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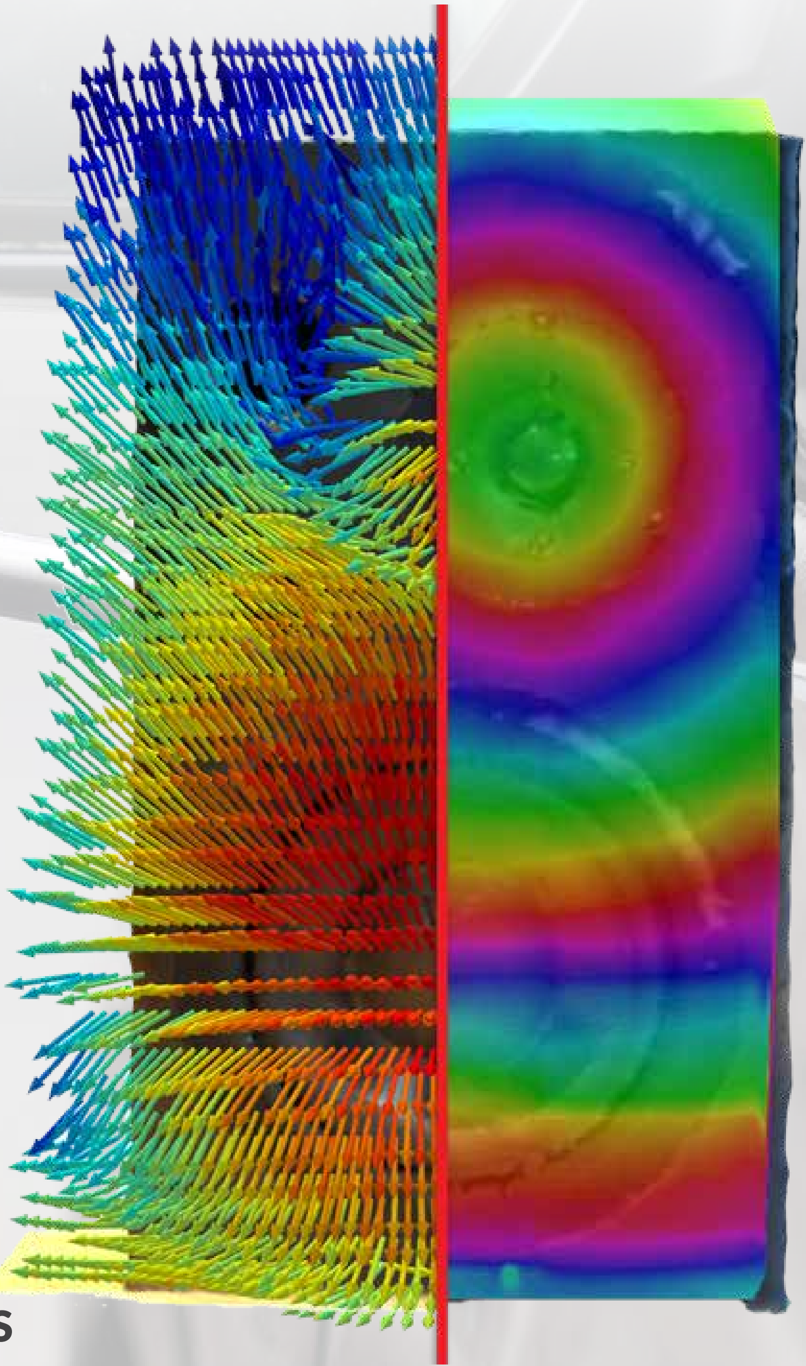

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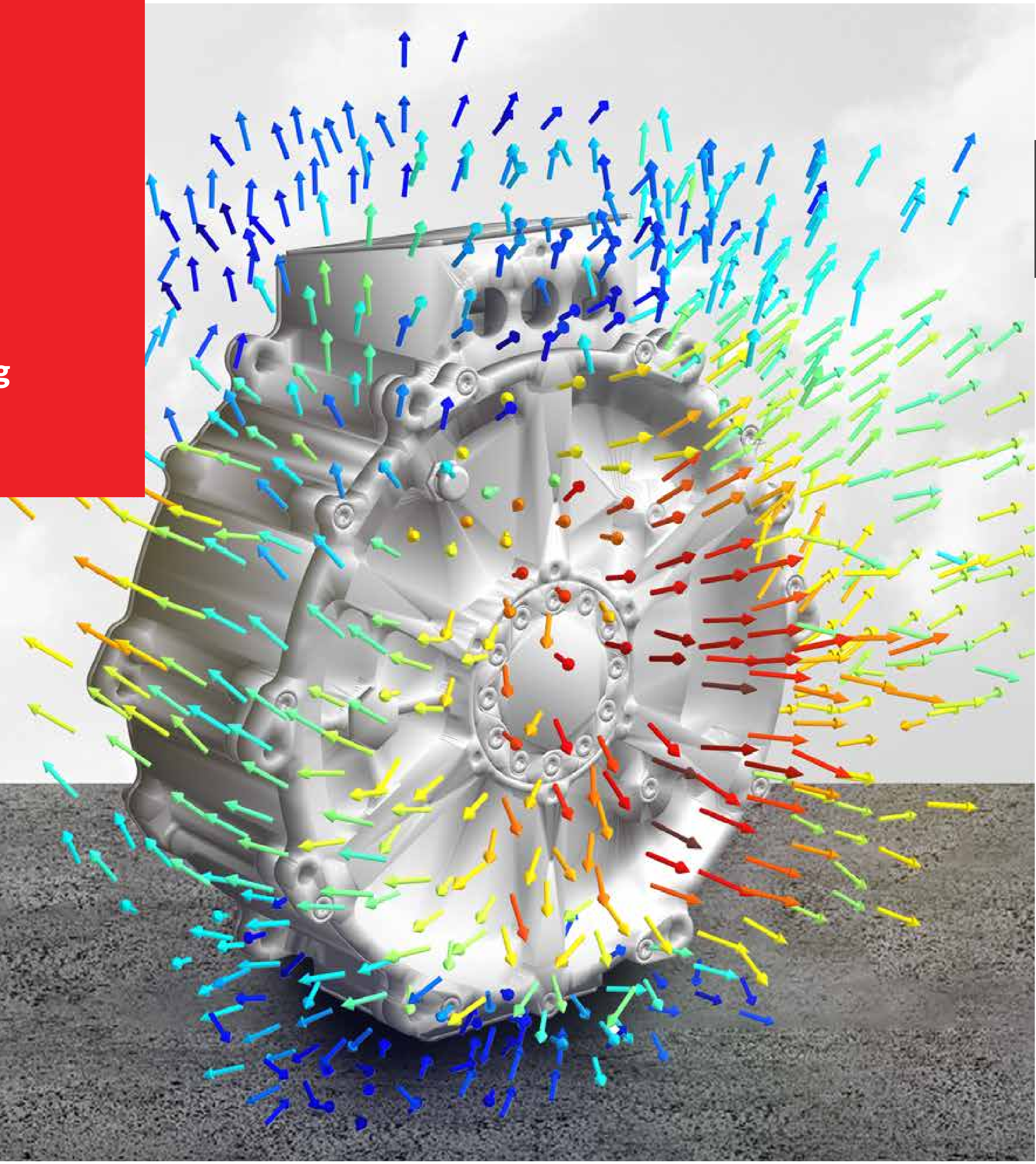

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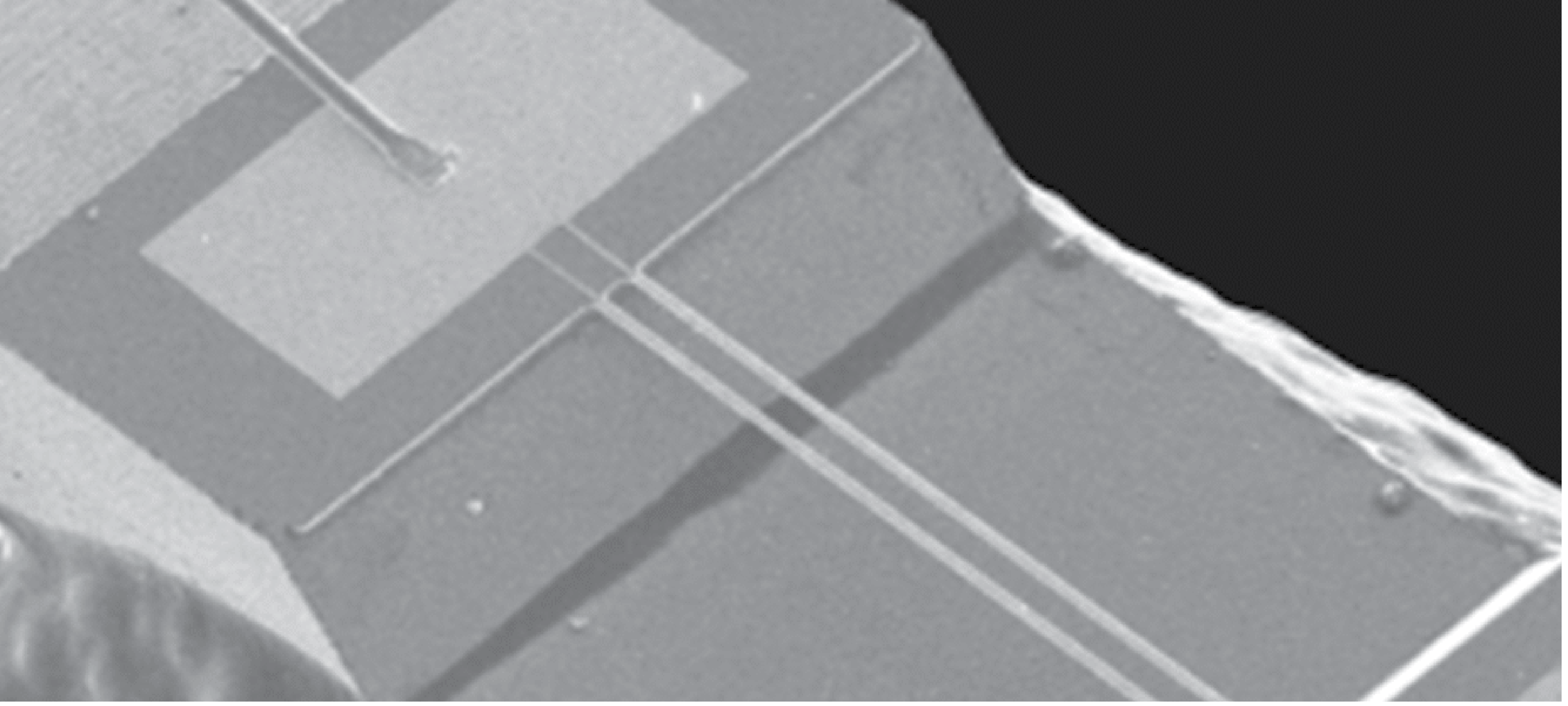
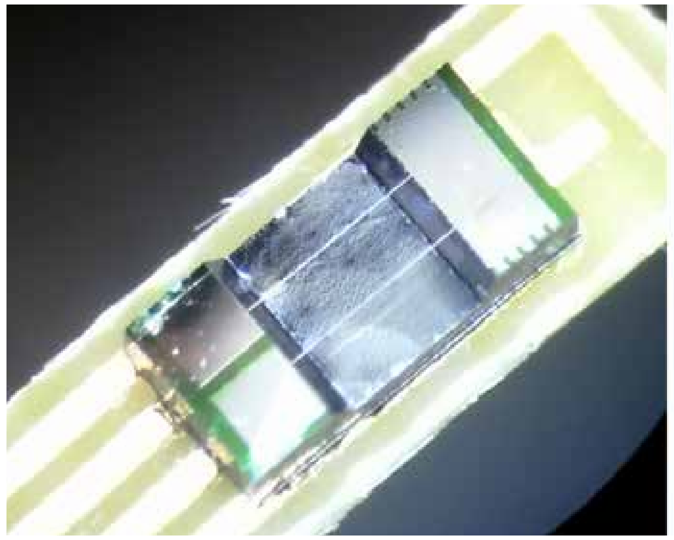


WHY PARTICLE VELOCITY?

