NOTIO

FINDING FREE SPEED: MASTER AN EFFECTIVE, ACCURATE AERO TESTING PROTOCOL

INTRODUCTION: WHY AERO TESTING?

PART 1: AERO TESTING BEST PRACTICES

PART 2: AERO TESTING PROTOCOL: USING THE NOTIO

Author **Rob Barrett**

Introduction: Why aero testing?

Aero performance is one of the holy grails of cycling, with aero equipment, aero positioning, and of course, aero bikes essential tools for many athletes. But rigorous aero testing falls into the 'incremental gains' category for many cyclists. It's something you know will help you… but how much? With a good testing protocol, perhaps more than you think. Using an on-bike aerometer can give you quick, accurate data on your CdA (Coefficient of Drag Area), letting you adjust your position, equipment, or elements of your technique and quickly see the effect on your aero performance. Increased aero efficiency gives athletes time and energy savings, making a significant difference in a race scenario.

The gains seen by incremental adjustments can be exactly that – incremental - and require precise measurement to provide data that cyclists can really use. Setting up an effective protocol for aero testing is essential to be sure accurate data is gathered and analysed, and aero gains can be realised.

While wind tunnels are frequently used by professional athletes and manufacturers to optimise aero performance, they remain out of reach for the average athlete. The benefits of on-bike aerometers in terms of both cost and accessibility – no need to book a facility months in advance – are well known. With the increasing uptake of these tools by coaches, fitters, and individual athletes, there is even more need for accurate and efficient testing protocols.

PART ONE

AERO TESTING BEST PRACTICES

Getting it right

There are many parameters involved in aero testing that can affect the results. They can be separated into two classes: the configuration of the bike and the rider, and the environmental parameters over which we have very little control. On-bike aerometers like the Notio measure the environmental parameters that affect the air density (Rho) and use that recorded data when processing the results.

The environmental parameter that it is most difficult to account for is variation in road surface and its corresponding effect on rolling resistance. Tire temperature also affects rolling resistance (Crr). A test environment with a consistent surface is preferable and will produce more reliable results.

In terms of the bike and the rider there needs to be a systematic approach to the sequence in which changes are tested. There are interactions between the various components, for example skin suits and helmets. There are multiple changes that can be made, and the permutations soon add up. That makes it important to track the variables being tested.

The amount of testing required can be optimised by testing the options in a logical order – one thing at a time.

Selecting a test venue

Selecting an appropriate venue is essential to accurate testing, in order to account for environmental factors and allow for proper calibration. The test venue can be one of the following:

- A flat “out and back” stretch of road, a minimum of three to five kilometers in length, with a consistent surface and minimal traffic.
- A dedicated cycle circuit with a consistent surface and minimal undulations.
- A velodrome.

Most on-bike aerometres like the Notio work best in low to moderate wind conditions with the wind in a near consistent direction. If the wind is gusting or at high yaw angles to the test direction, results will be less reliable. In general terms, the longer the duration of a test, the greater the accuracy.

Defining the starting position

There are two prerequisites that a rider should resolve before beginning aero testing. These are saddle position and the amount of "drop" that the rider is capable of sustaining for the duration of their target event.

The majority of riders can produce more power in their road bike position than in their TT aero position, primarily due to the closing of the hip angle in the TT position. The hip angle is dependent on the "drop" between the saddle and the elbow pads, and also the fore and aft position of the saddle with respect to the axis of the bottom bracket.

The rider needs to balance the gains to be made from riding in the TT aero position against any power loss from adopting that position. A useful rule of thumb is to maximise the ratio of average power divided by CdA, but of course the rider can't do that until they have some CdA measurements. Optimizing this number becomes an iterative process.

The place to start is on the turbo trainer, using various combinations of saddle position and drop to find a position that feels comfortable and sustainable. The rider can then perform a CP20 test to get an average power for 20 minutes and compare that to their CP20 result from testing in a road bike position. Once the rider is satisfied with the saddle position and drop, ensuring that it is comfortable, sustainable and provides safe handling of the bike, they can then start thinking about optimising the front end and other aero factors to get the lowest possible CdA, and the highest ratio for the TT position CP20 power divided by the CdA.

When adjusting position on the bike, it's important to measure virtually everything and record the measurements before starting the field testing. There is nothing worse than finding that you do not have the measurements to go back to a faster position you have tested previously. Every time you make a mechanical change, measure and record everything again. You can do this on paper to start with, but it is better to keep a record in a spreadsheet. An example of the measurements you would record is given at the end of this section.

One thing at a time

There are multiple potential changes in extensions, position, skin suits, helmets and so on that can be evaluated for aero efficiency. The place to start is with the changes that are at the front end of the bike, those that the air meets first. The way the air behaves after it has passed the first obstruction affects how the air will behave when it meets the next obstruction further back. Unfortunately, downstream behavior can also have an effect on things upstream, so the testing does become a cyclical iterative process, and, with any luck, a converging process.

What to test / order of testing

Most riders won't have the option of different base bars, but that would be the first thing to test if it is an option.

The obvious place to start, once the base bar is chosen, is with the extensions and riser stack. The hands and arms are the first thing that the air encounters. Already there are multiple variables with just the combination of extensions and riser stack, add to that the angling of the extensions and pads — now a standard feature on several market-leading systems — and the permutations multiply rapidly.

If you've already established the maximum sustainable drop on the trainer, start with that and look at extension styles and angles of attack. Start at the extremes – for example, S-bends and horizontal forearms compared to extensions with a larger angle, which produce a "high hands" position. Select the faster of the two for comparison with the next option, and so on.

Once settled on extension style, drop, pads and angle of attack, move on to testing that position with a range of helmets. In general, the gap between the rear of the helmet and the shoulders / back needs to be eliminated, and the uppermost part of the helmet is ideally no higher than the highest point of the shoulders / back. This is something that can also be evaluated on the trainer before field testing.

Once settled on a helmet choice, move on to tests skinsuits if you have the luxury of choice. Again, you need to keep a record of what you test so that you can always go back to the fastest combination after you have experimented with other options.

We are focusing here on the rider's position and equipment, as that accounts by far for the largest portion of aero drag – up to 80% – as opposed to the bike itself. However, wheels are also frequently tested. Rear disk wheels tend to outperform deep section rear wheels. Often, though, most riders will only have one disk wheel to choose from.

For front wheels it comes down to two factors: speed (aero efficiency) and handling. High performance front wheels tend to be expensive, so the best option is to borrow them to test before making an investment decision.

Repeat tests to validate the results

One of the best ways to convince yourself that your testing results are accurate is to perform repeat tests. This can be testing two of three configurations on the day in A-B-C-A-B-C mode or A-B-C-C-B-A mode, or testing the same configuration on different days.

