THE SECRET, SAVVY UNDERWORLD OF TRIATHLON'S ADDICTION TO THE WIND TUNNEL

DRAG RACE

By Jay Prasuhn

Lance Armstrong's return from retirement began last November, when he had his time trial position re-assesed at the San Diego Low Speed Wind Tunnel.

JAY PRASUHN

It's probably the biggest day of the year at the San Diego Low Speed Wind Tunnel, and tunnel engineer Dave Sanford, a whip-thin, serene and unassuming brainiac, is addled. Lance Armstrong announced his return to cycling four weeks before and scheduled a day at the tunnel to test his position, inviting just about everyone to come watch.

After presenting credentials and signing in at a table outside the confines, a chosen few were permitted to watch Lance's personal entourage: a large collection of videographers and grips holding booms, personal photographers, numerous bike engineers, all scrambling around the seven-time Tour de France champion shrink-wrapped in a black kit and set atop a Trek TTX.

Surveying the bedlam as photographers beckon for "just a few more photos," Sanford is at his desk in the tunnel's control room and slowly drops his face into his hands. "We won't get any data today," he says. His eyes peer back up to the scene, then descended back into his hands. "What a damn mess."

Let's get one thing straight: While Chris Lieto and Lance and Levi and Torbjorn and Michellie all love wind tunnels, wind tunnels are not sexy. They're not cool, they're not fun. Rather, consider adjectives like drab and monotonous.

Australia's Craig Alexander dialing in his setup prior to racing and winning the 2008 Hawaii Ironman.

ROBERT MURPHY

"I'M A WIND TUNNEL JUNKIE—WHEN I DO HAVE MONEY THAT'S WHERE I GO."

"The wind tunnel is alluring, fabulous, frustrating and painful, all at the same time," says Zipp Speed Weaponry engineer Josh Poertner. "They will tell you something, but won't give you any hint or clue as to why. It is what it is and you can't dispute it, but there's no insight as to why. And I'm a guy who loves to find the why. A couple of hundred hours a year in them, it's a love-hate thing."

Wind tunnels are boring. They're cold, dank and musty. Even in bright, sunny San Diego, the plain words WIND TUNNEL scripted on front of the slate gray building seem to blend into the flat façade next to long-term parking on one side, the roar of planes taking off from the Lindbergh airport tarmac a football field away. There's a reason the Marine Recruit Depot is just down the road: With the dull noise of commercial aircraft competing with the din of Interstate 5, it's a shit location, a perfect revolving door for weeding out the uncommitted.

It's evidently also a great place to blow wind on things. Walk out of the sun and into the catacombs, and the scene gets bleak, with the cheery ambience of D block at Rikers Island and cinder brick walls painted with more gray. A dead, cool air hangs as dialogue and footsteps bounce hollowly off the walls.

Just as you start picking paint chips off those same walls, the winds come. The control room comes to life, and Sanford barks out orders. "C'mon Lance, choke up. A little more."

As observers fix their eyes on Armstrong tearing away at his Trek and looking every bit the part of the comic book character *The Punisher*, the cold cylinder pours over him a stream of 30-mph wind. The comeback for Lance is on, and his first order of business is to seize wind tunnel numbers.

And that's about as exciting as it gets. Because for every Lance, Torbjorn Sindballe, Craig Alexander or Kristin Armstrong appearance at the illustrious tunnel, there are 15 tests of a wheel. A fork. A frame. With tests run at zero yaw. Five degrees. Fifteen degrees. Back to five. Over and over. And over. While the press is off covering some race, the most thrilling moment at the wind tunnel is when someone fixes a pot of coffee.

Or a wheel company discovers a negative-drag wheel.

ROBERT MURPHY

"Woo-hoo! Check that out!" yelled Poertner at a session in 2007, as he and several of his designers swarmed to a computer monitor to examine numbers churned out after studying a test disc wheel two years ago. "I can't believe it—we just got 80 grams of negative drag!" The second test proved it—the shape of the wheel actually propels the wheel forward. It was a first, and it made a typically quiet day in the dark confines of the San Diego Wind Tunnel an exciting one.

Indeed, while the wind tunnel lacks sex appeal on its face, what comes from it—a slippery bike, a bullet-shaped bike position, a wind-cheating wheel—now, *that's* sexy.

