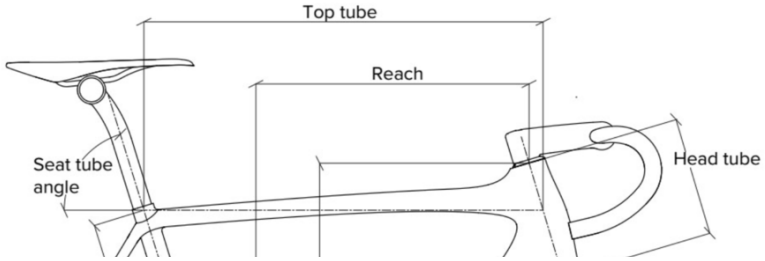
Written By Matt Surch

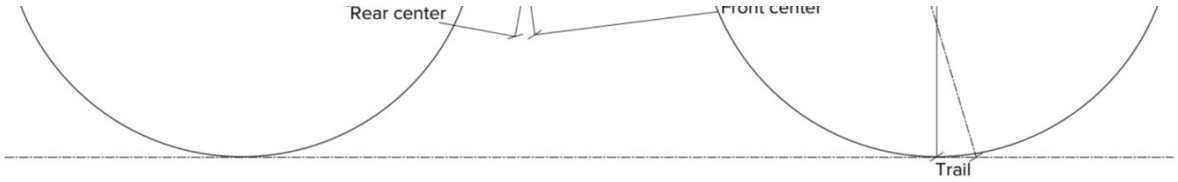
MATTER of FACT: How to Understand Gravel Bike Geometry

In MATTER OF FACT: Gravel Bike Key Questions and Materials, I walk through key questions a prospective buyer or builder should ask when evaluating gravel riding needs. I also took a look at the pros and cons of the typical frame materials available.

In this article I get into three aspects of frame geometry: trail, wheelbase, and ride height. These aspects are worth spending some time getting comfortable, or at least acquainted with, if you want to make sure you land on a bike that meets your expectations.

You can find the rest of my writing on the subject of gravel bikes here.



