COLNAGO

Y1Rs

**WHITE PAPER**

# **Y1Rs**
# Built to defy wind

## #BuiltToDefyWind

Y1Rs was born to be the ultimate weapon for races where speed is the crucial factor. The key words: extreme aerodynamics for maximum efficiency and **speed during the stage**, and impressive stiffness to **dominate the final sprint**.

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# FROM-RACE-TO-RACE APPROACH

Following the same From-Race-to-Race approach adopted with V4Rs, the input for this project came directly from the WorldTour teams.. And the input was clear: bring aerodynamic and bicycle responsiveness to a new level. At a competitive weight.

For Colnago this request became 4 focus areas:

1. **Aerodynamics**
   - From simulation to real world approach
   - Optimization of profiles and shapes
   - Total integration
2. **Real Stiffness optimization**
3. **Maximum efficiency from new UCI regulations**
4. **Sizing and geometry**

All the new parts and components followed the same strict validation procedure consolidated with V4Rs:

a. Concept and Design
b. Prototype phase
c. Internal testing and design selection
d. Complete system final confirmation

# 1. AERODYNAMICS

**The whole design process of Y1Rs was data driven.**

A massive use of CFD* simulations and experimental wind tunnel tests have been carried out to define the overall shape of Y1Rs and its subassemblies, with a particular focus on the frontal area. The analysis has been carried out thanks to the partnerships with two prestigious technical universities: Khalifa University (Abu Dhabi, UAE) and Politecnico di Milano (Italy).

جامعة خليفة Khalifa University

POLITECNICO MILANO 1863

**The state of the art of 'Design for Aerodynamics' in the bicycle industry today is:**

- To carry out CFD simulations to select the most promising design.
- To validate the results achieved results in the final stage

CFD tools are extremely powerful nowadays, allowing detailed analysis of the bicycle's aerodynamics. However, because of strong assumptions which are required by the computational tools and procedures, the analyzed riding conditions are often oversimplified.

**Colnago's approach for Y1Rs goes beyond conventional aerodynamics analysis for bicycles:**
With the support of partners and thanks to new technologies, in particular 3D printing, which allows quick prototyping with almost no constraint in term of shape, simulations and experimental validations were carried out together since the beginning of the 'Concept and Design' phase. In fact, with 3d printing, an idea or 3d sketch can easily turn into a physical prototype.

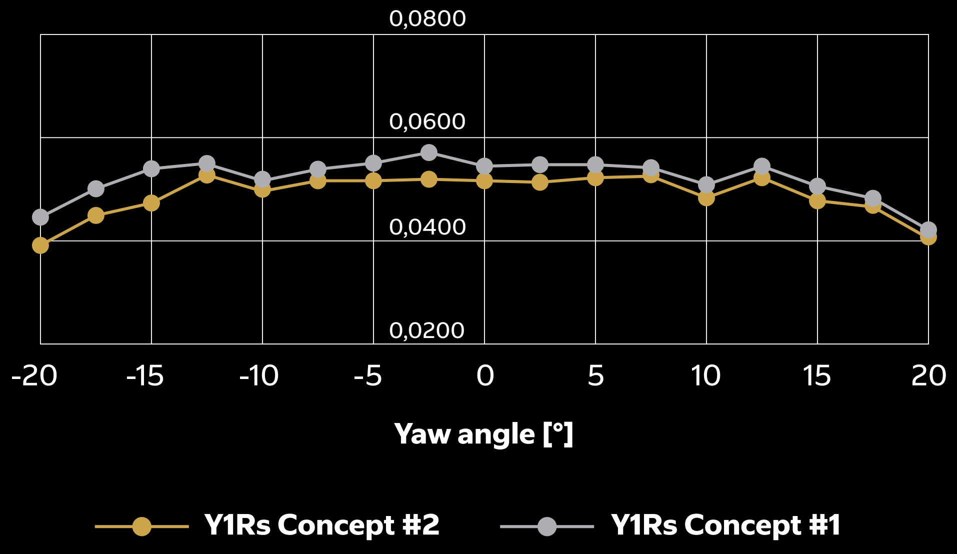
**The advantages of this approach:**

- Validate design and simulated results in each step, not only at the end of the process
- Use the acquired data to build more and more accurate CFD model to represent reality.

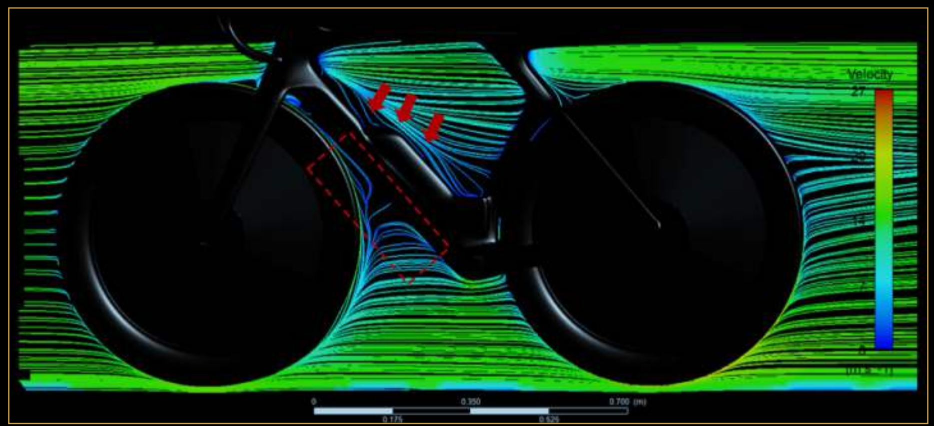
> ***"By collaborating with two university research institutes - Politecnico di Milano and Khalifa University - Colnago has developed an aerodynamic analysis model of unparalleled accuracy."***

*CFD (Computational Fluid Dynamics): is a branch of fluid mechanics that, thanks to specific software, uses numerical analysis to solve problems that involve fluid flows. Related to cycling, it is useful to simulate the airflow around the bike and drag force of different design solutions.

Examples of experimental test and simulation to select two different down tube solution on bicycle preliminary design




a.



