

GEGEN DEN WIND



Der Windkanaltest 14 aktueller Wettkampflaufräder zeigt, mit welchem Radsatz sich wertvolle Sekunden für den Sieg sparen lassen. Praxis- und Labortest klären, welche Räder auch abseits der Wettkampfpiste eine gute Figur machen

TEXT: ROBERT KÜHNEN
FOTOS: MATTHIAS BORCHERS, ROBERT KÜHNEN

“There is never too much wind for aero wheels,” says Olivier Mouzin, the Development Director for the French wheel manufacturer Mavic. “Wind is good!” To demonstrate his point, he sets up a Comet disc wheel in the wind tunnel which will serve as a reference during testing. He closes the door to the metering chamber and starts the generator which provides high voltage power to the wind tunnel at the Technical University of Lyon. The fan picks up speed. We are watching through a window how the wheel that is set in a holding device is spinning faster and faster on a treadmill. Then the wheel is turned against the direction of the wind in an increasingly shallow angle.

A monitor on the control panel allows us to observe the forces which the air stream is applying to the wheel. When the wind blows diagonally (at 22°) against the wheel from the front we can see proof of Mouzin’s thesis: the curve which shows the force that is necessary to spin the wheel drops off rapidly. The disc wheel spins almost on its own without propulsive force and is “sailing” close to the wind. The thrust exerted on it by the air stream and the resistance are in balance. If this were a race at high speeds with just the right crosswind, the cyclist would not have to exert much energy to keep this wheel moving.

Sounds good—unfortunately, crosswind has not only a propulsive effect on the disc wheel, but it also creates interference because the large effective area allows it to affect the steering as well. Consequently, the use of disc wheels is mostly limited to rear wheels, and if the wind is too strong, they are not used at all. Therefore, we focus our test on aerodynamic spoke wheels that are available for prices between 700 Euro and the incredible amount of 3.690 Euro. All these wheels are

für Aero-Laufräder“, sagt gut!“ Um das zu beweisen, beim französischen Laufscheibenrad im Windkanal en wollen. Er schließt die den Generator, der den Universität von Lyon mit äse kommt auf Touren. ir, wie das Laufrad in der band beschleunigt und in aufstrom gestellt wird. stands verfolgen wir, welerad ausübt. Als der Wind (d) anbläst, sehen wir den Kurve, die zeigt, mit welerden muss, fällt rapide ab. rafffrei, „segelt“ am Wind. ung und der Widerstand tießes Beientsprechenmpo muss ein Radfahrer s

KURZ & KNAPP

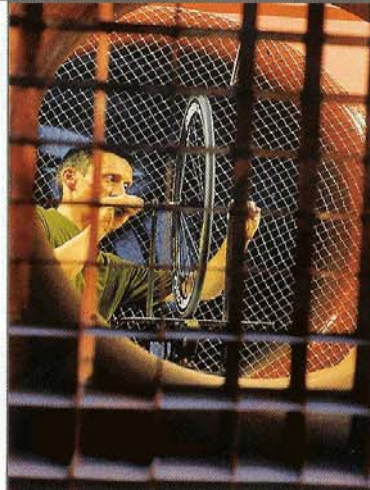
IN A NUTSHELL

Aero wheels require attention to detail. A low number of flat steel spokes in combination with streamlined high profile rims reduce the air resistance. Different manufacturers make use of this recipe in different ways. Ambrosio lags behind because of a high number of round spokes. Citec offers the best compromise between aerodynamics and suitability for daily use. Lightweight manufactures a spoke wheel that is completely constructed from composite materials—thus, the lightest wheel in the test is also the most expensive one by far.

Olivier Mouzin wuchtet ein Mavic „Cosmic Carbon SL“ Vorderrad im Zentrierständer mit Bleigewichten aus. So bereitet er die Laufräder auf die Messung im Windkanal vor.

