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::::::   FIT INSTITUTE SLOWTWITCH   ::::::
:::::   GENERATING ROAD FIT COORDINATES   :::::
::::::::::::::   F.I.S.T. SYSTEM SECTION 1 of 4   ::::::::::::::

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Hallmarks of F.I.S.T.

The F.I.S.T. process, or method, or protocol for bike fitting has as its hallmarks the following:

- Process-Based Rather Than Product-Based Transactions.
- Prescriptive Selling.
- Ecumenical versus Parochial.
- Dynamic versus Static Fitting.
- The Use Of Fit Bikes with Specific Functionality.
- Consensus versus Individualized Positioning.
- Tactile versus Display Retailing.

These phrases above might seem alien or confusing or suspicious, but as I describe them below I think you'll find you're already engaged as a fitter or retailer in behaviors or approaches that match what I'll write about below. The F.I.S.T. system is, as much as anything, an identifying and codifying of common sense approaches to fitting and retailing that empower specialty stores and fitters with tools and methods that differentiate it from mail order or virtual approaches to selling or fitting.

<u>Process-Based Rather Than Product-Based Transactions</u>

You are now no longer in the business of selling a product. (News to you, I'll bet.) You are now in the business of selling a *process*, the end result of which is a *prescription*. This is not new, it's not revolutionary, and in fact many of you have been doing this for a long time and it's just never been put to you this way.

For example, if you enter a specialty running store, and the salesman has you walk back and forth so that he can analyze your footfall; if he has you run on a treadmill so he can analyze your gait; if he measures your foot for length and width; you've entered his process, the output of which is not a shoe, per se, it is a prescription for a shoe.

You can't run in X because it's too wide; Y is too narrow; Z doesn't have enough medial support for your over-pronating footfall; other shoes have too much ramp for your midfoot strike; and that leaves a list of shoes that may work for you.

This *process* emotionally glues the customer to the output. You can just about see the change occurring in a customer who walks in thinking Nike and ends up—post process—thinking Asics, or Asics but not New Balance, or Newton but not Mizuno (at least, that's what a good process does.)

Bike companies are embracing prescriptive selling. Not only are Specialized, Cannondale and Trek in it, so are Fizik, Selle Italia and Prologo. How long do you think it's going to be before helmets, cycling shoes are sold this way?

It's not that there haven't been processes before now—e.g., Fit Kit; the Serotta method—but the landscape is different. There's a new urgency. Nothing like the heft of Specialized (BG Fit aka Body Geometry) has ever been placed behind a fit system designed as a pre-sale process.

Prescriptive Selling

In 2003 we launched the F.I.S.T. system for tri bike fit. Our process helped retailers and fitters identify a set of fit coordinates, that is, saddle height, saddle set-back or –forward, cockpit distance, handlebar elevation and so forth.

The problem with this system was it left you with a question: "What bike in my store matches this position?" Most bike professionals now know what "stack" and "reach" are, and these metrics flowed from my need to answer this question. The only way I could match one bike to another, truly, precisely, was through boiling down every bike into an absolute length and height, for fitting purposes. Identifying and naming stack and reach gave me the raw materials necessary to answer this question.

Consequently we now have a kind of Part 2 of every fit process: "Here are the bikes that match your fit coordinates." This question must be answered in a granular fashion, almost to the millimeter. This is what the F.I.S.T. system does. This is what any worthwhile fit system does.

Ecumenical versus Parochial

It isn't enough to know what Trek or Specialized or Cannondale bike works for your customer. You just know all the bikes that work for your customer, or at least all the bikes that you sell. The F.I.S.T. system is, and will always be, an ecumenical, which is defined as "nondenominational, universal, all-embracing, all-inclusive." The alternative is parochial, defined as, "provincial, narrow, small-town, illiberal, intolerant." One dictionary added the definition: "jerkwater."

Our intention, at F.I.S.T., is to produce a system that is all-inclusive, rather than jerkwater.

Dynamic versus Static

You'll note an explosion of fit bikes now on the market. There's the Exit Cycling fit bike; the Purely Custom fit bike; a bike from Shimano that's an update of the Bikefitting.com fit bike; Retul has a fit bike; and, there's the DFU fit bike made by Guru. There are many others. But these bikes mentioned above all have something in common. They're all "X/Y" fit bikes. They all adjust horizontally or vertically. Only in these two axes. There's a special reason for that, and we'll discuss that shortly.

The point in mentioning this is: fit bikes are exploding onto the market because we've reached a tipping point in the industry where both retailers and end-users recognized the value in a "dynamic" protocol. What we all mean by this is: We fit you while you're aboard the bike pedaling.

The alternative is to fit you using a static protocol. The famous Lemond method for generating saddle height (remember, .883 of inseam?) is an example of a static measuring process or system or protocol. The Hinault system, Fit Kit, anything that measures limb lengths and generates a set of fit coordinates or a bike geometry is a static system.

Why do we champion a dynamic system? Consider the Lemond formula for a moment. Lemond's pedaling dynamics were those of a "heel dropper," and no doubt his formula worked for him. But it does not work for a significant portion of cyclists who do not drop their heels at the bottom of the pedal stroke to the degree Lemond did. On the other end of the spectrum was Marco Pantani and Jacques Anquetil, who were toe pointers. Most of us like somewhere in between.

Let us consider two riders who have the same morphology (same inseam, height and so forth). One is a heel dropper, while the other is a toe-pointer. These stylistic preferences are best uncovered while someone is aboard a fit simulator, pedaling. If you use a static formula to determine saddle height, you're not able to factor in pedaling dynamics. So, unless you want to force someone to pedal with a precise dynamic—with a precise degree of plantar angle at bottom dead center (BDC)—different riders who are morphologically identical would have different knee angles at BDC if one was a toe pointer, one a heel dropper.

Most people agree that the important metric in seat height is knee angle at BDC. If you think about it, when you look at a rider and you think his seat's too high or too low, what is it that's causing you to come to that conclusion? It's that knee angle at BDC. Too bent? Seat's too low. Too straight? Seat's too high.

You can see how pedaling dynamics inform the knee angle at BDC, and that's why the Lemond formula; or trochanter height; or sitting on the saddle, with your heel on the pedal and with a straight leg; are all static formulae that do not consider pedaling action. Yes, these will give you a rough approximation of saddle height. But if you want to dial saddle height in, this metric really must identified be while pedaling.

<u>Fit Bikes</u>

These are not requirement for the F.I.S.T. protocol, they're simply tools that make dynamic fitting much easier, much quicker, much more accurate.

There are three basic requirements for a fit bike. First, it must adjust in a way that matches the protocol you use. For example, I like to isolate handlebar elevation from other fit parameters. When I'm choosing between two handlebar elevations, I don't want the handlebar to adjust along the head angle bias; rather, I want the handlebar to adjust vertically. This means my fit bike cannot be "angular" in its orientation, rather "X" and "Y" (up/down or back/forth).

Does the saddle it need to adjust this way as well? It depends on the protocol you use. A case can be made for saddle height to adjust along the seat angle bias rather than vertically. But, to me, not the handlebar, which must adjust X/Y.

The second imperative of a fit bike is that it adjust quickly. Not only does this make the fit go a lot faster, it diminishes the time between two adjacent fit options, increasing the relevant feedback to the rider.

Third, these bikes have to output metrics that port into a system that generates complete bike solutions. Remember the two parts of any good fit system? First, it must yield a set of fit coordinates. Second, it must prescribe a bike or bikes that match those fit coordinates. If a fit bike outputs either stack and reach, or the X and Y distances between the bottom bracket and the handlebar clamp, you the fitter can easily, quickly, accurately prescribe the bikes that match the position.