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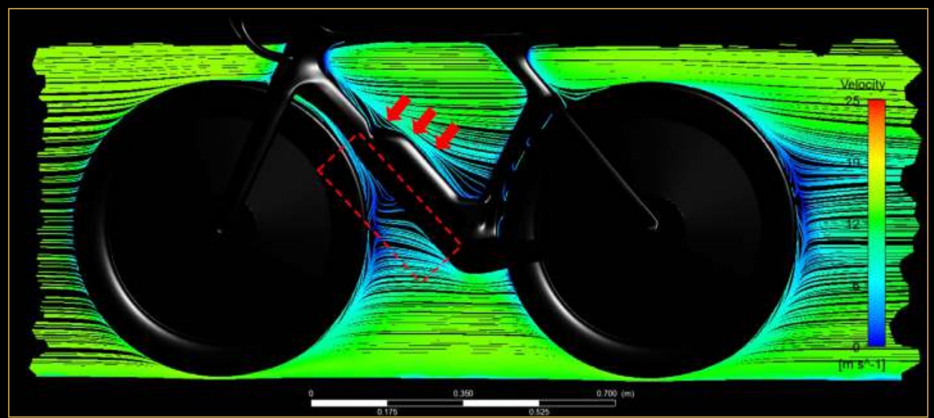


**Notes for reading Plot and Table:**
• The "Yaw" on the horizontal axis is the wing incidence angle. For instance, 0° yaw means that the wind is perfectly in the direction of the bicycle speed, while 45° means that the wind is perfectly lateral and its speed is the same as the cyclist's speed. According 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.



This is one of the first prototypes used to fine tune our CFD model. The final bike is the result of multiple iterations"

## Build up Colnago CFD model:
## Not only a matter of drag

The overall drag is a force acting opposite to the relative motion of the bicycle. It is the combination of two effects:

• Pressure drag: responsible for most of the drag and generated by pressure difference between the front and the rear of the bike and cyclist. High pressure in the front and low pressure behind, mean high power required to the rider to overcome this pressure difference, which generates a 'suction' effect. For example, when the air flow detaches from a body, it suddenly generates a pressure difference, and so drag.

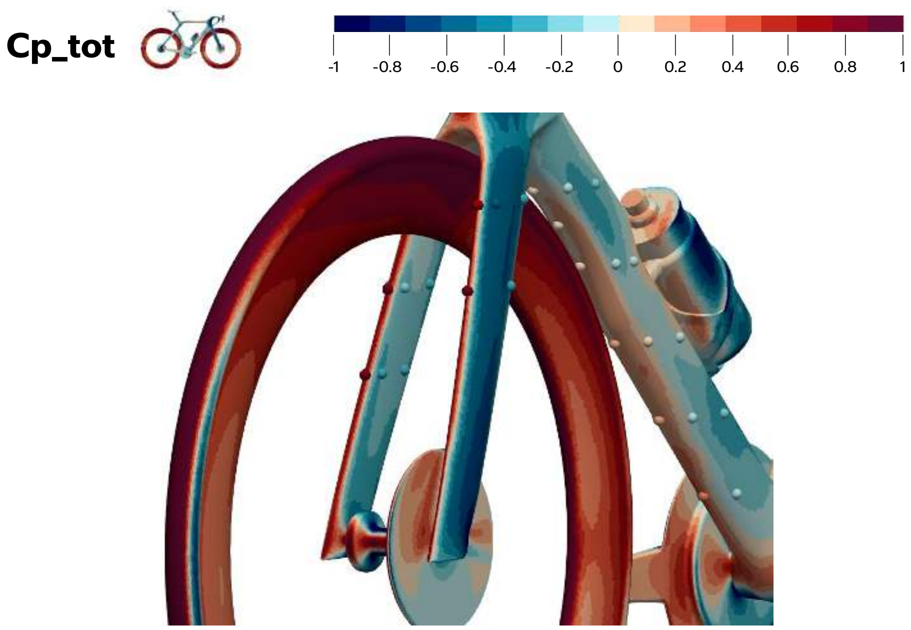
• Friction drag: due to friction between the fluid and the external surface of a solid body. Because of relatively low speed and air viscosity, its contribution is usually smaller than pressure drag in cycling.

> *Colnago drilled holes in a frame at 70 different points and inserted sensors to measure the air pressure on each individual area of the bike.*



Considering the extreme level of bicycles' aerodynamic performance nowadays, pushing forward the level of performance means refining the analysis tools more and more, understanding in detail what is happening in the thin layer of air in contact with the bike. Where flow can detach, generating drag. This thin layer is called the Boundary Layer* and the more its analysis is refined, the longer the computational time is (increment more than linear!). That's why most of the standard CFD analysis simplifies it. To understand the Boundary Layer, Colnago carried out a bike pressure mapping to characterize the real behavior of flow in contact with the bike and build up more accurate models.

The pressure mapping test consists in installing pressure gauges on specific points of bike or components (average of 70 gauges per bike). Of course, a custom frame must be built for this purpose to route all the involved cables, and this was possible thanks to 3d printing.
The main area of interest was the frontal area, responsible for most of the drag of the bicycle and featured by an air flow not yet perturbated by the presence of the cyclist. The gauges have been placed in different positions on the fork, cockpit headtube and downtube, both in simulated attached and detached flows area in order to investigate both the absolute value of the punctual pressure and to locate the flow detachment points under different wind conditions (flow speed and yaw angle).




*Boundary layer is the thin layer of fluid in the immediate proximity of the body surface formed by the fluid flowing along the surface. Its thickness depends on different factors (kind of fluid, speed, analyzed body geometry, etc.) and for bicycle analysis it is usually a few millimeters thick.

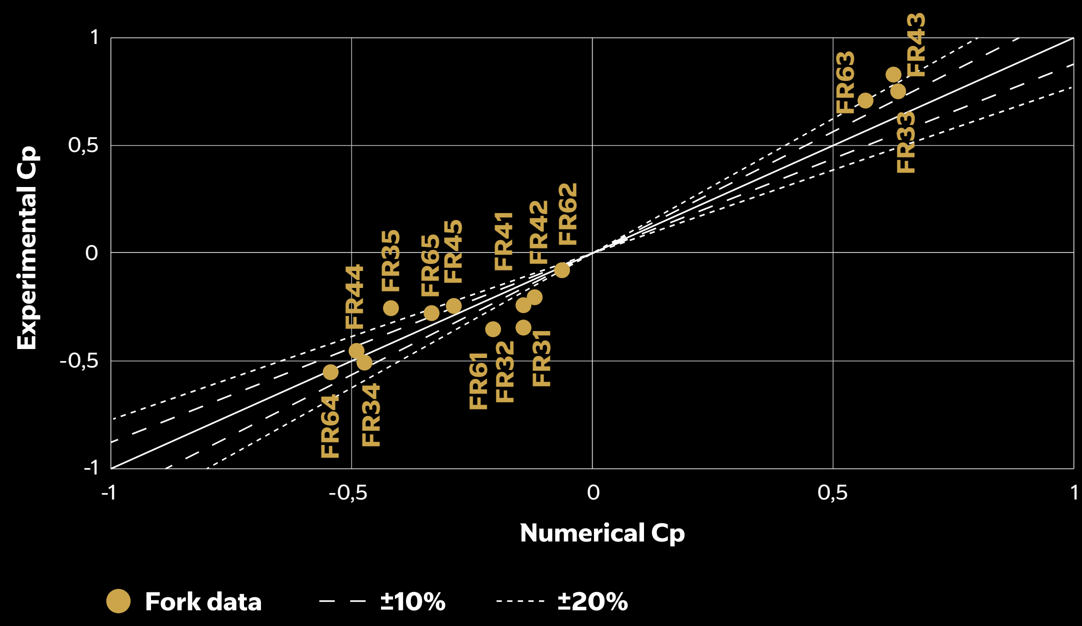


Once this huge amount of data has been collected in the wind tunnel, the most difficult and interesting part of the job was to fine tune the CFD model to match experimental results (mesh analysis, turbulence models, boundary conditions, flow and bicycle characteristics, etc.)

