Body-In-White Design for a Six-Passenger Sports Car Architecture: Maximizing Body Stiffness and Meeting Strength Requirements Using HyperWorks

Key Highlights

Industry
University / Automotive

Challenge
Design a six-seat sports car using innovative sheet-folding technology

Altair Solution
Utilize HyperMesh, OptiStruct, and HyperView to meet all structural design targets

Benefits
- Structural body stiffness for torsion and bending exceeded design targets
- Chassis met or exceeded strength requirements

Customer Profile

The Deep Orange Program of the Clemson University International Center for Automotive Research (CUICAR) is a graduate automotive engineering program that immerses students into the working environment of the automotive OEM and supplier. Working collectively, students, multi-disciplinary faculty, and participating partners focus on designing and fabricating a new vehicle prototype over a period of two years. Each project focuses on applying innovative design processes and tools to vehicle development and integrating the resulting design with breakthrough product components-providing the automotive students with hands-on experience in vehicle design, engineering, and prototyping. The Deep Orange Program is part of the larger CUICAR strategic focus of conducting interdisciplinary research that addresses industry and societal challenges related to the adoption of advanced automotive design technologies and product innovation.

The Deep Orange Program has partnered with Altair to apply advanced computational simulation methods to their vehicle designs. Altair-sponsored internships and fellowships have enhanced student learning through providing webinar-based and on-sight instruction of Altair HyperWorks simulation technologies. An example of these simulation-based design applications is the CUICAR Deep Orange 3 Program, the third generation vehicle prototype designed and engineered by the Clemson engineering graduate students. Deep Orange 3 features a load-bearing structure based on innovative sheet-folding technology and a unique 3+3 seating configuration package

Keywords: CUICAR, HyperView, HyperMesh, HyperWorks, OptiStruct

CUICAR Success Story

"Altair gave us a tremendous amount of support by teaching the HyperWorks Suite to our graduate students for application to our body-in-white development. With HyperWorks we were able to develop the best topology while creating a lightweight structural design using the folded metal origami technology."

Dr. Paul Venhovens,
BMW Endowed Chair-Systems Integration
CUICAR Faculty

in a sports car architecture. The following describes this design and summarizes the application of Altair HyperWorks to meet the necessary engineering structural performance requirements for the underlying body structure.

Concept Design for Occupant Configuration & Body Structure

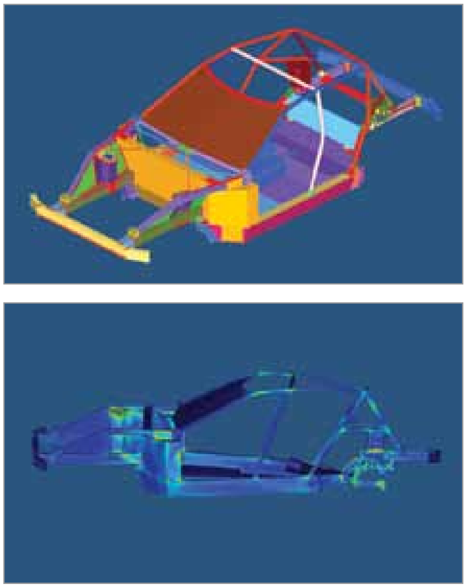
The goal of the Deep Orange 3 Program was to develop a vehicle based on the architecture of a mainstream hybrid concept marketed toward Generation Y. The primary sponsor of the program was Mazda North American Operations. The Art Center College of Design was the design partner.
A unique interior seating concept was derived based on extensive Generation Y market analysis. The 6-seater concept was developed to accommodate four 95th percentile male occupants in the outboard seats and two 50th percentile male occupants on the middle seats using a 2-row, 3+3 seating configuration.

The corresponding body-in-white (BIW) structural design concept was chosen to explore the Industrial Origami® patented technology that enables the folding of lighter gauge material into complex shapes for the body structural members. The forming is completed with simple, low-cost fixtures, at the assembly location. Developing the geometry, topology, and functionality of the BIW components required extensive collaboration between design students and chassis, power train, body structures, and occupant packaging students while carefully balancing design requirements for BIW stiffness, packaging space, cost, and weight. An aluminum BIW design was synthesized from many trials and experiments for forming body structural members using the Origami®