Another way to check consistency of results from test day to test day is to use a benchmark system. For example: start a test day with a known configuration from a previous testing day. Rather than have a single benchmark configuration you can choose the fastest configuration from the previous test day, and then try to better that by testing small incremental changes.

When you are seeing small differences in CdA from, for example, testing different front wheels or testing aero helmets, it is always better to use a repeating alternate testing protocol such as A-B-A-B-A-B. Changing wheels and changing helmets is a relatively quick process as no mechanical changes are involved.

Examples of Measurements to Record

Floor to elbow rest / hoods road bikes	rear
(Drop measured from height of elbow)	front
Floor to centre of cranks	
Floor to saddle (through the bolt)	
Back of elbow rests to saddle / front of hoods road bikes	
(measured to front of saddle TT bikes / middle saddle road bikes)	
Front axle to BB (horizontal)	
Top of saddle from top of frame	
(measured through the clamp bolt)	
Top of saddle from BB axle (on the angle)	
(measured through the clamp bolt)	
Off-set BB to saddle (middle road bikes)	
(measured to tip of saddle TT bikes)	
Centre of seat post to centre of steerer	
Saddle through the clamp bolt to sole of shoe	
(bottom of peddle stroke)	
Floor to centre of front of extensions	
Tip of saddle to tip of extensions	
Drop - floor to saddle minus floor to elbow	

PART TWO

AERO TESTING PROTOCOL: USING THE NOTIO

Aero testing with Notio

Much like how the testing protocol outlined in Part 1 requires a deliberate process to achieve accurate results, using a tool like the Notio requires correct setup and calibration. Once the setup is complete, gathering and analysing data can provide valuable insight into training and equipment choices over the long term.

Mounting the Notio

Ideally the Notio should be mounted on the centre line of the frame. That position usually results in the Notio being too close to the extensions for repeatable results when optimizing the front end. A better option is mounting the Notio on the base bar, adjacent to the right-hand brake lever and as far forward as possible when testing different styles of extensions, elbow pads and helmets. However, this option can be subject to wind measurement erro if there is crosswind (yaw).

Why calibration is important

The Notio uses two pressure readings as part of the instrumentation process. The wind speed is calculated by a function that uses the two values for pressure, one from the Pitot tube (dynamic pressure), and the other the static pressure.

However, because of where the Notio is mounted on the bike, the configuration of the front end of the bike affects both of these pressure measurements. The Notio would need to be 10 feet in front of the bike to be able to measure the actual wind speed. By measuring the ground speed and averaging the air speed measured by the Notio, we can calibrate the system to allow for the way that the bike affects the pressure readings.

The calibration accuracy can be increased by recording multiple sets of data and taking an average of the calibration factors.

Testing changes in configuration

When changing the configuration of the bike it is possible that the change will affect the calibration, particularly if the change is towards the front end of the bike, such as the extension configuration, base bar, helmet type, or front wheel. Fortunately, the same data can be used for both calibration and analysis.

Basic guidelines to use when recording the calibration data for the Notio using an “out and back” test venue.

Distance

The recommended distance to calibrate the Notio device is 6000m performed as two legs of 3000m, at threshold speed, with an easy section in between. If there is wind at the venue, a head and tail wind will give a meaningful result. If the wind is a crosswind the data will not be as consistent, and the result will be less accurate. The same applies if the wind is gusting.

Speed sensor

Use a magnet-based speed sensor if possible, rather than a hub mount sensor. The magnet systems appear to offer better speed accuracy. Remember to measure the circumference of the wheel (the one with the speed sensor) and check that the correct circumference is being used with the Notio app (and your Garmin if you are using one).

Recording process

Start the recording from the Aero test tool in the App or from your Garmin head unit. Take 500 metres to accelerate up to your threshold speed. When performing calibration, it is essential to be as consistent as possible in terms of speed, position, and gear ratio. Try to avoid power surges and shifting if possible. Ride the test sections as smoothly as possible.

When you have completed both sections (out and back) stop recording from the Aero test tool in the App or from your Garmin head unit.

If using a Garmin, you must “Save” the ride to ensure that the Notio stops recording and the ride data is saved. The green light on the Notio will return to “solid” from the “fast flashing” when recording is stopped correctly. When the recording is stopped and the ride saved, the ride file will be uploaded to the user’s Notio cloud account so long as there is a suitable internet connection.

Basic guidelines to use when recording the calibration data for the Notio using a velodrome or a cycle circuit.

Distance

At a velodrome or cycle circuit venue the rider will be doing laps. At an indoor velodrome, eight to ten minutes of steady-state laps will be sufficient. At an outdoor velodrome or a cycle circuit, where the lap length can vary, 15 to 20 minutes of data would be sufficient. On a cycle circuit, completing at least five complete laps of steady state riding is preferable.

Speed sensor

Use a magnet-based speed sensor if possible, rather than a hub mount sensor. The magnet systems appear to offer better speed accuracy particularly on steeply banked velodromes. Remember to measure the circumference of the wheel (the one with the speed sensor) and check that the correct circumference is being used with the Notio app (and your Garmin if you are using one).

Recording process

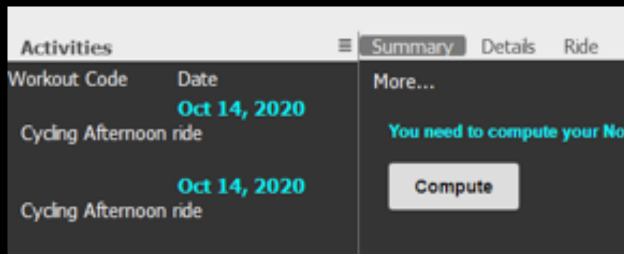
Take one or two laps to accelerate up to your threshold speed, or sufficient distance on a cycle circuit. When performing calibration, it is essential to keep the same line and be as consistent as possible in terms of speed, position, and gear ratio. Try to avoid power surges and shifting if possible. Ride the test laps as smoothly as possible.

Start and stop the recording from the Aero test tool in the App or from your Garmin head unit.

If using a Garmin, you must "Save" the ride to ensure that the Notio stops recording and the ride data is saved. The green light on the Notio will return to "solid" from the "fast flashing" when recording is stopped correctly. When the recording is stopped and the ride saved, the ride file will be uploaded to the user's Notio cloud account so long as there is a suitable internet connection.

Analysing the calibration results for an "out and back" using NotioGC (Golden Cheetah)

Download the data to NotioGC using the "sync" function and click on the "Compute" button.