Except for the 4-spokes wheel by Xentis that Jan Ulrich recently rode during the Tour Time Trial in St. Etienne, all wheels rely on a conventional design with spokes which are tightened by pull. Most of the rims—which are generally made for tube tires—consist of carbon. These wheels offer an array of diverse and attractive surfaces: Lightweight displays pure technology. Zipp integrates small indentations into the rim that are similar to a golf ball. Mavic woos [riders] with a graphically attractive carbon cover layer. The volume and the depth of the rims vary considerably and some of the more voluminous wheels are remarkably light. The lightest set by Lightweight scratches the 1 kilogram mark—a stunning experience when you pick up the wheels or ride the first few meters. The carbon wheels manufactured in one piece beat the conventional “Olympic Gold” spoke wheels by Tune by a few grams.

When the road begins to ascend, weight (and not only the weight of wheels) becomes increasingly important for the competitive rider—unless the weight limit of 6.8 kilogram that is stipulated by the UCI for the complete bicycle set is not already reached. Every gram that can be saved translates proportionally into performance and ride time during an ascent, and not even the tiniest improvement can be ignored. One percent of reduced weight during a steep ascent is almost equal to a one percent improvement in ride time.



Blick in den Windkanal: Ein Vorderrad wird in die drehbare Messwaage gespannt

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Light wheels offer a small additional advantage above the weight tuning that focuses on other bicycle parts. Since the mass of the wheels has to be moved forward and rotated at the same time, a lower weight has a positive effect on both contributing factors (kinetic and rotation energy) to the overall performance. For this reason, the table shows the measured values for the acceleration energy next to the weights. It is, however, necessary to remember the overall extent of this influence. At a speed of 30 km/h the mass of the wheels represent only about five percent of the total energy of the system that includes the bicycle and the rider.

The low weight of some wheels should not obfuscate the fact that the slow-down effect of the air stream on the forward motion during a typical time trial event is overall more significant. The rider fights against the wind continuously, whereas he rides uphill only from time to time. Measurable differences in the aerodynamic quality of wheels appear at a speed of 30 km/h, but it becomes really interesting above 40 km/h. The difference between the best and the weakest wheels in the test amounts to about 7 Watt (for a single wheel) at a speed of 40 km/h. At the same performance level an athlete is thus able to increase his speed by 0.8 km/h—which, in a time trial of around one hour length at an average of 300 Watt, allows him to reach the finish line about 66 seconds sooner. At a speed of 50 km/h and with moderate crosswind, the considerable amount of 48 Watt is necessary to counter the air resistance of a single standard wheel with a square rim. A moderately aerodynamic wheel such as Mavic's Ksyrium SL necessitates 32 Watt; the best wheels in this test (Zipp 808) require only 17 Watt.

VOM STRASSEN RAND

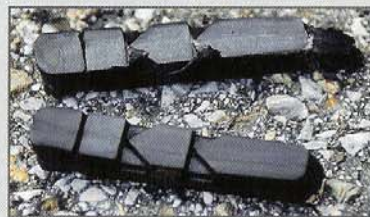
Erfahrungen aus der Praxis

FROM THE ROADSIDE

Practical Experience

Aero wheels are competitive tools—and they may not necessarily be the best choice for training and touring. The biggest shortcoming of the carbon rims is their braking behavior. They brake poorly and braking can be difficult to control. Only Campagnolo, Xentis and Lightweight displayed an average dry braking performance during our test rides that was comparable to regular aluminum rims. The other carbon rims result in a weaker braking delay. Within the scope of this test it was not possible to ascertain reliable results with regards to the behavior of carbon rims under wet conditions. However, wheels with aluminum sides such as Mavic or Citec wheels offer a reliable braking performance under any circumstances. The roughened braking zones of the CKT rim worked surprisingly well when they were new, but only a few kilometers of braking sufficed to smooth them out and to significantly reduce the braking performance. The rim treatment on the Gipiemme [wheel] (“Short Braking System”) produced opposite results. In new condition the front wheel could not be blocked at all, whereas the rear wheel could only be blocked with difficulties. The braking distance became unpleasantly long. After about 50 kilometers the weak braking behavior had improved to an acceptable level which nevertheless was still below average in comparison to aluminum rims. It has been our experience that synthetic material offers better braking results than cork. Comparative rides with different carbon brake pads identified the CKT brake pad as overall reasonably “compatible”. It resulted in an acceptable braking performance on most rims. The Bontrager pad stood out at the other end of the scale. It was incompatible with almost all the rims, even with the Bontrager rims. Five manufacturers (Campagnolo, Bontrager, CKT, Corima, and Zipp) offer their own version of carbon brake pads. The Campa combination is the best match, as the pad resulted in the best braking performance on the Bora rim. A common problem shared by all pads is that the special stoppers wear out rapidly. The Zipp pads (manufactured by Kool Stop) showed significant signs of wear after only about 130 kilometers on a diverse, hilly route.

