Mitsubishi develops vehicle platform with support of LMS

Strategic partnership with LMS enables automaker to meet critical vehicle targets and to accelerate vehicle development cycle

ENGINEERING INNOVATION

Faster to market with fresh designs of multiple vehicle variants... all while controlling costs, minimizing weight and delivering cars that meet the highest quality, performance and safety requirements. To achieve these daunting objectives, Mitsubishi Motors Corporation is working with LMS in a strategic partnership to frontload vehicle engineering and optimize designs for critical attributes earlier in the process. LMS recently supported Mitsubishi in reaching these objectives on a new small-car platform with multiple upper body designs. Mitsubishi also teamed with LMS to deploy these advanced simulation processes based on LMS Virtual.Lab for the development of innovative future vehicles.

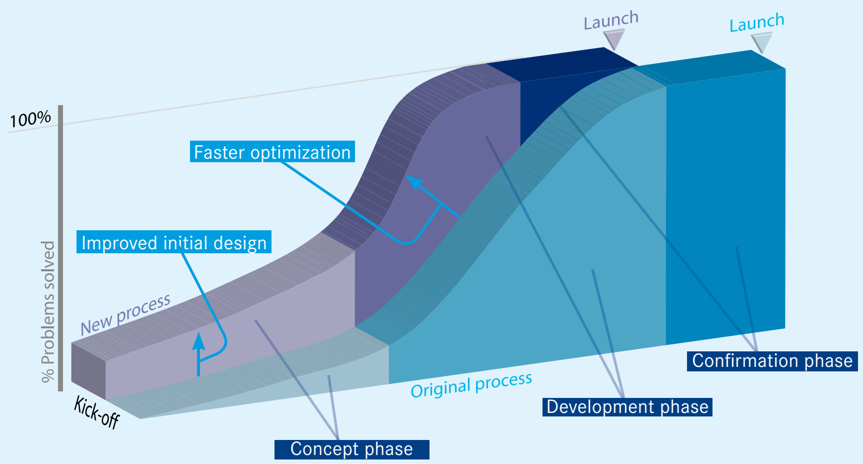
Meeting vehicle development challenges

The concept stage of vehicle development traditionally focuses on form and fit factors. But every early design decision has a significant impact on the intrinsic structural and dynamic properties that determine the function of the car. The tremendous importance of getting the design right up front is even magnified when developing a new vehicle platform for many different upper body variants. In such case, designers and engineers must take into account the first vehicle released in the market as well as make sure the new platform can accommodate other body styles with a wide range of requirements and operating conditions.

Mitsubishi Motors and LMS recently collaborated in a strategic development program with a two-fold objective: co-develop a new small vehicle platform suited to fit multiple upper bodies and deploy an optimized vehicle development process based on the breakthrough simulation capabilities of the LMS Virtual.Lab platform. The program focused on frontloading attribute engineering in the concept stage and on guiding the first detailed design of components and subsystems. This allowed Mitsubishi to eliminate a series of weak spots and potential problems in key attribute areas such as body rigidity, ride and handling, durability and NVH early in the development process, even before the creation of detailed CAD models.

Mitsubishi and LMS also implemented a new approach in the detailed design and engineering stage that allows Mitsubishi engineers to simultaneously optimize components and sub systems in converging on the required performance targets in much less time than is usually taken.

"As a result of the strategic program with LMS, our development teams can optimize designs in the early concept stage, before detailed CAD modeling, and perform fewer and faster iterations during the detailed development stage. Thanks to these advances, Mitsubishi compressed the development cycle and realized a major leap forward in shortening time to market and lowering costs," says Hirotaka Shiozaki, Manager of the CAE and Digital Engineering Group at Mitsubishi's Vehicle Development Engineering Center in Okazaki, Japan.



Mitsubishi Motors compresses vehicle development by refining the design in the concept phase before detailed CAD and by performing fewer and faster analysis/test/redesign iterations during development

Frontloading attribute engineering in the concept stage

During the conceptual phase of the project, four upper body shapes were developed to fit on a new platform chassis design. Based on initial styling information for the upper bodies (outer shape and sections), an initial platform design needed to be engineered in detail. At the same time, a first upper body concept needed to be studied to provide input for detailed CAD design. The major challenge was in developing a concept design for optimal performance in terms of body rigidity, ride comfort, handling, crashworthiness, durability and NVH - with very little platform information and no upper body data available. To efficiently identify and eliminate problems in the early conceptual design, Mitsubishi and LMS worked on deploying specific sub-processes: first, the fast creation of finite element models of the platform and upper body variants suited for different attribute studies; second, the generation of accurate loading information for the respective attribute analyses; and third, the deployment of efficient approaches to detect weak spots and simultaneously assess the impact of design changes on key attributes.

Since no detailed model information on the upper bodies models was available for the platform concept development, LMS and Mitsubishi engineers created simulation models by combining the finite-element model of the new platform and morphing predecessor FE models to fit the new styling lines of the different upper bodies. LMS Virtual.Lab Morphing and Mesh Based Design allowed them to stretch an existing FE mesh to a new target shape. In this way, all four upper body shapes were developed in only five weeks - a task that otherwise would have been impossible since no CAD data was available.
The loads for fatigue life predictions were estimated through a combination of test data from predecessor vehicles and full vehicle multibody simulations on the suspension. As loading conditions for NVH on the other hand, the experimental suspension and powertrain interface loads were used.

