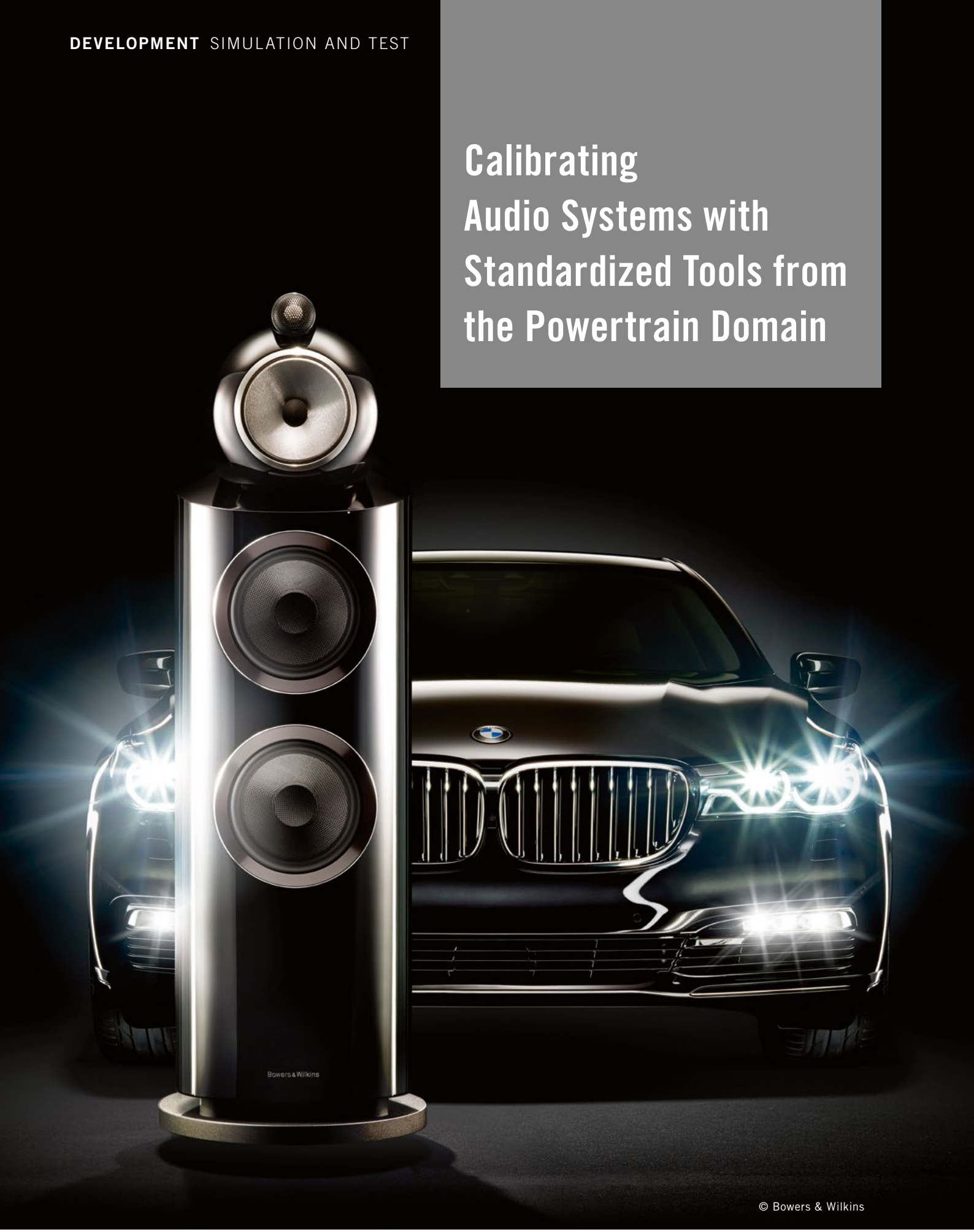
Calibrating Audio Systems with Standardized Tools from the Powertrain Domain



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Audio systems have to be individually calibrated for each vehicle model to ensure perfect audio experience for all passengers. To calibrate audio ECUs, a heterogeneous development environment with a variety of tools and programs is used. BMW is taking a new approach by combining Etas Inca with the XCP communication protocol to form the core of a standardized workflow.

INDIVIDUAL ADJUSTMENT

Perfect sound is one of the elements that makes premium car models so luxurious. To ensure the best possible audio experience for all of a car's occupants, development teams custom-fit digital amplifiers to match the cabin features of each model. As well as taking into account the type of vehicle, they also consider the number, position, and performance of the speakers – and the parameters for coupés, SUVs, and station wagons often differ to a significant degree. At the same time, safety considerations always take a front seat.

