VITTORIA
WHITE PAPER

MAKING SENSE OF RIM AND TIRE WIDTHS

HOW RIM WIDTHS AFFECT TIRE SIZE, PROFILE, AND PERFORMANCE

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IN RECENT YEARS, BICYCLE TIRE CROSS-SECTION WIDTHS HAVE GROWN INCREASINGLY LARGER. DESPITE THE HISTORICAL WISDOM WHICH HAS TRADITIONALLY TRADED NARROWER WIDTHS FOR THE PERCEPTION OF INCREASED SPEED, RECENT DATA FROM BOTH LAB AND FIELD TESTS HAVE PROVEN THE CONTRARY, SHOWING MEASURABLE PERFORMANCE BENEFITS IN ROLLING PERFORMANCE WHEN A RIDER SWITCHES TO A SLIGHTLY WIDER TIRE.

AS THIS TIRE TREND EVOLVES, THE QUESTION THEN BECOMES ONE OF RIM COMPATIBILITY.

REGULATING THIS RELATIONSHIP IS THE EUROPEAN TYRE AND RIM TECHNICAL ORGANISATION (ETRTO), WHICH EXISTS TO STANDARDIZE AND HARMONIZE TIRE AND RIM FITMENT, ENSURING COMPATIBILITY AND SAFETY FOR USERS. HOWEVER, WHILE THIS STRUCTURE PROVIDES BOUNDARIES, UNDERSTANDING THE INTRICACIES AND RESULTING OUTCOMES OF VARIOUS TIRE AND RIM WIDTH COMBINATIONS CAN PROVE CONFUSING.

THE FOLLOWING WHITE PAPER EXPLORES THIS PHENOMENON FURTHER, DIVING INTO THE EVOLUTION OF PERFORMANCE BICYCLE TIRE AND RIM WIDTH, THE BENEFITS THEY PROVIDE, AND THE RELATIONSHIP ETRTO REGULATIONS PLAY IN THE PERFORMANCE EQUATION.

INTRODUCTION

Across industries, the pneumatic tire has changed the way we live and travel within our world. This simple yet effective device allows cars to drive, trucks to transport goods, and airplanes to land. Without the clever invention of the air-filled tire, none of this would be possible. As a cyclist, it is humbling to realize that our sport was the first inflection point of such a widespread benefit.

Inherently, pneumatic tires rely on air pressure to securely affix themselves to the rim, while simultaneously providing the ability to absorb impacts and provide traction. Pressure is what keeps the tire in place under acceleration, hard braking, and panic maneuvers. This set of tasks are critical for both the safety of the rider as well as for the performance of the wheel system.

To contain this air pressure and achieve these user benefits, proper fitment as well as a congruent interface between the tire and rim are crucial. Without both factors aligned, reliable compatibility cannot be achieved.

Given this, how might a consumer know which rim and tire may or may not be compatible? What may be the effect of tires and rims which are not ideally suited for use with one another?

In the following sections, we will take a practical look at how these measurements are formulated, as well as what to expect when you deviate from the norms which the system was designed upon.

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SECTION 1.
A FOUNDATION OF COMPATIBILITY

As standard, bicycle tires communicate dimensions within their stated size to use as a consumer reference, showing the rider what they can expect from a properly assembled wheel and tire system. These dimensions exist to guide compatibility of wheels the tire can be mounted on, as well as the cross-section width a user can expect once the tire is inflated. For example, a popular road bike tire size is often communicated as "700x28", where the two stated dimensions relate to the approximate inflated tire diameter and the exact tire width per model size variant.

The three main sizing standards are the French system, the Inch system, and the ETRTO system. All three systems assume that the tire is being measured when mounted on a wheel which uses the specified design rim internal dimension, relating to the given tire size.

The French system uses an estimated outer tire diameter in the first dimension, and tire width in the second dimension, both in millimeters (example: 700x28).

The Inch standard is similar to the French standard, but uses the Inch equivalent of the estimated outer tire diameter and tire width (example: 29x2.4). Both are inherently imprecise, as the outer diameter is estimated, and varies based on tire width.

