Aero Testing Confidence Limits

I have been asked the question, how accurate are the results from aero testing?

It is not a straightforward answer as there are margins of error in multiple aspects of the process.

If we start from the point of view of collecting the data, we are basically recording power and speed from sensors. We are reliant on the precision and accuracy of the sensors.

Typically, a power meter manufacturer quotes accuracy within one percent. We don't know if that one percent is a constant off-set or if it is a short term variable off-set of plus or minus half or one percent? And if it is variable, does it vary with a short random time constant or does it drift around with a slow time constant. Short term variations will average out if the test runs are significantly longer than the period of variation; longer term drift will not average out in the same way.

Here is a table that shows the results of varying the power in one percent increments. There are screen shots in Appendix One.

Power Increase	CdA	CdA Increase	Percentage
	0.2280		
1%	0.2310	0.0030	1.30
2%	0.2335	0.0025	1.07
3%	0.2360	0.0025	1.06

Given that the Golden Cheetah Aerolab calculation is "by eye" i.e. lining up the green and blue lines, there is an error in that process of around plus or minus half of one percent. However, by using synthetic constant data it is possible to see a difference in calculated CdA of around a one percent change in CdA per one percent increase in power.

Speed sensors are reliant on wheel revolution counts, and the circumference data for the wheel being used. It's logical to assume that as tyres and tubes warm up that there will be a variation in pliability that will change the effective circumference by a marginal amount. You can't rely on GPS speed; it just isn't accurate enough. Just look at a GPS trace after a turbo session. GLONASS is better, so I'm told. Ideally, we want to be using a magnet based speed sensor rather than an inertia speed sensor, as the inertia type have been known to add extra beats, particularly when used at steep banked indoor velodromes.

The effect of temperature on rolling resistance (Crr) is also significant, for example, a change in Crr from 0.004500 to 0.004000 represents a difference in calculated CdA of around three percent.

Let's take our wheels out of a warm house at 20 degrees and go to an outdoor track where the track surface temperature and air temperature are about ten degrees. After a period of normalisation the difference in Crr is going to be about plus 0.000500.

Crr change	CdA	CdA Increase	Percentage
0.004500	0.2280		
0.004000	0.2350	0.0070	2.98

Now let’s go to that same track on a sunny summer’s day. Take the wheels out of our air-conditioned car at 20 degrees, do a test run, and then change the stack with the bike exposed to full sun. The tyre temperature is likely to rise to 35 to 40 degrees, because of the radiated heat. This will result in a difference in Crr of around minus 0.000500.

The bottom line here is that you need to be aware of the effects of temperature on Crr. You can buy an Infrared thermometer to measure tyre and track temperatures, but you need to be careful not to leave that device exposed to full sun light or it will read incorrectly.

Test results from different days

It is pretty much a certainty that there will be different environmental parameters for tests performed on different days. Using a benchmark set-up is one way of getting some degree of meaningful comparison for results obtained on different days.

If we assume for a moment that we can test with constant environmental conditions, then the error margin is just down to the precision and accuracy of the sensors, and the error margin associated with the analysis method, usually Aerolab in Golden Cheetah.

If we are generous and assume an error margin of just plus or minus one percent from the measurement and analysis system, and then we take a nominal CdA of 0.2000, then one percent of that is 0.002, so the actual CdA could be 0.198 or 0.202. That spread of 0.004 roughly equates to four watts at 40kph and seven watts at 50kph.

How do you establish the margin of error in your testing protocol?

Test protocols and techniques can help improve the quality of the results. A good place to start is by doing multiple runs with exactly the same setup. The results should all be the same within the plus or minus 0.002 limits. You may see some drift due to environmental parameters. You may see some differences due to small changes in the position you have on the bike for each run after the pit-stops.

What you will get from this is an idea of the spread of results for the initial benchmark set up. If you then test two different set ups (using the A-B-A-B-A-B-A test method) you’ll be able to see if the differences are significant or within a similar spread of results to that which you saw from the benchmark test. If the results are within the spread that doesn’t mean that A and B are equivalent. What it means is that the measurement system can’t resolve any differences between A and B because of the inherent margins or error in the system.