Belag markierte das andere Ende der Skala, er harmonisierte mit fast keiner Felge, auch nicht mit der von Bontrager. Fünf Hersteller (Campagnolo, Bontrager, CKT, Corima und Zipp) bieten eigene Carbon-Bremsbeläge an; am besten aufeinander abgestimmt ist die Campa-Kombination, der Belag erzielte auf der Bora-Felge die beste Bremsleistung. Allen gemein ist der rasante Verschleiß der Spezialstopper. Die Zipp-Beläge (hergestellt von Kool Stop) waren nach rund 130 Kilometern auf einer abwechslungsreichen, hügeligen Strecke schon deutlich abgenutzt.



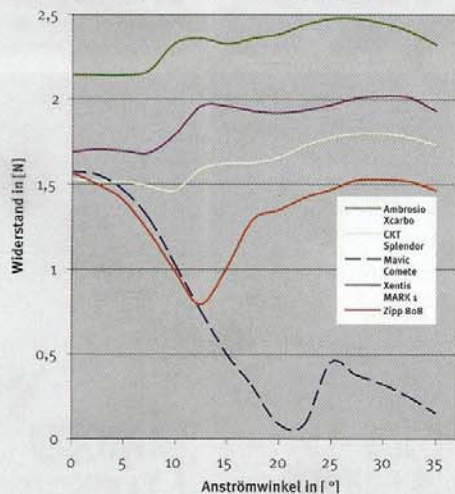
Oben: Zipp-Bremsklotz im Neuzustand, darüber mit Verschleißspuren nach 130 Kilometern
Links: CKT-Felge mit angerauten Bremsflächen, nach kurzer Ausfahrt glattgebremst (hell)

The enormous importance of aerodynamics at higher speeds makes it clear. Any personal best can only be achieved with aerodynamically well constructed wheels. But which concept is the optimal solution? The leading contender on the aerodynamics scoreboard which reflects the proportional influence of crosswind is Zipp's "Speed Weaponry" 808. Only the disc wheel used as a reference was slightly better. The Zipp wheel sets a new standard with its extremely high and broad rim, and offers convincing results in situations where the wind blows from the front or side. The Zipp wheel performs neck to neck with the disc wheel up to an angle of 12.5 degrees—however, it is not possible to determine if or to what degree the dimples on the rim are responsible for this result. Jens Voigt who placed second with this wheel in the race Liège-Bastogne-Liège can rejoice at any rate. His passion for breakaways during crosswind situations is supported by his team through optimal equipment. The tall rider from Mecklenburg believes he can really feel the difference. "With crosswind these wheels spin almost on their own," he told us during a conversation in June, quite some time before the test was performed.

In contrast, the only 4-spokes wheel performed disappointingly. The Xentis "Mark 1" displays a rather untypical behavior. Instead of decreasing, the resistance increases with higher streaming angles. This result also contradicts the acceptable drag value in frontal streaming situations. Above an angle of 12.5 degrees, only the Ambrosio "Xcarbo" with its many spokes gets worse results. This shows that the looks of a wheel do not allow reliable conclusions regarding its aerodynamic quality.

Overall, it may or may not be better to place too much value on the aerodynamic ranking list. The tested wheels are not far apart in their performance results and all keep conventional wheels at a clear distance. Since the aerodynamic characteristics of the various wheels show so little difference, their fitness for everyday use and practical concerns should also become a determining factor for any purchasing decision. Such considerations identify the Citec with wire rim and an aluminum brake surface as the clear leader ahead of all the other carbon-based competitors. Without support by a whole team of mechanics, both the gluing of tires and the braking performance on carbon rims can become cumbersome. Based on the test results in the various categories, it is therefore advisable to pick the wheel that offers the best match for the particular personal requirements—or simply, the one that is the prettiest.

