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About Altair

Altair empowers client innovation and decision-making through technology that optimizes the analysis, management and visualization of business and engineering information. Privately held with more than 2,000 employees, Altair has offices throughout North America, South America, Europe and Asia/Pacific. With a 28-year-plus track record for high-end software and consulting services for engineering, computing and enterprise analytics, Altair consistently delivers a competitive advantage to customers in a broad range of industries. Altair has more than 5,000 corporate clients representing the automotive, aerospace, government and defense, and consumer products verticals. Altair also has a growing client presence in the life sciences, financial services and energy markets.

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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DUEM DURHAM UNIVERSITY ELECTRIC MOTORSPORT

Reducing Weight and Maximising Fuel Efficiency of a Formula Student Car with OptiStruct

Key Highlights

Industry
Education, Motorsport

Challenge
Remove weight and improve performance of a Formula Student vehicle

Altair Solution
Optimisation with HyperWorks tools

Benefits
- Reduce weight of vehicle while keeping or increasing the component stiffness
- Speed up development time
- Save material and real-world testing
- Reach top rankings during competitions

The Formula Student competition is hosted annually by the Institute of Mechanical Engineering (IMechE) at the Silverstone Formula 1 track in the UK. It is highly competitive with 178 teams from 38 countries worldwide registered to compete in 2014. To win, teams need to demonstrate their technical, engineering, design and manufacturing skills. They also need to reflect the changes and demands of the industry while considering new developments in commercial car racing.

Saving mass is critical for designing an efficient, fast and cutting edge car. The lighter a car is, the better it becomes in terms of acceleration and handling, as well as in fuel efficiency.

Durham University Electric Motorsport (DUEM), are a UK-based team of students who design, build and race electric vehicles.

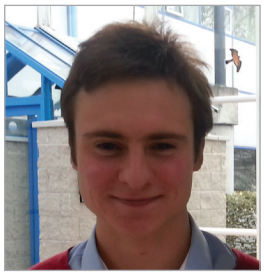
The team takes members from all years in the engineering department, drawing on different levels of experience. Projects and technical work is carried out by students who volunteer to work outside of university hours to participate in motorsport competitions.

Their Track Record

In the 2008 North American Solar Challenge, the team received the 'best rookie team' award, finishing 14th out of 26 competitors. They were the only British team to compete in the event. In 2011, the team placed 33rd out of 42 in the World Solar Challenge, Australia.

Keywords: Formula Student Electric, HyperWorks, OptiStruct

DUEM Success Story



"Altair has brought us analytical techniques for optimisation and in depth structural analysis. Assisted by this powerful suite of software, we are creating designs which push the structural boundaries and advance the development of sustainable transport." – Joe Stallard, H/O Body Structures, DUEM.

The team plans to enter the 2015 World Solar Challenge with an all-carbon fibre monocoque and an innovative aerodynamics design. With entries in both the UK Formula Student competition and World Solar Challenge, DUEM is currently designing and building its first Class 1 Formula Student car, which will compete at Silverstone in summer 2014. The car will be fully electric, with a steel space frame, carbon fibre bodywork, LiPO4 batteries, and class leading aerodynamic package for low drag.

The team prides itself on innovation. In 2013 they were the first Formula Student team in Class 2 to design a Regenerative Magneto Rheological (MR) suspension system. The team achieved 7th place out of 22 teams. The use of a MR suspension system allows for a flat and stable ride as the action of each wheel is smoothened and isolated. The system can be integrated with a vehicle's stability control to enhance stability on gravel and slippery road surfaces.

