 3 resolution of 0.004

3) The CdA/HR field records the cumulative average CdA measured as the lap proceeds.
4) Whenever a lap is marked, for the next 30 seconds the measured value of the previous lap's CdA is shown on the bike computer display, and also in the HR field of the ride file. The last-lap CdA is shown as a horizontal line with a length of 30 seconds, that follows immediately after the end of the previous lap. For example, in this ride file, lap 4 ends at 14:01:


Isaac for Mac: APG3P4FWb36_02_23_2020_1628_13_Miles_HiDef 2.ibr
PStroke
Ride:
Note
---------Selection Stats---------
Distance: 1.20 mi (0:04:05)
Energy: 42.1 kJ
Cals Burn: 40.3 kcal
Climbing: 6 ft
Braking: 0.0 kJ (0.0%)
Min Avg Max
DFPM Pow 0 172.0 229 W
Aero 0 126.7 176 W
Rolling 34 41.0 44 W
Gravity -250 -1.5 215 W
Speed 14.8 17.8 19.1 mi/h
Wind 15.4 18.3 21.3 mi/h
Elev -277 -275 -269 ft
Slope -3.2 -0.02 3.2 %
Cadence 30 75.8 86 rpm
HR 209 221.9 228 bpm
NP 175 W
CdA: 0.391 m^2; Crr: 0.0054
215 lb; 2/23/20 4:38 PM
71 degF; 1013 mbar
View DFPM
Laps
Peaks
GPS
01.0 mi 0:05:00 12.5 mi/h 77 W
01.3 mi 0:00:51 14.4 mi/h 111 W
02.4 mi 0:04:07 17.4 mi/h 162 W
03.6 mi 0:04:04 17.8 mi/h 173 W
04.8 mi 0:04:04 17.5 mi/h 162 W
06.0 mi 0:03:57 18.2 mi/h 170 W
07.2 mi 0:04:08 17.4 mi/h 145 W
08.4 mi 0:03:52 18.5 mi/h 182 W
09.6 mi 0:03:53 18.5 mi/h 150 W
10.8 mi 0:03:49 18.9 mi/h 166 W
12.0 mi 0:04:08 17.3 mi/h 148 W
13.2 mi 0:04:01 17.6 mi/h 163 W
13.3 mi 0:00:39 12.2 mi/h 0 W
Power (W)
Wheel Wind
Speed (mph)
Drafting
Cad (rpm)
HR (bpm)
Gear Ratio
Out of Saddle Coasting Braking
Elev (ft)
Slope (%)
00:06:41
00:08:00
00:09:00
00:10:00
00:11:00
00:12:00
00:13:00
00:14:00
Time

and the CdA for lap 4 is 223÷180 = .403 (the HR value 223 is shown in Selection stats)



5) Whenever a lap is marked, AeroPod adjusts as needed the calibration of the accelerometer for the just-completed lap. The value of lap CdA is computed with the updated calibration; this means that the lap CdA (which is the updated measurement shown for 30 seconds after the completed lap) might differ from the cumulative CdA gathered during the lap. This phenomenon is noticeable on lap 6, the first lap where the cyclist rides in the drops position.
6) Whenever a lap is marked, the cumulative CdA value is reset and a new test begins

Here is CdA lap data AeroPod measured for this Aero Test/Profile 4 ride:

Hoods:

Lap 2 .389
Lap 3 .403
Lap 4 .396

Drops:

Lap 5 .377
Lap 6 .355
Lap 7 .372

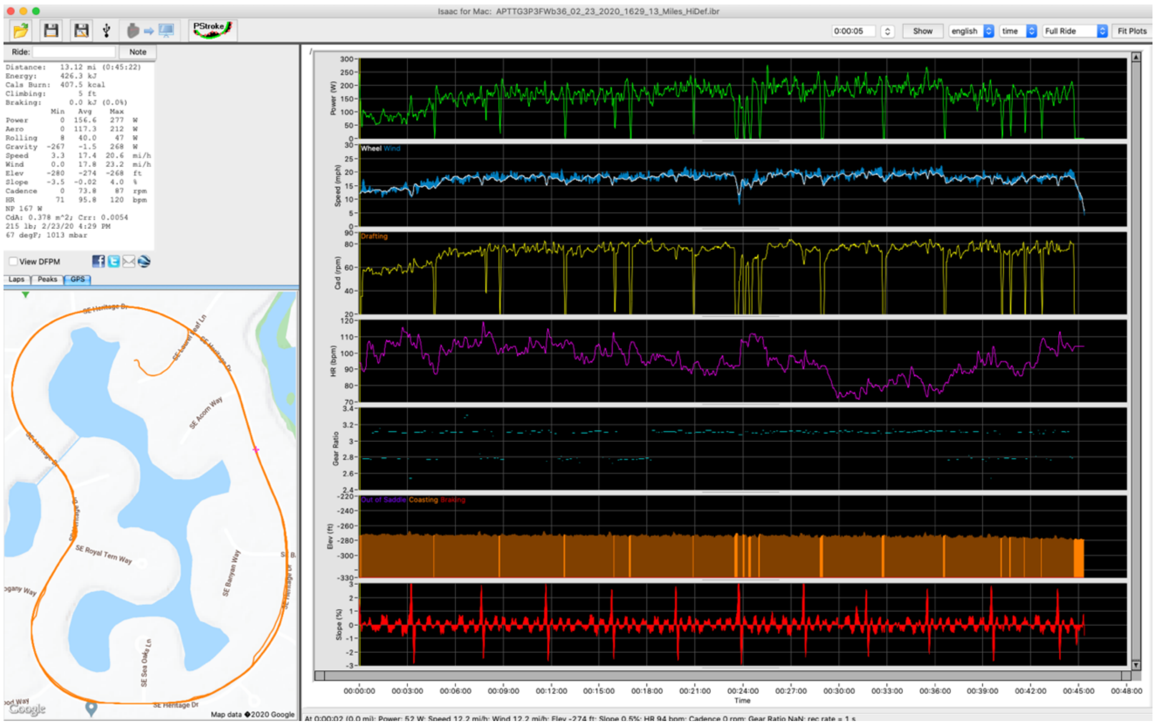
TT

Lap 8 .292
Lap 9 .308

These values are very close and consistent; more laps in each test position would yield even better results!

Using Isaac to Analyze CdA data using Profile 3

Here is the same bike ride, recorded on another AeroPod that was set to profile 3:



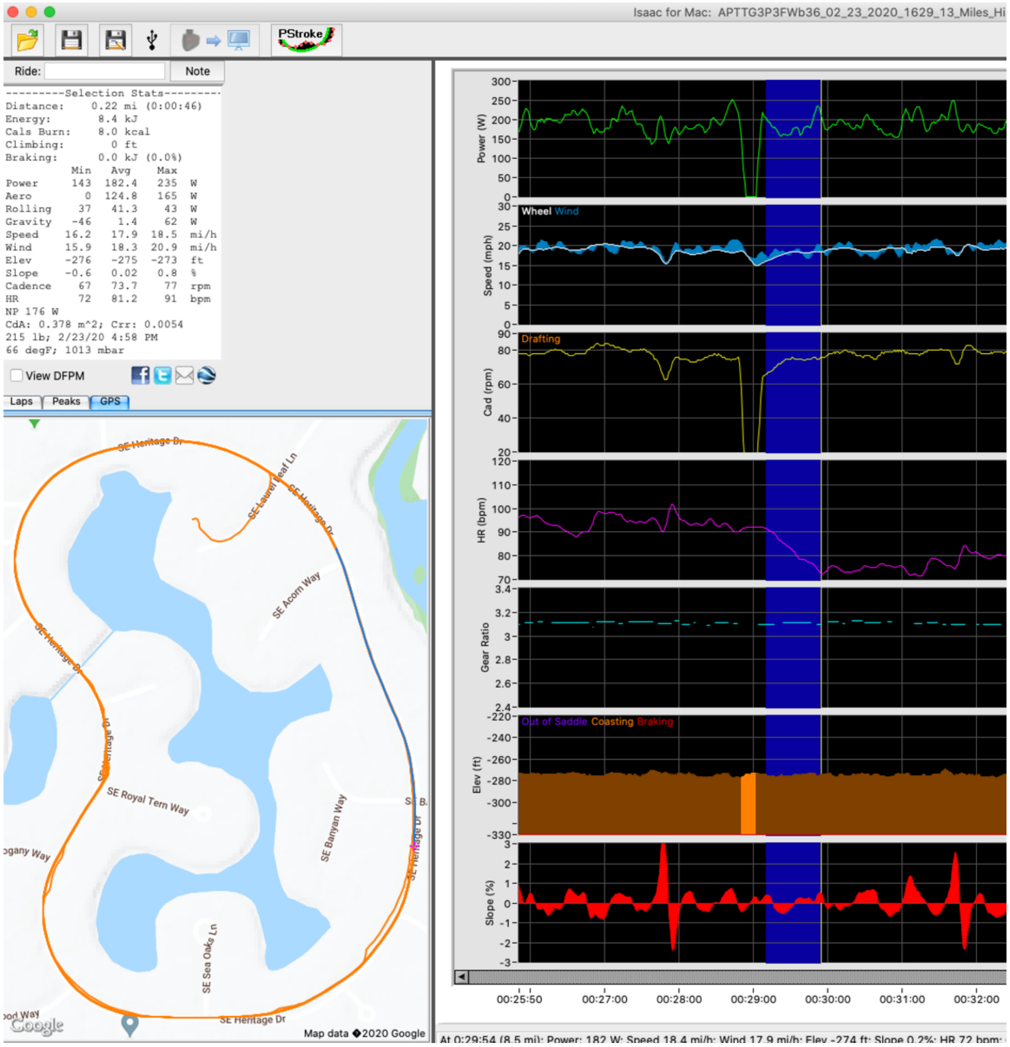
Compared to the Profile 4 ride, there are some important differences you'll see in the Profile 3 Training/Racing mode:

1) The CdA data recorded in the HR channel is converted with the following formula, *which is different from the conversion formula used for Profile 4*

$CdA_{profile3} = HR * 4 / 1000$

(AeroPod users using older versions of FW will note that the profile 3 CdA conversion formula is the same as used in earlier versions of AeroPod firmware)

2) The value of CdA moves around from second to second. This is intentional; profile 3 is intended to give the cyclist quick feedback whenever ride position is changed. For example, at minute 29 the cyclist moves from the drops into a TT position. The CdA reported decreases from 0. 372 (drops CdA) to 0.298 (TT CdA) in less than 1 minute

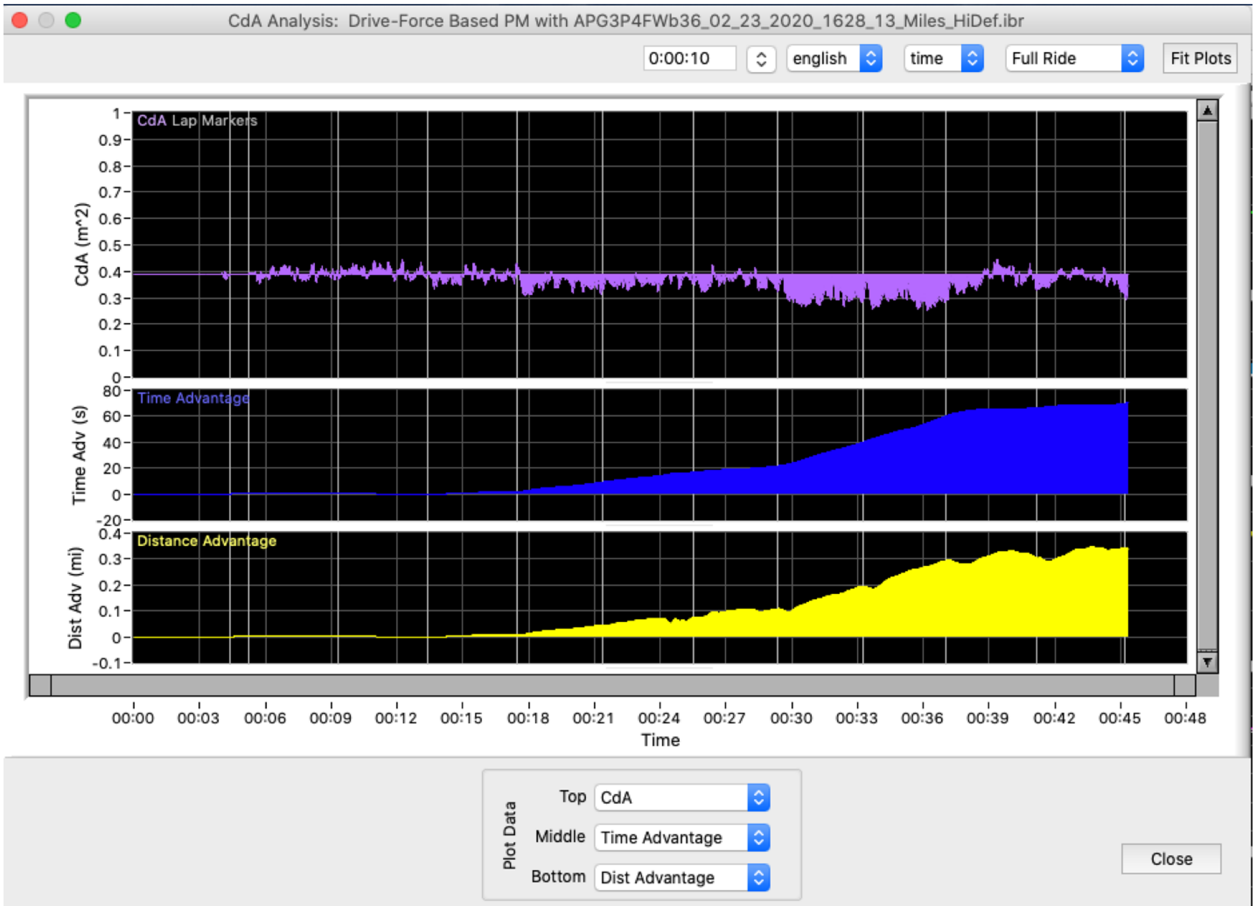


3) The tradeoff required for profile 3 rapid responsiveness of CdA measurement, is CdA measurement variability: because power data used for CdA calculations is inherently noisy, and because just a few seconds of data are used in profile 3 CdA measurements, second-to-second CdA data in profile 3 will vary around the "correct" value. As you ride more with profile 3, your mind's eye will become accustomed to do internally smoothing CdA data, and you'll be able to judge pretty accurately your current CdA

Time Advantage/Distance Advantage analysis using Isaac

Isaac includes a special window ("Tools/CdA Analysis…") for more detailed analysis of your CdA data.

Here is Time/Distance Advantage analysis for this ride:



Remember that, for the first 18 minutes of the ride, the cyclist was on the hoods, *his default riding position*. This means that there is no aerodynamic time or distance advantage, because his actual riding position (hoods) was the same has his default riding position (hoods). As the middle and bottom graphs show, for the first 18 minutes of the ride the accumulated time advantage and distance advantage were nearly zero.

From minute 18 to minute 29 (3 laps) the cyclist becomes more aerodynamic by moving to the drops, and by minute 29 the more aerodynamic drops position results in a time advantage of 20 seconds, and a distance advantage of 0.1 miles. What does this mean? By riding more aerodynamically in the drops, in the 11 minute period between minute 18 and minute 29, the cyclist covered the distance traveled about 20 seconds faster than if he had traveled that same distance on the hoods. Alternatively, it means that the cyclist traveled about 0.1 miles farther than he would have if he had cycled for the same amount of time while on the hoods.

