

SOUND AND VIBRATION NEWS

ISSUE# 12

WAVES

DECEMBER 2019



SOMETHING QUIET THIS
WAY COMES

FIDELITY FIGHTS BACK

DESIGNING A SOUND
SOURCE

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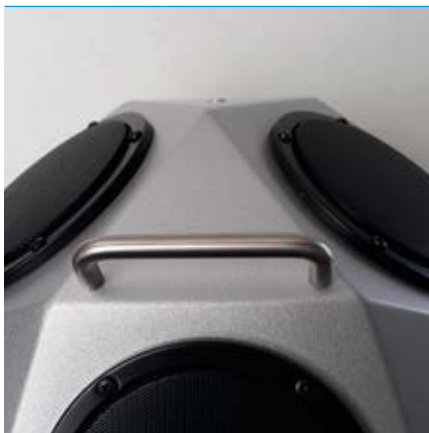
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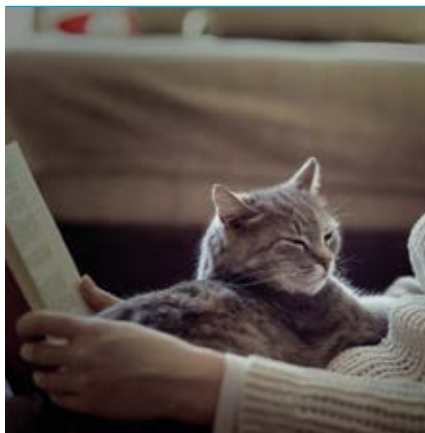
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FRONT COVER IMAGE

Pass-by testing

Photo courtesy of Applus+ IDIADA

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LETTER FROM OUR PRESIDENT

THIS WORLD IS AN EVER-CHANGING PLACE – IN RELATION TO HOW WE WORK AND HOW WE LIVE

Everyone involved in production and testing is well aware that industry is in a constant state of progression. New technologies arise and new testing requirements are needed to ensure safety, durability and customer acceptance. But it's not just the industrial sectors that change, evolve and grow over time. The world, itself, is in a constant state of flux resulting from changes in technology and the contrivances of living in the modern world. The articles in this issue showcase how product testing is evolving to match changing needs while ensuring our safety, and also provide other perspectives on how we relate to and impact the world around us.

The increased electric and hybrid market is a step towards a greener world, and also contributes to the reduction of noise pollution with a considerable lack of noise. But electric and hybrid vehicles are, in fact, a bit too quiet. So while some manufacturers are dealing with increased noise restrictions for internal combustion engines, like Mercedes-Benz in *Today's proving ground for vehicles of the future*, others, like IDIADA in *Something quiet this way comes*, are focusing on the opposite end of the spectrum to ensure that electric vehicles can be heard by pedestrians.

Sound and vibration are also more than safety factors; they are a fundamental way in which we interact with and understand the world around us. They are a tremendous part of our lives. Our Physics of Sound and Vibration series explores the mechanics behind sound propagation, and in *Fidelity fights back*, Jude Mansilla explains why quality sound reproduction is so important. And rounding out that theme, we can think about how sound and vibration can also be used to fundamentally alter how we perceive the world around us and, perhaps, look at things in a different way, like in *There and back again*.

I hope you enjoy this issue, and I look forward to greeting you in the next issue so that we can explore together where the future will take us and how we can influence that journey for the better.



JOE VORIH
PRESIDENT



TODAY'S PROVING GROUND FOR VEHICLES OF

Mercedes-Benz' decision to build a new proving ground was spurred by its global target of achieving homologation of all vehicles so that any vehicle will meet or exceed projected global standards regardless of country or region of origin, combined with the need for durability testing.



THE FUTURE

All photos courtesy of Mercedes-Benz.

Iracemápolis, a municipality in the state of São Paulo, Brazil is well known for two things. It is the birthplace of the now retired footballer Elano, and the home of the Mercedes-Benz do Brasil Ltda car production plant. Now, it is also home to the largest and most impressive proving ground in the southern hemisphere.

Located next to the plant, the US\$25 m proving ground was inaugurated in May 2018. With cutting edge technology and covering a stunning 1,300,000 m² (the equivalent of 150 football pitches), it is the most advanced proving ground in Brazil. Able to simulate the roads of Brazil and indeed any other country in the world, the proving ground is mainly used by Mercedes-Benz to test its trucks, buses and other commercial vehicles. However, 20% of the track's current usage is by other automotive manufacturers who take advantage of the first-class amenities on offer.

The state-of-the-art proving ground has 12 km of track and covers the equivalent of 150 football pitches

MADE TO MEET ALL STANDARDS

A specialized facility housing advanced digital technology and connectivity is located alongside 12 km of track, divided into 16 individual tracks (asphalt, concrete and off road), accommodating all of Mercedes-Benz needs – from durability testing to acoustic and thermal comfort testing and off-road testing for extra-heavy vehicles. Using special techniques and materials, the tracks have a lifetime of 30 years, ensuring high accuracy and repeatability.

One of the focus areas of Mercedes-Benz in Brazil is the need to reduce the overall noise of their production vehicles, mostly trucks. The transition to meeting ISO 5130: 2019 *Acoustics – Measurements of sound pressure level emitted by stationary road vehicles* happens in three phases, but the end result is that they must reduce overall noise by 2 dB by 2023. A 2 dB reduction in overall noise may not sound like much, but even for a decently sized commercial vehicle like a semi-truck, this is a huge deal. Finding areas where noise can be reduced requires mammoth effort from the team, a variety of different tools and analysis techniques such as noise source identification (NSI), pass-by testing and source path contribution (SPC). ►



TODAY'S PROVING GROUND FOR VEHICLES OF THE FUTURE

The new pass-by test track conforms to ISO test procedure-based regulations such as UN/ECE R51.03 (noise emission)



PASS-BY NOISE TESTING

The new pass-by noise test track at the proving ground was built according to ISO 10844:2014 guaranteeing characteristics of construction such as size, demarcations, texture, porosity, longitudinal and transverse irregularities. ISO certified in March 2019, it also conforms to ISO test procedure-based regulations such as UN/ECE R51.03 (noise emission) for cars, vans, trucks, buses and motorcycles with

emphasis on total vehicle test including tyre noise, static noise, horn and external noise conformity of production (CoP).

The potential of the new track and the directive of global homologation motivated the pass-by team in Brazil to look at new tools for their measurements. With new standards, more complicated scenarios and test procedures, it was the natural time to transition from IDA® to LAN-XI

data acquisition hardware and from PULSE™ LabShop to BK Connect®. The connectivity and simplicity of the LAN-XI hardware combined with the ease-of-use and guided processes of the BK Connect software speed set-up and data acquisition, and reduce the possibility of error and non-valid data.

"During the pass-by procedure, it is often necessary to understand the behaviour of noise sources with embedded measurements. Our system presents a very flexible platform, essential for NVH solutions. BK Connect benefits, like the guided user interface, and particular features, like being able to obtain vehicle data through the CAN Bus module, provide a lot of agility in managing and comparing results through the database," says Gaetano Miranda, Development Engineer and NVH (noise, vibration and harshness) specialist in the field of test track and pass-by.

STATE-OF-THE-ART NVH SOLUTION SET

A perfect complement to the pass-by system, the state-of-the-art PULSE Array Acoustics, Road Vehicles Moving Source Beamforming system is used during the development stages to identify the main sources of noise and their contribution quickly and accurately. "The dynamics of sound radiation during pass-by noise testing is often not trivial and the beamforming system applied for pass-by noise helps us to quickly and efficiently understand the main sources, enabling customized and smart solutions," says Fabio G. Bueno, physicist and NVH specialist at Mercedes-Benz testing department. Both Fabio and Gaetano are enthusiastic about their NVH solutions and work with a range of troubleshooting tools and technologies for internal noise development, such as spherical

"THE FIRST BENEFIT OF BK CONNECT IS ITS FRIENDLY GUI. IT IS VERY EASY COMPARED TO PREVIOUS PASS-BY SET-UPS."

FABIO G. BUENO, PHYSICIST AND NVH SPECIALIST AT MERCEDES-BENZ



HEAVY-DUTY TESTING

One of the trucks put through its paces at the proving ground is the brand new, high-technology Actros, due for launch in 2019. The Actros range, first introduced in 1995, are heavy-duty trucks used for long-distance, high-volume distribution and construction equipment haulage. These trucks are subjected to rigorous functionality and durability tests and their components and systems are also extensively evaluated to ensure vehicle strength and robustness and to optimize the NVH characteristics of said components. ■



beamforming, conformal mapping, SPC and sound quality.

A CRUCIAL PART OF DAIMLER GROUP'S DEVELOPMENT PLATFORM

Mr. Camilo A. Adas, Senior Manager of Development and responsible for the proving ground says, "This proving ground represents our way of preparing for the future. With these tracks, we can test the most technological and innovative

Mercedes-Benz trucks. Our proving ground is a further contribution in the direction of innovation and evolution, reinforcing our presence in the Daimler Group's global development platform." ■

FIDELITY FIGHTS BACK

If you've been around long enough, you'll remember when hi-fi meant sitting in front of two loudspeakers in a room, spending time dedicatedly listening to music – something many young people have never experienced. Today, premium audio increasingly means smart speakers, sound bars, and headphones. And nobody seems to sit anywhere for very long.

Over the past three decades, the way we consume music can be described by some as surrendering quality to convenience. Music media itself has transitioned from analogue to physical digital, to downloadable digital, to streaming digital, with increased loss and compression all along the way.

Loudspeakers have followed a similar path, as carefully crafted sound fields ceded their place to compact, wireless smart speakers, often found in several different locations within a single home. In fact, smart speaker unit shipments were up more than 90% in 2018 alone. Even traditional home theatre surround systems are being increasingly replaced with sound bars, with sound bar shipments up by over one million units in 2018.





BY: JUDE MANSILLA
 Founder and Principal
 of Head-Fi.org

Jude Mansilla is the Founder and Principal of Head-Fi.org, the world's largest online hi-fi community, focused on headphone audio, sound quality, and emerging technological advancements. ■

SMART SEDUCTION

How did this happen? What seduced us into surrendering quality for convenience so easily? The bulk of the answer is probably right in front of you, and fits in the palm of your hand. It's your smartphone.

The Pew Research Center reports that an astounding 81% of Americans now own a smartphone. That's a number akin to every single American alive over the age of 14 – one-third of whom Pew found are online “almost constantly”. Consider that our phones are portable screens, packed with advanced media capabilities like high-resolution audio and video, constantly connected to the sum total of the world's media, all of which is ours to enjoy instantly and on-demand.

How does such a thing not become our new media hub? It's easy to see how traditional hi-fi has come to occupy a diminishing place within our lives.

Hi-fi, however, is still alive and well. Headphones, both over-ear and in-ear, have now become the prevailing transducer for mobile platforms. They are, like smartphones, both portable and ubiquitous. In 2018, the worldwide headphone market was 380.7 million units, representing a value of US\$22.9 billion, both of which are staggering, growing statistical realities.

