V4Rs

WHITE PAPER

COLNAGO

INTRO

The bicycle is an extremely complex system made up of many parts, subsystems and components, and the numerous required performances can trade off between each other. When supporting a top-level team there is no room to neglect any single aspect: in one racing season, or even in one race or stage, there are several conditions and situations in which the rider who wants to win must not accept compromises. To develop a bicycle that performs the best in all racing conditions is a tough job, especially when the starting point is the V3Rs, a bike which is already a proven winner in all kind of competitions: 2 TDF GC, Monument Classics (Liegi, Lombardia), Classics (Strade Bianche and cobble-stone stages), sprint finishes, etc. The only possible way to evolve without neglecting any detail is to work directly and constantly in contact with the best and most demanding riders in the world: from the initial design inputs, to the final race validation, passing through all the development phases. The new Colnago V4Rs was built to do one thing: **BUILT TO WIN**.

FROM-RACE-TO-RACE APPROACH

The new V4Rs has been designed starting from the direct inputs of the professional riders of UAE Teams. The evolution touched all the areas of the performance:

a. Aerodynamics
b. Weight
c. Real Dynamic Stiffness
d. Sizing and geometry
e. Design robustness and maintenance

All the new parts and components followed the same strict validation procedure:

a. Concept and Design
b. Prototype phase
c. Internal testing and design selection
d. Complete system validation in racing conditions

This final step is what really makes the difference, all the sub-systems come together to deliver the final behavior of the bicycle, and its final performance is never the sum of the performance of each component (in engineers' language, there is no superimposition of effects principle). Therefore, despite all the innovative testing methodologies and validation, the best way to check that the improvements are consistent and not simply the result of a different trade-off position, is to take the whole system to performance limits (i.e. race conditions) and collect data and feedback.

a. AERODYNAMICS

The V4Rs has been conceived as a fully-integrated system. While working on the aerodynamics in order to reduce the overall drag, the superimposition of effects simply doesn't work. All the components must be developed and tested together in order to prove the overall benefits. That's why all the presented data is obtained with the bicycle in race-ready configuration, which means that it is equipped with head unit and 2 bottle-cages but one bottle only (as in the crucial race phases).

This process of design and development started from the bike frontal area, which has a huge impact on the drag, both directly (A factor in the formula) and through its shape, by affecting the overall Cd factor.

Equation 1: Drag force formula

$$F_D = C_D A \frac{pV^2}{2}$$

- F_D is the drag force
- C_D is the drag coefficient
- A is the reference area
- p is the density of the fluid
- V is the flow velocity relative to the object

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Integration

The optimization of the frame frontal area involved an evolution of the head tube geometry. Its shape has been revised and perfectly integrated with the new lightweight fork (designed to allow an effective tire clearance up to 32mm) and with the new cockpit. Although the head set upper bearings are bigger than those of the V3Rs, allowing the cables to run inside without the need of the D-Shaped steerer column and enhancing the overall front-end stability, the overall shape has a better drag. This, of course, required deep surface modeling to keep the frontal area smaller and a better aerodynamic shape factor.

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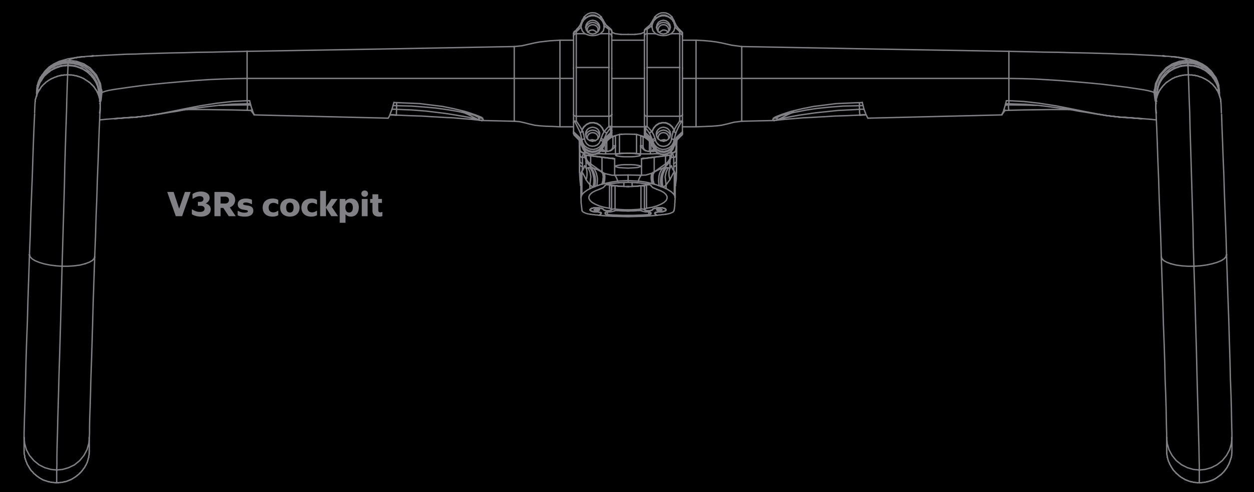