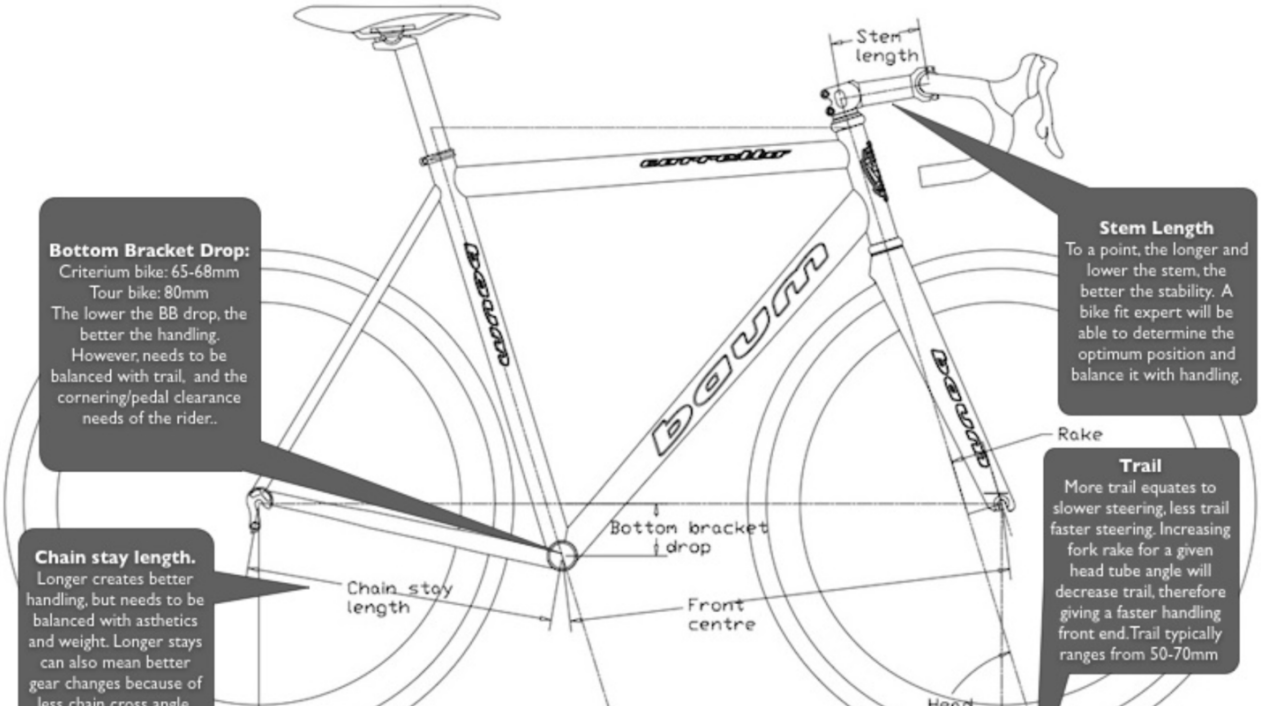


It seems wise to first clarify what 'geometry' is in relation to bikes. In this context, we're talking about the critical angles between frame tubes that are used to accomplish two things:

1. provide the right fit of rider to bike
2. provide the desired ride characteristics from the bike under that rider.

My analysis of geometry charts from different brands' gravel bikes reveals that some lean toward a mtb crowd, and others toward the cyclocross end of the spectrum in terms of fit. The former is more upright, and the angles are slacker. This is to provide more stability at speed on loose surfaces, which some riders will want.

Stability at speed comes down to a few key geometry factors: fork rake and fork trail, wheelbase, front-centre, and bottom bracket height. More on these below.



Bike companies that produce stock geometry bikes tend to make a range of sizes for each of their models. Meanwhile, custom builders will build bikes in dimensions tailored to their clients. Both parties are constrained by a few aspects of the overall system:

1) Forks are mass produced in a small variety of lengths for a given wheel size, and with a small range of rakes (more on rake below). Custom forks in carbon are very rare.

2) Each bike is constrained by bottom bracket and crank standards, which determine how wide the bottom-bracket shell can be (or narrow), which affects tire clearance. If you want to use a road crank on a cyclocross frame (as is standard), the arms will hit the chainstays if you place them too wide in an effort to fit a 50mm tire.

3) Each bike is constrained by the rear hub spacing dimensions available, which influence the angle of the chainstays into the bottom-bracket shell, and thus crank clearance.

4) Front derailleur clearance to the back tire affects chainstay lengths. The introduction of single-ring drivetrains has enticed many builders to ditch the front derailleur, and use shorter chainstays.

5) Drivetrain function - simply, if chainstays get too short, drivetrains don't work well. Cervelo has pushed about as far as typical drivetrains can handle, 415mm chainstays. 420mm tends to be the shortest stay length we see on gravel bikes these days.

