Put the Top Down and Drive

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Summary:
Saab Automobile AB used MSC.Nastran as their primary tool for structural dynamic analysis and structure-borne acoustics calculations to the development process of a new convertible. Design studies early in the development cycle and easily shared data improved interdisciplinary collaboration between the NVH and the chassis departments, enabling Saab to realize a vehicle balanced between weight, safety, and NVH performance. With the help of MSC.Nastran and related SimOffice products, Saab has shortened time-to-market while maintaining safety and validating noise & vibration performance.

At Saab's Noise and Vibration Center (NVC) in Trollhättan, Sweden, MSC.Nastran is the primary tool for structure-borne acoustics calculations. Per-Olof Sturesson, manager of the NVC, recognizes the numerous advantages in using MSC.Nastran, which he states to be the best tool for doing this type of analysis. "It offers many important features for structural dynamics, especially good shell elements and a superior eigenvalue extraction, and also features optimization capabilities." Also, corporate cooperation within General Motors is supported, as MSC.Nastran bulk data makes it easy to share and exchange models and modeling techniques. "By sharing the same input deck and getting similar results, we save time," Sturesson says.

Saab also uses other MSC.Software products, including MSC.ADAMS for multibody simulation and for calculating powertrainrelated excitation and engine/powertrain displacements as well as powertrain mount forces. The forces resulting from this virtual assessment are then applied on a trimmed body structure to calculate sound pressure levels, for example, at all occupants' ear positions in the vehicle. Vehicle system models are also used for NVH analysis, including road-induced noise and vibration analyses.

Simulation at Saab
"Virtual assessments are definitely a way of lowering cost," Sturesson says. "You have a better chance of getting it right the first time." For example, MSC.Nastran can predict noise and vibration performance of the concepts early in the development phase, which is the most important time for major design input. Later in the development cycle, the measurements of the actual vehicle allow only for small changes, which in most cases are too small to improve the design. Sturesson explains, "If road noise is still too high once the first hardware prototype is built, it is too late to do anything thorough about it. You have to do the work not only during the design phase but even earlier - when you are developing the concepts." For today's car manufacturers, VPD is an absolute must for accelerating time-to-market. "Engineers did a lot more physical hardware work 10 years ago, and today, with VPD, we save at least one year of development time compared to then," states Sturesson.

MSC ✕ **Software**

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The Process Begins

At the beginning of a new car's development cycle, Saab first works on an overall concept. Noise and vibration targets are usually set at the beginning of the project. Therefore, Sturesson's team must give their input on the expected NVH behavior as early as possible. To do so, they either take a suitable model and modify the geometry through concept studies, or they use a crude simplified model to show that a major topology change is possible without relying on computer-aided design (CAD) data. Once it is ascertained that the new concept is better than the existing one, the CAD data becomes a necessary means to proceed with the investigations.

CAD data also allows the same model to be shared with other disciplines. Different departments can work on the design simultaneously. If the NVH department is investigating a new rear suspension, they will work with the vehicle dynamics department using the same CAD model. Design changes that might change the crash behavior have to be cross-checked against the durability aspects, and many others.

Once there is a design freeze and an official release of CAD data, the NVH department usually uses a fresh CAD model. This model undergoes meshing activity to get a new body-in-white, with new door closures and a new chassis. Then the body and chassis are trimmed, requiring a trim parts map and inertial properties for non-structural parts. Bushing rates have to be determined and collaboration with other departments begins. When the modeling activity is finished, the status of the project is presented at project management meetings where decisions are made and design problems identified.

To fix the problems, analyses of the necessary changes are made and their influence on the whole vehicle identified. The NVH department performs structural dynamics, structural acoustics, and frequency response analyses with MSC. Nastran, and also looks into optimization and design sensitivity.

Many Departments - One Car

To optimize a vehicle design, interdisciplinary work is a must. "No one would buy a car that is best-in-class for its NVH performance but lacking in safety performance," says Sturesson. For the best overall performance, compromises must be found.

As different departments seek solutions for different targets, conceptual studies very early in the development phase are necessary to get satisfactory results faster. Conflicts between ride, comfort, handling, and NVH are common. "You have to do concept studies in terms of suspension and body design, attachment point design on the body side," Sturesson notes. "The challenge is to look into the suspension architecture on the chassis side, which needs to be in line with other characteristics." As the chassis department focuses on handling issues, early cooperation is needed in order to take into account noise and vibration issues.

A good example of Saab's development process is the new Saab 9-3 convertible. The NVH department started with benchmarking activities, experimental modal analysis, and road measurements on convertible vehicles, providing early data that indicated what targets needed to be reached. In the next step, optimization studies showed what design changes would be required. "We found out that it is not enough to optimize, for example, just gauge thickness. One also needs to change the local sections to increase the section heights in order to have better structural integrity," explains Sturesson. After more than 100 iterations on the body, they improved the model by degrees and finally came up with a vehicle balanced between weight and NVH performance.

Ergonomics issues were also considered, since the change of a local section of the car could result in occupants having difficulty getting in and out of the car.

"The car would never have been as good in terms of structural feel, structural integrity, without this kind of work," Sturesson adds. Changes later in the development phase would have cost Saab a lot more. "It was definitely a cost saver in terms of product force and total development work," Sturesson says. "Late changes mean a lot more effort in terms of manpower and time - you have to work a lot harder."

Getting the Most from VPD

Sturesson makes it clear that from a CAE perspective, MSC.Software products have definitely proved their value: "We would never have had a competitive vehicle without it - we would definitely have lost sales." He adds that in the case of the Saab 9-3, fewer simulations would have driven costs higher. "We had two engineers working on the convertible project for half a year with very good results," he says. "We would never have achieved this kind of result with two hardware loops. Never!" Using VPD, Saab engineers have a greater influence on the development of a new product than was previously possible. "If you need to push your structural body stiffness (static torsional stiffness) with 250%, which we actually did, you cannot do that if you are using an old model and just making small changes. You need to do a lot more and early enough," Sturesson explains.

VPD Drives the Future

Sturesson says, "At Saab, we intend to extend our capabilities in all areas as well as in NVH. We would like to do a lot more work with other areas and disciplines, for example, in powertrain-related simulations where there is an intake and exhaust noise. Sturesson believes manufacturers and engineering teams need to work for greater acceptance of simulation results." He concludes with his personal vision: "If a top manager asks us how confident we are in our results, we should be able to say, 'I'm 95% confident.' This is where I would like to be with VPD in a couple of years."