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Aerodynamic Drag Area of Cyclists Determined with Field-Based Measures

James C Martin, A Scott Gardner, Martin Barras, David T Martin

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Exercise and Sport Science, University of Utah, Salt Lake City, UT 84112; Australian Institute of Sport, Belconnen, Canberra, ACT 2616, Australia. Email. Reviewer: Carl Paton, Centre for Sport and Exercise Science, Waikato Institute of Technology, Hamilton, New Zealand.

Aerodynamic drag is an important factor in the performance of competitive track and road cyclists. Recently we used wind-tunnel testing to validate a practical measure of aerodynamic drag derived from a field test. We present here instructions for performing the field test on a straight flat road or in a velodrome, and we include a spreadsheet for performing the calculations.
KEYWORDS: model, performance, test, track, velodrome

Reprint pdf · Reprint doc · Spreadsheet · Commentary by Carl Paton

These instructions pertain to a spreadsheet that will allow you to determine aerodynamic drag area (C_DA) from six field trials. Data must be recorded by an SRM or other accurate power measuring device. Please refer to our recent paper for additional details (Martin et al., 2006). Note that in the paper we used a two-step process to first determine friction (μ) and then to determine C_DA. This process worked quite well with a large number of samples (several data points from many riders) but μ tends to be unstable when evaluated with a few points. In the current spreadsheet we have given some typical values for μ that will facilitate more robust calculation of C_DA. While this approach will introduce some error, it will likely be a small error in a small term, so the overall impact on C_DA should be negligible.

General Instructions

Start by going to the Air Density Calculator tab. Enter a value for temperature in degrees Celsius in cell A2. Enter a value for relative humidity in percent in cell B2. Enter a value for barometric pressure in cell C2. Barometric pressure must be in units of millibars and the values must be absolute. This may be difficult to determine because weather stations often report barometric pressure values corrected to sea level. The most direct way to determine barometric pressure would be for you to have a barometer on site during your testing. These can be purchased for as little as US$30. Alternatively, if you are in the USA you can go to the website and find a station near your testing site. You will need to set the output to metric units.

Both the road and track calculations must be based on six trials. Do not leave cells blank. If you cannot do six trials, you could enter data for some of the trials twice, but that is not ideal. Each trial should be done a constant speed throughout the test section. The range of speeds you use should be as wide as possible, from say 10 km/h to as high a speed as the rider can hold steady for the test section. By setting the speedometer to km/h you will get maximum resolution. You will need to convert the speed to meters per second for the spreadsheet calculations.

Instructions for a Straight Flat Road

We have not specified a length for the “test section” but we recommend as great a length as you can find that is straight and flat. We have used 470 m with very good results.

Start by going to the C_DA for a straight road tab. You will need to enter the following values for each trial:

1. Column A: Bike and rider mass in kg.
2. Column B: The road grade in percent. Note that this will depend on the direction. Positive grade denotes uphill and negative grade denotes downhill. These values can be obtained from local government agencies. Ask for “as built plans” or “as built surveys”.
3. Column C: Wind velocity in meters per

second must be entered for each trial. To enter the proper value you will need to know the wind velocity and direction as well as the direction of the road. From those data, you must determine the component of the wind that is parallel with the road. We will assume that you can make those calculations and will not attempt to explain them. Negative values denote wind in the same direction as the bicycle is traveling and positive values denote wind that opposes the rider.

4. Column D and E: Velocity and the beginning (initial) and end (final) of the measurement interval in meters per second. These can be read off of the SRM data but you must know the time associated with the start and end.
5. Column F: Average velocity over the measured section in meters per second.
6. Column H cell H2 only, enter a value for rolling friction. Typical values are given for a track, a rough road, and a smooth road.
7. Column I: Enter the average power recorded during the measurement section.
8. Column J: Enter the time required to cover the measurement section for each trial.
9. When you have entered all these values the bike and rider CDA will appear in cell B12.
10. The goodness of fit of your data can be seen in cell Q9. That value should be around 0.98 or better.

Instructions for a Velodrome

The spreadsheet does not account for wind in a velodrome. Wind will tend to cancel for a complete lap, however these effects are non-linear and you should do testing in the calmest conditions you can or on an indoor velodrome. The spreadsheet assumes a complete lap and your data might be improved by doing 2 or more laps. This will be difficult at high speed so you may want to use more laps for lower speeds and less laps at the higher speeds.

Start by going to the CDA on a velodrome tab. You will need to enter the following values one time only:

1. Cell B2: The length of the track in meters
2. Cell C2: The height of the saddle from the ground in meters.
3. Cell H2: Enter a value for rolling friction. Typical values are for a track are 0.0025.

You will need to enter the following values for each trial:

4. Column A: Bike and rider mass in kg.
5. Column D and E: Velocity and the beginning (initial) and end (final) of the measurement interval (e.g., one lap) in meters per second. These can be read off of the SRM data but you must know the time associated with the start and end.
6. Column F: Average velocity over the measured section in meters per second. This could be obtained from the SRM or calculated from the track length and the lap time.
7. Column I: Enter the average power recorded during the measurement section.
8. Column J: Enter the time required to cover the measurement section for each trial.
9. When you have entered all these values the bike and rider CDA will appear in cell B12.
10. The goodness of fit of your data can be seen in cell Q9. That value should be around 0.98 or better.

Reference

Martin JC, Gardner AS, Barras M, Martin DT (2006). Modeling sprint cycling using field-derived parameters and forward integration. Medicine and Science in Sports and Exercise 38, 592-597

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