

# NVH SIMULATOR HELPS SUBARU FINE-TUNE SOUND PACKAGES

For Subaru, 2016 was its ninth consecutive year of sales increases in the US. It plans to continue its success by listening carefully to customers' needs and preferences, and it has gained valuable results from sound simulation tests.



## SUBARU



### CHALLENGE

- To better understand customers' sound expectations
- Improve NVH performance and character
- To evaluate sound and vibration in current and virtual vehicles

### SOLUTION

- In-depth studies of vehicles – with subjective and objective measurements
- Source path contribution (SPC) projects
- NVH simulations to create sound quality targets and identify users' preferences

### RESULTS

- Current sounds fine-tuned and different characteristics evaluated
- New virtual vehicles created to explore aggressive and sporty sounds
- Ideal engine characteristics determined

“IT’S REALLY A POWERFUL TOOL – AND THE FACT THAT IT IS INTEGRATED WITH THE UPSTREAM ENGINEERING AND DISCOVERY WORK IS FANTASTIC.”

*Katsuyoshi Tanaka, General Manager of the Engineering Department*

*Subaru Research and Development.*



## BACKGROUND

Subaru means “unite” and it refers to the six stars on the logo that stand for the six companies united under the Fuji Heavy Industries (FHI) group. The company started in 1917 in Japan as an aircraft research laboratory but soon began producing aeroplanes. After WWII, the company created a scooter with the spare parts from aeroplanes and eventually got involved in car making. The first Subaru car, the Subaru 1500, was created in 1954. In the 1990s, the company concentrated on rally cars, such as the Impreza WRX, winning the world championship several times.

Subaru is distinct from many of its Japanese competitors: it still makes almost 75% of its cars sold internationally in Japan. Its only

overseas manufacturing facility is in Indiana in the US, and Subaru is growing significant market share and customer loyalty in the North American market. Sales of the Outback model increased by 22.7% through the first three months of 2016, compared to the same period in 2015, and December 2016 represented the best month ever for Subaru of America, topping off the best year in the company’s history in terms of both sales and market share.

Subaru has been investigating the way its customers expect their cars to sound. Customers are increasingly concerned about acoustics and this is a major factor when developing new products. The relationship between sound quality metrics and human perception is not

fixed, and customer expectations can change over time.

Ryan Plum, Manager in the Body & Vehicle Evaluation Department at Subaru, says: “The US is our biggest market and we have indeed experienced a lot of growth here. We want to keep that momentum and keep in touch with our customers’ needs and preferences going forward.”

## CHALLENGE

To assist in creating comfortable vehicles, Subaru wanted to identify the sources of vibroacoustic emissions that drivers both hear and feel.

In addition, Subaru wanted to ensure it was



# “WE HAVE A LONG HISTORY OF TRUSTING BRÜEL & KJÆR’S MEASURING EQUIPMENT IN OUR TESTING.”

Ryan Plum

Manager, Body & Vehicle Evaluation, Subaru



continuing to deliver what customers want from their vehicles in terms of NVH performance and character. The company wanted to understand sound and vibration strengths and weaknesses – also in vehicles that are not built yet.

## SOLUTION

### Source path contribution (SPC) projects

At the Application Research Centre with Brüel & Kjær’s Global Engineering Services, Subaru conducted numerous in-depth studies of sound and vibration of both its competitors’ and its own vehicles – with both subjective and objective measurements.

In 2016, to understand how vibrations develop from the source into effects, a road

noise SPC project was conducted. This enabled Subaru to gain insights into the origins of sound and trace them back to the root cause, such as a specific engine mount.

Tests were done on a Subaru prototype vehicle, under several different operating conditions. A test-based SPC model was built to predict the noise contributions from different sources and to identify the dominant sources and paths affecting these contributions.

### North American jury study

To ensure that the Subaru prototype met North American customers’ expectations, another project was developed to create sound quality targets and a subjective jury evaluation using the Brüel & Kjær NVH Simulator was carried out.

The simulator rapidly enables the identification of the desired sound quality by letting users hear alternative sound packages, which can be modified in real-time. It provides a focal point where all the latest data can be assessed for the impact on sound, by experts and non-experts alike.

The jury test included five vehicles with different sound characteristics (three measured vehicles, and two digitally modified vehicles) and was developed to determine customer preferences for the different engine sounds. Users experienced and evaluated the sounds and vibrations of real and virtual vehicles while ‘driving’ through virtual scenarios. The simulator responds to the driver’s input, reproducing the correct sound and vibration for the vehicle parameters, in conjunction with a representative visual scenario.

## RESULTS

The SPC analysis identified structure-borne/airborne and front versus rear contributions and the results were analysed to determine the dominant sources and paths that contribute to the receiver’s experience.

“We’ve been able to find and attack unwanted NVH characteristics from a very detailed and specific methodology. The SPC testing has been effective in both issue discovery and modelling of the subject car, moving into different techniques and strategies to attenuate any issues,” explains Ryan Plum.

Using the NVH Simulator, Subaru made some very interesting and useful discoveries about how sound volume, character, and response expectations are quite different for customers driving its traditional sedans, wagons and SUVs compared to customers of its sporty models – even in some cases where the same people own both cars.

“In a neutral, relaxing and even fun environment, the results from our customer clinics using the NVH Simulator have helped us learn the likes and dislikes of customers in a way that is easy for everyone to understand – from

the specific NVH engineers in the company to executives,” explains Ryan Plum.

“We’ve been able to fine-tune our current sounds to try different things and also create completely new ‘virtual vehicles’ to explore how far we can push things in terms of aggressive or sporty sounds that customers want in their daily driven vehicle. In some cases, we’ve also received really strong feedback about what our customers do not want.”

## CONCLUSION

Subaru is using the results from the various studies to identify and tackle unwanted NVH characteristics and to decide which sound and design technologies to use – and which are not cost-effective, considering customers’ needs within different segments.

The NVH Simulator is an effective way of capturing non-expert, subjective opinions in a real-life context, and it enables converting

these opinions into clear engineering goals. The NVH Simulator has helped Subaru’s team to accurately recreate the noise and vibration of their vehicles in an interactive environment. “It’s really a powerful tool – and the fact that it is integrated with the upstream engineering and discovery work is fantastic,” says Katsuyoshi Tanaka, General Manager of the Engineering Department at Subaru Research and Development.

Subaru is in no doubt about the value of the sound and vibration tests, and it plans to continue to pursue the collaboration with Brüel & Kjær. “We continue to use these studies to help us determine the ideal engine characteristics for a segment. It can save us a lot of time and money and also help to avoid a complete ‘miss’ when designing or tuning a vehicle’s sound package,” concludes Ryan Plum.

“THE NVH SIMULATOR HAS HELPED US LEARN THE LIKES AND DISLIKES OF CUSTOMERS IN A WAY THAT IS EASY FOR EVERYONE TO UNDERSTAND – FROM THE SPECIFIC NVH ENGINEERS IN THE COMPANY TO EXECUTIVES.”

*Katsuyoshi Tanaka, General Manager of the Engineering Department  
Subaru Research and Development.*



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