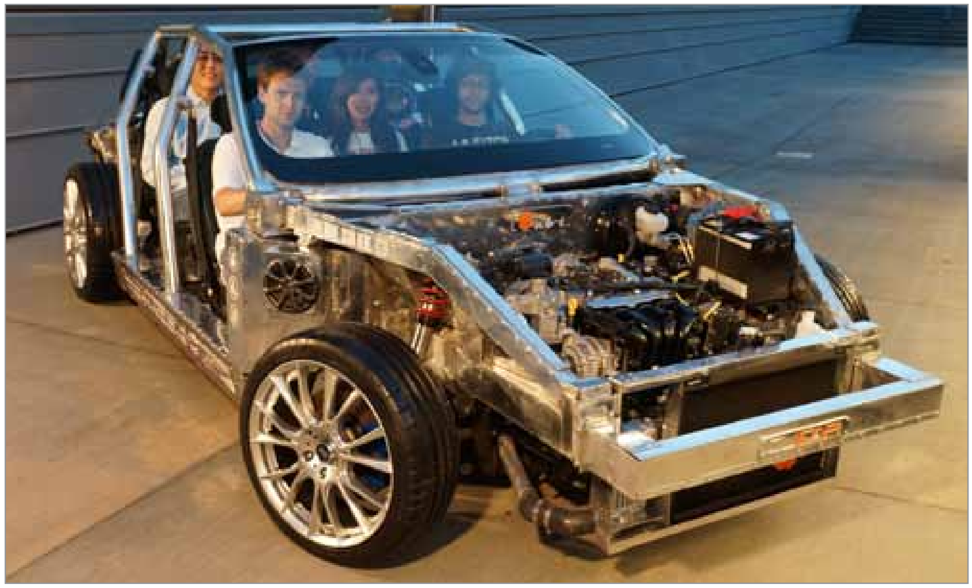
Vehicle FMT Card Board Mock Up with Front Seating Configuration

Vehilce FMT CardBoard Mock-Up for Shock Tower

Finite Element Model-Shock Tower



Top: Complete BIW CAD Model
Bottom: Finite Element Results - Torsional Stiffness



Body-In-White Structure

Folded Metal Technology (FMT). A card board mock up was used to demonstrate feasibility of the FMT. The feasibility assessment was particularly important in highly loaded structural areas (strut tower and front body mount). As a result of the mock up studies, the FMT was applied to the front crush structure, the passenger compartment floor area, and the rear crush structure. The upper body structure (roof and body pillars) was constructed from tubular aluminum.

Design Simulation Using HyperWorks

A CAD model for the BIW design that resulted from knowledge gained during the cardboard mock up fabrication was built using SoildWorks and was imported into HyperMesh. All of the FMT structural parts and tubular space frame components were modeled using 2D shell elements. Thicker-gauge BIW components, representing crucial design areas where the front subframe mounts to the body structure were meshed with 3D hexagonal elements.

A series of in-depth finite element analyses covering torsional and bending stiffness, natural frequency, and dynamic pot-hole and bump loads were completed using the Altair OptiStruct finite-element solver. The finite element results, reviewed by applying the Altair HyperView post-processing module, showed that the BIW design met all the program requirements for body stiffness. Finite-element analysis of the front sub frame, applying dynamic loads from acceleration, braking and cornering maneuvers, showed that stress allowables in strength-critical areas were not exceeded.

Manufacturing of the Deep Orange 3 Car

After results from all of the HyperWorks simulations showed that the BIW chassis met or exceeded strength and stiffnesss requirements, the team members, in consultation with the program primary suppliers, performed all the construction on the vehicle. All of the FMT body components for the front sub-structure, floor, and rear sub-structure were bent to shape using the experience gained from forming the card board mock-up. The complete FMT BIW design was completed using aluminum and structural adhesives. Seats for the unique 3+3, 2-row passenger compartment were installed, along with the instrument panel, steering wheel, and driver powertrain controls. The front sub-frame, designed via finite-element simulation to support the front engine powertrain, was mounted to the forward body structure. The powertrain, a four-wheel drive concept based on a front-wheel-drive, downsized turbocharged 4-cylinder internal combustion engine and a rear wheel electric motor drive configuration was installed.

In conclusion, Altair HyperMesh, OptiStruct, and HyperView played a significant role in enabling the Deep Orange 3 Team to meet the structural requirements for the BIW design. “Altair HyperWorks was a most useful tool for enabling our Deep Orange 3 body structures team to meet our BIW stiffness and strength design targets,” stated Dr. Imtiaz Haque, Executive Director of CUICAR. After vehicle construction was completed, the Deep Orange 3 vehicle was successfully showcased at the annual Specialty Equipment Marketing Association (SEMA) show in Las Vegas, Nevada.

Visit the HyperWorks library of

Success Stories

at www.altairhyperworks.com

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 1,800 employees, Altair has offices throughout North America, South America, Europe and Asia/Pacific. With a 27-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 3,000 corporate clients representing the automotive, aerospace, government and defense, and consumer products verticals. Altair also has a growing client presence in the electronics, architecture engineering and construction, 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.

www.altairhyperworks.com

Altair

Altair Engineering, Inc., World Headquarters: 1820 E. Big Beaver Rd., Troy, MI 48083-2031 USA
Phone: +1.248.614.2400 • Fax: +1.248.614.2411 • www.altair.com • info@altair.com