There are two "hallmarks of F.I.S.T." that I have not described yet:

- Consensus versus individualized positioning.
- Tactile versus display retailing.

One of these I'll describe just below, and the other later on.

Themes Supporting F.I.S.T.

We take a conservative approach, in that we are resistant to positions that deviate from the norm. A position ought to "look" good and by "good" we mean similar to the positions achieved by the typical fit, trim rider.

We obviously assume that there is an identifiable "typical" position and, further, we believe it can be quantified. At least the edges can be quantified, and whether it's our own "confirmers" (we'll get to what these are) or the high and low numbers in an angular range described by Retül, almost every fit system defines and prescribes elements of bike position that slot a rider into a "typical" position.

While we don't place overmuch weight in these metrics, the Lemond formula for saddle height, and knee-over-pedal-spindle, are examples of methods designed to get a rider to mimic a typical saddle height or saddle setback. All these methods have at their core the view that there is a typical, identifiable position that represents a consensus way that riders tend to sit aboard their bikes, and that this consensus position is the goal.

This is the way just about every sport is taught; while we differ one to another in small ways, there is a great deal of conformity between adherents in the important elements of technique. While "everybody is different" is a popular saying, when it comes to medicine, science and just about every outcome-based endeavor while "everybody is the same" is obviously not entirely true it is a truer, or at least a more helpful, reliable and actionable statement, than "everybody is different."

We therefore champion sameness, consensus, conformity. We are resistant to positions that are novel, unique, unidentifiable. When the end result of a F.I.S.T. protocol generates a position that is outside what we expect to see, in my opinion we can't just accept it. We ought to ask why our subject deviates from the norm. Maybe there are good reasons why, in which case, okay.

But it would be against the spirit of a F.I.S.T. session to generate a position that looks unnatural and not investigate why this happened.

We hold this view for two reasons: First, of course, because we believe people are, in general, more alike than they are different and as a consequence bike positions ought not to often vary significantly from the norm. Second, if you and your subject conspire to generate a novel and unusual bike position there is every likelihood there is not a bike built for sale for that rider.

<u>Confirmers and Drivers</u>

How do we know that a position conforms to a norm? Every fit system, almost without fail, has what I will call "confirmers." They are ranges inside of which we expect to see our riders fall.

For example, in the Holmes-Pruitt method of determining saddle height either the included or exterior knee angle is measured, and the rider's knee, using the knee as the fulcrum and the greater trochanter and maleolus as distal ends of each arm of the angle, falls inside of this angular range.

This range is a confirmer. A confirmer is a distinct from a driver. The latter is what we use to "drive" the rider toward a specific position. Why isn't this angular range a driver? Because it's a range.

For example, the F.I.S.T. system, using our "landmarks" (the trochanter and the maleolus are examples of landmarks), establishes a range of 135° to 143° for (exterior) knee angle. If knee angle were a driver, then I'd just pick 139° and establish a saddle height that gives me that angle. Obviously there are other imperatives driving the fit or else we wouldn't allow for a knee angle variant from the center of the range.

The fitter's eye, the comfort and power as perceived by the rider, heart rate, power, the fitter will determine for himself what it is that drives the position. For me, the fitter's eye and feedback from the rider are probably, usually, the two most important drivers, in that order. But if the rider ends up with a knee angle outside of my established range, either I've measured badly; or my established range needs tweaking; or there's something unique about my rider causing him to vary from the norm; or I've done a bad job fitting. Hence the need for confirmers, to double-check your work.

The F.I.S.T. Bike Fit Protocol

The above having been established, let us dive into the F.I.S.T. process for fitting. Below is a step-by-step tutorial on how we execute a road bike fit. Tri bike fitting is similar in theme but quite variant in how we set up a fit bike, and in what we expect to see as a final set of fit coordinates.

Because the fit coordinates are so different for tri than for road, the kinds of bikes that elegantly fit up underneath those coordinates are different. The main difference between a tri bike and a road bike is not the shape of the tubing or where the brake calipers are mounted; the big difference is geometry. When I designed the first of the modern tri bikes back in 1989 (the Quintana Roo Superform) there was nothing special about the frame, the shapes or the materials. The differences were geometric: seat angle, cockpit distance, head tube and chain stay lengths, front centers.

Indeed, the entire F.I.S.T. process can be boiled down to this: identify the most comfortable and powerful position for a rider, and then find the bike (road or tri) that best fits up underneath that position.

In Advance of a Bike Fit Session

The F.I.S.T. protocol is a dynamic protocol. Since our job is to find the most efficient and comfortable saddle and handlebar positions while he's riding his bike, we discover them while he's… well… riding a bike!

Because we have certain expectations for a road fit session (there is a saddle setback, cockpit distance, handlebar elevation we expect to see based on the morphology of the rider), we'll set up the fit bike in a way that's most likely to get us through the session in a predictable, efficient way. Which we'll get to in a moment.

But there's something else that must be tackled and it does not really fall neatly into order, as in, step-1, step-2. It's the problem of contact points.

Contact Points

The bad news: it is impossible to generate a good set of fit coordinates if you don't solve the problem of point tenderness. The good news: If you work at a bike shop, here's an opportunity to do some good all the way around.

When the rider is aboard his bike, there's practically nothing your customer would rather have than a comfortable saddle underneath him. By happy coincidence, there's little you would rather do during a fit session than sell him one.

What this requires is for you to have an inventory of saddles that are likely to work well for a cross section of riders. Both road and tri. Tri saddles are specific to tri, and while you don't need a ton of these saddles, there are six or eight that work nicely for that community.

You don't need a ton of saddle inventory. You just need at least two per model: one for display and demo, one to sell.

This is important. An awful lot of problems manifest themselves as screwy fit coordinates, when in fact they're "point contact" problems. Someone who sits back in the saddle during a tri fit, with a humpy lumbar region, might not like to sit rearward, and might not have a humpy spine. Rather, that rider might be protecting him/herself from a saddle that's spiky and uncomfortable on one's tender anatomy.

So, fix these point tenderness issues first, if you can, and then the rest of the fit will flow nicely.

The Fitter's Secret Weapon

In my experience, chamois cream is a nice luxury for road bike riding. It's almost a necessity for tri bike riding. Having a tube of chamois cream in your fit studio will solve some problems. Some tenderness issues are not just where your body contacts the bike (saddles, armrests, etc.), but your body rubbing against itself. This is especially true in tri, when a rider chooses to ride with a flatter back, and on or near the nose of the saddle. A little chamois cream (well, actually, a lot of chamois cream) prior to mounting the fit bike is the experienced fitter's best kept trade secret.

How do you determine the right saddle?

The first thing I do is ask, "Is there a saddle you prefer?" This is the question I ask whether the fit is road or tri. The answer might be unequivocal. "Yes, I ride a Selle Italia SLR." Okay. That's what you put on the fit bike.

If the rider equivocates, then you port into a segue in the fitting process, where you choose (and almost certainly sell) a saddle.

<u>Tactile versus Display Retailing</u>

You might remember I deferred discussion on this F.I.S.T. hallmark, and now we're going to have it.

To me, process-drive transactions, prescriptive selling, the tools that help this (like fit bikes, X/Y tools, goniometers or motion capture systems), are all more than just themes and tools that fit neatly, and discretely, into "bike fit." They are means by which retailers adhere the rider to his bike, as well as to his store.

Beside solving the rider's puzzle – how to ride comfortably, with economy of motion, faster, and pain free – the retailer is allowing the customer to taste, smell, feel, sense the product as he is choosing and purchasing it. This you can't do mail order.