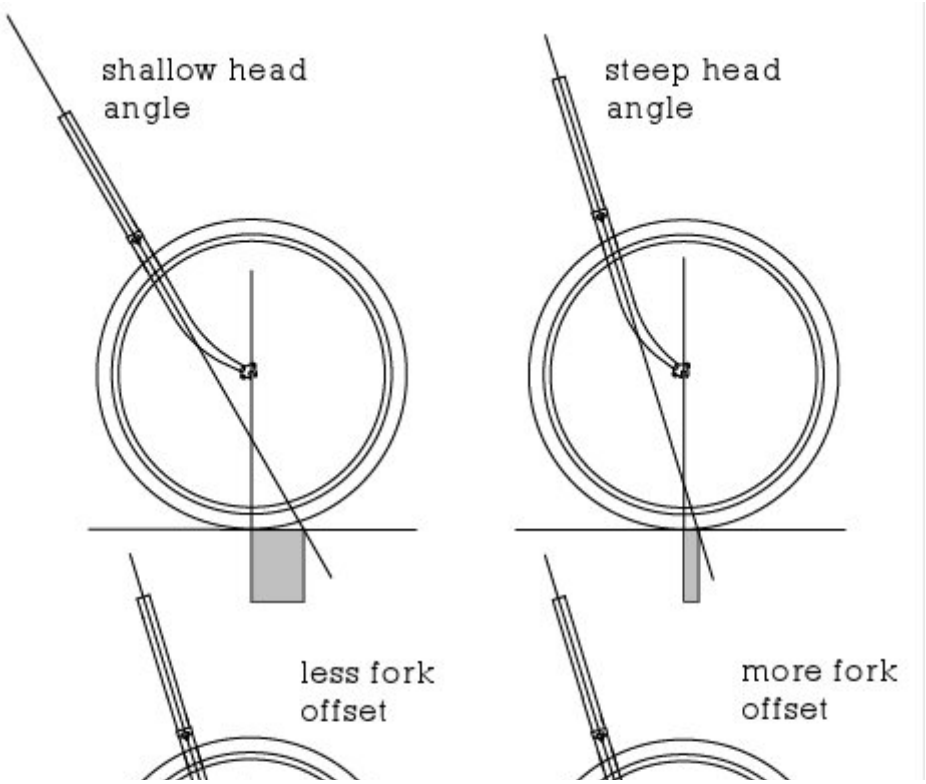
Front-end Geometry: Forks, Rake and Trail

Most of the constraints discussed above don't manifest as issues for the average rider, because they tend to be dealt with in similar ways across the board, with the exception of fork geometry. This is where builders who have the ability to either make or source forks with different rakes for each of their sizes will have the edge in terms of handling. However, if we look at ENVE, for example, who produce perhaps the best carbon forks on the market, we'll see that each fork comes in one rake alone. In the case of their gravel fork, rake is 47mm.

oversized head-tubes. From a handling perspective, however, being able to spec the best of two rakes has its benefits, andI can attest that their forks ride very well.

If you look at geometry charts across the industry, you'll see that some companies use the same fork rake for each of their sizes in a given model. This is because it's too costly to source more than one fork for use across sizes. Some companies, if they are doing enough volume, will use two rakes, which will improve things. However, in general, the bikes are being designed so that the most common sizes, 55-58cm have the 'ideal' geometry, while the extremes - x-small and x-large - wind up with less than ideal geometry.

For example, the smallest size offered in a given model will use a very raked out head angle (slack, perhaps 69 degrees), but the same fork rake as a bike with a 73 -degree head angle in a common size. The result is two very different trail values, and thus two bikes that ride rather differently. Spoiler, the small bike won't ride as well as the bigger bike. This is why small riders are often best served going with bikes made by custom builders who can build them custom forks in the rakes required. Yes, they are heavier, but handling should trump weight.



A proposed solution I submit to the industry, would be a fork that uses a thru-axle design that accepts eccentric insert to offset the axle front to back, thus adjusting rake. We're only talking about a difference of millimetres. I hope we see one of the leading carbon fork brands come out with such a design soon. (**UPDATE**: Two manufacturers either read this when I originally posted it in 2017, or came to the same conclusion independently: Columbus and Cervelo)

In practical terms, what sort of trail is good for gravel? Well, it depends...sorry. What does it depend on? Tire diameter and volume, primarily. Secondarily, body positioning. I don't think this is the time to get deep into trail, I'll try to keep my advice simple here.

The 'right' amount of trail you're looking for in a bike has a lot to do with how fast you'll ride it, and what the surfaces will be like that you'll ride on. Really soft surfaces are best ridden on a bike with low trail, which means the front wheel doesn't tend to want to flop over when leaned. This is key when turning on loose surfaces, because you want the wheel to be able to slide a bit without actually turning under. Think motorcycle-style counter-steering; that's what you want the bike to want to do.

If you will carry a load up front - perhaps in a handlebar bag - you'll want low trail. Read Jan Heine's reams of writing on randonnee bikes if you are keen to learn more about loaded off-road riding.

So, you want me to throw out a trail value that's good, right? Ok.