What is perhaps more surprising is that consumers have now begun to yearn for fidelity once again. As headphones have evolved into the primary means of audio delivery for many of us, we have ceased to view them as merely acceptable alternatives, now demanding greater sound quality. “Mass premium” headphones (US\$200 and above) comprise one of the fastest growing segments of the headphone market, accounting for 29% of the total market value with only 6% of the unit volume!

Naturally, people are also showing a greater willingness to pay for improved content itself. Spotify recently revealed it now has over 100 million Premium users, a six-fold increase since 2015. That's over 100 million Spotify customers with access to their highest tier of streaming quality (320 kbit/s equivalent). And while boutique music streaming services like Qobuz and TIDAL have been offering high-resolution (higher-than-CD-quality) music streaming tiers for years, that space has been validated perhaps most strongly by industry giants Amazon.com and Sony launching their own high-resolution music streaming services.

Like many others in the Head-Fi community, I'm an unabashed, unapologetic, proud audiophile, and even I am encouraged and excited by trends I'm seeing for the future. Remembering where premium audio has been, looking at where it is now, and peering into the future to see where it's going, is as exciting as the market itself.

Unless otherwise indicated, all market data was provided by Futuresource Consulting. ■

“I'M AN UNABASHED,
 UNAPOLOGETIC,
 PROUD AUDIOPHILE.”

JUDE MANSILLA



A NEW WHITE PAPER FROM THE STACKS

APPLICATION OF SOUND SOURCE IDENTIFICATION USING CLEAN-SC ON A TURBOFAN ENGINE



Identifying acoustic sound sources is a key issue for low-noise design of propulsion systems. The Japan Aerospace Exploration Agency and Brüel & Kjær have been involved in acoustic measurements using sub-scale models and full-scale systems.

Propulsion systems, for example, jet engines and rocket motors, are the main intensive sound sources aircraft and space vehicles. In this white paper, the authors have tried to detect these sound sources using phased array microphones. Successful examples are the comparison of the sound source maps observed behind the mixer nozzles of a turbojet engine, or at the exhaust of the launch pad model. The CLEAN-based spatial source coherence (CLEAN-SC) method as well as non-negative least squares (NNLS) detects sound source maps with better

resolution, compared to former approaches such as the delay and sum (DAS). This paper describes the application of CLEAN-SC techniques on a small turbofan engine, DGEN380. A 9-armed foldable array was placed at the side of the engine in an open environment. For comparison, a random-geometry array for wideband holography (WBH) was included in the engine test during the test cell operations. The source maps by the CLEAN-SC agreed well with the results of existing methods of the DAS, WBH and NNLS, and provided better resolution in detecting sound sources. The extended CLEAN-SC, correlating a reference signal in the array with other array signals, suggested a potential for evaluating directional contribution of jet noise source. ■

SEE MORE

Read the full white paper at

www.bksv.com/whitepapers



THERE AND BACK AGAIN, AN ARTIST'S TALE



Courtesy of John Grzinich

Jacob Kirkegaard is a Danish sound artist and composer whose work has been presented across the world in galleries, museums, international art exhibitions and concert spaces, and is represented in the permanent collection of LOUISIANA – Museum of Modern Art in Denmark. Jacob is also a founding member of the sound-art collective freq_out and the non-profit arts organization TOPOS. In 2016, Kirkegaard was the sound-artist-in-residency at St. John's College, University of Oxford, UK.

Jacob Kirkegaard began playing the guitar at 12, transitioned to the cello and was lured into using sound to create art by a radio programme that introduced him to something called *musique concrète*, a style that uses recorded sounds as the raw materials for the finished product. For Jacob, the natural world is filled with music, hidden and unedited deep within the earth's surface or caught in the current of an urban waterway. ►

THERE AND BACK AGAIN, AN ARTIST'S TALE



Courtesy of Inuk Silis Høegh

"AS AN ARTIST, I COULD CREATE A HORRIBLE IMAGE THAT MAKES PEOPLE CLOSE UP AND PUSH IT AWAY, BUT IF I CAN MAKE SOMETHING INTERESTING, WITH A KIND OF AESTHETIC, THAT WILL BRING THEM CLOSER AND GIVE THEM AN AWARENESS OF THAT EXPERIENCE."

JACOB KIRKEGAARD

For more about Jacob and his compositions, visit fonik.dk

THE SEEMING SILENCE ISN'T ALWAYS GOLDEN

The goal of Jacob's work isn't only to paint a vivid picture of problems in the world or shock his audience with gruesome details of a planet in terror. That, he believes would be counterproductive. According to Jacob, "we, as humans, distance ourselves from things that make us uncomfortable. How do we learn to deal with what distances us?" And with that mindset, he looks for ways to create what he calls a listening space, a space that will encourage reflection on the world around us that we don't want to see or hear. He has composed

sound works from the abandoned spaces in Chernobyl and Fukushima and of melting ice in the Arctic. With his latest works, listeners take a trip, following waste with recordings in Denmark, Latvia and the extreme destination of the Dandora dumpsite in Nairobi, Kenya, and its challenges with waste management, and he broaches the uncomfortable topic of the final stop in the human condition, exploring acoustic environments related to human post-mortem.

In many of his works, Jacob must find a way to close the distance between the

audience and those things that make them uncomfortable. And the subjects of his latest works – burning trash and decomposition – are far from the comfortable zones most of us live in.

HEARING ABOUT IT ANOTHER WAY

In Kenya, Jacob spent a considerable amount of time recording massive piles of waste. The sun beating down on the trash generates enough heat to start fires and create a wasteland of burning plastic. It's in this noxious environment that some of the locals wander through the waste looking for salvage, braving



Dandora dumpsite in Kenya. There is currently legislation for the relocation of the landfill but disputes concerning the new site have delayed the process

Courtesy of Jacob Kirkegaard



Courtesy of John Grzinich

The same durability and high seismic resonance provided by the titanium housing and design of Type 4514-002 that enabled Jacob to measure inside piles of waste or mounted on massive incinerators at extreme temperatures were the same qualities he would need for recording in Kenya. ■

toxic levels of heavy metals and other pollutants – a few suffering burns from the smouldering fires.

What could possibly make this a scene that draws one in? Just about everything that can be seen in this scenario is unappealing and, likely repels rather than attracts. To get past the distancing visual, his goal is to bring his audience closer in, to go beyond the macro dystopian visuals to an audio microcosm and find the sounds and rhythms of the waste. On the surface, there is the wind blowing across the debris, creating a soundscape of the surface, but deeper in, there is the settling decomposition of the waste beneath.

TOOLS OF THE TRADE

Since he first began his artistic journey, his efforts to procure the recordings that he would use as the raw materials for creating his sound spaces would require more equipment than standard microphones. He was first introduced to recording with accelerometers and hydrophones while working on his master's degree at the sound department at the Academy of Media Art in Cologne,

Germany. Since then he has used them many times to get recordings in some very extreme environments – from using hydrophones to record the cracking, melting ice from deep inside glacial crevices in Greenland to recording with an accelerometer to capture the sound of thermal springs and volcanic activity in Iceland.

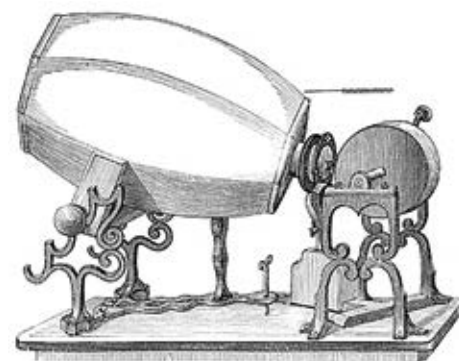
WHERE THE SOUND TAKES US

Thinking outside traditional recording methods allows Jacob to get inside the environment, be it mounds of trash or melting ice, and record the vibrations as the raw audio tracks that he uses to create the final piece. After scrutinizing his recordings, he can begin to identify the natural rhythms and tones produced by the burning, settling, decomposing heaps of trash and layer the tracks on themselves to build a new sound, disassociating the audience from the source material and providing a listening space where they can reflect on the moment they are in, and then step across that threshold to associate that moment with the things they don't want to see – or hear. ■

“EVERYTHING HAS SOUND, BUT MY EARS ARE SO LIMITED. USING HIGHLY SENSITIVE GEAR, I CAN GO BEYOND MY CAPABILITIES. WITH MY MEASUREMENT MICS, HYDROPHONES AND ACCELEROMETERS, I CAN HEAR THIS WONDERFUL WORLD OF ‘MICRO-SOUND’, THIS POPPING, CREAKING, PULSE IN EVERYTHING.”

JACOB KIRKEGAARD

SO, WHAT IS THIS?



Look closely, think, and then turn to page 25 to find out if you are right.



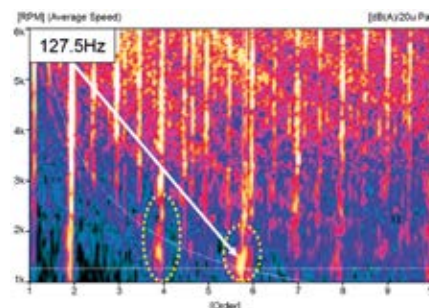
FROM DIAGNOSIS TO SOLUTION – FAST

What can be done with an interior noise problem? By applying advanced tools and methodologies, the cause of interior vehicle noise can be quickly developed and validated to derive a solution.

Engineers in the automotive industry continue to be under pressure to reduce the time-to-market, while designing vehicles with respect to noise, vibration and harshness (NVH). With thousands of components interacting within a vehicle structure, noise is hard to predict and to design for. Engineers must anticipate problems and have the right tools and expertise to identify and solve NVH problems in the final phase.



BY: **EDMAR BAARS**
Co-founder
Vibroacustica



The order and its frequency: order 5.8 at a frequency between 120 to 130 Hz, as the compressor has five pistons and the pulley ratio is 1.16

TRIAL-AND-ERROR METHODS UNSUCCESSFUL

In one case, Vibroacustica was able to assist a customer that had been working for months, with some success, to identify the source of an interior vehicle noise problem, which had begun when the heating, ventilation and air conditioning (HVAC) system was modified. At speeds from 1300 to 1500 rpm, the interior noise increased by around 10 dB.

Engineers were trying to figure out if the source of the noise was the HVAC system itself or if it was the path that was transmitting the sound. The HVAC noise transmission involves several sources and paths and several natural frequencies coupling together. So, it was difficult to identify the main noise source and the main path by traditional trial-and-error methodology.

SOURCE PATH CONTRIBUTION METHOD

Vibroacustica has been a Brüel & Kjær partner since 2010 and provides engineering services for the whole of Latin America, specializing in noise, vibration, and thermodynamic applications. It also has experience working on compressors used for refrigeration.

