Perspectives and Current Developments for NVH Data Acquisition and Analysis

Josef Hobelsberger, Müller-BBM VibroAkustik Systeme GmbH, JHobelsberger@MuellerBBM-vas.de

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ABSTRACT

New analysis methods complement classical approaches in the vehicle NVH development by reducing and accelerating iteration steps to obtain a target sound. Therefore, tools are required that allow an integrative approach of sound engineering and structural analysis and enable a precise simulation and modification based on measured data. The Response Modification Analysis (RMA) is such a hybrid solution, which provides indications of relevant transfer paths taking into account the sensitivity of response channels to modifications of reference channels.

1. Introduction

Increasing demands for the vehicle design and engineering process in combination with demands for noise and comfort of many vehicle models in parallel need very efficient development processes, tools and cycles. As new vehicle variations come faster to the market, the development cycles turn shorter and shorter. At the same time automotive OEMs are focusing on cost efficiency during the vehicle development. Therefore the demand for simulation grows, as well as needs for more testing and quality assurance of simulation results. To manage the increasing amount of testing, manufacturers try to integrate the different components (e.g. whole vehicle, power train, chassis …) in a global NVH development approach.

An early integration of sound quality targets becomes more important in the vehicle development process. To achieve these targets engineers use traditional established methods as well as new approaches. In most cases standard analyses are applied for mobile troubleshooting for the basic evaluation of the test candidate's behavior. Psychoacoustic parameters are influencing and supporting the iteration loops to obtain the target sound. The subjective perception of the emitted sound is approved by hearing comparison and jury validation tools.

At the same time structural analysis indicates sources and paths of dedicated airborne and structure-borne contributions. A useful and more accurate method to determine sources and paths is the (Operational) Transfer Path Analysis. To balance both sound engineering and structural analysis a tool is required which integrates sound design approaches into Transfer Path Analysis.

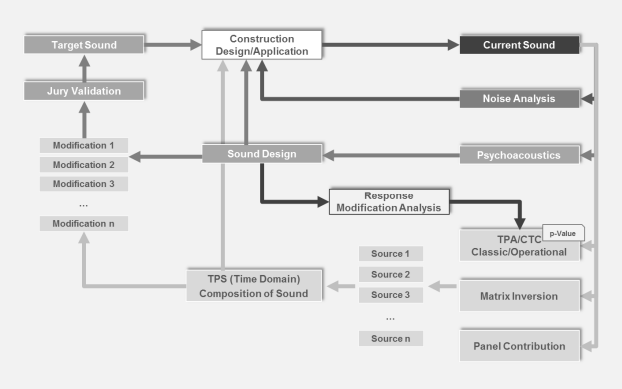

Fig 1: NVH Development Cycle

2. Response Modification Analysis (RMA)

The purpose of a Transfer Path Analysis (TPA) is to identify sources and critical sound and vibration paths contributing significantly to the interested response signal (e.g. sound at driver's ear).

Over the last years, the method of Operational Transfer Path Analysis (OTPA) [1], [2], [3] has been proved to be a fast and efficient method to identify those path contributions on vehicles.

Based on the results of an OTPA, measures should be derived to optimize the response signal. Currently known methods of OTPA determine only dominant sources and paths. The optimization of single dedicated paths usually influences the entire system, making it difficult to predict the impact of local changes to the result.

For more efficient engineering on the targeted sound of a vehicle the Response Modification Analysis (RMA) has been introduced, merging OTPA with sound design.

Instead of simulating the effect of a modified transfer path on the response signal (bottom up approach), the RMA allows a virtual modification of the response signal analyzing the sensitivity of the transfer paths to this modification (top down approach).

RMA completes OTPA used to determine linear transfer functions {H} between simultaneously measured references (sources) {X} and responses {Y}. The relationship between these signals is represented as

$$\{H\} = \{X\}^{-1} \cdot \{Y\} \quad (1)$$

With a local modification of the system responses {Y'} using RMA (e.g. local damping of the amplitude curve), a modified data set of transfer functions {H'} is generated.

$$\{H'\} = \{X\}^{-1} \cdot \{Y'\} \quad (2)$$

From the differences between the original and the modified data set of transfer functions, those sources or paths with the highest impact on the modifications and the targeted sound will be identified. Knowing the structural behavior and the influence of a targeted modification on the entire system, a systematic modification of physical transfer paths is possible with less steps of iteration.

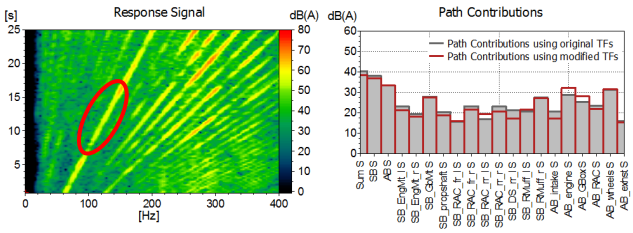

Fig 2: Response signal with local virtual modification (left diagram), sound pressure path contributions on the driver's ear response position with and without local modifications (right diagram)

3. Open Loop Testing

To carry out precise measures using RMA, it is recommended to acquire data during operating conditions, thus representing the real behavior of the test candidate under typical driving conditions. At an early stage of the vehicle development process, the traditional NVH methods are mainly used for analyzing individual components whereas RMA is focusing on an integral NVH solution which benefits from a new open loop testing approach.

With open loop testing all important signals and parameters will be acquired with a versatile dynamic data acquisition system. Users acquire mono and binaural acoustic signals in conjunction with structural signals (e.g. accelerations, strain gauges …), digital parameters (CAN-Bus, FlexRay™, EtherCAT®) and environmental parameters (e.g. temperature, combustion indices …). With an early involvement in the NVH testing and the global physical description of the test candidate, it becomes more transparent for users in evaluating measures related to causes and effects. Comprehensive fingerprints of the vehicle can be considered without specific modifications.

Based on the acquired data, a comprehensive analysis with respect to sound engineering using psychoacoustic parameters and structural analysis is possible. Through the basic knowledge of the vehicle behavior further modification processes can be performed using RMA as a hybrid solution for simulation and testing, thus reducing the need for mechanical modifications.

4. Summary

Due to the constantly increasing demands of vehicle design and development, flexible tools are required which allow reducing and/or optimizing the sound and vibrations at the sources or via the transfer paths. By the influence of component properties at an early state in the development cycle, the vehicle can be optimized with respect to acoustic and vibration. For this, a holistic view of the interactions is necessary. Open loop testing with time-synchronous data acquisition of different data sources together with RMA forms the basis for this efficient development process:

- Earlier testing
- Less testing and shorter testing times
- Hybrid NVH tools for improvements.

References

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