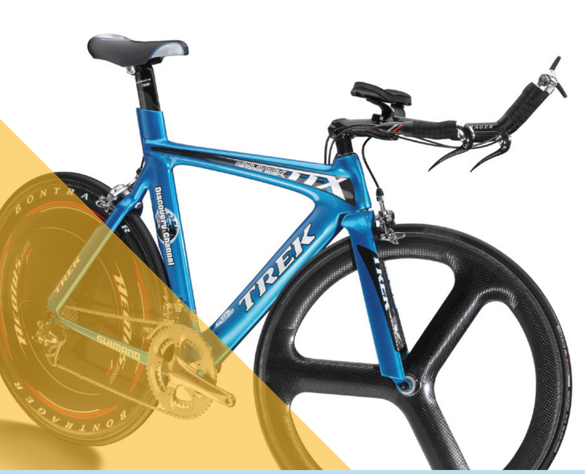

AMD
Smarter Choice

Setting a new standard for triathlon/time trial bikes

AMD 64 Opteron™

Trek Bikes breaks new ground for lightweight, aerodynamic performance through the use of powerful design simulation technologies

THE CHALLENGE

- Develop an aerodynamically superior bike that provides a competitive advantage for triathlon and time trial racers
- Reduce overall weight while maintaining or improving frame strength
- Optimize complex composite manufacturing processes to control costs

THE SOLUTION

- Deploy powerful design geometry optimization and simulation technologies, utilizing SolidWorks 3D CAD software powered by 64-bit Dual-Core AMD Opteron™ processors
- Simulate both design performance and complex composite manufacturing
- Leverage AMD Turion™ 64 mobile technology-based notebook computers to communicate innovative designs in the field to secure racer buy-in and input

THE IMPACT

- Accelerated product time-to-market
- Cut 200 grams of weight from aerodynamically advanced bike frame
- Maintained 30-to-50-percent increase in bike frame stiffness
- Set a new standard for lightweight, aerodynamic bike performance for triathlon/time trial racing

Trek Bikes has become an undisputed leader in the development of bicycle racing technology, a reputation the company firmly established by helping Lance Armstrong win a record-setting seven consecutive *Tour de France* races. While the global bicycle manufacturer has expanded and diversified its operations into other areas of cycling — most notably, through the development of consumer products targeting a mass market — Trek has remained true to its roots in racing and continues to make professional cycling the primary focus of its research and development (R&D) efforts.

From the company's headquarters in Madison, Wisconsin, Trek R&D engineers strive to continue the Trek tradition of introducing breakthrough cycling concepts and bicycle racing innovations that secure and extend the firm's technology leadership position. With each new advance in cycling technology, it becomes increasingly more difficult and challenging to create and develop the revolutionary new cycling concepts and breakthrough racing innovations of the future.

To meet its seemingly insurmountable R&D challenges, Trek product developers not only look for ways to adapt existing cycling technology for other applications but also leverage the most powerful design geometry optimization and simulation technologies to support the company's advanced development efforts. Trek brought both approaches to bear in the development of the Equinox TTX 9.9 SSL racing bike.

First ridden by Lance Armstrong in the 2005 *Tour de France* time trials, the TTX is unique because of its use for both road-racing time trials and triathlon competitions. A road cyclist races alone against the clock during a time trial, as does a triathelete, for the most part, on the second leg of the triathlon, a competition comprising a 2.4-mile swim, followed by a 112-mile bike ride, followed by a 26.2-mile (marathon) run. Because the rider cycles alone in both instances, rather than riding in a pack as in most road races, the bicycles require unique aerodynamic, weight, and strength characteristics.

According to Road and Triathlon Product Manager Tyler Pilger, the goal in the development of the TTX 9.9 SSL (Super Sexy Light) model was to eliminate a significant amount of weight from the innovative, aerodynamically superior design of current TTX models, which minimizes draft and improves performance.

“The simulation power supported by SolidWorks and AMD enables us to refine and perfect the design geometry to minimize drag before building a single prototype. This capability saves an incredible amount of time and money while improving product quality and innovation.” **— Michael Sagan, Trek Product Development Technology Lead**

“A weight reduction of 200 grams, combined with the most aerodynamic bike design available, provides important performance enhancements for triathletes and cyclists,” Pilger explains. “Our customers are looking for every conceivable advantage they can find, so a 200-gram advantage is a big deal. We already had a 100-gram advantage over the previous TTX model and wanted to use new materials and geometry optimization and simulation techniques to shave another 200 grams off the SSL, giving us a 300-gram advantage. Our other goal was to accomplish this weight reduction while maintaining the 30-to-50-percent stiffness improvement we achieved with the TTX, which improves stability and makes the bike faster in the corners.”

To tackle the TTX 9.9 SSL challenge, Trek designers and engineers used SolidWorks® 3D CAD software and other advanced design simulation software tools powered by 64-bit Dual-Core AMD Opteron™ processors. Trek product designers harnessed the computing power of Dual-Core AMD Opteron processor-based workstations to perform design iterations, simulate design performance, optimize composite manufacturing processes, and achieve the desired weight reduction for the TTX.