Achieved results:
• Analysis at punctual pressure and adjustment of CFD model and mesh
• Precise locate flow detachment and turbulence characterization.

| Experimental Drag Area | Standard Method and Tool | Colnago Simulation |
|---|---|---|
| Reference value | ~ 30% average error | ~ 15% average error |

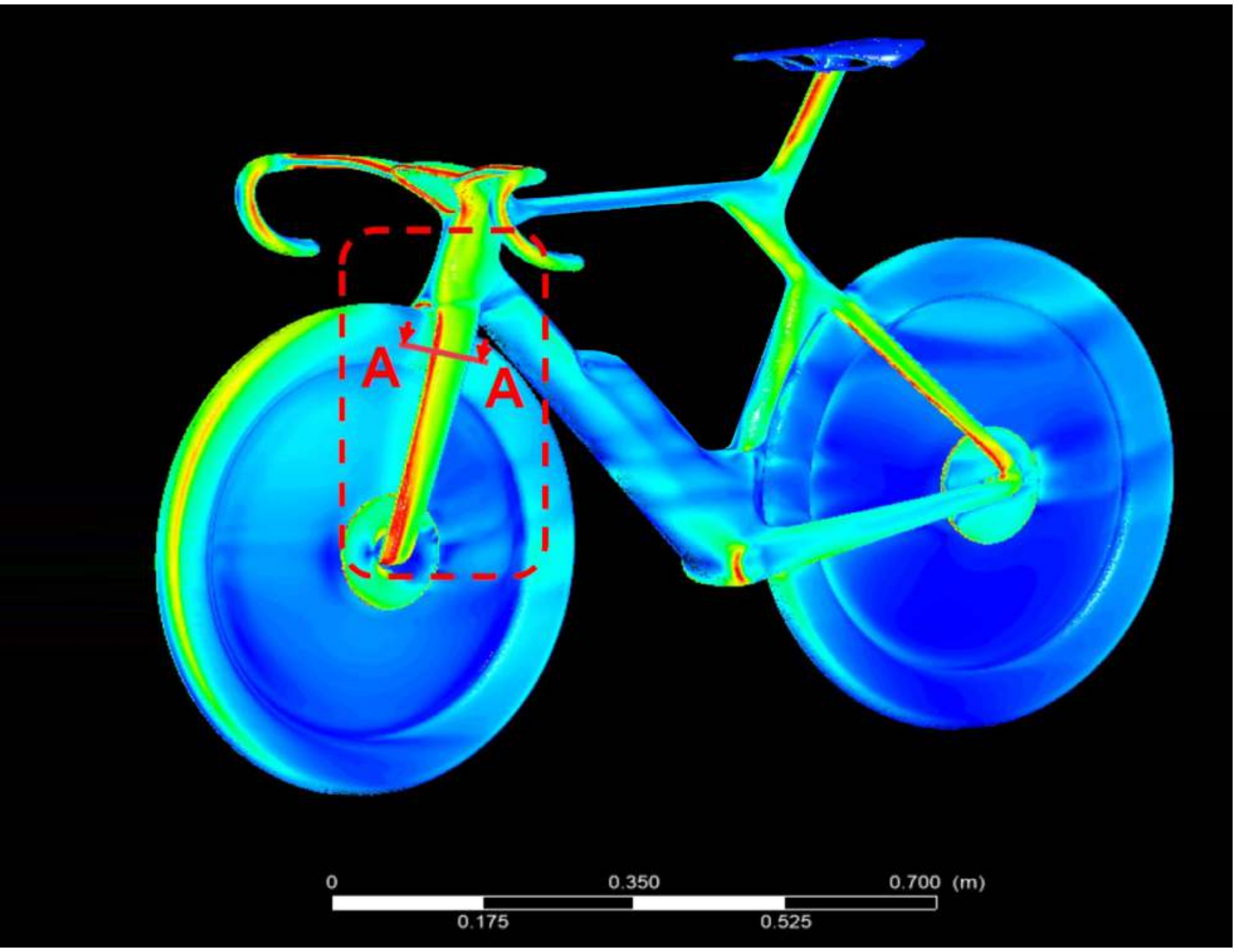
> ***“Colnago CFD model is twice more accurate than the standard method used in aerodynamic studies.”***




Example of deviation between experimental value and value estimated by the CFD model on a fork arm. The average error of our model is 15%, whereas with current standard models it is around 30%

## Results: Optimization of tube profiles and position and frontal area:

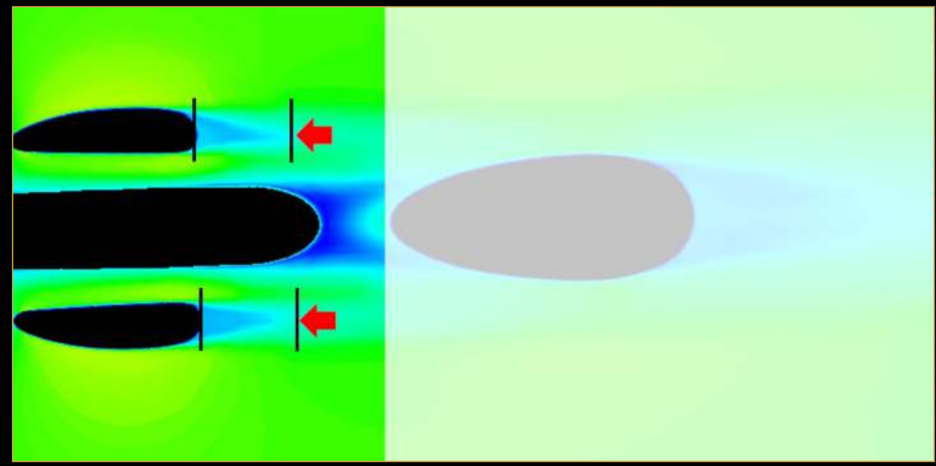
• Optimization of profiles. Each profile has been optimized in both frontal wind and in most frequent cross wind conditions according to WAD weighted value.