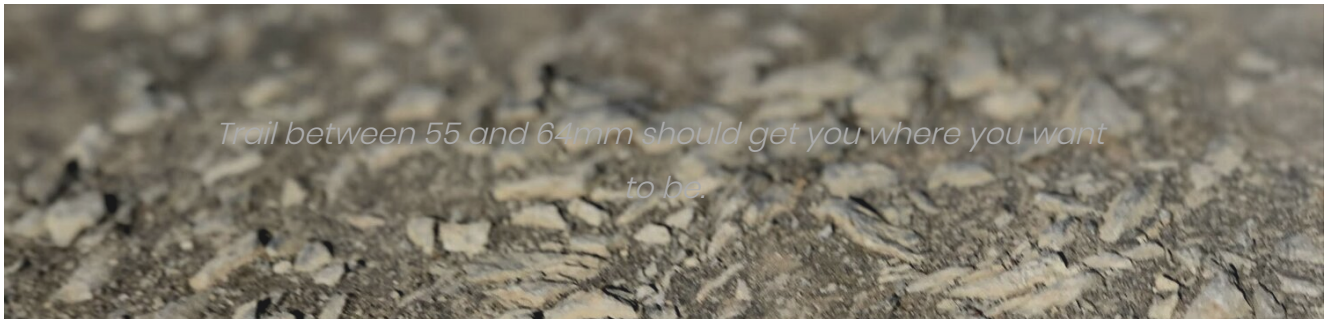
My custom Steelwool Secteur 18 is extremely stable on loose, fast descents with tires from 28mm up to 35mm. It's probably best with 32mm tires. Here are the bike's specs:

- *Head Angle 72.5*
- *Seat Angle 73*
- *Chainstay length 422mm*
- *Bottom Bracket drop 80mm*

- *Rake 49mm*
- ***Trail 58mm***

With 32mm tires, its trail is 58mm. This is on the low end of the trail spectrum, and I find it works exceptionally well. With 28mm tires, the trail drops by 1mm. For the sake of comparison, my Steelwool cyclocross bike also handles very well on gravel, and it has a steeper head angle (73 degrees), a higher BB (70mm drop), and a slightly less raked fork (47mm). With a 33mm tire, the trail is 57mm - neat, eh? With a 35mm tire (like the Compass Bon Jon I use a lot), the trail becomes 58mm. Look at that, exactly like my Secteur with 32s! I'll go as big as 38mm on this bike, which brings trail to 59mm.

UPDATE: The bikes I've been riding more recently (2018, 2019) run longer trail than my older bikes, and I enjoy them equally! Trail is complicated, and the numbers don't tell the whole story. My aluminum Brodie Romax cyclocross are at 64mm trail with 700c x 35mm Bon Jon tires, which feels great. With 650b x 48mm tires, trail drops to 62mm. My custom titanium T-Lab gravel bike has a slacker headtube and more rake on the fork, but it's trail numbers are identical. These two bikes don't handle the same! Both are great, however. The T-Lab has the edge for sure when it comes to dealing with slippery off-camber terrain, which the numbers don't reflect at all.



Trail between 55 and 64mm should get you where you want to be.