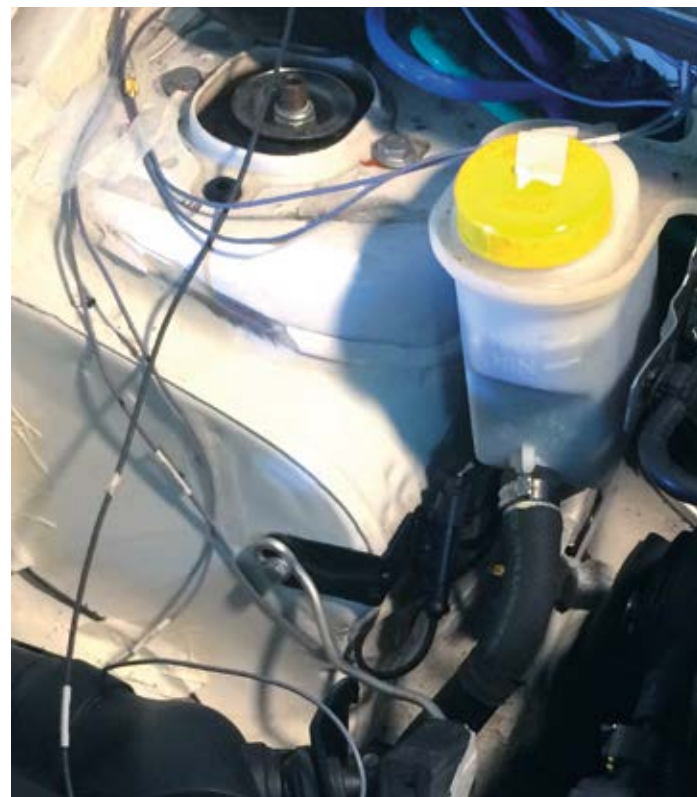
The Vibroacustica engineers worked with their customer's engineers and applied advanced methods including source path contribution (SPC) techniques, experimental modal analysis, and operating deflection shapes (ODS) analysis to fully understand the problem.

The SPC method was fundamental in identifying the cause of the noise and indicating a direction to follow. This method meant the engineers could understand how vibrations developed from the HVAC system into effects at the receiver position, and enabled them to trace the noise back to the specific root cause.

UNDERSTANDING THE CAUSE

Understanding the cause of the problem is essential to achieving a successful solution. Engineers used an energy propagation map to visualize how energy was propagated from the source to the interior of the vehicle in the form of noise. This map helped them to elaborate on their hypotheses and to apply the SPC method.

From the energy propagation map, a hypothesis diagram was built, which presented possible causes that could generate the problem.



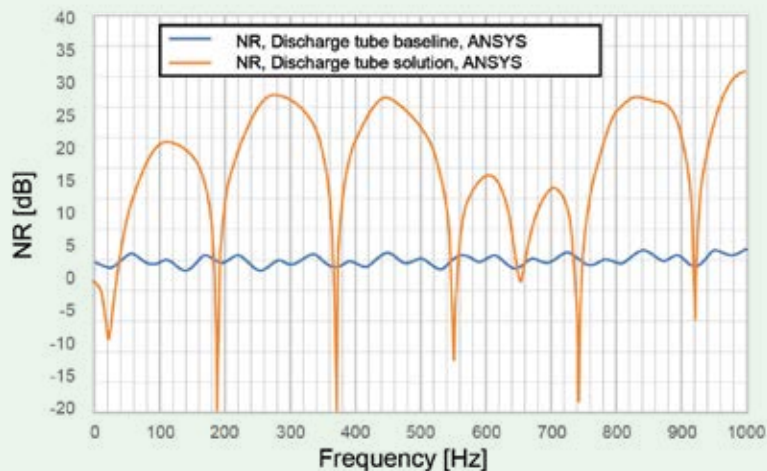
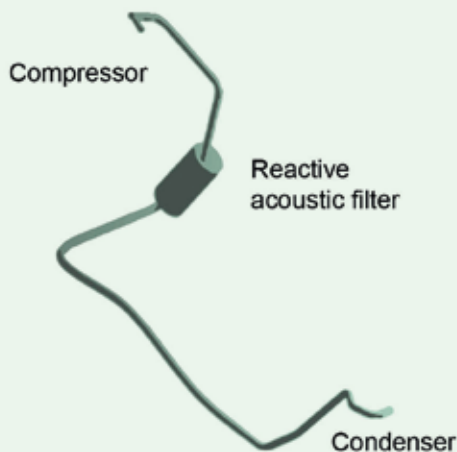
FINDING THE BEST RESPONSE

Using these methodologies, the engineering team discovered that the main cause of the problem was the new compressor, which had a high discharge gas pulsation that excited the condenser's natural frequency, coupled with the front chassis natural frequency.

A number of options existed to change the structural power transmission path: changing the chassis, changing the condenser, and/or changing the radiator/condenser assembly pads. However, the team knew that it is often more complex and less effective to pursue this type of solution because they could risk shifting the problem to another rotation or frequency. An alternative type of solution is to reduce the excitation; that is, to reduce the pulse that reaches the condenser. ►

FROM DIAGNOSIS TO SOLUTION - FAST

Ten filter configurations with different volumes were evaluated to meet the 15 dB attenuation criterion around 130 Hz



Considering the time available, the engineers decided to introduce a reactive acoustic filter in the high-pressure piping between the compressor and condenser. The volume was defined by numerical simulation, using the acoustic finite element method. The noise reduction was simulated and several filter configurations with different volumes were evaluated to meet the 15 dB attenuation criterion at around 130 Hz.

VALIDATED SOLUTION

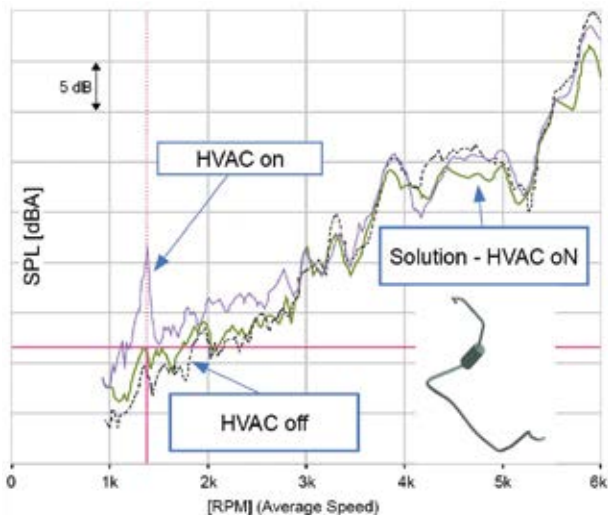
To confirm the proposed solution, a prototype was built and tested on a vehicle. The internal pressure level results showed

a 10 dB reduction at 1350 rpm. So, the proposed solution successfully reduced the internal noise levels to the same levels as when the air-conditioning system was off.

In just 10 days, the engineers were able to clearly identify the main cause of noise inside the vehicle and to develop and validate a solution based on prototype tests, demonstrating the significant advantage of applying relevant methodologies and simulation to these types of problems.

In fact, Vibroacustica continues to apply these solutions in different situations for problem-solving, benchmarking, and to gain a deeper understanding of issues. As Edmar Baars, one of the founders of Vibroacustica explains: "We use the SPC methodology to estimate the operational forces and then use these forces to simulate internal noise and develop noise control solutions by simulation, looking for the internal noise level and spectrum. The SPC method is an invaluable tool that can identify main paths and solutions, evaluate modifications, compare subsystem sensitivity, and estimate the excitations force." ■

Overall sound pressure level measured inside the vehicle as a function of the engine speed when the AC is on and off



PHOENIX TESTLAB PREVENTING GAPS IN A

360° TEST LAB

Based in Blomberg, Germany, Phoenix Testlab GmbH is an independent and accredited test laboratory and certification institute for products, systems, and components from various sectors of industry. ►



PHOENIX TESTLAB PREVENTING GAPS IN A 360° TEST LAB

The LDS V8 shaker system with its new hydrostatic bearing table



PHOENIX TESTLAB

Phoenix Testlab, celebrating its 25th anniversary this year, covers a wide range of test disciplines. The breadth and depth of their test capabilities allows them to provide a full set of tests, coordinating all the activities within the same facility and taking care of the entire process for the customer removing the need to coordinate different service providers.

MEETING THE CHALLENGES OF A CHANGING WORLD

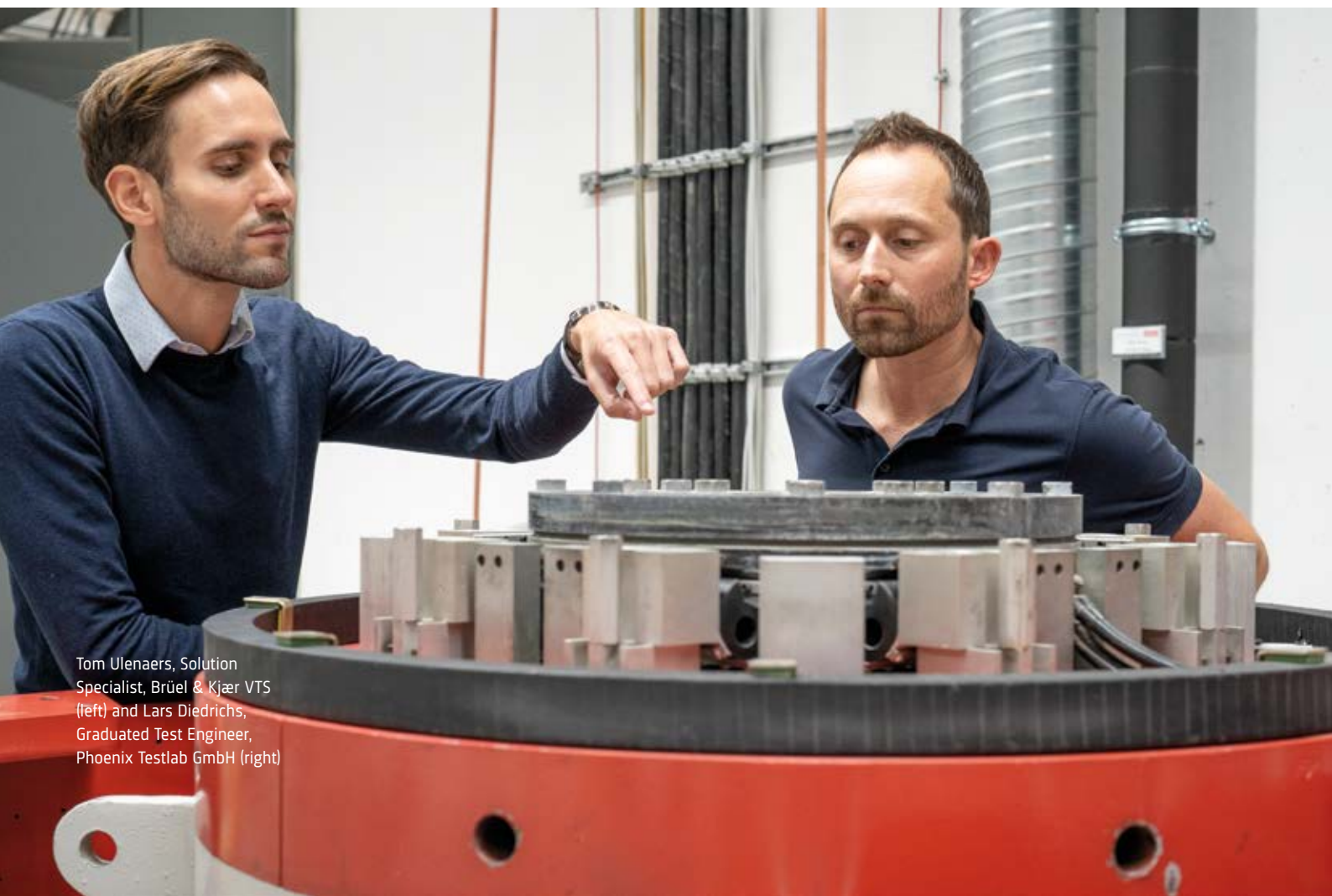
To meet the latest requirements in its testing

endeavours, the test house must undergo continuous adaptations and upgrades. Current and future test procedures can therefore be performed in accordance with international standards to support customers' needs ranging from product development to market introduction.

