

SIEMENS

Ingenuity for life

Automotive and transportation

Hyundai Motor Company

Leveraging Simcenter Engineering and software to balance handling, NVH and ride comfort

Product

Simcenter

Challenges

Solve a booming noise issue in a prototype van

Detect design or construction flaws early and avoid them in the future

Develop a process to balance NVH with handling and ride comfort early in design

Keys to success

Unify test and simulation approach to develop a harmonized refinement process

Leverage Siemens' vast engineering knowledge for optimizing and balancing conflicting requirements

Strike the right balance between detail and accuracy

Results

Balanced handling, NVH and ride comfort

Realized harmonized full-vehicle performance for multiple attributes

Developed an integrated approach for benchmarking, target setting, design and validation

Saved time and cost by shifting the workload emphasis to the early design stages

Siemens solutions enable Hyundai Motor Company to apply an integrated approach for benchmarking, target setting, design and validation

Balance is everything

In the engineering world, performance targets are often in conflict. For example, a lightweight design might offer the best results for fuel efficiency but could negatively impact other performance issues such as noise, vibration and harshness (NVH), handling and ride comfort. Multi-attribute balancing (MAB) is key to addressing complex engineering challenges and safeguarding the balance between design options and functional performance. Thanks to the continuous development of computer-aided engineering (CAE) and system simulation, manufacturers can predict the relative losses across a range of attributes such as NVH, fuel efficiency and

drivability. Balance is everything and MAB has changed the game.

The act of MAB enables the user to detect design or construction flaws early on, or even avoid them altogether. The time and cost savings during the development and manufacturing process are far-reaching. Yet, only a minority of original equipment manufacturers (OEMs) use MAB to its full potential.

Taehoon Lee, senior research engineer at Hyundai Motor Corporation, states, "Hyundai Motor Corporation has set a firm goal to create a culture of constantly evolving innovation. Our motto is, "New thinking in automobiles." Being true to this vision simply requires vigorous and continuous pursuit of the latest engineering technologies." Hyundai Motor Company has found a trusted partner in Simcenter™ Engineering, which is part of Xcelerator™ portfolio, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software.

Ride shake



2nd order booming



Impact



Operational measurements on roads.

“The experienced Simcenter engineers have always given us technical confidence and a fitting balance between detail and accuracy. In the past we have solved many of our problems with their help.”

Taehoon Lee
Senior Research Engineer
Hyundai Motor Company

Handling, NVH and ride comfort

In collaboration with Simcenter, the Hyundai Motor Company team used a methodology that goes beyond troubleshooting an NVH issue. It applied an integrated, comprehensive approach that included competition benchmarking, target setting, design and validation in order to balance handling and NVH along with ride comfort.

Although the project highlights NVH performance, it goes well beyond that scope. Initially, in an unreleased minibus variant, Hyundai Motor Company identified a constant vibration on the rear seats as well as at the driver’s foot location. From the outset, Hyundai Motor Company made it clear that resolving troubleshooting activity was to be part of a unified approach to develop a more harmonized refinement process to balance attributes like handling and NVH along with ride comfort.

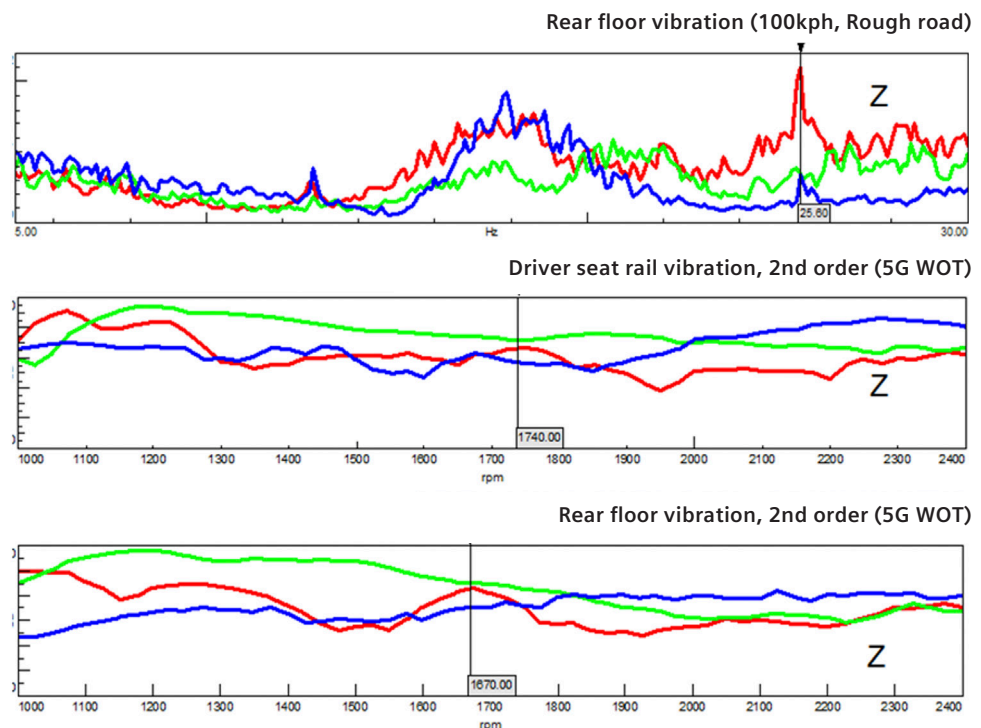
In order to do a proper balancing act subjectively and objectively, test and

simulation were simultaneously applied to identify the current design issues. Next, the result was validated against the best-in-class competition.