The ETRTO standard differs from the French and Inch standards by using the tire width and the bead seat diameter (example: 28-622). This gives two precise measurement points which are fixed, regardless of tire width, and is therefore more accurate.

However, the consumer facing sizing convention only tells part of the story. While these external dimensions represent the outwardly facing product, they are dependent on the lesser-known set of dimensions, which play the key role in fitment, size, and ultimately, performance.



FIGURE 1. A road tire being measured for width.

In simple terms, for every bicycle tire produced, there is a specific set of rim dimensions it was designed around. This collection of dimensions can be found on the design rim, which is unique to each specific tire size, according to the European Tyre and Rim Technical Organisation (ETRTO). Each design rim serves as a controlled foundation of compatibility from which to accurately build a given tire upon.

While the design rim is a singular collection of dimensions, it is not the only rim width which the given tire may be mounted on, as ETRTO allows for a small range of compatible rim widths +/- per tire width. However, with few exceptions, the design rim is the only rim which the tire will measure accurately upon in relation to the stated tire width, unless alternatively specified by the manufacturer. This is an important point to realize, as your rim may or may not match the design rim dimensions of your tire, which will directly influence the actual width, profile, and even circumference of the tire.

To better understand this, consider that external tire size points to the dimensions of the finished product when inflated, while the deeper math of the design rim relates to the touch points of the tire and rim, dictating how the external dimensions measure.

On the design rim, there exists a myriad of standardized internal dimensions and angles. However, for the purpose of comparing tire width as it relates to rim width, the two dimensions of the design rim which are most operative are bead seat diameter and internal rim width. If you ask most cyclists, many will not know what these measurements are on their own bike, so if these terms are foreign to you, fear not. In the following sections, we will define these terms and outline the role they play in accurate tire sizing.

TIRE WIDTH (mm)	18 - 22	23 - 28	29 - 34	35 - 46	47 - 57	58 - 65	66 - 70	71 - 83	84 - 113	114 - 132
DESIGN RIM WIDTH (mm)	15	19	21	23	25	30	35	45	76	94

REFERRED TO CLINCHER TIRES (HOOKED AND HOOKLESS RIMS)

FIGURE 2. ETRTO Design Rim chart.

RIM WIDTH (mm)	TIRE WIDTH (mm) 18	20	23	25	28	32	35	37	40	44	47	50	54	57	60	62
13c	■	■	■	■												
15c			■	■	■	■										
17c				■	■	■	■	■	■	■	■	■				
19c					■	■	■	■	■	■	■	■	■	■	■	■
21c							■	■	■	■	■	■	■	■	■	■
23c								■	■	■	■	■	■	■	■	■
25c										■	■	■	■	■	■	■
27c											■	■	■	■	■	■
29c													■	■	■	■

■ RECOMMENDED RIM WIDTHS

REFERRED TO CLINCHER TIRES (HOOKED AND HOOKLESS RIMS)

FIGURE 3. ETRTO recommended internal rim widths per tire width.

SECTION 2.
BEAD SEAT DIAMETER

In the 700x28 example referenced earlier, the approximate external wheel/tire diameter is expressed as "700", which measured in millimeters. This is the cause of much confusion, and so we will first begin by giving some context.

Prior to the ETRTO standard, a commonly used sizing convention was known as the "French Standard". This standard utilized a combination of a number (which represented an estimation of the diameter of an inflated tire), followed a letter which gave an indication of tire volume. As the tire volume across variations increases, the rim diameter reduces, maintaining a fairly consistent outer diameter of the wheel system.

The image below shows five variations of a 650 mm system. The center example is known as 650B, which was a historically relevant variation which found a resurgence in modern off-road cycling around 2015, and is still widely used today.

