



Fietsen
 $F = F \cdot v$
 $F_{\text{tot}} = F_x + F_y = \mu \cdot m \cdot g$
 $F_{\text{drag}} = \frac{1}{2} \rho C_d A \cdot v^2$
(Zie ook: The drag force equation
Woods-King, Phys. Today 40 (2008))

Biofysica
• Kracht van de wind
• Green house effect
• Luchtdruk (levens)
Bv. SPRT

Sport in vacuum
• ...
• ...
• ...

Workshop
• ...
• ...
• ...



En Cd dan?
dy.

Optie 1: Berg Fietsen
• ...
• ...
• ...

Optie 1: Berg Fietsen
• ...
• ...
• ...

Biofysica

- Keuzeonderwerp
- Geen harde eisen
- Leefwereld leerling

dus...SPORT

Sport in examens

- Powerskips (2017)
- Sprong bij Volleybal (2015)
- Strategiebepaling bij Wielrennen (2014)
- Highland Games (2014)
- Kogelstoten (2014)
- Sprint (2013)

Workshop

**Onderwerp 1: Wielrennen
Onderwerp 2: Schaatsen**

**Daarna: zelf aan de slag
Ontwerpen van een
sportopdracht!**

Fietsen

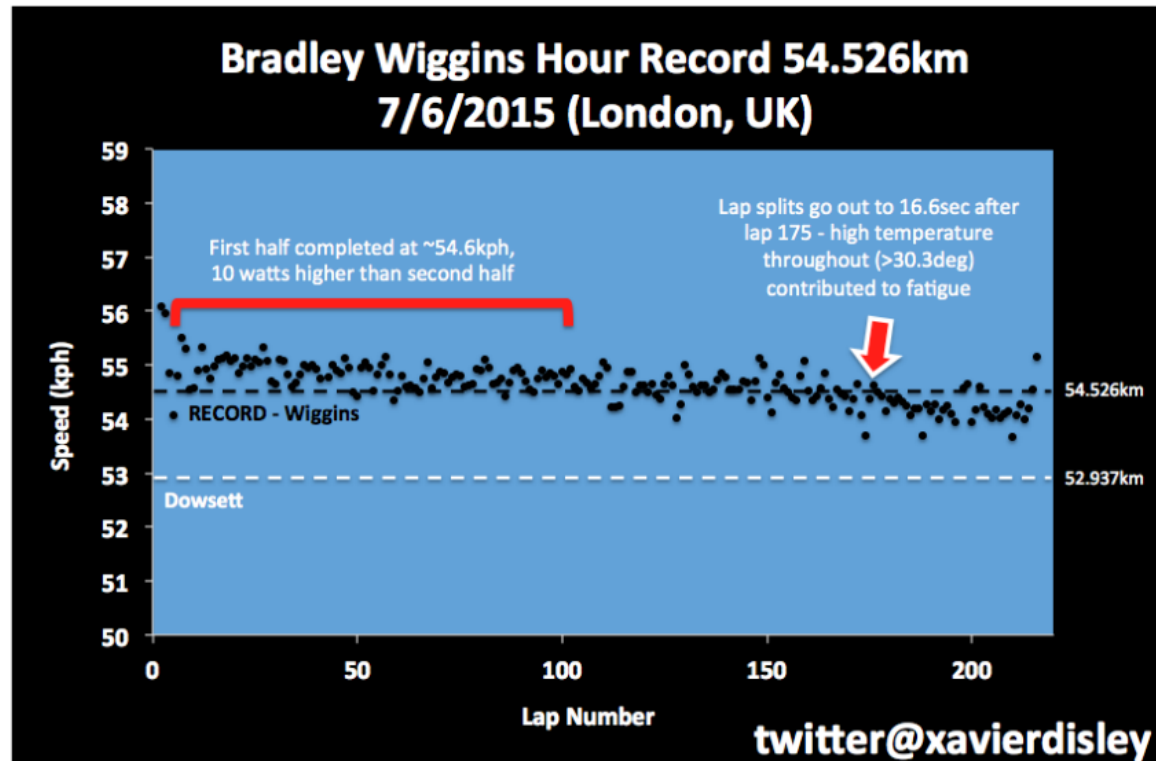
$$P = F \cdot v$$

$$F_{rol} = \mu \cdot F_N = \mu \cdot mg$$

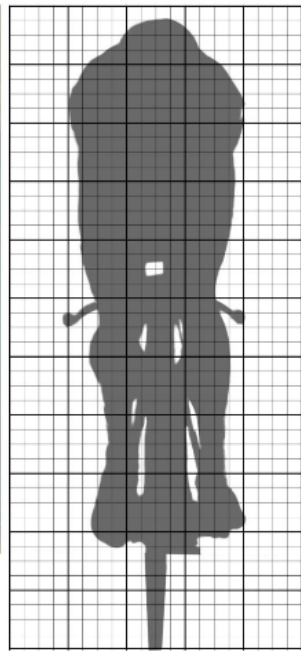
$$F_{lucht} = \frac{1}{2} \rho C_d A \cdot v^2$$

