Vertex Fit Cycle White Paper

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Summary

The Vertex Fit Cycle (US Patent #7976433) is a cycling fit simulator ("fit bike") that has several unique design features not found on any other fit bikes. These features were incorporated to make the fit process easier and more intuitive for the fitter, and to provide better feedback for the athlete regarding the effects of position changes. This white paper will point out these key attributes versus other fit bikes, and discuss their importance to obtaining optimal positioning for the athlete.

Figure 1: The Vertex Fit Cycle – a fully automated, computer-controlled cycling fit simulator employs a fixed saddle and mobile bottom bracket to enable unmatched rider and fitter feedback and ease of use.

Why create a radical new fit bike concept?

I created the Vertex Fit Cycle as result of my dissatisfaction with all existing fit simulators on the market. As a fitter, athlete, and engineer, I believe a cycling fit simulator must possess the following characteristics:

Full automation with computer control: It is essential that the athlete can feel position changes while working under load, without being disturbed by manual adjustments to the fit platform. Too, the fitter must be able to easily make precise changes in contact point position, and these changes must be easily quantifiable, reversible, and repeatable.

Ability to change each fit variable INDEPENDENTLY: This is a big one as ALL OTHER FIT BIKE DESIGNS FAIL here. Changing fit parameters in the same way that a bike is adjusted, or in X/Y orthogonal directions (for the saddle), necessarily results in multiple fit parameters being changed. This to me was entirely

unacceptable for both the fitter and the athlete. If you cannot isolate each variable, how does the fitter or athlete know which variable is really affecting performance/comfort? Of course the bike must also be able to adjust multiple variables simultaneously and instantly if desired. The critical design feature of the Vertex Fit Cycle is the stationary saddle: once mounted it never moves (other than tilt). The bottom bracket and bars move relative to the saddle, and furthermore the bottom bracket travels in an arc at a constant radius (= saddle height) from the top of the saddle. This feature is the ONLY way to enable independent fit parameter adjustments without requiring manual or computer-controlled compensations to multiple axes.

Ability to save and recall various fit coordinate sets: Toggling the athlete between two different fit coordinate sets while pedaling under load provides incredibly powerful feedback for both the athlete and fitter. We have captured many videos of candid athlete reactions when, after being fitted to a new position, we instantly return them to their old position. Frequently the athlete cannot believe how terrible their old position was, even though they may have ridden it for years and have only been riding the new position for 20 minutes. This simply cannot be achieved with a non-motorized, non computer-controlled fit bike.

Rapid saddle adjustment and changes: Certainly saddle choice can be one of the most important aspects of obtaining a good fit. Hence an ideal fit platform should allow quick saddle swaps WITHOUT changing saddle height or relative seat angle or saddle fore/aft. Furthermore, the saddle tilt must be adjustable while the athlete is riding under load so that the athlete can quickly feel the best tilt setting. We developed the Vertex's unique saddle cassette mechanism so that saddle stack could be adjusted before loading the saddle and that saddle swaps would take seconds while leaving fit parameters CONSTANT. This makes the Vertex a powerful platform for facilitating saddle selection and sales.

Wireless multi-platform control: We did not want the Vertex to be tethered to a computer. Hence it has onboard electronics and computers contained within the frame and can be controlled via any wifi-enabled device with a browser: Phone, tablet, or PC; providing unmatched versatility for the athlete and fitter. The onboard browser-based user-interface (UI) allows full wireless control of the Vertex's 4 axes, and displays real-time positioning data as well as bicycle matches (road or tri) for the current coordinate set. Fit coordinate sets can be saved and retrieved as needed from any wireless device.

In-depth analysis and configuration of bike matches and options: Once the rider's fit coordinates are determined, the fitter should be able to go far beyond a "dumb filter" list of bikes automatically spit out of a database. They should be able to conduct a detailed analysis of best bike matches, and then be able to virtually build those bikes (including super bikes) to determine the exact configuration that matches the rider's fit coordinates. The Vertex Road and Tri apps (PC-based) wirelessly import Vertex coordinates and generate a wealth of fit data: all typical bike measurements, bar stack and reach, frame stack and reach, etc. This data is then automatically incorporated into dozens of standard or super-bike specific configurator calculators that allow the fitter to spec and build the rider's dream bike without guesswork. The fitter can easily tell the athlete exactly what size of which bike works best, and how it should be set up. Obviously this makes the Vertex an unmatched platform for generating INFORMED bike sales and accordingly happy customers.

Wireless load control and realistic road feel: The fitter must be able to wirelessly control the power load output by the rider, and the rider must feel like they are actually riding a bike, not fighting a roller lacking natural momentum. We chose the Wahoo Kickr as the resistance unit for these reasons.

Durability and portability: We required that the Vertex must be able to withstand regular use under heavy rider power outputs, and that the axes must have no problem moving under these conditions. Hence we use our Vertex as a "super trainer" for indoor workouts as well as a fit platform. We also did not want the unit to be permanently attached to a platform or PC.

These attributes seemed obvious and essential to me, yet no fit bikes possessed them all.

The Vertex Concept

What is important to the athlete? From a bike fit perspective, there are some key measurements or coordinates that determine if an athlete is efficient and comfortable. The most obvious and perhaps important is saddle height. Although this is measured in many different ways, biomechanically it is the maximum distance from saddle seating surface to pedals (saddle height is most commonly measured to the center of the bottom bracket but crank length must be specified). Also extremely important is effective seat angle, or saddle fore/aft relative to the bottom bracket. Again there are many ways to measure this and different saddle characteristics can throw most of these measures into a sea of uncertainty. What actually matters is where the rider sits in space relative to the bottom bracket. Assuming constant saddle height (an assumption that proves invalid on any platform other than the Vertex), changes in effective seat angle affect power output via hip angle and weight distribution; and running efficiency off the bike for triathletes. Saddle tilt is another saddle parameter of much importance, but more so for comfort. Saddle SETBACK, or the horizontal distance of the saddle behind the bottom bracket, is just an easy surrogate for seat angle given a constant distance to the pedals – yet it is not in and of itself an important measure biomechanically.

Once an efficient and comfortable saddle position is determined, horizontal and vertical distance to the bars as experienced by the athlete will affect comfort, power, aerodynamics, and propensity for injury. The fitter is always balancing these outcomes versus the athlete's personal experience level, goals, fitness, and flexibility (meaning not just the athlete's range of motion but WHERE do they have good versus poor range). In this case it is the bars' position relative to the saddle that matters – this is what the rider feels – versus the bars' position relative the bottom bracket (an important measure as far as defining the setup of an actual bike).