Wheelbase

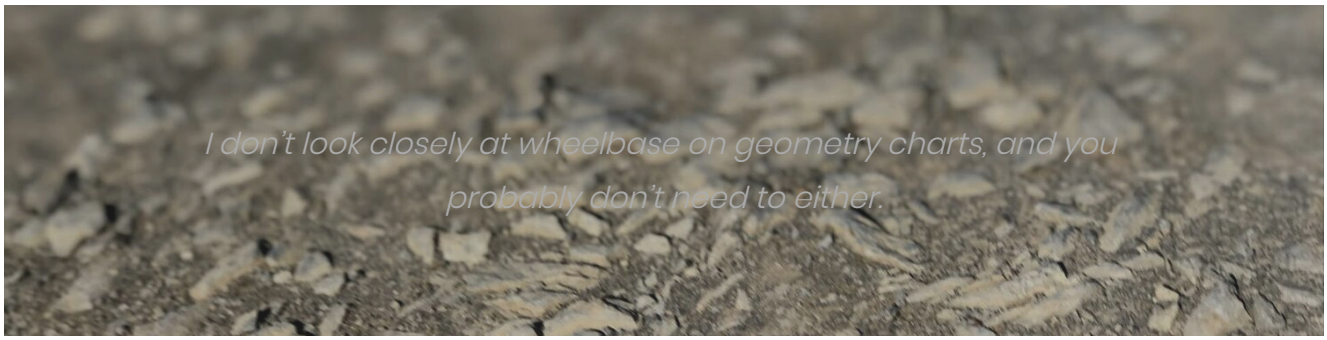
Wheelbase sort of takes care of itself, in most cases. A short wheelbase bike is sort of like short skis. It won't track as well on loose surfaces as a longer wheelbase bike. This is why downhill mountain bikes have gotten progressively longer over the years. Longer front ends and longer forks make the bikes track straighter and more stably. Note that their handlebars have also gotten much wider to compensate for their raked out geometries.

On a 'gravel bike,' using a straight seat-tube (still the standard, mainly because of front shifting requirements) means chainstays can only get so short while maintaining tire clearance to the seat-tube and front derailleur. So a designer has to determine what the maximum tire size should be, then build the chainstays long enough to achieve the tire clearance desired to the seat-tube. For a cyclocross bike, this tends to be about 425mm. The Specialized Crux, for example, uses this length for every size. As with touring bikes, where stability at speed is a priority, long chainstays (430mm +) can contribute to a long(ish) overall wheelbase, which make for stability.

finding their way into gravel in the guise of what I'd call 'fat tire road' or 'all-road' sub-categories of either road or gravel; take your pick.

While wheelbase might stay the same, the feel of bikes build around these different approaches will vary considerably, especially out of the saddle. Essentially, the head-tube swings back and forth when we turn the bike, in relation to the front wheel's contact with the road/trail. The longer the stem, the longer the further the head-tube swings for a given amount of angling of the front wheel. With forward momentum pushing the head-tube forward through space, the further it swings from centre, the more the trailing frame wants to push it, again, in relation to the front tire tracking on the ground. If you picture what happens when a rider crashes on a turn in cyclocross, for example, most of the time the front tire slides, then actually rolls backwards as the head-tube pushes the wheel beyond the angle it can grip the ground. I'm sorry if I'm not explaining this as clearly as one might.... On my understanding of these dynamics, I think a longer-than-typical front end on a gravel bike is more desirable than the opposite. We're talking about maintaining the same weight over the front wheel, but achieving this in a different way than typical.

UPDATE: I applied this rationale to the geometry spec of my custom T-Lab gravel bike, which is toward the dropbar MTB end of the spectrum. In short, it worked out exactly as I'd hoped; the bike handles like a boss! Look for another post on details.



I don't look closely at wheelbase on geometry charts, and you probably don't need to either.

Ride Height

1. it enables easier bunny-hopping of barriers than a low centre of gravity;
2. it means pedals have more clearance to the ground for pedaling through turns and across off-camber sections.

But how is a high centre of gravity achieved? There are two ways, aside from changing wheel diameter:

1. Bottom bracket height. The higher it is, the easier it is to pull the front wheel off the ground, pivoting around the rear axle.
2. Crank length. Long cranks require a low saddle, short cranks allow for a higher saddle.

Crank length impacts centre of gravity while in the saddle, but not while standing. Descents are ridden standing, so long cranks are not a good way to get the weight low.

For a bike that will never see barrier hops and aggressive cyclocross racing, a high bottom bracket will serve no useful purpose on a gravel bike. Instead, it will make descending unstable. Rather than feeling like you sit 'in' the bike, you'll feel like you sit 'on' it. In my eyes, the only way a high-bottom bracket cyclocross bike is good for gravel is if it has disc brakes and allows the rider to use 650b wheels (see this resource for wheel dimensions). I created the table below to capture the range of bottom bracket heights between bikes I ride on gravel, compared up against a typical 'euro-style' cyclocross bike, the Ridley X-Night.

