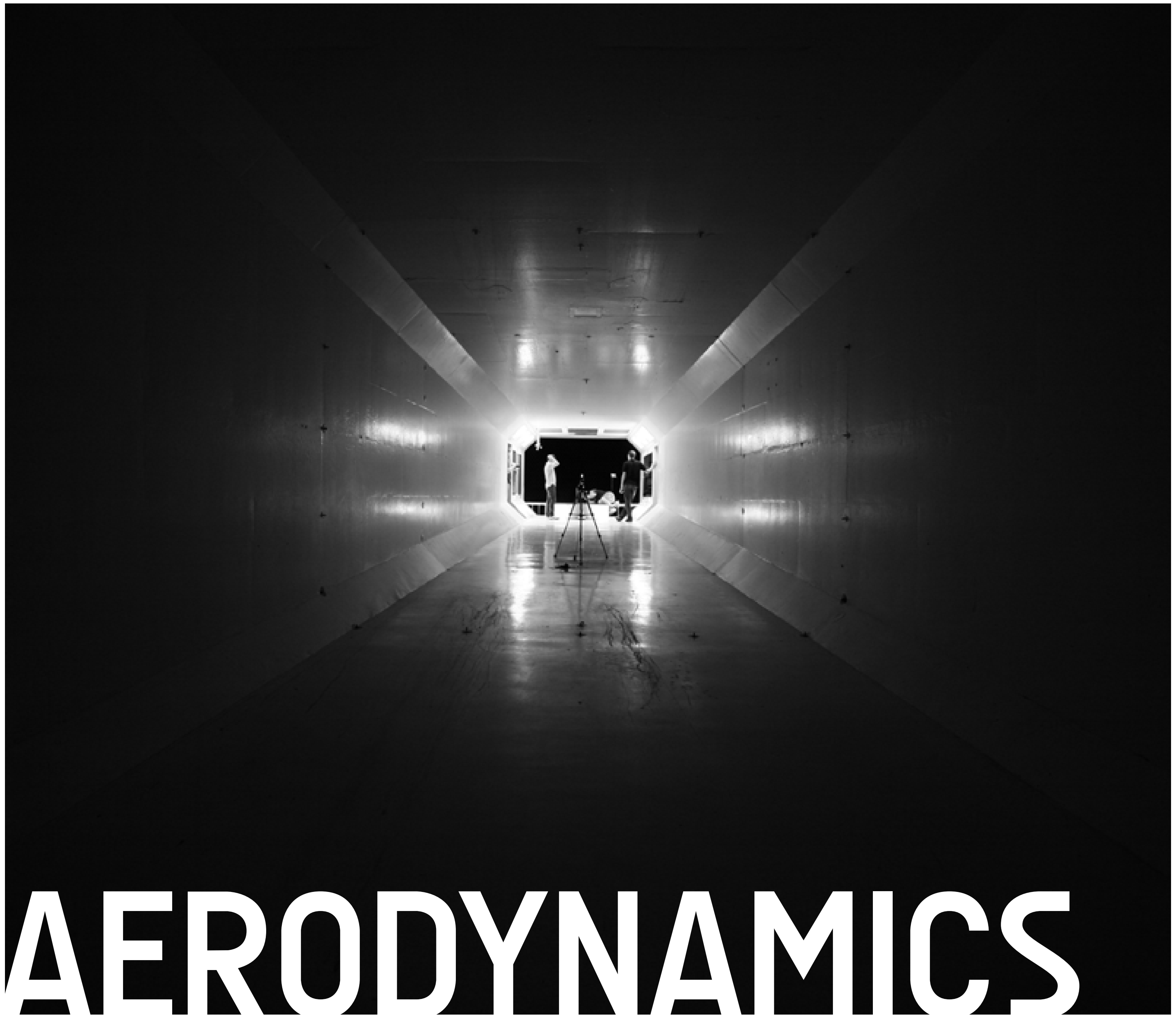


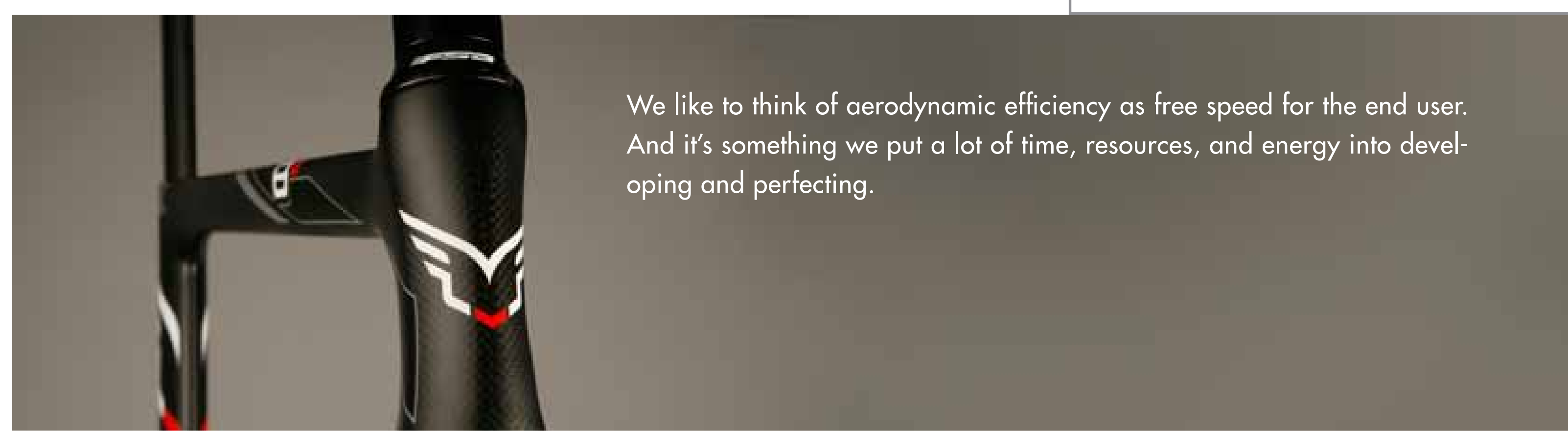
AERODYNAMICS

FELT'S AERODYNAMIC TECHNOLOGY

AERODYNAMICS

An object is considered aerodynamic if its shape reduces the drag from air moving past it when compared to similar objects with similar purpose. In context, if you can build a bike that's just as light and stiff as your competitor's, but make it require 15 less watts to move at the same speed due to superior aerodynamic efficiency, you've created an advantage.