The best way for an athlete to perceive the potential benefits or detriments of various fit coordinate changes is to vary them independently and instantly, while the athlete rides with effort. A fitter can use his experience and measures (body angles, etc.) to guide the process, but athlete feedback is crucial. Which brings us to….

What's wrong with "traditional" fit bike designs? It should be fairly obvious by now that any fit bike that is not completely automated is simply inadequate. I personally cannot imagine trying to use a fit platform where I must turn hand wheels, use power tools or similar, to move the machine. Add the fact that most machines do not provide position data in real time and do not have an app to analyze fit data; the reason perhaps why you see many so-called high-end fit bikes tucked back in a dark corner of a local bike shop,

repurposed as a spider farm. They are simply too much trouble to use in the real world and not effective in making the fit process spectacular for both the athlete and fitter.

The other HUGE problem is that EVERY ONE of these bikes hold the bottom bracket stationary and move the saddle and handlebars. What's wrong with that? Well, what happens on your bike if you raise the saddle? Saddle height increases; additionally, the bars are now lower (more "drop") and the reach to the bars is greater. Congratulations, you changed three fit parameters with one small adjustment. You may have changed effective seat angle as well – take my word for it. Or what if you decide to push your saddle forward 2cm? You also just lowered your saddle height by maybe 6mm (significant in the bike fitting world) and decreased bar reach. So in effect you need to make THREE mechanical adjustments just to change ONE fit parameter.

Disturbingly, all fit bikes other than the Vertex suffer from the same confusion for the athlete AND the fitter. Some fit bikes don't even increase saddle height along the proper axis. The saddle just goes vertically upward, or upward at some random angle– changing effective seat angle along with saddle height. Don't forget about bar drop and reach – that just changed too.

What's right about the Vertex design? In the Vertex world, the saddle seating surface is the sun around which the fit coordinate planets revolve. The saddle is fixed to the Vertex frame (not withstanding that it can tilt and be swapped out in seconds), and the bottom bracket swings in an arc from a virtual pivot point on the saddle seating surface. Yes, it orbits around this Vertex Point atop the saddle - at least along an arc of about 21 degrees – the relevant range for cyclists. So this allows the fitter to fearlessly change the seat angle while the rider hammers away, WITHOUT CHANGING ANY OTHER FIT VARIABLES. The bottom bracket always maintains a constant distance from the saddle, as do the bars (because the saddle doesn't move!). Therefor the rider feels ONLY the effect of changing seat angle and not some mish-mash of changing saddle height, seat angle, bar reach, and bar drop. And the fitter can observe the effects of changing this ONE variable.

If the fitter is dialing in saddle height, the Vertex bottom bracket moves along the radial line that defines effective seat angle. Nothing else that matters to the rider is changing. JUST SADDLE HEIGHT. This makes it a joy for the fitter and provides superior feedback for the rider. Of course, the bars can be moved in X and Y to change bar stack and reach, *but only if the fitter wants to change them, not as a by-product of saddle position changes.*

Figure 2: Vertex Fit Cycle radial bottom bracket movement is used to change Saddle Height and Seat Angle. Once mounted, saddle is stationary (other than tilt). Hence changes to Saddle Height and Seat Angle do not affect Reach or Drop to bars.

