PRO-LITE

Aerodynamics and Power: Rome and Padova Design Concepts

For truly uncompromising athletes, aerodynamic and raw performance are serious business. Every little bit counts. With an experienced professional development team at the helm, the Rome and Padova have each seen the benefit of ground-up design.

Rome: 5-Spoke Aerodynamics
Designing a 5-spoke carbon wheel demands attention to three primary areas that we can divide thusly:

Directional Leading Edge – This is the forward edge of the wheel that faces resistance in the direction that the bicycle is traveling. This is where most of the resistance comes from as the wheel pushes through the air to displace it.

The Rome uses a streamlined shape, similar to an airplane wing (sometimes referred to as a NACA airfoil), but without the lift. This shape addresses turbulence both on the forward edge and on the trailing edge. The Padova uses a flat streamlined shape, similar to an airplane body.

In both cases, the primary source of drag is pressure drag, along the leading edge, as it is with most bicycle wheels. (1)

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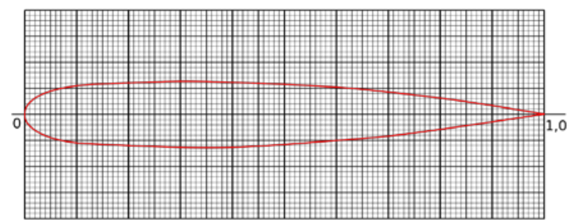
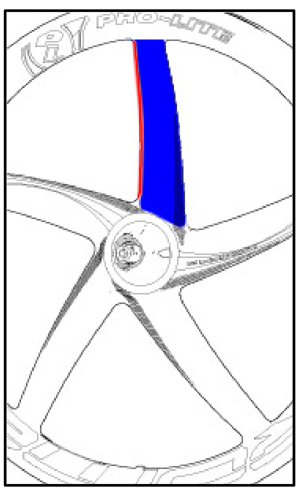


Leading edge **Trailing Edge**



Forward Swept Curved Planform
Narrow at the top
Wider near the hub

Rotational Leading Edge – The wheel does not actually follow the same path of movement experienced by the rider. While the rider is moving forward, the wheel is actually rolling, with the wheel not moving at all at the point of contact with the ground and the top section of the wheel moving at speeds up to double the speed of the rider. During early wind tunnel testing, it was discovered that a gently curved planform provided the best aerodynamic performance when facing both rotational air resistance and directional air resistance. The spokes on the Rome are curved forwards and tapered close to the rim. This improves performance where wind speed is highest (near the top) and pushes the turbulence away, down the spoke.

Strength Characteristics – As important as aerodynamics are, even more critical is the strength of the carbon fiber structure. Carbon fiber is not well suited to sharp angles, so the overall shape of the spokes has been adjusted for ultimate lateral and torsional strength within the parameters of the aerodynamics. In the Rome, using layers of unidirectional carbon fiber plus layers of woven 3k cloth and pre-impregnated carbon fiber gives an exceptionally strong, shock resistant wheel that won’t let you down.

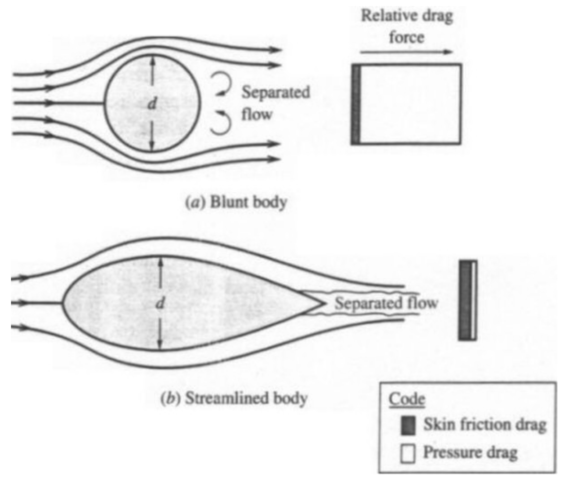
Finding a balance of these different issues required some serious fine tuning during the years before it was unveiled to the public.

Padova: Disc Aerodynamics
Just as with the Rome, aerodynamic performance is a balance of three characteristics. Fortunately, the disc wheel is significantly simpler.

Dimpled surface – It's a great idea, but with one serious flaw. Dimples work on spheres and cylinders but not on flat surfaces such as those seen on disc wheels. The same is true for fuselage and wing surfaces on airplanes. Don't believe us? Look at any airplane made in the last 70 years. See any dimples? Again, for the gritty details you can read the explanation made by rocket scientists.

"The reason we do not see dimples on other shapes, like wings, is that these particular forms of boundary layer trips only work well on a blunt body like a sphere or a cylinder." – aerospaceweb.org (2)

Adding dimples to the side surface of a wheel for 'improved aerodynamic performance' is a bit like adding cobblestones to a road course and claiming it makes the route faster. Dimples may have a minute improvement on lower profile rim under some circumstances, but on an oblong, streamlined shape with large surface area, it is more likely to increase surface drag. This is why you don't see dimpled surfaces on F1 cars or airplanes.



Which of these shapes looks more like your rim?

"More streamlined shapes like the airfoils used on wings are dominated by a different kind of drag called skin friction drag." "Past experience, including short-term positive experiences with surface finish changes, taught us that revising the shape was more effective than revising the surface finish." "For comparison, going from a cylinder to an aerofoil, the drag (again depending on speed and scale) goes from a coefficient of drag of above 1.0 for the cylinder (except at high speed or scale) to a drag coefficient of less than 0.1 for an aerofoil called a NACA 0030. This over 90% reduction makes a 25% reduction in drag seem small by comparson." **-** *Willem Toet, Head of Aerodynamics, Sauber F1 Team, Sauber Motorsport AG (3)*

Toroidal shape – There are two primary benefits to using a toroidal shape. The first is that it does allow a laminar flow. The second is that it does actually yield improved strength against lateral forces. Why not use a toroidal shape then? Although it is able to maintain a laminar flow for very low drag, it isn't actually discernably *better* than a flat surface. Look at an airplane body for an example. It doesn't bulge at the center for practical reasons. Secondly, while there is a small improvement in strength at the flange, this comes at the cost of having to use more material to physically cover the area and small surface features like this can damage brittle fibers like a standard 3k weave. This means significantly increased costs and a decreased overall strength to weight ratio. Would you pay more for something that was heavier than it needed to be? Or weaker than another wheel of similar weight?

Flat disc – Keeping it simple turns out to be the best policy then. Not only does this give the rider the best bang for the buck, it also provides the best all-around aerodynamic performance, with streamlined body. Further, the strength can come from the unique internal construction to make a wheel strong enough for even the strongest track sprinters to accelerate without breaking. Mechanical efficiency is the first link in the chain and requires a rigid, strong and stiff wheel.

For sheer zero compromise aerodynamics, a gloss finish is the simplest, but we allowed ourselves a little vanity and used a sweet satin finish designed by Basler in Switzerland, so you can look as good as possible while riding as fast as possible.

So the design of the Padova came down to some rather simple decisions. We chose to use top quality carbon fiber, molded to a flat surface around a proprietary internal reinforcement structure, bonded at the flange with unique 3M microspheres to some exceptionally smooth Japanese angular contact EZO bearings.

The result? A truly world-class disc wheel.

References:

(1) http://www.altairhyperworks.ca/ResLibDownload.aspx?file_id=803 (PDF download)
(2) http://www.aerospaceweb.org/question/aerodynamics/q0215.shtml
(3) http://www.formula1-dictionary.net/dimpled_surface_finish.html