Expanding experimental acoustic testing

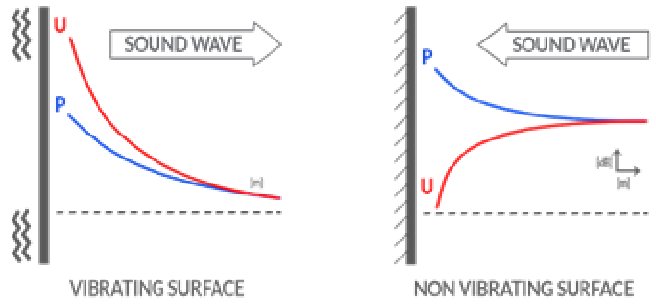
Acoustic measurement has long been centered around sound pressure. Microphones measure pressure variations, standards are formulated in terms of pressure levels, and specifications are commonly expressed in decibels referenced to pressure. Sound pressure is practical and well understood. However, from a physical point of view, a sound field is not defined by pressure alone.

A propagating sound wave consists of two coupled quantities: sound pressure and particle velocity. Sound pressure represents the local compression and rarefaction of the medium, while particle velocity describes the oscillatory motion of the air particles themselves. Pressure is a scalar quantity; particle velocity is a vector quantity. Together they form the complete description of an acoustic field.

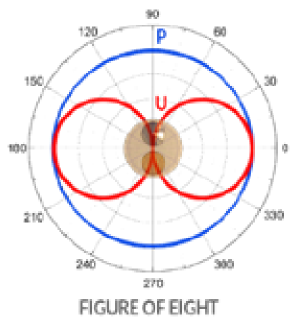


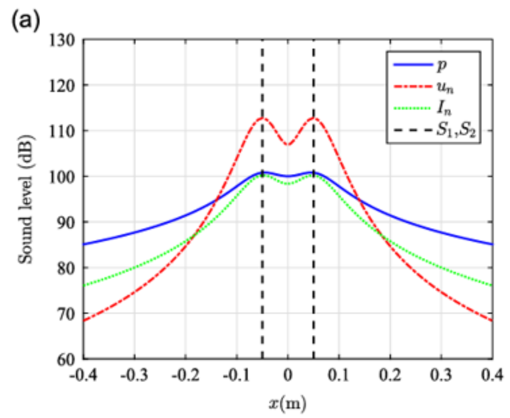
In ideal free-field conditions, pressure and particle velocity are proportional and in phase. Under these circumstances, measuring pressure often provides a sufficiently accurate representation of the field. In most "real world" environments, however, boundary conditions, the presence of multiple sources, sound scattering and reflections affect this relationship. For example, close to vibrating surfaces, particle velocity is directly related to the structural motion, while pressure may already be influenced by reflections and interference effects.

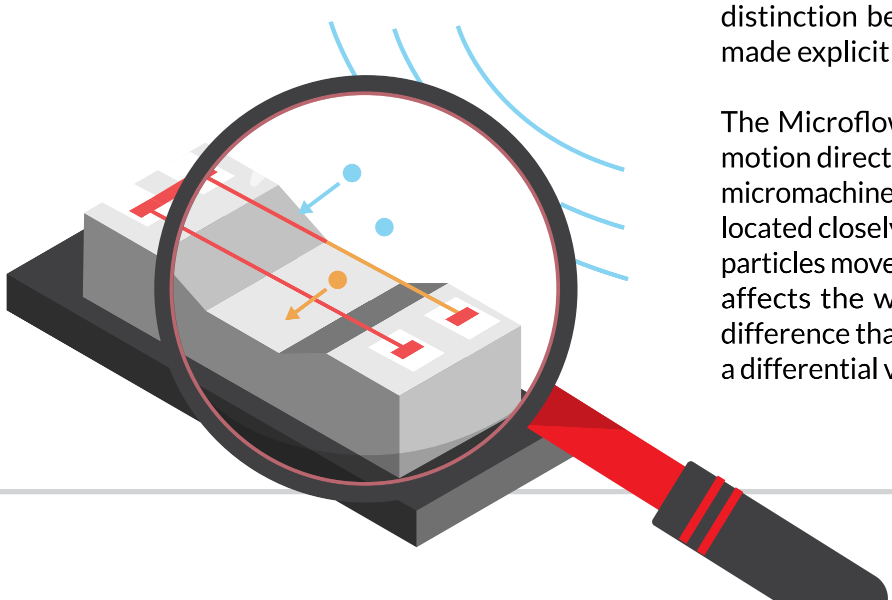
Near rigid, non-vibrating surfaces the opposite occurs: particle velocity approaches zero due to the boundary constraint, while pressure increases as incident and reflected waves superimpose. In such regions, high pressure does not necessarily correspond to strong acoustic radiation, but rather to a local amplification of the background noise



*"**Pressure** reacts to the room. **Particle velocity** reacts to motion."*







These spatial variations highlight an important distinction. Pressure reacts to the acoustic environment as well as to the source, whereas particle velocity is mainly linked to motion. Measuring particle velocity therefore provides additional insight, particularly in the very near field of vibrating structures or in environments where reflections are present. The ability to distinguish between motion-related effects and purely reflective pressure build-up is key to identify effectively the main sound radiating sources.

Because particle velocity is a vector quantity by nature, its measurement inherently contains information about the direction of sound propagation. A particle velocity sensor exhibits a frequency-independent figure-of-eight response, measuring excitation along its sensitive axis and rejecting motion perpendicular to it. In diffuse sound fields this directional characteristic reduces the contribution of the surrounding sources compared to an omnidirectional pressure microphone. This behavior is not imposed electronically; it follows directly from the physics of measuring a vector quantity.

Measurements based on particle velocity can achieve a spatial resolution that is roughly twice as high as that obtained using sound pressure alone. As a result, methods that incorporate particle velocity are able to resolve finer spatial details in the acoustic field, providing more precise localization and characterization compared to approaches that rely solely on sound pressure measurements.

When sound pressure and particle velocity are measured simultaneously at the same location, acoustic intensity can be determined directly. Acoustic intensity is defined as the time-averaged product of pressure and particle velocity and represents the rate of energy flow through a surface. In propagating fields, pressure and velocity share a similar phase as energy is mainly transported outward. In partially standing or reactive fields, the phase relation between pressure and velocity changes and the net energy transport may be reduced even when pressure levels remain high. Observing both quantities allows the distinction between stored and radiated energy to be made explicitly.

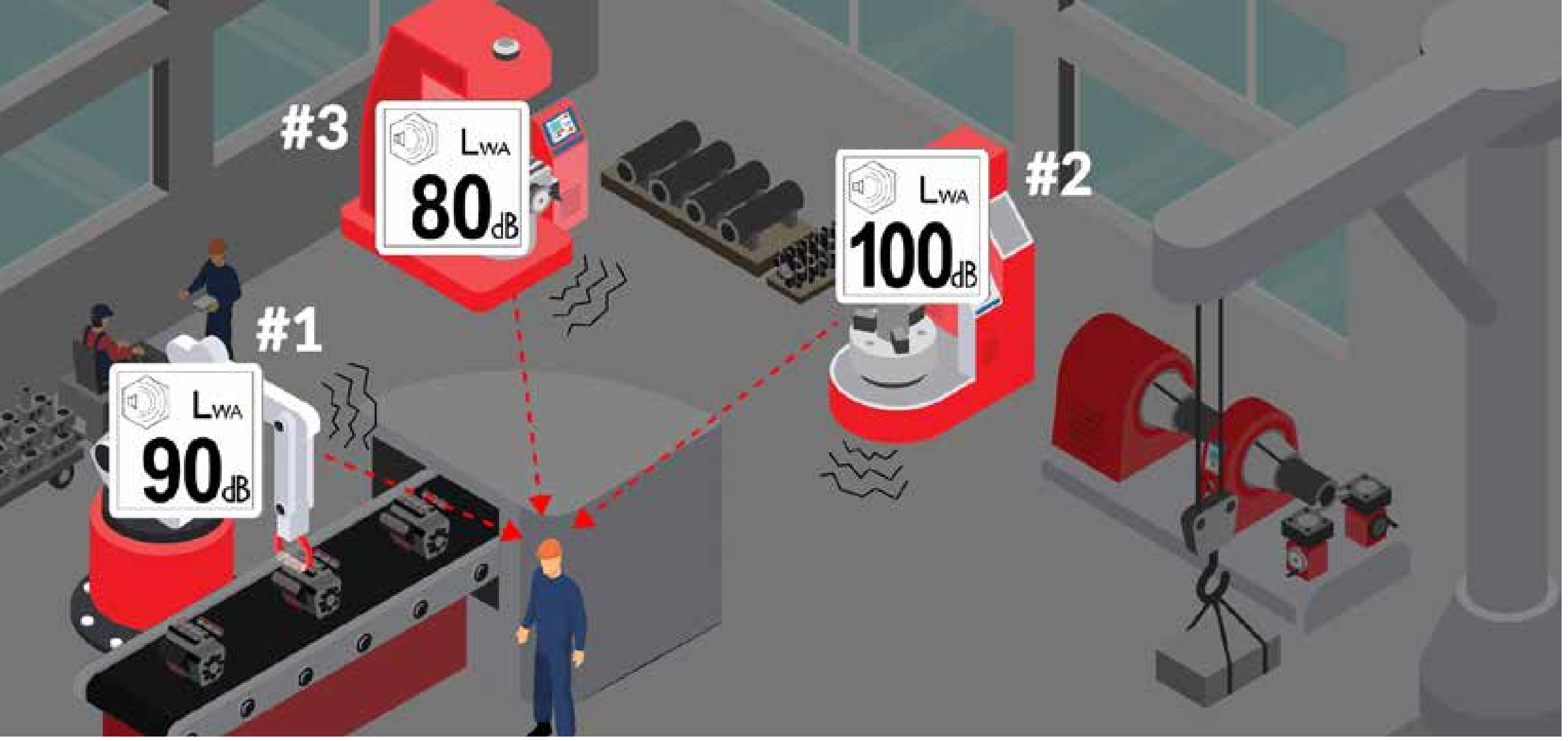
The Microflown particle velocity sensor measures this motion directly using a thermal operating principle. Two micromachined platinum wires are electrically heated and located closely together, just few microns away. When air particles move due to an acoustic wave, convective cooling affects the wires differently, creating a temperature difference that changes the wire's resistance resulting in a differential voltage proportional to the particle velocity.

The sensing element contains no conventional diaphragm and relies on heat transfer rather than mechanical displacement. Its compact size and intrinsic directionality make it suitable for combination with a pressure microphone in a single probe configuration,enabling the direct determination of broadband acoustic intensity.

In controlled laboratory environments, pressure-based measurements remain effective and standardized. As measurement conditions move closer to real operating environments, the acoustic field becomes more complex and the influence of the source surroundings becomes critical. In such situations, access to particle velocity alongside pressure provides a more complete representation of the sound field. Rather than replacing pressure measurement, particle velocity sensing complements it by capturing the vector component that is fundamental to acoustic theory.

Sound consists of compression and motion. Measuring both quantities aligns the measurement practice with the underlying physics and enhances the understanding of how energy is generated, transported, and radiated in practical applications.

