GETTING TECHNICAL:

SHARP AS A RAZ

WORDS: Dave Stewart
PHOTOS: Jamie Clarke

» THE FIRST PART OF THIS SERIES "STRAIGHT AS AN ARROW" WENT THROUGH HOW TO CHECK THAT YOUR BIKE WAS STRAIGHT AND YOUR RIMS WERE TRUE. IN THIS PART WE WILL LOOK AT THE SHARPNESS OF HANDLING AND HOW THE TRADE OFF BETWEEN A MACHINE BEING BOTH NIMBLE AND STABLE CAN BE ACHIEVED IF YOU HAVE A VERY BASIC UNDERSTANDING OF GEOMETRY.

When designing the Aprilia RRV450GP machine, our base model as far as geometry went was the Honda RS250 GP machine and all of our initial targets were centred around getting as close to that machines geometry as possible. The Honda runs a headstock angle (rake) of 22.8 degrees and a ground trail of 78mm, which when combined with its wheelbase of just 1340mm, makes it one of the best handling bikes in the world. It not only gives superb front end grip, but also plenty of feedback so you know exactly what's going on under the front tyre and that lets you ride with confidence. The delicate relationship between rake, trail, wheelbase and a host of other factors, meant building the Aprilia RRV450 was never just about bolting a decent set of road-race forks into a Supermoto chassis. That simply doesn't work, as plenty of others have found out by trying to do exactly that.

Anyway, you have to understand the rolling chassis as a whole package and to do so it is necessary to understand the basic terms of reference first. So here is a simple list of the things that combine to define every motorcycles handling characteristics.

WHEELBASE: Is the distance between the absolute centre of the front and rear tyres contact patches. In a static situation this is exactly the same as the distance between the centre of the front wheel spindle and the centre of the rear wheel spindle. Dynamically, that can change due to something called tread squirm that we will come on to when we deal with tyres.

A motorcycle with a long wheelbase will generally be very stable, but also very slow to turn through tight radius corners. Running wide on tightening 'power neutral' type of turns can be as a result of the wheelbase being too long. If your bike suddenly manifests this tendency after changing your gearing, take a look at how far back the rear wheel is in its adjustment range. If you've lengthened the wheelbase by putting on a much smaller sprocket and moving the rear wheel right back to obtain the correct chain tension, you may need to pop a couple of links out of the chain length to get back to your optimum wheelbase.

Conversely a motorcycle with a very short wheelbase may suddenly become very twitchy and unstable on the straights and very fast "power on" curves. Again, if you've just put on a really large rear sprocket and moved the rear wheel all the way forward, your bike may suddenly display this tendency simply because you have inadvertently

» 1. Uncanny triangles. These two triangles have a very special influence on the bikes handling,

OR

shortened the wheelbase.

RAKE (see picture 2): Is the angle of incidence between a perpendicular line drawn through the front wheel spindle and another line drawn from the centre of the headstock and down the centreline of the forks. On road race motorcycles the range of rake can be anywhere from 21.5 degrees to 28.5 degrees depending on the model. The more acute (smaller) the angle of rake, the more sensitive the steering becomes. If you go too far though, the front tyre contact patch starts to overlap the area directly under the headstock, causing massive instability. The general balance is to keep the rear edge of the tyres contact patch very slightly ahead of the steering head, as this gives the best trade off between sharp turning and a stable feel.

TRAIL (see picture 3): Goes hand in hand with rake to define the sensitivity, sharpness and stability of every front end. The trail is the distance on the ground between the centre of the front tyres contact patch and the imaginary point where the line drawn from the headstock through the centreline of the front wheel spindle, touches the ground. This is not always directly related to the rake angle, as sometimes the wheel spindle is offset ahead of the centreline of the forks to give an element of castor (sometimes rudely referred to as 'shopping trolley' offset). Castor simply helps with the self-centring of the steering and is most often engineered in when small angles of rake are required in order to keep the forks as upright as possible to minimise any added stiction. It is also used to calm down nervous bikes as the axle is set forward of the steerings heads angle of incidence.