V3Rs cockpit

V4Rs - The new cockpit CC.01

Although the V4Rs is compatible with third-party cockpits, the overall platform has been optimized with the new Colnago cockpit CC.01, which has a drag surface reduced by up to 16% compared to the cockpits mounted on V3Rs, and at the same time the shape has been designed as a NACA-derived profile in order to have the minimum impact on the air flow, which is laminar and clean while impacting the components.

This aerodynamic evolution was carried out without reducing the cockpit's overall stiffness, which is as important as aerodynamics in sprint and acceleration.

Furthermore, for a perfect match and lower drag, the cockpit is offered also with the new 3D-printed, cyclo-computer support, compatible with Wahoo Bolt V2 (with further compatibilities yet to be announced). This detail, on top to the astonishing and clean aesthetics, also provide a measurable (!) 0.75 W* saving at 50km/h, which is highly relevant, considering the small area of the component.

*WAD = Weighted Average Drag (i.e. the sum of power at different yaw angles, weighed by the probability of occurring in such a condition).

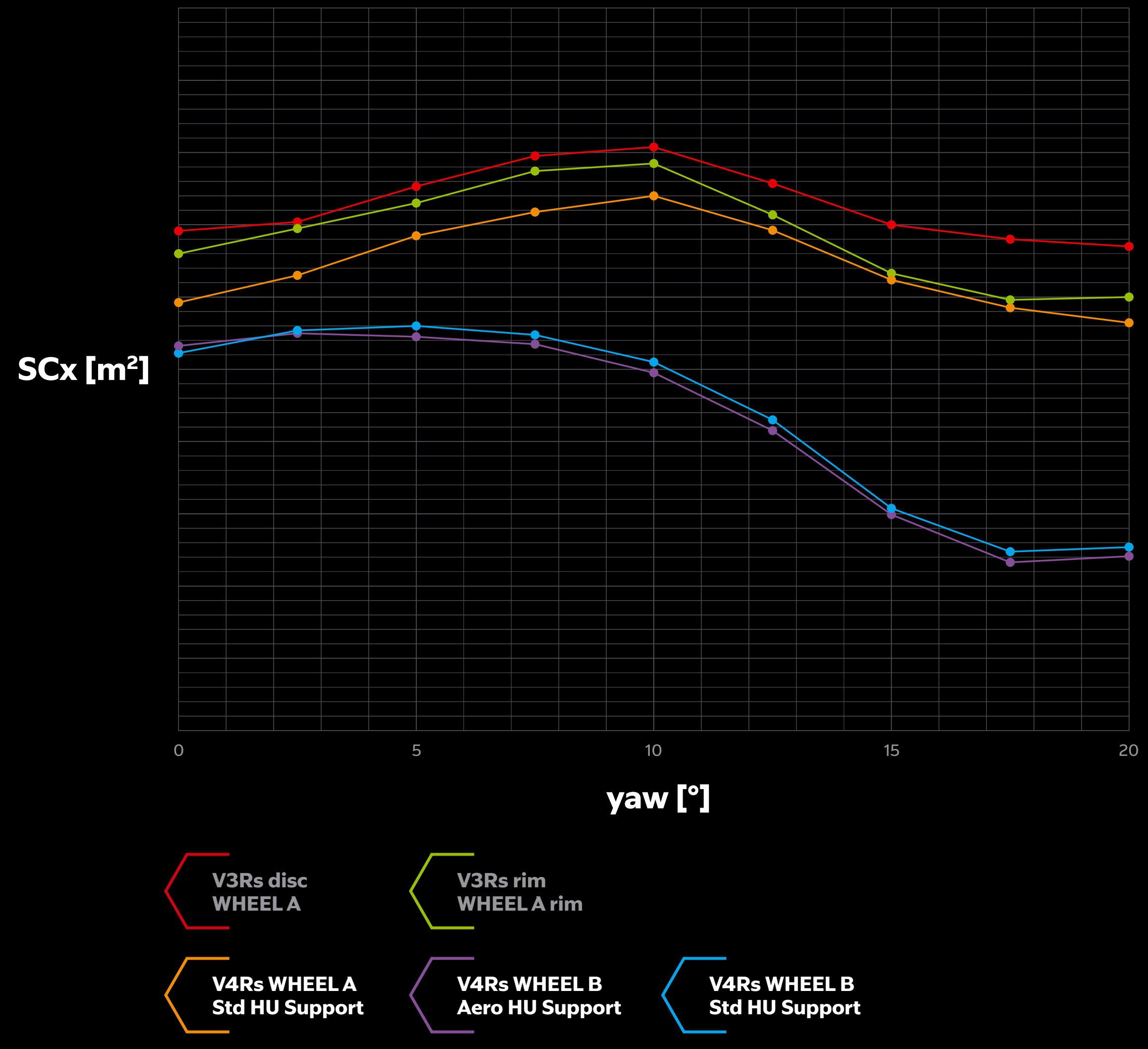
Results and Data

All the data has been collected with a wind speed of 50km/h

WHEEL A is a baseline reference wheel, kept constant in the comparison between V3Rs and V4Rs. The research of the Colnago engineers passed through the evaluation of many different wheels and the results of the matching wheels (named WHEEL B) has been presented to show the advantage of a fully optimized platform.

Bicycle only - Racing-ready configuration

(with head unit, 2 bottle-cages but one bottle)



Plot 1 Scx stand-alone bicycle with spinning wheels and no pedaling (only positive yaw)

Table 1: Savings stand-alone bicycle with spinning wheels and no pedaling

No wind (0°) & WAD, rider speed 50 km/h	V3Rs rim WHEEL A rim	V4Rs WHEEL A Std HU Support	V4Rs WHEEL B Std HU Support	V4Rs WHEEL B Aero HU Support
Saving [%]				