*"The ability to distinguish between motion related effects and purely **reflective pressure build-up is key** to identify effectively the main sound radiating sources"*



UNDERSTANDING AIRBORNE TRANSFER PATH ANALYSIS

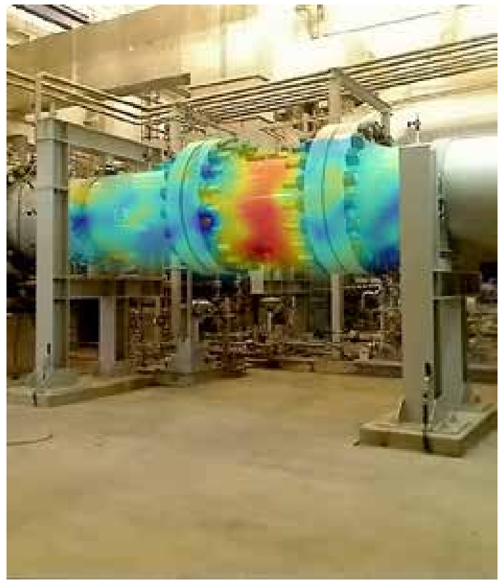
Effective Use, Limitations and Common Misconceptions

In many industrial environments, the key acoustic question is not simply "Where is the noise coming from?" but rather "Which sources are most relevant at my location?". That receiver position may represent the ear position of a driver in a vehicle, a passenger seat in a train or aircraft, an operator workstation on a factory floor, or a defined compliance measurement point. In all these cases, effective noise reduction depends on identifying and ranking the relative contributions of multiple radiating panels or sources to one specific location. Airborne Transfer Path Analysis (ATPA), also known as Panel Noise Contribution Analysis (PNCA), provides a structured and physically consistent way to answer that question.

*"the key acoustic question is not simply "**Where is the noise** coming from?" but rather "Which sources are most **relevant at my location?"**."*

From source localization to contribution ranking

A near-field sound map may reveal an apparently prominent radiating area. However, strong local radiation does not automatically translate into a strong contribution at a distant receiver. Directionality, propagation effects, and cavity reflections can significantly alter how sound travels between two points. A visually prominent "hot spot" may, in practice, have only a minor impact at the listener position.

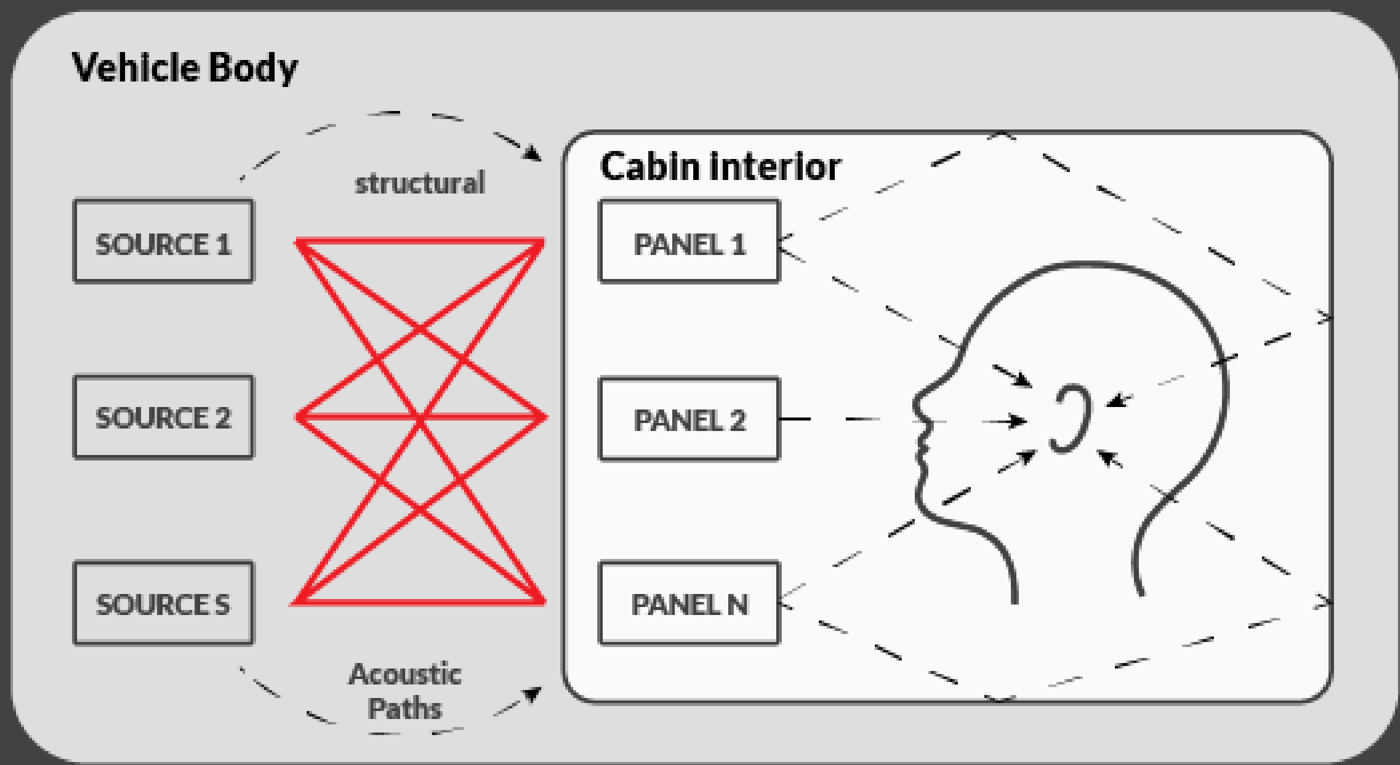


ATPA shifts the focus from radiation strength to acoustic contribution. Instead of asking where sound is generated, it evaluates how much each radiating surface contributes to the pressure at a specific reference point. The total sound pressure at that location is expressed as the sum of individual contributions, allowing the relative importance of each area or source to be quantified and ranked.

Coupled Vibro-Acoustic Systems

In complex engineering systems, noise rarely originates from a single mechanism. Structural forces excite panels, airborne sources inject additional energy into the environment, and structural–acoustic coupling further complicates the behavior. Once radiated, sound propagates through a network of direct and indirect paths shaped by geometry, boundary conditions, and structural properties.

Solving the complete coupled vibro-acoustic problem is theoretically possible, but in many practical applications it is neither necessary nor efficient. Instead, the focus is placed on the airborne radiation of the structure. The continuous surface is discretized into individual panels, and the influence of each panel or source on a defined receiver position is evaluated separately. In this way, the sound pressure at the reference location can be reconstructed as the sum of the individual contributions, making it possible to quantify and rank their relative acoustic importance.



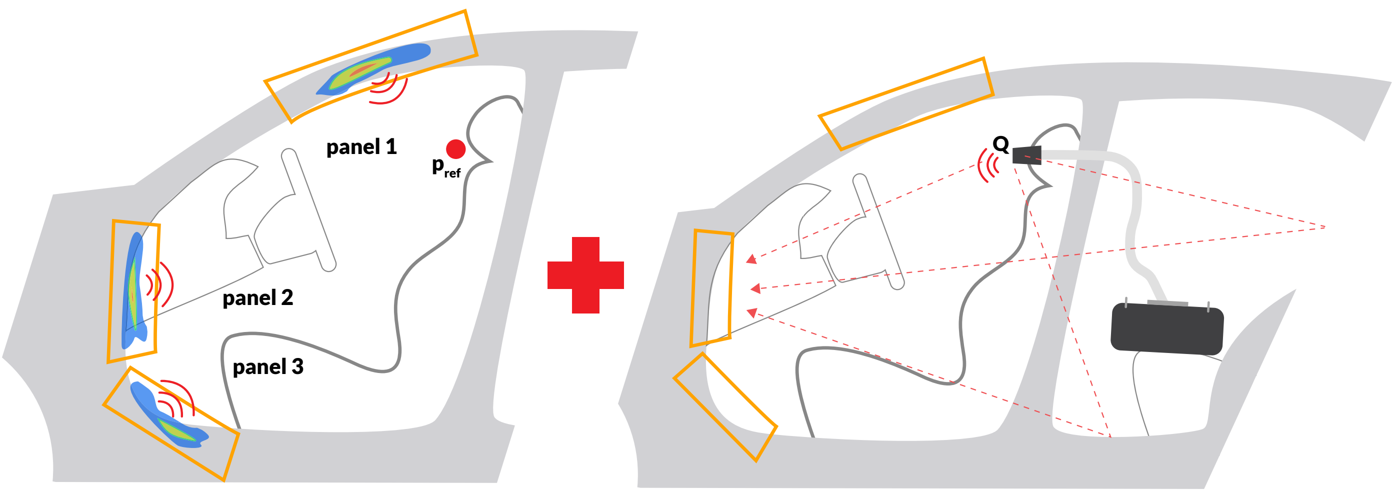
Measurement Methodology

Sound pressure contribution analysis requires two types of information: the acoustic strength of each radiating area and the transfer characteristics between those areas and the receiver position. These quantities are obtained by defining two acoustic states within the same spatial domain.

In the operational state, the structure radiates under normal working conditions. Sound pressure and normal particle velocity measured close to the surface describe the acoustic excitation of each panel. This characterization can be performed using different techniques. While inverse approaches based on microphone arrays are common, a more direct assessment of the emitted acoustic energy can be achieved using particle velocity–based or sound intensity–based measurements taken in the near field of the source.

In the reciprocal state, the system under investigation is inactive. A calibrated monopole source, such as a volume velocity source, excites the sound field at the defined receiver position. Measurements are then carried out near the same surface regions to reciprocally determine how sound propagates from each area to the target location. The resulting transfer functions capture the propagation effects between emission and reception points.

By combining the operational radiation data with the reciprocal transfer functions, the pressure contribution of each panel to the defined receiver position can be calculated. This separation between source strength and propagation path avoids assumptions about radiation efficiency and enables a direct evaluation of sound pressure contributions.



Spatial sampling of the acoustic field

One key aspect in achieving accurate results is ensuring that the sound field is sampled with sufficient spatial resolution. This can be accomplished using different measurement strategies.

One option is to use multiple sensors placed in the near field of the structure. Particle velocity sensors or sound intensity probes can be distributed across the surface, either simultaneously or through step-by-step repositioning, to characterize the relevant excitation sources.

Alternatively, if the operational condition is time-stationary, the sound field can be characterized by scanning with a single probe. By manually moving the probe across the different excitation areas or surface regions, spatially distributed data can be reconstructed.

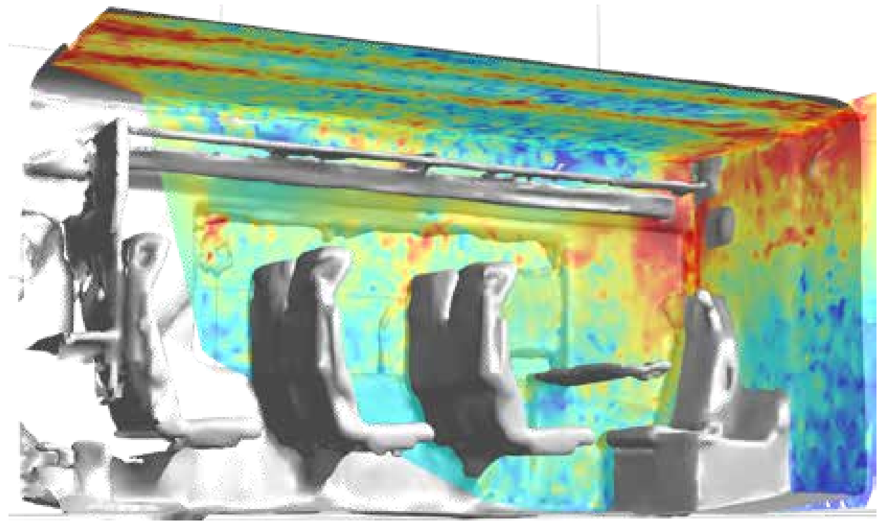
Both approaches provide the required spatial information. The selection depends on practical constraints such as accessibility, hardware complexity, and measurement time. While arrays allow improved characterization of temporal variations, scanning approaches can deliver higher spatial resolution, particularly at higher frequencies, provided that time-stationary conditions are fulfilled.