To me, this is where the lines between bike fitting and point-of-sale merchandising blur. Let us take as an example a thing called a SwitchIt, made by BikeFit System's Paul Swift. It allows a saddle to be changed in about 10 seconds, underneath a rider without him every having to dismount the bike. Some fitters have these on their fit bikes. Other fit bikes are not as seamlessly compatible with the SwitchIt.

But here's what some of those shops do. They retask their old Waterford Fitmasters, or Serotta Size Cycles, or Calfee or any number of older style fit bikes, as saddle testing units. These all are quite compatible with the SwitchIt.

It may be that if I don't find a quick and obvious saddle fix prior to commencing the fit session I might segue to the SwitchIt-powered saddle testing station and go through a half-dozen saddles quickly, finding the one that grants the most comfort to the rider. No, I don't know the rider's end position, but I have a pretty good idea how it's going to end up, because I have "confirmers" that predict a range for saddle height, setback, cockpit and handlebar elevations based on the rider's morphology.

So, I rough out in a minute or two the rider's predicted position and that's usually good enough to test the saddle.

I'm working on other point-of-sale displays right now that will perform double duty as both product displays and tactile testing stations. The enterprising retailer of the future will find ways to outsmart and outmaneuver mail order by presenting a set of tactile experiences that cannot be matched outside the specialty, walk-in motif.

Point tenderness problems are not limited to saddles, but for the purposes of fitting must include handlebars or aerobars. I have testing displays for these as well. Best to solve as many of these problems as possible prior to mounting the fit bike. However, some problems don't arise until during the fit. As the back gets flatter and flatter during a tri bike fit saddle problems that were not evident early in the fit become acute during the fit, as the saddle begins to impress itself on the tender parts of the rider's trunk.

At whatever point during the fit contact point problems arise you must stop the fit and solve that problem. You very simply cannot establish good fit coordinates while point tenderness problems arise. You might have special solutions for this, such as pressure mapping. Fine. But there's a chicken & egg problem. You might not discover a point tenderness problem until the fit has progressed to a certain point and the problem suddenly presents. This happens. It's the fruit of your work. A saddle that did work in a bad position isn't working in the good position you're generating. Stop, fix the point tenderness problem through a trial-end-error process of changing equipment, and then proceed.

Just realize that changing saddles is not as simple as, well, changing saddles. There is about 35mm between the lowest and highest profile saddles out there, measured as the distance from the saddle's rails to the top of the saddle. So, as you're changing saddles you'll have to normalize for saddle height profile and also setback, if the rider sits the new saddle differently than the saddle it just replaced.

This might be the ugliest part of bike fit, the least codified, the least understood, the most trial and error, where in the art and science of bike fit it's mostly art, not so much science, and what art there is is black.

Pardon the detour, let's get back to the roadmap.

Preparing the Fit Bike

Now the rider must hike his leg over the saddle and start a-pedaling. Right?! He's going to jump on that DFU and ride it like an urban cowboy!

Well, we're just about ready. Not quite. When he or she hikes his leg over the saddle, that saddle's already going to be sitting somewhere in space. Likewise, so are the handlebars. And let's assume that we're talking about a road race bike, and a road race fit, or road fit, or road bike fit.

By "road" or "road race" I'm just talking about a standard bike with road (i.e., drop) bars, rather than a tri bike or a mountain bike.

<u>Adjust Crank Length</u>

If your fit bike has an adjustable crank, then set the crank for the length you want. We have no wisdom for you on crank length. At least, not for road. Tri bike fit? Yes, we do have a bit of wisdom, but we'll talk about that when we talk about tri bike fit. All things equal, I tend to stick to conventional wisdom. For a 5'2" gal, it's a 165cm crankarm. For a 6'2" guy, it's a 175mm crank arm. For everyone in between, it's correspondingly somewhere between those two lengths.

<u>Establish Saddle Setback</u>

No, it's not convenient or efficient just to set the saddle anywhere, nor should the handlebars just be stuck somewhere in space.

Below is one of a series of horrible equations you'll get in this document. It's the "formula" for where we start the process, and it's based on "expected" saddle height. How do we guess what a rider's saddle height is? Well, did he bring in his existing bike? Since we're going to guess, then that saddle height is probably as good a guess as any. Otherwise, Lemond formula, brushing the unshod heel on the pedal spindle, whatever you want. We're just looking for a best guess.

The saddle height is measured from the BB to the top of the saddle, midway between tip and tail.

The starting saddle setback – for road, not for tri! – is determined according to this formula:

10% of expected saddle height plus 1mm for every cm of saddle height above 70cm, or minus 1mm for every cm of saddle height below 70cm. Oh, that was terrible! Let me try to make it less terrible.

Let's say a rider's saddle height is 70cm. The starting setback is 10 percent of that, which is 7cm (or 70mm). That's it. Simple. The nose of the saddle should sit 70mm behind the bottom bracket spindle.

But the saddle setback is not scalable according to that 10% formula. It needs to grow at a slightly higher rate, and that rate is 10% of saddle height plus 1mm more per every cm of saddle height. So, a saddle height of 72cm does not yield a setback of 72mm, rather 72mm (10% of saddle height) + 1mm for every 1cm of saddle height above 70cm. Therefore, a saddle height of 72cm yields a saddle setback of 74mm.

A saddle height of 78cm is 8cm more than 70cm, so it's 10% of 78cm (78mm) + 8mm = 86mm.

A saddle height of 82cm mandates a setback of 82mm + 12mm = 94mm.

Got it?

The opposite is true for smaller riders. For saddle heights lower than 70cm, we don't need and can't use all the setback we get through the 10% rule. We need to subtract 1mm for every 1cm lower than 70cm.

So, a saddle height of 68cm does not yield a setback of 68mm, rather 68mm – 2mm = 66mm.

A saddle height of 63cm yields a saddle setback of 63mm – 7mm = 56mm.

<u>Shallow to Steep</u>

Those of you who are hip to typical saddle setback numbers might recognize that this is a shallow, aka laid back, relaxed setback. It isn't because we believe in relaxed setbacks. It's because we don't know where, along the gradient from shallow to steep, a rider might prefer his or her setback.

If you take all Slowtwitch readers who are enthusiastic road bike riders, they average a setback of 8.3% of saddle height. If you take an entire Pro Tour team and average them out, it's more like 9.5% of saddle height (we measured 2 pro tour teams, one averaged a setback of 9.0% of saddle height, the other was just shy of 10% of saddle height). Some individual riders were at 10.5% of saddle height.

Some of this depends on the profile of the team. If you establish an average of, say, 9% of saddle height as a typical saddle setback, taller riders tend to have more than this, shorter riders less than this. That's why our formula for starting saddle height has that little 1mm for every 1cm kicker to the 10% formula.

Even so, our 10%+ setback for every rider with a saddle height over 70cm is a laid back seat angle. Why? Because our protocol takes a rider through the gradient of shallow to steep, in that order, in that direction, and we know that somewhere in there the rider will find the setback (seat angle) he wants.

Why don't we just stick him at a particular setback and be done with it? That's what knee-over-pedal-spindle (KOPS) is. In that case, we see what the "driver" of the position is, don't we? Your knee position drives the saddle setback.

Here's the problem: Are you a crit racer? Are you a road racer? Do you climb a lot? Do you tour? Do you ride almost always on the flats? Are you non-competitive? Do you ride with a low front end or a higher front end? Terrain, effort level, morphology, your desired "just riding along" hands position, the purpose of your riding (competitive or not) all impinge on your decision of how steep or shallow you'll ride.