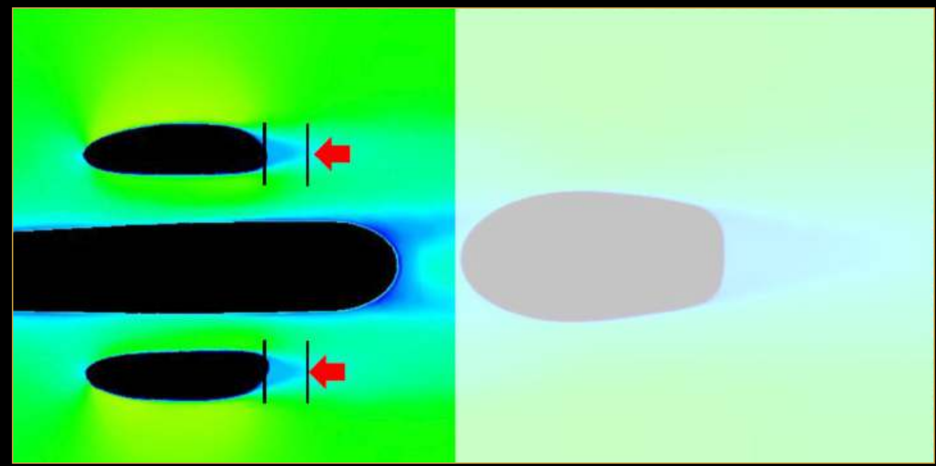

**Notes for reading Plot and Table:**
• WAD (Weighted Average Drag) drag, considers the drag at the different yaws, weighted with the probability to occur in such a condition (heavier weight for low angles and lighter for big angles). It represents an average value (or saving) across different conditions, which means that the effective saving for each ride (or race) can be lower or higher, according to the actual wing and track features. Someone may say it is not a real measurement, but it is still the most direct and intuitive way to sum up the behavior of a bicycle in a cross wind.



### Profile 1



### Profile 2

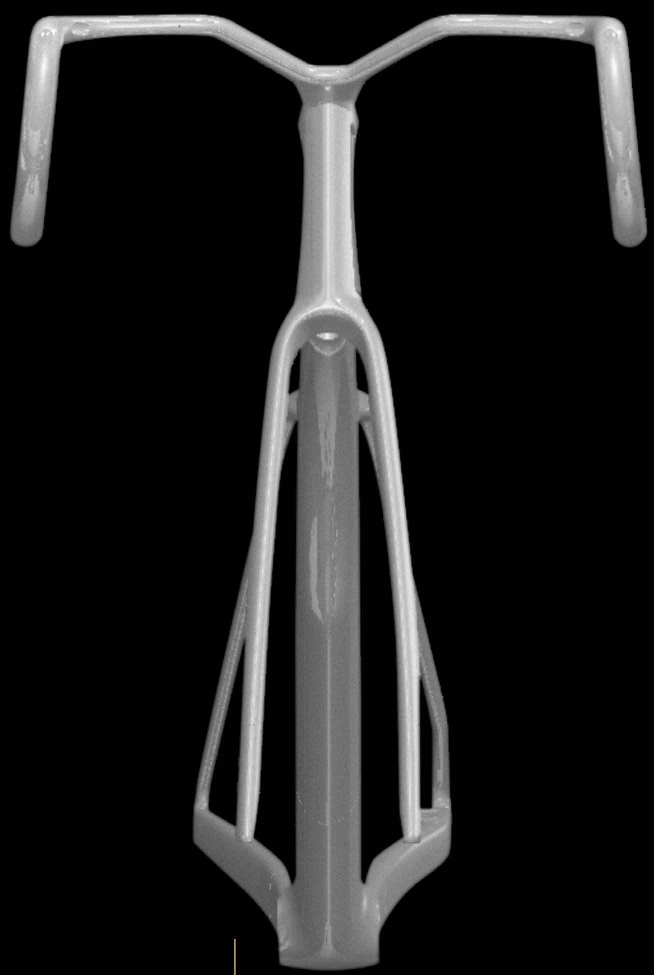


• Optimization of tube position. Tubes position has been optimized to achieve the best aerodynamics, without compromising stiffness and weight (ex. DT curvature and distance from the wheel)

# -19%

**Extremely reduced frontal area.**

The frontal area of Y1Rs is among the smallest in its bike category thanks to the innovative Colnago dual plate cconstruction which enables reduction of the head tube area by (reduce the headtube area by 19%) without compromising the overall stiffness.



**Y1Rs**
23438 mm2 *

**V4Rs**
28698 mm2 *

*frontal areas provided removing the drops, whose contribution is affected by the presence of hands and brake levers.



## Brand new integrated cockpit CC.Y1 with WYND© shape.

The new CC.Y1 is the most aerodynamically efficient drop bar Colnago has ever realized. Main features:

• Optimized foil profile for optimal efficiency

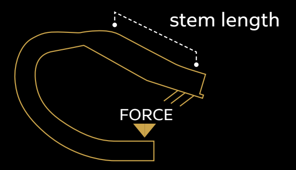
• Optimized V-shape for no flow detachment in the central area compared with traditional handlebar (simulation CC.01 vs CC.Y1)

• Full integration of the handlebar and spacers within UCI boundaries.

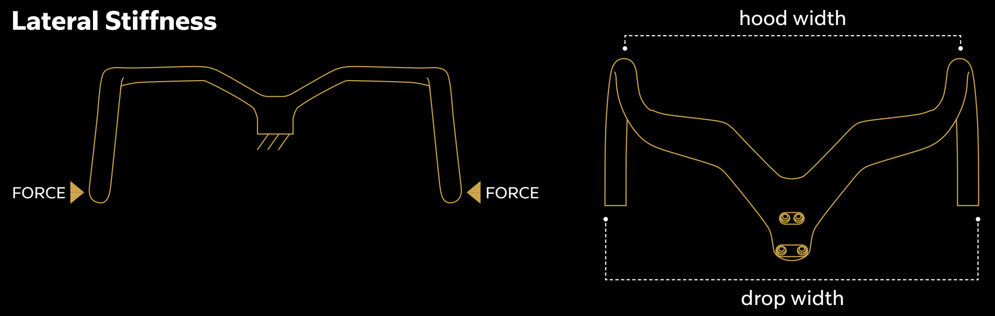
# +16%

The aerodynamic performance has been achieved without compromising the overall vertical and lateral stiffness. Being the bicycle conceived for fast riders and sprinters; high handlebar deformation cannot be tolerated. Therefore, once the shape has been confirmed, several carbon layups and headset concepts have been tested, before choosing the final one. The result is that CC.01 is stiffer than the selected reference handlebar on the market **(16% stiffer than reference competitor in vertical and lateral stiffness according to Colnago internal test).**