Felt does just that.



We like to think of aerodynamic efficiency as free speed for the end user. And it's something we put a lot of time, resources, and energy into developing and perfecting.

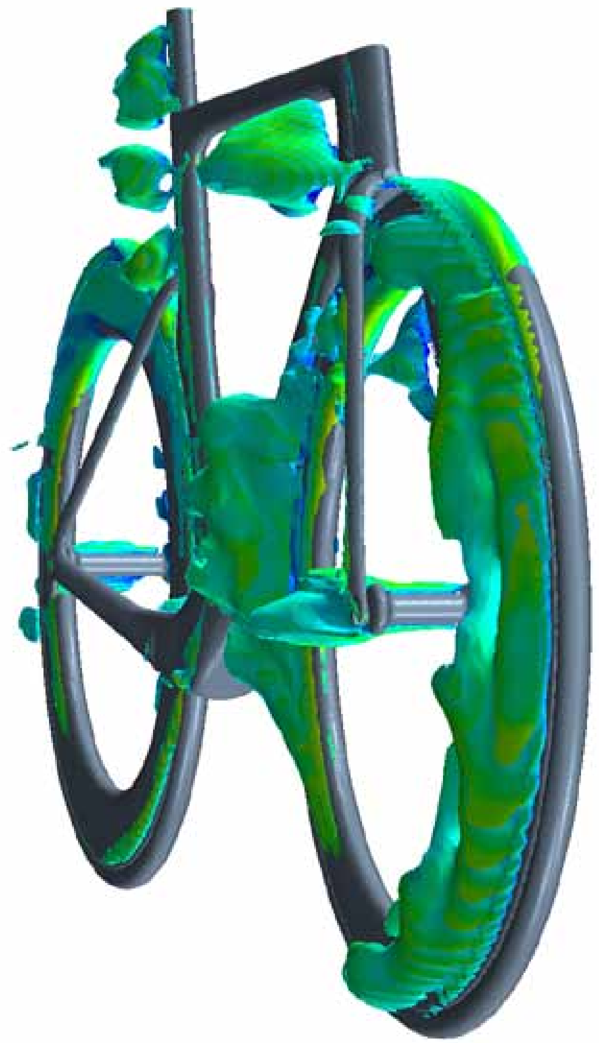
Before delving into all the ways Felt has leapt ahead in the realm of aero road and time trial bikes, it's best to understand a little more about the concept itself. The goal of all aerodynamic development is to reduce drag.