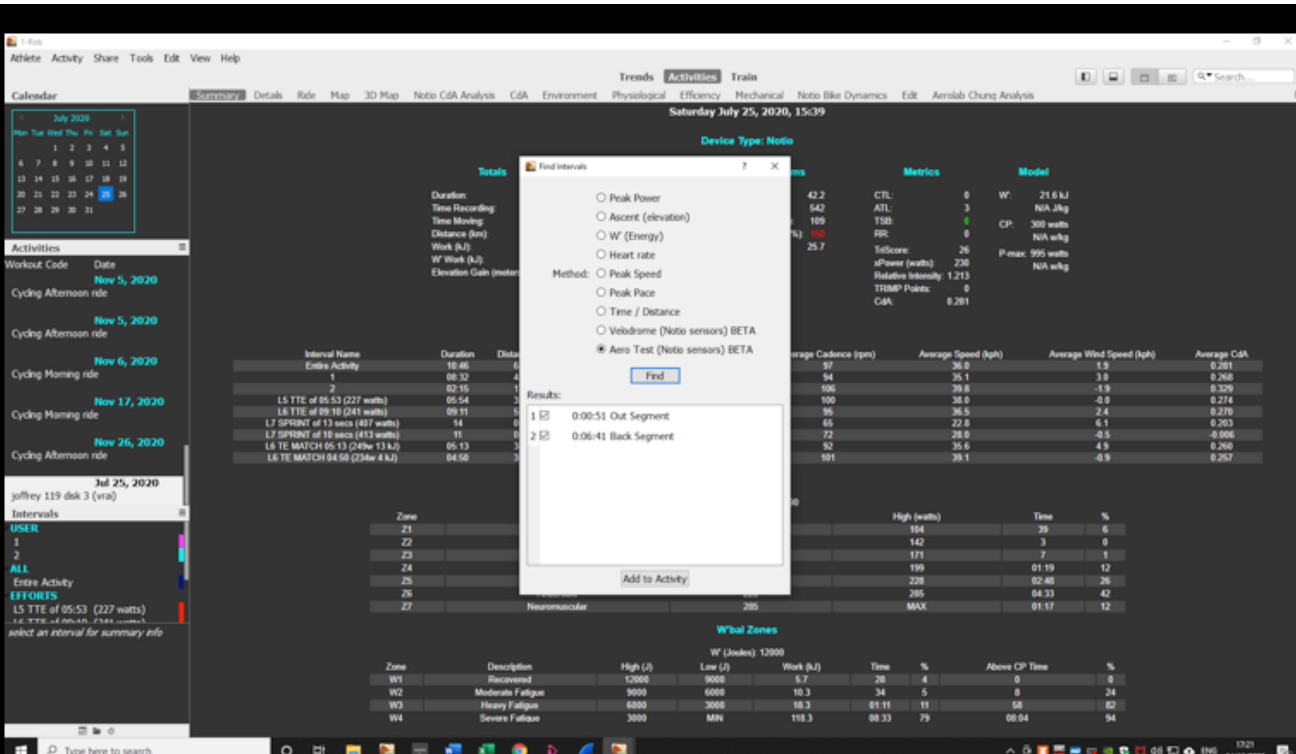


If the file does not appear when you attempt to sync the cloud file to NotioGC, then the file hasn't been uploaded to the cloud.

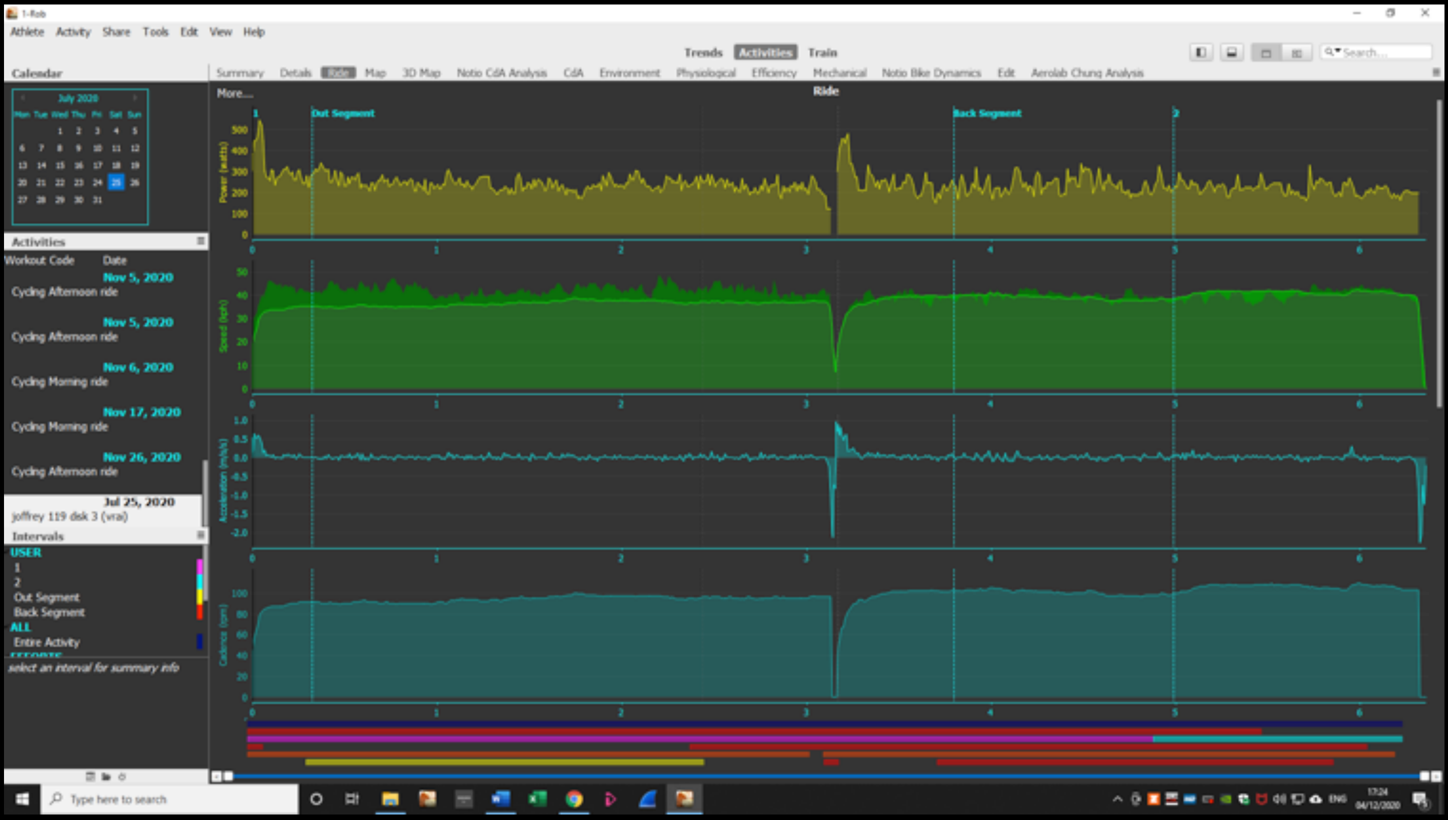
You may have to go around the "push" loop described below in "troubleshooting the sync".