Zie ook: *The Bicyclist's Paradox*
Randy Knight, Phys. Teach 46 (2008)

Constant Vermogen?

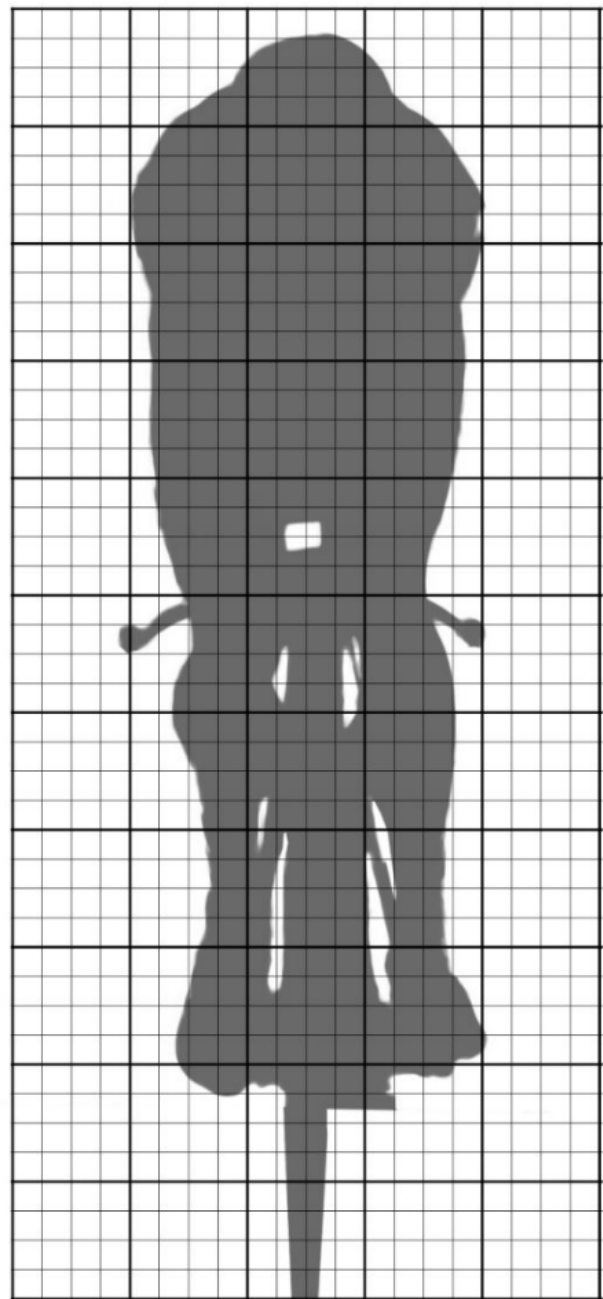


Frontaal Oppervlak



Old School
Hokjes Tellen





Old School Hokjes Tellen



PS Bestand Bewerken Afbeelding Laag Tekst Selecteren Filter 3D Weergave Venster Help

Naamloos-1 @ 5... x Naamloos-2 @ 1... x Naamloos-3 @ 5... x Naamloos-4 @ 6... x Naamloos-5 @ 5... x Naamloos-6 @ 5... x Naamloos-7 @ 6... x Naamloos-8 @ 5... x Naamloos-9 @ 6... x wiggins.psd @ 50% (Laag 7, RGB/8) * x Naamloos-10 @ ... x

Essentiële elementen

Historie Handelingen

- Canvaagrootte
- Rechthoek selectiekader
- Wissen
- Deactiveren
- Verplaatsen (Opslaan als)
- Selectie laden
- Selectie laden

Eigenschappen Teken Alinea

Geen eigenschappen

Laagen Kanalen Paden

Soort

Normaal Dekking: 100%

Vergr.: Vuls: 100%

- Laag 4
- Laag 6
- T 67,8 cm
- Laag 5
- Laag 7
- Laag 3
- Laag 2
- Laag 1
- Achtergrond