0°	2%	6%	10%	9%
WAD	4%	4%	14%	16%
Saving [Watt]				
0°	2,2	6,5	11,2	10,6
WAD	4,5	5,2	17,5	19,2

Real racing setup

(Bicycle + Pedaling Rider @90 rpm + Head Unit & support + 2 bottle cages with one bottle)

In order to test as close as possible to outdoor condition, the Real racing setup test has been performed with a real rider pedaling at constant rpm. The presented results are the average of 3 different data acquisitions for each setup, performed to reduce and compensate the measurement variability.

V3Rs disc WHEEL A
V3Rs rim WHEEL A rim
V4Rs WHEEL A Aero HU Support
V4Rs WHEEL B Aero HU Support

Plot 2 Scx Real racing setup

Table 2 Savings real racing setup

No wind (0°) & WAD, rider speed 50 km/h	V3Rs rim WHEEL A rim	V4Rs WHEEL A Aero HU Support	V4Rs WHEEL B Aero HU Support
Saving [%]			
0°	0%	2%	5%
WAD	1%	3%	6%
Saving [Watt]			
0°	0,8	7,7	20,0
WAD	3,9	13,2	27,7

Notes for reading Plot and Table:

The comparison between V3Rs and V4Rs is the difference between the brown and orange curves (same WHEEL A)

The blue curves show the further gain obtained with the best matching wheels (WHEEL B). Light blue with the standard head-unit support, dark blue with the aero head-unit support

The 'Yaw" on the horizontal axis is the wing incidence angle. For instance, 0° yaw means that the wind is perfectly in the direction of the bicycle speed, while 45° means that the wind blows perfectly in lateral direction, at the same speed of the rider.. According to scientific literature the most common riding conditions are from 0° to 12.5°, while bigger yaws are less common, due to some strong lateral gusts

WAD (Weighted Average Drag), takes into account the drag at the different yaws, weighted with the probability to occur in each condition (heavier weight for low angles and lighter for big angles). It represents an average value (or saving) across different conditions, which means that the effective saving for each ride (or race) can be lower or higher, according to the actual wind and track features