When using "out and back" calibration, create two intervals, one for each 3000-meter segment. The easiest way to create the two intervals is to use the "Aero Test (Notio sensors)" which at the time of writing is still in Beta test.

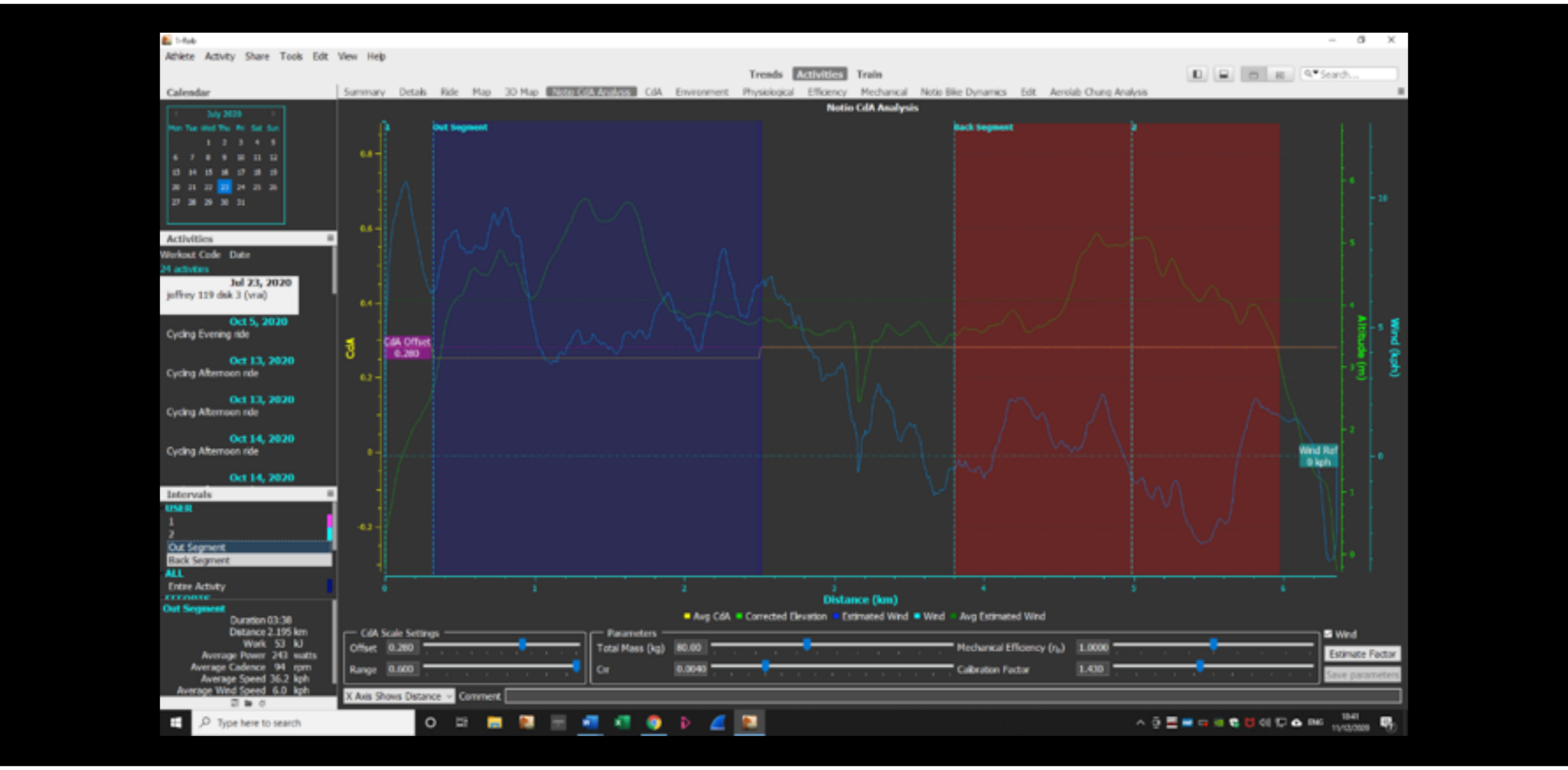
Right click on the ride in the "Activities" section on the left side of the screen and select "Find Intervals" from the menu.