Another thing to notice: from minute 29 to 37 (2 laps) the cyclist rides in an even more aerodynamic TT position. The steepness of the Time Advantage curve increases, which means that the aerodynamic gain from riding in the TT position is MORE than the aerodynamic gain from riding in the drops. If fact, in just 2 laps Time Advantage increases by *another* 40 seconds, to a total of 60 seconds. This means that the cyclist got to this point in the ride 60 seconds FASTER than if he had remained in his default hoods position, and that 40 seconds of the total Time Advantage were gained in just two laps of riding in the TT position.

One final thing to notice: at minute 37 the cyclist goes back to riding on the hoods. What happens? Time Advantage and Distance Advantage “flatten out”, which means that the cyclist is no longer riding more aerodynamically compared to his reference position (which, as noted, is on the hoods).

POWER METER COMPARISON

If you'd like to see how your Device and your DFPM power measurements compare moment-by-moment, select "Tools/Power Meter Comparison". The following graph will appear:

In the top window AeroPod power is shown in white, and DFPM power is shown in green

In the middle window, Power Difference (AeroPod – DFPM) is shown

This plot introduces yet one more interesting metric available through AeroPod: "FREE POWER".

For the first 18 minutes of the ride the cyclist is in the default Hoods ride position. Remember that the calibration ride measured the default CdA, which for this cyclist is 0.391. So, and as expected, when riding in the hoods position the watts measured by AeroPod should be very close to the watts measured by the DFPM. In fact, for the first 18 minutes, where the cyclist rides on the hoods, the Power Difference graph hovers around 0, *as it should*.

Then, from minute 18 to minute 29, the rider goes from hoods (default) to the drops riding position and the average power difference INCREASES to about 10W. What is going on? In the drops the cyclist becomes more aerodynamic and bike speed increases, *even though there is no change in the amount of applied power*. Had the rider stayed on the hoods and pedaled harder to pick up the same amount of speed, how much extra power would it have taken? 10W!! By riding in the drops the rider effectively gets 10W of Free Power to boost his bike speed.

