DESIGN METHOD

FELT'S DESIGN METHODOLOGY

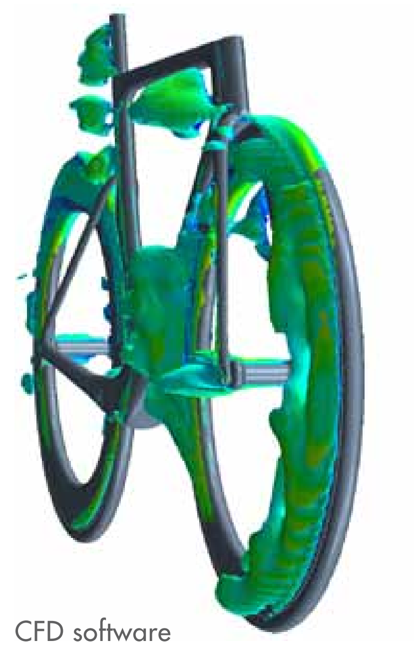
The introduction of a new Felt bicycle comes at the conclusion of a long, thoughtful, and rigorous process. The amount of time from initial concept development to a new bike's arrival on the shop room floor can literally take years to complete. Sure, we could do things faster and cheaper. But there is good reason for this measured approach. Our goal is to produce the best bicycle possible, regardless of how long it takes.

Step one in this process is initiating dialog between our extended family of experts. Felt-sponsored teams and athletes, engineers, and product designers are all encouraged to put forth ideas about what they want from a new bike. This open discussion is critical, and helps Felt pin down core objectives. Once those goals are fleshed out and clarified with concept sketches, the design process begins.

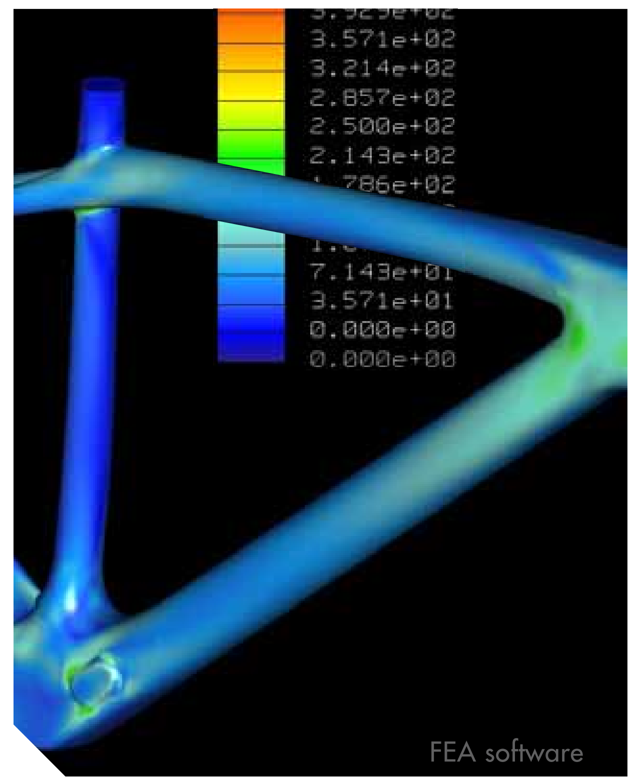
Each new frame first comes to life in a virtual world. Felt's team of experienced engineers create everything from the ground up, using an array of cutting edge computer software, including Finite Element Analysis (FEA), Computer Aided Design (CAD), and Computational Fluid Dynamics (CFD).

All of this technology allows us to specify and experiment with every dimension of every component of every new bike. We can also look at the effect and fit of components such as wheels, brakes and derailleurs in 3D, allowing us to understand how a complete bicycle is going to work as a whole.