Subsequently, multi-attribute optimization methodologies were applied to detect weak spots in the platform and upper body designs using the models obtained by mesh morphing and the developed load cases. "These early concept analyses allowed us to identify and eliminate weak points in the platform design that were common among multiple upper bodies," explains Shiozaki. "Based on the results, the platform concept was frozen and the initial design fixed taking into account body performances like NVH, acoustics,

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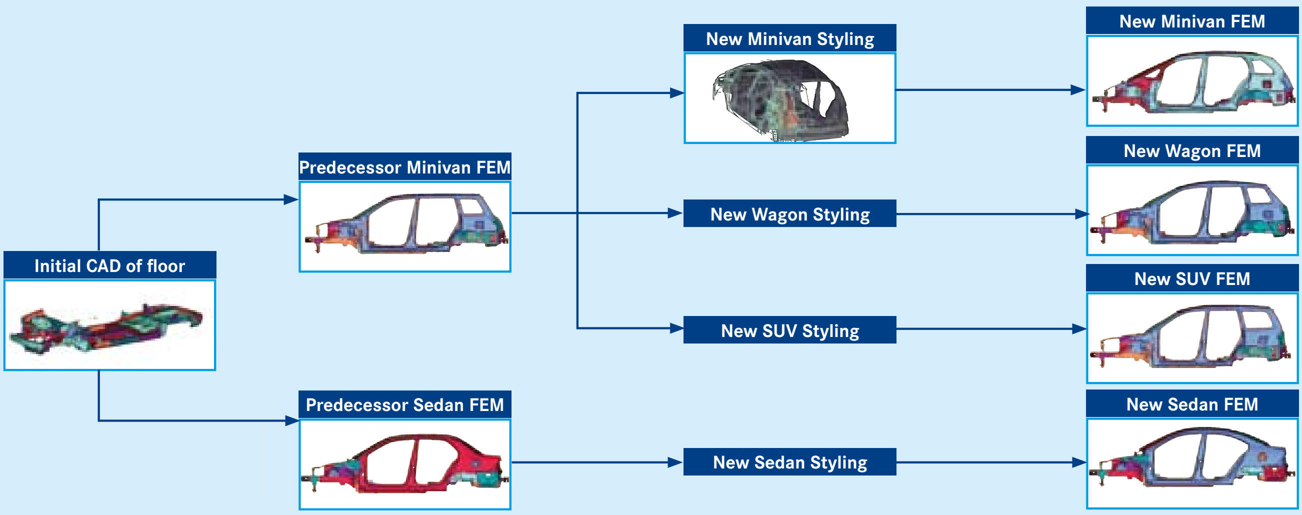
body-in-white rigidity, durability, and crashworthiness. Both the chassis and powertrain mounting layout concept, and the initial bushings stiffness values were fixed considering ride and handling performances like harshness, shimmy, powerplant shake, idle vibration, etc. Based on pre-CAD studies, we were able to avoid these weak points showing up in the initial detailed designs.”

Detailed Engineering and freeze of upper body design

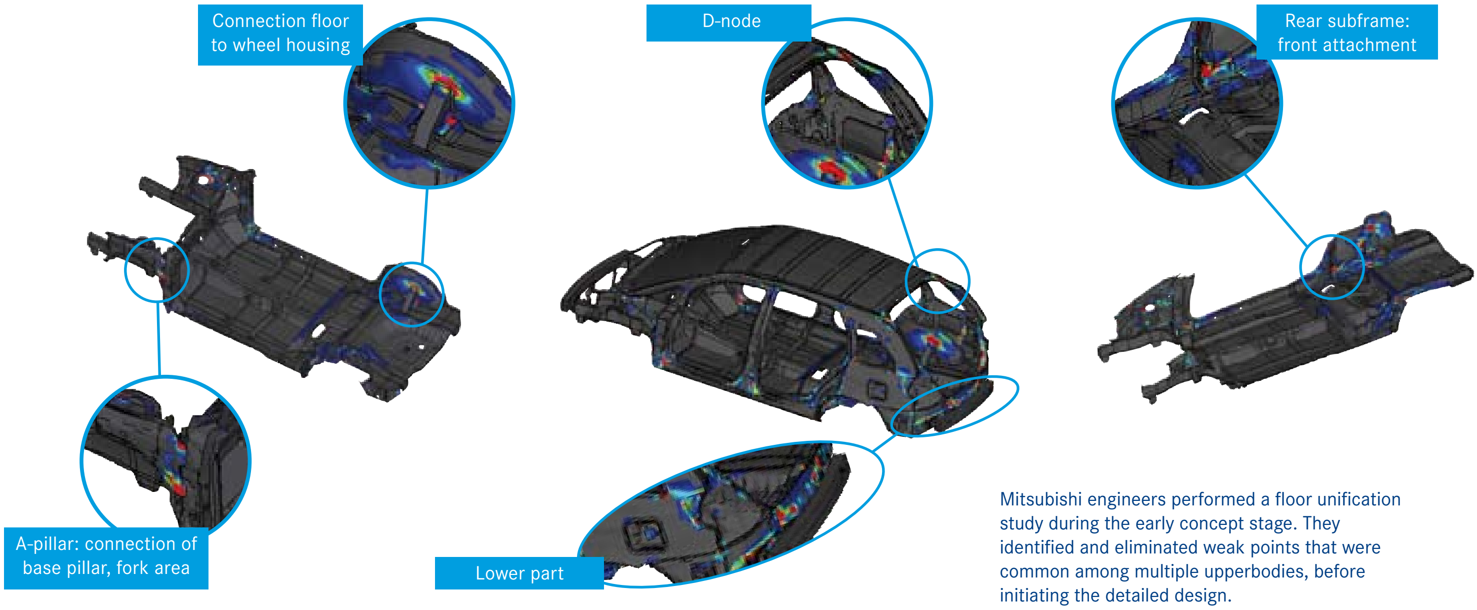
For the detailed development phase, a building-block approach was used with the aid of LMS Virtual.Lab to combine multi-body simulation and FE models representing vehicle attributes for all the various components and subsystems. Loads determined from the conceptual phase were then applied to this full vehicle model for the analysis of noise, vibration, handling and fatigue life, using detailed simulation to pinpoint and improve weaknesses in the upper body design.