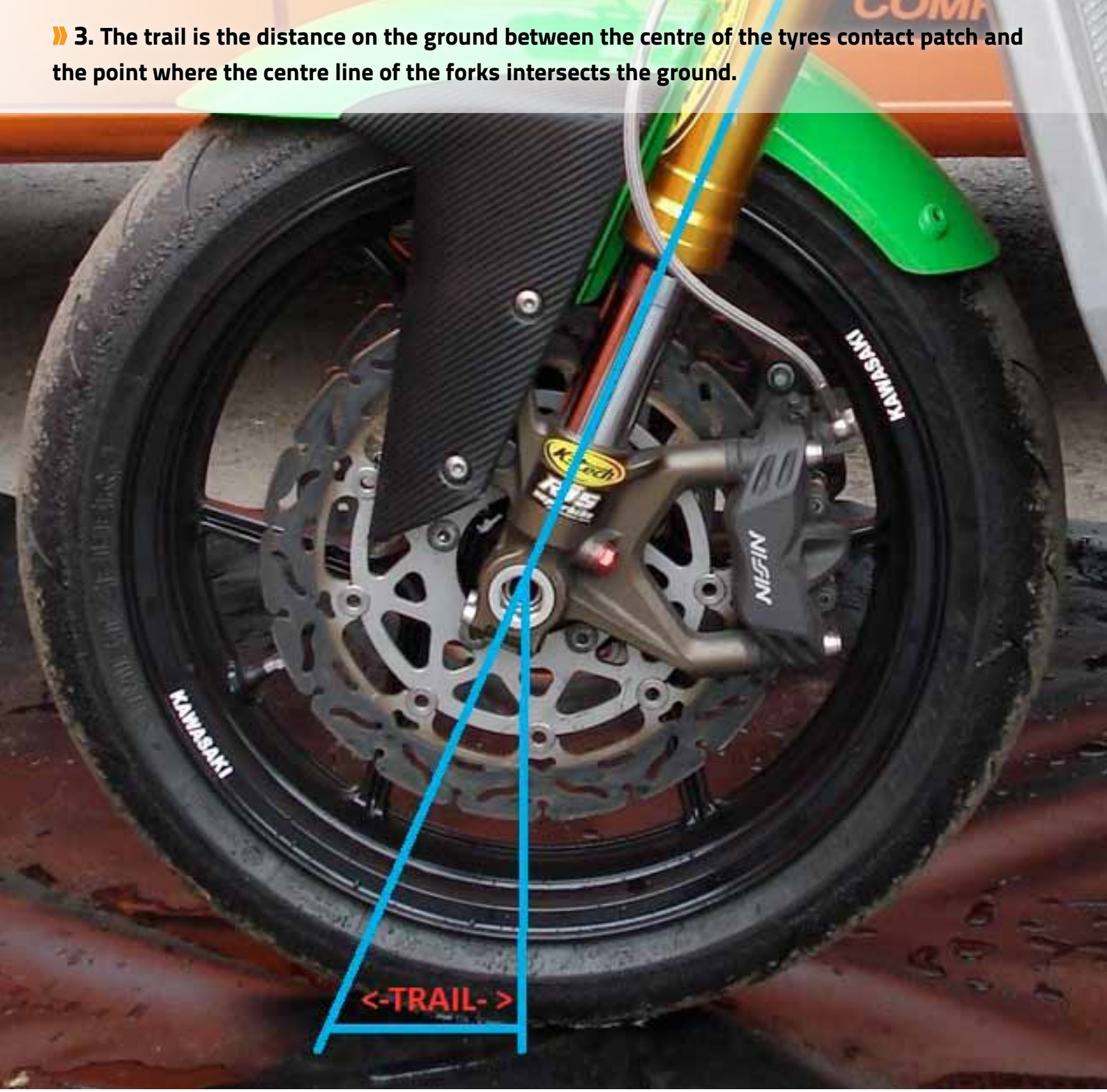
SWING ARM ANGLE (see picture 4): This is the angle between a line drawn parallel with the ground through the swing arm pivot point and the line drawn through the centre of the rear wheel spindle and the swing arm pivot itself. Race bikes have a surprisingly large variation of swing arm angles that all actually work on the various models, dependant on the correlation between wheelbase, suspension travel range and swing arm length. We found that an angle of 9 degrees worked very well on the RRV450, as opposed to the standard 8 degrees of the RS250 Honda. This was calculated based on the RRVs slightly longer wheelbase of 1388mm, influenced largely by its longer swing arm @ 498mm. The swing arm angle and length have a critical effect on rear end grip and the wear rate on the rear tyre due to the tyre slip angle this helps to induce.

An interesting little fact I discovered whilst working on the original drawings for the Aprilia RRV450 racer, was regarding the two basic triangles relating to every sweet handling genuine race bike built since the first Yamaha YZR500 back in the 1990s. Draw two triangles, the first using the centre of the headstock, the front wheel spindle and the rear wheel spindle. Then draw another using the centre of the headstock, the front wheel spindle and the swing arm pivot. Measure the three sides of each triangle adding the totals together and you will find that the smaller one is almost exactly two-thirds of the larger one. (see picture 1) I never found a purpose built racer that fell more than 3% outside of those parameters, although I stopped short of measuring a Harley flat-tracker! This tells us that the relationship between the spindles, headstock and swing arm pivot point is crucial to good handling.

Moving on to more practical matters, a

» 2. The rake is the angle between the centre line of the forks and a perpendicular line through the headstock,

» 3. The trail is the distance on the ground between the centre of the tyres contact patch and the point where the centre line of the forks intersects the ground.



very good place to start setting up your bike is by measuring and adjusting the static sag both front and rear. First, you'll need to have the springs of the correct weight for your body weight, including all your riding gear. Once you know your accurate 'ready to race' weight, speak to a suspension expert such as James Holland on the Ohlins service vehicle in the paddock (www.jhsracing.co.uk) or Ron Williams at Maxton (www.maxtonsuspension.co.uk) and they will advise you on the correct springs and how much static sag you should be running as a base setting.