The Challenge: Remove Weight and Improve Performance

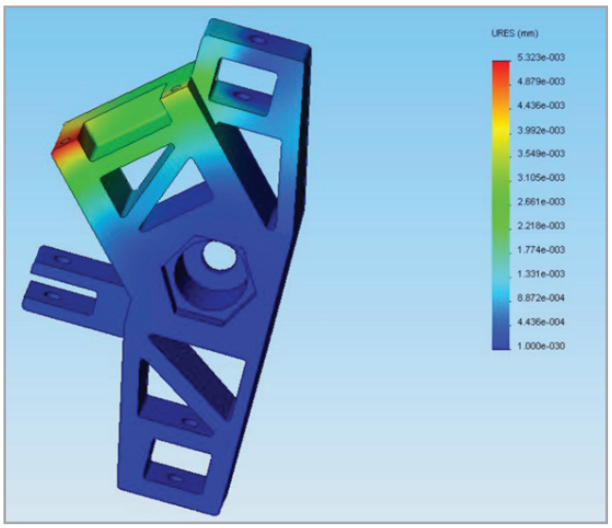
In this project, DUEM wanted to demonstrate how they have applied the latest weight saving technology to achieve a faster, more efficient car by optimising an upright design for multiple load cases.

Optimising the upright design is a complicated challenge, requiring design for multiple load cases including bump, cornering, braking and acceleration loads. Low un-sprung mass is a critical goal for excellent dynamic response. The upright is a 'big hitter' part of the car where mass reduction will enable not only faster vehicle straight line acceleration, but also improved cornering and grip. Geometrical features are important for the effective packaging of brakes, bearings and other components within the rim. Implications of suspension failure are severe from a vehicle safety point of view. Stiffness is essential to ensure good handling and that all the moving parts operate efficiently and effectively.

The conventional means of design iteration for many load cases by removing areas of low stress at each iteration is usually very time consuming. The original component took many weeks to design, and the final solution was not necessarily the most structurally efficient.

The Solution: Optimisation With HyperWorks Tools

As existing users of the Altair HyperWorks simulation suite, the DUEM team looked to OptiStruct, which is part of the suite to help meet this challenge. OptiStruct is a design tool found within the Altair HyperWorks



The original process did not produce the best results

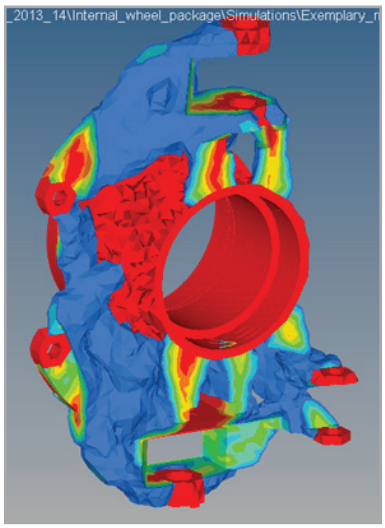


Figure 1: Without draw direction constraints

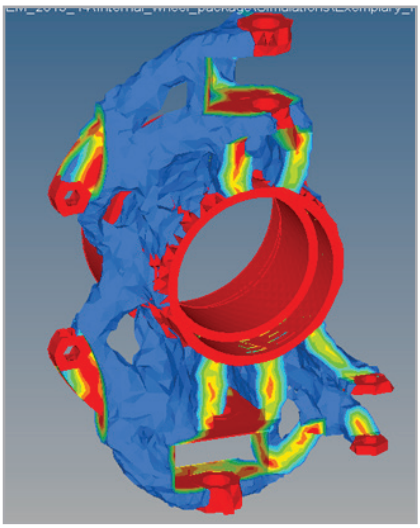
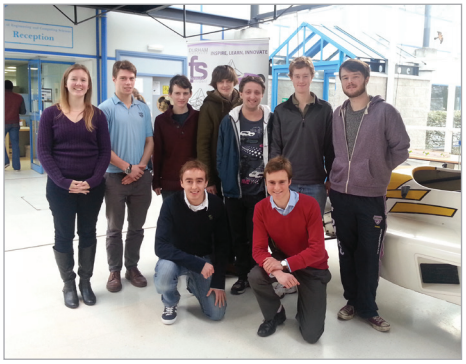
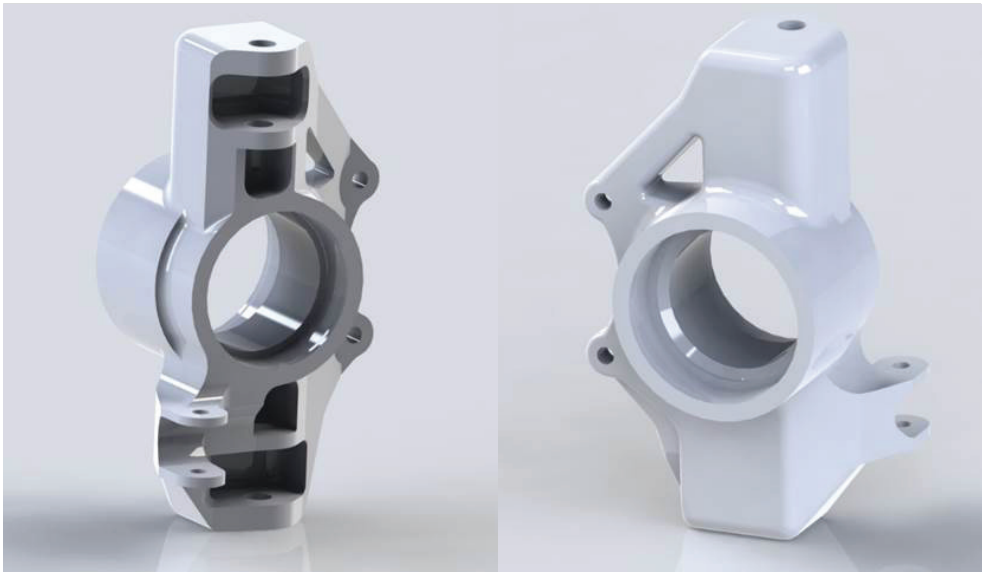


