

Optimization: Taking a Different Tack

A **slick design** and the **use of new materials** make the **Fila sailboat** a force to **contend** with on the **competitive boat racing** circuit.

By **Beverly A. Beckert**

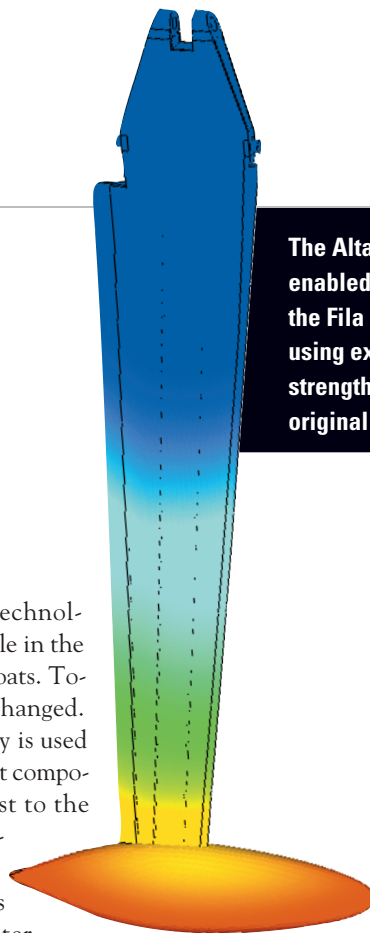
Sailboat racing requires safe, fast, easy-to-handle boats. Just ask Jean-Marie Finot, renowned for building such high-performance vessels.

His French company, Groupe Finot, has been in business more than 30 years. During this time, he has constructed all types of boats, including those that compete in "extreme" races.

One such sailboat, the Fila, typifies advancements made in boat design: this 60-ft., open yacht features the use of new materials and components refined through the use of computer simulation.

The Fila sailboat, designed by naval architect Jean-Marie Finot, competes in "extreme" races. It features the use of new materials and components refined through the use of computer simulation.





The Altair OptiStruct optimization software enabled engineers to redesign the keel of the Fila sailboat (left). The optimized keel, using extra high-strength and ultra-high-strength steels, was 100 kg lighter than the original (right).

A New World

Thirty years ago, technology hardly played a role in the design of racing sailboats. Today, everything has changed. Computer technology is used not only to design boat components – from the mast to the hull – but also to fine-tune them.

Groupe Finot reports it introduced computer-aided design (CAD) technology in 1972. Today, Finot engineers use computer technology in virtual product prototyping, optimizing the shape of the hull and refining boat lines.

According to Finot, “Hulls, structures, ballasts and rudders, sail sets and other elements are studied and improved by these methods.” In addition, the company notes it is tapping computer tools for laminate calculations, which are essential for the optimization of planking sampling and crossbeams.

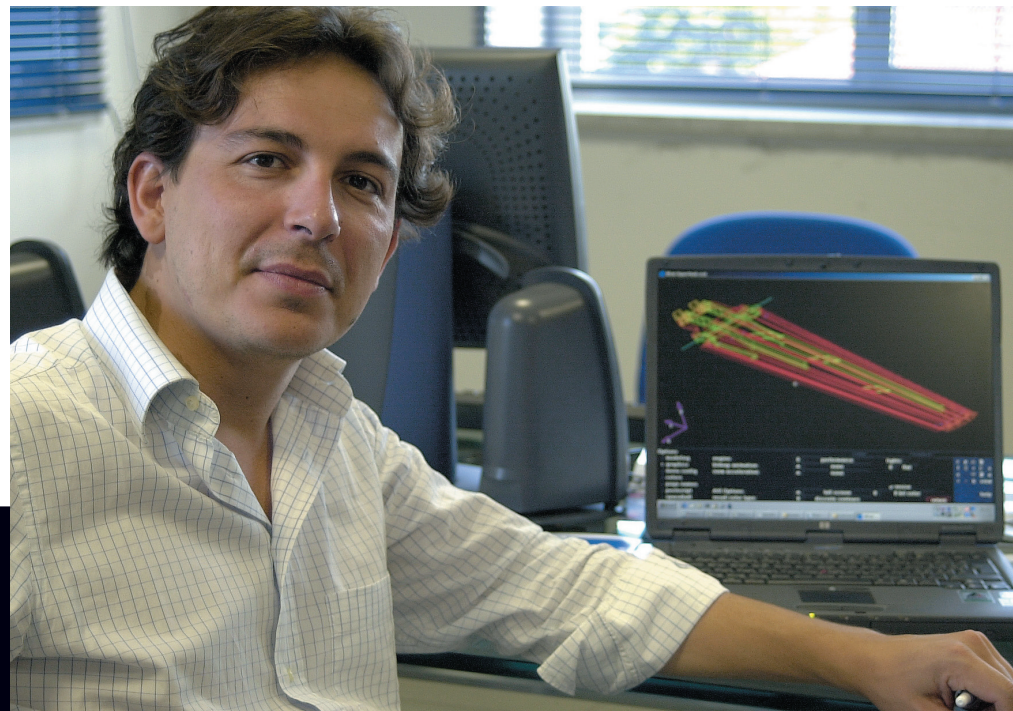
“This extremely valuable tool,” according to Groupe Finot, “has enabled us to increase working capacity and quality, giving us 10 times more options to play with and allowing a large number of fast alterations. It is used for both races and sea and testing tank trials.”