Materials advancements over the last 20 years have been exceptional, but wind tunnels are arguably the greatest catalyst for progress in the bike industry in the last two decades. Since the 1989 Tour de France, when Greg LeMond used wind tunnel testing to help beat Laurent Fignon by eight seconds, "the tunnel," as it's affectionately called, has made heroes. As recently as last year, Spaniard Carlos Sastre, a noted climber with weak time trialing ability, used what he learned in the tunnel to record a solid final time trial and retain the maillot jaune at the Tour de France. Bike powerhouses such as Lieto and Sindballe are riding away to podium finishes with drag numbers in their back pocket. Athletes are transforming into missiles. Bike manufacturers are reversing typical marketing tactics: Instead of spending millions to hire a rider to market around, they put that money into aerodynamically developing the bike or aerobar or wheel, and hawk that instead. The equipment is no longer the side note, it's the centerpiece.

Really, though, is it all hot air blowing in our faces? Wasn't it Lance who once said, "It's not about the bike?" Well, when we as consumers are plunking down eight Gs for our ride, when Lance himself handpicks a team to optimize every molecule of his equipment and every micrometer of his fit so his time trials leave zero to chance, when the Hawaii Ironman a few years ago saw a small Canadian bike manufacturer—Cervelo—overleap juggernaut Trek in the pier bike count, well, it's more than hot air. It's the winds of change.

Greg LeMond testing in the Texas A&M tunnel in 1990.

JOHN COBB

"I REMEMBER WE WERE WORKING with Greg LeMond at the Texas A&M Wind Tunnel and Lance Armstrong walked in," says Charlie French, a 20-year veteran engineer with Scott Bicycles. "Greg looked at him and said, 'You're kind of a big guy.'" The year was 1988, and while LeMond had a Tour de France title to his name and was making his return to racing after recovering from a hunting accident, then-triathlete Armstrong was a junior triathlete kicking the big boys' asses, and just starting to flower in road racing.

It was the advent of bike-related wind tunnel testing. An object called the aerobar had been prototyped in 1987 and bolted onto the handlebars of pro triathlete Brad Kearns.

French worked with then-colleague Boone Lennon in creating the first mass-marketed aerobar.

"Boone told me he had an idea for a handlebar and we came up with a wooden aerobar that looked about like a toilet seat. It clamped onto the bar with u-bolts. We later made some of conduit," says French. "We took the aerobar to the Texas A&M Wind Tunnel and worked with Greg LeMond on it."

Boone's idea came from his being a ski coach in Sun Valley, Idaho, and Scott's product involvement in the ski segment. He figured, "We're spending this money on skiers, why wouldn't it work to test someone on a bicycle?"

While Scott USA went straight to market with the aerobar, others like Bill Powers at Profile Design, Canadians Gerard Vroomen and Phil White of Cervelo Bicycles and Jim Gentes of Giro Helmets pushed tunnel testing as a way to develop their products. Among them, two men—Steve Hed and John Cobb—were front and center of the work. For Cobb, it has been a labor of love. And an often fruitless one.

"I drive a piece of shit Kia because my money is tied up in the Texas A&M tunnel," Cobb says flatly. "I'm a wind tunnel junkie—when I do have money that's where I go. It's where I learn. I don't have an engineering degree, but I look at things, sometimes something strikes me, and I study it. It's a huge thing to me. My wife, on the other hand, has other things to say about the wind tunnel. But when I'm there, by myself and it's quiet and I can sit and think and nobody's bothering me, I love it."

As a racecar driver and bike shop retailer in Louisiana, Cobb was an occasional visitor to College Station, Texas, testing at the A&M Oran W. Nicks Low Speed Wind Tunnel. In 1982 and '83, while Dave Scott, Scott Tinley and Mark Allen were waging war in Kona on round-tubed road bikes with standard road drop bars, Cobb worked in the tunnel, mostly on his Formula Ford, but he had a customer who suggested testing his bike. After Cobb crafted custom struts to hold a bike up, a little cottage industry grew.

Cobb started working with Steve Hed in 1984. Quintessential tinkerers, Cobb and Hed started doing aero bike fittings with pro triathletes Ken Glah, Colleen Cannon, Scott Tinley and Mike Pigg. Renowned for his design capabilities, Cobb was a fixture in College Station. But finding a good test rider to derive consistent data was a challenge.

U.S. Olympic cyclist Sarah Hammer
JAMES CASSIMUS

"YOU CAN DRAW UP NICE AERO DESIGNS ALL YEAR, BUT YOU DON'T KNOW IF IT WORKS UNTIL YOU TEST IT."