### Vertical Stiffness




### Lateral Stiffness




| | Sizes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **hood width - drop width** | 377-400 | 377-400 | 377-400 | 377-400 | 377-400 | 397-420 | 397-420 | 397-420 | 397-420 | 397-420 |
| **stem length** | 95 | 105 | 115 | 125 | 135 | 95 | 105 | 115 | 125 | 135 |



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## Integrated bottle cages

Standard bottles are not aerodynamic. However, they are the lightest and most practical solution both in races and in training. Colnago designed custom bottle cages to perfectly match the shape of the frame, **minimizing the aerodynamic loss due to the bottles**. Everything at a competitive weight and within UCI constraints.

The downtube bottle cage also features support for a Di2 battery in the downtube, further easing mounting and maintenance.

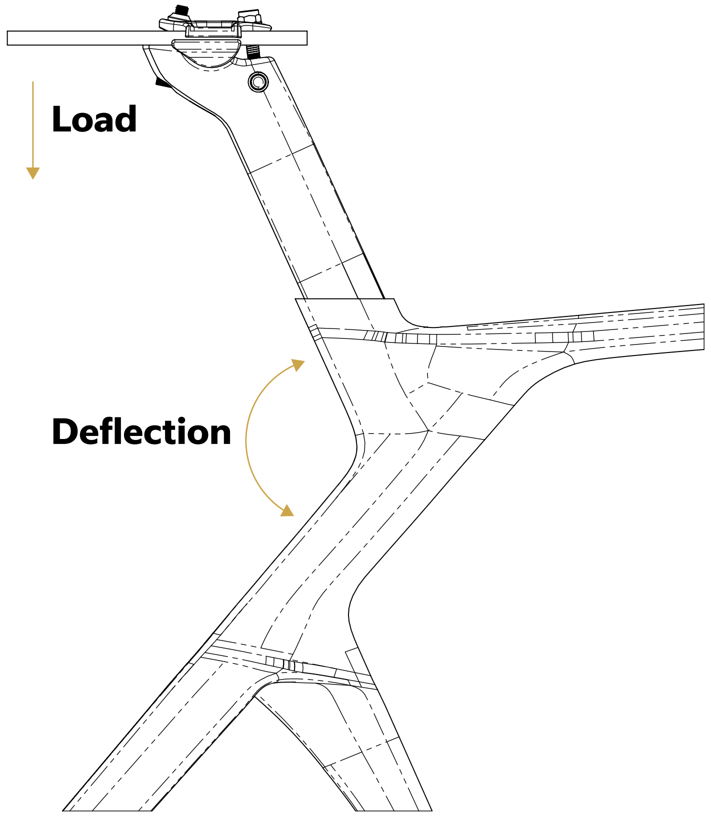
## Seatpost joint - DEFY© shape

This zone was designed on the basis of the new, more permissive UCI regulations on the development of bike shapes.

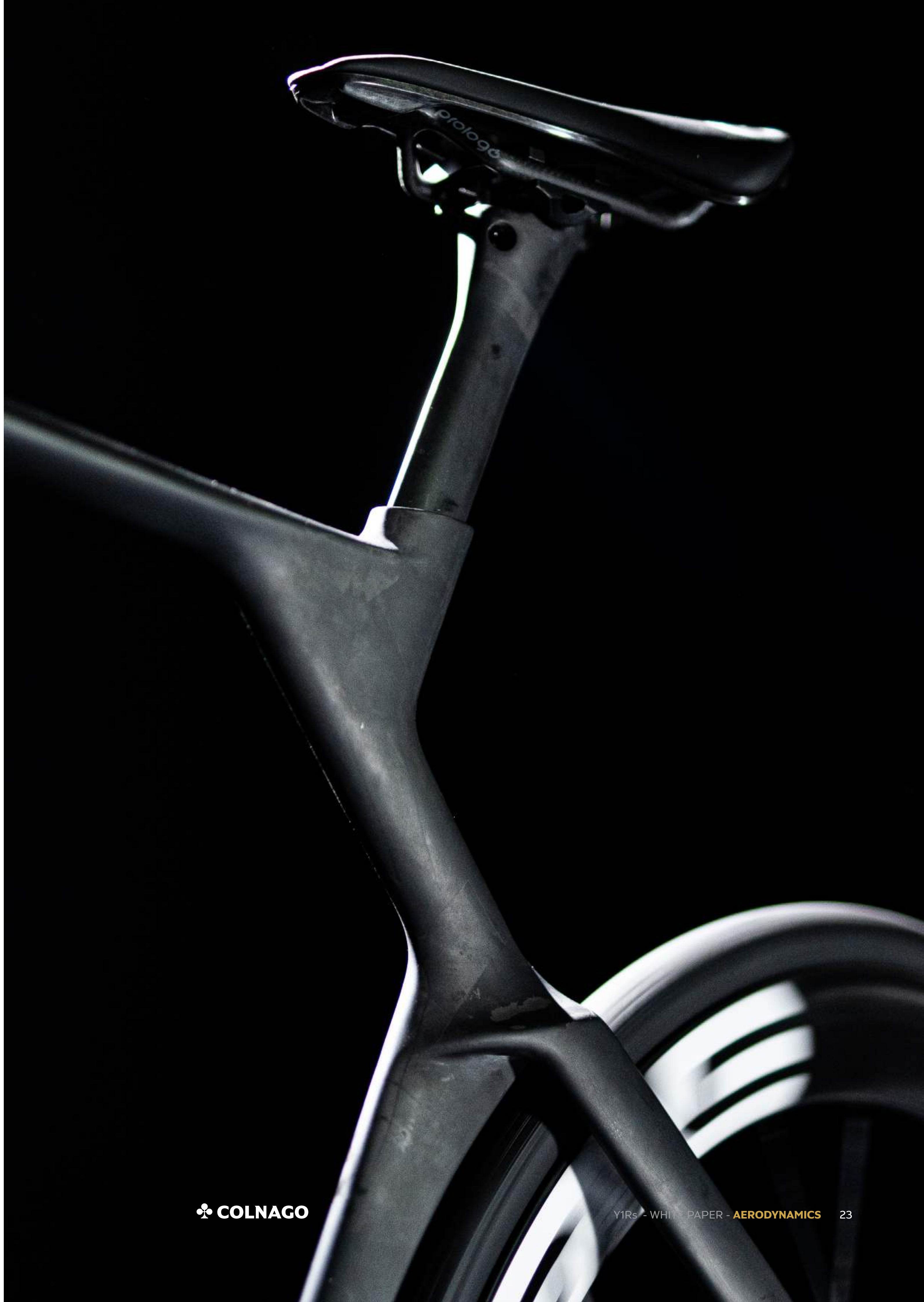
The seatpost joint area is now a sort of union of two inverted 'y's'. The seatpost is misaligned in relation to the seat tube, which also has a different angle of inclination.