Luftwiderstand bei Seitenwind



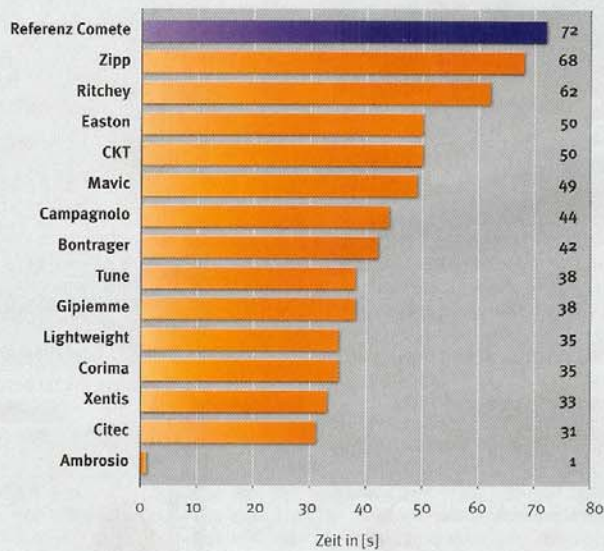
Air resistance with crosswind

The graphs show the air resistance of the wheels relative to crosswind. When the wind blows from the front, all test wheels—except for Ambrosio—perform equally well. Significant differences can be observed in crosswind situations. The resistance of Xentis increases with the streaming angle—aerodynamically, just the opposite of what is intended. To prevent a decrease in speed the rider has to use more energy although the wind blows from the side. The aerodynamically optimal disc wheel performs very differently. The air resistance of the "Comete" sinks towards zero when the wind blows from the side. Good competitive wheels display a similar behavior. To some extent, they create propulsion which lowers the resistance—as in the case of the Zipp 808 wheel up to an angle of 12.5 degrees.

Zeitgewinn in Sekunden

Time gains in seconds

The air resistance of individual wheels is a factor that is hard to gauge for most bicycle athletes. To demonstrate the effect better, TOUR applied the wind tunnel measuring results of all wheel sets to a 40 kilometer time trial over a flat route and calculated the time gains. The comparative reference was the time gain that can be achieved with a wheel set of the type "Mavic Ksyrium SL." The rider is presumed to sit aerodynamically correct and to pedal with 300 Watt.



AND HERE'S HOW WE TESTED

SO HABEN WIR GETESTET



SIDE STIFFNESS (Seitensteifigkeit)
 The wheels are mounted with a quick release skewer and turned sideways by pulling on a cable at and between the spokes. The force and distance are recorded with a computer. The minimal side stiffness is measured in Newton per millimeter for the front and rear wheel. The higher the value, the better.



BEACHELUNGSGESCHW. 1

ACCELERATION ENERGY
 The bare wheel is suspended on the rim and a magnet is added. The wheel is turned along its rotational axis. After the wheel is leveled off, a bicycle speedometer is used to measure the period duration. This process is repeated three times. The measuring results for the front and rear wheel are then used to calculate the work required to accelerate the wheel set including the tires from zero to 30 km/h. Smaller values are better.