Source: *This article was adapted from an original publication on the Microflown Technologies blog. To read the full article, visit: www.microflown.com/blogs/understanding-airborne-transfer-path-analysis*

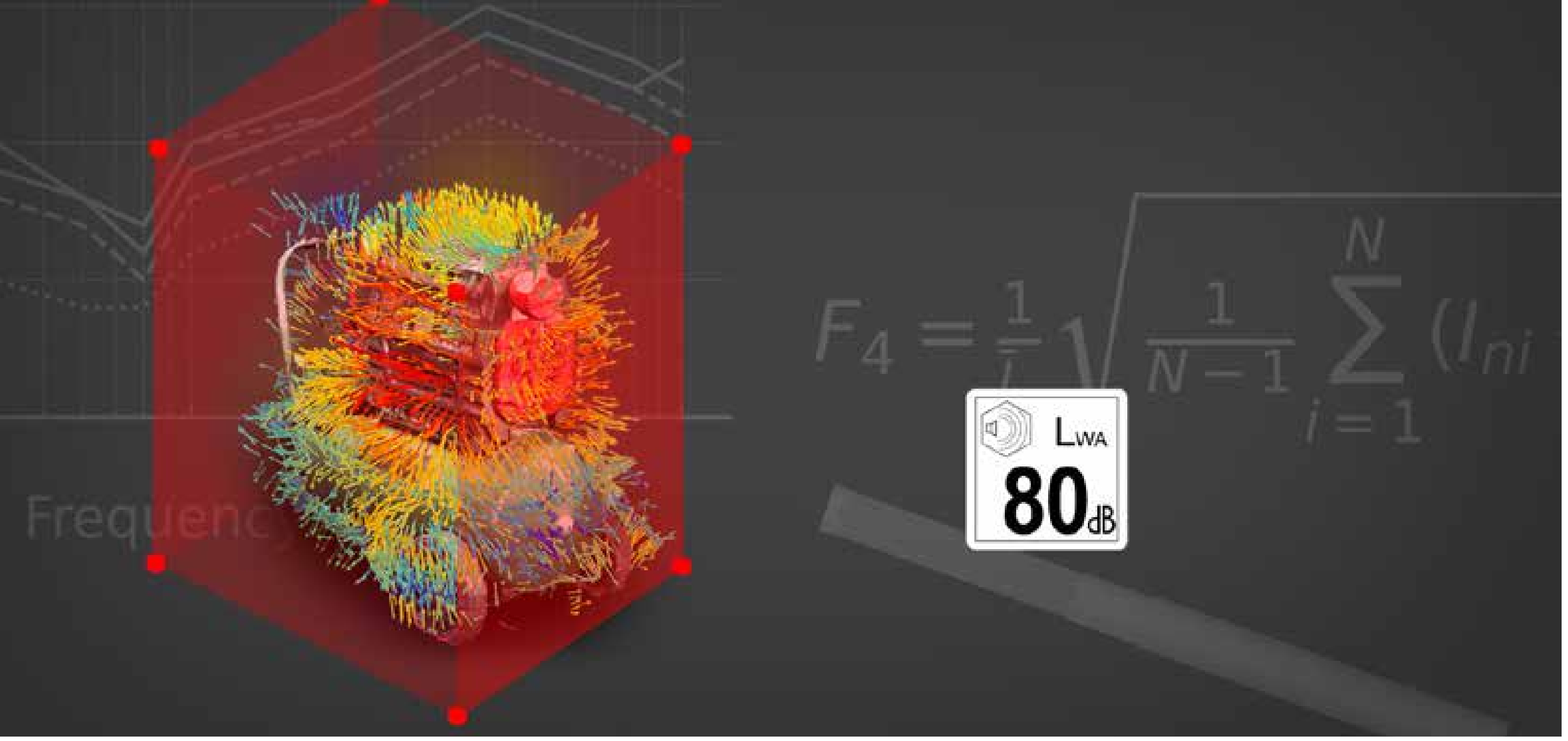
Why sound source ranking matters

In complex vibro-acoustic systems, multiple panels often radiate simultaneously. Without a clear ranking of their contributions at a defined receiver location, noise reduction measures tend to rely on trial and error. Damping may be applied to non-critical panels, insulation may be oversized, and additional mass may be introduced without delivering the expected improvement at the target position.

Contribution analysis replaces assumption-based decisions with quantitative evidence. By identifying which panels dominate at the receiver within specific frequency ranges, engineers can implement countermeasures that are directly optimized for that location. Structural modifications, damping treatments, absorption materials, or isolation strategies can then be applied precisely where they will have the greatest impact on the sound pressure experienced at the receiving point.



The result is not only improved acoustic performance, but also a more efficient use of material, development time, and cost. In this way, airborne transfer path analysis becomes a practical engineering tool for achieving measurable and technically justified noise reduction at a defined receiver position.



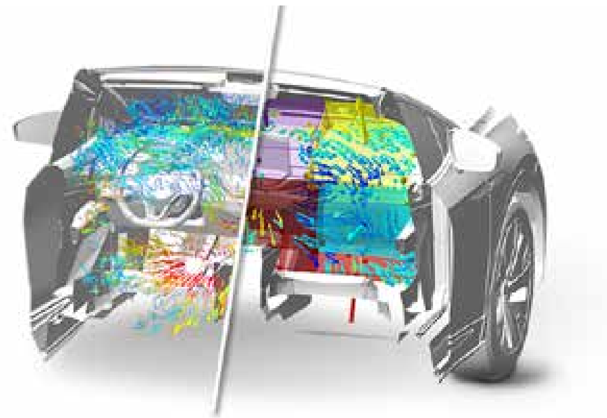
RETHINKING SOUND POWER MEASUREMENTS OUTSIDE THE LAB

Moving beyond the anechoic chamber without compromising ISO accuracy

Sound power is more than a specification on a datasheet. For engineers working in noise, vibration and harshness (NVH), it is a validation tool, a benchmark for comparison, and often the decisive metric in product development and quality assurance. Yet while the definition of sound power is clear, measuring it accurately outside a controlled laboratory remains a persistent challenge.

For decades, reliable sound power determination has been closely associated with anechoic or hemi-anechoic chambers. These environments provide the acoustic purity required for standardized measurements, shielding the process from reflections and environmental disturbances. In real-world industrial settings, however, such ideal conditions are not always available. Production constraints, safety considerations, and cost limitations often mean that measurements must take place in semi-reverberant or untreated spaces.

Traditional sound intensity measurements based on pressure-pressure (P-P) probes are particularly sensitive to such environmental factors. Background noise, reflections, and field non-uniformities can significantly influence the results. Achieving ISO-compliant measurements in non-ideal conditions therefore demands either strict environmental control or a reconsideration of the measurement principle itself.



A More Robust Alternative: P-U Probes

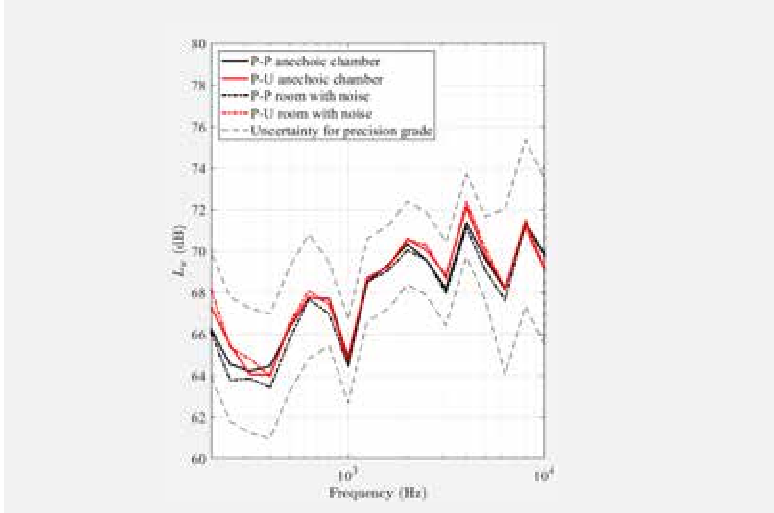
The use of pressure-particle velocity (P-U) probes in sound power determination was established through foundational work by Finn Jacobsen at DTU, particularly in his 2006 paper on the calibration of pressure-velocity sound intensity probes. These sensors measure pressure and particle velocity simultaneously at a single point, allowing sound intensity to be captured directly without relying on phase-matched microphones or spatial gradient assumptions.

A key advantage lies in the figure-of-eight directivity pattern of the particle velocity sensor, which naturally attenuates diffuse and off-axis noise. Compared to P-P probes, this makes P-U probes significantly less sensitive to background noise and room reflections.

Controlled Validation Under Realistic Conditions

In comparative research, P-U and P-P probes were evaluated in both an anechoic chamber and a typical untreated laboratory. A stationary three-way loudspeaker served as the reference source to assess measurement consistency.

Under reverberant and noisy conditions, P-P probes showed considerable deviations in field indicators. P-U probes, by contrast, maintained their accuracy and demonstrated only limited dependence on environmental factors. The results underline a clear conclusion: while P-P probes depend strongly on room quality, P-U probes achieve reliable precision even in less controlled spaces, particularly when measurement distance is optimized.



Industrial application: AC motor case study

In 2025, a collaborative study by Dana and Siemens extended this approach to an industrial environment. The objective was to determine the sound power of an AC motor during speed sweeps in a non-anechoic laboratory. Due to high rotational speeds and high voltage conditions, conventional scanning methods were neither safe nor repeatable.

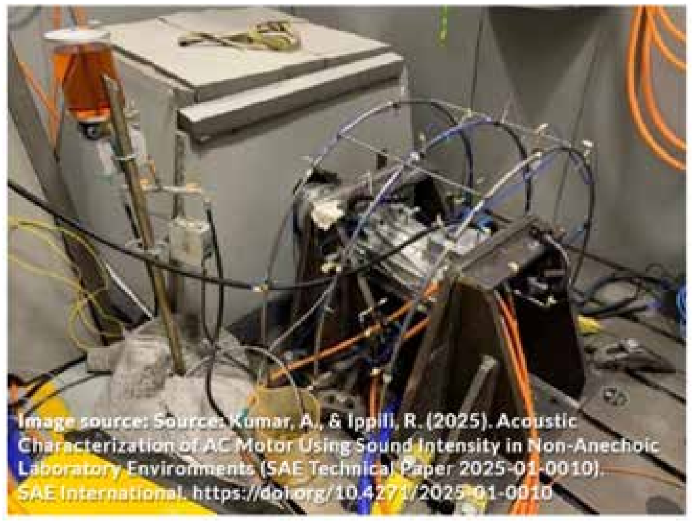


Image source: Source: Kumar, A., & Ippili, R. (2025). Acoustic Characterization of AC Motor Using Sound Intensity in Non-Anechoic Laboratory Environments (SAE Technical Paper 2025-01-0010). SAE International. https://doi.org/10.4271/2025-01-0010

A half-cylindrical array of 27 P-U probes was deployed, and measurements were performed according to ISO 9614-1. Probe distribution and surface discretization were guided by the F4 non-uniformity index.

All ISO field indicators were satisfied, and the results aligned with ISO 3744 reference measurements conducted in a hemi-anechoic chamber.

What it means for NVH teams

This method enables ISO-compliant sound power measurements in semi-reverberant or otherwise imperfect environments without compromising data quality. While proper setup remains essential, most NVH software platforms support pressure-particle velocity technology.