To understand exactly what drag is, think of a baseball being dropped into a swimming pool. As soon as the ball hits the water its rate of descent drastically slows. This is because the water in the pool is being forced to move around the ball, thus creating drag on the ball. Air does the same thing when forced to move around objects (such as bikes). And though it's not quite as dramatic as our ball and water example, when you consider that bike races are often won by hundredths of a second, the importance of decreasing drag becomes obvious.

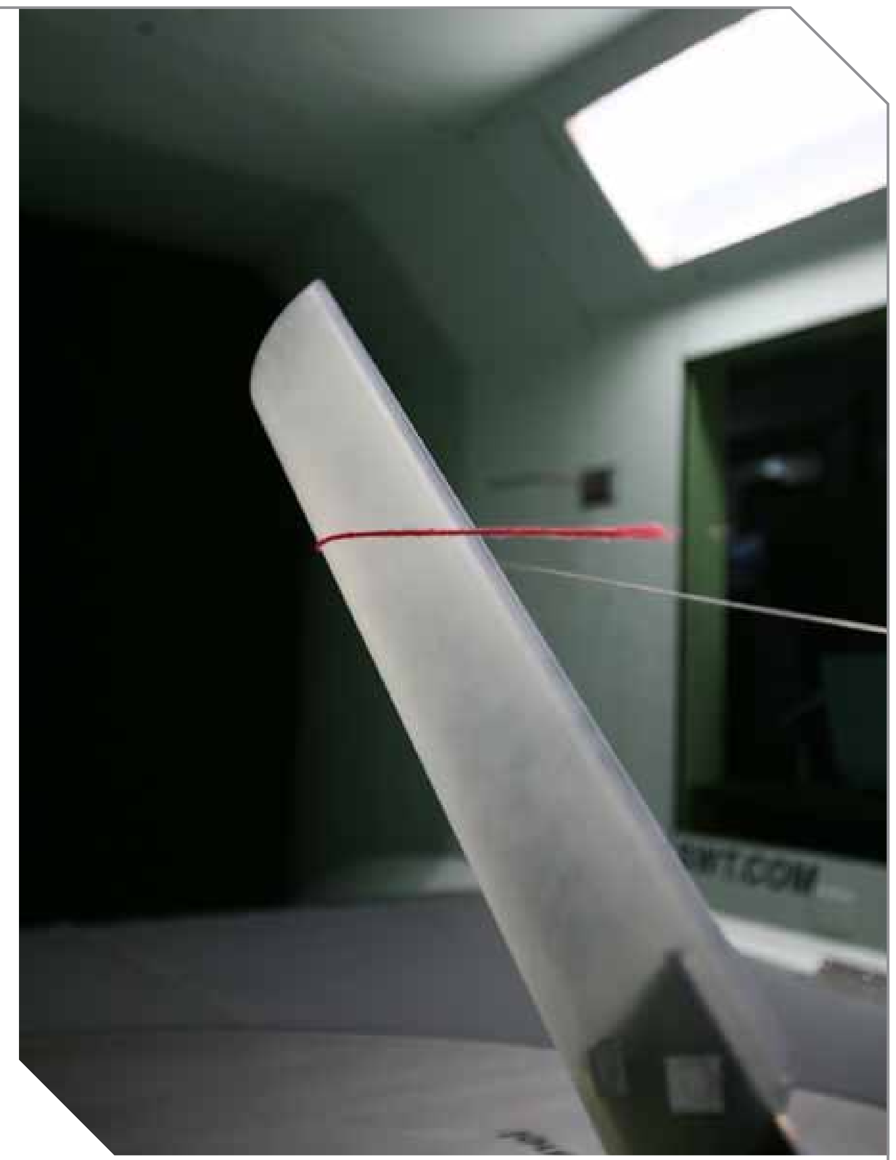
Indeed, bikes that create the least drag via enhanced aerodynamics are more efficient and faster. That means its rider must expend less energy for the same outcome. Or put another way, you'll have more gas in the tank at the end of a long day in the saddle, ready to launch a race winning sprint while others fade.