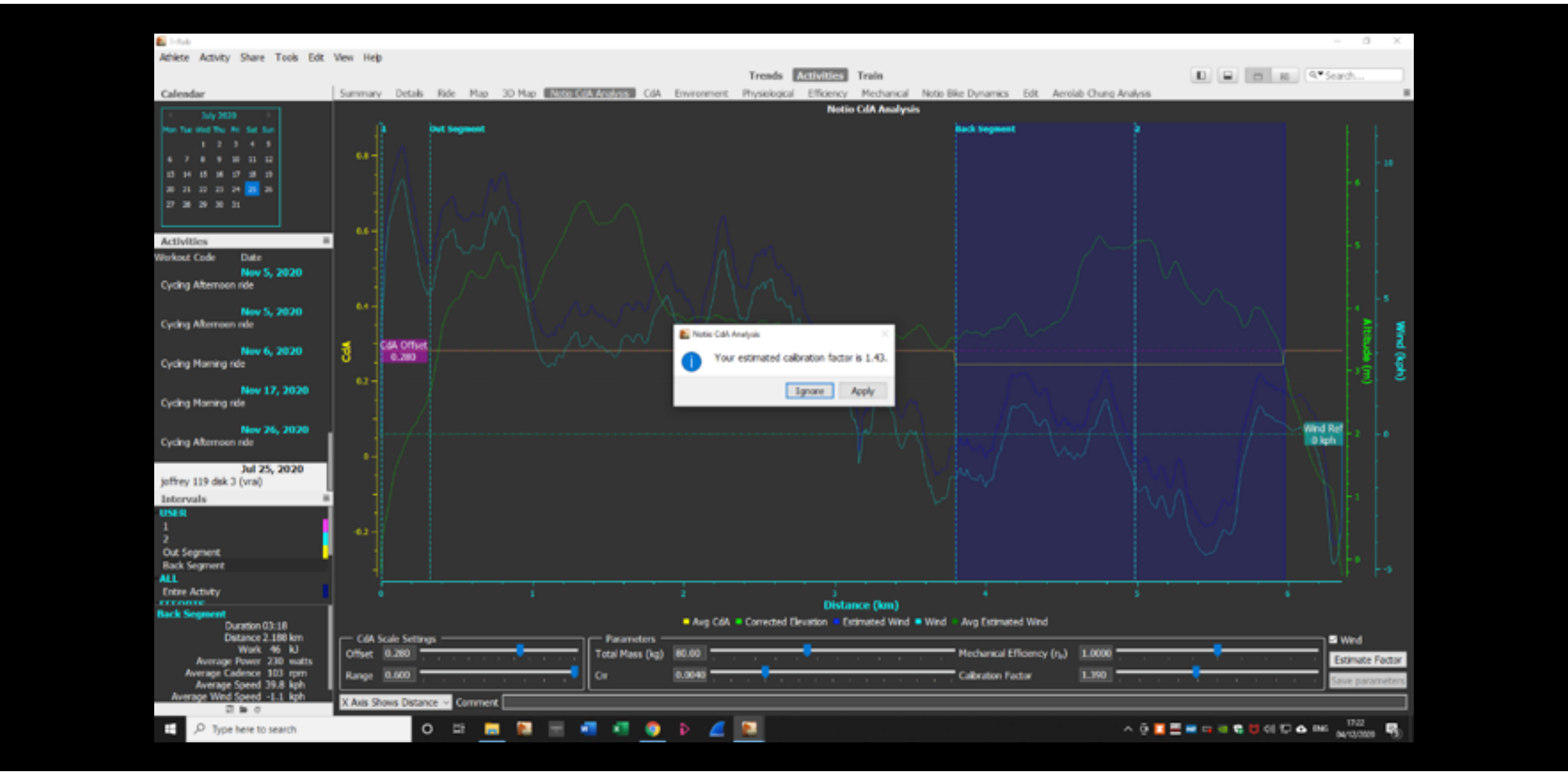
The “Out Segment” and “Back Segment” intervals will be displayed in the “Ride” screen.



Switch to the “Notio CdA Analysis” screen. Select the “Out Segment” and “Back Segment” in the “Intervals” panel on the left side of the screen by left-clicking on the segments.

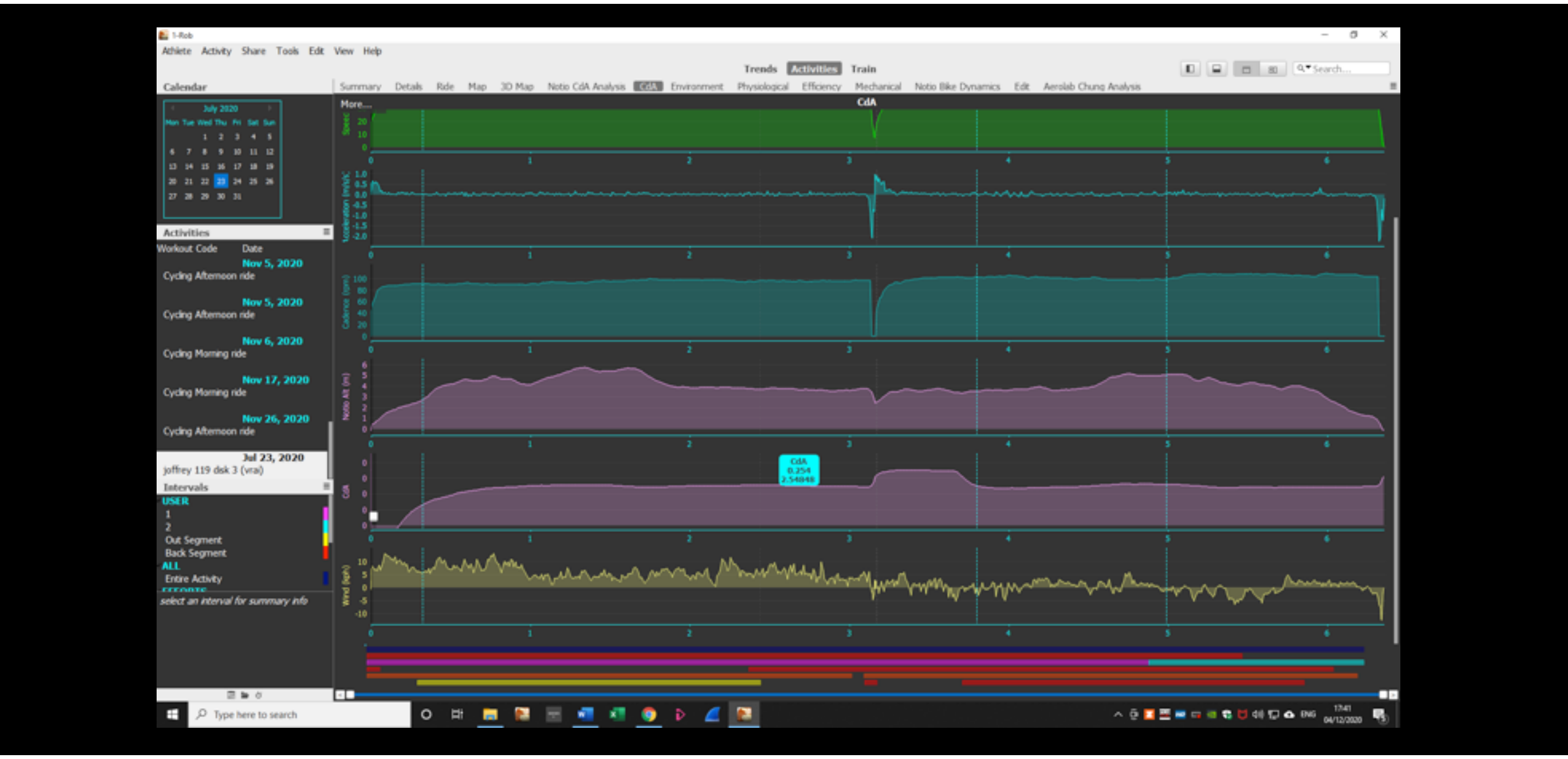


…. then select “Estimate Factor” ….