Groupe Finot says it devotes a minimum of 30% of its time to new research, registering patents and using new techniques and materials. The company is always on the lookout for any new opportunities to improve its boat design concepts.

In Ship-Shape

It came as no surprise, then, that work began on a project to improve the performance of the Finot-designed Fila after Italian sailor Giovanni Soldini piloted it to victory in the “Around Alone” race in the fall of 1999 (see *Soldini to the Rescue*). Soldini invited Altair Engineering’s Italian office in Lecce to optimize the design of the sailboat’s keel – the foundational structure of the ship.

The Fila features a hydraulic “canting” keel which plays a crucial role in sailboat racing. Its job is to re-right



Antonio Del Prete and his design team devoted approximately 3,500 man-hours to testing different keel conditions. Engineers used OptiStruct to evaluate the sailboat’s flow resistance and analyze the structural loads and stresses on the keel.



the boat when the wind tips the boat to one side – or even capsizes it. When the boat lists to one side, there is more wetted surface area and friction as the boat cuts through the water, resulting in reduced speed. The canting keel, which rotates around the boat, increases the stability and speed of the boat by keeping it upright with the sails in the wind.

Altair's Antonio Del Prete, mechanical engineer and project manager, explains that the goal of the Altair engineering team was to optimize the internal structure of the keel. Engineers focused on reducing the keel's weight, lowering its center of gravity and attaining the maximum rigidity.

The team began by assessing the design of the keel, which was made of extra-high-strength steel. Altair collaborated with steel manufacturers SSAB Tunnpå and SSAB Oxelösund to increase the use of extra-high-strength and ultra-high-strength steels in the new keel.

Keel Calculations

Del Prete explains that the keel consists of a bulb at the bottom and the fin, which attaches to the hull. Thanks to simulation software that evaluated the new materials and a new shape, engineers were able to transfer weight from the fin to the bulb, increasing the

Soldini to the Rescue

Giovanni Soldini is something of a national hero in Italy. Although his roots are in landlocked Milan, he has long been considered to be among the best solo sailors. Since the tender age of 16, he has made a profession of challenging winds and waves that we mortals only see in our nightmares.

During the Around Alone race in 1999, Soldini gained worldwide reputé after saving the life of Frenchwoman Isabelle Autissier when her boat sank. She was not the only one to face problems – many other boats fell victim to the rough weather in that race. But Soldini rode out the storm and won the race.

It was during the third leg of the event that Autissier experienced problems with the boat's autopilot, which malfunctioned and resulted



in the boat capsizing. At the time, she led the overall race.

Soldini heard the news and informed race headquarters that he would alter his course to search for Autissier. With the assistance of meteorologist Pierre Lasnier, he honed in on her approximate location.

After several hours, he found the capsized boat but did not see Autissier. Soldini circled her boat a couple of times. Then, on the third pass, he hit the boat with a hammer. Autissier emerged, got into her lifeboat and Soldini tossed her a line. Soon, she was safely onboard the Fila, and the racing adventure resumed.

