Design and Optimization of a High Performance C-Class Catamaran with HyperWorks

Key Highlights

Industry
Marine, Educational

Challenge
Building a high-speed, lightweight 25ft long, 14ft wide catamaran

Altair Solution
Laminated Composites Design and Optimization using HyperWorks

Benefits
Shorten the development time of a high-tech foiling catamaran with wingsail with Altair's superior composites optimization technology.

Customer Profile

Born in 1961, based on a challenge between Great Britain and the United States about who builds the fastest catamarans, the 'C-Class' has been the driver of many innovations in the world of multihull sailing. Whether it is Dennis Connor's 1988 America's Cup Winner 'Stars and Stripes', the 90ft trimaran of BMW Oracle with a sail double the size of a Boeing 747 wing, or the AC72 class of the 34th America's Cup in 2013 - all have borrowed and learned from the C-Class designs. Today, with their hydrofoils, rigid wing sails and all carbon composites structures, they are capable of reaching speeds of over 35kts and thus are amongst the fastest inshore circuit racing sailboats in the world.

The École de Technologie Supérieure (ÉTS), which was founded in 1974, is part of the Université du Québec's network and is one of the biggest engineering schools in Canada. It is located in the center of Montréal and has more than 7000 students in several programs covering all major parts of industry. Team Rafale grouped together aerospace engineers, as well as faculty members and students from ÉTS, who took on the ambitious challenge to design, build and race a C-Class catamaran in the 'Little America's Cup' (Geneva Lake, Switzerland, September 12th through 20th 2015). During this event, considered as the C-Class World Championship, they faced some of the biggest names of the sailing world including Franck Cammas, skipper of the America's Cup team Groupama, Olympic sailors and several times world champions.

Building a high-speed, lightweight catamaran

The class rules were very simple: Build a catamaran less than 25ft long with a maximum width of 14ft and less than 300sq ft. sail area.

Keywords: C-Class Catamaran, OptiStruct, Hydrofoils, Wing sails, Little Americas Cup, Team Rafale

Team Rafale Success Story

"The HyperWorks advanced composite optimisation process was a key factor in meeting our weight and strength targets on Rafale's major components. The semi-automate process allowed the team to go through many more design iterations within a matter of hours rather than days."

Julien Chaussée
Lead Design Engineer and founder
Team Rafale – ETS

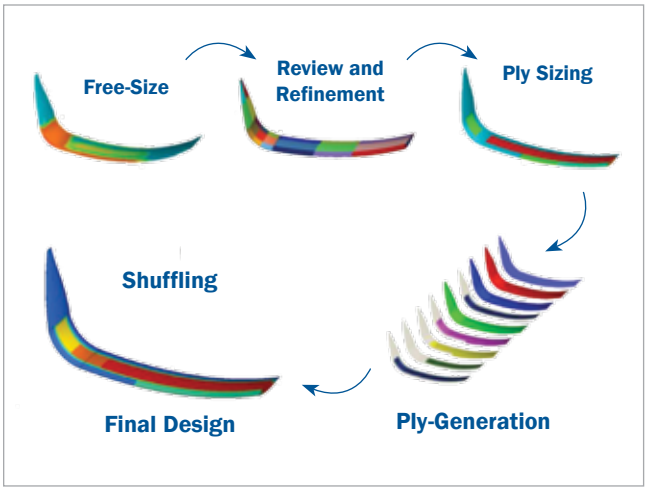
These rules presented the participating teams with a challenging opportunity to drive innovation and use the best materials possible. For the students of the ÉTS Team Rafale, this was an especially formidable task as the catamaran needed to be built in less than 18 months. Although, the hydrofoils are less than two square feet in surface area, they needed to be able to lift the entire boat and its two-man crew out of the water. The 30ft mast at the heart of the rigid wingsail carries almost 4000 lb. of compression while weighing less than 30lbs.