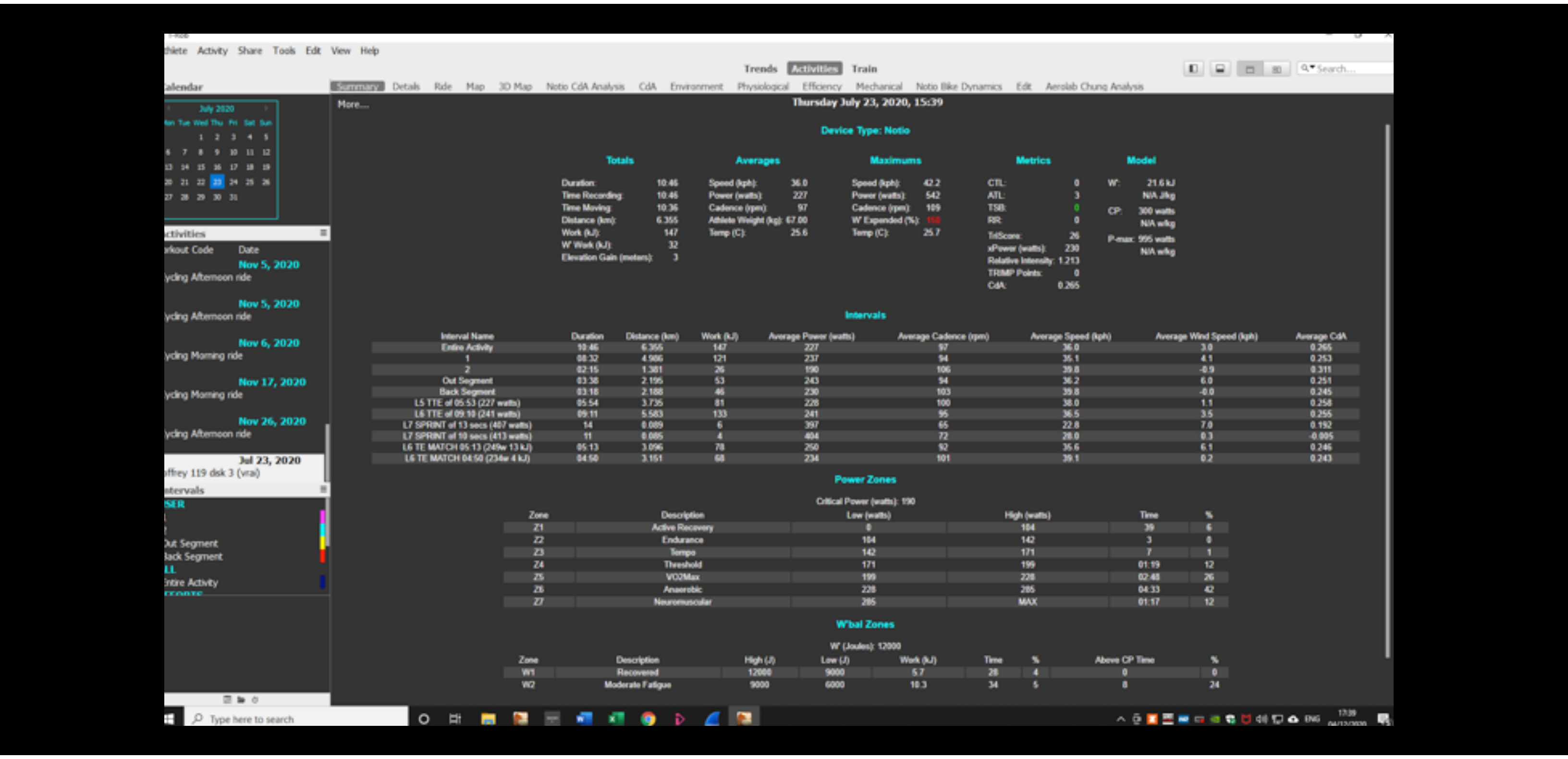


…. and “Apply” from the pop-up.

With the calculated Calibration Factor entered in to NotioGC the CdA screen looks like this:

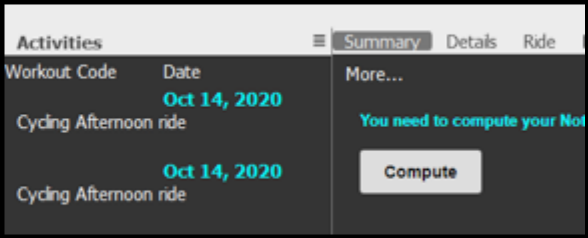


And the summary screen looks like this:



Analysing the calibration results for a velodrome or a cycle circuit using NotioGC (Golden Cheetah)

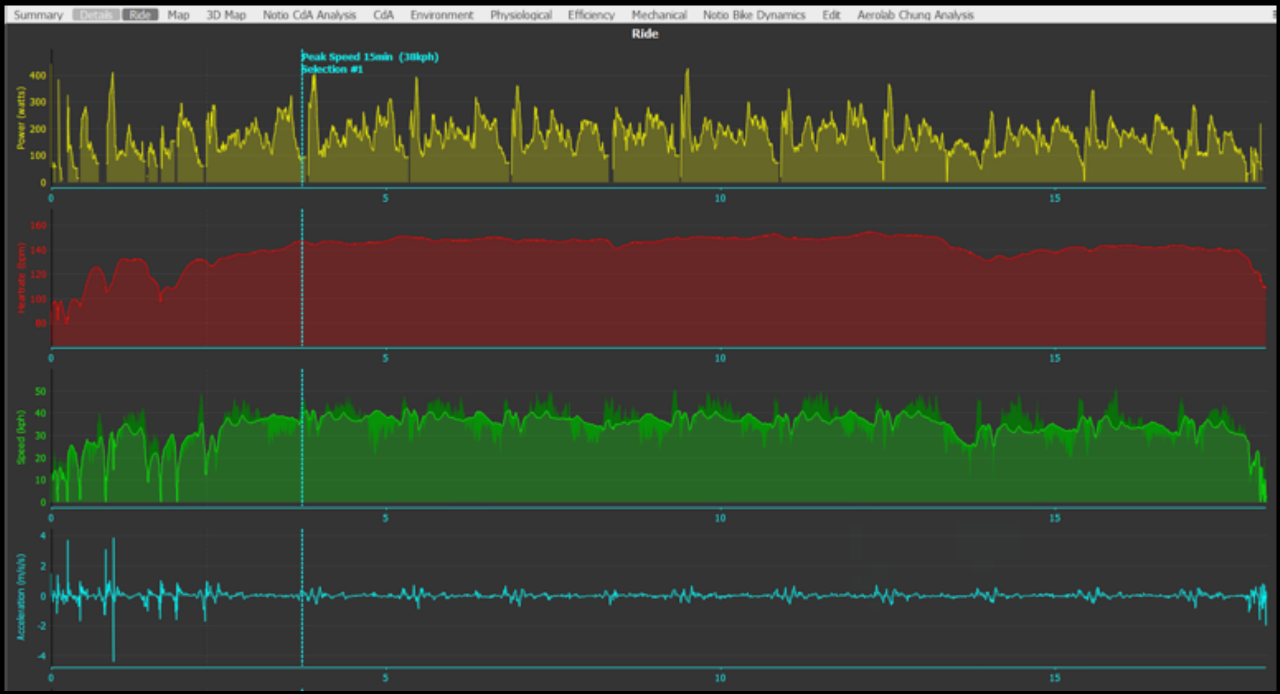
Download the data to NotioGC using the "sync" function and click on the "Compute" button.