HERSTELLER	AMBRASIO	BONTRAGER	CAMPAÑOLO	CITEC	CRT	CORIMA	EASTON
Modell	4 Carbon	Race 3 Lite Carbon Aero	Bone 03	3000i aero	Splendor	Aero	Tempest II Carbon
Preis (Setz)	1.299 Euro	1.499 Euro	2.300 Euro	999 Euro	1.499 Euro	800 Euro	1.200 Euro
Bezug/Info	Paul Lange 09 11 19 88 00 paul.lange@de 26 / 28	Bibiscope 01 80 19 90 10 bontrager.com 26 / 26	Campagnolo Deutschland 01 26 7 17 26 30 campagnolo.com 26 / 21	03 30 80 4 / 30 35 citec.de 26 / 26	09 11 19 44 33 00 old.bike.de 26 / 24	016 02 13 72 47 corima.com 26 / 24	014 34 20 00 200 grafic.com 26 / 26
www							
Speichenzahl	36 / 28	36 / 28	36 / 28	36 / 28	36 / 24	36 / 24	36 / 28
Variante	[Icons]	[Icons]	[Icons]	[Icons]	[Icons]	[Icons]	[Icons]
Lieferumfang	[Icons]	[Icons]	[Icons]	[Icons]	[Icons]	[Icons]	[Icons]
Wert: 4 Setz (20/25/30 km/h)	9,8 / 10,1 / 11,5	9,7 / 11 / 13,4	9,7 / 11,8 / 13	9,7 / 10,1 / 10,9	4,7 / 11,5 / 10,7	9,3 / 11,8 / 10,7	4,7 / 11,1 / 10,6
Beschleunigungsenergie (J)	214 Joule	209 Joule	193 Joule	193 Joule	109 Joule	205 Joule	195 Joule
Seitensteifigkeit (N/mm)	VR 69,2 / HR 29,7	VR 67,1 / HR 43,1	VR 54,5 / HR 44,4	VR 55,3 / HR 25,8	VR 49,2 / HR 34,0	VR 69,2 / HR 37,7	VR 60,9 / HR 46,2
Felge (H x B)	20 x 46 mm	20 x 43 mm	20 x 50 mm	20 x 30 mm	20 x 45 mm	20 x 46 mm	20 x 38 mm
Gewicht (Setz)/Limit (g)	1.655 g / 200 kg	1.499 g / kein Limit	1.490 g / 80 kg	1.495 g / 80 kg	1.495 g / 110 kg	1.422 g / kein Limit	1.380 g / kein Limit
PUNKTE EINZELKONSTRUKTIONEN							
Aerodynamik	[Bar]	[Bar]	[Bar]	[Bar]	[Bar]	[Bar]	[Bar]
Beschleunigung	[Bar]	[Bar]	[Bar]	[Bar]	[Bar]	[Bar]	[Bar]
Aerodynamik	[Grid]	[Grid]	[Grid]	[Grid]	[Grid]	[Grid]	[Grid]
Gewicht	[Grid]	[Grid]	[Grid]	[Grid]	[Grid]	[Grid]	[Grid]
Laufstabilität	[Grid]	[Grid]	[Grid]	[Grid]	[Grid]	[Grid]	[Grid]
Bremsverhalten	[Grid]	[Grid]	[Grid]	[Grid]	[Grid]	[Grid]	[Grid]

SPINNECO: 1. Schraubenzieher 2. Drehwiderstand 3. Störwind-Modell 4. Carbon-Modell 5. 30 km/h-Bremsen
 1. 200 2. 200 3. 200 4. 200 5. 200 6. 200 7. 200 8. 200 9. 200 10. 200 11. 200 12. 200 13. 200 14. 200 15. 200 16. 200 17. 200 18. 200 19. 200 20. 200 21. 200 22. 200 23. 200 24. 200 25. 200 26. 200 27. 200 28. 200 29. 200 30. 200 31. 200 32. 200 33. 200 34. 200 35. 200 36. 200 37. 200 38. 200 39. 200 40. 200 41. 200 42. 200 43. 200 44. 200 45. 200 46. 200 47. 200 48. 200 49. 200 50. 200 51. 200 52. 200 53. 200 54. 200 55. 200 56. 200 57. 200 58. 200 59. 200 60. 200 61. 200 62. 200 63. 200 64. 200 65. 200 66. 200 67. 200 68. 200 69. 200 70. 200 71. 200 72. 200 73. 200 74. 200 75. 200 76. 200 77. 200 78. 200 79. 200 80. 200 81. 200 82. 200 83. 200 84. 200 85. 200 86. 200 87. 200 88. 200 89. 200 90. 200 91. 200 92. 200 93. 200 94. 200 95. 200 96. 200 97. 200 98. 200 99. 200 100. 200 101. 200 102. 200 103. 200 104. 200 105. 200 106. 200 107. 200 108. 200 109. 200 110. 200 111. 200 112. 200 113. 200 114. 200 115. 200 116. 200 117. 200 118. 200 119. 200 120. 200 121. 200 122. 200 123. 200 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