That's why Felt engineers spend countless hours experimenting not only with the shapes of tubing used to build its bicycle frames, but also how those shapes effect the movement of air around the frame. And this process is never done in a vacuum. Instead, equal attention is always paid to the aerodynamic effect of various components such as wheels, brakes, forks, and seat posts, because in the end, real world conditions are the only conditions that matter.

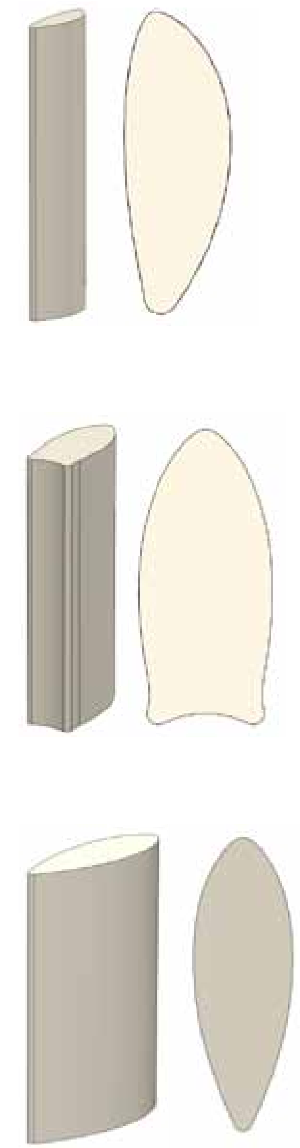
Wind tunnel testing reveals and confirms what was concluded while using CFD analysis



CFD analysis provides an accurate preview of what to expect during wind tunnel testing

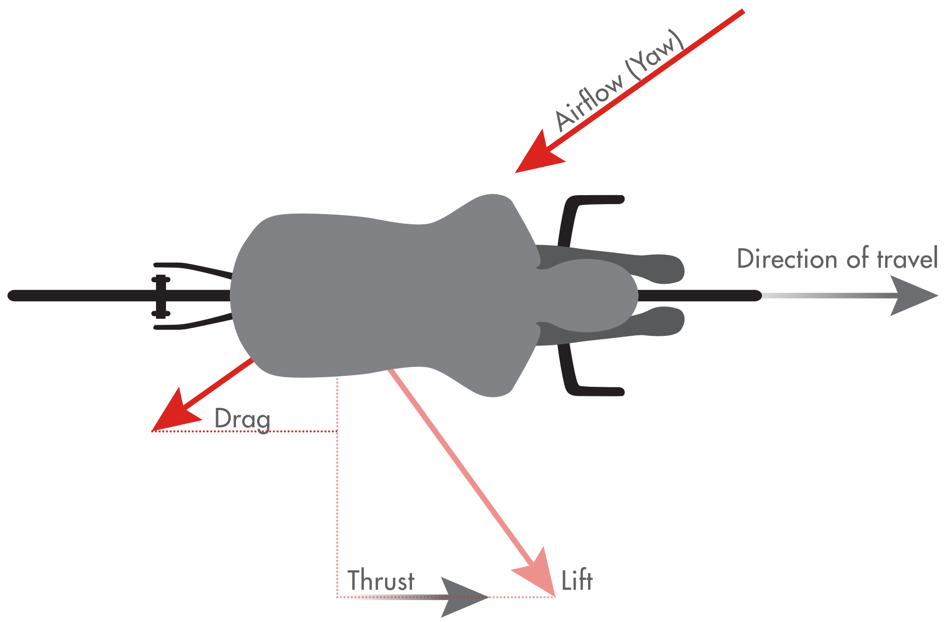


Testing a section for a downtube for aerodynamic efficiency



Variations of aero-tubing

Aerodynamics Phenomena Diagram



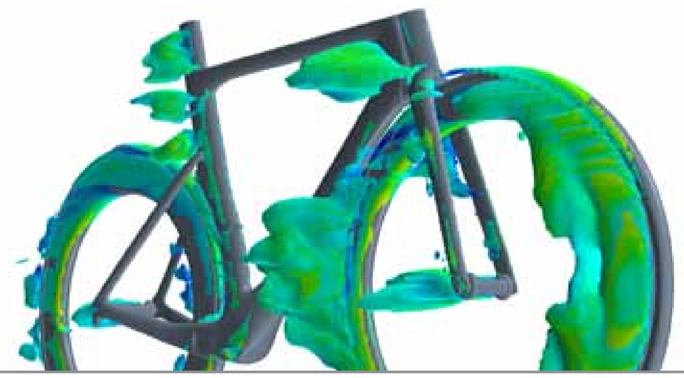
This same big-picture ethos is applied to experimentation with various yaw angles. For those unfamiliar with the term, the angle of the wind a rider is pedaling into is known as the yaw angle. So for example, if there is a direct headwind the yaw angle is zero, but as the wind approaches from one side or the other, that number begins to increase. Since the yaw angle is seldom a steadfast zero degrees during any given bike ride, designing a bike to excel in that condition is not a practical resolution. Felt's aerodynamic bikes are engineered to be particularly efficient in a range of 5-15 degrees of yaw, which is far more common.