50% Doc: 8,62 M/21,4 M

02:13 15-12-2017

Histogram

Kanaal: Kleuren

Bron: Hele afbeelding

Gemiddeld: 0,00	Niveau: 0
Std.dev: 0,00	Aantal: 349201
Mediaan: 0	Percentage: 1
Pixels: 349201	Cacheniveau: 1

67,8 cm

Histogram

Kanaal: Kleuren

Bron: Hele afbeelding

Gemiddeld: 98,08	Niveau: 24,24
Std.dev: 24,24	Aantal: 105
Mediaan: 105	Percentage: 295391
Pixels: 295391	Cacheniveau: 1

67,8 cm

Histogram

Kanaal: Kleuren

Bron: Hele afbeelding

Gemiddeld: 0,00	Niveau: 0
Std.deviate: 0,00	Aantal: 0
Mediaan: 0	Percentage: 0
Pixels: 349281	Cacheniveau: 1

Histogram

Kanaal: Kleuren

Bron: Hele afbeelding

Gemiddeld: 98,08	Niveau: 100
Std.deviate: 24,24	Aantal: 295391
Mediaan: 105	Percentage: 100
Pixels: 295391	Cacheniveau: 1

Rolweerstand

www.bicyclerollingresistance.com

Brand	Model <small>(click for detailed overview)</small>	Year	Price	Check price	Width	Weight	85	85	85	85	Function Test	Road Ranking
							85 PSI	85 PSI	100 PSI	120 PSI		
					MM	Grams	Watts	Watts	Watts	Watts	Test/Run	
Vibiana	Corse Speed (open TL)	2016	High	Pricing	23	225	19.9	9.2	8.3	7.7	0/15	Review
Vibiana	Corse Speed (fullsize)	2017	High	Pricing	23	259	12.7	11.1	9.9	9.1	0/15	Review
Continental	Grand Prix TT	2016	High	Pricing	23	195	14.9	11.8	10.5	8.9	0/14	Review
Hutchinson	Fusion 5.0 Galaxi TL	2017	High	Pricing	23	200	14.6	12.3	11.0	10.1	0/15	Review
Sponkload	Turbo Carbon	2016	High	Pricing	24	224	19.0	12.5	11.1	10.1	0/14	Review
Kwell	P. Zero Velo TT	2017	High	Pricing	24	164	14.6	12.2	11.0	10.2	7/14	Review
Continental	Grand Prix SuperSoft	2017	High	Pricing	23	179	15.0	12.5	11.0	10.2	7/15	Review
Milachi	Power Competition	2016	High	Pricing	23	212	16.6	12.8	11.8	10.9	11/12	Review
Schwalbe	Pire One Tubeless	2016	High	Pricing	23	257	14.8	12.8	11.6	11.0	11/16	Review
Continental	Grand Prix Force II	2016	High	Pricing	24	196	16.2	13.4	11.6	11.0	0/14	Review
Bertagor	R4 320	2016	High	Pricing	23	228	16.4	13.9	12.2	11.3	10/14	Review
EGP	Tungsten Speed	2017	High	Pricing	23	190	17.5	14.8	12.9	11.8	7/15	Review
Continental	Grand Prix Attack II	2016	High	Pricing	22	162	13.9	14.6	12.7	11.7	0/14	Review
Schwalbe	One Tubeless	2014	High	Pricing	23	244	12.3	12.8	12.2	11.8	12/18	Review
Vibiana	Rakine Pro Speed	2016	High	Pricing	23	239	17.4	14.3	12.8	11.9	0/15	Review
Continental	Grand Prix Attack II	2014	High	Pricing	24	174	14.6	14.7	12.9	12.1	11/15	Review
Vibiana	Corse G4 (open)	2016	High	Pricing	23	255	16.2	14.1	12.9	12.2	11/15	Review
Schwalbe	One Wizard	2014	High	Pricing	23	243	16.6	14.0	12.8	12.3	12/14	Review

All bicycle tires are tested on a rolling resistance test machine with a 27 cm drum and a 120W electric motor. The drum is covered with diamond plate to simulate an average road surface.



Measurements are taken with an Arduino microcontroller and special software. The Arduino calculates the average power required to keep the drum at 200 RPM over a period of 30 seconds, using a microcontroller to measure RPM. Great results in a very short time.

After a warming period of 10 minutes, this test is run three times. These calculate the average of these three runs. After a correction for the elastic energy of flexing and subtraction of the power required to spin the drum and wheel is 100 WPM, the result is the rolling resistance in Watts.