	Niner MCR (rigid fork) **29x2.4"**	Steelwool Secteur 18 **700 x 25**	Steelwool Secteur 18 **700 x 32**	Steelwool Truffle Pig **700 x 35**	Ridley X-Night **700 x 32**	Ridley X-Night **700 x 38**	Ridley X-Night **650b x 38**	Ridley X-Night **650b x 45**	Ridley X-Night **650b x 50**
Wheel radius	372	336	343	346	343	349	330	337	342
BB Drop	60	80	80	70	64	64	64	64	64
BB height	312	256	263	276	279	285	266	273	278
	Too high to feel great anywhere	A little low for off-road, great on smoother surfaces – very stable	Not bad for off-road, best high-speed gravel handling	Good for off-road, great for high-speed gravel	Euro-cross style, good for bunny-hopping and off-camber turns in cx races, good for off-road, great for high-speed gravel	Not bad for off-road (good pedal clearance), poor for high-speed gravel	Not bad for off-road, best high-speed gravel handling	Good for off-road, great for high-speed gravel	Good for off-road, great for high-speed gravel

A low bottom bracket will feel stable, all other factors consistent. In addition, if/when riding on slow, rocky trails, the rider's foot will be closer to the ground for dabs. How is this achieved?

If the wheel diameter is fixed, the 'drop' of the bottom bracket below the horizontal line dissecting the wheel axles determines the bottom bracket height. A 'low' figure for a 700c bike is 80mm (see the Secteur 18 above), which used to be common for most road race bikes. A 'high' figure would be 65mm (see the Ridley X-Night above). I've seen bikes with

wheels...). If it's a cyclocross bike, the bottom bracket drop is set with a particular outer tire diameter in mind. If it's a race bike that the designers expect to be raced as its primary function, the assumption will be that 33mm tires will be used (I used 32mm above, from the linked table). With that size tire, one can use a high-ish bottom bracket drop and keep the centre of gravity reasonable for all-round performance.

I raced this bike a few times with these Bontrager 700c x 38mm tires, notably, at Vermont Overland. They measured closer to 40mm, and felt good at speed, as this bike has 70mm bottom bracket drop. Rim brakes made it impossible to run 650bs.

inertia of larger tires increases stability at higher speeds, so in many cases the bike will feel fine.

If it's a disc bike we're talking about, one could avoid the problem of excessive ride height by using 650b wheels with 38mm or larger tires and end up keeping the bottom bracket at about the same height. The table above shows that the geometry of a 'euro style' cyclocross bike like the Ridley X-Night is good for smoothish gravel riding when using 700 x 32 or 33 mm tires. So if one is going to get away with using tires 33mm or smaller for road and gravel riding, a bike like this will work well. However, if one wants to take on rougher terrain, 33mm tires are often not big enough. Bumping up to 770c x 38mm tires (some CX bikes fit larger, up to 42mm), the bottom bracket height becomes too elevated for high-speed stability on loose surfaces.

The better approach is to either choose a bike with a lower bottom bracket for use with 700c wheels, or, adapt a high bottom bracket bike like the Ridley with 650b wheels. For my disc bikes, my rule of thumb is that when I want to run tires larger than 700c x 38mm I swap to 650bx 42mm or 48mm. The exception to my rule would be applied if I was going to ride far and long on rough terrain that didn't require much bike handling; think Dirty Kanza. For that sort of thing I'd want a 'juggernaut' tire set-up, like a Rene Herse Snoqualmie Pass in 44mm, or Antelope Hill in 55mm.

Now what?

Where do we land? In terms of format - this isn't a geometry thing - disc brakes lend the most versatility to a given bike, in allowing the rider to relatively easily adapt the bike to the terrain to be ridden. This applies to wheel diameter and rim width. That is, if one wants to run a range of tire volumes on a given platform, it's ideal to match rim widths to tire widths. This will become more common as the years pass, but to future-proof, discs will allow for maximal flexibility, and reduce brake adjustments when swapping between wheels. You'll be hard-pressed to find a new cyclocross or gravel bike with rim brakes in 2019.