Don't misconstrue this into thinking that Felt only considers a limited window of variables. Since Jim Felt designed and built his first triathlon bike more than two decades ago, the overreaching goal has remained unchanged. Felt bikes are constructed to be both fast and efficient in a full array of wind conditions.

Some people design bikes that just put up great wind tunnel numbers at certain yaw angles so they can use that information in marketing. That's not the Felt way. We don't even publish wind tunnel numbers because it's not real world. Sure it's a great tool to compare prototypes within a given company, but it really doesn't show whether or not a bike will deliver faster race times because wind tunnel testing is so subjective.

Instead of taking this oft-followed myopic approach to aerodynamics, where wind tunnel numbers are held above all else, Felt employs a more thoughtful, multi-tiered aerodynamic design process that combines virtual, wind tunnel, and real world testing. Sure it takes more time, but there's no arguing with the end results. Anyone who has ridden our DA time trial bike or AR road bike already understands.

The Felt aero design process begins in the virtual world using cutting-edge computer software known as CFD, or Computational Fluid Dynamics. Commonly used in the design of Formula 1 racecars, multi-million dollar yachts, and in the aerospace industry, CFD lets Felt engineers analyze complex airflows that create unwanted drag on rider and bike. With CFD, Felt engineers can predict how various frame shapes and designs will perform in real-world wind conditions.



It's like having a wind tunnel in your computer. It literally calculates the finite details as 'air' passes over the frame and components. Almost any situation can be analyzed such as the effects of different yaw angles and wind speed.

Even with this top-tier technology, it's still a time consuming process. For each run, it takes approximately 6-7 hours to do the math. Custom macros allow the software to run days unassisted for multiple variations.

But the output is worth this arduous effort. Using CFD, Felt engineers can examine everything from the effects of various tube shape designs to what happens when you change the gap between the rear tire and the seat tube.

We're able to run a host of variations and figure out which work best. Custom plots and CFD charts allow you to look at pressure, velocity, and turbulence, and then compare those numbers to other variations in design. In contrast to the wind tunnel where all you get is one number - force. In many ways the software allows us to do more than the tunnel.

Of course, Felt has not forsaken the wind tunnel. Unlike many other manufacturers, it is a vitally important cog in the aero bike design process. Many companies don't go into the tunnel until a bike is already finished. At that point it becomes just a marketing tool, and not part of the development process.

Felt takes an entirely different approach. After literally hundreds of hours of CFD analysis, Felt constructs a 1:1 scale prototype model fully built up with components, and then heads to the wind tunnel to both validate the aerodynamic principles refined in CFD, and examine the effects of various components on a bike's total performance.

This is key. Instead of wind tunnel tested, Felt aero bikes are wind tunnel developed. We are bringing prototypes to the wind tunnel, making changes, and then going back and refining the design before the carbon fiber molds are ever cut. There is a big difference between sticking a finished bike in the wind tunnel and blowing air at so you can say you were there, versus multiple trips making changes, before you finalize the design.

When molds are finally made, prototypes are built and delivered to Felt's core family of key testers. This includes both sponsored athletes such as two-time Olympian Sarah Hammer, Olympic time trial gold medalist Kristin Armstrong, as well as Felt's

Making an on-the-fly edit in the wind tunnel

experienced in-house staff. Everyone in this group gets a chance to present feedback, all of which is incorporated back into the finished product.

Those finished products include Felt's renowned DA time trial bike, Tour de France proven AR aero road bike, and TK series track bikes, which will be piloted by numerous 2012 Olympians. All three are considered best-in-class aerodynamic bikes, and

all three provide the "free speed" that separates an average aero bike from a great one.

A DA gets laid up in its mold

Armstrong rides her AR to victory

Jim Felt sets up a bicycle in the wind tunnel