"Dan [Empfield] was talking to Steve and me and said, 'Hey, I've got this road racer kid staying with me now, but he lives in Austin. You oughta use him,'" Cobb recalls. "So this 19-year-old Lance Armstrong guy would come as a model, because he was good at pedaling steady. Then he turned out to be a pretty good bike racer." It was the start of a relationship with Armstrong and Armstrong's sponsors, who took advantage of Cobb's tunnel pedigree. While Hed helped hone Armstrong's time trial fit, Cobb advised on his bike fit and designed an aero helmet that Giro created for Armstrong. With the primary investor in Blackwell Research folding up shop last year, Cobb still routinely does contract design for brands including Rudy Project and Wilier Bicycles, as well as launching his own brand, Cobbcycling.com.

Hed, meanwhile, was trying to find a solution for his friends, who weren't permitted to use a disc at the Hawaii Ironman. "My friend Scott Molina couldn't use a disc there, so then it became a pursuit of finding the fastest wheel that wasn't a disc, so it spurred our making the CX60, the first deep-section wheel. That was one of my first focal wind tunnel-designed products. With that, the Olympic project stuff going on, the start of athlete fitting and the whole aerobar thing, there was a lot of action in the late '80s and early '90s."

Then a strange thing happened: Testing and thus product advancement stalled, with only stalwarts Hed, Cobb and Cervelo making pilgrimages to Texas A&M. "Phil and Gerard from Cervelo were there because it was part of their school model, to build

Felt Racing namesake Jim Felt, center, working with his team in mission control.

JAMES CASSIMUS

an aerodynamic bicycle. They loaded a minivan from Canada with piles of crap," Hed recalls. "At the same time, Dan Empfield from Quintana Roo bicycles was not so much concerned with aerodynamics as he was with creating a bike to put you in the right position. It all kind of came together at the same time."

Of course, the sport boomed again in the late '90s, and technology spiked with it. "All of a sudden a manufacturer can spend some money and actually end up with a product that gives them a return on investment for the cost of testing in a wind tunnel."

Hed still works with Lance, but his business is built on boring time at the tunnel, blowing wind on wheels. Last fall, the day before the Lance Armstrong circus, Hed—Armstrong's longtime fit expert—was in the tunnel. No press, just 20 or so wheels, some production, some tan prototypes leaning against the wall, waiting for their turn for testing. While Chrissie Wellington and Lance Armstrong are a focus, so are age groupers.

"Can you get by with bad stuff? Sure—it's still the engine, your training and your desire. But like a golfer or a fisherman or an audiophile, the trickle-down effect for a triathlete to have aero wheels and a slick system makes you feel good about your racing—it's just part of the culture," Hed says. "What I'm trying to do is make sure the equipment is relevant to whom our users are. It's fun for us to have our products used on the top Ironman guys and at the Olympics and Tour, but how do you differentiate between that equipment and the 48-year-old age grouper, to help that person go faster? That's the fun for me—and that's where a tunnel is valuable."

DAVE SANFORD HAS DONE IT ALL. He has the authority to tell Lance Armstrong to keep his head still. He's told Torbjorn Sindballe to stop moving his arms. He's been in charge of aerodynamically testing million-dollar airplane models. Commercial aircraft. Classified military weaponry. Olympic luge team members.

And trash cans.

"It's a big deal in the Midwest," says Sanford. "A company wanted to find out at what speed they blow over. When they sell a million of these things, it's a big selling point." Real glamorous.

The guy brings to mind a pocket protector-using, protractor-wielding engineer. A geek. Of course, all the guys involved in tunnel testing, from the tunnel engineers to wheel and frame designers to fit specialists, resonate aero geekiness.

Chris Lieto? Geek. Steve Hed? Geek. John Cobb, Jim Felt, Bjorn Andersson, Gerard Vroomen, Craig Turner, Torbjorn Sindballe, Mark Andrews—all geeks—industry rock star geeks, but geeks nonetheless.

"Once you get into it, into the meat of wind tunnel testing, it's like watching grass grow," says Specialized bicycles engineer Mark Cote. "If you're measuring aero on wheels or five bike frames, you have a minimum of seven yaw angles and two to four wind speeds. It gets long and exhausting, but what's cool is that at the end of the day, the yaw charts are a picture of how a bike's going to perform. It gets me excited every time."

Geek.

Swedish triathlete and bike powerhouse Bjorn Andersson awaits several wheel tests before getting his chance at fit testing.