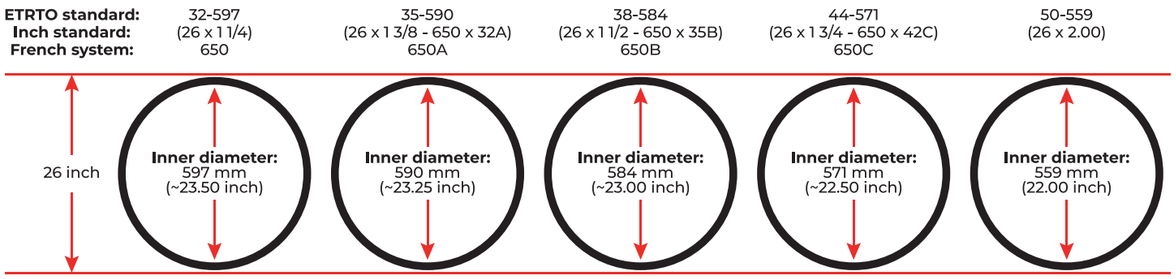


FIGURE 4. Different versions of the 26 inch tire standards.

This combination of number and the letter provides an estimation of the outer diameter of the tire, but without giving precise indications to the end user. While helpful in terms of consistency in the outer diameter of the wheel system, it is certainly a confusing approach.

Additionally, because each tire has its own construction and materials, each may also react differently to the internal air pressure, allowing for a variance in fixed diameters. Lastly, as users often utilize differing air pressure levels based on load, the amount of deformation lacks consistency across variations of the French standard.

For this reason, ETRTO has standardized and harmonized the designation by removing this variable and referring to a unique unambiguous measurement, the rim bead. In terms of wheel diameter, the critical (and exact) measurement for compatibility is where the tire beads meet the rim, known on the rim as the bead seat. This area is the horizontal shelf at the internal base of the rim wall, where the tire bead will sit, once the tire is inflated within the specified useful pressure.

As this shelf runs uniformly within the rim walls, around the entirety of the rim, it forms a measurable diameter. No matter the width of the rim, the bead seat diameter is fixed for the wheel size and does not vary. Conversely, you may also consider this dimension as a sort of internal diameter for a tire structure, which keys into the same dimension on the rim. As a result, this is obviously smaller than the external wheel and tire system dimension once inflated. In the case of the compatible wheel for a 700x28 tire, the bead seat diameter of this wheel measures 622 mm, as regulated by ETRTO. For this reason, you may see a tire which has a commercially stated size of 700x28 also communicate a stated dimension of 28-622.

The key takeaway here is that bead seat diameter forms the foundation upon which all other tire dimensions are built and does not vary based on tire width. It is critical for proper fitment, air retention, and maximum pressure blow-off certification.

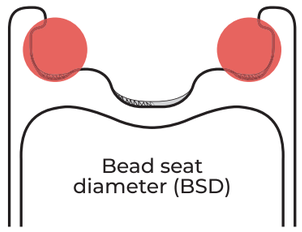


FIGURE 5. Cross section showing bead seat of rim.



FIGURE 6. Vittoria package which shows both French and ETRTO sizes.

SECTION 3.
INTERNAL RIM WIDTH

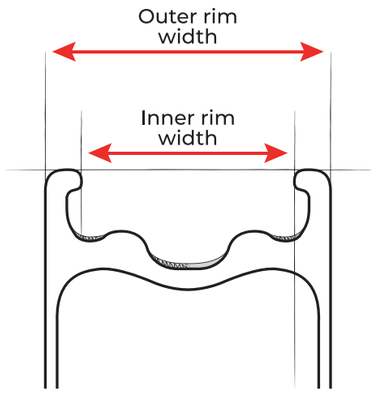


FIGURE 7. Cross section showing bead seat of rim.

Once we've established that the bead seat diameter of the rim is ETRTO compliant and compatible with the tire of choice, we must then turn to internal rim width to ensure accurate tire width. Internal rim width is simply defined as the internal distance between the vertically positioned rim walls, in which your tire will sit. Think of this as a vertical complement to the bead seat diameter, as this dimension plays a critical role in dictating tire profile and width.