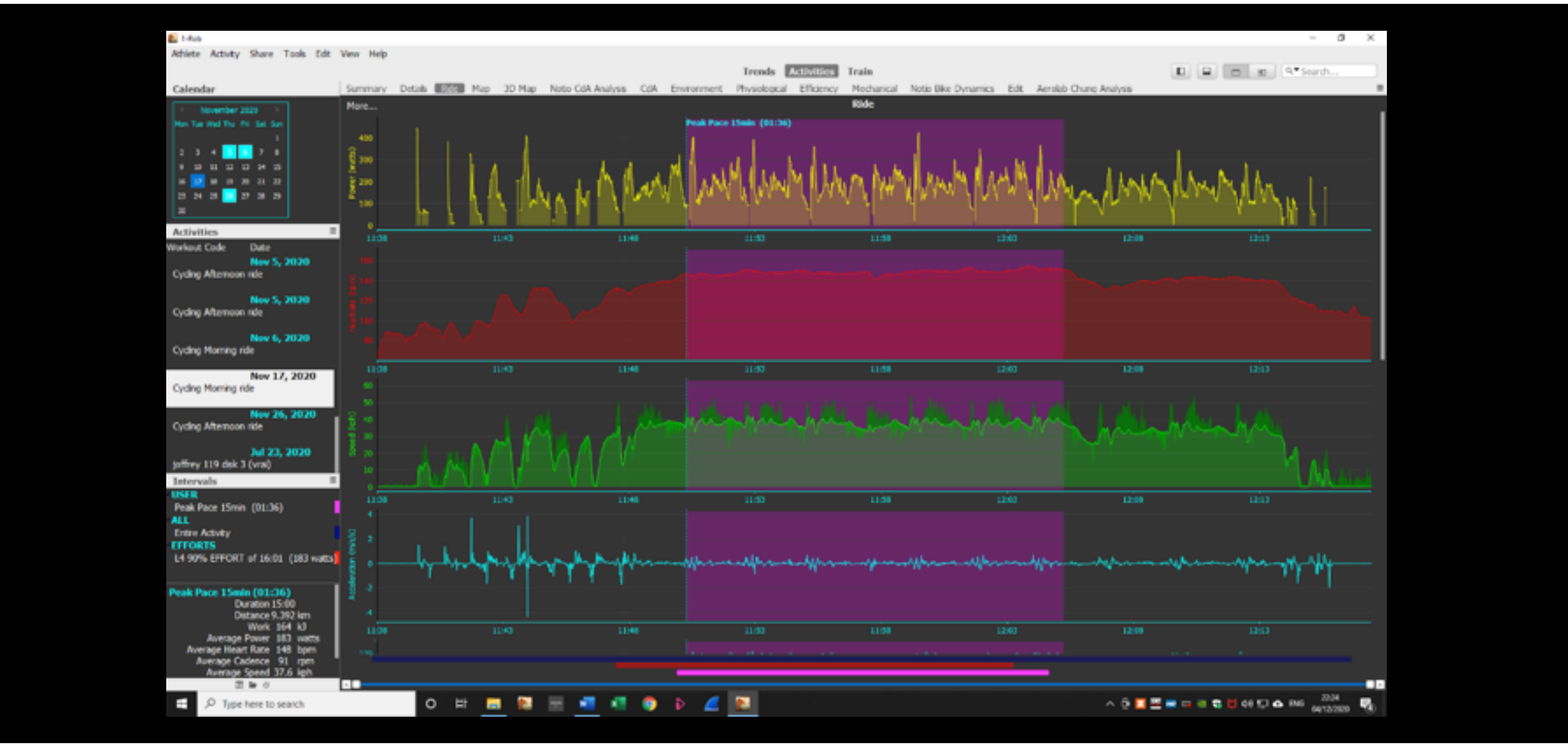
If the file does not appear when you attempt to sync the cloud file to NotioGC, then the file hasn't been uploaded to the cloud.

You may have to go around the "push" loop described below in "troubleshooting the sync".

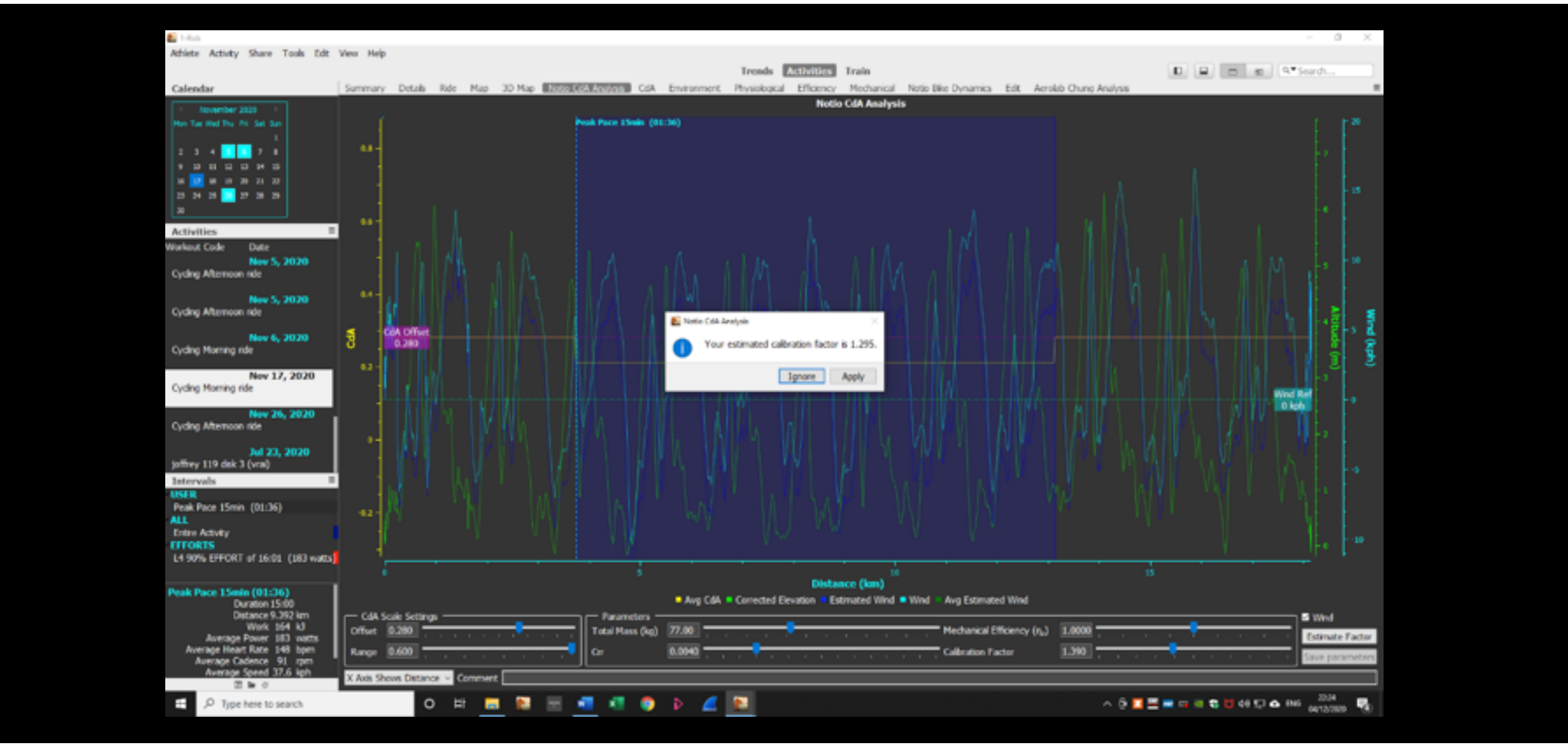
When using a velodrome or a circuit, create just one interval. The best way to do this is to manually create the interval by clicking and dragging from the chart. By using the GPS view of your ride, it should be easy to select the complete loop that will function as your interval.