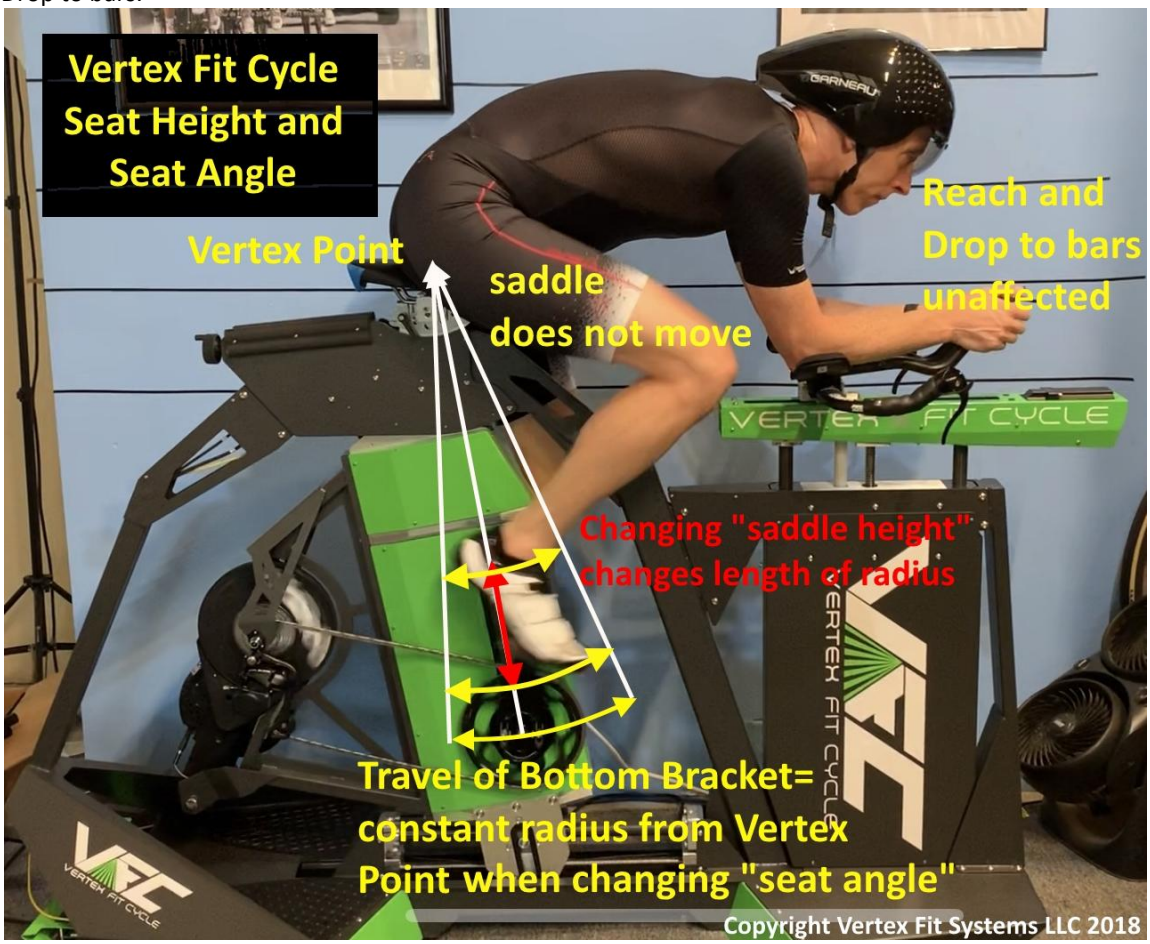
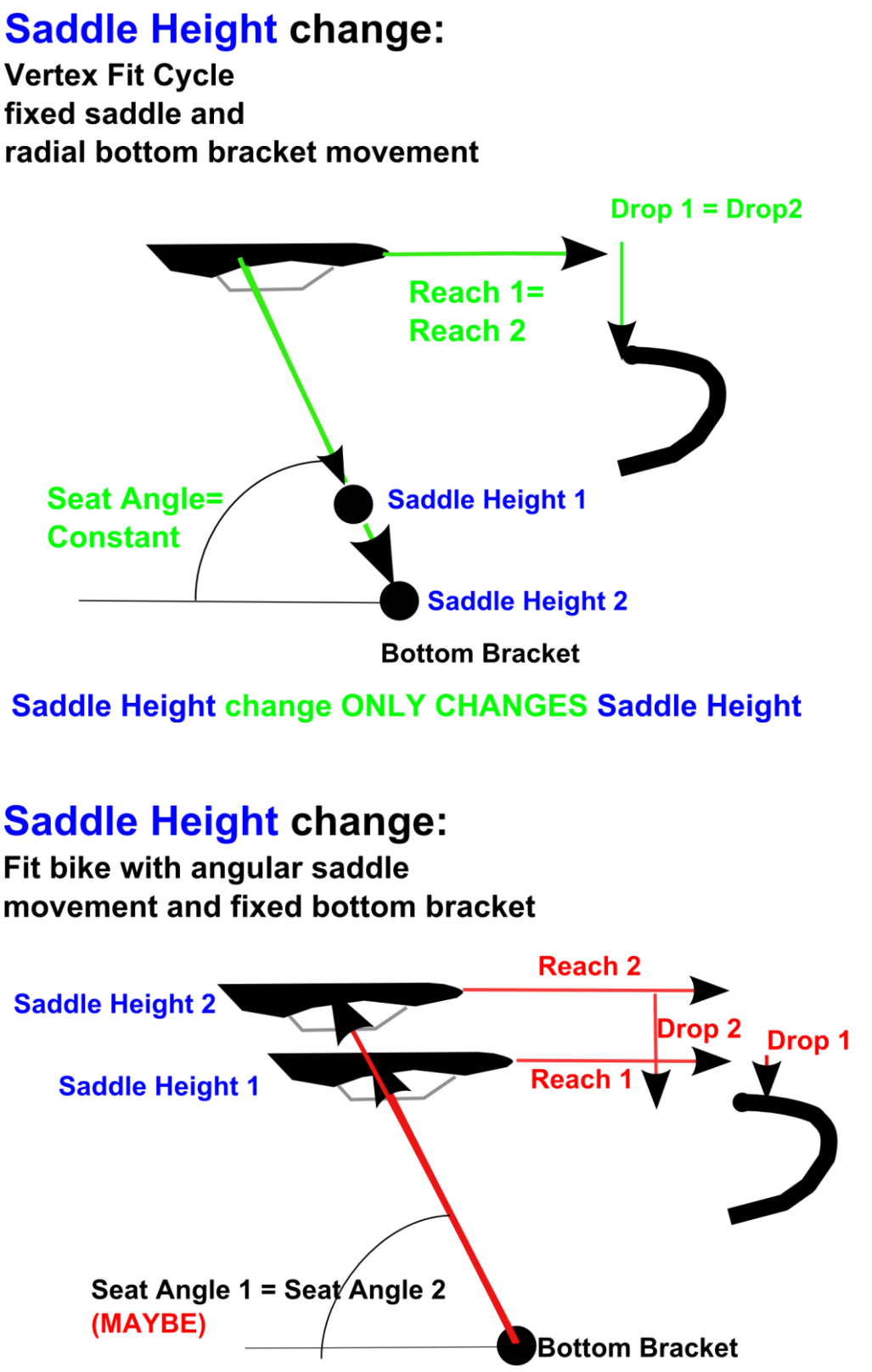
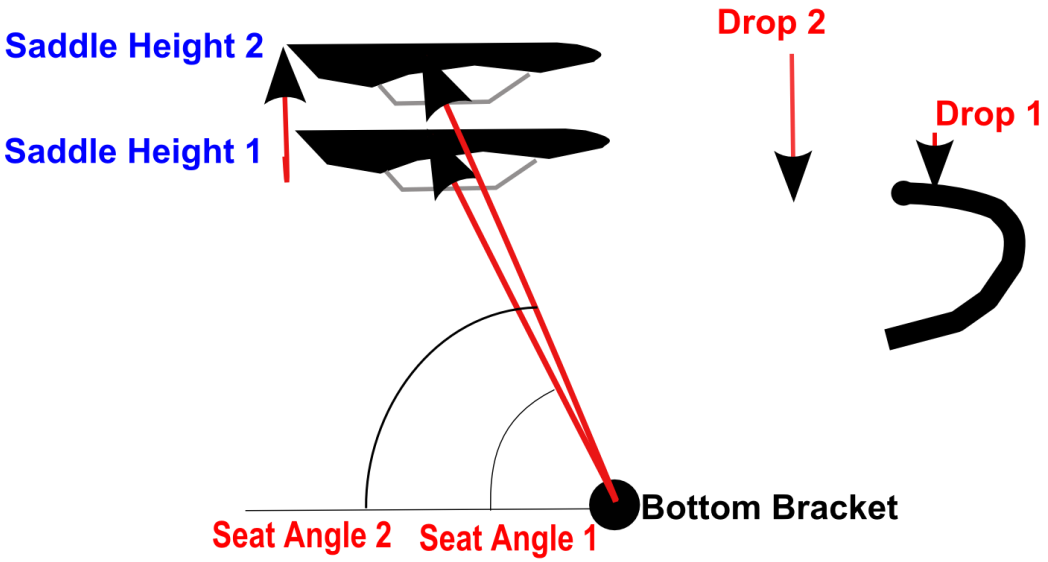


Figure 3: Comparison of Vertex Fit Cycle contact point adjustments and outcomes vs traditional fit bike designs.