Your measuring point should always remain constant and the best/easiest place to make any measurements is directly above the centre of the rear wheel spindle for rear sag and at the base of the headstock for front sag. You can see on the attached images that we used the leading edge of a piece of tape fixed to the rear seat unit to ensure we were always measuring to exactly the same point. If you look carefully, you'll also see that the point directly above the rear spindle moved very slightly after we adjusted the chain.

You want to know what the travel is and to do that you need to completely unload the suspension. You can either jack the bike up under the engine to unload the suspension or suspend the very centre of the bike from an overhead beam. Don't try this on a beam that has a strip light attached to it! (Yes, I was picking bits of glass out of my hair for days after I tried that one!)

Once the rear suspension is completely unloaded, take your measurement from the datum point to the centre of the wheel spindle. Before you do anything else, take a look at your chain. Is it completely taut? If it is, just slacken off the chain adjusters a little and see if the rear wheel drops a fraction more. If it does, then your chain was too tight and that would cause it to restrict your rear suspension movement. This is a common fault and one that inevitably results in poor handling and eventually a broken chain. Re-adjust the chain so that it is just tight with the wheel dropped right down and when you put the weight of the bike back onto the tyre measure your chain free play, as that is how it needs to be every time you adjust it.

Put the weight back on the rear tyre and bounce the bike up and down a few times to return it to its normal position at rest, then take your measurement again – that is your static sag. Your suspension supplier will be able to advise you on a good base

» 4. The Swing Arm Angle is the angle between a line drawn parallel with the ground and the line through the swing arm pivot and read wheel spindle.

» 5. Whilst taking these measurements, you'll need a young and fit assistant (I had to make do with Rodger!)

setting, but just for information I used to set my Supersport bike up with between 8 & 12 mm of static sag dependant on the circuit. Generally on smooth flowing circuits you are able to run slightly less sag, leaving more free suspension travel to play with in your normal adjustments. Whereas bumpy circuits or places with lots of heavy braking benefit from more sag to smooth out the ride and reduce the 'skating' effect under sharp braking.

Next you'll need someone to steady the bike whilst you sit on it, fully clothed in all your race gear. Bounce up and down on it a couple of times then let it settle with you in your normal riding position and get someone to take the new measurement. If your spring is of the correct weight, you should find that your 'laden sag' (the difference between the distance fully unloaded and the distance with you sitting on the bike) is in the range recommended by your suspension supplier with the preload rings set at about halfway in the adjustment range. Again just for information, my Supersport bike was set up with between 28mm & 32mm of 'laden sag' for most circuits. If you're not able to attain the figures you're looking for without using up too much of the available range of adjustment, you need a different spring either length or weight wise.

Repeat this process on the front end with the preload set in the middle of the adjustment range, bearing in mind that the actual amount of static and laden sag you're looking for are likely to be slightly bigger measurements on the front of the bike. I used 24mm to 28mm static sag and 34mm to 38mm laden sag on my bike, but again you are best off starting with the base settings recommended by your own suspension supplier.

You will end up with your own preferred settings for each circuit and you should remember to make a note of everything you do together with the most important thing of all – your base setting. If you ever get hopelessly lost, or end up simply chasing a problem around with no success, you can then always go straight back to your base settings and start again.

Always use a witness ring on one fork leg and the stanchion of the rear shock to see how much travel you are actually using on track. This can be a simple small cable tie that you push down against the dust seal before each session on track. When you get back to the paddock you will be able to see at a glance just how much travel you are using, because the witness ring will be sitting at the highest point it has been pushed to during that session.

On modern production based race bikes, the major geometry angles listed above are built in and you largely have to deal with the basics you have, but there are things you can adjust to affect the general balance and feel of your bike.

For example, dropping the forks through the yokes by even a few millimetres increases the sharpness of the rake and speeds up the steering. Beware though as it also changes the weight bias from rear to front slightly. Lifting the rear end by adjusting the rear shock length or by changing the 'dog bones' on the rear linkage has a very similar effect. The key difference between those two adjustments is that the first also lowers the centre of gravity of the bike (beneficial) but reduces the ground clearance (detrimental), whereas the second raises the centre of gravity of the bike (detrimental) but increases the ground clearance (beneficial). In both instances you are also very slightly reducing the trail, but in the latter instance you are also increasing the swing arm angle thus altering the drive and rear end feel.

There are a myriad of other things you can do, dependant on the technical regulations for your class such as;- fitting an adjustable swing arm pivot, changing the rising rate linkage on the rear shock, fitting adjustable cups into the headstock bearings to allow adjustment of rake & trail or even using adjustable triple clamp yokes. We will touch on some of those in the next article, where we will primarily be dealing with front forks and the rear shock absorber.