Some facts about the test:

- 27 cm drum diameter.
- Drum speed of 200 RPM which translates to a speed of 18 mph / 29 km/h.
- Diamond plate drum surface.
- No air load.
- 100 WPM.
- Computerized measurements.
- Controlled temperature between 21-24°C / 70-75°F.

For a detailed explanation of the rolling resistance test visit www.bicyclerollingresistance.com.

Rolling Resistance Test Results

Rolling Resistance Test Results Speed: 20 km/h / 12 mph, Load: 10.2 kg

Power Value	Coef/Resist (W/kg)
Rolling Resistance 140 psi / 9.7 Bar	Not Tested
Rolling Resistance 120 psi / 8.3 Bar	13.2 Watts
Rolling Resistance 100 psi / 6.9 Bar	13.9 Watts
Rolling Resistance 80 psi / 5.5 Bar	15.7 Watts
Rolling Resistance 60 psi / 4.1 Bar	15.5 Watts
Rolling Resistance Coefficient (Crr) 140 psi / 9.7 Bar	Not Tested
Rolling Resistance Coefficient (Crr) 120 psi / 8.3 Bar	0.0068
Rolling Resistance Coefficient (Crr) 100 psi / 6.9 Bar	0.0067
Rolling Resistance Coefficient (Crr) 80 psi / 5.5 Bar	0.0061
Rolling Resistance Coefficient (Crr) 60 psi / 4.1 Bar	0.0065

Performance in the rolling resistance test is great. At an air pressure of 120 psi, rolling resistance is a low 13.2 watts, which is excellent for a Tour / Race type tire. Dropping air pressure to 100 psi results in a rolling resistance of 13.9 watts. Lowering air pressure even lower results in a rolling resistance of 15.7 watts at an air pressure of 80 psi.

Noteworthy is the very flat rolling resistance graph of this tire. Dropping air pressure to 80 psi increases rolling resistance by only 1.5 watts per tire. This is a great feature because rider comfort will increase greatly at 80 / 90 psi at a very low cost.

Brand	Model (Click for detailed overview)	Year	Price	Check Prices	Width	Weight	RR 60 PSI 4.1 bar	RR 80 PSI 5.5 bar	RR 100 PSI 6.9 bar	RR 120 PSI 8.3 bar	Puncture Test	Read Review
					MM	Grams	Watts	Watts	Watts	Watts	Tread/Side	
Vittoria	Corsa Speed (open TLR)	2016	High	Pricing	23	225	10.9	9.2	8.3	7.7	8 / 5	Review
Vittoria	Corsa Speed (tubular)	2017	High+	Pricing	23	209	12.7	11.1	9.9	9.1	8 / 3	Review
Continental	Grand Prix TT	2016	High	Pricing	25	195	13.9	11.8	10.5	9.9	8 / 4	Review
Hutchinson	Fusion 5 Galactik TL	2017	High	Pricing	25	288	14.6	12.3	11.0	10.1	9 / 5	Review
Specialized	Turbo Cotton	2016	High+		24	224	15.0	12.5	11.1	10.1	9 / 4	Review
Pirelli	P Zero Velo TT	2017	High	Pricing	23	163	14.6	12.2	11.0	10.2	7 / 4	Review
Continental	Grand Prix SuperSonic	2017	High	Pricing	23	179	15.0	12.5	11.0	10.2	7 / 5	Review
Michelin	Power Competition	2016	High	Pricing	25	212	16.6	13.6	11.8	10.9	11 / 3	Review
Schwalbe	Pro One Tubeless	2016	High	Pricing	25	257	14.8	12.8	11.6	11.0	11 / 6	Review
Continental	Grand Prix Force II	2016	High	Pricing	24	196	16.3	13.4	11.6	11.0	9 / 4	Review
Bontrager	R4 320	2016	High+		25	226	16.4	13.9	12.2	11.5	10 / 4	Review
Zipp	Tangente Speed	2017	High	Pricing	25	190	17.3	14.6	12.5	11.6	7 / 3	Review
Continental	Grand Prix Attack II	2016	High	Pricing	22	182	17.9	14.6	12.7	11.7	9 / 4	Review
Schwalbe	One Tubeless	2014	High	Pricing	25	344	16.3	13.8	12.5	11.8	12 / 8	Review
Vittoria	Rubino Pro Speed	2016	High	Pricing	25	206	17.4	14.3	12.6	11.9	8 / 3	Review
Continental	Grand Prix 4000S II	2014	High	Pricing	25	215	15.5	13.7	12.9	12.2	11 / 5	Review
Vittoria	Corsa G+ (open)	2016	High	Pricing	25	255	16.3	14.1	12.9	12.2	11 / 5	Review
Schwalbe	One V-Guard	2014	High	Pricing	25	243	16.6	14.0	12.8	12.3	12 / 4	Review

ature st	Read Review
5/5	Review
3/3	Review
4/4	Review
5/5	Review
4/4	Review
4/4	Review
5/5	Review
7/3	Review
7/6	Review
4/4	Review
7/4	Review
3/3	Review
4/4	Review
7/8	Review
3/3	Review
7/5	Review
7/5	Review
7/4	Review