At this stage, CAE models would usually have been individually modified and re-analyzed for each of these design fixes. This would probably take months for the many iterations to resolve the often-conflicting requirements for variables such as vehicle weight versus crashworthiness, or ride comfort versus handling. Through the newly implemented approach, Mitsubishi engineers are able to simultaneously deliver the required simulation models for the different attributes. This allows them to quickly gain insight in the underlying phenomena and easily evaluate design alternatives.

To complete this process in a few weeks, Mitsubishi performed cross-attribute optimization using LMS Virtual.Lab Optimization to evaluate the contribution of each design variable and the impact of design modifications on the overall design. “In this way, we can develop an optimal design that balances all attributes simultaneously,” notes Shiozaki. For example, the optimization process enabled engineers to better arrive at a refined functional design of a cowl top, by considering pedestrian safety, interior



In this pilot program, four upper bodies were morphed from predecessor vehicles and fitted to a single chassis using LMS Virtual.Lab.



Mitsubishi engineers performed a floor unification study during the early concept stage. They identified and eliminated weak points that were common among multiple upperbodies, before initiating the detailed design.

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acoustics and handling simultaneously. Low cowltop stiffness was required for pedestrian safety.
Lateral stiffness in the front shock absorber connection point was increased for optimal handling performance. Modal structural modes were balanced against acoustic cavity modes, to minimize the engine noise radiated from the windshield and the dashboard. "Having capabilities to simultaneously optimize all variables at once saved considerable time and improved the overall quality of the vehicle design," says Shiozaki.

Design validation instead of late-stage troubleshooting

In the confirmation phase, the LMS hybrid simulation approach was used by Mitsubishi to validate the vehicle configuration and guide countermeasures to refine functional requirements that did not fully meet the targets. LMS Virtual.Lab was used to apply forces measured from physical prototype testing to a simulation model for predicting vehicle performance. Any changes can be made to the model and re-evaluated instead of building and re-testing multiple prototypes, thus eliminating numerous physical tests.
To improve interior acoustics, for example, a hybrid model consisting of FEM subframes assembled using FRF-based substructuring was loaded with test-derived forces to determine floor vibration and interior road noise. Guided by these results, Mitsubishi and LMS engineers lowered interior sound levels by refining the suspension modal alignment with body and subframe modes. Another benefit of the hybrid approach is the extension of the frequency range from road and engine noise, with test data and finite-element results coupled by FBS. Using a validated simulation model is a major breakthrough advantage over late-stage vehicle testing of numerous prototype variants, which is an expensive and time-consuming process to find the root cause of multiple problems and explore design alternatives to eliminate all trouble spots.

Productivity improvements and future plans

According to Shiozaki, the deployment of the new process allowed Mitsubishi to very effectively meet the critical vehicle targets in terms of body rigidity, ride comfort, handling, crashworthiness, durability and NVH. In addition, Mitsubishi managed to save a full prototype cycle, without a single compromise on the final vehicle quality. Finally, the implementation of LMS Virtual.Lab solutions for Morphing, Noise and Vibration, Structures and Acoustics has lead to efficiency gains of more than 50% compared to previous generation processes.

"Using LMS Virtual.Lab and the multiple breakthrough technologies is revolutionizing vehicle development at Mitsubishi," explains Shiozaki. "Simulation-based development allows us to frontload attribute engineering in the concept stage, guide major design options from a functional engineering perspective and compresses the development cycle significantly. We dramatically reduced the time our engineers spend on non-value added tasks and better utilize their creativity and expertise in developing innovative car designs that strengthen our competitive position in the automotive market and will allow us to compete more effectively in the decades ahead." ■

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