All the savings are calculated with respect to the V3Rs disc bicycle, equipped with WHEEL A

b. WEIGHT

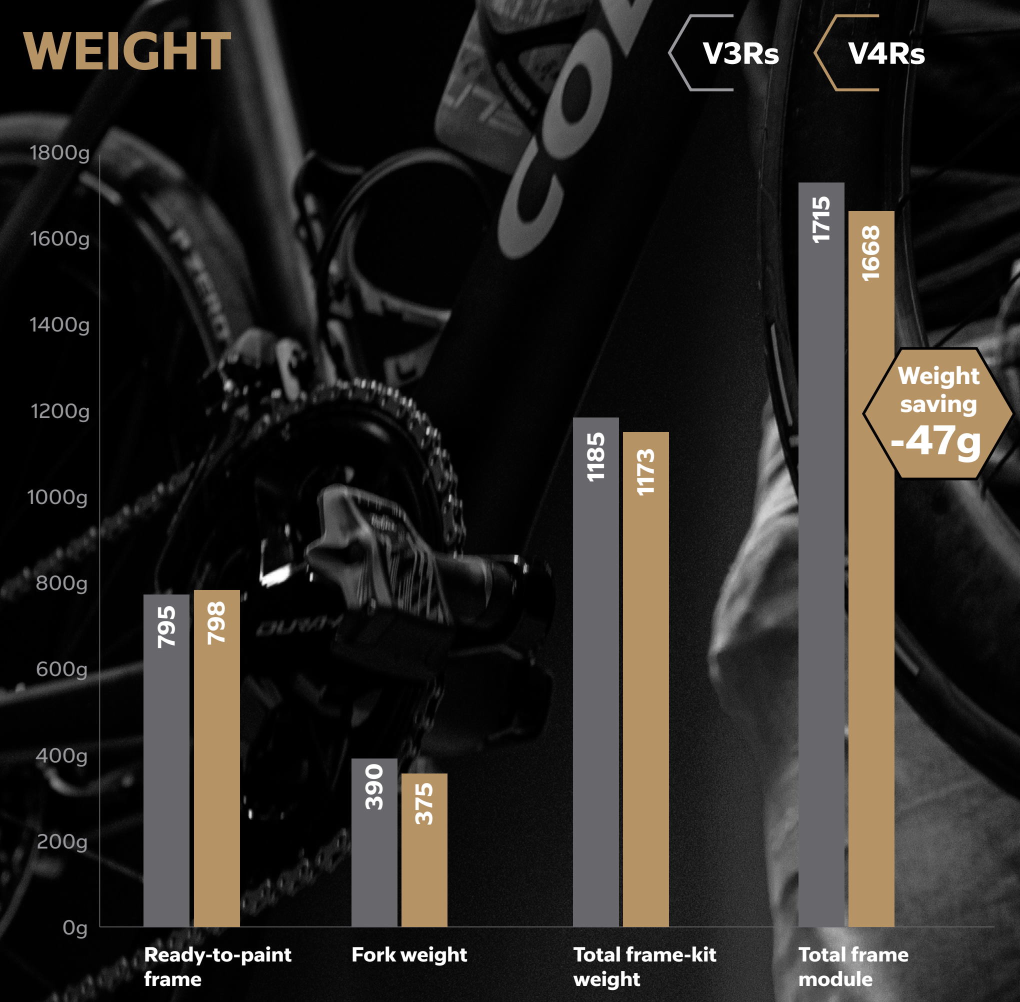


Table 3 Weight and saving different module components (V3Rs size 50 vs V4Rs size 48.5)

Ready-to-paint frame weight is measured before the painting phases without the removable parts

Total frame-kit weight is the sum of the ready-to-paint and fork weight

Total frame module:
-V3RS frame-kit + SR9 + HBR41 + Head set
-V4RS frame-kit + CC.01 + Head set