The chart above reflects that fact that a low ride height provides less pedal clearance for rocks and roots on trails. However, I don't personally get hung up on this aspect. At 312mm (yes, this is more than a foot!) off the ground, my Niner is so high my tip-toe reaches the ground when I'm in the saddle, and I would take a lower ride height over more pedal clearance on this bike any day. For reference, my Brodie cyclocross bikes with 70mm drop are TOO LOW for trails when run with 650b x 42mm tires. Pedal strikes are common. However, those same frames with 650b x 48mm tires are excellent on trails AND dirt roads.

I must admit that while I have a good sense of the geometry I want in a 700c wheeled bike for gravel, the opportunity to design a 650b/700c platform would present interesting challenges. I would run a front derailleur for certain, which would preclude using much shorter than typical chainstays (though the new direct-mounts for front derailleurs could help). The rear end of the bike could remain typical, albeit with tire clearance for 50mm tires achieved by using asymmetrical chainstays like the Open UP or 3T Exploro. I would prefer either thin seat-stays for passive suspension, or perhaps a Moots YBB-style in-line shock on the seat-stay yoke. I would tend toward a top-tube with a flattened profile for a

The experiment has gone great so far; stay posted for a feature on the bike.

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Chris Jones 6 days ago · 0 Likes

Hi Matt,
I am a tall guy at 6'4" and am confused by what seems to be the norm on the bigger sized gravel bikes. Super steep head angles, 73º+, and really short front centers, sometimes shorter than endurance road bikes. On my very typical geo gravel bike I have been over the bars, hard, more times in the past 2 years, than riding aggressively on Mountain bikes, once I got away from long stems 22 years ago. Many of the gravel bikes in my size have shorter FC's and steeper head angles than any road bike I have owned(Started racing in 1990). This type of geo may make sense on cyclocross bikes, but my only experience is road and mountain. With Mountain bikes longer FC's(and RC's) are amazing for guys my size as I finally don't feel like I'm perched on top of the bike for the first time in my life. I understand that many gravel bikes are being marketed to road cyclists, but short bikes suck in the dirt for tall people. I have even started to wonder if there is any advantage on the road to the super short wheelbase on the road for us tall folk, other than the drafting advantage and being compliant with the wildly restrictive UCI frame rules. Once I cornered a long MTB bike for the first time I was quickly converted to longer is better, my current MTB has 112 mm longer FC and 15 mm longer RC than my bike 5 years ago and I could never go back. On the smaller sizes I don't think the bikes need to get longer, or at least not much longer, as the Center of gravity of the rider is lower, and they usually have slacker head angles already.

To your knowledge is the reason for steep, short gravel bikes for tall riders just a carry over from the road world, or is there some advantage outside of drafting(which is a concern of mine 0% of the time)?

have become. There was little conversation around geo for small or tall riders in the early years of MTB development either, that surfaced after at least a decade of focus on other aspects that were easily quantified: weight and stiffness, primarily. Then, suspension travel: 3 inches, WOW!!!

Wheelbase is a metric I've seen people focus on way too much, from a short-is-best bias. This cut across MTBs for a long time, and now we see it migrating / being ported over from road bikes to gravel bikes. I also feel this is generally a problematic bias, and I think I know where it comes from: parking lot tests. Meaning, bikes with short RCs feel 'zippy' at first pedal. If they also have a short FC, they feel extra 'zippy.' While a short wheelbase might be totally proportional and AWESOME! for a small rider - as you say, low centre of gravity - it's far from AWESOME! for a tall rider; it's not stable at speed. Yes, there's nuance: a short RC (410mm, for example) can be part of a stable platform if the body weight is well distributed AND the centre of gravity (GoG) is kept low with a classic bottom-bracket drop of about 80mm. With a 175mm crank, as a tall rider would use, saddle height wouldn't be super high, and with 25ish mm tires, the overall ride height would be good. So a classic road bike with a long FC to accommodate the reach of a tall rider (6' +) can use a steep HTA (73.5 - 74 degrees) AND feel good; the wheelbase is long enough to mute the steep HTA, and fork rake can be tuned for nice trail. With a small tire there's just not that much grip, so a 'direct steering' dynamic can balance out a bit more slide than one would get with more rubber on the road.