Nowadays, test houses are facing multiple challenges from their customers: faster product launches and realization, an increasing number of stakeholders per project and the frequent release of new test technologies and standards. To meet

the latest requirements in its testing endeavours, the test houses must undergo continuous adaptations and upgrades. Additionally, companies like Phoenix Testlab are facing growing pressure to deliver increasingly complex customer projects on time, while ensuring the high quality expected of a test lab.

Test house customers are also looking for a full-service package that includes the construction and manufacture of fixtures, data monitoring, testing and submission of reports and certifications. In addition,



Tom Ulenaers, Solution Specialist, Brüel & Kjær VTS (left) and Lars Diedrichs, Graduated Test Engineer, Phoenix Testlab GmbH (right)

Brüel & Kjær VTS'
Global Field Service
team at work



with several people involved in the same project, Phoenix Testlab must seamlessly liaise with them all. To be able to offer customers peace of mind while ensuring a fruitful revenue generation, the test house must ensure that their equipment is up to date with standards and regulations and that equipment uptime is maximized.

VIBRATION TESTING AND MORE

Phoenix Testlab has recently installed a new hydrostatic bearing table on an LDS V8 shaker system, one of their eight LDS shaker systems.

This means that the test house has the ability to not only simulate test theoretically, but it can also run the equipment with the latest toolsets and physically perform the tests to the latest standards.

At the beginning of the year, the test house invested in a Brüel & Kjær platinum contract to cover its LDS shaker systems. This all-inclusive solution has a same day technical call back response. Lars Diedrichs,

IT'S A TWO-WAY STREET

Brüel & Kjær Associate Product Manager, Carlotta Basile comments that, "Phoenix Testlab is an important representative partner, and we always want them on board. At the moment, we are working on the release of a new technology for our shaker systems, and Phoenix Testlab is a part of this development and review process. We take inspiration from this customer-centric approach. It is the result of many years of positive work together". ■

Graduated Test Engineer, Phoenix Testlab, says, "We want to be a reliable partner and service provider for our customers. To ensure this, we chose the platinum coverage. Our claim to quality and professionalism means that our customers should not be affected by any technical problems in the laboratory."

WHAT THE FUTURE LOOKS LIKE

Phoenix Testlab is growing at a fast pace, and this is one of the reasons behind its recent investment in a new testing facility and its focus on understanding new trends, such as battery testing. In fact, some Phoenix Testlab laboratories are fully booked for the next 12 months. Furthermore, they have also noticed a growing interest in monitoring and bench design, as well as a need for improving the connection and communication between shakers and climatic chambers. Mr Diedrichs summarizes, "Our collaboration with Brüel & Kjær is very positive, their service engineers are knowledgeable and very competent – quite simply we trust them". ■

SPOT THE DIFFERENCE

Can you spot the five differences between these two pictures?

See the solution on page 39.



OPTIMIZING THE FUTURE DRIVING EXPERIENCE

From sustainability to safety, electric vehicles to autonomous cars, the automotive industry is transforming rapidly. With the market narrowing, the user experience will be the differentiating factor, and one future trend – simulation – will be invaluable.

"The VW Dieselgate accelerated the end of the diesel era," says Giorgio Adriano, Business Development Manager, Automotive, Brüel & Kjær. "Diesel may not be as bad as it's made out to be, but the result is clear. OEMs are rapidly moving towards electrification, at high costs."

There's currently little competition in the electric vehicle (EV) or hybrid (HEV) market, with each vehicle enjoying its own broad segment. But in just five years, the market will close up as more OEMs launch their own hybrid or electric model. Down to the battery's chemistry and components, there will be little in terms of technology to differentiate vehicles at each price point. That leaves two to three cars at a similar price, and with similar components, range, and performance.





Giorgio Adriano,
Business Development
Manager, Automotive,
Brüel & Kjær



Dave Bogema,
Product Manager –
NVH Refinement,
Brüel & Kjær



Mark Allman-Ward,
Senior Application
Specialist,
Brüel & Kjær

"It's a technical challenge and a business model challenge," explains Dave Bogema, Product manager – NVH Refinement, Brüel & Kjær. Millennials are more environmentally conscious and under more economic pressure than the boomers before them. Will upcoming generations buy as many cars? And what will ownership look like in 10 to 20 years? New technologies such as autonomous driving will open up whole new opportunities for ride-sharing and shared-ownership models. "We're at an inflection point," says Dave Bogema. "The industry is undergoing a big change – and change goes hand in hand with innovation."

SOUND AND VIBRATION AS THE DIFFERENTIATOR

Whether it's a choice between a purchase or service, an EV or autonomous car, as the market evolves and narrows the user

experience will be the ultimate differentiator. As Mark Allman-Ward, Senior Application Specialist, Brüel & Kjær, explains: "Aesthetics has traditionally been a key focus area for OEMs – but when you sit in a car, you can't see its colour! Meanwhile, speed limits cap your max speed and give a similar driving efficiency. That leaves the driving experience as the differentiator: suspension, driving dynamics and noise, vibration and harshness."

NVH has long played a subtle but important role in the driving experience. From the slam of the car door to the beep of a low fuel warning, the wrong noises can make a car sound cheap and unreliable – regardless of the actual cost and quality. The right noises add a sense of premium quality, and even pleasure and excitement, and the vehicle's sonic identity can further differentiate the model or brand as a whole. Future trends and technologies bring more opportunities to develop the driving experience through NVH.

THE SOUND OF ELECTRIC

Designing the sound of EVs brings new challenges and opportunities. All cars need to become more efficient. For combustion engines this is to meet tightening fuel regulations, while for EVs it's about increasing range. But decreasing weight increases noise and discomfort. This poses a particular challenge for electric engines, which make little sound to mask the road and wind noise.

Sound designers need to get creative to make the best user experience for EVs. The sound of a combustion engine is both a familiar and a pleasant one for many drivers. But EVs offer a blank slate and the chance for innovation. ►

"WE CRAVE INFORMATION. IF YOU'RE NOT INVOLVED, YOU CAN ONLY PROCESS WHAT'S LEFT. EVERY SINGLE SOUND IN THE CAR WILL BE MORE SIGNIFICANT WHEN YOU'RE NOT DRIVING."

MARK ALLMAN-WARD,
SENIOR APPLICATION SPECIALIST



OPTIMIZING THE FUTURE DRIVING EXPERIENCE

Regulations in both the EU and the US are making warning sounds for pedestrians mandatory. But drivers are also missing crucial feedback from the electric engine, from torque to the basic “Is this thing on?”. This can’t all be done visually – or with more annoying beeps. As Giorgio Adriano describes it, “The sound and haptic feedback should welcome and guide you, from opening the door to sitting down, from pushing the start button to letting you know the car is ready to go and, finally, generating a sound that will make driving that car a unique experience.” We are heading into an age of digital NVH, where the basic sounds of the car can be managed reasonably well by the development teams. The sounds, and to some extent the vibrations, the users experience can then be added late in the development by software or a data upload.

THE DRIVERLESS DRIVING EXPERIENCE

Communicating through sound and vibration will be even more important with autonomous cars, where there’s less involvement and less trust, especially at the beginning. “We crave information,” says Mark Allman-Ward. “If you’re not involved,

you can only process what’s left. Every single sound in the car will be more significant when you’re not driving.” The volume of information available, when you consider car-to-car communication, is set to grow exponentially – some of that will be interesting to occupants, but there will be far too much information to deliver it all visually.

Some people will want to know exactly what the car is doing. Others will want to use the space to work or relax. Sound designers will need to remove unnecessary sound and vibration and consider the best way to convey crucial information. This could be haptic feedback when the car is speeding up or slowing down, or a pleasant sound when riders reach their destination. The whole experience, from seat configuration to sound preferences, can be personalized through explicit or learned feedback.

LOOKING INTO THE FUTURE

Simulation in product design and development is becoming more prevalent and more important. Used in the automotive industry for years, simulation is now becoming faster, more accurate, and more heavily relied on. Brüel & Kjær and VI-grade have a unique set of tools to simulate NVH, driving dynamics, and Advanced Driver Assistance Systems (ADAS). The result is a quicker, cheaper development process – increasing development efficiency and reducing time to market. And with a user experience that will make the vehicle stand out in the future market.

“It’s one thing to calculate that a change will be ‘3dB louder’,” says Dave Bogema. “But that doesn’t mean much to most people. What does that sound and feel like? The NVH simulator brings all this data to life so you can make design and development decisions easily and with confidence.” ■

AVAS REGULATIONS

New EU regulations came into force in July 2019, requiring all new electric vehicles to be fitted with an Acoustic Vehicle Alert System (AVAS). In the US, the National Highway Traffic Safety Administration will require all new electric vehicles to emit artificial noise by September 2020. A car’s AVAS must sound when reversing or travelling below 12 mph (19.3 km/h) in the EU or 19 mph (30.5 km/h) in the US. ■

NVH SIMULATION

Developers make changes throughout a vehicle’s development. It is useful to evaluate the effects of alterations and trial alternative design solutions – such as modified components – in a virtual prototype. With Brüel & Kjær’s NVH simulation, it is possible to test the NVH effects of alternative designs back-to-back, without making a physical prototype. Simulations can combine real-world test data and data from Computer Aided Engineering (CAE) models, interfacing with all common CAE codes. ■

“WE’RE AT AN INFLECTION POINT. THE INDUSTRY IS UNDERGOING A BIG CHANGE – AND CHANGE GOES HAND IN HAND WITH INNOVATION.”