Convinced of this combined test and simulation approach, Lee and his team decided to step outside of their comfort zone. “We were mainly working with Simcenter Testlab, but more recently we are enriching our NVH business by combining test with Simcenter 3D and Simcenter Amesim software tools. This helps us to meet our engineering challenges by harmonizing full-vehicle level performance” says Lee.

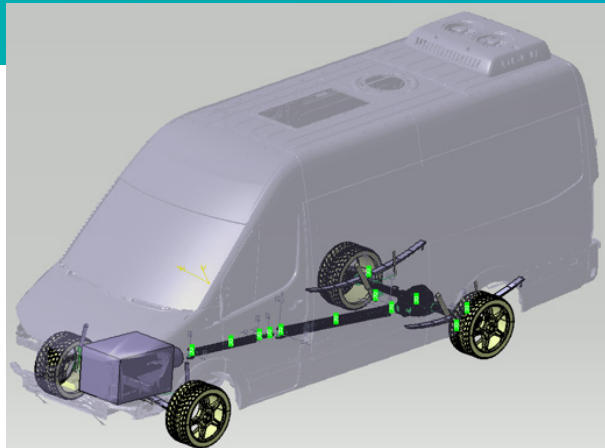
Target setting

Rigorous testing usually defines the beginning of a new test campaign, when benchmarking and target setting takes place. This was done by setting a Hyundai Motor Company prototype van nose-to-nose with competitor vehicles. Next, Simcenter Engineering experts identified the locations that generated the booming noise using the transfer path analysis (TPA)



Target settings (red: HMC van, blue: competitor 1, green: competitor 2).

method. This data enabled the engineers to define preliminary countermeasures. During the entire testing campaign, data for populating the future CAE vehicle model was being acquired with dedicated Simcenter SCADAS™ hardware. "I have been using Simcenter software and testing equipment for about 20 years. Simcenter Testlab is reliable and robust and much easier to use than our previous solution," says Lee.



Multibody model of Hyundai Motor Company van and DOE and optimization process.

Simulation phase

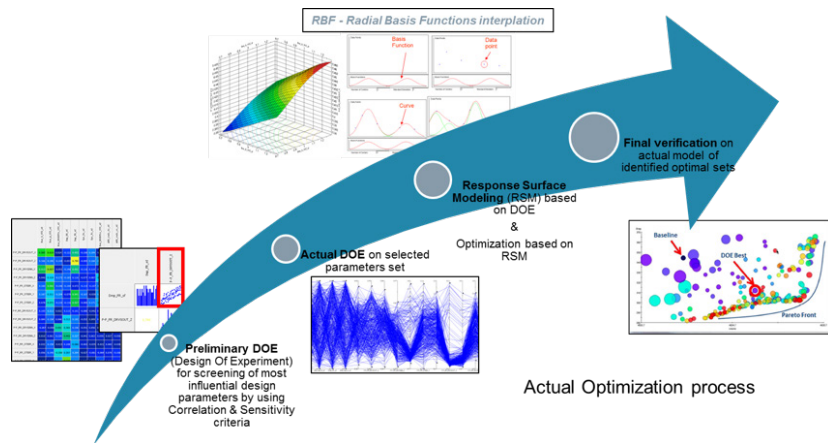
When using CAE, it is essential the vehicle model properly represents not only the dynamic properties of the various subsystems (for example, tires, suspensions, powertrain, etc.), but also the excitation inputs, such as road profile and engine internal loads. These critical data points are often unavailable as input data or take a great deal of effort to be measured.

In this project, dedicated and advanced reverse engineering CAE procedures were used to identify road profiles and engine internal loads to properly populate and excite the 3D vehicle model. In this way, better prediction levels could be reached by using data measured during the test campaign.

The main goals of the CAE phase were to:

- Build a validated multi-body model of an HMC van
- Replicate tested maneuvers and predict targets, such as acceleration
- Study countermeasures to improve wide open throttle and ride shake without affecting harshness

A preliminary and extensive design-of-experiment (DOE) study was performed to gain an understanding of which design parameters were the most influential. After this, an optimization process was run based on the response surface model to identify the best compromise for parameters configuration. Using the final optimal sets gained from these processes, the MAB process was performed and validated using 3D models.



“Siemens’ Simcenter solutions are considered the most reliable option on a global basis. Our commercial vehicle engineers are proud to use them.”