The seat tube now follows the rear wheel, in pursuit of greater aerodynamic performance in a critical area for airflow.

The seatpost, on the other hand, is more inclined than usual, ensuring greater compliance. The effect is a bike that - despite the increased stiffness of the frame - is pleasant to ride over long distances and in longer training sessions.





## The Test and Final Results

At the end what matters for WorldTour teams is how faster the bicycle is with respect to previous models and competitors.
To acquire a reliable dataset in the wind tunnel on a complete bike is not so easy. . The best way to acquire repeatable and comparable data is designing a Colnago own test setup. **A fully adjustable 1:1 mannequin has been internally designed and 3D printed to repeat the exact WorldTour team rider position** with no variations along all the testing days. As the rider is responsible for the great majority of the drag, a small variation of his/her position from a test to another can make the data acquisition not reliable.

## In the wind tunnel Colnago always tests in two different configurations

**Stand-alone bicycle:**
(Bicycle +2 bottle cages with one bottle, @50km/h, yaws 0°÷15°)

**Complete racing setup:**
(Bicycle + Mannequin +2 bottle cages with one bottle, @50km/h, yaws 0°÷10°)

A standalone bicycle usually offers more accuracy, but it doesn't represent what happens in the real world since the bike is always interacting with the rider, who is responsible for most of the drag. For Colnago it is crucial that results are coherent in both setups. The presented results are the average of 3 different data acquisitions for each setup, performed to reduce and compensate the measurement variability.

> ***In a real racing setup, you need 20 watts less on a Y1Rs to go 50 km/h than if you were riding a V4Rs***

The difference with the top aero competitor is small in the condition of absence of wind. However, as soon as the weather starts to be more windy (with wind coming either from the front or from a slightly lateral direction) Y1Rs increases its advantage on its closest competitor in the market in terms of aerodynamic efficiency.



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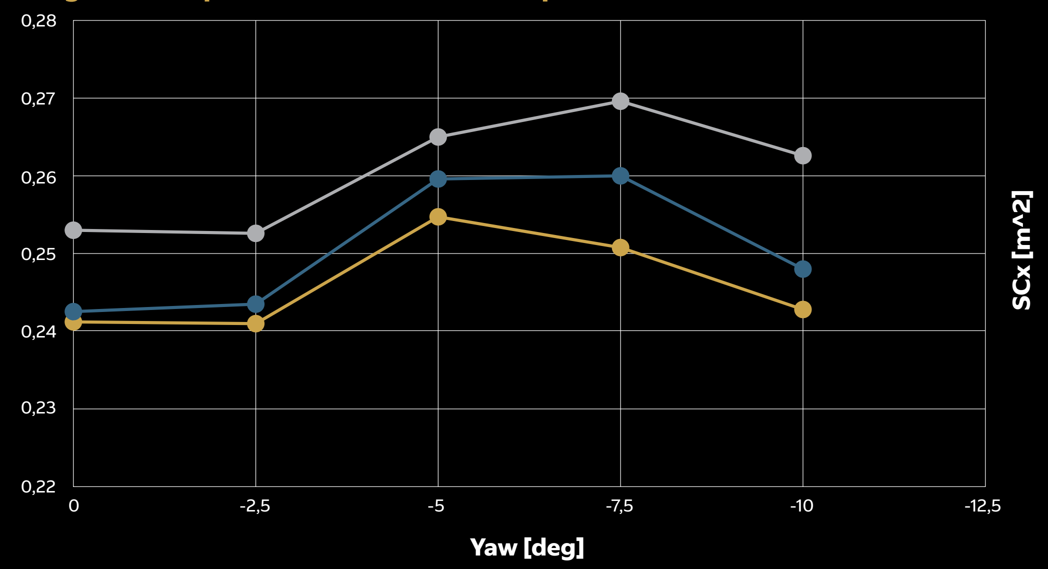
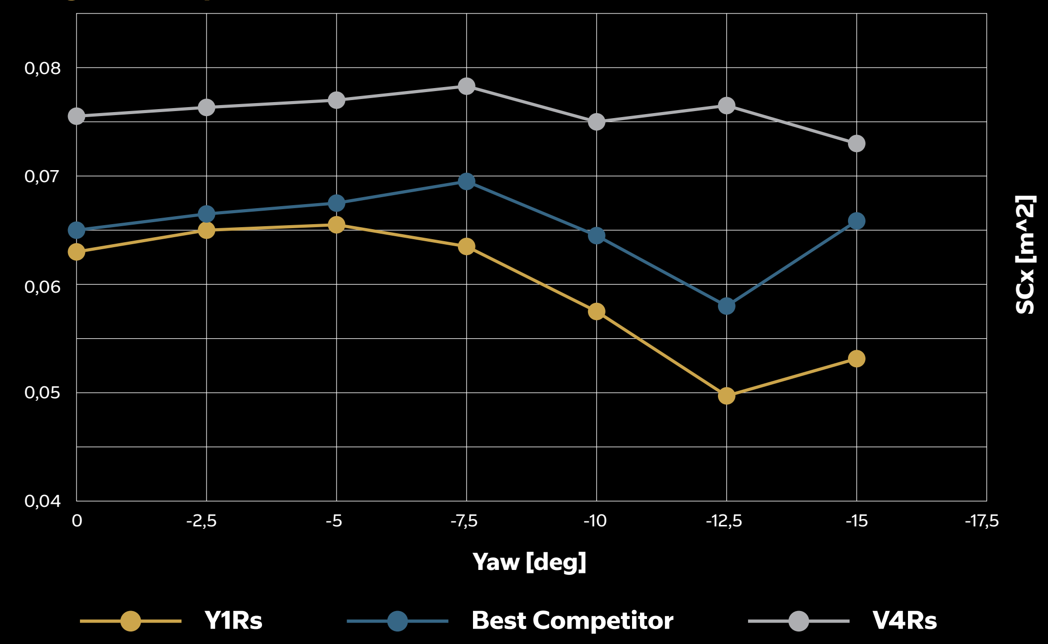
**Drag area comparison - Bike with Mannequin**