As the tire is inflated, the pressure expands the tire beads outward until limited by the rim walls which secure their position. Once the tire beads are secured by the rim walls and sitting fully upon the bead seats, the pressure builds rapidly within the tire, forcing the tire into its final shape. Assuming the tire is produced to ETRTO standards, and assuming the internal rim width matches the design rim, the fully inflated tire will measure accurately regarding the stated width, within a range of tolerance which considers the different constructions and materials, the normal production variability (given the inherent elastic nature) and the testing variability.

Therefore, internal rim width is vital in the user experience, especially when setting expectations for true sizing.

As mentioned previously, the design rim is a target set of dimensions on which the tire was built. However, since there is a small range of other compatible internal rim widths for each tire width which are also ETRTO compliant, there exists a possibility that your tire may be mounted on a slightly narrower or slightly wider rim. In either case, when deviating from the internal width of the design rim, it is to be expected that the tire will not measure exactly true to stated size.

Assuming the wheel safely fits within your frame and fork, and that the chosen internal rim width is within the acceptable ETRTO range for the given tire, then this is perfectly acceptable.

This can be a common scenario for users of modern tires on older rims which may use a narrower internal rim width but are otherwise perfectly functional. Similarly, with the recent crop of wider rims, mounting this same width tire on a wider rim will most certainly increase the measured width.

The question remains, how much wider can the rim be, and what effect will this have on the tire. In the following section we explore this relationship and provide a general guideline for what to expect when experimenting with tire size.



FIGURE 9. Internal rim width measurement.

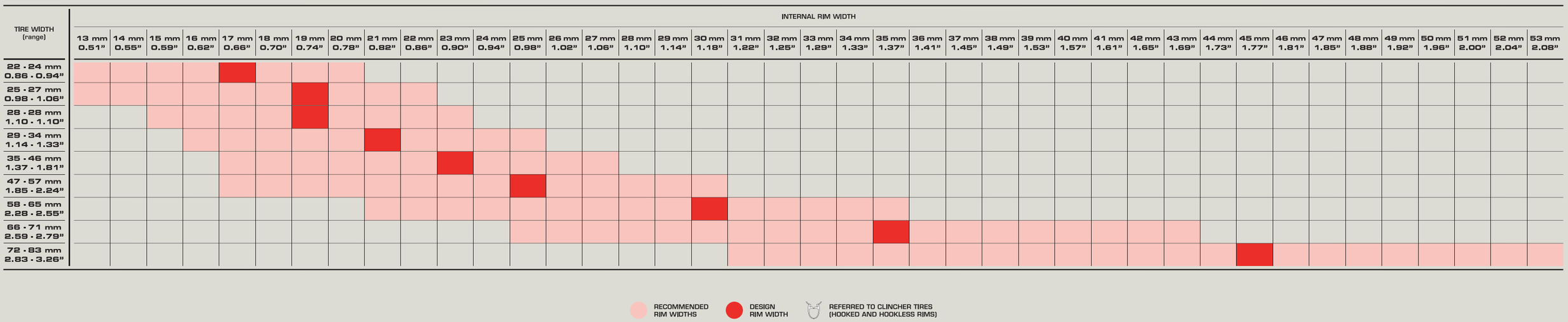


FIGURE 8. Tire measurement chart showing range of compatible rim/tire sizes (ETRTO standard).

SECTION 4.
SIZING UP/DOWN - THE COMPATIBILITY SPECTRUM

Over time, popular performance tires have grown wider, as the benefits of slightly wider tires have been discovered. The reasons are many, including increased rolling performance, better grip, and reduced rider fatigue. To ensure proper fitment and tire profile, ETRTO has also increased the corresponding internal rim width range, including the design rim per tire size.

This is all well and good if you are a rider who happens to own multiple wheel sets to choose from, or alternatively may be purchasing tires to go along with a new wheelset. However, the issue is often the mere fact that tires are a consumable item, and wheels are ideally not. For many, this means that once you have committed yourself to that expensive set of race wheels, you are similarly committed to whichever internal rim width the rims happen to provide.

