

Vehicle Sound Engineering: Innovations and Transformations

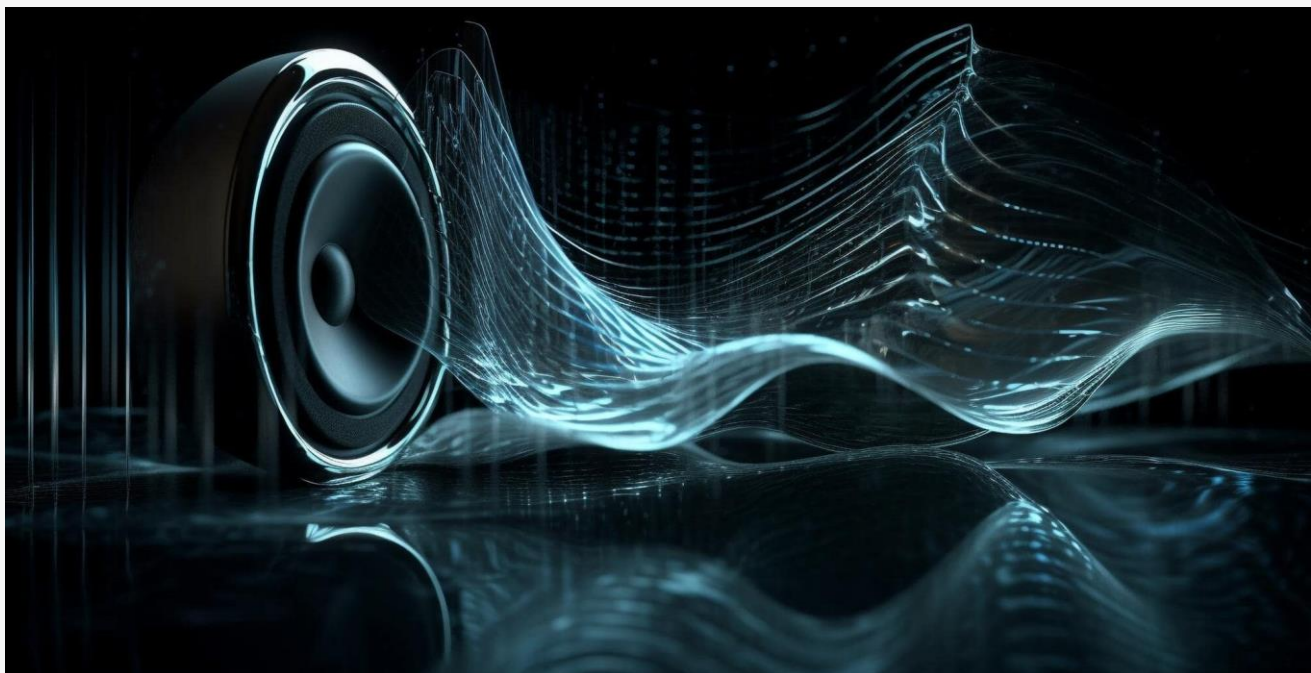


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In the quest to redefine the auditory experience of automobiles, automakers are pushing the boundaries to engineer the perfect sound environment both inside and outside their vehicles.



Collaboration between the business world and academia has given rise to a groundbreaking simulator designed to analyze, replicate, and fine-tune the sounds emitted by motor vehicles. Dr. Paul Jennings, affiliated with WMG at the University of Warwick, Dr. Garry Dunne from Jaguar and Land Rover, and Roger Williams of Sound Evaluations, are at the forefront of this innovative venture, dedicated to curating car sounds that align with their respective brands' identities. It's a well-known fact that every sound, from the reassuring thud of a door closing to the gentle hum of a motor or the vigorous growl of an engine, wields a profound influence on a potential car owner's choice. In essence, sound has the potential to be the ultimate deciding factor when selecting a vehicle.

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In recent years, a notable trend has been the overall reduction in vehicle noise levels. Automotive engineers and designers have invested considerable effort in eliminating excess noise from vehicles. This has been achieved through quieter engines, enhanced manufacturing processes, streamlined aerodynamic designs, and advancements in tire technology. Yet, when most drivers step on the gas pedal, they don't crave silence; they yearn for a sense of power, sportiness, luxury, or refinement.