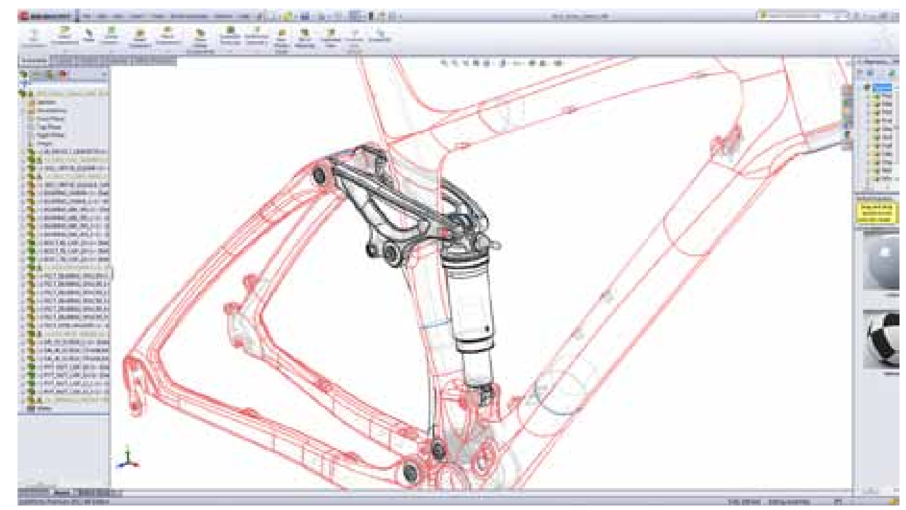
Felt's team of engineers then analyze geometry and frame size dimensions, determining how these complex relationships will affect handling and ride quality. Aerodynamics, stiffness, and compliance are also considered and manipulated via adjustments to tube shape and wall thickness. If the project is a full-suspension mountain bike, linkage design and wheel path is assessed, refined, and tested.



CFD software



FEA software



CAD SOFTWARE

It's in this phase that some of Felt's most successful technologies such as the Bayonet Steering System and Equilink suspension first came to life.

Everything we learn, be it molding processes, shapes of tubes, lay-ups, or any other – it just keeps building on Felt's end product. Everything builds on what's already been learned in the past. For example, when our engineers started working on the new DA time trial frame, we already knew how to design the tubing intersections so they would yield a stiffer frame. By always targeting total synergy, we can build a better bicycle.

When aerodynamics are a factor, like with the DA for example, Felt begins by constructing virtual 3D models in CAD where they can be analyzed and refined with the CFD software. When this first step is complete physical models are made using a process called StereoLithography (SLA) in which an actual 3D prototype model is printed and can be further analyzed, and then tested in the wind tunnel.

In the past, tube sections were formed one at a time out of wood or plastic, resulting in inconsistent and inaccurate shapes. Today, we can create a digital SLA model using CAD software then send that file to a company that literally prints an exact 3D replica made of plastic. SLA allows us to take what's working in CFD and bring it to the wind tunnel for validation, and further refinement.

3D printed SLA prototypes

Making revisions in the wind tunnel

Felt takes what it's learned in the tunnel and continues to tweak the model until it's exactly where the engineering team wants it to be. This is a hugely important point. Felt doesn't simply use the wind tunnel to ascertain how well a finished product works, or as a marketing tool. Instead the wind tunnel is an integral part of Felt's design arsenal and is used throughout the process.

Aero testing an SLA model

Based on the results of this extensive and calculated development, both virtual and real world, tube shapes are adjusted and refined dozens of times before actual full prototypes are produced. When a full bike finally enters the prototype phase, its design has already been subjected to countless hours of analysis and tweaking. Only when engineers are completely satisfied with these outputs will mold machining begin.