JAY PRASUHN

Sitting at the helm of a computer as his team operates the tunnel for each two-minute test, Sanford has the unenviable task of crunching the numbers that each test produces, working with consultants to interpret them for the consumer.

In Mooresville, N.C., at the A2 Wind Tunnel, tunnel operator Mike Giraud does the same. But with his bike background as a team mechanic and fitter for the Saturn road racing team and Timex Multisport Team, he's able to make his own interpretations. Either way, it's rote, boring work. But the data that come out have value. Big dollar value.

"Sometimes the bike guys are going, 'What are the others up to?' They're not trying to do anything coy, but it's still cutthroat," Sanford says. "We don't say anything. When people aren't used to my silence, my response is, 'Do you want me to tell them what you're doing?' We have classified clearances, so we're used to not talking about things. They can trust us to not give away the engineering finds they paid money for."

Wind tunnels are literally tubes of wind. Imagine a giant doughnut. Put a gigantic fan at one side of the doughnut. Put a test subject at the opposite end. Wind from the fan blows to the opposite side of the tunnel. A glorified bathroom scale measures deflection based on how much frontal area forces the test subject backward—and there's your drag. Pretty simple.

The main complexity with the wind is taking that air and making it uniform. Since winds can eddy and swirl like water in a stream, tunnels have honeycomb screens that distribute the airflow evenly as it enters the test section, where a test subject is situated. In San Diego, vanes direct the wind around the tube and into the screen for a uniform stream of frontal wind.

In North Carolina, the entire hangar is the tunnel. When the fans are turned on, one standing outside the test section can feel a slight breeze. But when the wind circles around to the front of the rider and is funneled into the tunnel, it accelerates rapidly to 25 mph testing speed.

It's after the propellers shut down that the work begins: reading what the wind tells them. The test subject, whether it's a wheel, a rider or a 1,200-pound cruise missile, is fixed to a plate—a sort of massive bathroom scale. The scale is a bit more sensitive than your home version, however; capable of reading pull in every direction, it can measure the force a 25-mph wind places on a wheel or 800 mph of airspeed places on a scale-model jet fighter. That force, or resistance, is drag.

And reducing the forces of drag (or creating down forces in the case of race cars) is what wind tunnel testing is all about. Whether the tester is a Tour pro or a pro triathlete or an age grouper, the goal of going to the wind tunnel is to learn how to punch the smallest whole in the wind. At the same time, the rider doesn't want to sacrifice power output. And therein lies the quest for the Holy Grail, the perfect setup: aerodynamics and power.

Finding the Holy Grail is a challenge even for a man considered one of the most aero and powerful triathletes on a bike. "I'm a big guy, so it makes it hard to get a really low number," says Swede Bjorn Andersson as he sat on a table at the San Diego Wind Tunnel last winter, waiting for a Hed wheel to finish being tested. The guest of sponsors Hed and FIT Multisports, Andersson was making his second fitting trip to the tunnel. "I'm looking at trying to be more

Desiree Ficker is working with Carmichael Training Systems and Retul in a long-term effort to establish a more aggressive bike position.

ROBERT MURPHY

efficient, to save some energy. If I have a few different positions and numbers, I can do some training with my power meter on the road and find what's best. This is valuable stuff to me."

While wind tunnels are de rigueur at the moment, the two-wheeled market developed only in the last decade. Before that, the largest industry customer was aviation, with the military testing aircraft and missiles and private sector companies such as Boeing and McDonnell Douglas developing passenger airliners. They conducted flutter and yaw tests of scale models to help determine how a full-sized plane will behave in the air.

And while engineers will say testing missiles is interesting to them, they're passionate about bike stuff being fun. "You kidding?" Sanford asks incredulously. "Testing model planes or someone like Fabian Cancellara? I can tell you, it's made watching the Hawaii Ironman or the Tour de France a lot more personal for us."

IT WAS THE EQUIVALENT OF A NASCAR pit crew wheel change. The boys flew in, T-handle wrenches at the ready. Unbolting from opposite ends, they popped the wheel out of the fixture in three seconds. As it's leaned against the wall, the new prototype is already being loaded into the fixture, bolts spun to lock it in place. The old wheel is scooped up, and both men retreat from the tunnel, pulling the heavy door shut behind them. Time: 45 seconds. Do it again 12.8 minutes later. Ten hours a day. For five days. Three times a year. "You try to maximize your investment," Poertner says, "but the 12.8 minutes between changes—it's like watching paint dry."