The Free Power benefit is even more dramatic when the rider is in the TT position, from minute 29 to 37. Compared to riding on the hoods, the rider picks up close to 40W of Free Power. Think about that…if there are two identical cyclists riding side by side, one in the TT position and one on the hoods, the cyclist riding on the hoods has to pedal with 40W more power to maintain the same speed as the cyclist in the TT position. Ouch!

TIPS AND TROUBLESHOOTING

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

- <u>I don't see CdA data on my bike computer</u>; I see dashes (---) in the power/CdA/Time Advantage/wind speed/slope fields
  1. Make sure DFPM is working
  2. Make sure AeroPod is paired to your bike's speed sensor (solid green light when button is pushed)
  3. Wait to turn-on Garmin until AFTER your AeroPod is awake and paired (solid green→off).
  4. Ride for a few seconds; this often causes normal readings to begin (--- go to numerical readings)
- <u>When I change ride positions, my CdA and Time Advantage values doesn't change immediately</u>
  1. Make sure you're riding in Profile 3. *When AeroPod is set to Profile 4 you won't see any rapid changes in CdA or Time Advantage*
  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
  3. PROFILE 3: Time Advantage is related to CdA, so Time Advantage measurements will also lag by about 60 seconds.
- <u>My CdA values vary in Profile 3, even when I stay in the same ride position</u>
  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
- <u>My CdA number changes some when I ride on different road surfaces</u>
  1. This is normal. CdA reported by AeroPod will change when road surface type changes, because road surface changes cause rolling resistance (Crr) to change. AeroPod *<u>assumes</u>* Crr does not change
- <u>My CdA number changes when I ride the same roads on different days</u>
  1. Make sure to inflate your tires to the same pressure prior to every ride. Different tire pressures cause Crr (and, consequently, 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 recalibrate itself. In some cases, it can take up to 10 minutes for AeroPod to fully calibrate itself.
  3. PROFILE 4: make sure you mark each completed lap.
  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

- <u>Profile 3: My Time Advantage information seems “off”</u>
    1. When you ride in your “normal” position Time Advantage should not change much
    2. With Raptor, you can reset TA to “0” by tapping the temple (lap marker)
    3. If Time Advantage changes, even when riding in normal position, then do a new calibration ride
    4. It is normal for Time Advantage measurements to lag by about 60 seconds
- When testing, I don’t see significant changes in CdA when I change “x” (“x” is changing to a different piece of equipment, or to a different ride position)
    1. For best highest accuracy measurement of CdA, use Profile 4 for CdA Testing.
    2. It’s easier to measure small CdA changes when you test at higher speeds—22 mph or more
    3. Make sure AeroPod 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.
    5. In profile 4 testing, small differences are more easily detected over longer testing laps—10 to 15 minute 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 assumes your DFPM is working properly and that its wattage numbers are “correct”.
    2. If your DFPM is reading high, then AeroPod will report CdA numbers that are too high.
    3. If your DFPM is reading low, then AeroPod will report CdA numbers that are too low.

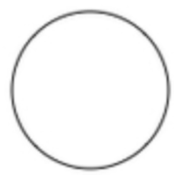
APPENDIX: What is "CdA"?

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:



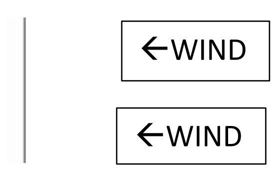
Round disk, frontal surface area A = 1

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:



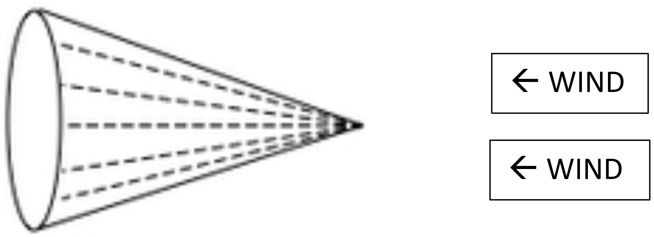
As it turns out, the Cd of a round, flat disk is 1.17. So, the CdA of our round, flat disk is

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

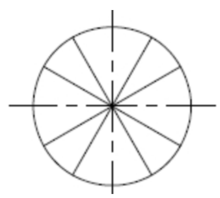
"1.17" is the CdA used to calculate in wind forces acting on a flat disk with area "1".

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.



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—<u>FRONTAL SURFACE AREA IS STILL “1”</u>

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, ***CdA_{cone} = 1 x 0.50 = 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!

<u>So, a round, flat disk becomes more “aero” by adding a conical aero shape in front of it!</u>

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.