Saddle Height change:

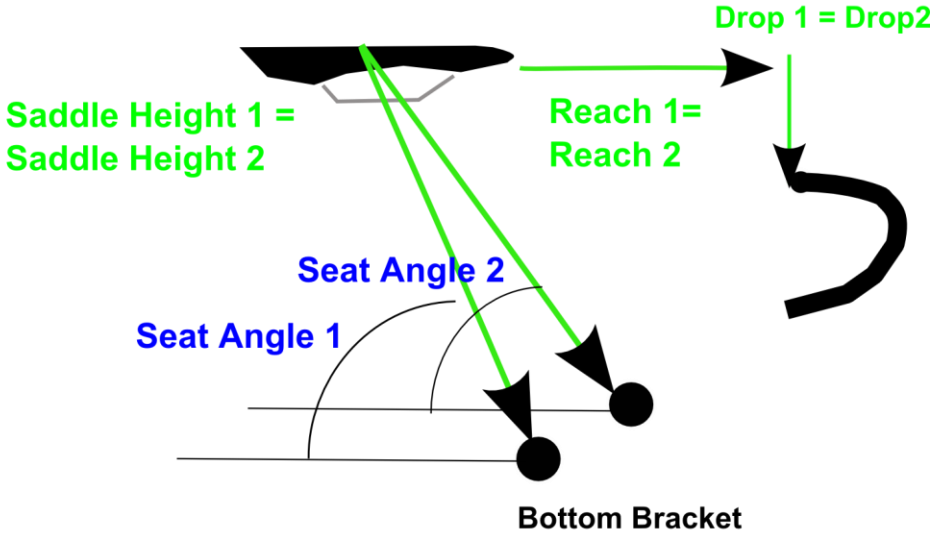
Fit bike with X-Y saddle movement and fixed bottom bracket



Saddle Height change ALSO CHANGES Drop and Seat Angle

Seat Angle change:

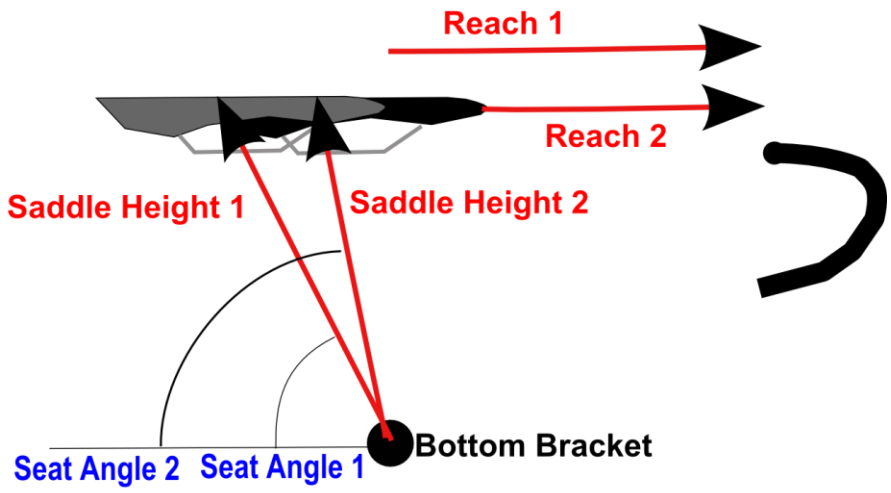
Vertex Fit Cycle fixed saddle and constant radius bottom bracket movement



Seat Angle change ONLY CHANGES Seat Angle

Seat Angle change:

Fit bike with horizontal (X) saddle
or bottom bracket movement
(pretty much all of them other than Vertex)



Saddle Setback change, which does change Seat Angle,
ALSO CHANGES Saddle Height and Bar Reach

Saddle Control

The Vertex Fit Cycle employs a unique saddle cassette system which enables rapid saddle swaps (rider stands up on pedals, swap takes seconds) with ZERO change in saddle height. The mechanism also allows saddle tilt adjustment WHILE the athlete is riding under load. Hence each saddle can be set at the most comfortable tilt angle as perceived by the rider.

The Vertex comes with multiple saddle cassettes so that the fitter may pre-load saddles while the athlete is riding. This cassette is adjusted for saddle stack before attaching it to the Vertex so that each saddle maintains identical seat height (distance to the pedals). The rider only feels the differences between saddles while fit coordinates are kept constant. It is possible for the athlete to test a dozen saddles in a fraction of an hour.

Figure 4: Vertex quick-change saddle cassette mechanism allows rapid saddle swaps without dismounting rider and with no change is seat height.