Streamlining aerodynamics in a virtual wind tunnel

To produce a lighter, faster triathlon and time trial bike, Trek product developers knew they would have to develop the newly introduced OCLV Red Series™ material and use aluminum inserts to create a super-light, yet strong, frame and fork set on the SSL. But the first order of business was validating that the TTX’s streamlined, aerodynamic frame would support the reduced weight of the SSL model.

“Aerodynamics represented the most important characteristic on the SSL,” Pilger points out. “We asked our design engineering team to use our SolidWorks design models and advanced computational fluid dynamics (CFD) software running on powerful AMD Opteron processor-based systems to run high-end simulations on the TTX for the purpose of making the design as aerodynamic as it could be.”

According to Michael Sagan, Trek Product Development Technology Lead, the Trek engineering team created a virtual wind tunnel using SolidWorks, imported design models, and CFD simulation software on AMD-based workstations. “The simulation power supported by SolidWorks and AMD enables us to refine and perfect the design geometry to minimize drag before building a single prototype,” Sagan stresses. “This capability saves an incredible amount of time and money while improving product quality and innovation. When we did final testing in an actual wind tunnel, we determined that our virtual simulations were 90-percent accurate.”

Using CFD simulations, Trek was able to optimize the geometry on the TTX frame to improve its aerodynamic performance, particularly on the down tube. “The down tube on the TTX looks more like a wing than a tube,” Pilger notes. “The taper rate changes as the down tube approaches the bottom bracket and becomes rather thin but remains incredibly strong.”

Simulating performance, manufacturing processes

After optimizing the TTX’s aerodynamic performance, Trek engineers still had to validate the strength of the streamlined design as well as simulate the complex composite manufacturing process that would play such an important role in meeting the team’s weight-reduction objective on the SSL. As it had with the virtual wind tunnel, the TTX design team used SolidWorks design models and structural analysis tools to create a virtual testing regimen that precisely simulated Trek’s extensive physical testing protocol.

“In addition to validating the aerodynamics of the TTX design, we had to ensure that our sleek, new frame was strong and durable enough to sustain the loads and forces generated in

a time trial or triathlon race," Sagan explains. "We used analysis software to simulate impact and other structural tests. Our final physical testing confirmed a simulation accuracy rate of 95 percent."

Composite R&D Engineer Brian Schumann used high-end, nonlinear contact analysis tools to study how the thickness and orientation of the composite layers, as well as the material used, impact the amount and direction of areas of strain. "The ability to run these analyses efficiently on an AMD Opteron processor-based workstation allows me to study how variations in composite layers — taking material out of one area or adding it to another area — affect overall stiffness," Schumann explains. "With these tools, we are able to specify the deposition of each layer of material during production, in terms of orientation and thickness, to maximize stiffness while achieving our ambitious weight-reduction requirements on the SSL."

Mobility facilitates rider buy-in, input

Another important aspect of the SSL development involved engaging customers — triathletes and road-racing cyclists — in the process, to solicit input and secure buy-in for the lighter, aerodynamic SSL design. Mark Andrews, a Trek Triathlon Specialist who has competed in 14 Iron Man triathlon competitions, and Scott Daubert, Trek Teams Liaison, who works with The Trek/AMD/Discovery Channel professional cycling team, both used SolidWorks design visualization and communications tools and AMD Turion™ 64 mobile technology-based notebook computers to demonstrate SSL design concepts in the field.

"It's important during the initial design process and prior to production to have our customers in the loop," Daubert stresses. "The sooner we can show them the concept, the better. We not only listen to what they have to say but also take it to heart because their input often helps us to shape the project. I use the SolidWorks viewer on my AMD-powered laptop, which has a nice, big screen, to show colorful, highly rendered visuals to customers. In addition to facilitating input and discussion, high-quality visuals help us to obtain buy-in, especially with a team that may be reluctant to change."

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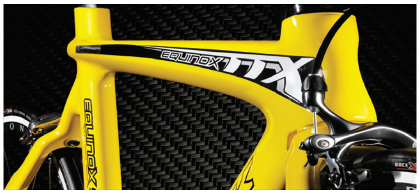

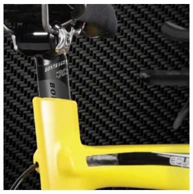

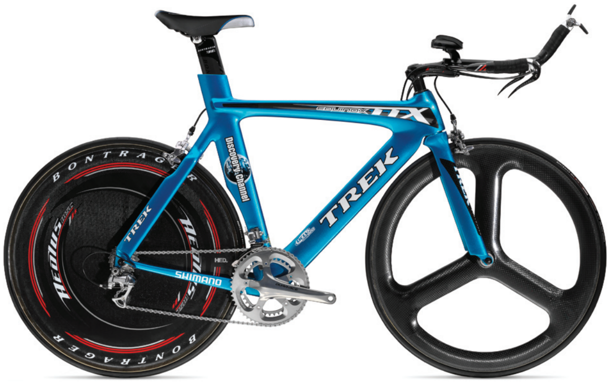

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