Design and Optimization using HyperWorks

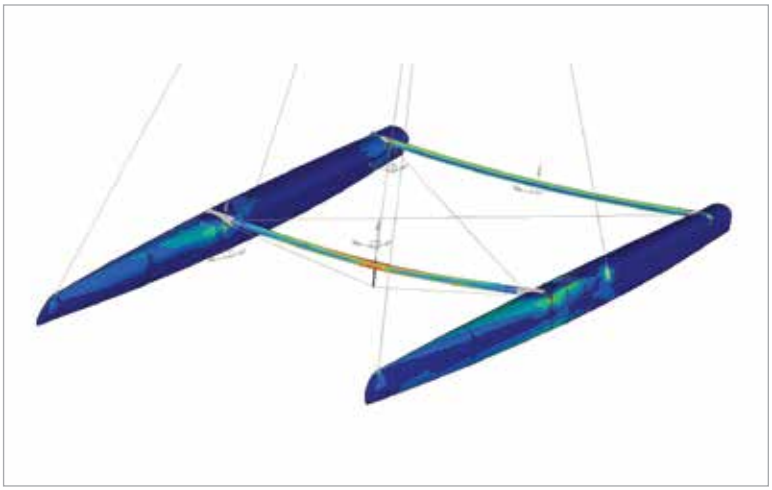
Accomplishing the above has been no mean feat! Team Rafale began building the catamaran in December 2014, and completed the build-phase mid-July 2015. The result is a catamaran with full carbon fiber composite design including a 45ft tall 300sq ft. rigid wing-sail and hydrofoils, the latter being required to lift the boat and its crew completely out of the water, while remaining as small as possible to reduce drag.

To achieve this, every component needed to be systematically optimized and weight had to be designed out from the outset.

This is where Altair's OptiStruct and its composite optimization process have proven invaluable. Having previously worked with Altair's HyperWorks, Julien Chaussee, a former member of the British "Invictus" team and Lead Design Engineer and founder of Team Rafale at ÉTS, picked the Altair software suite for the design, analysis and optimization. Being already well established



Hydrofoil composites optimization with OptiStruct



Compression test strain results of the catamaran platform

Hull platform and wing sail closely before public presentation

Close-up of the 300 sq ft carbon fiber wing sail

in the aerospace industry, OptiStruct's innovative composites optimization process was one of the key factors which guided this decision "We picked HyperWorks for design and optimisation mostly based on my previous experience with it. I have been working with it since 2007. For me the key aspects that guided my choice were the simplicity and rapidity to setup an optimisation. This is especially true for the composite optimisation process which was one of the most important aspects for us. The process is well established and allows rapid transitions from one phase to another" said Julien.

Altair's OptiStruct allowed the team to very quickly cycle through multiple design iterations, taking the requirements and manufacturing limitations into account. All major components benefited from this design approach including both cross-beams, the hydrofoils and the foiling rudders. Each component was run through the three-phase laminate composite design optimization process. In the initial step a free-sizing optimization determined thicknesses for each individual ply orientation angle. In the second step a ply bundle optimization decided how many layers of each ply shape were required while taking manufacturing constraints into account. In a final step the ply-shuffling optimization determined the best sequence of the layers found with previous steps. Bidirectional communication with CAD systems ensured quick realization of these results.

Shortcut to a Lighter Design with OptiStruct

The high level of automation and OptiStruct's ability to directly import, optimize and export composite data helped the team drastically reducing turnaround times between iterations. This allowed the exploration of various options to meet the aggressive weight targets. The main cross beam, which can sustain up to 3000 lbf of load from the mast compression, weighs only 18lbs. The final hydrofoil design has less than 2sq ft. projected area and weighs less than 30lbs while being able to produce up to 1000lbf of vertical lift.

The ambitions for Team Rafale for their first participation in the Little Cup were not a podium position; it is a great accomplishment for the team of students to be on the starting line of this prestigious event. The first goal was to reach the starting line with a true and state of the art C-Class catamaran, the second to compete in all the races with a boat holding up to the loads along with professional level competition. The latter cannot be underestimated, as these boats are fragile in nature and one of the competitors actually had to retire due to damages after a capsize. Those two missions were fully accomplished.

Many success stories can be found along the way, such as Rafale lifting off the water the very first time in Canadian Waters only a month before the event. Another was reaching a top speed of 26.7 knots (30.7 mph). The passionate team of students was received extremely warmly and admired throughout the competition. Members of other teams provided them with valuable input and took action to improve the boat further. The Hydros Foundation – organizer of the Little Cup - wished to present them a Special Prize for their passion, hard work and tenacity in this high level competition. This is a very good starting point for the team for their next competition; we hope they will improve the boat further for the Little Cup in 2017. Paired with more simulation with Altair products the team can set their expectations significantly higher.

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About Altair

Altair is focused on the development and broad application of simulation technology to synthesize and optimize designs, processes and decisions for improved business performance. Privately held with more than 2,600 employees, Altair is headquartered in Troy, Michigan, USA and operates more than 45 offices throughout 24 countries. Today, Altair serves more than 5,000 corporate clients across broad industry segments.

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About HyperWorks®

Performance Simulation Technology

HyperWorks is an enterprise simulation solution for rapid design exploration and decision-making. As one of the most comprehensive, open-architecture CAE solutions in the industry, HyperWorks includes best-in-class modeling, analysis, visualization and data management solutions for linear, nonlinear, structural optimization, fluid-structure interaction, and multi-body dynamics applications.

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