Success Story

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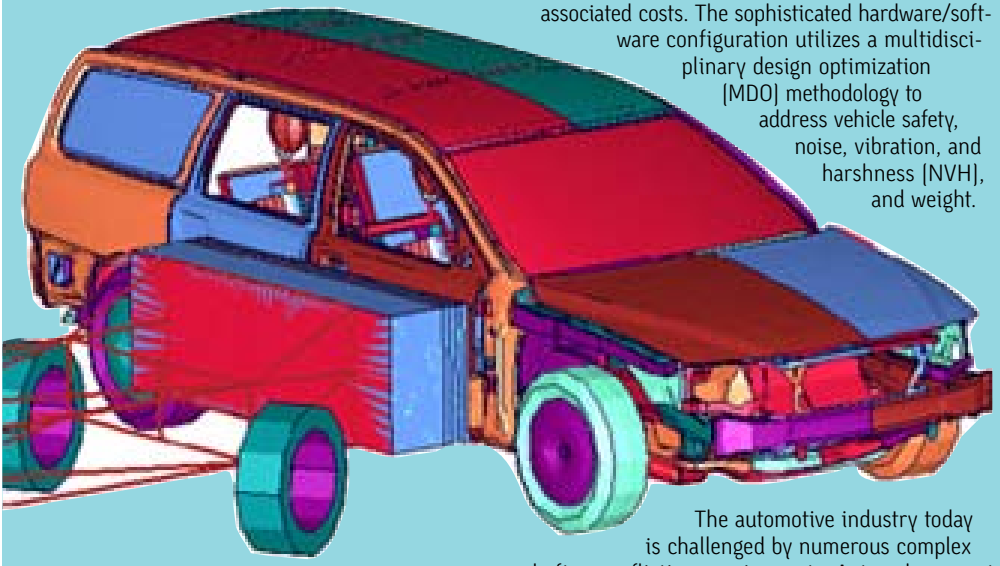
Achieving Six Sigma Designs with Multidisciplinary Design Optimization —A Project of Volvo Cars and SGI

In a fiercely competitive global marketplace, manufacturers continue to seek strategies to improve product quality and slash development cycles. Ford Motor Company (Dearborn, Michigan) worked with SGI (Mountain View, California) to develop a high-performance computing environment that enables Ford to enhance its vehicle designs while significantly reducing computing time and associated costs. The sophisticated hardware/software configuration utilizes a multidisciplinary design optimization (MDO) methodology to address vehicle safety, noise, vibration, and harshness (NVH), and weight.



The automotive industry today is challenged by numerous complex and often conflicting requirements. Automakers must compress vehicle design cycle time, lower the weight and cost of vehicles, and improve product performance—e.g., durability, NVH, safety, and ride quality. To satisfy these stringent requirements, auto manufacturers such as Ford and Volvo Cars are increasingly relying on the use of more formal and structured approaches to design, analysis, and optimization. The vehicle design process has always involved intensive collaboration among specialized teams, each with its own, conflicting considerations. A successful design requires manufacturers to integrate the workflow process and come up with an overall optimum design across all disciplines. Often, designs are passed between product teams several times until the differences are minimized and a mutually acceptable solution is found.

In today's fast-paced marketplace, the traditional new-vehicle design approach is too sequential and time-consuming. The need to reduce time to market for new vehicles, as well as the increased affordability of high-performance computing, which can process hundreds of simulations concurrently, has led to the increased adoption of MDO. The goal of MDO is to provide a more consistent, formalized process for complex system design than is found in traditional approaches, as well as to impact the product design cycle through timely, performance-based design direction. In essence, MDO aids in the management of the design process workflow itself.

A major challenge in applying MDO to automotive manufacturing is the sophisticated high-fidelity models that have evolved as the standard in the industry. Without superior computing power, elapsed computing time for such detailed models could take years. An effective integration of HPC, storage, and advanced visualization methods with MDO methodology can enable faster MDO solution times and superior designs.

SGI has continued its MDO success with Volvo Cars, which is part of the Ford Motor Company. In a recent project between Volvo Cars and SGI, the two companies set out to optimize the Volvo V70 vehicle system

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for minimum weight while meeting crashworthiness standards and design targets for NVH levels and reducing the elapsed solution time for such intractable problems.

SGI began the Volvo Car Safety Group MDO project in May 2001 as a value-added initiative of its high-performance computing environment powered by an SGI® Origin® 3000 128-CPU server installation. Subsequently, Volvo Cars upgraded to an additional 64 CPUs in May 2002, as well as CAE and MDO services.

Dr. Srinivas Kodiyalam, SGI's manufacturing industry program manager, adds, "The Volvo Cars MDO program was very successful. Working together, the SGI and Volvo Cars teams obtained a feasible design while also reducing vehicle body weight by 2.5% to 10.5% for multiple constraint conditions. We also reduced car body frequency response levels, satisfied safety requirements, and integrated the iterative vehicle design process. In all these cases, the design objectives would never have been achieved in the required time frame without the use of the MDO techniques and a high-performance computing environment." The MDO project allows engineers and analysts to address multiple safety failure modes including full frontal impact, frontal offset impact, side impact, and roof crush, as well as NVH. The design of complex structures such as cars and trucks involve a simulation environment with several of the following characteristics:

- A high number of design variables
- A substantial number of design subsystems and engineering disciplines
- Interdependency and interaction between the subsystems and disciplines
- Large, complex models across all engineering disciplines
- Iterative design and analyses processes

An environment with these attributes would benefit from the use of MDO and HPC. "Due to the level of complexity and dimensionality, high-performance computing systems are critical for large-scale MDO in order to impact the product development cycle," says Kodiyalam. "In addition, a heterogeneous mix of simulations is common with MDO. These various simulations put different strains on the compute systems. Some are I/O intensive. Others require fast CPUs with high CPU-to-memory bandwidth. And, since all these simulations need to be conducted simultaneously to impact the design cycle, the computing environment must be capable of effectively running the complete mix of simulations."

SGI trained Volvo Cars engineers on MDO technology in November 2002 as part of the knowledge transfer process. The MDO solution comprises an SGI® HPC server running several software products including ModelCenter® from Phoenix Integration for the MDO process workflow integration, RADIOSS from Mecalog for safety discipline analysis, MSC.Nastran™ for NVH discipline analysis, TH++ 4.1 from Mecalog, and MATLAB® from Mathworks for postprocessing crash simulation time histories.

SGI is focused on utilizing its MDO expertise in helping its customers achieve Six Sigma—a highly disciplined process that helps companies focus on developing and delivering near-perfect products and services. Sigma is a statistical term that measures how far a given process deviates from perfection. Design for Six Sigma allows engineers to predict production and performance capability early in the product development process and improve it, rather than reacting to poor performance after the fact.

Volvo V70 Vehicle Model—Side Impact with SINCAP Barrier

Volvo V70 Vehicle Model—Side Impact with IIHS Barrier

Volvo V70 Vehicle Model—Roof Crush

Volvo V70 Vehicle Model—40% Offset Deformable Barrier

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