So, what is a rider to do if they want to explore wider tires while using their existing wheels?

The technical answer is to acquaint yourself with the usable tire widths for the given internal rim width and stay within this range when shopping for tires. This approach will often give a broader range of tire options than one may assume and will likely allow for an appreciable change in feel and performance.

However, how this larger tire actually fits the given rim can often times be confusing. For example, assume you purchased a set of carbon road race wheels a few years ago, which feature a 19 mm internal rim width. You are currently using a 28–622 tire (aka 700x28), which fits well, and measures accurately, as the internal width of design rim for the 28 mm wide tire is aligned at 19 mm. All the hype is telling you to try a wider tire, so you upgrade to a 30x622 tire, only to find out it "measures small" at 29 mm.
Before you head to the internet forums to express your disappointment, consider this... the 30–622 tire uses an ETRTO design rim with an internal width of 21 mm. Therefore, it is expected to measure 30 mm in width when measured on a 21 mm internal width rim. Going to a smaller 19 mm rim brings the tire beads closer together, reducing the measured cross section width of the tire.

As a general rule, the tire width changes by ±0.4 mm for every 1 mm difference from the design rim internal width. For example, a 28–622 tire designed for a 19 mm rim and mounted on a 23 mm rim will have an approximate width of: 28 + 0.4 × (23 – 19) = 29.6 mm, plus or minus the tolerance specified by ETRTO for that tire size (±2 mm in this case).

Similarly, if you were to take the same 28–622 tire which you've familiarized yourself with using on your old 19 mm internal width rims and mount it on a wider 21 mm internal width rim, the tire would actually grow by roughly 1 mm, likely measuring close to 29 mm in cross section width.

The example gets really wild when you consider MTB tires, which are typically larger in volume compared to road tires. Not that long ago, a 29x2.25 tire was designed around a 21 mm internal rim width. As some of these tires have stood the test of time, many users have older versions of these tire models and are using them on modern wheels which feature an internal rim width of 28–30 mm. This means that the same tire could grow by as much as 4 mm in cross section width, if it were mounted to a modern 30 mm internal rim.

SUBJECT TIRE WIDTH	23	24	25	26	27	28	29	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66
TIRE WIDTH WHEN MEASURED ON ETRTO SPECIFIED INTERNAL WIDTH DESIGN RIM	23	24	25	26	27	28	29	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66
RELATED ETRTO SPECIFIED DESIGN RIM INTERNAL WIDTH	17	17	19	19	19	19	21	21	21	21	23	23	23	23	23	23	25	25	25	25	25	30	30	30	30	35
TIRE WIDTH ON DESIGN RIM +1 MM INTERNAL RIM WIDTH	23.4	24.4	25.4	26.4	27.4	28.4	29.4	30.4	32.4	34.4	36.4	38.4	40.4	42.4	44.4	46.4	48.4	50.4	52.4	54.4	56.4	58.4	60.4	62.4	64.4	66.4
RELATED INTERNAL RIM WIDTH (DESIGN RIM +1 MM)	18	18	20	20	20	20	22	22	22	22	24	24	24	24	24	24	26	26	26	26	26	31	31	31	31	36
TIRE WIDTH ON DESIGN RIM -1 MM INTERNAL RIM WIDTH	22.6	23.6	24.6	25.6	26.6	27.6	28.6	29.6	31.6	33.6	35.6	37.6	39.6	41.6	43.6	45.6	47.6	49.6	51.6	53.6	55.6	57.6	59.6	61.6	63.6	65.6
RELATED INTERNAL RIM WIDTH (DESIGN RIM -1 MM)	16	16	18	18	18	18	20	20	20	20	22	22	22	22	22	22	24	24	24	24	24	29	29	29	29	34

REFERRED TO CLINCHER TIRES
(HOOKED AND HOOKLESS RIMS)

FIGURE 10. Tire measurement chart showing range of compatible rim/tire sizes (ETRTO standard).