**Drag area comparison - Stand-alone bike**




The absolute values of SCx are dependent on the wind tunnel and the airflow characteristics used during the test. All tests were carried out on the same day and in the same wind tunnel, replicating the same conditions.

| | Bike with Mannequin | | Stand-alone bike | |
|---|---|---|---|---|
| | Power 0° [W] | WAD [W] | Power 0° [W] | WAD [W] |
| **Y1Rs** | 395 | 474 | 103 | 117 |
| **V4Rs** | 415 | 499 | 123 | 145 |
| **BEST COMPETITOR** | 396 | 482 | 106 | 126 |

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# 2. REAL RIDING STIFFNESS OPTIMIZATION

Y1Rs is conceived to be the fastest Colnago road racing bike, and, consequently, the best choice for sprinters. WorldTour sprinters look for two main performances: aerodynamics and stiffness.
Colnago has developed new testing setups and methodologies to measure the frame deformations in different points under multiple loads, to simulate what happens in real riding conditions. The deformations are then summed up in one number that Colnago calls Real Riding Stiffness. With the same approach adopted as for the V4Rs, the stiffness has been increased to offer what the bicycle has been designed for, maximum responsiveness in the final sprint.

RRS-Sprint is a combination of rear triangle stiffness, bottom bracket stiffness (out of plane*), fork stiffness (out of plane*) and handlebar stiffness (vertical and lateral). Loads are settled to simulate a sprint of 1500W with an average rider weight of 75kg, RRS-Climbing is a combination of bottom bracket stiffness (in plane*), fork stiffness (in plane) and handlebar stiffness (vertical) and seatpost (in plane*). Loads are settled to simulate a 60kg rider, climbing in a seated position at 390W.

| | **RRS-SP (sprint position)** | **RRS-ST (climbing position)** |
|---|---|---|
| **V4Rs** | Reference value | Reference value |
| **Y1Rs** | 3.5% stiffer | Aligned |

*Out of plane means that forces are applied in a plane angled with respect to the longitudinal plane.
**In plane means that forces are applied parallel with the longitudinal bicycle plane.

## 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 the rider is forced to climb seated.

## c. TO ACHIEVE THE BEST FROM THE NEW UCI REGULATIONS

In 2021, when the development of Y1Rs officially started, the UCI had just communicated the upcoming regulation revision, which allowed a 8:1 tube profile* and new possible positions for the seatpost.

From here the characteristic Y-shaped seatpost joint has been conceived. Advantages:

• Best compliance with the ground in the seated position. In long flat stages or in a breakaway it is important to maintain the aerodynamic tuck position to maximize aerodynamic efficiency. The Y-shaped seatpost joint (seat tube-seat stays – seatpost) allows better vertical vibration and shock absorption compared to traditional solutions, without affecting the stiffness at the bottom bracket and at the rear hub. Benefit for the rider: more comfort in tuck position with no power loss.
• Given a tube cross section placed in accordance with the wind flow, the more this tube is tilted in the direction of the wind, the longer its relative profile with the wind is. This must be achieved without significantly increasing the length and consequently the weight. Longer profiles mean more probability for the air flow to be linear, in an area already affected by the riders' spinning legs.

* The 8:1 ratio of the tube profile means that for every 8cm length of each tube, its minimum width is 1cm



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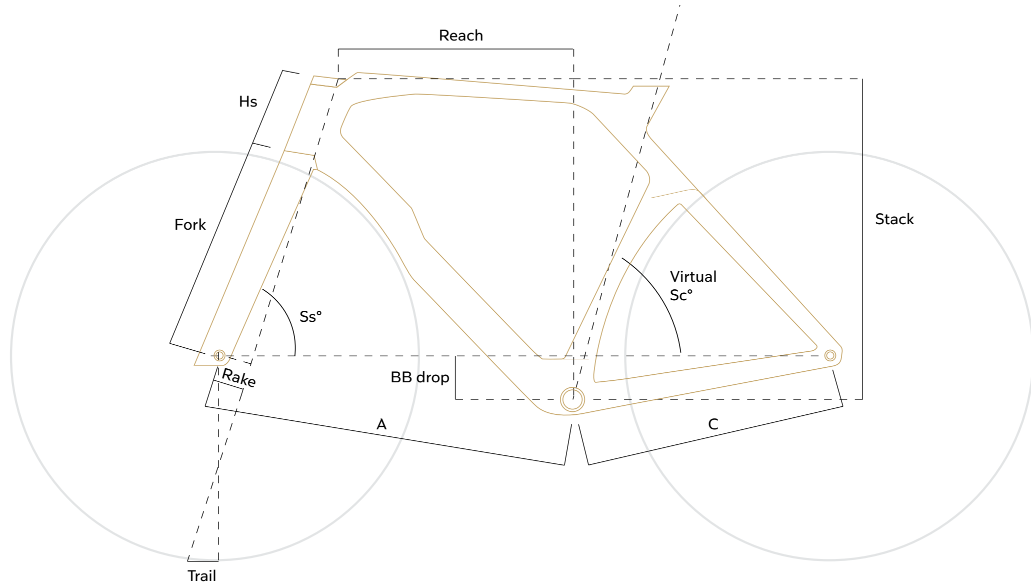
## d. NEW RACING GEOMETRY, AVAILABLE IN 5 SIZES




| Size | Ss° | Sc° | Reach | Stack | Fork lenght | Rake | Trail (28-622 tyre) | Hs | C | A | BB drop |
|---|---|---|---|---|---|---|---|---|---|---|---|
| XS | 70.8 | 75 | 368 | 495 | 376.5 | 55 | 61 | 88.5 | 408 | 577.5 | 74 |
| S | 71.9 | 74.5 | 377 | 520 | 376.5 | 49.5 | 59.5 | 108.5 | 408 | 579.5 | 74 |
| M | 73 | 74 | 386 | 540 | 376.5 | 45 | 57.5 | 126.5 | 408 | 581 | 72 |
| L | 73.5 | 73.7 | 395 | 565 | 376.5 | 42.5 | 57 | 150.5 | 408 | 590 | 72 |
| XL | 73.5 | 73 | 404 | 590 | 376.5 | 42.5 | 57 | 176.5 | 408 | 606 | 72 |

Y1Rs geometry and sizing is the result of a continuous exchange of feedback between Colnago and the two WorldTour teams, UAE Emirates and UAE ADQ, to cover the needs of all the riders aiming for maximum speed in flat or rolling races.