DAVE BOGEMA,
PRODUCT MANAGER – NVH REFINEMENT

THE TECHNICAL DESIGN CHALLENGES OF THE OMNIDIRECTIONAL SOUND SOURCE



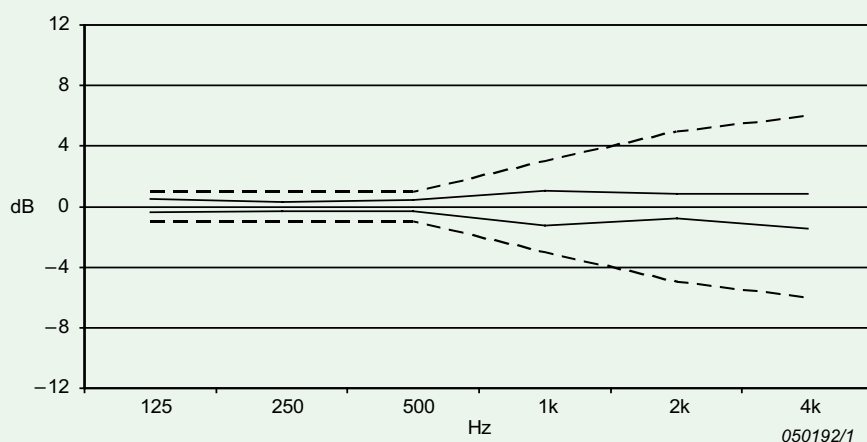
BY: HAN VERTEGAAL
ACOUSTICS
ENGINEERING

The omnidirectional sound source is the most described and used source in building and room acoustic measurements. Usually, little thought is given to it, yet this seemingly simple device has several interesting aspects of which many may not be aware. Here, we focus on some of the technical challenges we encountered when designing and constructing an omnidirectional sound source.

DIRECTIVITY

The core requirement regarding sound sources for building acoustics and room acoustics is the sound directivity. The maximum deviation from the mean sound pressure in any direction as a function of frequency is specified in ISO 140 (building acoustics) and ISO 3382-1 (room acoustics).

Directivity for OmniPower Sound Source



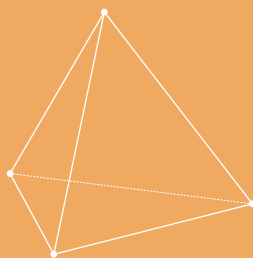
Directivity for OmniPower Sound Source Type 4292-L according to ISO 3382: maximum deviation from mean for gliding 30° arc. Upper and lower curves are the ISO 3382 tolerances

Each standard has different limits, with ISO 3382-1 being somewhat stricter than ISO 140.

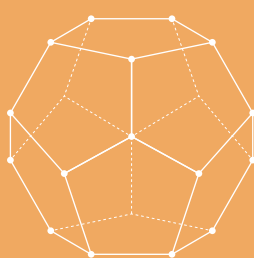
The directivity of a sound source is mainly determined by the shape of its enclosure, and to a lesser degree by its loudspeakers. The most uniformly built shapes are the regular polyhedral, or Platonic solids:

tetrahedron, cube, octahedron, dodecahedron and icosahedron. The dodecahedron, with its 12 faces, provides a good fit for the directivity requirements in the ISO standards. A relative of the dodecahedron is the icosidodecahedron, which has 12 pentagon-shaped faces and 20 triangular faces. These small triangular faces reduce the overall outer diameter and provide space for connectors, grips, threaded holes and rubber feet, resulting in a more ergonomic and aesthetically pleasing device. Although more difficult to construct than the dodecahedron, these advantages justify the choice of the icosidodecahedron for Type 4292-L. ►

Regular polyhedra



Tetrahedron

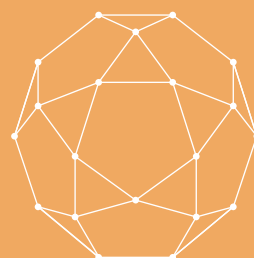


Dodecahedron



Icosahedron

Icosidodecahedron



THE TECHNICAL DESIGN CHALLENGES OF THE OMNIDIRECTIONAL SOUND SOURCE

Grip, rubber feet and top mounting hole



SPECTRUM

The minimum required frequency range in 1/3-octave bands for ISO 140 is from 100 Hz up to 3150 Hz, optionally expanded at either end to the 50 Hz and 5000 Hz bands. The minimum range for ISO 3382-1 is the full octave bands from 125 Hz to 4 kHz, and for speech transmission index (STI) measurements, the 8 kHz full octave band is also required. The resulting range to cover all these standards and applications is 50 Hz to 10 kHz in 1/3-octave bands. To accomplish this, the source needs wideband loudspeakers. Adding a woofer for low frequencies can sometimes be useful, but this complicates the source and makes it non-concentric. Covering the full range with the 12 wideband loudspeakers is the preferred option.

In addition to the range of the spectrum, ISO 140 also specifies that, in a given source room, adjacent 1/3-octave bands should not differ in level by more than 6 dB. This requirement cannot be guaranteed by the source alone, as it also depends on the acoustic properties of the room itself. Equalization of the source signal may therefore be required. The 'eq' noise signal in Brüel & Kjær's Power Amplifier Type 2734 has been 'pre-equalized' for Type 4292-L, minimizing the chance that

the level difference between adjacent bands exceeds 6 dB in real-world measurements.

STABILITY

Although not specified in any of the standards, the stability of the output level and spectrum over time is a very important property and often overlooked. OmniPower Sound Source Type 4292-L is capable of handling high power for many hours with minimal changes to the spectrum and output level.

The cooling is determined by both the design of the individual loudspeakers as well as the construction of the sound source enclosure. OmniPower is equipped with loudspeakers that were developed specifically for this application. The lightweight neodymium magnets used in this loudspeaker are much smaller than

the traditional ferromagnet which also means they have a much smaller surface area from which to radiate heat. A heatsink was added to remedy this problem while keeping the loudspeaker weight well below that of a traditional design. Additional self-cooling capacity was added by using a phase plug, which enables improved airflow around the voice-coil.

Eventually the heat radiated by the loudspeaker must reach the environment, and a metal enclosure is essential to transport heat energy from the inside of the enclosure to the outside. Type 4292-L uses aluminum to optimize weight and thermal conduction.

The first designs of the OmniPower Sound Source uncovered an interesting phenomenon that surprised even the loudspeaker manufacturer. The workmanship was such that some enclosures



W 130 SN: a specifically developed loudspeaker in close cooperation with Visaton GmbH



Mounting piece with vent hole above the connector

were completely airtight. As the air inside the enclosure heated up, the internal air pressure also went up. This in turn restricted the movement of the diaphragm, reducing the natural cooling of the voice-coil. At high power, this would quickly lead to a runaway temperature, stopped only by the voice coils burning out! This prompted the addition of a small vent to equalize the pressure inside and outside the source.

SOUND LEVEL

In general, for sound insulation measurements, very high output levels are desirable to ensure levels sufficiently above the background sound levels in the receiving room. This can place significant strain on the loudspeakers, which will heat up until thermal equilibrium is reached with the surroundings, or until the loudspeaker voice-coil melts.

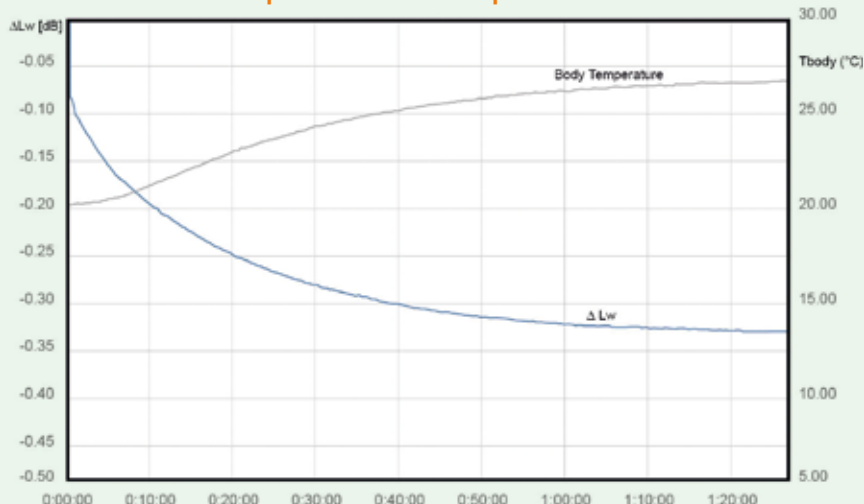
Efficient cooling ensures that the loudspeakers reach thermal equilibrium as fast as possible after the initial voice-coil

heating. The electrical resistance of the voice-coil rises with temperature, causing the acoustic output of the source to drop. This so-called compression happens very quickly, typically within 10 seconds after applying a high-power signal, at which point the output level may have dropped by approximately 0.1 dB. As the voice-coil continues to heat up until thermal equilibrium is reached, the drop in output power should be minimal, particularly during a measurement.

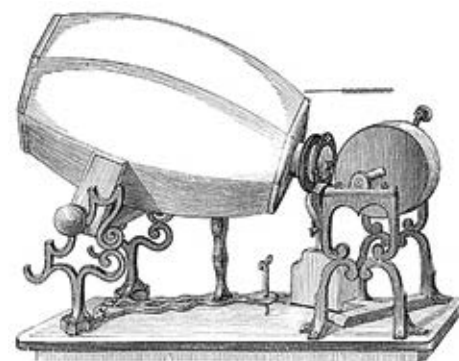
MAINTENANCE

As with other measurement equipment, it is not only important that a sound source functions as specified when new, but also that it continues to do so after years of use. To this end, Brüel & Kjær offers a certification service for Type 4292-L. In the certification process, the source is first taken through a regular production test, where any repairs that may be needed are performed. It is then measured and checked for compliance to its specifications by an independent laboratory. ■

Relative broadband pink noise sound power level vs time



SO, WHAT IS THIS?



The phonautograph

Thomas Edison is the name generally associated with the first recording and playback device (1877), and that same year, a French poet, Charles Cros, got some acclaim for submitting a description of a recording/playback device called a paleophone (though none were known to have been made) to the Académie des sciences. However, the device shown 'half-way' beat both of them to the punch. Another Frenchman, Édouard-Léon Scott de Martinville, patented the phonautograph in 1857 and created the earliest known recording of a human voice that same year. Unfortunately, the device could only record the sound, not play it back; it took the advent of the computer age to enable playback. ■



You can hear an 1860 recording here

THE PURRRFECT POWER

A purring cat is a contented cat, and although that is often the case, cats also purr when injured, frightened or giving birth. In fact, there is extensive documentation that suggests that low frequencies, at low intensity are therapeutic. Cats purr during inhalation and exhalation at frequencies between 20 Hz and 150 Hz. These frequencies correspond exactly with the best frequencies determined for bone growth, fracture healing, pain relief, relief of breathlessness and inflammation. In a way, cats purr the pain away. ■

The low frequency of the purr helps promote bone strength

The vibrations from purring stimulate healing, helping your body fight infection and reduce swelling

A cat's purr decreases the symptoms of dyspnoea (difficult or laboured breathing)

Purring can help heal muscle, ligament and tendon injuries



WHO SAID WHAT?

Listening to a
cat's purr lowers
blood pressure

Petting a cat calms
nerves, reducing
stress levels

The healing power of
a cat's purr extends beyond
self-healing. It is also very
therapeutic for humans

Cat owners have
40% less risk of
heart attack



"THERE IS GEOMETRY
IN THE HUMMING OF
THE STRINGS, THERE
IS MUSIC IN THE
SPACING OF THE
SPHERES."