SECTION 5.
PROFILE AND PERFORMANCE

All this sizing discussion is exciting for a tire nerd, but it's important to realize that in these examples, the tire isn't actually growing or shrinking. The effect of increased or decreased cross section width is simply the lateral positioning of the beads, which then has a direct impact on the cross section profile of the tire once inflated.

Traditionally, tires have had a cross section shape which sort of resembled the outline of a lightbulb. As the outer edges of a lightbulb are quite a bit wider than the base, so too is the widest point of cross section width on an inflated tire, as compared to the internal rim width which it sits within. This shape allowed the tire to deform dynamically, producing a comfortable ride with an abundance of traction, as the tire flexed within its physical range.

More importantly, the traditional shape of the inflated tire profile tends to be round, allowing it to remain tangent to the surface of the ground throughout the lean range when cornering, maximizing surface area and grip.

However, when deviating too far from the design rim for a given tire, this profile can change and have a measurable effect on this critical profile attribute. As the tire is stretched to the limits of the acceptable wider rim range options, the cross section height reduces slightly, and the tread band becomes flatter. The sidewalls of the tire can be more exposed in this scenario, potentially leading to increased casing cuts. Additionally, the rolling performance may suffer if the tire is not able to deform as designed, due to the change in shape and height.

So why the allure of wider rims?

In simple terms, wider rims allow for two main benefits.

First, a wider rim ultimately allows for a wider tire while remaining in compliance with ETRTO regulations. As stated previously slightly wider tires allow for an increase in rolling performance, more grip, and a reduction of rider fatigue. These factors are paramount in modern road racing, particularly as mixed surface Spring Classic style races blur the line with the emerging all-road and gravel categories. However, simply using a wider rim for the ability to use a wider tire is only part of the story.



FIGURE 11. Riders on Roubaix type surface.

FIGURE 12. Tire contact patch while leaning/cornering.

STANDARD 28 MM TIRE ON STANDARD 19 MM RIM
(internal rim width)

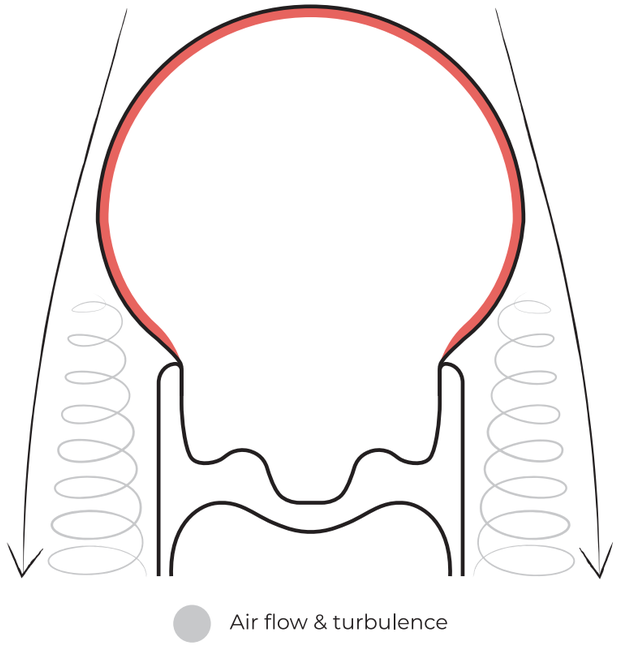


FIGURE 13. Tire cross section, showing lightbulb shape.