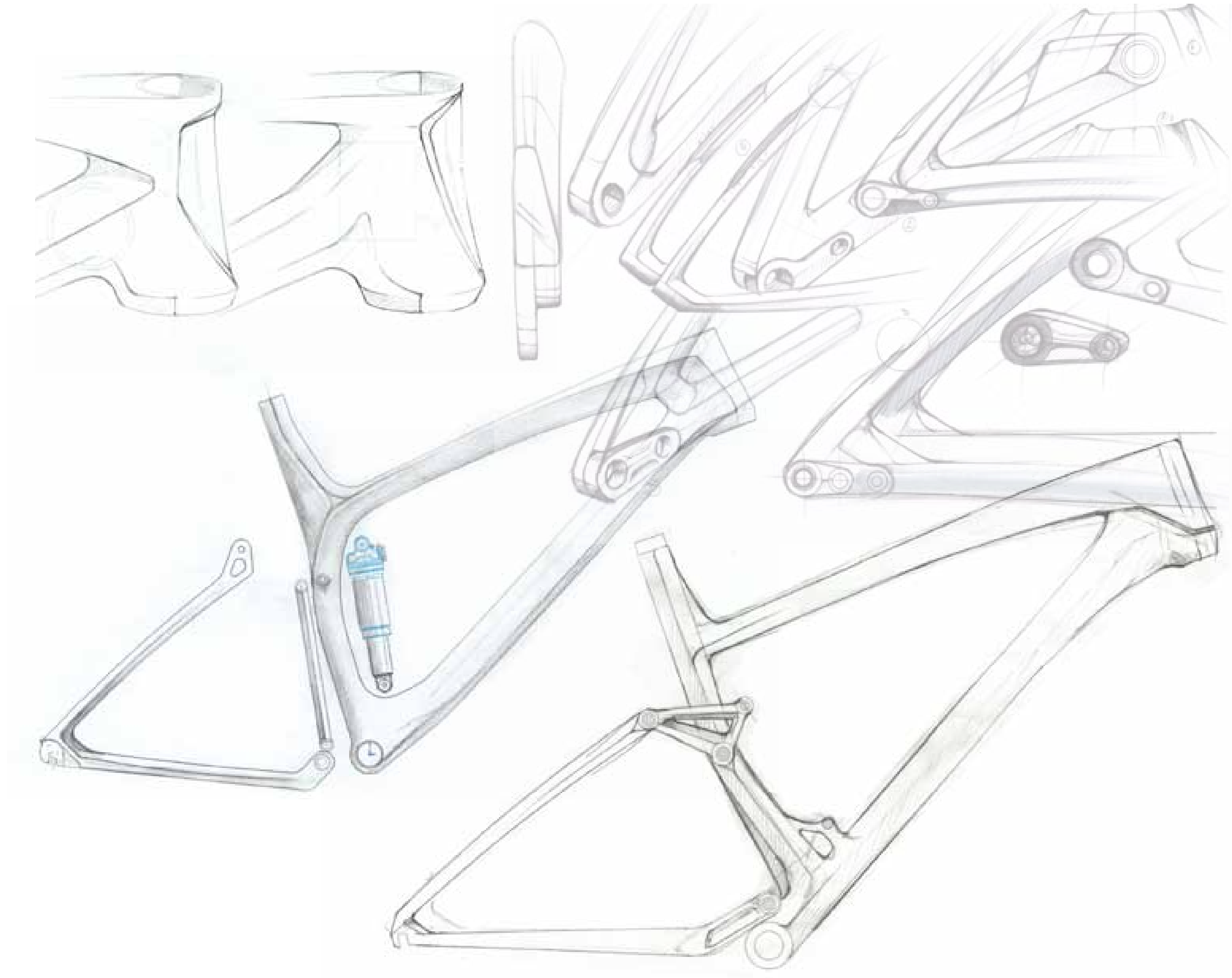
Once the manufacturing molds are fashioned, prototype frames are produced. Engineers now begin experimenting with various lay-up configurations and varying blends of carbon fiber. These subtle but critical adjustments allow for alterations in ride quality, impact resistance, stiffness, compliance, and frame weight.

We utilize this flexible development approach that's based on the desired characteristics that we want each bike to have. This allows us to focus on the most critical elements of each bike.