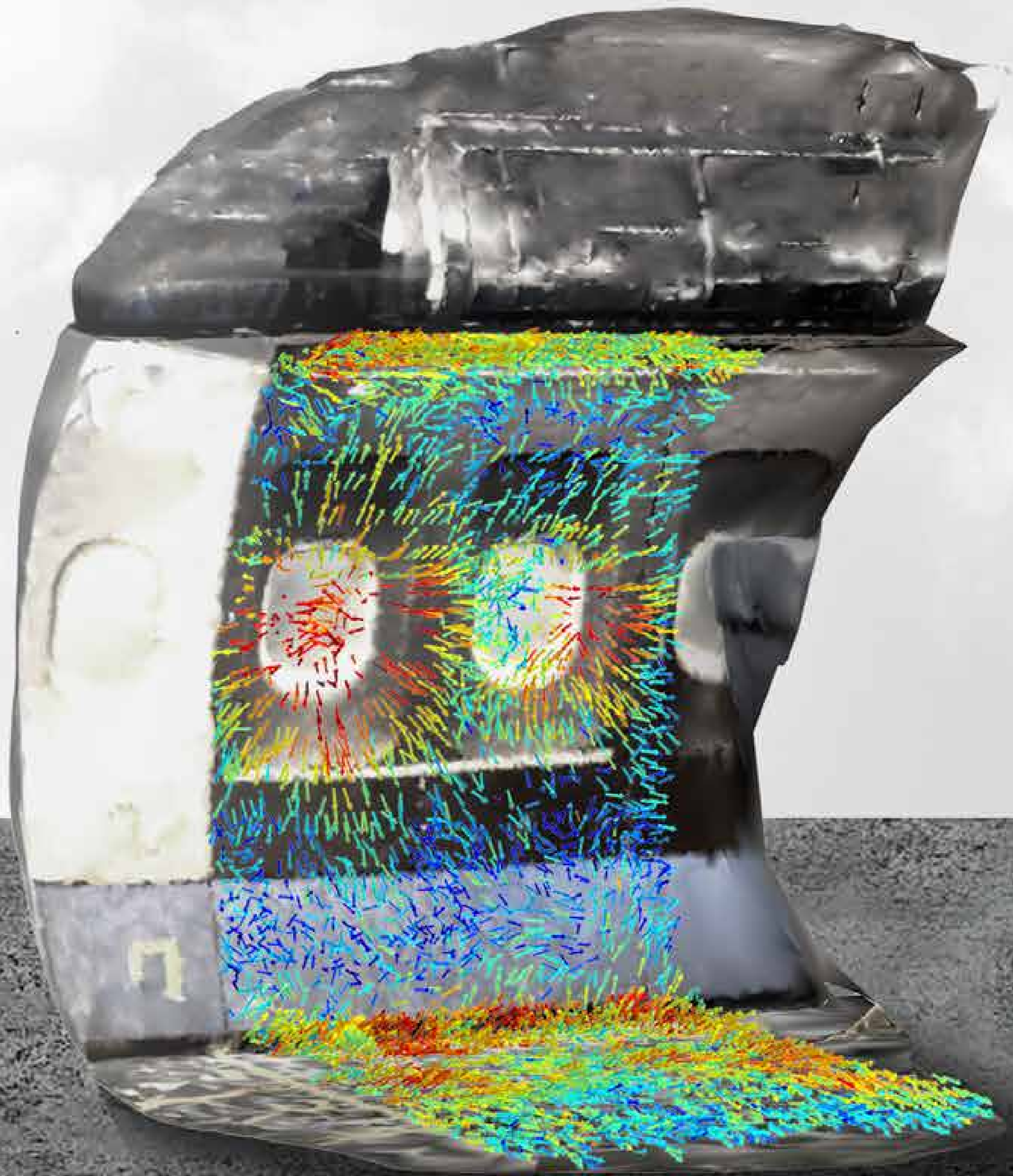
Compared to the cost of modifying a test facility or repeating uncertain measurements, a well-configured P-U setup provides a practical and efficient alternative. The approach is particularly relevant for EV drivetrain acoustics, test benches with limited acoustic isolation, and industrial product validation under time pressure.

Source: *This article was adapted from an original publication on the Microflown Technologies blog. To read the full article, visit: www.microflown.com/blogs/sound-power-outside-lab*

In collaboration with Lufthansa

VISUALIZING AND QUANTIFYING AIRCRAFT CABIN NOISE

Within the aircraft cabin, acoustic engineers encounter distinctive obstacles in their quest to create a pleasant and comfortable auditory environment for passengers. The constant hum of engines, disruptive airflow noises, and vibrations pose significant challenges in achieving optimal acoustics. This case study delves into troubleshooting techniques and highlights how Lufthansa successfully identified crucial points of interest, enabling them to overcome these hurdles and deliver a comfortable experience for air travelers.



Lufthansa

Lufthansa, a renowned global airline, leads the aviation industry with its commitment to excellence and innovation. With a vast history and worldwide reach, Lufthansa serves millions of passengers annually, offering premium air travel services. To ensure a quiet and comfortable travel experience, Lufthansa collaborates with Microflown, leveraging their advanced technology and expertise. Together, they localize noise sources, with the aim to achieve quieter cabins, elevated passenger comfort, and a superior standard of air travel for valued customers.

Lufthansa

Goal & requirements

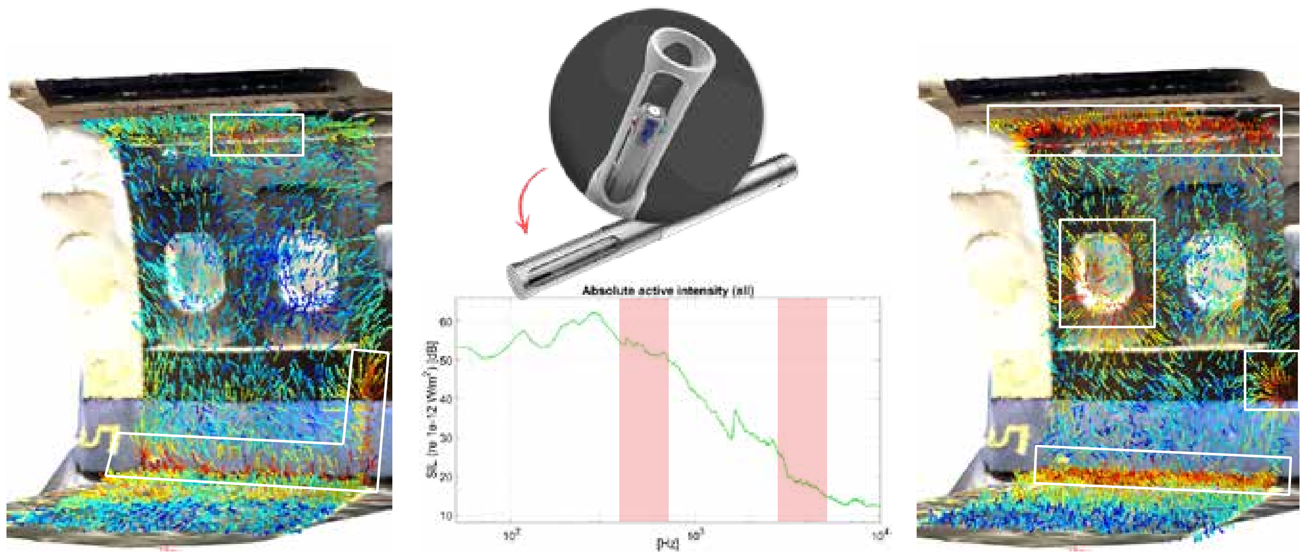
Lufthansa seeks to enhance the acoustic environment within the airplane cabin through this feasibility study aimed to drive innovation and improve the overall acoustic environment for a more comfortable travel experience.

- Detecting sound sources and leakage in an airplane cabin interior

Measurement Methodology

This case study utilized two measuring solutions to tackle acoustic challenges. The Voyager, a portable multi-channel acoustic analyzer, captured data through listening tests conducted by scanning with a PU probe near the cabin panels. The evaluation encompassed sound pressure and particle velocity signals. Real-time filtering tools were employed to concentrate the output on specific frequency bands of interest. Leveraging the distinctive capabilities of particle velocity proved invaluable in the field, particularly for detecting acoustic leakages

Once this was done the team switched to Scan&paint3D to efficiently scan an entire cabin section in just around 30 minutes. To achieve this, multiple measurements were taken of each sub-section individually, with an average measurement duration of approximately 4 minutes. This approach ensured accurate and detailed analysis of the sound field in the cabin, providing valuable insights for effective noise control and troubleshooting efforts.



500 Hz octave band

The radiation area is located at the intersection of the floor with the cabin wall panel. But with the difference that at the top and very centralized there is a prominent radiation spot coming from the partition between the wall and the luggage carrier.

4 kHz octave band

The upper and lower sections show similar behavior to previous bands. The left window, close to the outside speaker, is a significant radiation area for this frequency band too. Radiation/leakage is concentrated around the bottom sides of the window. Particularly, there is a specific area at the far right where the panel bottom walls intersect, showing strong radiation.

Outcome

Despite the challenging acoustic conditions in the target environment, sound source localization and quantification was performed effectively in the full audible range without introducing any extra absorption material into the cabin. The results were used to inform potential construction changes.

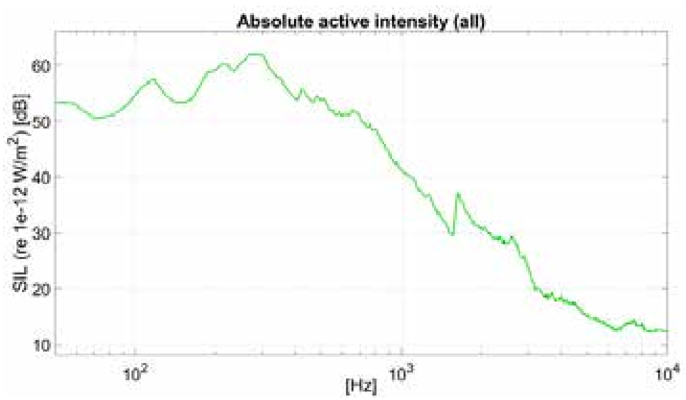
Key findings of this investigation are:

• The Voyager has effectively identified key noise sources and regions of interest.

• The integration of the Voyager with the Scan & Paint 3D solution has facilitated comprehensive identification of noise and leakage sources, providing a visual representation of the entire sound field.

• The most significant radiation/leakage per frequency band is observed at the intersection between the floor and cabin wall. Other source/leakage areas largely coincide with intersections involving other panels, the floor, and windows.

• Faster scanning has demonstrated effectiveness in achieving reliable results



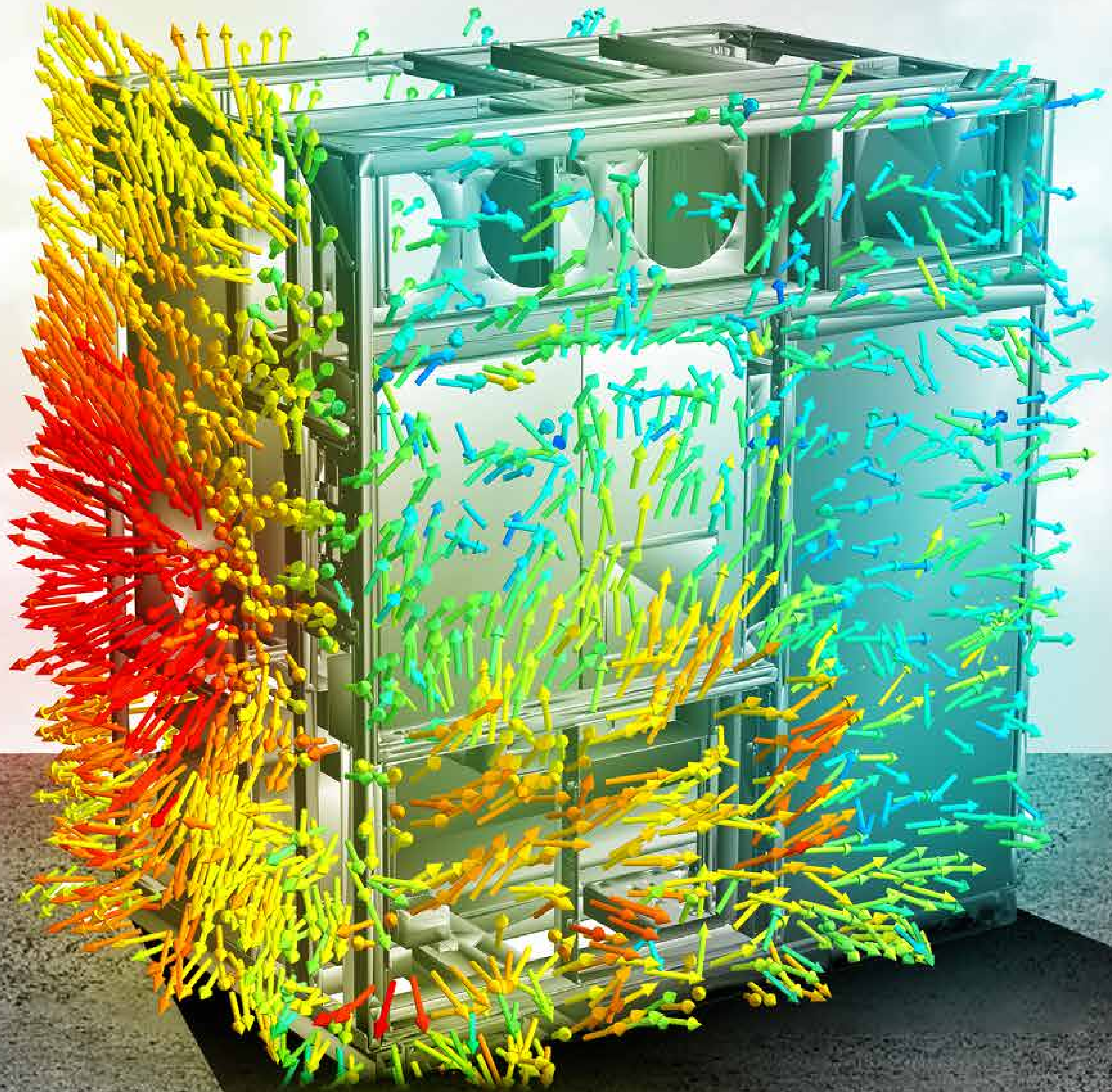
Source: *This article was adapted from a case study originally published by Microflown Technologies. To explore the full case study, visit: microflown.com/hyundai-case-study*