VITTORIA 29 MM WIDE RIM TIRE ON 25 MM RIM
(internal rim width)

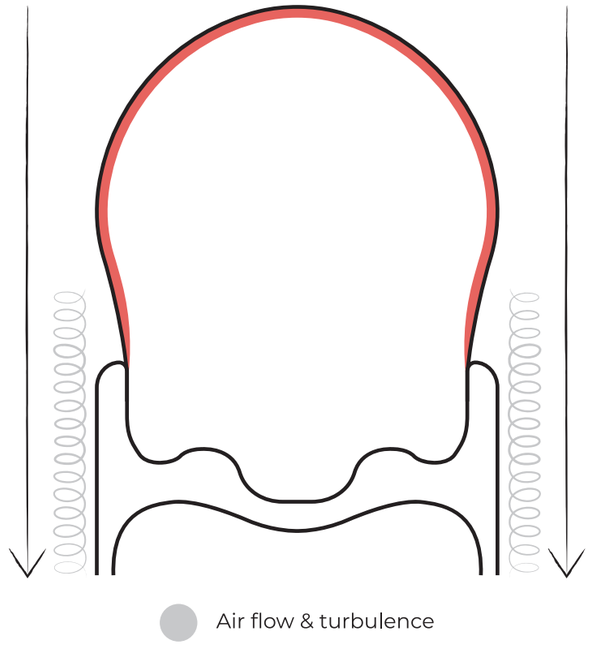


FIGURE 14. Wide Rim tire cross section.

The second and perhaps more critical reason is the ability to manipulate tire profile.

By using a wider rim with the cleverly dimensioned tire, the sidewalls of the tire form a straighter path vertically into the rim wall which reduces the traditionally curved lightbulb shape discussed previously. This factor provides a measurable aerodynamic effect, which when combined with the larger volume tire, creates a definitive competitive advantage.

To achieve this effect, the most narrow ETRTO compliant tire width is chosen for the given internal rim width, side-stepping the traditional design rim to tire width relationship. In doing so, the stated tire width varies from the measured width, but it is acceptable as it remains within the compatible tire width range. However, this comes with the typical tradeoffs which we discussed earlier in this paper.

To allow riders to have their cake and eat it too, brands have taken notice. As an example, Vittoria has created "Wide Rim" versions of the Corsa Pro, Corsa Pro Speed, and Corsa N.EXT models, all of which are available in a 29-622 size and are optimized for a wide 25 mm internal rim width. The 29 mm width was specified as it is the most narrow ETRTO compliant size which is compatible with a 25 mm internal rim width. These optimized versions have been adjusted to ensure proper tread coverage, tread profile, and cross section height, while retaining the aerodynamic advantage of the wide rim approach.

When these 29-622 tires are mounted on the intended 25 mm internal rims width, they measure true to size at 29 mm in cross section width.

At this point, people often ask... couldn't I simply mount a size 700x26 tire on this exact 25 mm internal rim, and have the same effect? Afterall, the design rim size for a 26 mm wide tire is 19 mm, so using the .4/1 guideline (25-19=6, 6x4=2.4 mm) the 26 mm tire would grow by about 2.4 mm in width when mounted on a 25 mm internal rim, equating to roughly a 28.4 mm width, nearly equal to Vittoria's Wide Rim optimized tire.

While this would be true in terms of tire width alone, again, the cross section height would be disproportionally low, and the tread band disproportionally narrow, compromising all performance dynamics. Lastly, doing so would pose a safety concern, as the 26 mm tire is not ETRTO compliant with such a wide rim, disallowing this combination from a pure regulatory perspective.

Not to worry, Vittoria has done the hard math, offering a complete line of tires which fit the emerging Wide Rim aerodynamic performance trend, as well as the traditional rim fitment norms.

CONCLUSION

In the ever present desire to advance the evolution of this simple machine, it is easy to become lost in the jargon. Engineers and designers spend countless hours intending that each ride you take is the better than the last, despite at times how complicated the message becomes.

Understanding ETRTO regulations gives insight into tire and rim performance and compatibility, while also informing users in the quest to improve their individual ride.

The recent trend of wider rims and tires is no exception. It is perhaps the most relevant and practical example of how something so seemingly slight can have a measurable effect. Across categories, we have seen this trend manifest in various forms, from the Grand Tours of road racing to marquee gravel races such as Unbound, and to the podium of the mountain bike World Series.

No matter the venue, tuning the relationship between tires and rims remains a proven way to reduce the time to the finish line, and have more fun along the way.