Taehoon Lee
Senior Research Engineer
Hyundai Motor Company

Results

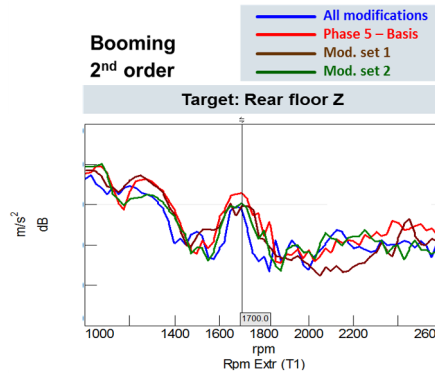
In the final stage of the project, the identified countermeasures at the suspension level were manufactured and tested by replacing the baseline measures. Three vehicle variants were set and their target acceleration compared. The team realized a final relevant improvement of up to -5 decibels (dB) for the most critical points.

This project proved that by leveraging the synergy of combining test and CAE, it is possible to more quickly and efficiently find successful countermeasures to the issues at hand.

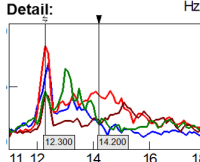
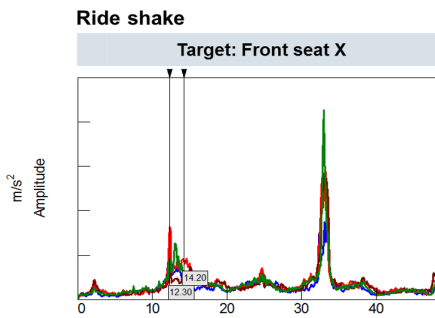
Rather than acting at the troubleshooting level, which is often too close to time-to-market, it is more efficient and convenient to front-load issues and improve the design of the chassis and body at an earlier stage in the vehicle development process. If structured chassis and body development involves CAE and test and is defined at an early stage, Hyundai Motor Company can optimize more kinds of performance, even those that may conflict.

Top of the V-cycle

Every OEM wants to avoid troubleshooting issues at the end the development process. That is why MAB is being considered at the top of the vehicle design cycle or the so-called V-cycle. System simulation allows Hyundai Motor Company to evaluate attributes such as NVH, ride comfort, fuel efficiency, thermal management and the impact of driveline controls side-by-side at the very first stages of development. Moreover, at every step of the decision-making process, attributes can be weighed against each other. As a result, manufacturers can minimize troubleshooting by constantly gauging and confirming the optimal set of parameters.



The "all modified" set gives the best improvement at the target peak, with an improvement of ~3-4 dB.



Clear improvement of main peak at 12.3 Hz (first wheel unbalance) and overall frequency range

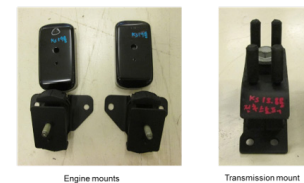
Chassis rear

Rear suspension parts modifications:



PT mounts

Powertrain mounts modifications:



Example of chassis and powertrain spare parts variants – Performance improvement confirmation test results.

“Hyundai Motor Company and Siemens will remain important partners for optimizing NVH in the future.”

Taehoon Lee
Senior Research Engineer
Hyundai Motor Company

Solutions/Services

Simcenter Engineering
[siemens.com/simcenter](https://www.siemens.com/simcenter)

Simcenter 3D
[siemens.com/simcenter3d](https://www.siemens.com/simcenter3d)

Simcenter Testlab
[siemens.com/simcentertestlab](https://www.siemens.com/simcentertestlab)

Simcenter SCADAS
[siemens.com/simcenterscadas](https://www.siemens.com/simcenterscadas)

Simcenter Amesim
[siemens.com/simcenter-amesim](https://www.siemens.com/simcenter-amesim)

Customer's primary business

Hyundai Motor Corporation is a global corporation that has created a value chain based on automobiles, steel and construction and includes logistics, finance, information technology (IT) and services. With about 250,000 employees worldwide, the company's automobile brands include Hyundai, Kia and Genesis. www.hyundaimotorgroup.com

Customer location

Seoul
South Korea

Taking the leap

Choosing to abandon a purely test-focused approach and combine it with CAE and systems simulation requires trust. Hyundai Motor Company is currently looking into system simulation, particularly Simcenter Amesim™ software, to keep better control of the time-to-market and reduce development cost.

Hyundai Motor Company never doubted the credentials of their partnership. "Siemens' Simcenter solutions are considered the most reliable option on a global

basis. Our commercial vehicle engineers are proud to use them," says Lee. "The experienced Simcenter engineers have always given us technical confidence and a fitting balance between detail and accuracy. In the past we have solved many of our problems with their help. We have established a mutual trust and global partnership in which we highly value the Siemens NVH technology, and in particular the Simcenter portfolio. Hyundai Motor Company and Siemens will remain important partners for optimizing NVH in the future."

"We have established mutual trust and a global partnership in which we highly value the Siemens NVH technology, and in particular the Simcenter portfolio."

Taehoon Lee
Senior Research Engineer
Hyundai Motor Company

Siemens Digital Industries Software

Americas +1 314 264 8499
Europe +44 (0) 1276 413200
Asia-Pacific +852 2230 3333

© 2020 Siemens. A list of relevant Siemens trademarks can be found [here](#). Other trademarks belong to their respective owners.
82180-C4 10/20 A

[siemens.com/software](https://www.siemens.com/software)