This is a part of the charm of a dynamic fit process: We can give the rider a test, at his chosen effort, on his chosen terrain type, allowing him to choose the setback he wants.

<u>One Fixed Parameter</u>

In order to use this protocol you can change a lot of things in order to dial in his position. You'll find his proper saddle height, which means moving the saddle up and down. You'll determine his proper cockpit distance, and handlebar elevation… by moving the handlebars back and forth, up and down.

But if you want to discover what saddle setback he wants out of several he might choose, the best way to do that is, in my experience, to leave that saddle sitting in that shallow setback position, optimizing the rest of the fit. Once the best set of fit coordinates has been established for that setback, then you can move the saddle forward a bit and optimize that position. Then move the saddle forward again, and re-optimize.

Each time you optimize a rider at a specific saddle setback you have executed a "trial." The Trial is a term of art in F.I.S.T.-land.

If the rider likes the slightly forward position more than the original rearward position – which he almost always does, because the rearward position is more laid back than the great majority of people want – then you can rule out that ultra laid back position. If you move him forward again, and he likes it yet better, great. If you move him forward again and he says, no, that's less comfortable, by definition the "trial" just prior to the one to steep is the keeper. At that point you've finished the fit. You're done. Well, you're done establishing fit coordinates. What you have left in front of you is to match those coordinates to complete bike solutions.

<u>Cockpit distance</u>

Remember, the rider hasn't hiked his leg over the fit bike yet. We're still setting it up prior to his getting on it.

What we're now going to do is fix the handlebars a specific distance out from the saddle, and here comes another nasty equation:

.72(overall height) - .78(saddle height) = saddle-to-hood-trough.

The "trough" of the hood – my term, maybe you prefer something else which is okay by me – is the low point in the hood just before the final upturn. So, let's take me. I'm about 6'1" which is about 185cm. My saddle height is fairly low at 75.5cm. which means I'm a little bit torsoey, which means I need a slightly longer cockpit (a bit more length in my position versus my height).

.72 x 185.5cm = 133.5cm
.78 x 75.5cm = 58.9cm
133.5cm – 58.9cm = 74.6cm

That's where I'll set the bars up, so that the hood troughs are 74.5cm in front of my saddle's nose, and, this is in a straight shot, not an X axis measure. Just, with the handlebars pointing straight run a tape directly from the saddle nose to the hood trough.

This is both a guide for setting up the bike in advance of a fit, and also a confirmer. Remember confirmers? They're little helps, little angels sitting on our shoulders, making sure we don't go astray. But don't make a confirmer a driver. This formula is subject to change. I'm always tweaking these.

Further, this formula does not – yet – take into consideration arm length. I've noticed that a rider's wingspan, fingertip to fingertip (pretty easy to measure), impinges on this formula. Wingspans longer than overall heights tend to push the handlebars out further than this formula suggests. The opposite is also true.

Me, I ride with a saddle-to-hood distance of about 73cm rather than the predicted 74.5cm. The formula is just a guess.

<u>Handlebar elevation</u>

Finally, we're going to set the handlebars to their proper starting elevation, for the purposes of bike fit session.

We'll again rest on a formula: 10 percent + 1cm raised. In this case, again, let's consider 10 percent of saddle height. If saddle height is 76cm, then 10 percent is 7.6cm. In actuality I expect the saddle to be lower than this when we end up with the final position. But remember, we're starting the rider sitting pretty laid back, and generally riders that sit shallow prefer their bars a bit higher.

As the fit progresses, and we move from Trial 1 to Trial 2, and so forth, the saddle will come gradually forward, the bars will gradually trend lower, and then we'll reach a point where the saddle is too far forward, maybe the bars are even a bit too low – as we've gone from touring to road race to criterium position if you prefer that parlance – and the rider will then alert us we've gone too aggressive. But we'll start with the bars slightly higher than we expect they'll end up.

Handlebar elevation is measured, by me, in the following way. If I take a carpenter's level, set one end on the saddle, the other end hovering in air over the stem, I'll then move the level very slightly to one side, so that I'm measuring straight down to the handlebar. I'll measure to the top of the handlebar just to the side of stem, which is on that 31.8mm section if in fact I'm riding a 31.8mm diameter bar.

If what I'm riding is 76cm of saddle height and if what I want is 10 percent of saddle height, plus 1cm higher, instead of 7.6cm of handlebar drop, I start with 6.6cm of handlebar drop.

Where does this rate in terms of handlebar heights?

If we take these same Mediterranean-based European pro tour teams, the average elevation drop — using my fit coordinate landmarks — is about 11 percent of saddle height. Riders on U.S. Pro Continental teams tend to ride with greater handlebar drops, but I suspect that's because they tend to ride more criterium-style races which favor steeper saddle positions and lower handlebars.

I've seen handlebar drops that are in the 15% range. That's a lot. When I see this one of two things are happening: Maybe the rider has a very long wingspan. Okay. That's going to drop his bars. Maybe the rider just rides with a very flat back for a long time. Okay. Maybe his job is to be the leadout man for a cycling team.

But it's also very likely that the rider has just been seduced into riding a low position and that rider will almost never get into his drops. In this case I submit that he's just riding too low. Even if he's a pro. Even if he's a top pro. If you never ride your drops you're losing a valuable position.

<u>Is Fit Bike Set-up Time Consuming?</u>

All that might sound like it takes a lot of time, but really it doesn't. You either measure the rider's inseam, give it the old Lemond Formula, and adjust the saddle height, or you measure the saddle height on his existing bike. Use that. That gives you the basis for the saddle setback and saddle to hood trough. Also it tells you handlebar elevation.

You've set the crank to the proper length, and the only other thing to do, really, is make determinations about equipment: the saddle, and the handlebars. Here's a tip. A rider who seems in danger of riding a position that's extremely long might benefit from a bar with a marginally longer reach (say, 90mm). A shorter rider who's going to be challenged just to find a bike narrow enough would always benefit from a handlebar with a short reach (70mm). I find in practice that starting out with short reach bars is a good default move.

Just realize that you have to take this into account when determining complete bike solutions. If you "prescribe" a certain bike, and you build this bike up and, lo, the bike is too long by 1cm or 2cm once it's built, it might be that you did the fit using a bar with a 70mm reach but the bike comes spec'd with an 80mm or 90mm reach bar and you didn't take that into account.

The only other thing you have to do is set the resistance on the fit bike. Start with something low. 120 watts. 150 watts. Depends on the rider, obviously.

Aboard the Fit Bike

Once the rider hops aboard, you'll see if the saddle height is about correct. If it's way off high or low, raise or lower the saddle until you get it to where it looks fairly close. Then have the rider dismount and adjust the saddle setback, cockpit and handlebar elevation accordingly. This won't take but a minute or two.

Then remount the bike and, yes, this is going to sound strange, but, lower the saddle maybe 1.5cm to 2cm. What's this all about?

It's been my observation that saddle heights are most safely and accurately achieved via starting with a saddle height slightly too low, and then raising that saddle height to appropriateness. Like unto the reasoning in the section above, if we start with a saddle too low, and we raise it to the point where the rider experiences the entire range of slightly-too-low to slightly-too-high, and we do this while the rider is pedaling, the rider is more to feel — in a way that is obvious to him — an overtall saddle. It's preferable both for performance and for injury reasons for the rider to err on the side of a saddle 3mm too low than 3mm too high. This protocol is used with that in mind.