All bicycle tires are tested on a rolling resistance test machine with a 77 cm drum and a 120W electric motor. The drum is covered with diamond plate to simulate an average road surface.



Measurements are taken with an **Arduino** microcontroller and special software. The Arduino calculates the average power required to keep the drum at 200 RPM over a period of 30 seconds. Using a microcontroller to measure input power results in a very accurate measurement.

After a warm-up period of 30 minutes, this test is run three times. I then calculate the average of these three runs. After a correction for the electric motor efficiency and subtraction of the power required to spin the drum and wheel to 200 RPM, the result is the rolling resistance of the tire.

Some facts about the test:

- 77 cm drum diameter.
- Drum speed of 200 RPM which translates to a speed of 18 mph / 29 km/h.
- Diamond plate drum surface.
- 42.5 kg load.
- Butyl tube.
- Computerized measurements.
- Controlled temperature between 21.5-22.5 °C / 70-73 °F.

For a detailed explanation of rolling resistance [check Wikipedia](#).

Rolling Resistance

Rolling Resistance
Inner Tube
Rolling Resistance 140 p
Rolling Resistance 120 p
Rolling Resistance 100 P
Rolling Resistance 80 PS
Rolling Resistance 60 PS
Rolling Resistance Coeffi
Rolling Resistance Coeffi
Rolling Resistance Coeffi
Rolling Resistance Coeffi

Performance in the ro
rolling resistance is a l
tire. Dropping air pres
Lowering air pressure
an air pressure of 80 p

Noteworthy is the very
pressure to 80 psi incr
great feature because
low cost.

Rolling Resistance Test Results

Rolling Resistance Test Results (Speed: 29 kmh / 18 mph, Load: 42.5 kg)

Inner Tube	Conti Race28 (100gr butyl)
Rolling Resistance 140 psi / 9.7 Bar	Not Tested
Rolling Resistance 120 psi / 8.3 Bar	12.2 Watts
Rolling Resistance 100 PSI / 6.9 Bar	12.9 Watts
Rolling Resistance 80 PSI / 5.5 Bar	13.7 Watts
Rolling Resistance 60 PSI / 4.1 Bar	15.5 Watts
Rolling Resistance Coefficient (Crr) 140 psi / 9.7 Bar	Not Tested
Rolling Resistance Coefficient (Crr) 120 psi / 8.3 Bar	0.00366
Rolling Resistance Coefficient (Crr) 100 psi / 6.9 Bar	0.00387
Rolling Resistance Coefficient (Crr) 80 psi / 5.5 Bar	0.00411
Rolling Resistance Coefficient (Crr) 60 psi / 4.1 Bar	0.00465

Performance in the rolling resistance test is great. At an air pressure of 120 psi, rolling resistance is a low 12.2 watts, which is excellent for a Tour / Race type tire. Dropping air pressure to 100 psi results in a rolling resistance of 12.9 watts. Lowering air pressure even lower results in a rolling resistance of 13.7 watts at an air pressure of 80 psi.

Noteworthy is the very flat rolling resistance graph of this tire, dropping air pressure to 80 psi increases rolling resistance by only 1.5 watts per tire. This is a great feature because rider comfort will increase greatly at 80 / 90 psi at a very low cost.

THE FORMULA FOR SPEED

"TRACKULATOR"
Check out the online tool that will do the math for you, so you can ignore everything on this page: analyticyccling.com

WATTS = $0.5\rho CdAv^3$

Want to know how far you can ride in an hour? Brush up on your math. It all boils down to aerodynamic drag and the above formula. v is your velocity. ρ is air density, which varies with barometric pressure, humidity, and temperature, all of which are influenced by altitude. Cd is the coefficient of drag. A soaring eagle has a great Cd . A brick doesn't. Humans are more like the brick. Finally, A is frontal area.