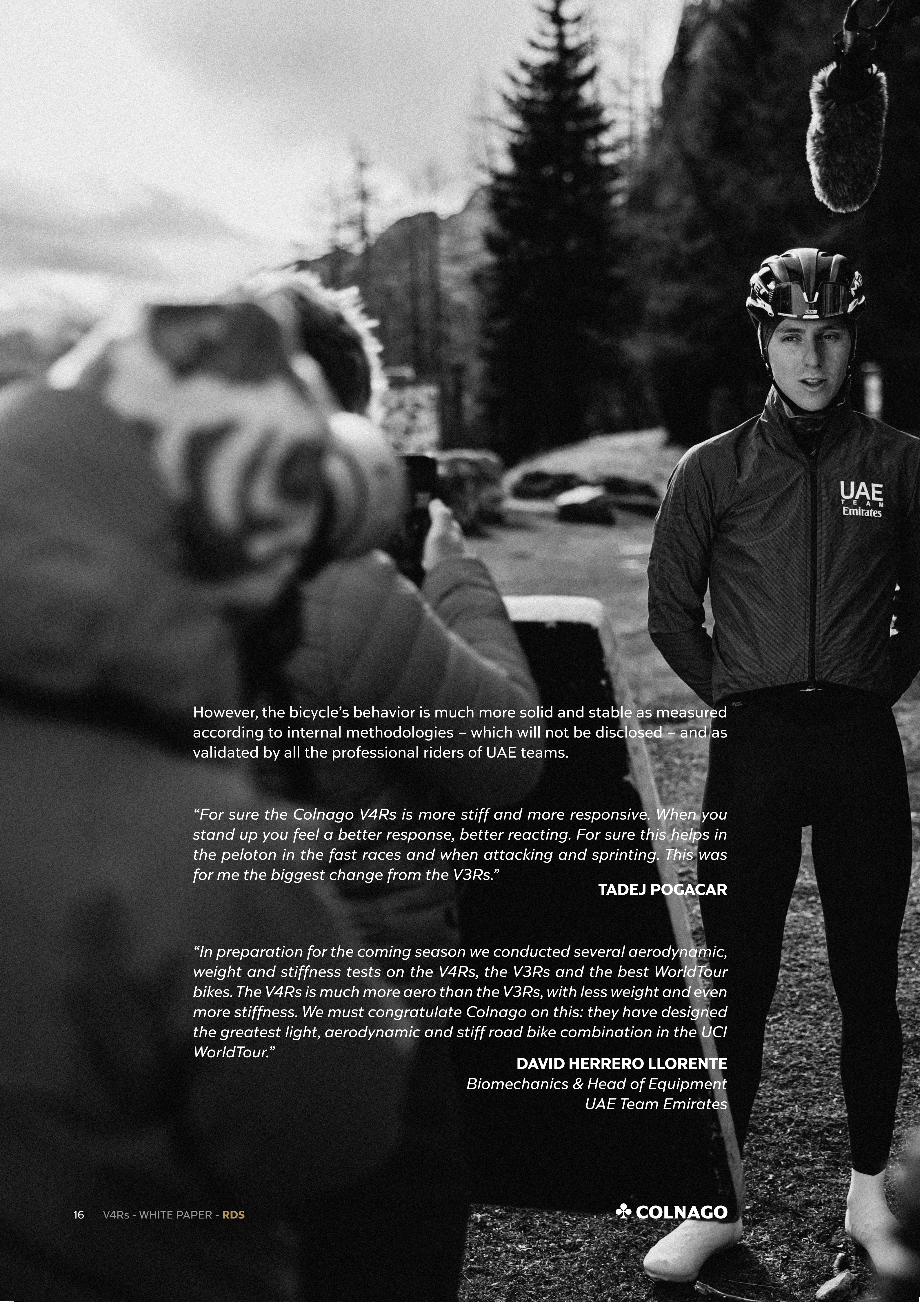
c. REAL-DYNAMIC STIFFNESS APPROACH (RDS)

During riding, a bicycle is subjected to several different loads, acting on the whole bicycle at the same time. To replicate and measure in indoor testing procedures able to stress the frame in many of these conditions at the same time, our engineers needed to develop internal testing methodologies in order to take into account both static and dynamic, and both flexural and torsional loads. The result is a bicycle within which all the **stiffnesses are fine-tuned and harmonized with each other to offer the maximum performance and balance in all the racing ultimate conditions**.

A clear example of this approach comes from the comparison between standard Zedler tests, which involve only one force component, statically applied: th most common parameters are maintained constantly in the new V4RS with respect to the previous V3Rs.

	HT Stiffness	BB Stiffness
V3Rs	Reference value	Reference value
V4Rs	**5-10 % lower***	**Constant***

*depending on sizes



However, the bicycle's behavior is much more solid and stable as measured according to internal methodologies – which will not be disclosed – and as validated by all the professional riders of UAE teams.

"For sure the Colnago V4Rs is more stiff and more responsive. When you stand up you feel a better response, better reacting. For sure this helps in the peloton in the fast races and when attacking and sprinting. This was for me the biggest change from the V3Rs."

TADEJ POGACAR

"In preparation for the coming season we conducted several aerodynamic, weight and stiffness tests on the V4Rs, the V3Rs and the best WorldTour bikes. The V4Rs is much more aero than the V3Rs, with less weight and even more stiffness. We must congratulate Colnago on this: they have designed the greatest light, aerodynamic and stiff road bike combination in the UCI WorldTour."