**With respect to V4Rs the main differences are:**
• Slightly steeper HT and Sc*angle, to accommodate a more forward oriented and tuck position to optimize aerodynamic and power transmission.
• Increased Reach/Stack ratio (curves moved to the right in the Reach-Stack plot) to accommodate more aggressive and extended positions.
• Custom fork for each size, to maintain the optimal constant trail along the sizes. The trail is the steering force arm on the ground which is strictly related to the handling of the bicycle itself. For Y1Rs the trail is clearly conceived for pure racing application. Intuitive handling and responsiveness of the steering action are the key words for this model.

* The SC is measured at an average reference altitude. The actual SC depends on the chosen saddle height.

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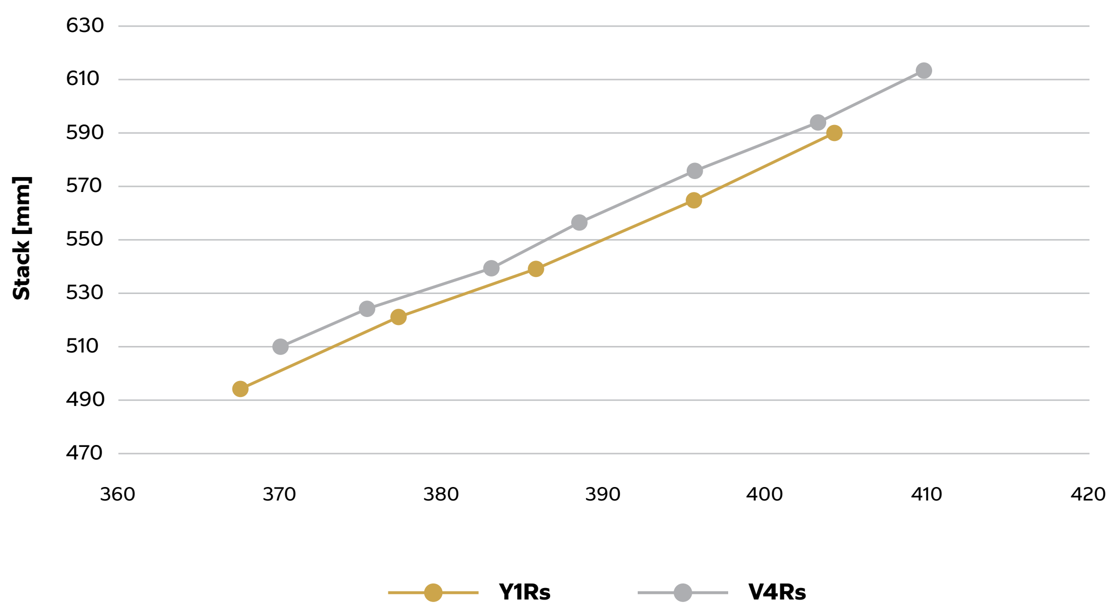



• Available with 2 seatpost options (0 and 15mm setback)
• Tire clearance up to 32-622

## WEIGHT

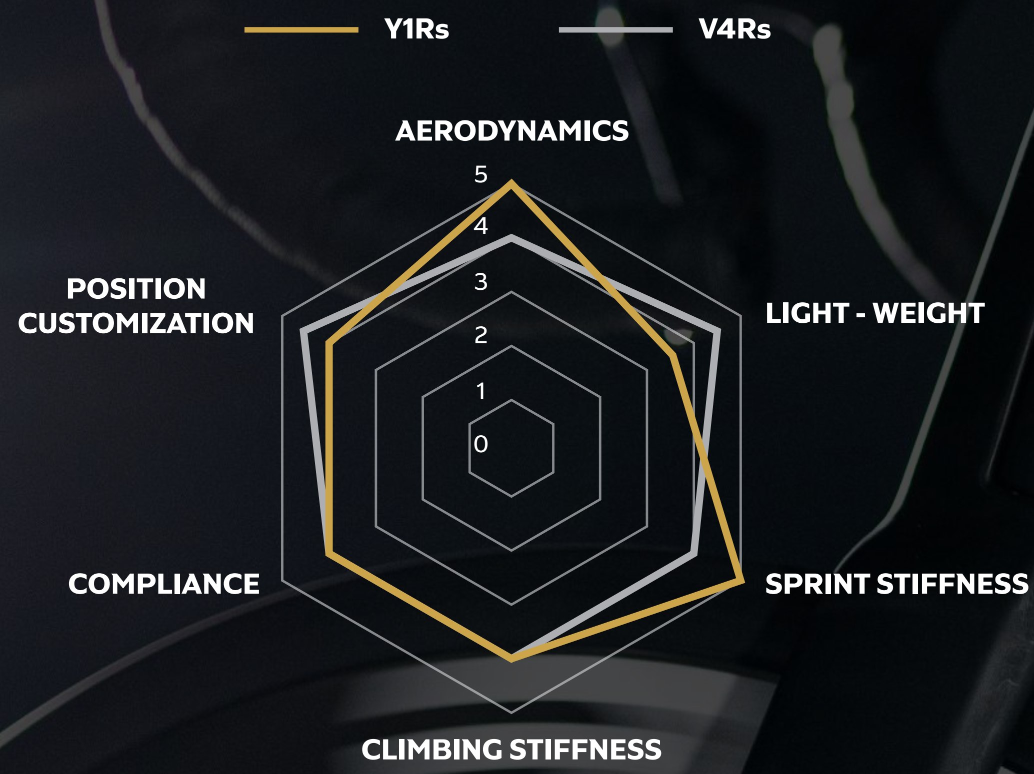
| Size | Ready-to-paint frame [g] | Fork weight [g] | Total frame-kit weight [g] | Total frame module [g] |
|---|---|---|---|---|
| Y1Rs | 972 | 450 | 1422 | tbc |
| V4Rs | 798 | 375 | 1173 | 1668 |

• 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:
  • Y1Rs frame-kit + CC.Y1 + Headset
  • V4Rs Frame-kit + CC.01 + Headset



**Position-setting tool for size and components**
Colnago has developed a tool, that, given input data from a biomechanical test or from an already owned bike, helps choose the most suitable frame size and components (handlebar & seatpost)

**Which model suits you best?**




Y1Rs is the ultimate aerodynamic machine designed for professional and expert riders for whom only speed matters. If you are used to an aggressive position and to high speed, Y1Rs accommodates your needs pushing your performance to the next level.
Results and victories say it best that the V4Rs is a perfect all-rounder, able to provide a top-level performance in whichever condition it faces, from steep climbs to bunch sprints, accommodating enhanced customization and ease of setup.

**#BuiltToDefyWind**

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