PYTHAGORAS OF SAMOS
(C. 570 – C. 495 BC)

This phrase attributed to Pythagoras could represent an early form of String Theory. The Pythagoreans believed that there was an underlying foundation of numbers that made up the essence of things. The "geometry in the humming" displays a direct relation to that concept, but the "music of the spheres"? The ancient philosophers conceptualized the celestial movements as spheres – Aristotle noted 55 of them. Their music refers to the mathematical harmony of their arrangement and movements. ■

HURRAY FOR THE ... RATS?



Strange as it may seem in 2019, people are still being seriously injured or killed by landmines placed in wars that, in some cases, have been over for decades.

There are ongoing efforts to clean up these millions of hidden mines, but it's dangerous work. Different techniques have been developed over the years to make it safer, but there's a new innovation that combines a rat and an accelerometer-laden backpack.

APOPO is a non-governmental organization that has been using rats, which they have dubbed HeroRATs, to find landmines and detect tuberculosis. Andrew McGregor became aware of them and their HeroRATs while working as a photojournalist in DR Congo during fighting there in 2007. Seeing what war and its accoutrements do to children, in particular, Andrew McGregor initiated a project to do something about it. One result was a wearable accelerometer-based technology, he co-invented with roboticist Ian Ingram, that aids the rats' training and helps them communicate to their handlers when they find a landmine.

Due to their fantastic sense of smell, intelligence, trainability and very low

breeding and feeding costs, rats make excellent landmine detectors. An added bonus is that they are too light to set off the mines. Currently APOPO click-trains rats to target specific scents. While the rats are highly proficient and successful, they are still rats, and the search method relies on visual cues picked up by a human handler.

The accelerometer-based system is an effort to improve training by further standardizing indication behaviour and facilitating field determinations by creating a secondary notification system. Andrew emphasizes, "We are still in the prototype stage; we have not solved everything we need to solve." Development is ongoing, and they continue to identify behaviour through acquired data that can help rats communicate with handlers. In the meantime, there are profoundly courageous people routinely removing landmines every day. Andrew closed the interview commenting, "The most effective tool we have is harnessing our collective moral and political will so that these weapons are cleaned up and never used again." ■

Andrew McGregor



SOUND GENERATION – STRUCTURE-BORNE SOUND

Previous articles covered the transmission of sound through air and how it is picked up by human hearing. This article addresses sound generation, particularly the vibration of solids and how that leads to sound – using an acoustic guitar as an example.

To generate sound, energy must be transformed into mechanical oscillations, and those oscillations must be efficiently transferred into the air. With a loudspeaker, there is electrical energy with a signal already containing the desired oscillation sequence. Electromagnetic interaction between a coil and a magnet transforms the electrical energy into the mechanical motion of a membrane, which then transmits the energy to the air.

However, in many systems the supplied energy does not have an oscillatory form. In the case of a guitar, we energize the system by pulling the string. When released, the string falls into an oscillation caused by the interaction between the string's tension force and its mass. In simple words, whenever the string is plucked, the tension force will try to return it to its default position, a straight line between its two anchor points. This accelerates the string so that the string gains momentum, which will keep the string going past the neutral position and deflect it to the opposite side. This in turn reactivates the forces

that try to straighten the string. This give-and-take repeats again and again to produce an oscillation.

STRING MOTION

Slow-motion playback of a plucked string shows that – rather than swinging from side to side – the 'triangular' displacement of the string will move around in cycles as two kinks, see box 1. The reason is simply that the string is a waveguide. Analogous to sound waves moving through air, the energy propagates as waves on the string, spreading from the initial point of disturbance to then moving back and forth between the string's anchor points. It is possible, however, to look at the vibrations differently: as the combination of several so-called standing waves. A standing wave is a pattern where the crests and troughs have fixed positions, so in contrast to normal wave motion, we do not see them travel. They are the result of waves travelling in opposite directions along a waveguide and interfering with each other, adding their effects or cancelling each other out. ►

SOUND GENERATION – STRUCTURE-BORNE SOUND

Observers will experience the result of the combination. If the timing of the oppositely travelling waves is such that these constructive and destructive interferences always happen at the same location, there won't be a perception of travelling; instead, the waves appear to stand still, but with an oscillating amplitude.

Each of these standing waves is associated with a frequency, the number of cycles per second that the string swings from one side to the other with that pattern, see box 2. The shape with the longest wavelength that can fit between the string's fixed endpoints is the half-sine wave. It has the lowest repeat rate. This frequency is known as the fundamental, and it is the frequency that we perceive as the pitch of the tone generated



BY: **MATHIAS SCHOLZ**
User Interface Designer
PhD Applied Acoustics
Brüel & Kjær

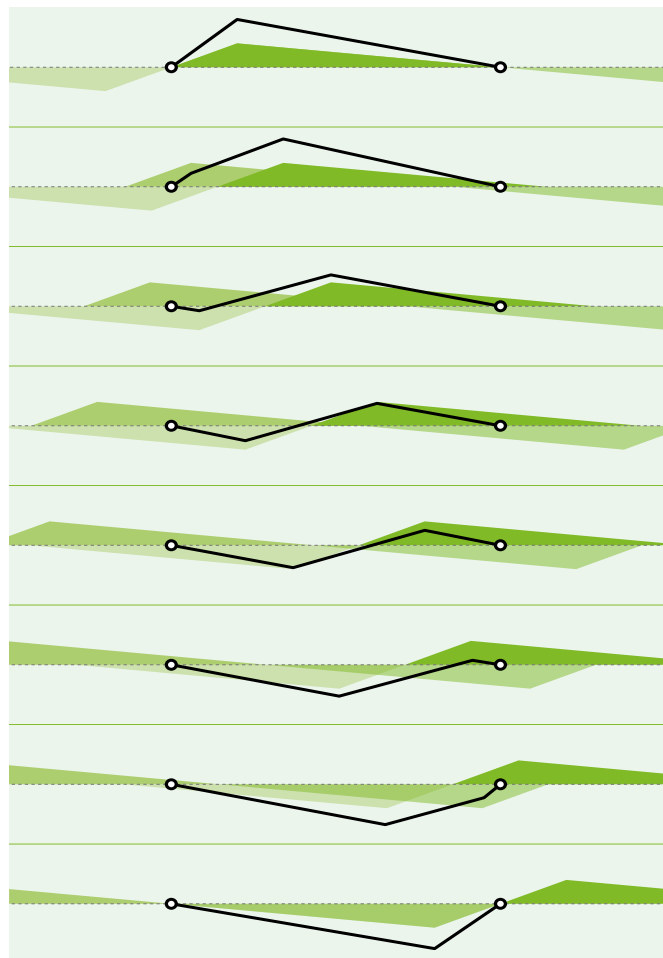
by the string. The other patterns are repeated at almost perfect multiples of the fundamental frequency – for each cycle of the fundamental, the others have already repeated two or more cycles. The more complex the shape, the higher its associated frequency. These additional frequencies are called overtones, and they enrich the sound.

While each of these shapes just moves from one side to the other, adding their displacements together gives the travelling, triangular disturbance. Looking at vibrations over time (the travelling kinks) or considering the individual frequencies (standing waves) is just two sides of the same coin. They are tightly connected: they just provide different insight into the same process. ■

BOX 1: WAVE MOTION ON A STRING OVER TIME

As soon as the string is released, the initial disturbance splits in two parts, simultaneously travelling along the string in both directions. When a kink reaches the end of the string, it is reflected and travels in the opposite direction, swapping sides. When the two waves align again, they briefly form the same, but mirrored displacement as during the initial plucked state. They then pass through each other, and the process repeats itself. During each cycle, a bit of the energy is passed on to the body of the instrument or lost due to damping, such that the magnitude of the displacement gets reduced over time.

Wave theory often describes wave reflection by adding a second wave arriving from beyond the end of a waveguide, here shown below the dashed line. Together, the waves on the guide and their counterparts must fulfil the boundary conditions. In this case, the condition is that the string can never move at its ends, it is fixed. This is only achieved if the waves presenting the reflections have a displacement of the same magnitude but opposite sign, cancelling each other out at the supports. After the waves meet, the ones representing reflections will enter the waveguide, whereas the original waves leave it by continuing beyond the fixed points. ■





This article continues on our blog! For the rest, including sections on damping, radiation and even modal analysis, please visit bksv.com/Part2

BOX 2: STANDING WAVES ON A STRING

The shape for the fundamental and its overtones will be the same for any string, though the associated frequencies depend on its length, mass and tension. An increased mass slows down wave propagation on the string, while an increased tension does speed it up. Looking at a guitar this is rather intuitive: the thicker, heavier strings create the lower pitched notes, and increasing the tension by turning the key will gradually raise the pitch of any string. Given a certain speed of wave travel, the longer the string, the longer it will take a wave to make one complete cycle on the string.

Thus, length, mass and tension stretch or shorten the timing for the interference of the oppositely travelling waves. The fundamental frequency for a string is then found by taking the inverse of the time it would take a wave to once travel back and forth between its supports. ■

Wave speed on string: $c = \sqrt{\frac{T}{m}}$ with T being the tension force in newtons [N] and m, the mass per unit length of the string in [kg/m]

Fundamental frequency: $f_1 = \frac{c}{2L}$ with c being the speed of wave travel on the string in [m/s] and L the string's length in [m]



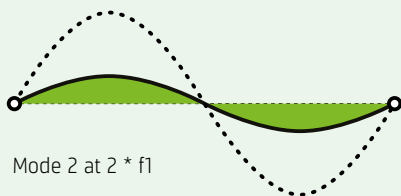
Mode 1 at f_1



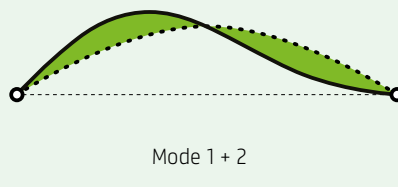
Mode 1



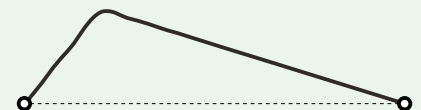
First 10 modes



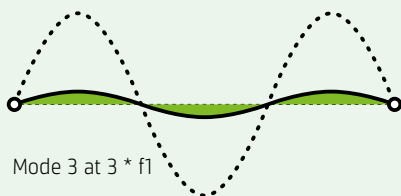
Mode 2 at $2 * f_1$



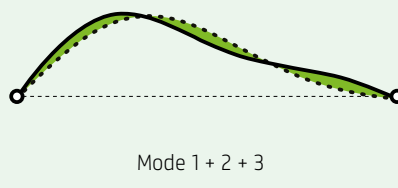
Mode 1 + 2



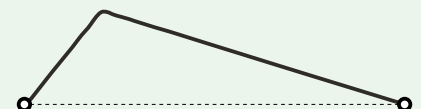
First 20 modes



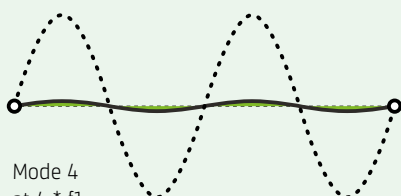
Mode 3 at $3 * f_1$



Mode 1 + 2 + 3



First 40 modes



Mode 4
at $4 * f_1$



Mode 1 + 2 + 3 + 4



First 80 modes

EXPERT PROFILE

THE HUMBLE GURU OF STRUCTURAL DYNAMICS

A brilliant mathematician, the Vold in Vold-Kalman, developer of groundbreaking algorithms, patent holder, published author, award winner and former infantryman – the knowledge, skills, experience and achievements of this ‘60% retired’ 72-year-old Norwegian are endless.