DAVID HERRERO LLORENTE
Biomechanics & Head of Equipment
UAE Team Emirates

We created internal methodologies to replicate the loading forces of standing-on-pedals and seated positions, and check the overall frame deformation and stiffness. We were able then to define what we call RDS (Real-Dynamic Stiffness), and characterize them in combined multi-load conditions. In particular, we compared all the prototypes in validated loading situation:

SP: Sprint position, a combination of loads applied both on the handlebar and on the bottom bracket, with both component laying on the front triangle plane and normal to the frame plane, aimed to simulate the flexural and torsional stresses at oscillating cambers

ST: Seated position, loads are applied only on the same plane of the front triangle to replicate all-round riding

Table 5 Real Dynamic Stifnees, Sprint position & Seated position

	RDS-SP (sprint position)	RDS-ST (seated position)
V3Rs	Reference value	Reference value
V4Rs	**4% stiffer**	**5% stiffer**

Since testing machines and methodologies are patent pending, only partial screenshot and info are disclosed

Sprint

In the sprint position, the rider imparts a force on the pedals whose directrix is off-axis to that of the bicycle.
In addition, a lot of power comes from the help of the arms, which pull and push on the handlebars, putting the frontal area under stress.

Seated climb

In the seated climbing position, the arms are lightly loaded and most of the weight is placed on the rear triangle.
This distribution of forces is even more pronounced when the climb is steep and you are forced to climb seated.

Pavé

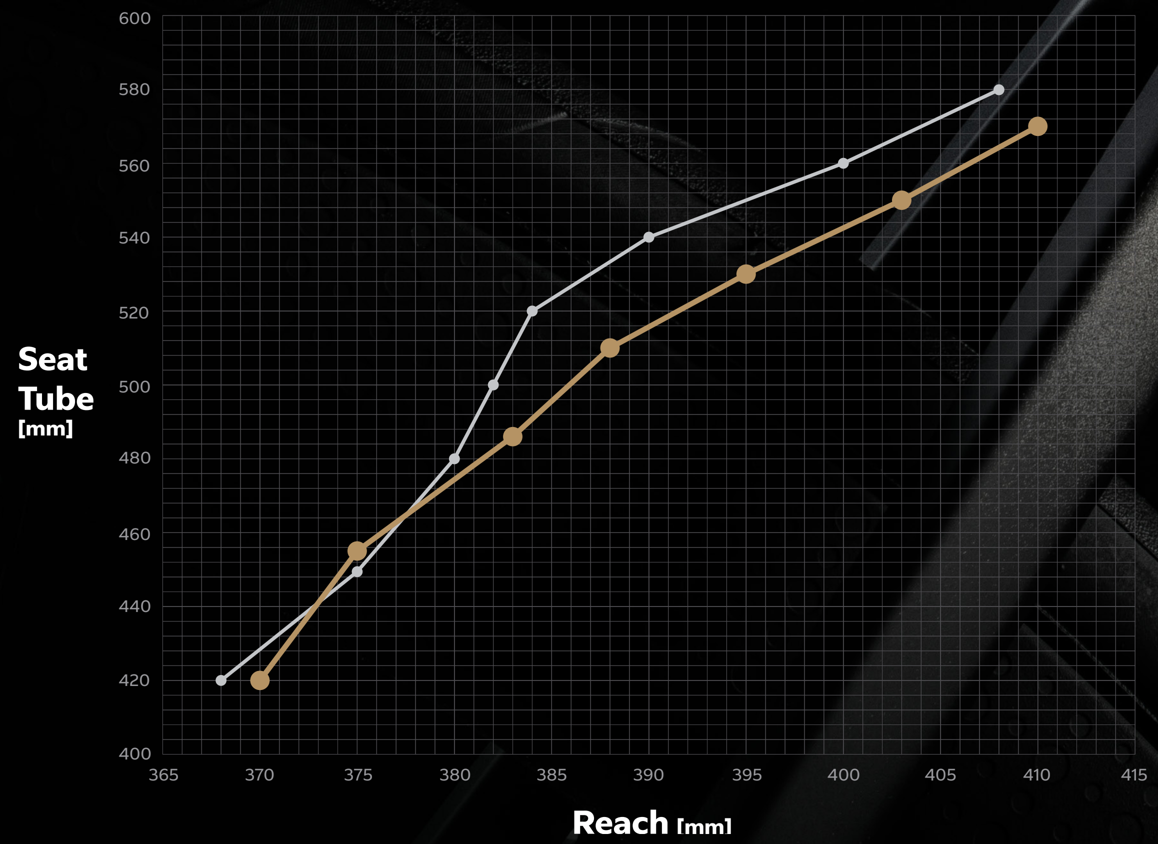
In the case of rough terrain, high-frequency impacts occur on both wheels from the ground.
These impacts combine with the stress caused by the forces from the cyclist's body: his weight and the push on the pedals.