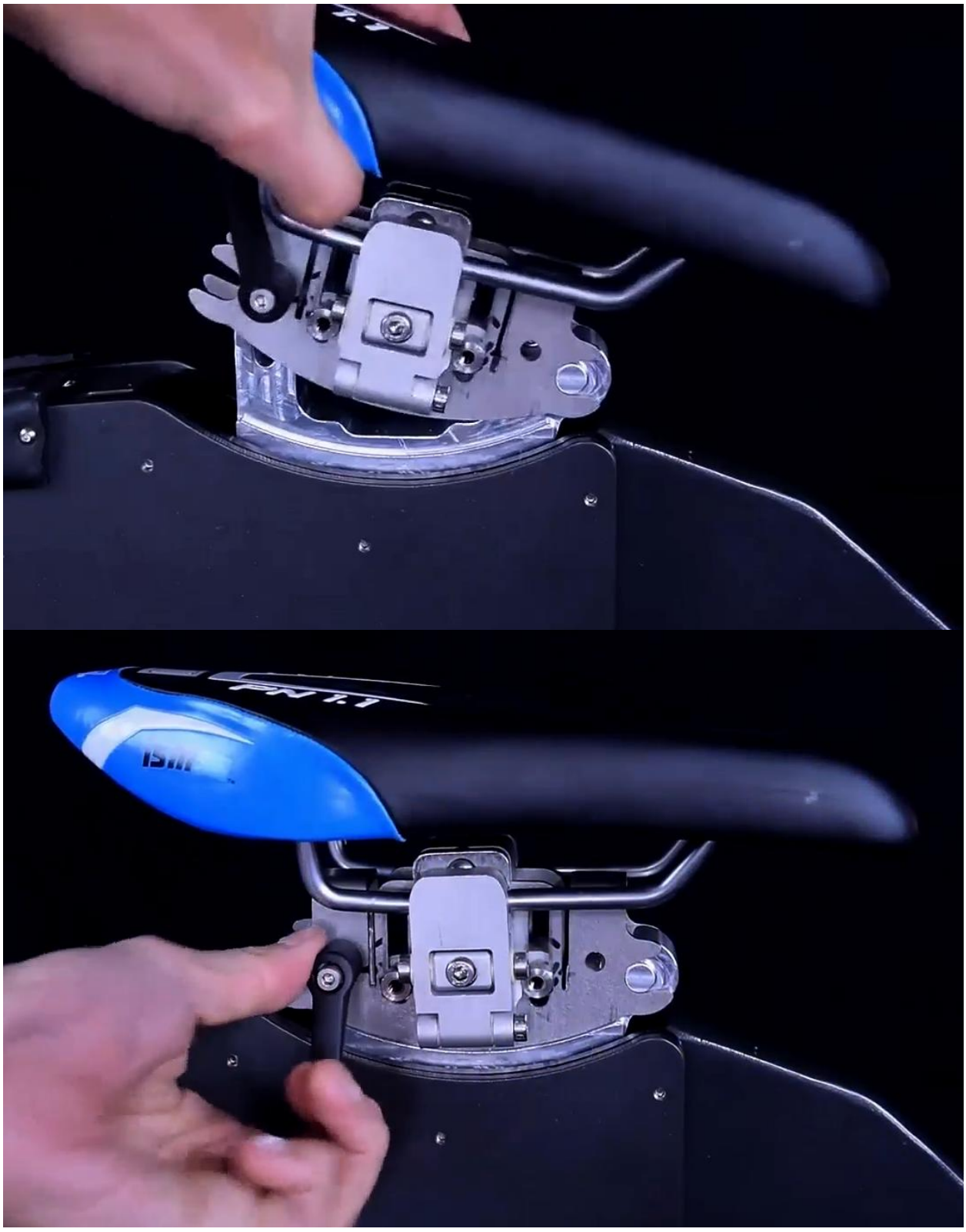
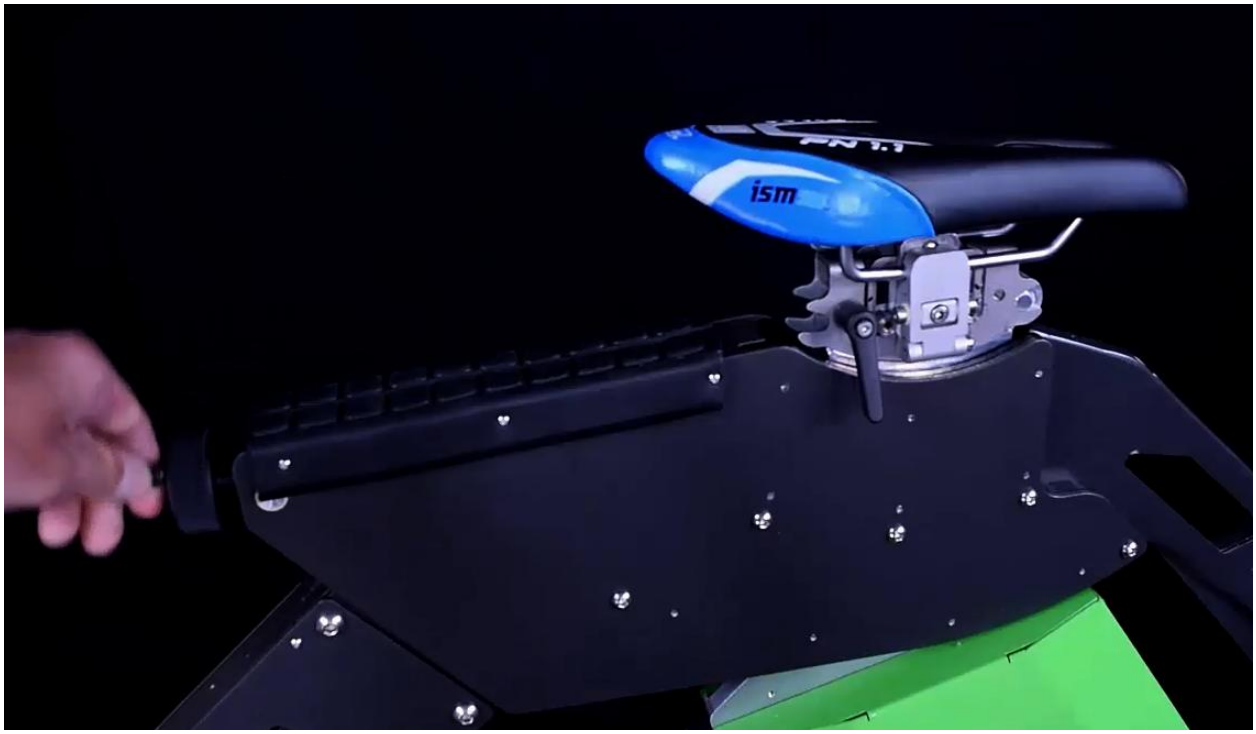


Figure 5: Vertex saddle tilt can be adjusted via a hand wheel while the athlete rides.



Bars and Cranks

The Vertex Fit Cycle uses a standard English- threaded bottom bracket shell and square-taper bottom bracket to accommodate adjustable-length cranks. The bars can be swapped in seconds via a single bolt and a 31.6mm bar clamp (no stem) without dismounting the rider.

Figure 6: Vertex handlebar clamp.

Vertex Fit Cycle Operation

The Vertex Fit Cycle software suite employs a layered approach in that the user can easily operate the device without needing to go into a great deal of detail or complexity. A mobile phone and a few on-screen button presses will do the trick. However, as the user desires more control and knowledge, the Vertex provides a wealth of information and powerful tools for bike fitting, cycling performance optimization, biomechanical research, and even rehab applications.

The Vertex user interface (UI) is browser-based and hence the Cycle is operable from any browser-equipped device. At its most basic, the UI allows the user to wirelessly move each of the 4 axes. It can also store coordinate sets for later recall, allowing the user to toggle between different "fits" so the athlete can experience the difference in stark contrast or the coach / researcher can observe and contrast the effects of changes. The UI also generates a constantly updating list of road bikes or tri/tt bikes that match the current Vertex coordinate set along with recommended frame stack and reach (based on a user-configurable front end – bars, spacers, stem - setup). Some users may find the functions provided by the UI to be all they need.

Figure 7: Vertex Fit Cycle User Interface provides precise control from any browser-equipped device.