Piloting the Fila, Soldini captured victory in 116 days, 20 hrs., 7 min. and 59 sec. His performance set a record in its class.

Contributed by Håkan Johansson, Ahrena Media AB

boat's "righting moment" in the process. By the end of the project, the optimized keel was 100 kg lighter.

The Altair team relied on Altair OptiStruct software to optimize the design of the keel. The program determines the best design based upon required structural parameters for a given package volume.

According to Del Prete, "We devoted approximately

Building Better Boats

Altair Engineering is no stranger to unique projects. In 1995 and again in 2000, the company dove into optimization projects connected with the America's Cup race.

Jeff Brennan, Altair's vice president of Commercial Software, explains that, in 1995, Altair helped the PACT95 America's Cup team optimize the strength and weight ratios of the hull and appendages for its Young America entry.

"We used our OptiStruct software," says Brennan, "to predict the optimal load paths for the boat's structural weight and mass. If you look at the inside of the hull, we determined the best placement for the ring plates and bulkheads. We developed a design that looked like a spider web of trusses. Virtual testing proved its feasibility." He adds that the hull is the only part of the boat's design that is secret from competitors:

optimizing it, then, can provide a team with a competitive advantage.

Although the yacht was defeated by New Zealand in the finals, its technical superiority prompted three American syndicates to approach Altair for help in designing entries for the 2000 race. Altair chose to collaborate with the AmericaOne team.

According to Brennan, "On this project, we again performed structural optimization of the load paths inside the hull. Our goal was to use as little material as possible to support the loading conditions, take the mass saved from the hull, put it in the lead keel bulb to lower the

center of gravity and improve performance." Brennan adds that Altair Engineering's product design consultants used an array of analysis software and their knowledge of materials and composites in the process.

Paul Cayard, skipper and CEO of AmericaOne, says, "Technology plays an

increasingly important role in the America's Cup design and design optimization process, particularly the structural design and performance of the boats. Altair Engineering's optimization services were readily and seamlessly integrated into our design environment and provided our team with some unique insights for improving the structural efficiency of the hull, resulting in a stiffer, lighter and faster boat."

"OptiStruct," notes Bruce Nelson, chief designer of the AmericaOne, "saved us countless hours of investigating nonoptimal solutions and focused our engineers on the best distribution of material. It also allowed us to develop an extremely optimized, lightweight and rigid structural framework."

What about the upcoming America's Cup race? Brennan says that Altair is being courted by several U.S. campaigns and will soon decide on a partner.



3,500 man-hours to test different keel conditions. The software evaluated worst-case conditions as well as the affordability of the solution." He explained that engineers tested the Fila's flow resistance and also analyzed the structural loads and stresses on the keel.

"The keel," says Del Prete, "is hollow inside. In order to ensure its stability and high performance, we needed a lighter structure and the right reinforcements to guarantee stiffness."

Engineers ran the simulations on a Hewlett-Packard UNIX server with eight processors. Because Altair OptiStruct is parallelized, problems were distributed across the processors, enabling engineers to run them faster and to try more variations.

According to Del Prete, work on the project began in July 2000. By March 2001, final drawings were delivered.

The Right Results

The Altair Engineering team set up an initial meeting with Finot, Soldini and the keel manufacturer to present the results for the optimized keel. Soldini,

an expert sailor, offered suggestions on how to simplify the assembly operation of the keel, so Altair made some minor modifications in its design.

In the final meeting, Del Prete reports that Finot was impressed with the new shape of the keel and said it was the best he had seen. This was high praise coming from a naval architect of his stature.

"For us," says Del Prete, "the redesign of the keel was a challenging yet exciting project. We are not keel experts. Yet, Altair OptiStruct enabled us to converge on the right design."

Del Prete adds that he and his team were able to draw on the experience of Altair's involvement in optimizing the inner hull structure of AmericaOne, which competed in the last America's Cup race (see *Building Better Boats*). "Optimization technology," concludes Del Prete, "can be used in a range of applications, including boat design. It helps good minds develop even better solutions." **C2R**

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