Innovative and racing-validated lamination

This result has been achieved thanks to the innovative carbon fiber lamination featured on the V4Rs. For the ultimate racing machine, many different layups featuring as many different stiffness matrices, have been developed, tested and validated for professional use. The final call was given to the riders themselves, who were provided for the most complete and stressful competition of the year (TDF 2022) with "PROTOTIPO" with the most promising layups, in order to bring the bicycle to real limit conditions (on cobblestones, in sprints, on climbs and downhills) and provide data and feedback to our engineers.

d. SIZING, HANDLING AND RACING “FEELING”

Based on professional riders’ inputs, the geometry (especially reach and stack) has been revised to have even more balanced performance in all the different sizes with respect to the V3Rs. For the V4Rs the relationship between seat tube length and reach is almost linear, which means easier and more precise size selection and more possibilities of position tuning for each rider.

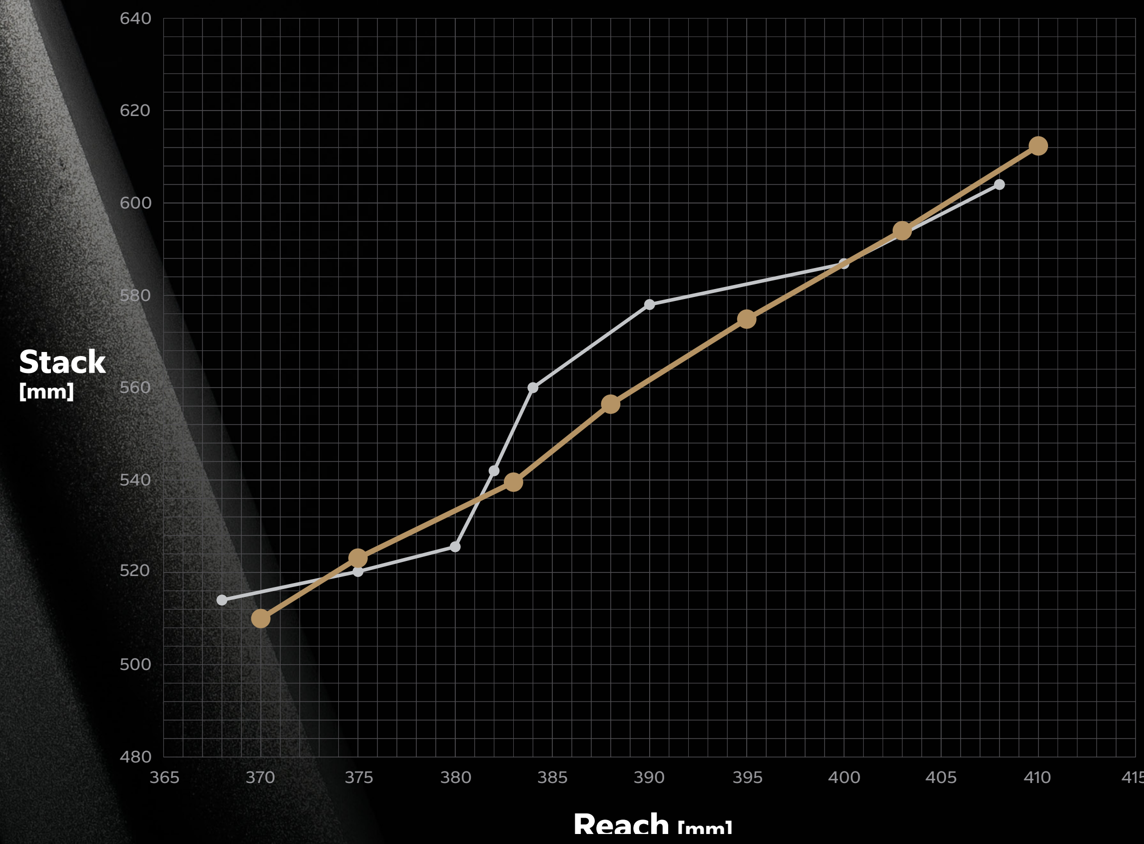


Plot 3 Seat Tube length vs Reach

V3Rs V4Rs

Furthermore, the stack / reach ratio has been optimized and harmonized among all the sizes, and the chain stay length has been reduced.