When his father got a job in Oslo, 10-year old Håvard Vold left Voll on the northwest coast of Norway. Despite moving to the city, the young Håvard and his mother spent idyllic, often soggy, summers travelling the country in old Austins, Rovers and Humbers camping out and enjoying nature with his map-maker father.

A lifetime of brilliance later, we caught up with Håvard Vold, who has returned to his hometown, where he combines a rural lifestyle with consulting work and local politics.

[What drew you to mathematics?](#)

I went to school in Oslo and did not distinguish myself in any way. I preferred languages, history and soft sciences but when I discovered the history of physics and classical math, something



clicked, so I went to the University of Oslo to study mathematics. There, I became involved and interested in a group of students and a pioneering faculty that ran the first general purpose computer on the campus. Math was transformed from proofs of existence to 'how do we compute credible approximations' to the solutions of monumental equations from mechanics, physics and chemistry. I was also enrolled into the Simula 67 language project to develop and programme random number generators for discrete event simulation. Simula 67, an extension of Algol 60, was the first ever object-oriented language, complete with classes, inheritance, polymorphism, encapsulation and virtual functions. This language was a precursor of the C++ language.

When did you become interested in structural dynamics?

My notoriety in computer science and numerical analysis translated into a job as junior lecturer at the University of Stuttgart's Institute of Statics and Dynamics of Aerospace Structures where I was mainly involved solving large equation systems on computers. In fact, the Institute was one of the pioneers of the Finite Element Method. I can honestly say that this was the first time I learnt anything whatsoever about engineering. Before that I had been an officer, a gentleman and a university don, but suddenly I found out that math and computers could be used for something useful.

Later, I was hired by SDRC to help write the new finite element code that was to go into what became known as the I-DEAS suite of programmes. All the work I'd been doing up to then was analytical and numerical, working on analytical models but SDRC had a test lab and that was the first time I'd seen dynamic and modal testing in action. A light bulb went off in my head – this was not just theory. Suddenly, I could see mode shapes and measure them – nature does behave in this way.

How did you evolve the polyreference method?

In the early 80s, SDRC and the University of Cincinnati had started looking at multi-point random excitation in modal testing, that is, when you basically put on several, independent and incoherent signal sources for vibration excitation. Traditionally, for complex structures, you found modes of vibration by looking at resonance peaks in the complex domain using sinusoidal excitation. However, this method required human judgement on whether two, closely spaced modes were repeated roots (a duplicate mode with linearly independent modal vectors) or truly independent modes. ►

HÅVARD VOLD

EDUCATION

1996 – 1974: PhD, Applied Mathematics, University of Oslo (UiO)

PREVIOUS JOBS

2004 – 2015: Vice President, Senior Technical Fellow, ATA Engineering

1993 – 2004: President, Vold Solutions, Inc.

1980 – 1993: Vice President, Senior Technical Fellow, Structural Dynamics Research Corporation (SDRC)

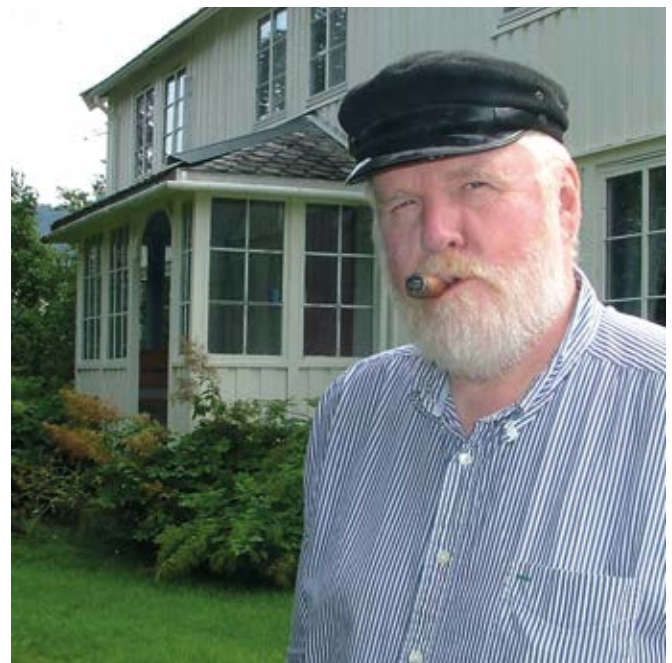
1984 – 1993: Adjunct Professor of Mechanical Engineering, University of Cincinnati

1978 – 1980: Co-founder, Teknisk Data, A/S

1974 – 1977: Assistant Professor, Institut für Statik und Dynamik, University of Stuttgart

1970 – 1974: Research Assistant, Inst. Math., University of Oslo

1968 – 1980: Infantryman, Royal Norwegian Army Reserves ■



THE HUMBLE GURU OF STRUCTURAL DYNAMICS



Then some people discovered an old technique by Gaspard de Prony from the 1790s, now known as the complex exponential method. I was asked by SDRC to explain it, and I found out that I could incorporate multiple exciter locations in the same computation, meaning that suddenly we'd have multiple views into a structure's dynamic characteristics such that we could separate modes of vibration that were close in frequency. It was a much more unbiased way of looking at things and provided a numerical method for dealing with repeated roots, symmetry and closed roots in a way that was never possible before

without human judgement. This was especially important for aerospace structures, which are close to being symmetrical and with light to medium damping.

SDRC recognized the commercial importance of the method and wanted to brand it. Since the core of the method related to resolving the individual contributions from multiple inputs (shakers), referred to as 'references' in SDRC parlance, it was baptized Polyreference.

"I SHOULD REALLY HAVE EITHER BEEN AN INFANTRYMAN, A PHYSICIST OR A MATHEMATICIAN BUT ENDED UP HAVING ALL KINDS OF GOOD CLEAN FUN IN ENGINEERING, SPECIFICALLY METHODS DEVELOPMENT."

HÅVARD VOLD

The first commercial implementation of the technique was in a programme called Modal Plus running on PDP-11s and, due to the popularity of the programme, we got extensive feedback from both the automotive and aerospace industries.

What were the challenges you have faced in your work over the years?

There have been so many things that would have been wonderful to work on but along comes an accountant saying: "there's no budget available". That, or "what you've done is good enough". It's as if researchers, developers or scientists were toddlers, then employers would be grown-ups telling them what they can't do.

What's the most rewarding thing you have done?

The continuous scan method in acoustics. In 2007 Brüel & Kjær and ATA collaborated to do acoustic holography on jet plumes. The technique allows you to calculate the sound field at any location using measurements of the sound pressure on a surface surrounding a given source so that you can get really pretty pictures with stream lines and phase information and all kinds of things that you don't have in beamforming.

By assuming that the noise source was stationary, we substituted a continuously moving microphone array which overcame the need for interpolation between point measurements on a classical array, which is particularly useful at high frequencies where microphone spacing requirements, due to short wavelengths, become the limiting factor. So instead of a cloud of measurement points, we now have a cloud of paths and the measurement density is much higher allowing more accurate measurements.

Since that initial work, we've continued the development and I've authored several papers on the subject and it's now being propagated to other countries and applications. I'm very proud of that because it's thinking outside the box. I'm not a professional acoustician so I never considered how difficult it might be – I just have ideas. Most of the time you get your face smacked but occasionally, things work out.

Share defining moments in your work.

In terms of modal testing, the aha moment was when I discovered that the single-channel, single-exciter, single-output equations could be reformulated into multiple-input multiple-output equations so now they're matrices and vectors instead



of scalars. This means that what we're getting out is consistent as opposed to looking through a series of keyholes and trying to put together a scene from a limited number of views. Now we have a total view of everything.

What is your greatest achievement and why?

In terms of producing an algorithm, I would say that my greatest contribution has been the Vold-Kalman filter, especially because of the impact it has had on preventive maintenance, troubleshooting and improvement of rotating equipment.

The Vold-Kalman filter is a time-domain method, which developed from work I started with Jan Leuridan from LMS on order tracking by Kalman filters. I developed the second generation of this filter with the support of SDRC and Brüel & Kjær. Unbeknownst to me, they decided to call it the Vold-Kalman filter and the name stuck. The method is mainly being used in the advanced work that's being done in the field of rotating equipment, and that makes me very proud. ▶

THE HUMBLE GURU OF STRUCTURAL DYNAMICS



“WHEN I WAS A RESEARCH ASSISTANT AT THE UNIVERSITY OF OSLO’S INSTITUTE OF MATHEMATICS, I DISCOVERED FFT AND THAT CHANGED MY LIFE.”

HÅVARD VOLD

Any unattained ambitions?

I think I’ve been incredibly blessed in my work and the opportunities I’ve had. I have been married 45 years and counting, I have family, friendship and the respect of my peers. We may aim for the stars but hitting the treetops ain’t half bad.

What are the best and worst decisions you have ever made?

The worst decision was to proceed on a copyright infringement case. I was given a finding of \$8000 in damages and ended up with a \$500,000 bill in lawyer’s fees. That was one really bad decision – even though I was right. I understood then that studying math is for idiots. I should have been a lawyer.

The best decision was moving back to the family farm. It’s good for the soul.

Is there one person who has inspired you in your life?

My wife Leita has been a wonderful inspiration. She’s always been a trooper, she has spine, she has worked with me, she has given me ideas, she has told me when to shut up. She has provided sense and sanity in my life and she is very smart.

Do you still wrestle with mathematical problems?

Yes, but they are not anything worthy of a Fields Medal. It’s more about the crafting side of mathematics where you try to put things together to make them work – I get algorithms to work.

Do gurus ever retire?

As long as I enjoy doing technical things, I will continue to do some consulting work. I’m still like a 12-year old boy who hasn’t discovered girls but who is having a great time finding out how a clock works – I still get a thrill from looking at gizmos and neat solutions to engineering problems. I’m also having fun fishing and exploring the fjords in my boat in all kinds of weather. The reason I moved back to the Norwegian countryside was to be close to my family, the familiar mountains and my old fishing spots. My mantra is: use your body, use your mind and you must smell the roses. ■

WHAT CHARGE INJECTION CALIBRATION IS AND IS NOT

Charge injection calibration (CIC; invented and patented by Brüel & Kjær in the middle of the 90s) is a convenient method to verify the integrity of a condenser microphone measurement channel, including the microphone cartridge, without any need for operator interaction.