There is a by-product of this protocol that is happily congruent with the paragraph above. If the rider happens to be a toe-pointer, you'll likely discover this while the saddle is migrating from it's too-low position to its proper position. If we started with the saddle at the expected end point, or with the saddle too high, we would not know if the steep plantar angle, at bottom dead center, of a toe-pointer was due to his toe-pointing technique, or if he's plantar flexing in order to reach a pedal from a too-tall saddle setting.

A Dynamic Fit

With the rider aboard, and pedaling, and the saddle lowered by that 1.5cm to 2cm, a couple of things are going to look funny. First, he's obviously riding a saddle too low. Second, he's sitting way back. He's going to feel as if he' riding something between a recumbent and a child's tricycle. That's okay. We'll quickly begin to solve the problem by incrementally raising the saddle.

The gold standard in fit bikes is one that can make changes while the rider is pedaling, shrinking the feedback interval down to zero. It's been my experience that using nomenclature similar to that you'll experience during an ocular exam is helpful. I'll give the rider two options: "I'm going to raise your saddle, and you tell me which of the two heights you like better. You're currently riding option-1. Ready for option-2? Okay, there's option-2, feel that? Yes? What's your preference, the prior option-1, or this current option-2?"

<u>Evidence of Appropriateness</u>

As you're raising the saddle incrementally, you'll be asking the rider, "Option-1 or option-2," or, "I've just raised your saddle, is this better or worse than the prior lower saddle height? Better or worse?" You'll eventually hear "worse" or "option-2" and then you know you've gone just a bit past the correct saddle height. At least as far as your subject is concerned.

Something should be obvious now, to you, the reader — and this is disconcerting to some. The "doctor" is relying on the "patient" for the diagnosis. At least in part. However, if you think about an ocular exam, isn't this what happens? The optometrist generates an ocular prescription based on the feedback of the patient. Likewise, we feel that the "patient," that is, the rider, is an integral part of the decision team when determining the correct fit coordinates.

This is one of three pieces of "evidence" suggesting a fit coordinate has been correctly hit upon. Another — and maybe the most important — is your fitter's eye. You might not know how good your eye actually is. But it's probably better than you think it is, as long as what your eye is attempting to judge is a subject actually pedaling his bike. These are the two main drivers of the fit: your eye (the primary driver) and the subject's perceived comfort and power (the next-in-line driver).

Third in line — at least as far as saddle height goes — is the "included knee angle." Imagine the rider stopping right at the bottom of the pedal stroke. The leg won't be straight. There will be some bend in the knee. Let's take a measure of this angle.

We're looking at this rider in profile, that is, we're looking at him from the side. We'll use the center of the outside of the knee — dead center, front-to-back, top-to-bottom — as the fulcrum of the angle. One arm of the angle is to the maleolus, which is that bony protrusion of the ankle (the Kathy Bates bone, if you've seem the movie *Misery*.) The other arm of the angle passes through the greater trochanter, which is the bony protrusion at the top of the femur (again, on the lateral side).

This angle should measure about 140 degrees. There's an acceptable range, and I'm happy with anything between 135 and 143 degrees, as long as my eye likes the pedal stroke, and as long as the rider feels that this is his best saddle height.

How do you measure this? With a goniometer, if you're stopping the pedaling action to take your measurement. Alternatively, you can measure this angle with a motion capture system. The advantage to a motion capture system is that it's a dynamic tool to measure a dynamic protocol.

The advantages to a goniometer are two: no motion capture set-up required; and a goniometer is $60. The disadvantage to the goniometer is that nobody, on his own accord, stops at bottom dead center with anything like his actual knee angle stricken while riding. Everybody stops with a straighter leg than is actually the case while pedaling. Why? Because everyone begins to raise his heel, anticipating the recovery phase on the backside of the pedal stroke, just before bottom dead center. This plantar flexing creates a more acute (bent) knee angle. But, nobody knows, just by feel, that they do this. Accordingly, you must be really good with a goniometer to get this angle right for your measurement. It takes a lot of training and practice. Most all else is pretty easy to measure with a goniometer, but not the knee angle.

Again, do not let the numbers drive the fit. I've seen a lot of fitters try to get the rider's saddle slightly higher or lower to stick the knee angle in the center of the range. Bad idea. While "everybody's the same" is a nominally true statement, it's within the context of microvariations. Just look at your face compared to all the other facial structures humans have. Basically, our eyes, nose, mouth, and ears are spatially represented almost identically, human-to-human. But, *almost*. If your eye, and your rider's best sense, conspire to agree on a knee angle of 136 or 143 degrees, don't let your goniometer or motion capture system sway you otherwise. Heck, that knee angle may be 140 degrees, and it might be that you're just a bad practitioner with the goniometer, or that you placed the motion capture sensors in the wrong place.

Okay, presto, you're done. Your subject's saddle height has been determined.

<u>Cockpit</u>

The cockpit distance should be pretty close to correct already. Remember, prior to the rider mounting the bike you set up the cockpit to be fairly close to correct using a static measure. Cockpit length is settled upon by the rider according to comfort and ergonomics.

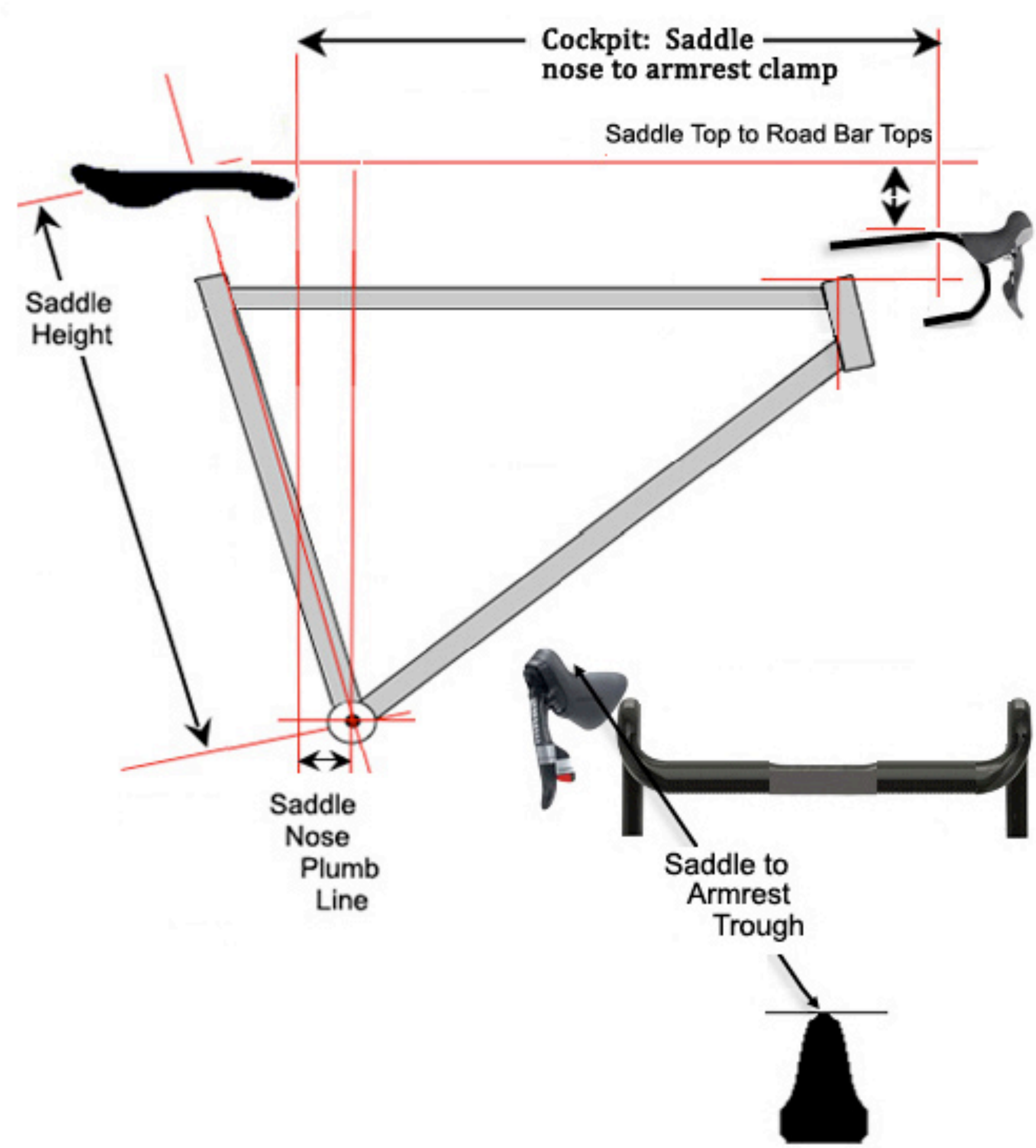
I have the rider assume what some call the "neutral" position: seated, with hands-on-hoods. My protocol for determining cockpit is as simple as asking: Do you feel too scrunched up? Or too stretched out? In my experience, riders are generally sufficiently body aware to express what they feel. If they show ambivalence this will be sussed out as the fit session progresses.