Switch to the "Notio CdA Analysis" screen. Select the single interval in the "Intervals" panel on the left side of the screen by left clicking on the segments.



With the interval selected click on the “Estimate Factor.” In this case it is a single interval from a circuit test.



Click on “Apply” to enter the “Calibration factor” into the box, and then click “Save parameters”.

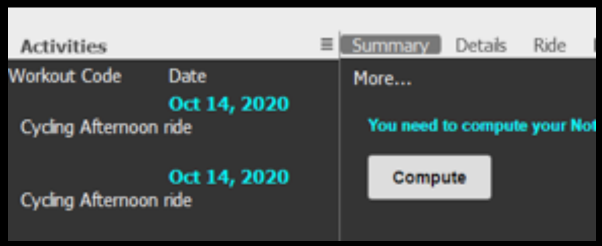
With the calculated Calibration Factor entered in to NotioGC the CdA screen looks like this:

And the summary screen looks like this:

Analysing the results with NotioGC

When you save a ride from the Notio app, or the Garmin head-unit, the file is automatically saved to the Notio cloud account.

Download the data to NotioGC using the “sync” function and click on the “Compute” button.



To sync the file to NotioGC, the command sequence is “Share / Syncronise Activities / Notio”. If the file doesn’t appear when you attempt to sync the cloud file to NotioGC, then the file hasn’t been uploaded to the cloud.

You may have to go around the “push” loop described below in “troubleshooting the sync”. If you have recorded laps using the Garmin lap function you will see the laps itemised in the Summary screen of NotioGC with a CdA associated with each lap.

If you have used the Notio app you can add notional laps manually using the “Find intervals” function using “Peak Speed” and a duration roughly equal to a lap time.

The first five intervals here are in the TT position, the 6th and 7th are relaxed position and riding on the base bar.

The CdA for the laps is shown in the summary screen.


Intervals

Interval Name	Duration	Distance (km)	Work (kJ)	Average Power (watts)	Average Heart Rate (bpm)	Average Cadence (rpm)	Average Speed (kph)	Average Wind Speed (kph)	Average CdA
Entire Activity	39:27	18.149	323	136	132	80	31.1	1.2	0.232
Peak Speed 3min #1 (38kph)	03:00	1.919	34	189	148	94	38.4	-1.2	0.200
Peak Speed 3min #2 (38kph)	03:00	1.906	34	188	151	93	38.1	1.5	0.199
Peak Speed 3min #3 (38kph)	03:00	1.887	34	192	149	92	37.7	-0.2	0.201
Peak Speed 3min #4 (38kph)	03:00	1.878	33	182	142	91	37.6	0.9	0.196
Peak Speed 3min #5 (37kph)	03:00	1.842	30	167	148	89	36.8	0.2	0.203
Peak Speed 3min #6 (34kph)	03:00	1.721	30	169	142	89	34.4	1.0	0.228
Peak Speed 3min #7 (32kph)	03:00	1.599	29	160	136	83	32.0	2.0	0.252
L4 90% EFFORT of 16:01 (183 watts)	16:02	9.896	177	184	146	90	37.0	0.3	0.199

In this data lap five is an outlier as there was period when the rider was on the base bar. The L4 90% effort of 16 minutes duration reports a CdA of 0.199. This is roughly the average of the individual laps. A margin of plus or minus 0.0015 units of CdA is within the ability of most riders to hold a stable position. The jump in CdA up to 0.252 is to be expected when switching to riding with the hands on the base bar for a whole lap. The rider in this example was wearing winter kit with a TT aero helmet. The bike was in full competition TT configuration.

Troubleshooting the sync

If you attempt to sync the cloud file to NotioGC (Share / Syncronise Activities / Notio) and the file doesn't appear, then the file hasn't been uploaded to the cloud account from the app. The data hasn't been lost. This is what you need to do to "push" the file to the cloud.

First make sure that the iPhone app has a reliable data service, preferably a WiFi connection.

Next delete the file (or files), that haven't uploaded from the file list within the app.

(Bottom left icon to open the file list, select the file, then use the three-dot icon top right to open the pop-up window, hit delete {which is in red}).

Next refresh the phone app file list (top right, NOTIO FILES), and download the missing data file from the Notio again. This action will reload the file(s) into the phone app and "push the file(s) to the cloud using the data network.

The Benefits of aero testing

While evaluating small changes in CdA may seem like a minor part of a training regimen, for many athletes, it's these incremental gains that make the difference on race day. Data-driven adjustments to position and choice of equipment make those choices and adjustments easier and faster. Testing with aerometers like the Notio also brings this type of elite training technique outside of the wind tunnel and into the hands of everyday cyclists and pros alike, as another key tool in an athlete's arsenal. Developing a reliable testing protocol as outlined here will help you test quickly and accurately to find your aero advantage.

#aero for everyone

visit notio.ai