



Formed by the Swiss entrepreneur Ernesto Bertarelli in 2000 to compete in America's Cup racing, Team Alinghi brought the Cup to Europe in 2003 for the first time in 152 years. Alinghi flies the colors of the Société Nautique de Genève, Switzerland, and comprises more than 100 team members of 20 different nationalities.  
©Stefano Gattini/Alinghi.

# World-Class Composites Analysis by Alinghi

Embracing Simulation Driven Product Development, Team Alinghi created their 33rd America's Cup yacht.

By Shane Moeykens, Strategic Partnerships, ANSYS, Inc.

The America's Cup, sailing's most prestigious regatta, staged its 33rd event in winter 2010. The contest pitted two 90-foot-long multihull yachts against each other, a break from the smaller, conventional sloops of previous races. Compared with traditional yachts, multihull vessels have a smaller proportion of the boat in the water, especially when "flying a hull" — a tactic that purposely raises all but one of the hulls out of the water to drastically reduce hydrodynamic drag. Because multihulls are so wide, they can carry much greater sail area than similar-sized monohulls, further increasing horsepower-to-weight ratio. The 33rd Cup boats were the fastest, most powerful and most extreme in the race's history.

Team Alinghi's catamaran, Alinghi 5, flew the colors of the Société Nautique de Genève, Switzerland.

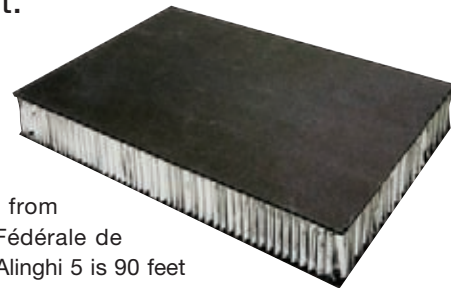


Starting the build: laying out honeycomb core material hull mold at Decision SA, Switzerland  
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A 23-member design team created the yacht with scientific advice from Ecole Polytechnique Fédérale de Lausanne (EPFL). The Alinghi 5 is 90 feet by 90 feet at the waterline, wider and longer above the waterline, and capable of speeds in excess of 40 knots. This giant is built almost entirely of light-weight, high-strength composite materials. During its maiden voyage, the crew succeeded in flying a hull, an accomplishment that owed much to the design team's detailed work, which relied heavily on simulation tools from ANSYS.

Design requirements for the 2010 race were unprecedented. Loading on structural components and vessel speed were unlike anything ever seen in America's Cup racing. Because of Alinghi 5's width, the crew would be subject to life-threatening conditions if the boat capsized — they would be propelled 90 feet into the air, traveling at high speed — so safety was a major concern from the beginning. Optic-fiber sensors provided real-time monitoring of strain on the hull, Y-shaped spine and boom, all constructed from composites.

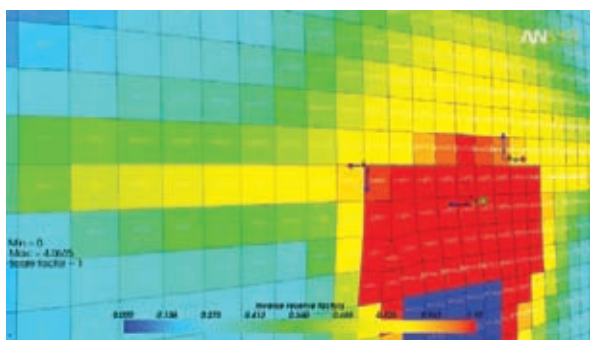
Alinghi 5 sandwich composite with the aluminum honeycomb core  
© Alinghi.