In collaboration with

ACOUSTIC CHARACTERIZATION OF AN ENERGY STORAGE SYSTEM

By Theo Lam & Tales Storrani

This case study examines the acoustic performance of a large mobile energy storage system (3 × 2.5 × 2.6 m) under various load conditions, focusing on both the internal components and the enclosure. Through in-situ measurements and advanced visualization tools, key noise sources such as fans, transformers, other components, and enclosure leakages were identified. The analysis also revealed unexpected acoustic leakage related to structural panel modes, providing targeted insights for design improvements. Despite challenging weather conditions, the campaign was successfully carried out thanks to a flexible and adaptive on-site setup.



In collaboration with Alfen

Alfen, a leading Dutch company, specializes in three key areas: Smart Grid Solutions, EV Charging Equipment, and Energy Storage Systems. Their systems provide a sustainable alternative to diesel generators, designed to deliver power in areas with limited grid access. A critical selling point of this technology is its low noise emission, making it well-suited for noise-sensitive environments, including nighttime operations in residential areas. To gain a deeper understanding of the acoustic performance, Alfen partnered with Microflown Technologies to carry out a thorough experimental campaign.

Goal & requirements

The main objectives of the acoustic assessment were to:

- Identify and localize the dominant noise sources within the device and its enclosure.
- Quantify and rank the sound emissions of individual components under different operational conditions.

Measurement Methodology

The acoustic measurements were carried out over two days at Alfen's directly in the facility in Almere, the Netherlands. The campaign began with preliminary scanning using the Voyager system to obtain a first overview of the acoustic behavior and to identify dominant noise hotspots. In this phase, Voyager served not only as a troubleshooting tool but also as the central data acquisition (DAQ) platform for the entire measurement campaign, reducing the amount of equipment required on site and enabling efficient switching between measurement configurations.

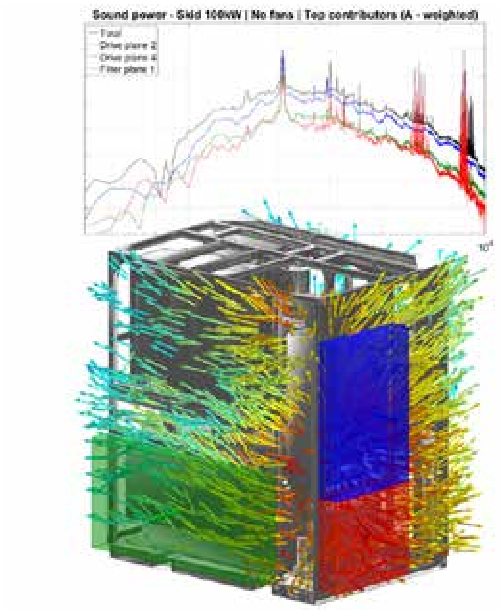
Building on these initial insights, 3D acoustic imaging was performed with the Scan&Paint 3D system, focusing on the device skid, the core system without its enclosure. This allowed for a detailed spatial analysis of individual components and their respective contributions to the overall sound field. In parallel, 2D acoustic imaging using the Scan&Paint 2D system was applied to the fully assembled mobile energy storage container, enabling evaluation of the system in its operational configuration.

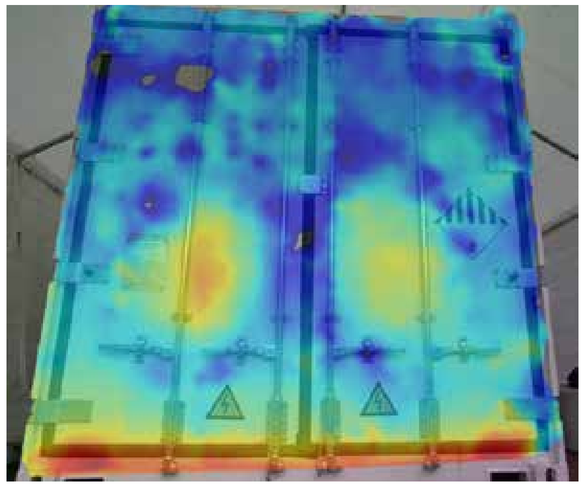
Together, the three solutions within the Microflown ecosystem provided complementary perspectives on the same system: rapid hotspot identification, in-depth 3D source characterization, and surface-based assessment of the complete assembly. Measurements were conducted under multiple power load scenarios and varying fan speeds to reflect the most relevant operating conditions. The device skid was tested indoors in a general-purpose workshop environment, while the complete system was assessed outdoors inside a pop-up tent to reduce the influence of UV exposure and rain during the measurement sessions.

Noise Source Identification via 3D Acoustic Mapping

The investigation began with 3D acoustic visualization to track how noise emissions evolved across frequency bands and power conditions. Sound intensity mapping revealed changing radiation patterns under varying loads, showing that one component consistently dominated the overall acoustic output, while other subsystems became relevant at specific frequencies. The 3D analysis also exposed localized increases in radiation at certain power levels and distinct tonal components in the higher frequency bands effects that are difficult to interpret using conventional acoustic color maps alone.

The study was then extended within VELO to include direct sound power calculations. By segmenting the system into individual panels, we quantified each component's contribution to the total sound power under different operating states. The results confirmed one primary noise source across most of the frequency range, with other components becoming more prominent at higher frequencies and generating clear spectral peaks. This combination of spatial visualization and quantitative sound power ranking provided both diagnostic insight and a solid basis for targeted acoustic optimization.





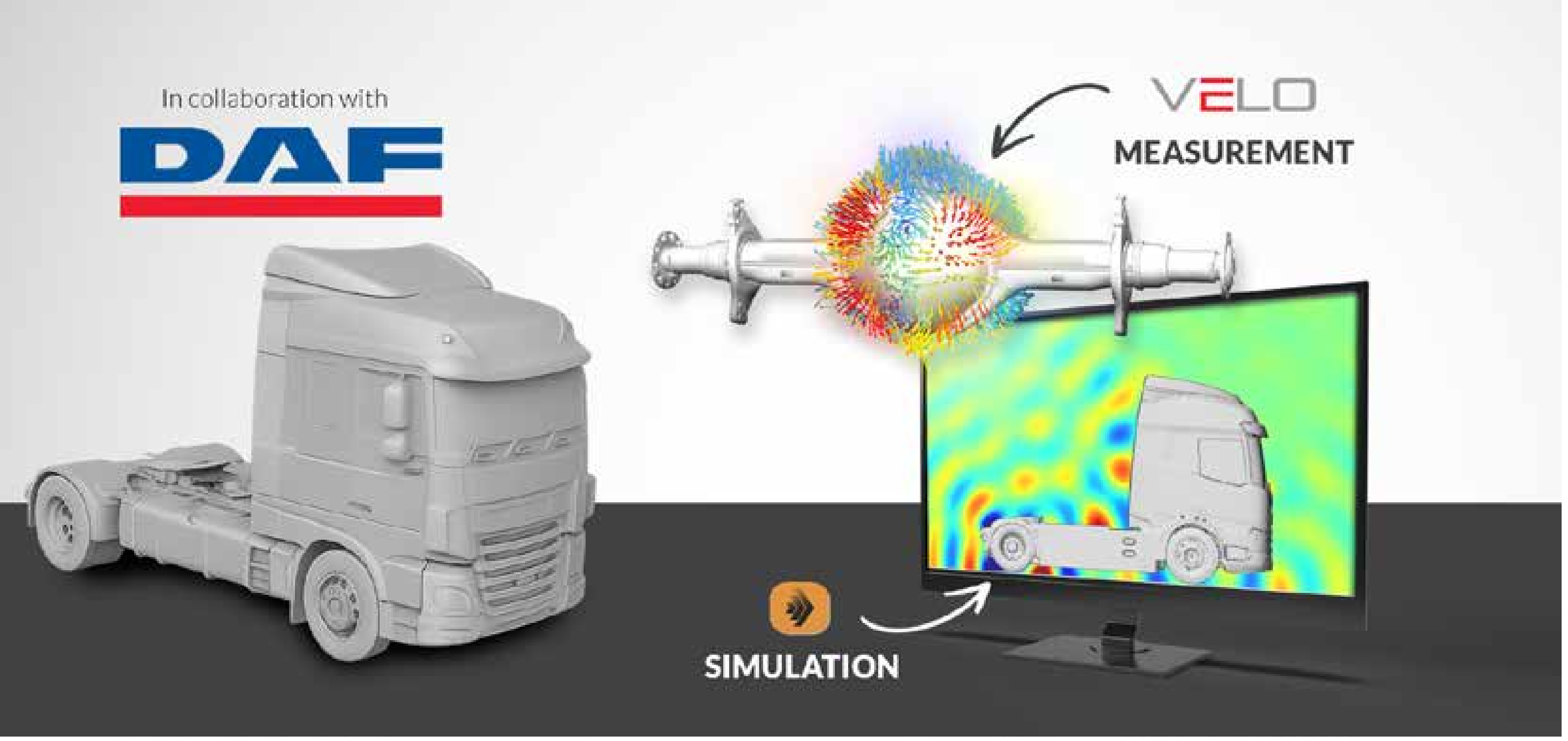
Structural Modes and Panel Radiation

After characterizing the system's core, the fully enclosed device was tested outdoors using 2D sound mapping. A key acoustic challenge in compact enclosures is the interaction between structural panel modes and acoustic leakage, particularly in the low-frequency range. In this case, below 150 Hz, velocity mapping revealed significant leakage at the bottom junction of the battery door, combined with structural resonance modes in the door panels. By visualizing these effects, we were able to pinpoint where structural reinforcement, improved sealing, and enhanced damping would deliver the greatest impact.

Structural Modes and Panel Radiation

This investigation successfully demonstrated the value of in-situ acoustic measurements using advanced particle velocity, based tools in both 2D and full 3D. The insights gained not only supported the validation of low-noise product targets but also provided actionable data to further enhance the acoustic performance of the energy storage system. This case highlights the value of real-time, on-site acoustic visualization, not just for data collection, but for reshaping understanding and enabling more effective steps toward reducing overall noise emissions.