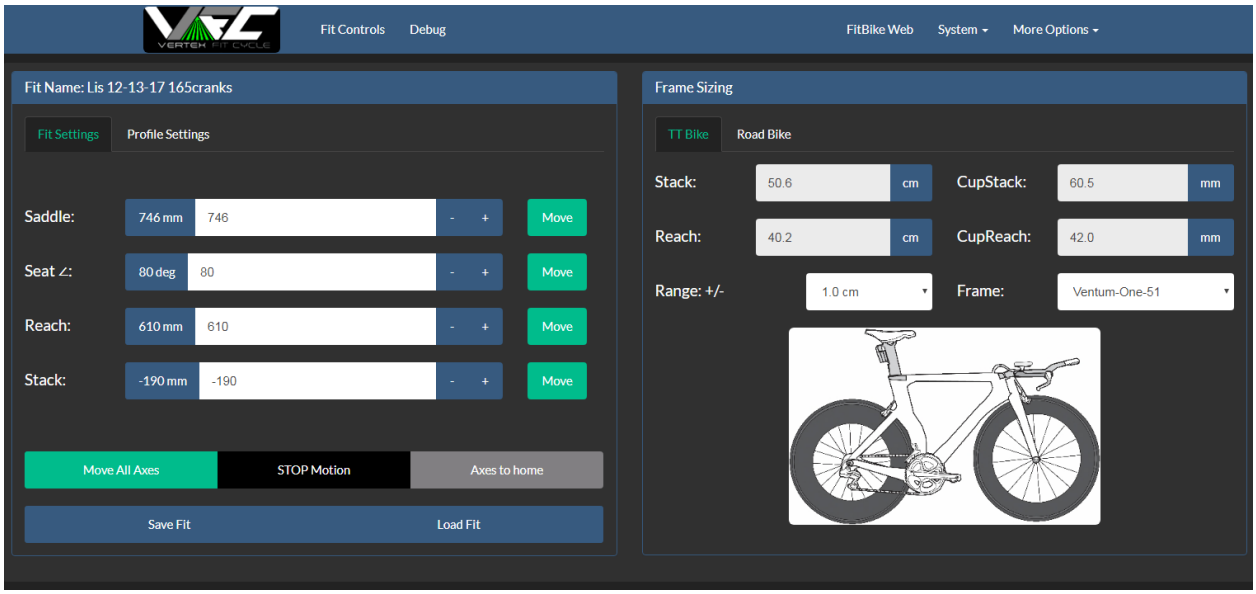
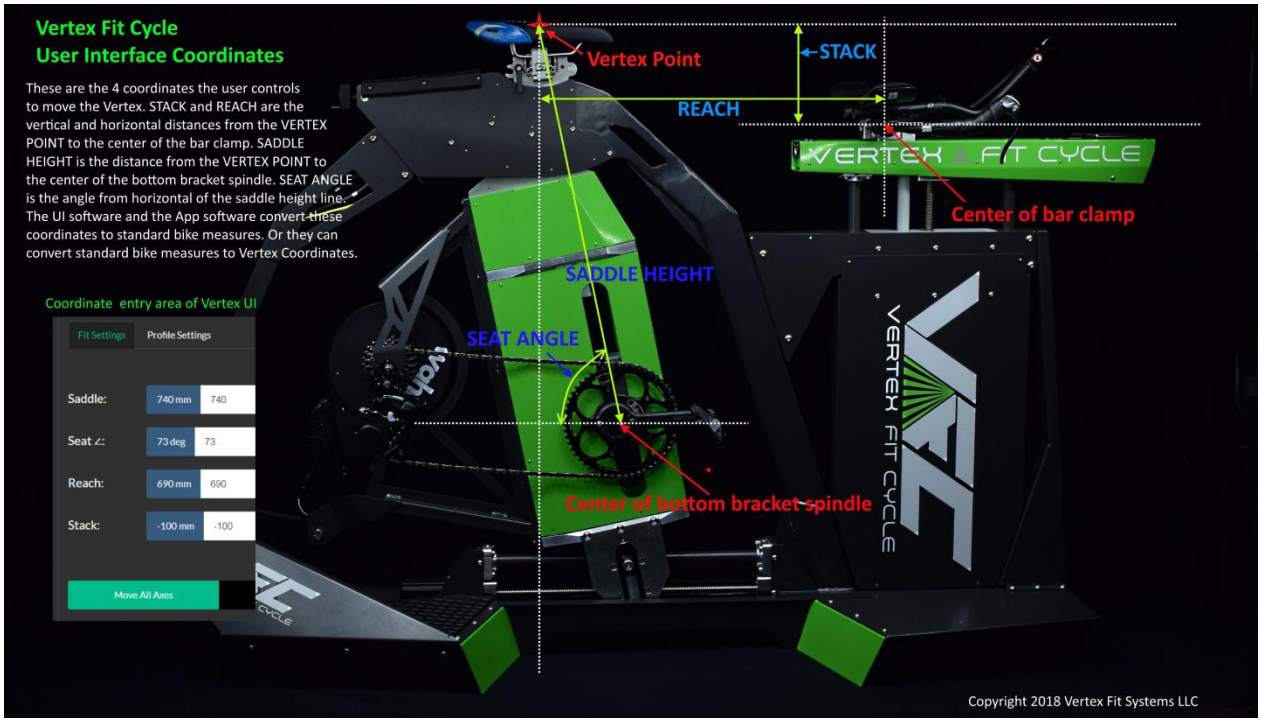


Figure 8: Vertex Fit UI axis movement controls. Coordinates may be typed in or incremented via the +- buttons. Clicking or touching any of the move buttons activates the Vertex. Position indicators show the position of each axis in real time.

Figure 9: Vertex Fit Cycle axis measurements.



Detailed Fit Analysis

The next "layers" in the Vertex Fit Cycle software suite are the road and tri/tt calculator apps. Each of these separate applications allows the user to go well beyond the relatively basic functions of the UI, providing the following capabilities:

-Conversion of client's bike measurements to Vertex coordinates in order to duplicate their bike with the Vertex as a starting point for fits, saddle selection, etc. (Figure 9).

-One-click import of Vertex coordinates instantly produces all relevant traditional bike fit measurements along with bike frame stack/reach and bike matches based on configurable default front end setup (Figure 10).

-Virtual build and configuration of bikes from an extensive market database. The database is compiled by us and corrected for errors in manufacturer data and specs. Choose bikes and configure them to match the athlete's fit parameters, know in advance how to build any bike for any client, and determine which are most suitable. Or simply determine how to configure the athlete's current bike to match his new fit (Figures 11 and 12).

-The tri app contains individual calculators for super bikes with proprietary front end setups. Each app allows the fitter to determine how to build the bike in advance to best match the athlete's fit. Each of these calculators is proprietary and adjusted based on our own measurements and build experience, and many contain recommended fit target windows for best fit (Figure 13).

-Other functions include fit sheet production.

Figure 10: Tri bike converter. Bike measurements entered into green boxes are converted to vertex coordinates.