<u>Elevation</u>

It is not usually the case that the default position we've chosen for handlebars is too low. When I move, now, to handlebar elevation, I'll again ask the rider to choose between two options, and the second option is with the bars about a centimeter lower. I'll ask, "better or worse?" Most probably the rider will choose the lower position. Remember, a very typical elevation among pro cyclists is 11 percent of saddle height. If we're starting out with the bars below the saddle "10 percent + 1cm higher," that's probably an elevation of about 8.5 percent of saddle height. The odds are that the rider will ask that the handlebars be lower. But not by a lot.

However, if the rider chooses "option-1" over the lower option, fine. I would in this case raise the bars to a point 1cm higher than "option-1" and repeat the process: which is, ideally, executed in a dynamic fashion (lower the bars 1cm while the rider is aboard and pedaling).

Once the rider is satisfied, this trial is done. You then either write everything down, everything being the relevant fit coordinates and the fit bikes output, at least the front (handlebar) output.



The things you write down:

Saddle height
Saddle to hood trough
Handlebar elevation
Handlebar X (or Reach)

Saddle setback
Saddle to handlebar center
Handlebar Y (or Stack)

You should also note whatever it is you're bolting onto the bike. If it's an Exit Cycling or Retul fit bike, you need to note the stem length, stem pitch, and spacers under the stem. And, the geometry of the handlebar (its reach and drop).

If you're using a Shimano, GURU or Purely Custom fit bike, you don't place anything except a handlebar on the bike, so you must note the bar's reach and drop.

You don't have to write any of this down if you have a GURU fit bike, because that bike automatically knows and records where everything is. If you don't have one of these, no worries, you just have to write these things down. One way or the other you have to archive your work. What happens if the rider doesn't like the position achieved during Trial 2? Then Trial 1 is probably the best position. If you don't have the fit coordinates written down then you'll have to do the fit over again.

Successive Trials

You've done most of the work. You already know the rider's saddle height. And the cockpit distance. And the elevation, though this is probably going to change slightly in concert with moving the saddle fore/aft.

The rider is off the bike when we're writing down his fit coordinates. I use a form made for the purpose. It's got a little stick diagram of the bike, with the values indicated: saddle height, saddle set-back, cockpit, elevation, hood-to-trough. For each value I'll have 5 boxes, labeled 1 through 5. All of the boxes labeled "1" are for the first trial.

For the second trial I'll move the saddle forward anywhere from 5mm to 8mm depending on the height of the rider. I'm 6'2", so I've got to move the nose of my saddle forward a greater amount than someone 5'2" in order to achieve the same angular difference in seat angle.

After you move the saddle forward, let us say, 7mm, you're still fairly rearward of the BB. Remember, if a typical saddle set-back achieved by a pro cyclist is between 9 and 9.5 percent of saddle height, we're still just over 10 percent of saddle height behind the BB.

Once we move the saddle forward, if the movement takes place horizontally, we'll need to normalize for saddle height. Refer to your basic high school geometry. If the saddle moves forward, a point on the saddle is sitting slightly closer to the BB. If you move the saddle forward 8mm, you'll need to move it up 2mm or so in order to retain the saddle height (move the saddle up about 1mm for every 3mm to 4mm you move it forward).

You'll need to move the front end of the bike forward that same distance. Move the handlebars forward 7mm. Now the rider can remount the fit bike for a second trial. As Proctor and Gamble puts it, "shampoo, rinse, repeat." The second trial is executed exactly as the first.

The second trial, like the first, fixes the seat angle, or saddle fore/aft. Everything else is fair game, but, not that. That's the immutable metric.

You'll find that this second trial takes very little time. You ask the rider if his saddle height is okay, and it probably is, because his leg hasn't grown or shrunk over the 10 minutes since you were executing his first trial. His pedaling dynamics will not have changed. Nevertheless, if he repents if his earlier decision on what constitutes a proper saddle height, and he says, "Upon reflection, I think I'd like the saddle slightly higher [lower], then, go with it.

You'll ask him whether he wants his cockpit distance extended or retracted. Very likely he'll prefer it very close to where it is, because it's the precise cockpit distance he chose for his first trial, and it's unlikely that his torso changed in dimension over the intervening 10 minutes since the first trial.

The one likely thing to change is handlebar elevation. Because you moved him forward 7mm, you've opening up his hip angle when he's pedaling. "O, the joy!" you might expect him to think. The more open the hip angle, the easier to push on the pedal, right? Not exactly. Only up to a point. A hip angle that is too obtuse is not as bad as an angle too acute, but it's less good than the right hip angle. The rider will usually choose for the bars to be slightly lower in the second trial to reacquire his correct hip angle.

How much lower should you go with the handlebars? Maybe 5mm at a time.

Now, the magic question: Sir [madam], do you like the first trial, at the shallower angle, more laid back, or do you like this second, slightly steeper position? Most of the time the answer is, I like the steeper position, because the first position was almost out-of-the-range too shallow.   And that's okay. We want the rider to know what too shallow feels like, and what too steep feels like, so that you, the fitter, are inoculated from any eventual question in your customer's mind as to whether every good option was presented.

Again, the fit coordinates are noted, in box-2 on the fit sheet described above.

Move the saddle forward again, but perhaps this time only 5mm or so. Shampoo, rinse repeat. As the rider whether he or she likes this new trial better than the trial just prior. Now the possibility that the rider says, "I like the prior trial better," becomes incrementally higher. But it's still more likely — just playing the odds — that the third trial will be preferred.

Move the saddle forward another 4mm or 5mm or so, and do it all again. Each of these trials should take no more than 10 minutes. By now, after all these trials, the saddle has been moved forward quite a bit. If my saddle height is 76cm, and I started 82mm of setback, let's say the second trial was performed with the saddle moved forward 7mm, then that trial was conducted with a setback of 75mm. If we moved the saddle forward 5mm for the third trial, then that trial was conducted at 70mm. For the fourth trial, if the saddle came forward 4mm, the setback was 66mm.

At this point, the saddle setback is 8.5% of saddle height. This is a very acceptable setback. However, the mean setback is somewhere between 9 and 9.5 percent. A setback of 8.7% is inside an acceptable range, but it's on the steep end. If the rider likes this position the best, I'd try one more trial, 4mm steeper.   That's 62mm of setback, it's just north of 8% of saddle height, and 8% really is close to a cut-off. Riders will almost never choose a setback that's less than 8% of saddle height, because too much weight is placed on the hands.