Sorry, this is getting pretty far into the reeds.... But that's what you came here for!

IMO, short RCs on gravel bikes need to be considered in relation to BB drop. If a gravel bike has a drop of 70mm, and 415mm chainstays, it'll be really easy to bunnyhop. It'll also feel 'zippy,' assuming the front end isn't really long. Even if it is long, it'll still hop easily. This might be ideal for some, but not for all. The 'power transmission' benefit we see marketed is not really something I believe manifests to a degree that overcomes the disadvantages some

CS, with not less than 70mm drop; closer to 80mm would be better.

For the FC, I have to think a lot of brands are anticipating gravel riders want a really heads-up position, especially since there are many riders getting onto gravel bikes as their first drop bar bike ever, as new riders, or perhaps MTB riders. I suspect they mostly don't yet understand that the better approach is to run long FCs, proportionally, and spec shorter stems than we'd see on road bikes. This very clearly follows the trend in MTBs, a facet of which is DH, where riders have gone WAAAAAAAAY long on their race bikes, and are generally loving it. They will admit they used to think long bikes wouldn't turn, but now they are pushing the limits to the point of actually having to bring it back a bit. The same has occurred with XC mtbs, and with a gravel example like the EVIL Shammy Hagar. A long bike, when executed right, biases weight a bit toward the rear more than a conventional road bike would, yet can remain nimble-handling because it can run a stem around 90mm, +/- 20mm or so, according to rider height. At 6'1". and having a long torso, I'm extremely happy on a 59cm top-tube and 90mm stem for the most demanding dropgnar riding I do or want to do.

So yeah, all this said, I think you definitely would be way happier and safer on a bike with a toptube about the same length as you'd ride for a 'full-race position' road bike, but with a stem and bar set-up around 4cm shorter. This is probably on the tough side to find, but there are some examples off the shelf, like the NukeProof Digger (http://nukeproof.com/products/digger-factory-2020). If you can get your stack and reach right on a frame like this, I think you'd love it. I had T-Lab build me an X3 in ti with the same sort of geo, and it has become my favourite bike, not least because it feels so much more stable at speed, and when things get crazy I have a better chance of saving it than on my other bikes with shorter FCs and longer stems.

Hope this helps!

angle and 4mm shorter reach, but much longer RC at 440. It is this bike http://vitusbikes.com/products/substance-v2-105-2018/ but with 700c wheels.

I know that what I ask this bike to do is not really it's intent, as I am asking it to be the bike that the Sammy Hagar claims to be, but still actually want it to work for some road and typical gravel riding. The gravel bike I will be on next will likely have a much slacker head angle, like 68-69°, 40-50 mm more reach, 80+mm BB drop, and clearance for 50c tires at least. One could probably claim that this approaches drop bar MTB status, but it is what would work best for me, for the terrain I ride in the PNW.

Luca 2 months ago · 0 Likes

Hi Matt, I'm Luca from Italy.
May a suggest you to complete this series of "frame understandings" with the consideration of the current wave of gravel bikes having rigid fork and rear "passive" travel (usually about 20mm). Is it worthy for you to have only the rear suspended? In my opinion, with only one silver bullet, I'd prefer to use it in the front compartment rather in the rear.
Last but not least, congrats for maintaining this nice website!

Luca

Matt Surch 2 months ago · 0 Likes

Hi Luca, thanks for the question, it's a good one. I actually have a fairly in-depth piece on suspension I drafted a while ago that I've been waiting for the right time to complete and publish. I think I'll incorporate your question and move that forward. Stay tuned!

der Poel

Herse Tires