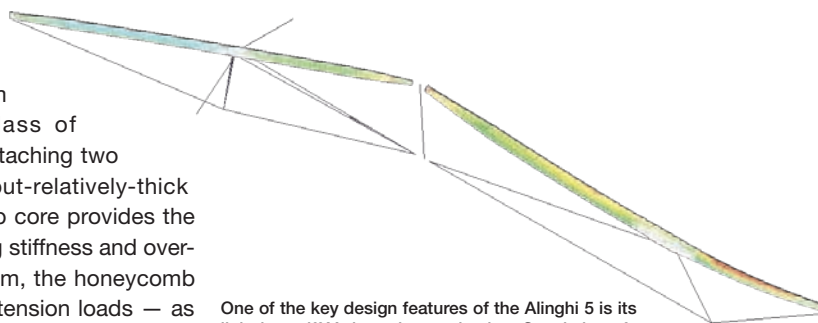
The catamaran has two hulls, built using a sandwich-structured composite with an aluminum honeycomb core. This special class of composite material is fabricated by attaching two thin-but-stiff skins to a lightweight-but-relatively-thick core. The thickness of the honeycomb core provides the sandwich composite with high bending stiffness and overall low density. Analogous to an I-beam, the honeycomb flanges carry direct compression and tension loads — as do the sandwich facings — and the web carries shear loads — as does the sandwich core. Commonly found in high-tech aerospace applications, an aluminum honeycomb core provides excellent strength, weight and corrosion-resistance characteristics. The skins of the sandwich-structured composite are a mixture of carbon fiber, epoxy and pre-impregnated laminates.

The hull is formed using a female mold. Laminate layers are applied at predetermined thicknesses and orientations, and then heated. This layer is bonded to the honeycomb core. The inner skin is bonded to the honeycomb structure, completing the sandwich composite. Eight to 10 layers of carbon fiber material are applied outside the honeycomb core, with another 10 layers on the inside. Nominally, the hull consists of 21 layers, including the aluminum honeycomb core.

Given the rules governing the America's Cup race, teams have relatively little time to design a vessel from scratch. Even the amount of time available for prototype testing is limited; hence, the design team must rely heavily on computer simulation. "During design, construction and on-the-water optimization of the yacht and systems, the major factor leading to success is the efficient use of time," said Kurt Jordan, the Alinghi engineer responsible for structural modeling. "The ability to trust our engineering simulation tools while moving from virtual design directly to systems on the water — with minimal or often no intermediate prototype or testing steps — is an inherent requirement for the America's Cup competition. For these reasons, we selected ANSYS as our exclusive supplier of engineering simulation solutions."



ANSYS Composite PrepPost software was evaluated by the team, which noted its usefulness for determining characteristic material properties of laminate materials, taking into account stacking of the layers (orientation, layering order, etc.).  
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One of the key design features of the Alinghi 5 is its light but stiff Y-shaped central spine. Consisting of a minimal truss system of compression members and the cable stays below them, the spine transmits the vessel's huge loads.  
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Every component of the Alinghi 5 underwent linear and nonlinear structural analysis. This work included a laminate optimization study for the hull that considered multiple load cases. Both macro- and constituent-level properties of the laminate materials were taken into account, specifying orthotropic material properties for each individual layer in the hull's sandwich-structured composite, using shell elements and the ANSYS Mechanical solver. The skin of the sandwich-structured composite exhibits nonorthotropic behavior due to the combined influence of each of the individual layers, their stacking order and alignment. To expedite this optimization study, ANSYS Mechanical runs were automated using batch file execution. Structural analysis was carried out on the composite-fabricated Y-shaped spine and boom using shell elements and a symmetry plane. While fabricated from composites, these components lacked any sort of honeycomb core.

Although the time frame allowed limited prototype testing, failure testing was performed on some of the structural components using test equipment at EPFL. For the laminate materials, cyclic testing was conducted to determine when the fibers commenced breaking down. Inspection of the laminates between tests was done using ultrasound measurements.

Concurrent with the structural analysis, Alinghi performed flow analysis using ANSYS CFX software. Virtually every component was evaluated from a hydrodynamics perspective, paying particular attention to the mast, the two main structural spars connecting the twin hulls, the rudder and the daggerboard. "The challenge is to determine the optimal compromise between the structural requirements and the hydrodynamic requirements," said Jim Bungener, Alinghi flow simulation engineer. "Thick, blunt bodies perform well from a structural perspective, but thin, narrow-profile bodies are desired for their drag properties. By working exclusively with engineering simulation tools from ANSYS, we had the ability to couple structural analysis with flow analysis, taking advantage of the compatibility between solvers within the ANSYS product suite." ■