This geometry affords a better balance, power transfer and the same race feeling for all the sizes.

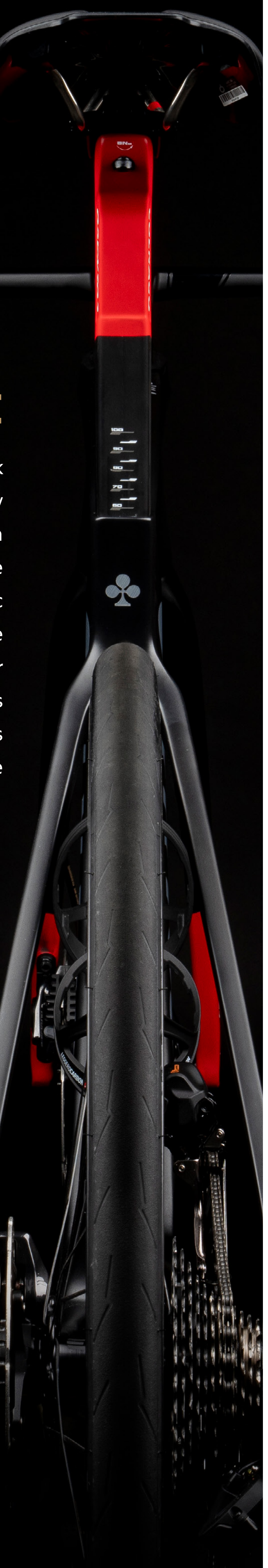


Plot 4 Stack vs Reach

V3Rs V4Rs

e. OVERALL ROBUSTNESS: CRASH WORTH AND MAINTENANCE

The overall design robustness of the bicycle can be crucial in 3-week competitions, as well as in a classic race. With respect to the V3Rs, the new V4Rs significantly improves the crash worth of the most exposed parts which may be subjected to impact in racing conditions. An example is given by the completely new designed seat stays, which, besides their more aerodynamic shape, also significantly improve the flexural and impact resistance. The robustness of this design also minimizes the need of maintenance in, for example, the new headset, fully provided by Ceramic Speed, which uses SLT technology with unique solid polymer and stainless-steel components to "remedy two of the most common causes behind bearing failure: the absence of lubrication and grease contamination through dirt ingress".



V series

Colnago introduced the "V" series in 2014. It consists of top-end monocoque carbon frames developed to satisfy the most demanding cyclists, who pay close attention to the weight-performance ratio. As the V1-r - the first model of the series - was the last developed in collaboration with Ferrari, the Prancing Horse logo is present on several parts of the frame.

2014

V1-r is one of the first frames on which critical aerodynamic studies were undertaken. All the tubes, including the fork and rear stays, have sections designed in the wind tunnel to minimise drag. These studies were then used and implemented on subsequent V2-r and V3Rs models.

2017

The **V2-r** - launched in 2017 - was further optimized for increased stiffness, better aerodynamics and a more pleasant look. It featured better carbon resin, an integrated seat clamp, a more full-bodied, stiffer saddle-node, and an overall increase in the stiffness of the BB area.

2019

In 2019 Colnago launched the **V3Rs**, which was even lighter and stiffer. It was designed to be the perfect all-round bicycle for performance-oriented riders. This bike was used both on flat and mountain races by WorldTour riders. Tadej Pogačar won the Tour de France 2020 and 2021 on a V3Rs.

About Colnago

Colnago Ernesto & C. S.r.l., known as Colnago, is a manufacturer of high-end road-racing bicycles founded near Milano in Cambiago, Italy, in 1954. The company first became known for high quality steel framed bicycles suitable for the demanding environment of professional racing, and later as one of the more creative cycling manufacturers responsible for innovations in design and experimentation with new and diverse materials including carbon fibre, now a mainstay of modern bicycle construction.

Among the many Colnago victories
18 Olympic Gold Medals,
63 World Championships,
23 Grand Tours,
41 Classic Monuments

Tadej Pogačar won both the 2020 and 2021 editions
of the Tour de France riding Colnago bikes.

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