FORCES AGAINST YOU

About 90 percent of your aerodynamic drag is a function of pushing air out of the way of your body. Aero gear will help, but for the most part, humans are bad at cheating the wind. What you can alter is how much is hitting the wind, by changing your position. There's a great primer on using Photoshop to calculate your frontal area here: cyclingpowerlab.com/CyclingAerodynamics.aspx.

THE BOTTOM LINE

A cyclist isn't a formula. It's hard to predict how your body will work while contorted—at threshold, for an hour. Tweaking your bars by five millimeters to reduce frontal area by 0.01 m^2 might improve the math, but it might also result in rocking shoulders or a loss of power due to poor hip angles.

TOTAL COST \$14,359

FRAME
Felt Tk FRD
\$4,000
A frame with a low stack height allows for separation of rider and bike at the arm pads, which yields cleaner air flow over the core of the bike.

SKINSUIT
Panache
V-lab **\$475**

HELMET
Bell Javelin
\$200
Air that becomes turbulent behind a rider's helmet isn't flowing as quickly as the air in front of it. This creates a pressure difference and, therefore, drag, effectively pulling the rider backward.

SADDLE
Pro AeroFuel
TT **\$200**

REAR WHEEL
Mavic Comete
\$2,900
At the London Olympics, the Comete was used in 90 percent of the medal-winning rides (27) in the track events.

REAR BEARING KIT
Ceramicspeed
\$439

CRANKSET
Shimano Dura-Ace track with Stages power meter **\$650**

FRONT WHEEL
Mavic I/O
\$4,000

FRONT BEARING KIT
Ceramicspeed **\$212**

COG
Shimano Dura-Ace, 15-tooth
\$30

CHAINRING
Shimano Dura-Ace 7710, 54-tooth
\$135
With a 54x15 gear ratio, at a cadence of 100rpm, on a 23mm tire, a rider will travel 45.335 kph; at 105 rpm, 47.588 kph

CHAIN
Shimano Dura-Ace 9-speed prepared by Ceramicspeed
\$139
The right chain can save you at least five watts when pushing 250 watts. That's two percent and could mean the difference between a world record or a painful waste of an hour.

AEROBARS
Felt Bayonet 3
\$300
Aero extensions that allow for upright forearms (while keeping the base bar parallel to the ground) have proven fastest in testing performed by aerodynamics firm Alptematics.

TIRES
Challenge Pista Seta
\$320 (2)
At a speed of 50 kph, the best and worst tubular track tires can mean a difference of between 7 and 10 watts.

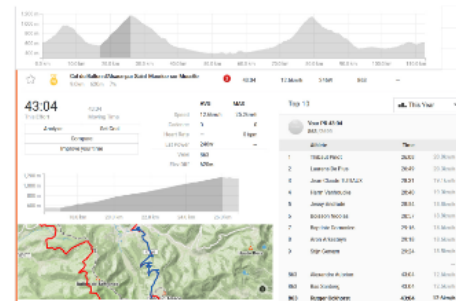
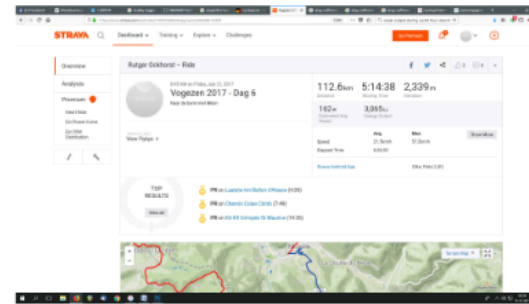
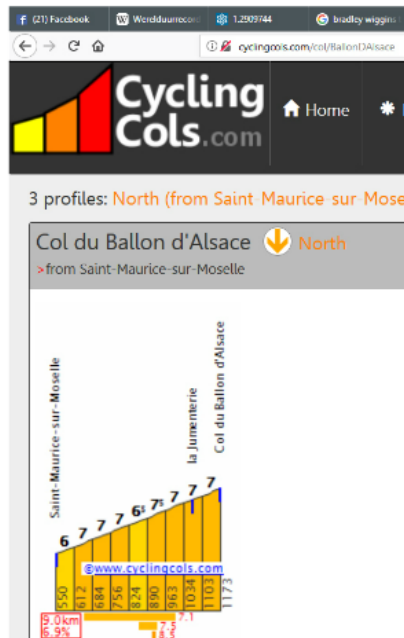
BOTTOM BRACKET
Shimano Octalink prepared by Ceramicspeed **\$359**



Eigen Prestatie Meten

- Constante hartslag = constant vermogen
- Geen wind, weinig luchtweerstand
- Geijkt traject