For example, drivers must still be able to hear the sound of the indicators and assistance systems even when listening to loud music. The sounds must remain audible, yet not startle the driver – for example, by interrupting gentle music with a much louder traffic update. To get the right balance, ECUs automatically control the audio system's volume based on the urgency of the various notification tones.

AS COMPLEX AS THE POWERTRAIN

Engineers have to choose from tens of thousands of parameters to calibrate modern infotainment ECUs. Yet although the complexity of the task is comparable to the parameterization of powertrain ECUs, no standardized processes or tools previously existed in the realm of audio engineering. Calibration engineers had to rely on heterogeneous toolchains with proprietary data formats and communication protocols. They also lacked any formal data description solutions along the lines of Asam MCD-2 MC language (a2l). This kind of file format – in which all the parameters and measured values are formalized and defined in a tool-independent environment – greatly facilitates the administration of large quantities of measurement and calibration data and benefits calibration engineers by providing fast access to this data. Previously, however, the lack of this formal data description made sound system calibration into an unnecessarily complex and arduous task. The use of heterogeneous toolchains also has the disadvantage of requiring a high degree of experience and individual expertise, which has also proved to be a stumbling block in the efficiency of the development process.

To tackle this challenge, the BMW Group joined forces with Etas to establish a new basis for sound system calibration. The goal was to establish a lean, standardized solution to replace the various proprietary measurement and calibration tools from different audio systems and ECU manufacturers. The partners struck out on an unconventional path, adapting Etas' established Inca solution for powertrains to the infotainment calibration procedures. This approach had the key advantage of being an established solution at OEMs and key suppliers. At the same time, however, there are significant differences in the procedures used to configure powertrain and infotainment systems.

STANDARDIZATION GUARANTEES MORE EFFICIENT PROCESSES

In order to properly address these differences right from the start, the project partners completely redesigned the Inca-based workflow for audio system calibration. Unlike powertrains, the data volumes in audio systems are very large – so this called for a correspondingly powerful system architecture. Multi-core processors with Linux operating systems are therefore standard in the audio environment, together with the use of high-capacity Ethernet buses. This is a key prerequisite for making rapid changes to calibration variables even when they involve thousands of parameters – for example, when modifying the parameters of complex filter banks. This more powerful system architecture makes it possible to output several hundred measure variables in "static lists" within a matter of milliseconds. Unlike powertrains, audio systems tend to feature very large numbers of calibration variables, but relatively few measure variables.

Integration of the Inca tool chain into this system architecture was a logical step, because future factors such as highly complex development tasks in the field of autonomous driving will continue to stimulate the increasing use of Ethernet bus systems and powerful multi-core processors. A key element of this new approach is the Universal Measurement

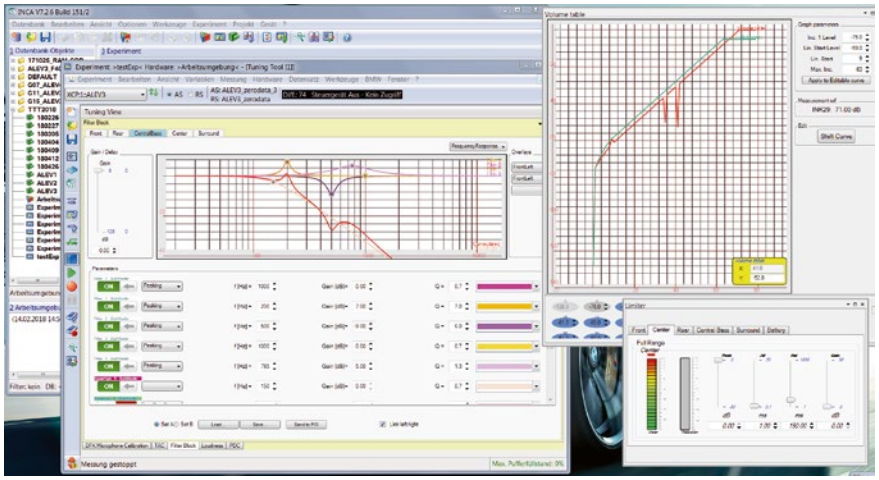

FIGURE 1 Plug-in for setting acoustic filter curves (© BMW)