Only 10 years ago, multisport saw an increasing number of aerodynamically shaped bikes. While Cervelo led the charge with its tunnel-tested Eyre and P2 at the time, others were getting on the bandwagon with knockoffs that simply looked aero. And at the time, that was enough to generate a sale. Still, Cervelo fought the good fight.

"You can draw up nice aero designs all year, but you don't know if it works until you test it," says Cervelo co-founder and engineer Gerard Vroomen. "It's one piece of the puzzle, or maybe a link in a chain. A lot of things you think would work great don't work at all. Maybe it works in the sense it looks fast, but you

AT THE BREACH

Want to realize your ultimate fit? Learn which aero helmet is right for you—or if an aero helmet is right for you at all? Need to determine your best wheelset for a coming race? Contact one of the several wind tunnels that conduct aero fit testing in the U.S. to find your answers.

SAN DIEGO LS WIND TUNNEL. San Diego, Calif. Lswt.com.

A2 WIND TUNNEL. Mooresville, N.C. A2wt.com

UNIVERSITY OF WASHINGTON KIRSTEN WIND TUNNEL. Seattle, Wash. Uwal.org

MASSACHUSETTS INSTITUTE OF TECHNOLOGY WRIGHT BROTHERS WIND TUNNEL. Cambridge, Mass. Web.mit.edu/aeroastro/labs/wbwt/index.html

TEXAS A&M ORAN W. NICKS LS WIND TUNNEL. College Station, Texas. Lswt.tamu.edu

COLORADO PREMIER TRAINING WIND TUNNEL. Fort Collins, Colo. Coloradopremiertraining.com

get a fast aero design by doing a lot of testing. It tells you if the design works, but it also helps you understand where it works, for your next improvement. Fortunately for us, our consumers aren't as fickle as some manufacturers think they are. The triathlon segment is a savvy one."

A decade on, bike companies have $300,000 computational fluid design programs that can predict wind flow on the computer. But the end-amen final component in product design is the tunnel—a real bike, real wind, real numbers. And it's the tunnel-designed and tunnel-proven products from brands such as Cervelo, Felt Racing, Hed and Argon 18 that lead the charge, while Asian catalog copycat brands—the ones that have a similar look yet exist absent a shred of tunnel testing to prove their designs—are falling by the wayside. Why? A carbon aero wheel is a carbon aero wheel, right?

Not when Zipp's new 2009 hoops have an aerodynamically proven five-curve sidewall. Today's tri consumers are more educated than even five years ago. They don't fall for marketing spin in a slick ad. They understand drag numbers, and the more numbers manufacturers release, the more credibility they earn—if the numbers come up roses or tank, they'll know. When a triathlete forks over nearly $3,000 for a pair of race wheels, the least he should expect of the product—beyond simple road-worthiness—is for that wheel manufacturer to create a $5,000 prototype wheel—no wait, 24 of them—ship them to the tunnel and spend $2,000 a day for five days to prove his spending was worthwhile.

Zipp has built its brand on the trust of the buying public, based largely on wind tunnel testing, and the aforementioned spend that accompanies it. Located in the hub of the auto racing industry in Speedway, Ind., Zipp has applied the aerodynamics testing of Indy 500 cars and created a dimpled juggernaut not on the basis of its big logos, but its big spending on aerodynamics research. What starts as a pile of crappy-looking, super-heavy plastic prototypes eventually results in thousand-dollar, super-light, aero-designed and aero-proven race wheels. When you see what goes into your new Zipp 808, you'll have a greater appreciation for the price tag.

"We'll make 100 computer models on one wheel and will take our 10 best models to the tunnel and find what seems to work," says Zipp's Poertner. "If the curve of wheel blue was good at one angle and wheel magenta was good at another, that'll be our next test visit—merging those two and seeing what happens. From that test session, we'll make our decisions and cut a tool. Our third trip is a validation. Our third trip is often what would be a first trip for other companies. We just came back from the tunnel with 10 to 20 grams of reduced drag at every wind angle, which is exactly what our prototype showed. When the CAD, the prototype, the mold, the data all match, it's like, whew, we're not insane—it all worked."

But the tunnel still never gives you the perfect answer. For every hint it gives you, there are 10 new questions. "I've done well with my designs over all this time, but man, my failure rate is so much greater than my success rate, it's depressing," Cobb says with a laugh. "But it's a fun chase for me—using a nitrogen bubble generator to examine vortices at slow speeds, and to figure out why it's forming eddies the way it is, awesome."