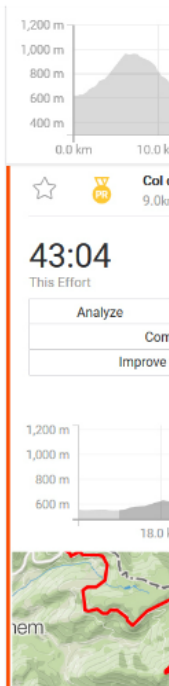
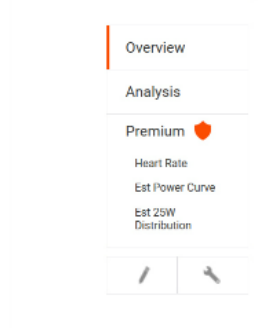
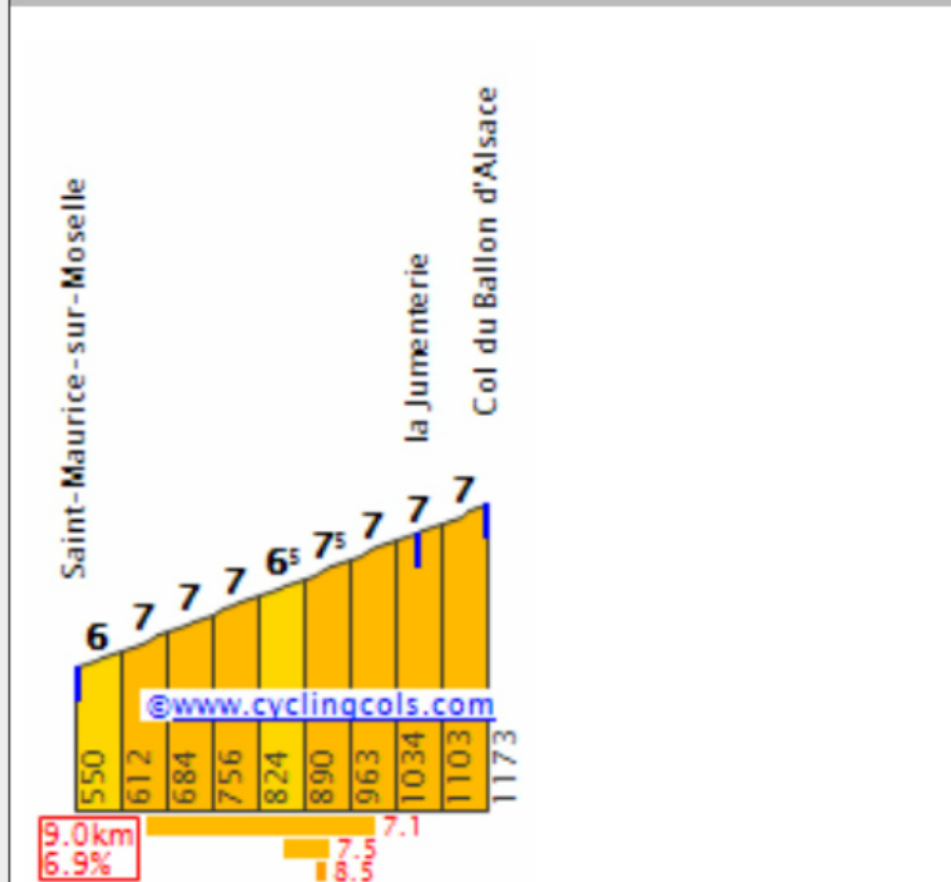
Optie 1: Berg Fietsen





3 profiles: North (from Saint-Maurice-sur-Moselle)

Col du Ballon d'Alsace ⬇ North
> from Saint-Maurice-sur-Moselle



Overview

Analysis

Premium

Heart Rate

Est Power Curve

Est 25W Distribution

Rutger Ockhorst - Ride

2 0



8:45 AM on Friday, July 21, 2017

Vogezen 2017 - Dag 6

Naar de bami met Milan

112.6 km **5:14:38** **2,339 m**
Distance Moving Time Elevation

162 w **3,065 kJ**
Estimated Avg Power Energy Output

	Avg	Max	Show More
Speed	21.5km/h	57.2km/h	
Elapsed Time	6:26:53		

[Strava Android App](#) Bike: Fiets 2 (K)

STRAVA LABS
[View Flybys](#)

TOP RESULTS

[View all](#)