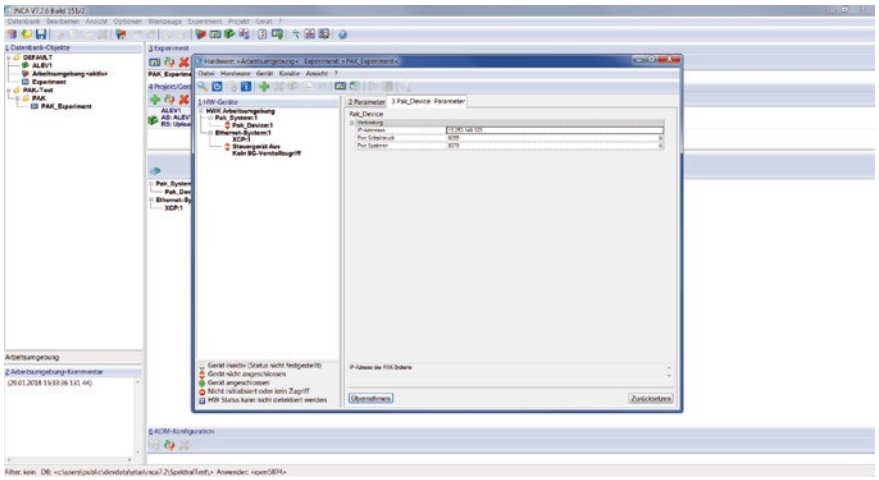

FIGURE 2 A third party PAK acoustic measurement system configured via Inca (© BMW)

and Calibration Protocol (XCP) – a communication protocol standardized by the Association of Automation and Measuring Systems (Asam) that is now also being deployed for the efficient parameterization of audio systems. Thanks to its clearly separated command and transport layers, the XCP can be used not just for CAN and FlexRay buses in powertrains, but also for USB or Ethernet data buses in audio systems. By integrating an XCP driver into the Linux operating system, the project team managed to achieve the necessary XCP connection via Ethernet.

REPLACEMENT OF NEARLY A DOZEN TOOLS

Etas' consistent efforts to standardize its tools paved the way for the use of Inca in audio systems. Implementing XCP in Inca according to specifications was key to helping ensure a smooth flow of data traffic. However, capturing and visually processing the audio measurement data in Inca was somewhat more complex. Measuring instruments for powertrain systems from the Etas ES series and the oscilloscopes used for drive applications proved unsuitable for the task. Instead, measuring and visualization solutions for acoustic design were called for here – for example, to set frequencies and to manipulate filters. Both partners therefore set to work to develop corresponding plug-ins for measurements and adjustments using Etas' instrumentation kit for Inca, **FIGURE 1**.

To facilitate the integration of third-party acoustic measuring instruments, the project team developed the Etas Hardware Integration Development Kit, a driver that provides third-party tools with the typical properties of measuring instruments that are commonly used in Inca/XCP environments, thereby enabling their seamless configuration and use in Inca, **FIGURE 2**. Audio calibration engineers can thus continue to use their habitual third-party acoustic measuring systems, displaying and further processing the measured data from these systems directly in Inca, **FIGURE 3**. Time-tested hardware is therefore still usable in the new workflow.

Once the prerequisites were established, a typical Inca workflow could be introduced. Inca-Flow helps expedite the process of scripting recurring measurement and adjustment tasks. In addition, BMW is already experimenting with virtualization – for example, by bypassing audio signals and quickly test new sound algorithms on the PC. It is precisely such virtualization that could raise development of sound systems to a new level of efficiency, making it an important tool for tackling increasing complexity in the years ahead.

SUMMARY AND OUTLOOK

Before making the switch to a standardized tool chain with Inca and XCP, there

FIGURE 3 Display of the acoustic spectrum; the measurement data was recorded with a third-party acoustic measurement system (© BMW)

was almost a dozen icons from different software tool providers to see on the desktop screens of BMW's sound engineers. Developers needed to know how to handle numerous proprietary standalone solutions in order to calibrate infotainment ECUs. This situation gave way to a completely new, standardized workflow with Etas Inca at its core. With only minor adjustments, this widely used platform in the automotive industry offers calibration engineers a development method to more quickly achieve optimum sound in every new vehicle model. What started out as a rather unconventional approach of using Inca in the audio workflow has thus yielded a robust solution for the future. Its use noticeably simplifies and expedites the development process in the infotainment sector.

In order to exploit the toolchain's full potential, it will be now enhanced with additional functions. It is already clear that the audio design for electric and hybrid vehicles will soon pose a whole new set of challenges for audio specialists.