Poertner adds: "The beauty of aerodynamics is there's no right answer. You look at Formula One teams with unlimited budgets, and they still find improvements, yearly, monthly, weekly."

And so, they test.

The echo comes over the speaker, bouncing off the walls of the tunnel. "OK, still for 20," A2 Wind Tunnel operator Mike Giraud says. I freeze, eyes locked on the imaginary dot in the center of the screen in front of me, conscious of my breathing—I know it's 10 grams of drag. NOW START PEDALING. A buzzer rings and the four props behind me whir to life, a light breeze lifting to a steady wind in my face. I began run No. 22: "Arms narrow, Specialized aero helmet, head ducked." After a few seconds, I glance at the power chart cast onto the tunnel floor, and am at my target half-Ironman speed of 21 mph. TAKING DATA. For one minute, I try to ignore the chilling breeze raking across my arms and face, imagining myself on the Queen K or the Pacific Coast Highway. It's a long minute of mental acuity, maintaining power, keeping my head position level, eschewing shifting. ALL RIGHT, YOU CAN REST. I sit up, breathing hard, awaiting a position change and yet another run in another couple of minutes.

The goal is simple: You generate power in watts by pedaling. While the marketers are so adamant that their bikes are the fastest, it's really just a drop in the aero bucket; it's the hulking mass atop the bike, legs spinning, that is the real aero drag, about 70 percent of the whole bike-rider equation. Your power to overcome that increases at the cube of your velocity. Long story short, as you go faster, the wind resistance gets four times tougher. If your answer is to ride harder, then you're in for a losing battle. "A 10 percent reduction in drag is significantly better than a 10 percent improvement in power output," Poertner says. What does that mean? Ride smarter, not harder—aero position matters.

Like power meters, wind tunnel fit testing used to be for the crème de la crème—Lance Armstrong and, well, Lance Armstrong. But as more tunnels began creating bike test platforms and streamlining the processes, costs to get fit have come down.

With that affordability come the business of making the bike and rider punch a smaller hole through the wind. Companies such as Multisports.com bring an aerodynamics expert like Kraig Willett to their wind tunnel fit camps to interpret the data for Joe Agegrouper, sending him home with a DVD of his fit experience and drag numbers. One bike manufacturer, Blue Competition Cycles, is cognizant of the entire aerodynamics package, offering buyers a chance to optimize the whole shooting gallery by giving away a free hour of wind tunnel testing at A2 Wind Tunnel when you buy its Triad tri rig.

"In the end, the bike itself isn't fast—it's just a stationary object. It's only fast if someone's on it," says Blue marketing manager Chance Regina. "It's stupid to say we have the fastest bike in the world. In what way? How do you compare it? There are just too many variables. If someone buys our bike, we can get them in the tunnel, where they can work on fit, selecting equipment, whatever they want. They'll come out informed—and we can honestly say they'll come out faster."

"IT'S STUPID TO SAY WE HAVE THE FASTEST BIKE IN THE WORLD. HOW DO YOU COMPARE IT? THERE ARE TOO MANY VARIABLES."

Aero guru Hed concurs that the bike and accessories are a small part of the equation—and this coming from a guy who makes a living selling race wheels.

"For the average person who wants to advance his racing, I still think aerodynamic fitting is a better investment than buying equipment," Hed says. "Get yourself fit and into a good position that's sustainable, and you've made huge strides. Thing is, one trip isn't going to do it. You get a position in the tunnel, get on the road, try it in the real world, come back in. The combination of power, comfort and aerodynamics—it's all part of the equation. You have to realize that what you get coming out of the tunnel for the first time is what you'll be riding in your Ironman nine months later. Understanding what drag is and understanding how important it is to you—or how not important it is—versus what you're putting out for watts, that's the goal."

While equipment testing is a challenge, testing humans is even more so. Apart from the boredom that sets in as athletes await their tests or sit idle between tests is the fact that a moving, breathing object can render test numbers useless. It's why Lance was—and is—such an ideal test specimen. "Bringing athletes in is so much harder. It's cold and miserable, and to convey to athletes that their breathing affects the data, it's hard. To tell them their shifting in the saddle does it, and oh, that thing you did with your elbow because you were uncomfortable, we had to scrap that run," Poertner says. "You're trying to find data that's within such a small margin of uncertainty. But at the day's end, the potential payoff can be large."ⓘ