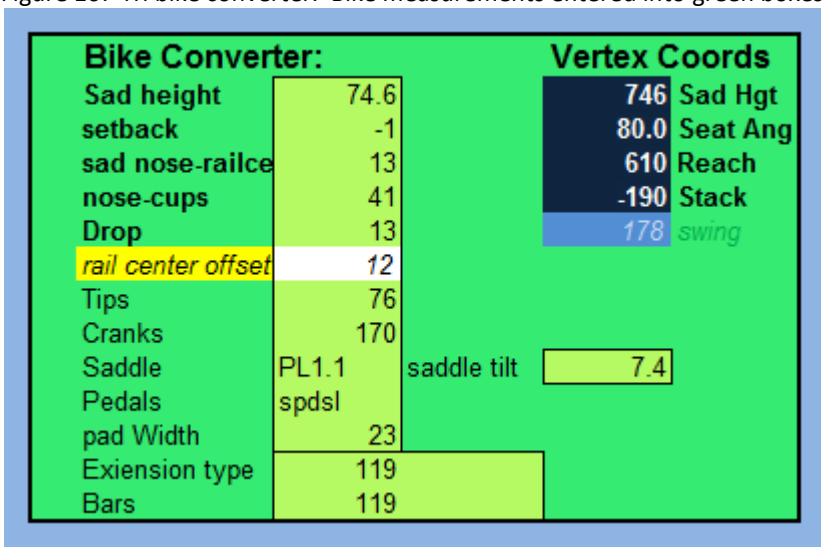


Figure 11: Vertex Tri Bike app – a portion of the dashboard that imports coordinates directly from the Vertex and generates bike fit measurements along with frame measurements.

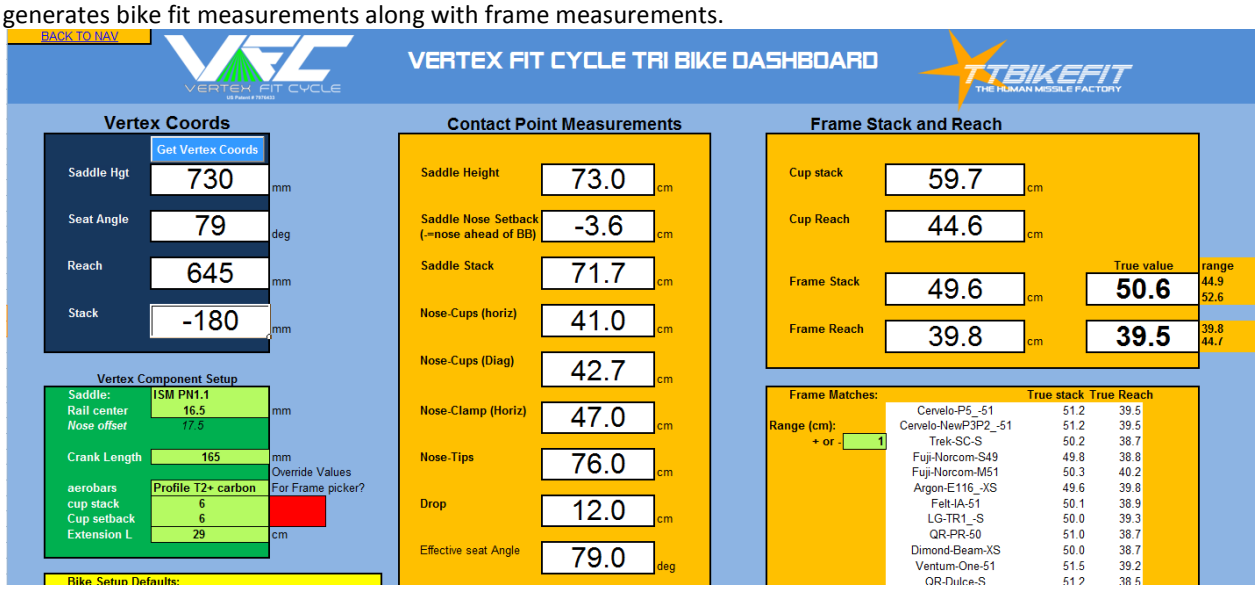


Figure 12: Vertex Tri Bike configuration app allows fitter to build bikes virtually and determine best matches for the athlete.

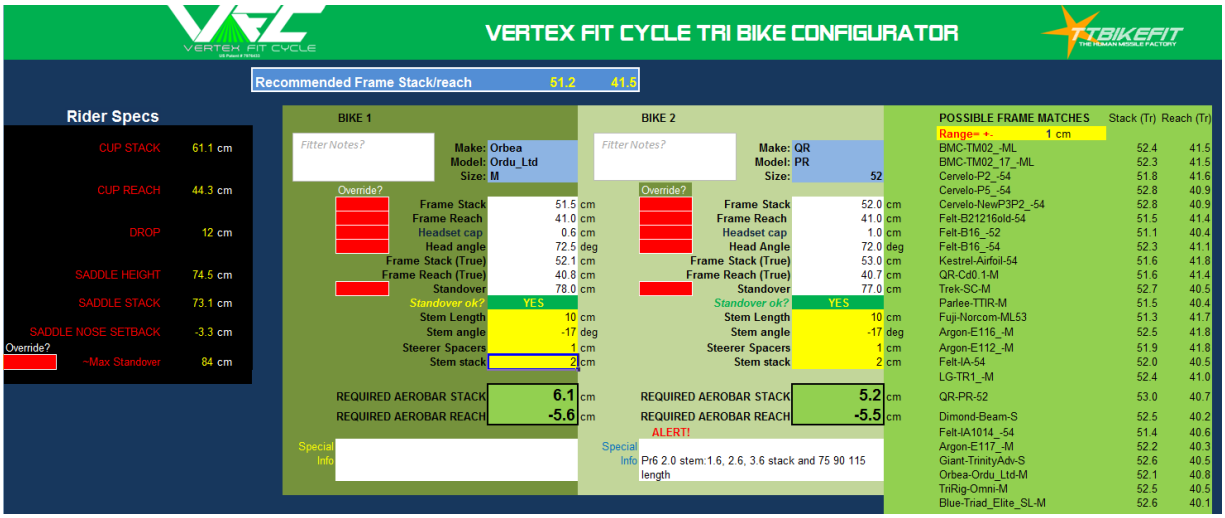


Figure 13: Road bike configuration app.