- PR on [Laatste km Ballon d'Alsace](#) (4:30)
- PR on [Chemin Colas Climb](#) (7:49)
- PR on [K6-K9 Grimpée St Maurice](#) (14:26)





Col du Ballon d'Alsace par Saint-Maurice-sur-Moselle

9.0km 620m 7%



43:04

12.6km/h

246W

863

—

43:04

This Effort

43:04

Moving Time

Analyze

Set Goal

Compare

Improve your time

AVG

MAX

Speed

12.6km/h

25.2km/h

Cadence

0

0

Heart Rate

—

0 bpm

Est Power

246W

—

VAM

863

Elev Diff

620m

Top 10

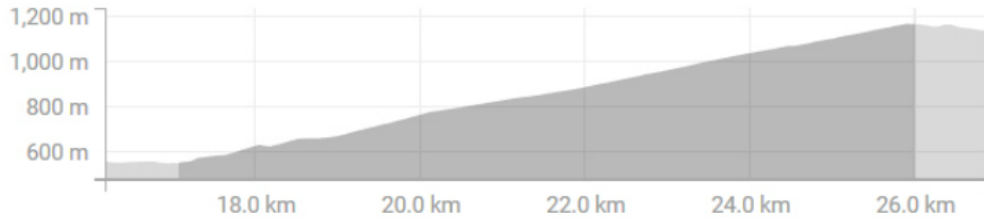
This Year



Your PR 43:04

863 / 2699

	Athlete	Time	
1	Thibaut Pinot	26:08	20.8km/h
2	Laurens De Plus	26:49	20.3km/h
3	Jean-Claude TUTIAUX	28:31	19.1km/h
4	Harm Vanhoucke	28:40	19.0km/h
5	Jessy Andrade	28:54	18.8km/h
6	Boisson Nicolas	28:57	18.8km/h
7	Baptiste Domanico	29:16	18.6km/h
8	Aron Arkesteyn	29:18	18.6km/h
9	Stijn Geneyn	29:24	18.5km/h
...			
863	Alexandre Aubrion	43:04	12.6km/h
863	Bas Sanberg	43:04	12.6km/h
863	Rutger Ockhorst	43:04	12.6km/h

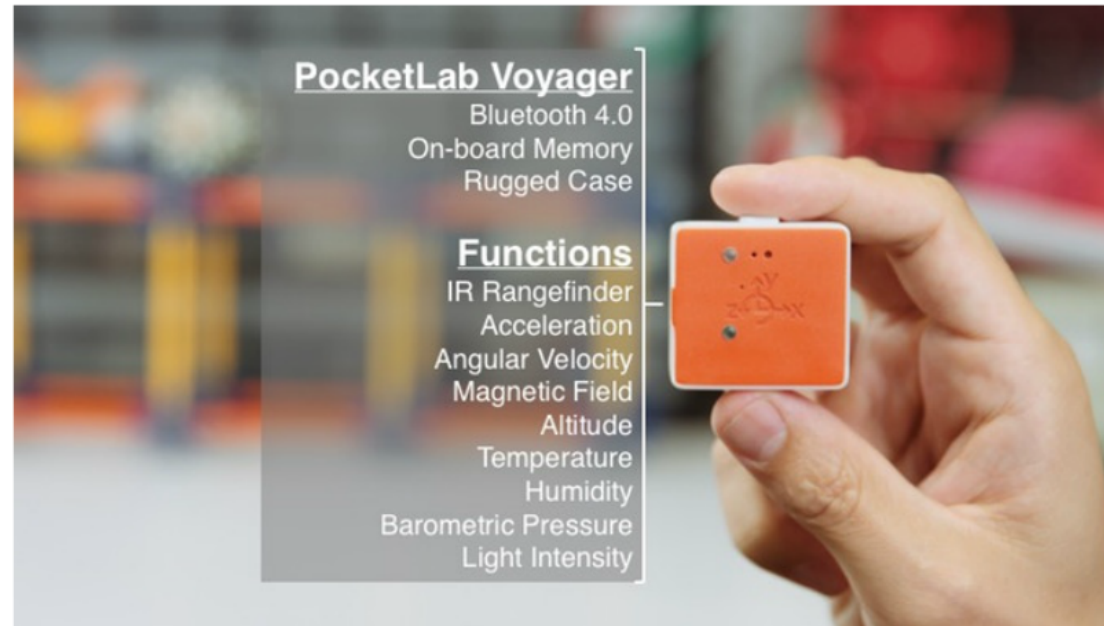


Optie 2: Proefopstelling



over naar Martin...

Voor straks



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