However, that's the range: 8% to 11%. Somewhere in there is the setback your customer prefers, and you don't and won't and can't know where along that gradient your customer prefers to reside. And this is the beauty, and necessity, of a dynamic fit. Only if you grant your customer the ability to select his or her preference will you dial in his or her fit. You can't do this with a static formula.

When the rider says, "Now that's too steep," you know the fit coordinates your customer prefers: those of the trial just prior. This is why you need to archive the coordinates of each successive trial: you won't know which of the trials your customer prefers until you reach the trial that is too steep.

That's it! Fit session over! But if you want to go down deep and stay down long in the field of bike fit, there's something you can do for extra credit.

Incline

The most recent interesting addition to road fit protocols is the use of incline. Virtually riding up a hill. How does this work its way into the protocol, and why?

First, it's always the goal of the fitter to provide the most realistic representation of the road during the fit session. The closer you can get to road conditions the more likely the fit will stick.

The second reason incline is important is due to the single most-often problem experienced by road fitters using protocols like this one: cockpits too short. Two techniques a fitter can use lengthen a rider's cockpit: effort, and incline. If your bike doesn't incline, at some point near the end of the fit, increase the resistance and have your rider produce a fair amount of effort. Then toggle between longer and shorter cockpits, and you'll often find that a cockpit maybe, on average, about 15mm longer is achieved.

This is important, because he's going to ride harder on the road than he is in the studio if you don't ask him to produce some effort during the fit. Usually, in the last 1 or 2 trials, that's when I'm going to ask him to pretend he's the leadout man for his sprinter, there's 1km to go, and he's got to keep the other teams from swarming him. He'll choose a longer cockpit, and that's generally more in line with how he'll want the bike when he's out on the road.

The other way to achieve a properly long cockpit during a fit session is to incline the bike. If your bike has this feature, incline it to 7% or 8% grade, have your subject ride both seated, climbing, hands both on the tops and the hoods, and then out of the saddle, hands on the hoods.

Riding out of the saddle will cure that rider of wanting a laid back saddle position. That shallow saddle (Trial 1) means the bars must be pulled back as well. Riding out of the saddle will be difficult with bars that close to the BB.

Trial 2 will find the subject riding with the saddle further forward by 7mm or 8mm and the bars therefore further forward that same amount (or even more of the subject chooses a longer cockpit while riding on the flat). That's going to feel more balanced when he's out of the saddle.

Do I change the cockpit distance while he's out of the saddle? Not during Trial 1. Usually not during Trial 2. Maybe during Trial 3. I usually don't move the cockpit out until I'm in what I think is the final trial. Then, I'll rotate the handwheel of my fit bike and let the rider have an additional centimeter of cockpit while riding out of the saddle on a climb. He'll almost always like that better. Then I lower the bike to level. Now he's probably feeling a little stretched out.

This is the decision he now must face: 1cm longer cockpit, feels better climbing, 1cm shorter, feels better on the flats. Let him decide. The beauty of this is that now you have an appropriately long cockpit, but not overlong, and you've given him the opportunity to test his positions in a multitude of riding conditions.

One thing: when you incline the bike, and especially when the rider is out of the saddle, you're going to need to add a lot of extra resistance to the bike. You add that resistance when the rider is out of the saddle, reduce when he's back sitting.

If your bike has no incline feature, no worries: we make our own incline tables for fit bikes. If you can't find it otherwise, shoots us an email and we'll point you to plans, and you can make your own incline table for any fit bike you have.

<u>Handlebar geometry</u>

I'm very picky about this. When I'm riding in what some call the "neutral" position—seated, hands on hoods—and I'm comfortable, I may well be uncomfortable when the road pitches up and I'm riding with my hands on the tops. This is a typical ascending position, and I like to be a bit more stretched out while seated, hands-on-tops than the typical handlebars grant me.

The solution here is simple. Let's say that a bar that isn't working for me has a bar reach of 90mm, and I'm riding with a 110mm stem. If I swap the bar out for one that has a reach of 80mm, and sub-in a stem of 120mm, presto, I've lengthened my cockpit (saddle nose to handlebar clamp) 1cm while leaving my saddle-to-hoods distance unchanged.   Still not enough of a change? I can place a bar with 70mm of reach on the bike with a 130mm stem.

By accounting for my comfort both with hands-on-hoods as well as with hands-on-tops I'm acknowledging that fit is more than just the satisfying of one rider position. There are 6 rider positions: riding on the flat, seated, with hands-on-hoods; climbing seated with hands-on-tops; climbing seated with hands on hoods; seated on the flat with hands-on-drops; standing with hands-on-drops (sprinting); and standing with hands-on-hoods (out-of-the-saddle climbing).

Mostly, the disconnect between tops and hoods is felt when seated climbing. I like the tops out in front of me when rhythm climbing. But I don't like the hoods too far out in front of me. For me, the recipe is a very short reach bar, which keeps the hoods in their proper place but pushes the tops further out. This is another virtue of having incline as a fit bike feature: it allows you to dial in handlebar geometry.

If you want to satisfy most of the possible options available to the rider, this can run into a fair amount of inventory: short and long reach bars in various widths.   All these bars must have hoods on them, and be wrapped in tape, so as to mimic the actual riding experience.

The Art and the Science

Ideally, we'd like to get rid of as much of the art of bike fit as we can, and replace it with science. Nevertheless, some of the art remains. Here are some tips that will make life easier for you.

<u>Women</u>

Fitting women requires a specific knowledge of bike geometries and why they are made as they are. Regardless of what bike companies tell you about women's geometries, the true limiters are the CPSC requirements for front/center.   Almost all road bikes are made with 700c wheels and, with bikes made of this wheel size, if you're a larger production bike maker, you're playing with fire if you make a bike with a front/center shorter than 57.5cm or so. This is the distance from the BB to the front wheel axle. This distance informs the amount of shoe overlap that will take place when the rider tries to turn the wheel while pedaling.

This means that bikes can only be made so “tight” or “narrow” in the cockpit. It is very rare to find a bike with a reach number lower than 360mm and, often, nothing lower than 370mm in a size run.

This means that you ought to plan ahead when fitting women. Make sure you put a short reach bar on the fit bike. This allows the bike frame to have more reach and still fit your rider.

Resort to every trick in the book to extend the cockpit of shorter riders. Make them ride under effort, use incline during the fit process if you have it available to you.

<u>Know your HX and HY Numbers</u>

Fit bikes tend, most often nowadays, to output HX and HY (the horizontal and vertical distances from the bottom bracket to the handlebar clamp, that is, the place where the handlebar passes through the stem). Try to get to know these numbers. The more familiar you can become with them, the more you can navigate your way out of trouble.

For example, no HX number lower than 420mm will yield a bike. Better yet 430mm. Also, HY needs to be somewhat more than HX. If, during a fit, you end up with an HX number that approaches the HY number, that’s trouble. A nice safe zone is when HY is between a fifth and a third (1.2 to 1.33) greater than HX.

<u>Pedaling resistance</u>

Every fit bike is going to have some sort of resistance unit, like a Computrainer or a Powerbeam or something that modulates the pedaling force required to turn the pedals. Err on the side of a pretty modest amount of resistance in the beginning, because the resistance will probably increase as the fit session progresses, and you don’t want to wear your subject out. Maybe 120 watts, maybe 150 watts, in the beginning.