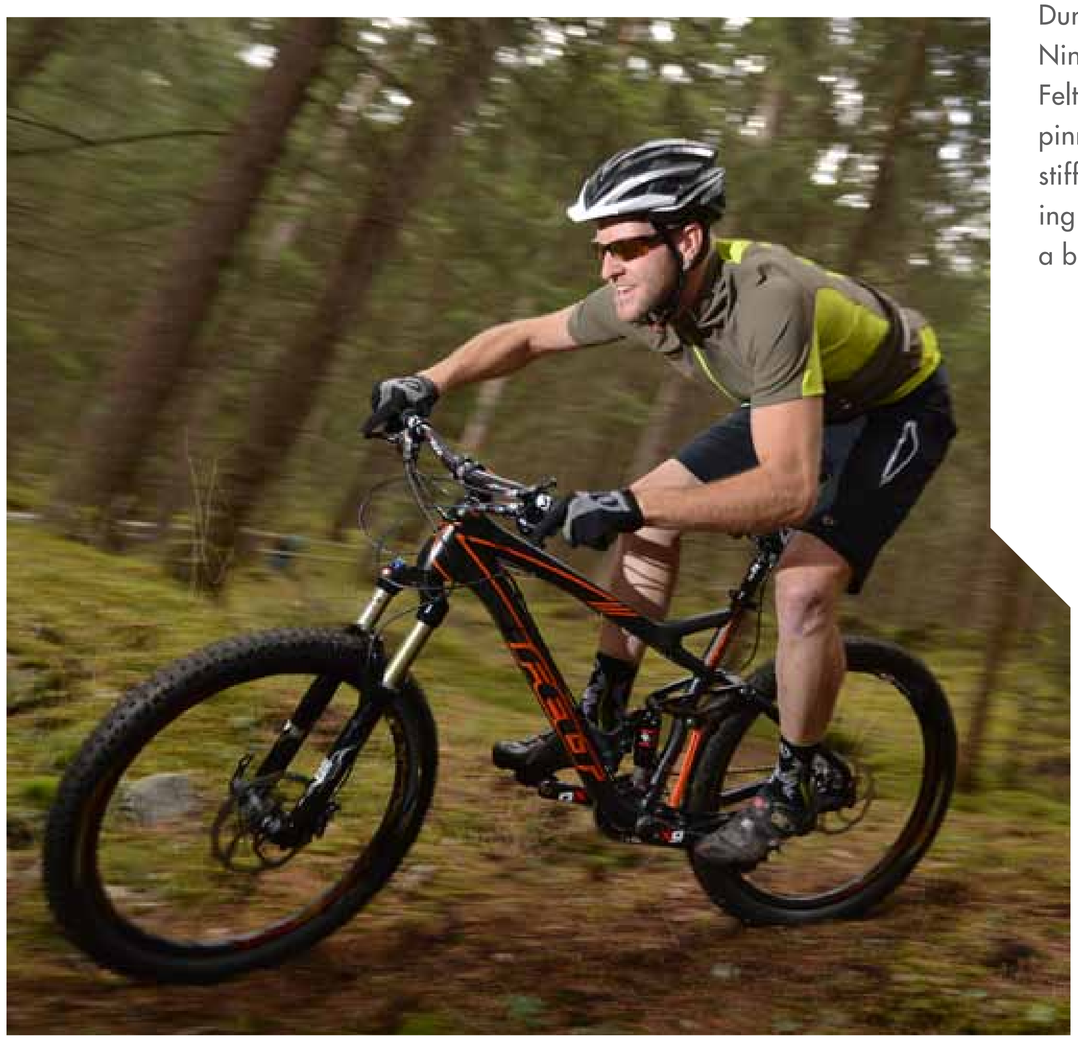
At the same time these prototype frames are brought to Felt's internal testing lab and subjected to rigorous static load and stiffness tests. This helps determine strength-to-weight ratios and gauge overall frame stiffness. It should be noted that Felt's internal standards are far higher than even the most stringent U.S. or European government requirements. Felt also inspects prototype models to assess manufacturing tolerances, surface finish quality, and precision alignment. Everything is checked, tested, and checked again.

Finally, and most importantly, these prototypes are ridden. And not just by pro athletes. Felt prides itself on being a company of cyclists. That makes us our own harshest critics.

The lifecycle of this design process varies from bike to bike and project to project. More complex endeavors such as full-suspension mountain bike frames or aerodynamic time trial machines spend extensive time in the development phase before the prototyping even begins. Meanwhile, carbon fiber road bikes and hardtail mountain bikes advance to the prototyping phase far faster, but then stay there for extended time until material selection and lay-up schedules are perfectly dialed. In all cases the goal remains the same: to achieve the perfect blend of technological innovation and material combination to achieve that lively feel that's unique to every Felt bike.



Those coveted characteristics are not limited to Felt's high-end bikes. Instead, there is a constant stream of trickle down technology. Of course there is an initial investment in research and design, but that's an investment Felt is always willing to make. A job done right on the high-end bikes opens that same technology to the rest of the range.



The final stamp of approval doesn't come from a computer program or a testing lab. That honor goes to the teams and athletes who use their Felt bicycles to do their jobs. Only after these demanding testers sign-off is it time to start production.