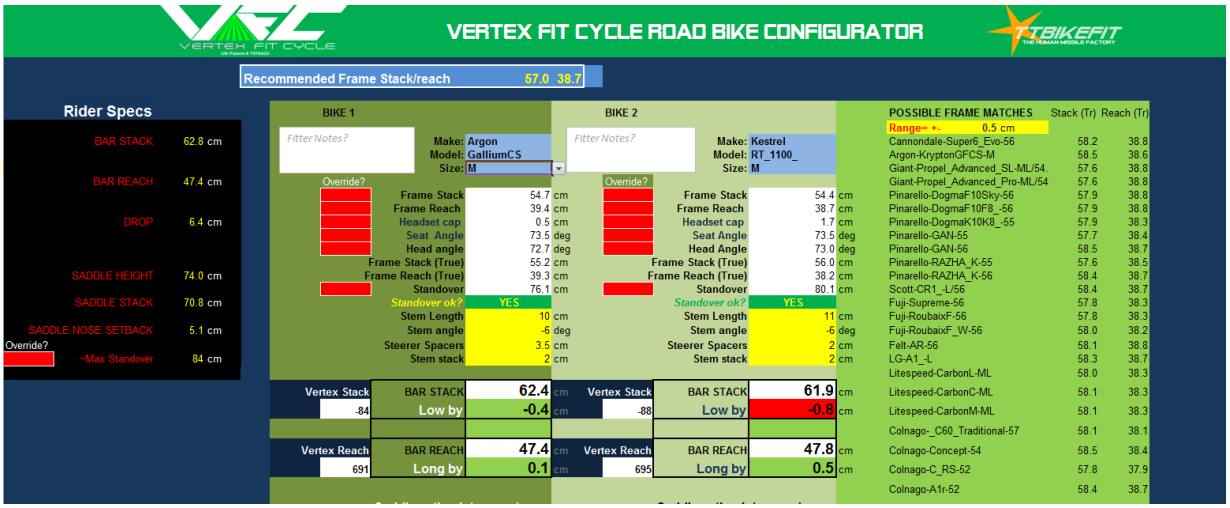
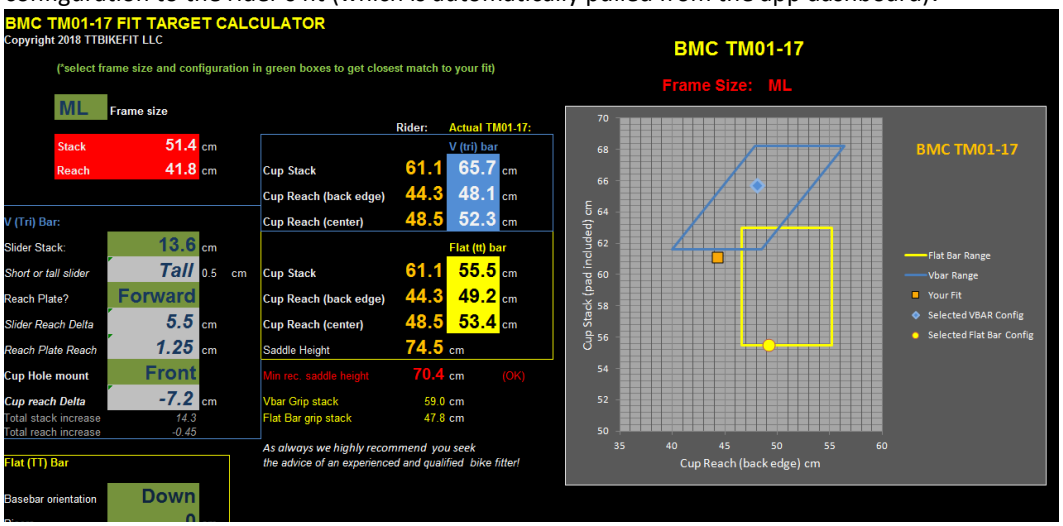


Figure 14: Just one of many proprietary super bike fit calculators. Each allows the fitter to graphically match the bike configuration to the rider's fit (which is automatically pulled from the app dashboard).



Vertex Fit Cycle Use Scenarios

Bike fitters and high-end bike shops: For fitters, the Vertex will become the centerpiece of their fit process. Once a baseline analysis of the athlete's current fit has been completed, the fitter can easily duplicate and store this fit on the Vertex and then systematically improve it while the athlete rides under load as controlled by the Wahoo Kickr and Wahoo app. Then the fitter can toggle back and forth between saved fits. This process provides an unmatched experience for the athlete and fitter.

The fitter can then easily determine (via the apps) how to configure the client's bike to match his new fit. Of course the fit process can include crank-length and saddle changes.

Another powerful application for the Vertex is in pre-buy fitting. The fitter can dial in the fit and then easily generate a list of bikes that will work well, or virtually size and configure a particular bike of interest to match the fit. Not to mention, the Vertex is an unmatched platform for saddle "test drives".

Coaches and training centers: The Vertex Fit Cycle is a superior platform to optimize rider performance via testing of small fit parameter changes. The coach or trainer can easily conduct systematic, controlled, repeatable trials to determine what affect various fit changes have on the athlete's perceived exertion, heart rate, power, metabolic efficiency, etc. The ability to toggle back and forth between coordinate sets while the rider works at high levels can provide extremely valuable information not easily obtainable otherwise.

Too, the Vertex is an unmatched training platform. An entire team of riders can have their fit coordinates, both road and tt, stored in the machine. 2 clicks or screen-taps and any team member can instantly train with their fit. The athlete can also do their own fit tests and experiments while riding via their mobile phone or a tablet.

Biomechanical Research: The Vertex Fit Cycle will facilitate research studies heretofore impossible to achieve. For one, the ability to sweep through a range of effective seat angles while maintaining constant

distance to the pedals opens up new research possibilities. The Vertex can easily be equipped with force sensors or power pedals for additional data.

Rehab: It is not difficult to imagine how the Vertex could be used for a variety of rehab applications (which is covered in the patent). The therapist can store patient coordinates, vary them to increase or decrease range of joint motion, or alter muscle activation during therapy sessions (via saddle height and seat angle adjustments). We believe that this is another fertile area for research where new and more effective rehab regimens could be developed around the Vertex's ability to change parameters while a patient rides. What were once non-billable spin bike sessions become active billable therapy sessions. Simple add-on accessories will adapt the Vertex for easy patient mount and dismount along with less athletic upright seating postures.

Availability

The Vertex Fit Cycle is currently available for purchase from Vertex Fit Systems in Warren, RI, USA. At the time of this writing there are 3 units in operation – one at TTBikeFit, one at The Energy Lab in Doylestown, PA, and one at La Bicicletta in Toronto, Canada with two more units soon to be distributed. We expect a new production run to begin in early 2019 depending on demand. Training on Vertex operation is included with all purchases.

For individuals or organizations looking to start or enhance a fit studio operation, TTBikeFit LLC in conjunction with Vertex Fit Systems LLC offers an affiliate program modeled after the successful TTBikeFit system. We believe this is the new paradigm for high-end bike distribution: a low overhead, high expertise concierge model where each customer is matched with the perfect bike; perfectly fitted and equipped. The Vertex Fit Cycle is the centerpiece along with a highly trained and knowledgeable fitter. TTBikeFit offers full training, branding, and its carefully cultivated process and industry contacts to qualified entrepreneurs. Please see TTBikeFit.com for more information.

FOR MORE INFORMATION

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VERTEX FIT CYCLE