Source: *This article was adapted from a case study originally published by Microflown Technologies. To read the full case study, visit: https://www.microflown.com/case-studies/acoustic-characterization-energy-storage*



HYBRID 3D SOUND INTENSITY MEASUREMENTS AND SIMULATIONS APPLIED TO A TRUCK REAR AXLE

By Fernández Comesaña, D., Vael, G., Robin, X., Orselli, J., & Schmal, J

Bridging Measurement and Simulation

Optimizing acoustic performance in modern trucks has become increasingly complex. With electrified powertrains, tonal components such as gear engagement frequencies become dominant contributors to vehicle sound radiation.

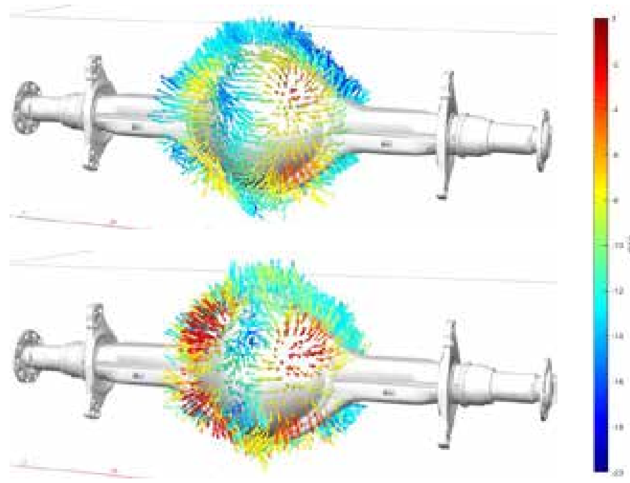
Rather than treating experimental testing and numerical simulation as separate workflows, this study combines both into a hybrid methodology. Spatially dense 3D sound intensity measurements are directly integrated into finite element acoustic simulations. The approach is demonstrated on a truck rear axle under stationary propelling and braking conditions.

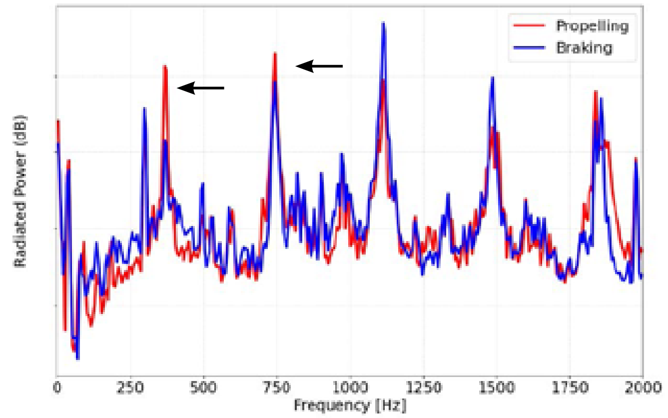
Rapid 3D Sound Intensity Acquisition

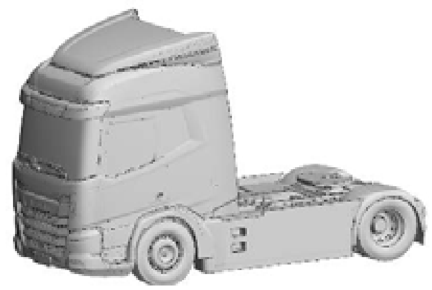
Using Scan&Paint 3D, a 4-channel sound intensity probe measured pressure and three orthogonal particle velocity components while being manually scanned 1–5 cm from the axle surface. Twenty-eight recordings were captured, totaling 45 minutes of scanning. The entire campaign, including setup and disassembly, was completed in approximately three hours.

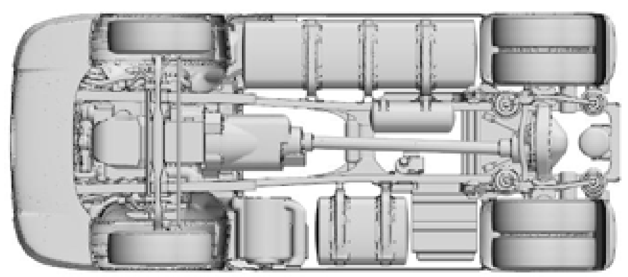
The continuous scans were discretized using a 20 mm grid resolution, yielding roughly 1,900 virtual measurement points per operating condition. Compared to traditional accelerometer-based methods, this approach provides significantly higher spatial density in a fraction of the time.

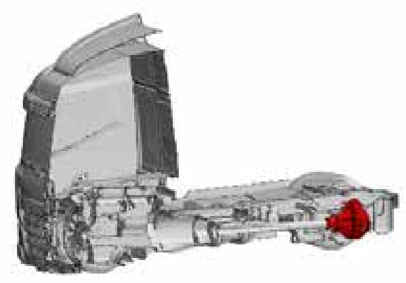
Broadband intensity maps revealed clear differences between propelling and braking conditions, primarily driven by changes in gear tooth contact within the hypoid gearset.











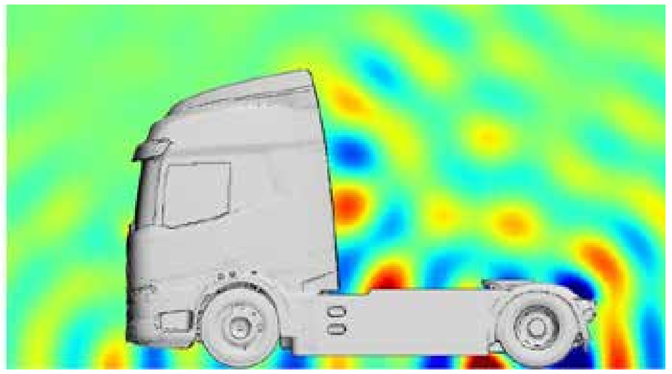
Frequency-Focused Radiation Analysis

The measured 3D particle velocity data, including phase information, was used directly as excitation input in Actran via the Boundary Condition (BC) Mesh method. Instead of building and validating a separate structural vibration model, measured surface data was projected onto a finite element mesh of the rear axle.

To extend the analysis, the rear axle was positioned within a vehicle-level CAE model using a shrinkwrap representation. This enabled simulation of far-field radiation and vehicle-level propagation effects. Simulated radiated power showed peaks at 375 Hz and 750 Hz, matching measurement results and confirming correct data transfer into the numerical model.

Vehicle-Level Propagation and Cabin Impact

With validated excitation data, simulation provides full-field insight beyond measured locations. Propagation maps showed strongest radiation beneath the vehicle, where floor reflections amplify sound levels, and elevated levels at the rear of the cabin. Forward radiation was reduced due to shielding by the cab structure.

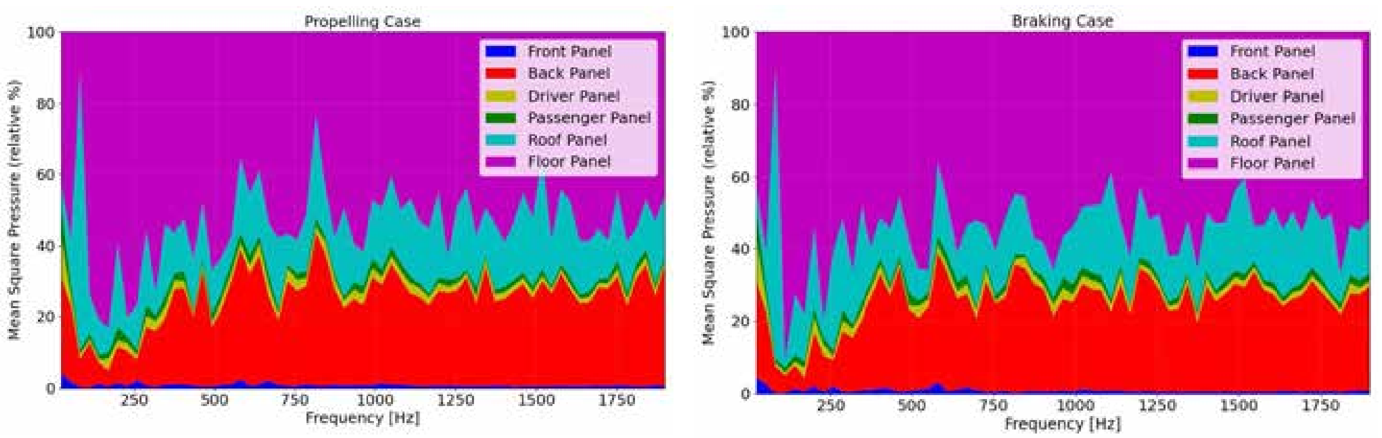


Cabin Panel Contribution Ranking

To assess structural impact, the cabin exterior was divided into six panels. Mean square acoustic pressure was calculated for each panel and ranked.

The floor panel showed the highest contribution, followed by the rear panel. Mapping pressure distribution at 375 Hz identified localized high-load regions that represent primary candidates for reinforcement or acoustic treatment. This approach creates a direct link between measured gear excitation, structural loading, and potential interior noise paths.

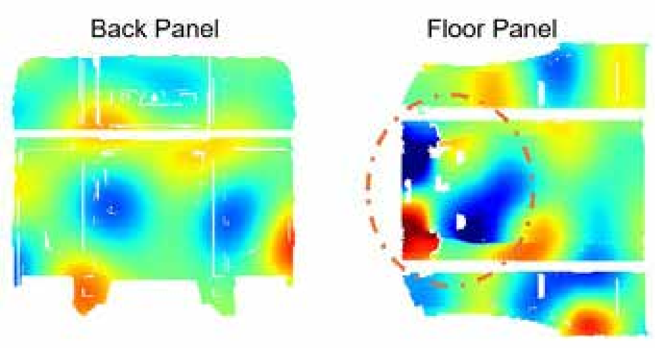
> *" When tonal gear **noise dominates**, understanding where and how it radiates **becomes essential**, not optional."*



Conclusion

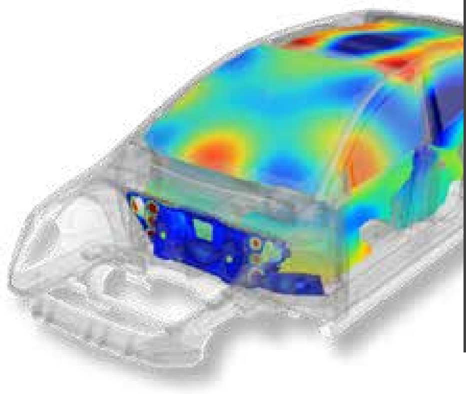
This hybrid workflow merges high-resolution 3D sound intensity measurements with predictive finite element simulations. The method enables rapid source identification, accurate radiation modeling, and targeted structural optimization within a unified process.

By combining measurement density with simulation completeness, engineers gain both diagnostic clarity and predictive capability — particularly valuable in late-stage development where rapid resolution of tonal issues is critical.



Source: *This article was adapted from a conference paper entitled "Hybrid 3D Sound Intensity Measurements and Simulations Applied to a Truck Rear Axle", originally published in In Proceedings of the SAE Conference 2025.*

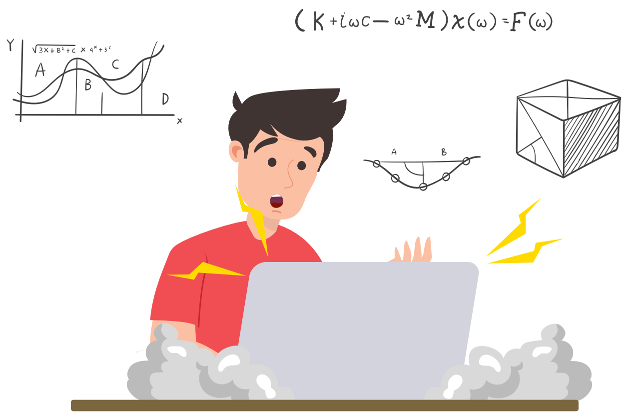
BRIDGING MEASUREMENTS AND SIMULATIONS IN ACOUSTIC DESIGN



Simulation has become an essential tool in modern acoustic design. Engineers in automotive, aerospace, and industrial sectors increasingly rely on acoustic simulations to predict performance, optimize noise treatments, and validate designs. Yet, even the most powerful acoustic CAE tools face practical roadblocks when applied to real-world systems.