For sound engineers, the challenge lies in capturing these subjective desires of customers and translating them into audible signatures for new vehicles. This entails infusing character into the vehicle's noise profile while preserving the perception of quality and solidity.

The Sonic Range

Creating desired auditory profiles for vehicles often involves manipulating or blending existing sounds or utilizing sophisticated engineering simulation tools. Numerous factors, including cost, weight, ride quality, handling, aesthetics, and manufacturability, exert constraints on the development of vehicle sounds. During the vehicle development process, continuous monitoring and fine-tuning are essential to attain the desired acoustic outcomes.

The intended sounds for new vehicles must be rigorously assessed and benchmarked against existing sounds and those of competitors. Valuable input from both customers and experts in Noise, Vibration, and Harshness (NVH) is crucial to comprehensively consider and evaluate all viable options.

A Novel Approach

Historically, traditional on-road testing served as a method for evaluating vehicle sounds, with inputs from NVH experts and customers. However, this method often struggled to maintain consistency and repeatability, and it was impossible to assess the sounds of vehicles that hadn't been built yet!

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In recent years, a collaborative team has been addressing this multifaceted challenge, drawing upon their collective expertise in sound engineering, computer-based modeling, artificial intelligence, product development, vehicle manufacturing, psychology, and marketing.

The initial research focused on developing effective jury evaluation techniques within a controlled listening environment (Figure 2). This setting facilitated direct comparisons and improved consistency and repeatability. These techniques, adapted from psychology and consumer industries, encompass paired comparisons and semantic differential approaches. Besides successfully customizing these approaches for automotive sound quality assessments, they also led to the implementation of a new target-setting process at Jaguar Cars.

Sound Perception Matters



The research yielded valuable insights into the subjective evaluation of vehicle sounds. For instance, it was discovered that when evaluating wide-open throttle acceleration sounds in second gear, assessors' subjective impressions could be categorized into two independent qualities: perceived power and refinement.

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This enabled different vehicles to be plotted in a two-dimensional target space, as depicted in Figure 3. Interestingly, vehicles from the same brand tended to cluster together. Consequently, manufacturers can now set targets for future vehicle sounds relative to their current models and competitors.

While these techniques have proven effective in linking engineering data to subjective evaluations, they do have limitations. Sound assessments should ideally occur during actual driving, amidst various stimuli that significantly influence sound perception. Moreover, evaluating a fixed, pre-prepared sound under repeatable conditions, such as second gear wide-open throttle, may not accurately reflect a typical on-road experience.

Calling the Experts

In the realm of vehicle sound design, automakers are laboring to create distinctive and brand-specific auditory environments. Whether it's a warning chime designed to capture the driver's attention or synthesized audio intended to give electric vehicles an acceleration note reminiscent of a traditional engine, automakers are leaving no stone unturned.

For instance, Lincoln collaborated with the Detroit Symphony Orchestra (DSO) to compose and record the informative chimes in its models. This innovative approach aimed to create a more inviting and human-centered cabin experience. Surprisingly, DSO members, armed with string and percussion instruments, generated over 100 audio options for Lincoln, far exceeding the actual requirements.

Similarly, BMW engaged the talents of Hans Zimmer, an Academy Award-winning composer, to collaborate with Renzo Vitale, BMW's creative director of sound, in crafting a unique acceleration sound for its electric vehicles. BMW sought a cinematic acceleration sound that could accentuate the emotional bond between driver and machine. Just as a movie's score heightens the emotion of a scene, Zimmer's acceleration sounds aim to intensify the sensation of speed that electric vehicles often fail to convey due to their near-silent drive motors.

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Sounds of Silence

In the realm of creating a tranquil driving environment, it's not just the pleasant sounds that matter; it's also about minimizing unwanted noises. These intrusions include motor whines, tire hums, and wind whistles. In every vehicle assessment, we meticulously measure sound pressure levels at the driver's ear during idle, wide-open throttle (WOT), and a steady 70-mph cruise. This comprehensive approach ensures that the auditory experience within the cabin is as serene as possible.

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