CASE STUDY: CONVEX THEORY DESIGN

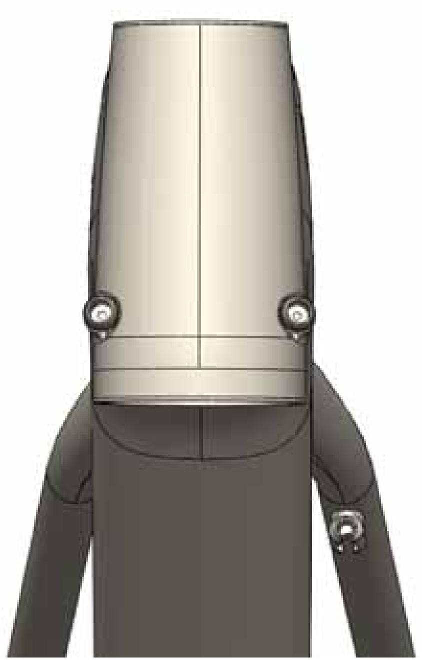
To fully understand the Felt design process it helps to see how it's delivered positive design change. The application of Convex Theory Design is the perfect example.

During the redesign of Felt's renowned Nine full carbon hardtail mountain bike, Felt engineers managed to attain cycling's pinnacle design achievement: increasing stiffness, maximizing strength, and reducing weight, while at the same time creating a better handling bike.

Felt engineers understood that there are typically two methods for increasing stiffness of a carbon frame. Add more material or add higher modulus material. But both strategies have downfalls. Higher modulus material is more expensive and more brittle. Extra material means a heavier bike.

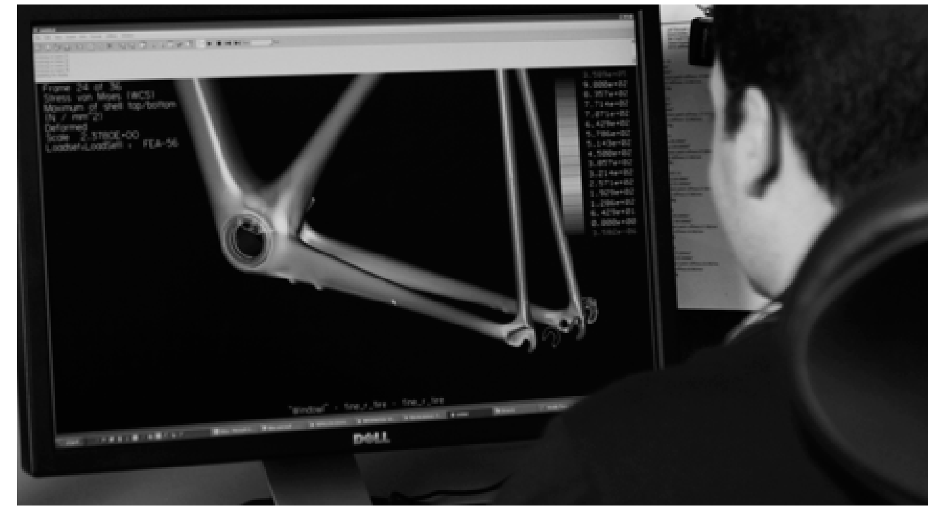
Felt went a different direction applying our Convex Theory Design. To understand this, think about carbon at its base level, unidirectional fiber that is basically parallel strings of carbon. Put these fibers under tension and they are stiff and strong. But now if you put these same fibers in compression they can easily bend and have little stiffness or support.

The Compulsion 'Convex' Head Tube



The Nine 'Convex' Head Tube

Now apply that idea to a frame. Wherever that surface is concave, the carbon fibers are working less efficiently and not in tension where it is the stiffest, but in compression where it has an opportunity to buckle. To solve this problem, Felt engineers "puffed" out all the frame's tubes so there were no pockets or concave sections, which would cause this unwanted compression. Instead the tube shapes keep the fibers in tension — for stiffness and strength.



FEA development

The Nine frame shows off some 'flowing, convex' surfaces

The concept was first applied during the design process of Felt's famed F1 road bike. Using CAD, engineers modeled a frame. Next, using FEA allowed them to add loads, and then determine areas of deformation. With that information in hand, Felt optimized the entire frame so it was completely balanced and absorbed stress equally throughout.

Those lessons, first gleaned during F1 development, where then applied to the Nine, a perfect example of how Felt consistently takes the important lessons it's learned in the past and skillfully applies them to the bikes of the future.