Why full acoustic simulations are so challenging

The first challenge lies in the input data. Many components are effectively "black boxes", suppliers may not disclose the full details due to intellectual property restrictions, and in some cases, they do not even have all the parameters required for an accurate model. Without this foundation, even the most sophisticated simulations start with uncertainty.



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Bridging Measurements and Simulations in Acoustic Design
Research

A practical alternative: Hybrid Acoustic Modeling

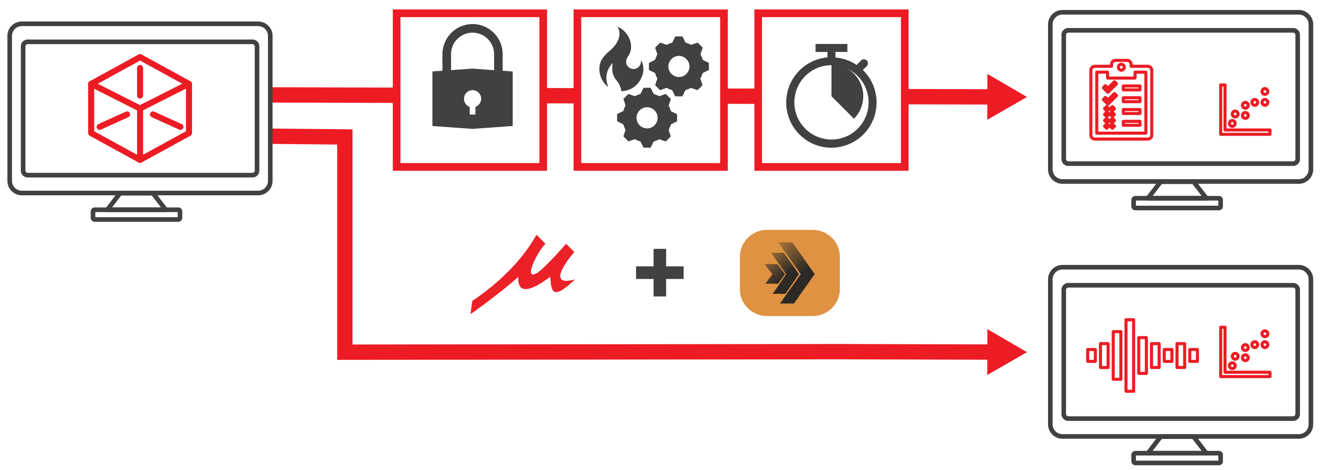
Hybrid Acoustic Modeling offers a way around these obstacles by combining the strengths of measurements and simulations. Instead of simulating every physical detail from scratch, engineers start with real-world measurements of the acoustic source and use them as the initial input. The simulation then focuses only on how that measured source propagates through the environment.

In practice, this means using high-resolution 3D sound intensity measurements, obtained with Microflown's particle velocity sensors, as the input to powerful simulation platforms like Hexagon Actran. The result is a workflow that bypasses the most difficult aspects of modeling, while still delivering reliable and predictive results.

Why it works

Hybrid Acoustic Modeling reduces uncertainty by grounding the simulation in real measurement data. Conditions such as load, temperature, and boundary effects are captured directly during the measurement stage, meaning the model begins with reality instead of assumptions. Once the source has been characterized, the propagation stage of the simulation becomes straightforward and efficient. Engineers can then evaluate different scenarios, introduce countermeasures, or study installation effects much faster than with conventional approaches.

This method not only accelerates the workflow but also strengthens confidence in the outcome. Potential treatments such as foams, covers, barriers, or alternative materials can be tested virtually before a single prototype is built. By combining accuracy, speed, and efficiency, Hybrid Acoustic Modeling proves especially valuable when projects are close to deadline and late-stage design changes need to be de-risked quickly.



As noise regulations tighten and product cycles accelerate, engineers are under growing pressure to make faster and more accurate design decisions. Hybrid Acoustic Modeling provides a practical solution by blending the realism of measurements with the predictive power of simulations.

By combining Microflown's sound intensity measurement technology with Hexagon Actran's simulation capabilities, engineers gain a robust and efficient workflow for addressing complex acoustic challenges. It is an approach that does not replace simulation, but strengthens it, ensuring that acoustic design is based on both accurate data and reliable prediction.

Source: *This article was adapted from a blog originally published by Microflown Technologies. To read the full blog visit: https://www.microflown.com/blogs/hybrid-acoustic-modeling-bridging-measurements-and-simulations-in-acoustic-design*

PUSHING ACOUSTIC MEASUREMENT BEYOND CONVENTIONAL LIMITS

Interview with material testing expert Maro Puljizevic

In this interview, Maro Puljizevic, R&D lead at Knauf Insulation a global mineral wool manufacturer, Maro shares how his team approaches acoustic challenges beyond the lab, from product development to quality control in noisy industrial settings. He explains why they moved past conventional microphone-based methods, how scientific transparency builds trust, and what it takes to bring meaningful acoustic insight into the factory of the future.

From laboratory acoustics to industrial reality

Can you briefly introduce yourself and your role?
"I work in the field of sound insulation at Knauf insulation, a global manufacturer of mineral wool. By trade, I am an acoustician, and I lead our research and development activities related to acoustic performance across different applications and industries."

What kind of acoustic challenges do you encounter in your work?
"Our challenges range from improving the acoustic performance of products to ensuring quality control during production. Many of these challenges occur in industrial environments, which are inherently noisy. Traditional acoustic measurement methods often struggle in these conditions, especially outside controlled laboratory settings."

When conventional methods reach their limits

What led you to look beyond traditional microphone-based techniques?
"At a certain point, we reached the limits of conventional acoustics. Classical microphones and standard methods work well in quiet, controlled environments, but production facilities are fundamentally different. Noise levels are high, and even achieving a short period of silence can be extremely difficult. That was the point where we realized we needed to move beyond classical approaches."

How did you gain confidence in using a non-conventional measurement technology?
"We took a careful and scientific approach. We performed benchmarking tests to understand where classical acoustic methods overlap with newer measurement techniques. The results were very convincing. The data could be validated, and we were comfortable with both the accuracy and reliability of what we were measuring."

The role of transparency and collaboration

How important was scientific transparency in this process?
"It was crucial. One of the things we really appreciated was the openness around research and validation. Being able to review scientific publications, peer-reviewed papers, and technical explanations gave us confidence in the technology and the people behind it."

Did this evolve into a deeper collaboration?
"Yes. What started as a user–supplier relationship gradually evolved into a research partnership. We identified shared research interests and began working together on topics that were relevant to both sides."

Can you give an example of such a research topic?
"One example is the study of membrane effects and their influence on acoustic performance. This is a phenomenon that classical acoustic approaches cannot fully capture. With alternative measurement techniques, we were able to investigate these effects in more detail and understand how certain surface layers can enhance—or reduce—acoustic performance if not treated properly."

> *" we reached the **limits** of conventional acoustics and had to go **beyond standard testing.**"*

Looking ahead

How do you see this collaboration developing in the future?
"The potential is very broad. Our portfolio spans multiple industries, from building construction to automotive and domestic appliances. Each presents different acoustic challenges. Addressing them requires a partner with deep technological expertise and a high degree of flexibility, which is why we see many future research opportunities together."

What role does acoustics play in the factory of the future?
"We operate in very noisy industrial environments. At the same time, we are committed to innovation, sustainability, and the health of our employees. Reducing noise exposure is an important part of that. Until recently, high noise levels were a major barrier to acoustic research in production environments. With new measurement approaches, we are now able to bring acoustic insight directly into these settings."

MICROFLOWN'S CODEWORD PUZZLE

Codewords are like crossword puzzles without clues: the letters have all been replaced by code numbers. Using the letters already provided, work out the rest by identifying the missing words!

Hint: all the words can be measured/characterized using Microflown's testing solutions

CODE KEY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
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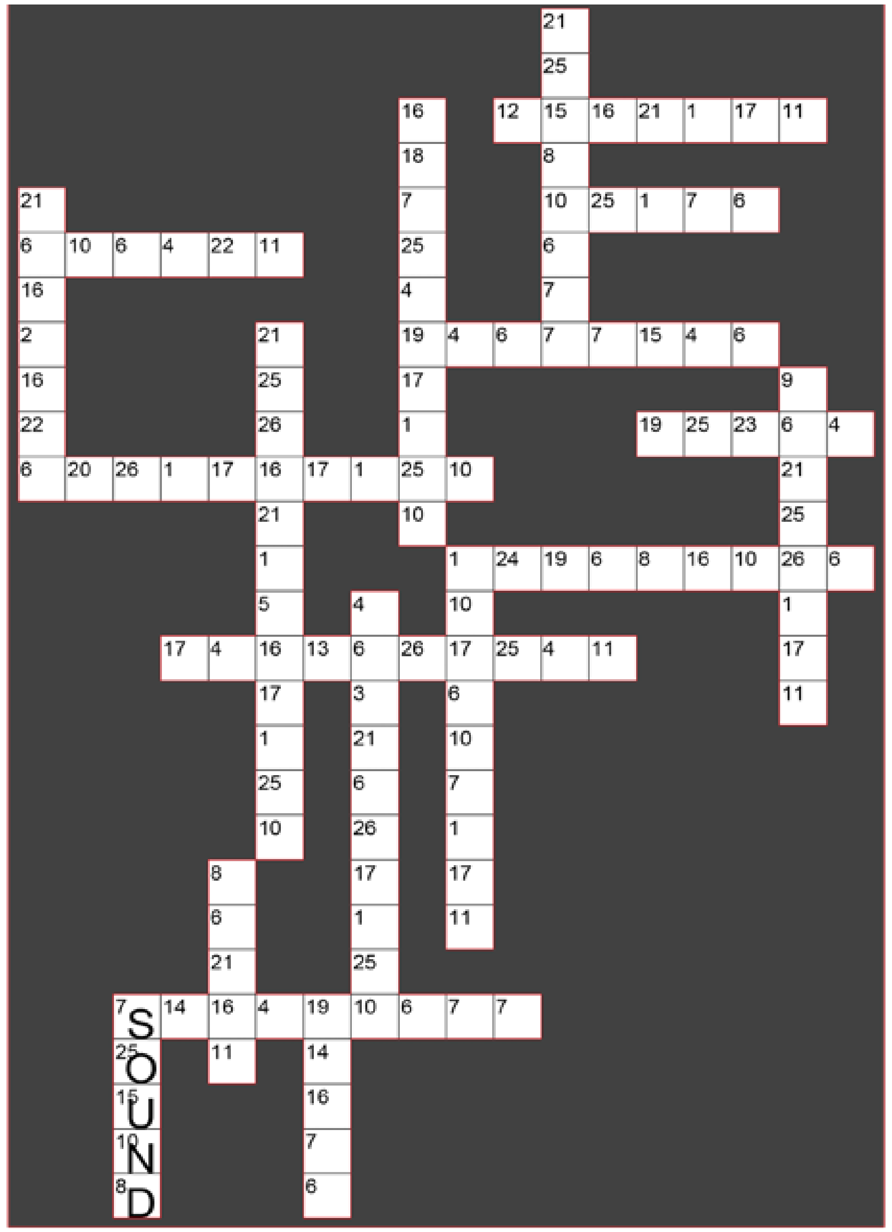

If you solve this puzzle you will get FREE

7	17	4	25	25	19	23	16	3	6	21	7

at the Microflown booth!

MICROFLOWN TECHNOLOGIES

DID YOU KNOW...?

"we reached the limits of conventional acoustics and had to go beyond standard testing."

p.29

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