As you get to the second trial, and the third, I’d increase the resistance to something like race conditions for a 1hr or 2hr ride, depending on the goals, the fitness—the basic profile—of the rider. If you choose to test these positions in each of various riding positions, I might increase the resistance momentarily while riding hands-on-drops, trunk on-the-rivet, because this is a position ridden under significant load, with a higher effort. Likewise if the bike is inclined, and the rider is seated, hands-on-tops or out-of-the-saddle and on the hoods.

At some point, the rider will want to test his position at a resistance commensurate with how he rides. Grant him that opportunity.

Cadence

Many riders will assume a lazy posture and approach to the fit session, not out of any lack of character, rather that they don't know any better. You might want to coach the athlete to pedal with a cadence that is real-world, and that real world is going to vary depending on the athleticism of the rider. However, in no case will it be less than 70rpm, and probably more like 75rpm or 80rpm. It might be as high as 95rpm, depending on rider's preference. Just exhort the rider to pedal with a cadence that's typical of that rider's road habits.

One thing: If, upon the adoption of a new, steeper trial, you find that a rider's cadence has suddenly quickened — if he rode 70rpm in trials 1 and 2 but of his own accord commenced riding 85rpm during trial-3 — this is "body language" for "I like this position!" The rider might not know it, perceive it, voice it, but this is what an increased cadence generally means.

The Very Unathletic

Will this protocol work for those who carry a 6th-grader above the beltline? Or for those who are just not blessed with speed? Yes. They will often opt for seat angles on the shallower side. They may also opt for a higher handlebar position, not because they are necessarily weak or injured, but because they have a simple clearance problem — they may have a belly that intercedes between their thigh and the optimal position of that thigh at top-dead-center, were that belly not there. Consequently, the bars are raised to get the belly out of the way. No problem.

In the end, it's rider preference, as long as the rider isn't preferring something way out of the norm. The idea is to try to draw the rider toward orthodoxy, for two reasons: the ideas of "sameness" and an attachment to "orthodoxy" are a value worth honoring, because you absorb and rest in the collective knowledge of those who came before you; second, if your customer can be drawn toward orthodoxy, production bikes are made for orthodox positions. One way to confuse, and maybe cheese off, your customer is to present to him a position that is not represented on your (or anyone's) showroom floor.

Fit to Reach

If you look at Stack and Reach numbers, what you'll find are road bikes with Stack numbers around 500mm and up to maybe 630mm. Add to that "acceptable" stem pitches of -17° to -6° and acceptable headset dust covers of "slammed" 5mm up to maybe 25mm and you have a total range of about 170mm between the lowest possible config on the lowest bike to the highest config on the tallest bike in the largest size.

Conversely, you've got a range of maybe 50mm in Reach between the tightest and the longest bikes, and you probably only have about 10mm, 20mm at the most, variance in either direction in acceptable stem length.

You have a lot more wiggle room in height than you have in length. So, keep an eye on the length of the position, as represented in HX. Here's what I mean. Take me as an example. I tend to ride 58cm bikes. I might ride a 110mm stem, I'll ride a 130mm stem, but nothing longer or shorter. This means my HX needs to be between 495mm and 510mm if I want to ride a typical 58cm bike with something within 10mm either size of a 120mm stem. Always keep an eye on that HX number.

Fit is One Thing, Handling is Another

Remember that all these numbers tell you how a bike will fit. They won't tell you how it will handle. Let me rephrase: a bike that fits well will, on paper, be much more likely to handle well. But two bikes that fit might not be equal in how they handle. This is especially true with women's bikes. If two women's road bikes have Stack and Reach numbers that match, but one has a trail of 55mm and the other a trail of 70mm, that latter bike is going to handle like a dump truck. Become a student of what geometric features that impact handling. Part of the art of bike fit is knowing how to parse between two bikes that can each work, fitwise, for the customer.

In Way of Explanation

Sometime we are asked about other protocol elements. Here are some answers to frequently asked questions.

Body Angles

Remember when we pulled out our goniometer and measured the included knee angle while determining proper saddle height? Why aren't we continuing to use the goniometer for, say, hip and shoulder angles? Actually, we do during tri bike fit. But not during road bike fit, because the angles the body makes are much more fungible during road riding that during tri bike riding. This is due to two factors. First, the hip angle is notoriously difficult to measure with any usable precision because — unlike when I the aero position during a tri bike ride — the elbow on a road bike is not fixed in a spot. Road riders are squirmy by design. And this is attached to the second reason body angles are hard to measure during road riding: such a rider uses a lot more of his saddle, fore/aft.

Hip angles during road bike riding tend to become more acute under load, more obtuse when riding easy. The angle becomes more acute through the rider bending his elbow. With so much change in elbow flexion, and so much fore/aft saddle movement depending on the effort expended, the questios become: "Which hip angle? When? At what effort? While sitting where in the saddle?"

This is distinct from tri bike riding, where, when a rider is in the aero position and is properly positioned aboard a comfortable saddle, he's pretty much glued there. You have hip and shoulder angles you can measure with precision.

Accordingly, we are less enthused about the use of body angles during road bike riding, hence motion capture systems and goniometers are of less utility other than during saddle height determination, where the knee angle is fixed because there is no way for that angle to be fungible, since the saddle sits a fixed distance from the BB.

That established, the F.I.S.T. protocol is expansive enough to embrace confirmers other than those listed here. If you want to use Retül, Dartfish or other motion capture and use body angles more liberally that we espouse here, no problem. The F.I.S.T. protocol does have "values" and they are explained very early on in this document. As long as protocol variances or additions do not violate these values F.I.S.T. is large enough to absorb them. These protocol nuances make you unique as a fitter.

KOPS

Note that we do not ascribe to the use of "knee over pedal spindle" when fitting. It's not that the knee should not be over the pedal spindle. And we don't mind if the knee ends up over the pedal spindle. We just think this is an often happy coincidence after a fit session has concluded. But we don't think KOPS should be a driver of position. It is simply a frequent output of a bike fit session. It's just like cockpit distances that are 75 percent of saddle heights. It's a coincidence. And it may work as a starting point of a fit session. It's just not a driver.

Range of Motion Testing

Why don't we perform these, prior to fit sessions? I'm not against them. I just find that the fit session aboard the fit bike generally uncovers any range of motion restriction that might have been evident during a pre-fit test. Further, you might find that a subject is capable of more once on the bike than what is predicted from such a test. That established, I am not abjectly opposed to such testing and these tests are not incompatible with the F.I.S.T. protocol as explained herein.

Pedal-shoe Interface

Many fitters will chastise us — with good cause — saying, "Your step-1 is really step-2; step-1 must be pedal-shoe interface." Point taken. Cleat mount, canting, stance width, is not a set of topics about which we are uninterested, or that we think is unimportant. Rather, we think it's its own animal. It's a proper topic of conversation, just not a proper part of *this* conversation.

Where We Go From Here

Now you have road fit coordinates. Next is to port them into a process that outputs the bike geometry solutions, including either custom geometry, or the production models that most closely match the coordinates for this rider.

That's a topic for another section. Fortunately, applications and algorithms exist that crunch this data and present it to databases regularly updated that house the geometrics of existing bikes for sale on your showroom floor. The elegance and efficiency of a process like this is not only the quick and precise generation of your customers best set of fit coordinates, but an almost-instant generation of a list of possible options matching those coordinates. Something like: 56cm Cannondale SuperSix with factory headset top cap, one 10mm spacer, and a 110mm stem in a -8° pitch.

Lordy! Can it get much easier?!

That next step — the presentation of fit coordinates to these apps and databases — is quick and easy, and is explained in a subsequent primer.