Figure 2: With draw direction constraints



Durham University Electric Motorsport Team

More than 30 undergraduate and post-grad students are involved in the team, with specialities in Vehicle Dynamics, Electronics, Aerodynamics, all working to design a green, efficient electric racer.



OptiStruct vastly reduced the time taken to develop the design, while conducting the work more comprehensively than a manual approach.

CAE suite. By predicting optimal shapes of structures early in the design process using topology optimisation methods, OptiStruct facilitates an analysis-driven design process that results in more efficient designs in shorter design cycle times.

As the design process advances, OptiStruct's powerful shape and size optimisation capabilities can be applied to further improve design performance. Using highly advanced optimisation algorithms, OptiStruct can solve the most complex optimisation problems with thousands of design variables in a short period of time.

The design region was imported into OptiStruct and meshed. Load cases were applied for a 2g bump, 1.6g cornering, 1.6g braking, and combined braking, bumps and cornering load cases. Manufacturing constraints such as draw direction were applied to ensure that the final result is feasible for manufacturing.

A Lighter, Stronger Upright

Different results were found for different stiffness targets and stress constraints – a number of simulations were required to investigate how the proposed geometrical solution varied with these targets.

The topology optimisation results in Figure 1 shows the model without draw direction constraints and Figure 2 shows the model with manufacturing constraints applied. The high density elements are shown in red and indicate a better result if the feasible region was extended further into that space. This was achieved with movement of the brake disc further outwards, which yielded lower stresses.

OptiStruct reduced the overall design cycle time of CAE-CAD iterations and enabled improvements. OptiStruct provides an optimised solution that considers multiple loading scenarios in a single analysis.

The quality of the tetra-meshing algorithm meant that meshing, rather than being a thorough and time consuming process, was swift. Element quality checks were easy to use and helped ensure the validity of the results that were obtained. The edge checker also meant that no internal voids appeared in the topology results.

The manufacturing constraints were simple to apply and made the software produce a result that could be machined cost effectively with just a 3 axis mill.

It was easy to interpret the results; the element density plotter gave great insight into what was happening and enabled insight into where design improvements could be made. This was very helpful and informative for the team.

The Future

DUEM has chosen Altair as a strategic partner to help them implement the simulation driven design process. They are looking to expand their use of simulation by using tools from Altair such as MotionSolve and the new Virtual Wind Tunnel for Multi-body dynamics (MBD) and external vehicle aerodynamics studies respectively.

With HyperWorks sponsorship in-kind Formula Student teams can make significant improvements to their design and build processes.

By using the same technology as automotive and motorsport industry leaders, students who are sponsored by Altair gain an insight into real-world engineering techniques.