Figure 1. CIC circuit. Typical values for a ½-inch microphone:
 $C_m = 15 \text{ pF}$, $C_c = 0.2 \text{ pF}$,
 $C_i = 0.1 \text{ pF}$ and $R_i = 15 \text{ G}\Omega$

INTRODUCTION

While CIC is not technically a 'calibration' method, the technique is sensitive to any change in the microphone cartridge's capacitance and the connected preamplifier (and cable), which indicates the microphone channel's condition.

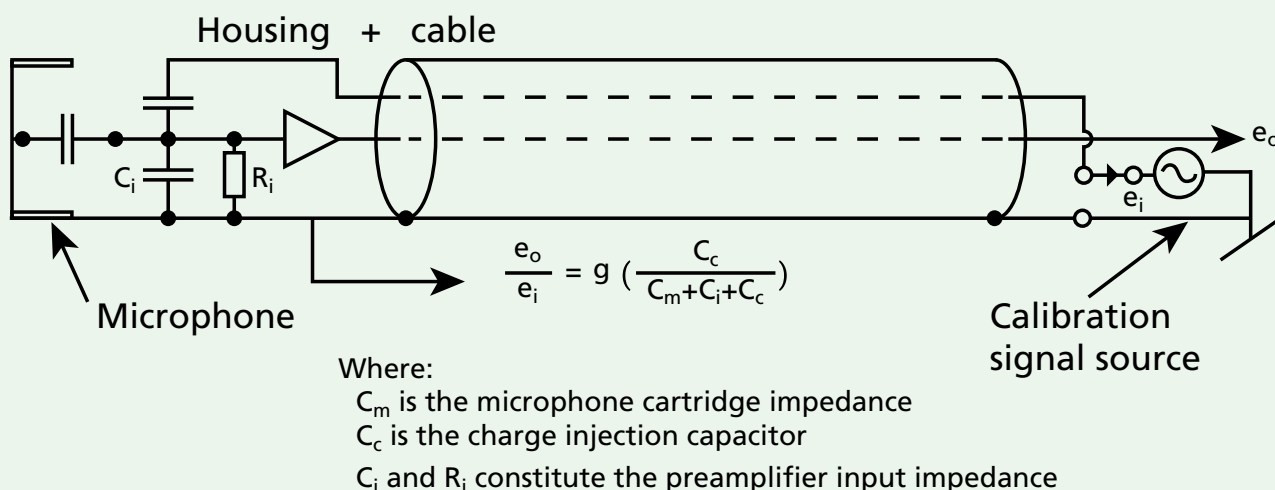
THE PRINCIPLE

In CIC, a signal is introduced through a small, highly stable capacitor built into the preamplifier in series with the combination of the microphone cartridge and preamplifier input, see fig. 1. The signal is divided between the small capacitor and microphone-preamplifier impedance, leading to an output approximately inversely proportional to the microphone cartridge capacitance. Any change in the microphone capacitance will be reflected in a change in the output from the measurement channel.



BY: **ERLING SANDERMANN OLSON**
 Specialist in
 microphone calibration
 Brüel & Kjær

As the signal is introduced directly to the microphone cartridge, changes in the electrical part of the channel will also be reflected in the output. When the signal is turned off, the capacitor has a small contribution to the input capacitance of the preamplifier with very little influence on the properties of the measurement channel. ►



WHAT CHARGE INJECTION CALIBRATION IS AND IS NOT

Figures 2a, b and c:
Comparisons of responses
that differ from the normal
condition indicate faults

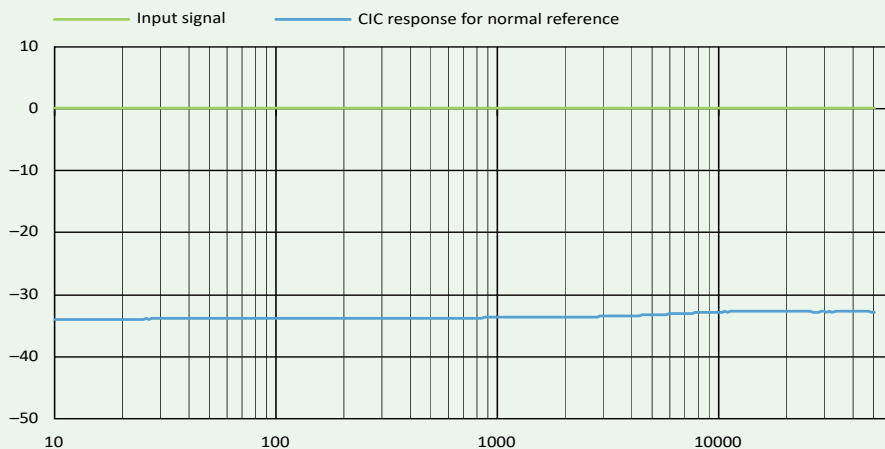


Figure 2a:

Normal working condition

This graph represents the input and response for a prepolarized microphone in good operating condition and no faults. The output derived under these conditions is used as the reference signal for future checks

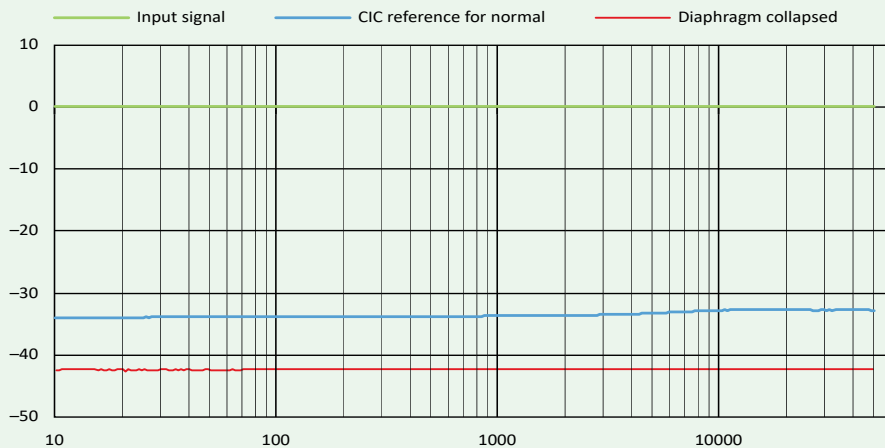


Figure 2b:

Reduced response signal

This graph represents a typical response pattern for a prepolarized microphone that has been damaged, and the microphone diaphragm has collapsed and is touching the backplate. The result is that the CIC signal is significantly reduced compared to the reference signal

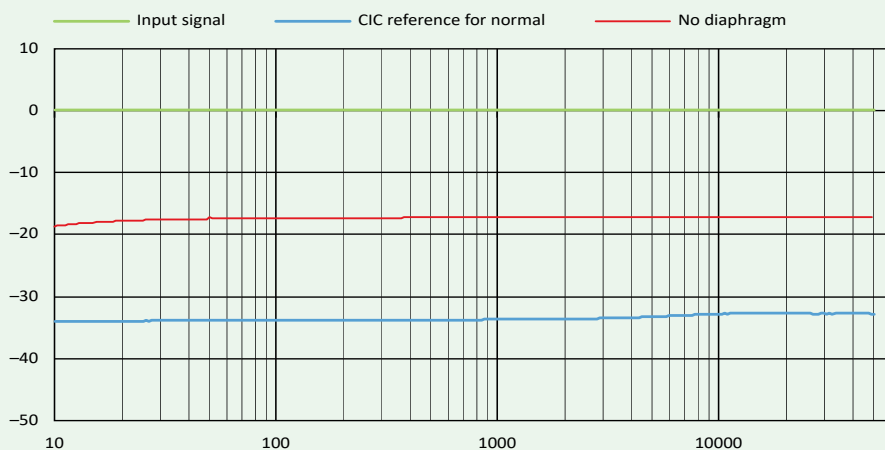


Figure 2c:

Increased response signal

This graph represents a typical response pattern for a prepolarized microphone that has been damaged and the microphone diaphragm has been destroyed (or missing for some reason). The result is that the CIC signal is significantly increased compared to the reference signal

SPOT THE DIFFERENCE

CIC IN USE

To use CIC, the measurement channel's response to the CIC signal is registered for reference, while the channel condition is known. A signal is applied for verification, and the response is compared to the reference response. If there is no difference, it is an indication that the channel is still in good condition.

Deviation from the reference response strongly indicates a fault in the measurement channel, and an investigation of the channel is required. Typical faults that can be detected with CIC include broken diaphragms, short-circuited microphones, contact failure between cartridge and preamplifier and cable breaks.

Other faults may be detected with CIC, depending on how severe they are. Changes in diaphragm tension or polarization voltage directly influence

the sensitivity and frequency response of the microphone, but such changes have a relatively small influence on microphone cartridge capacitance. For example, a 2 dB change in the diaphragm tension of a typical sound level meter microphone changes its capacitance (and thus the CIC signal) by approximately 0.5 dB.

CIC is not a replacement for acoustical verification, but CIC can extend the interval between routine acoustical calibrations. Also, CIC is an excellent tool for registering severe faults, but is limited when checking for small sensitivity changes, and even less effective for checking microphone frequency response. With high-quality, stable microphones, faults are likely to be due to events that significantly change the microphone. A stable CIC response is a reasonable indication that the measurement channel is functioning correctly. ■

The BK Connect® Acoustic Camera on page 19 was modified in five places.

Did you get it right?



SEE MORE

www.bksv.com/acousticcamera

WHAT CIC ACTUALLY IS..., FOR THE PERNICKETY TYPES

CIC is not actually a 'calibration' method. The name was intended to emphasize its application. To avoid the use of electrostatic actuators in outdoor microphones – due to a risk of false alarms and damage to the microphone – insert voltage preamplifiers were used to check the electrical part of the channel.

These preamplifiers are normally used for open-circuit sensitivity microphone calibration. This method was termed insert voltage calibration (IVC).

Later, microphone capacitance was included in the check, which was a leap forward in the channel check compared with the initial IVC method. To emphasize the leap forward, IVC became CIC. ■

SOMETHING QUIET THIS WAY COMES



Applus+ IDIADA offers design, testing, engineering, and homologation services to the automotive industry worldwide. A team of more than 2,700 professionals and an international network of subsidiaries and branch offices in 25 countries ensures that customers receive a fast and personalized service. IDIADA's headquarters, composed of a 360-hectare main technical centre, that includes its own proving ground and a comprehensive set of laboratories, is located near Barcelona, Spain.



Irene Arroyo Chao, is in charge of exterior noise tests at Applus+ IDIADA, and she is a woman on a mission – a mission to make sure that you know what's coming your way. ■

Photos courtesy of IDIADA



Traditionally pass-by noise measurement is a requirement for all automotive manufacturers as part of product certification, with measurement procedures defined in local and regional standards to ensure that noise levels are not exceeded, but times change. The introduction of extremely quiet electric vehicles (EVs) and hybrid vehicles (HVs) introduces more changes and challenges than just a different propulsion method; 'too loud' now only covers half of the problem. At higher speeds, tyre and wind noise conceal the noise of most modern internal combustion engines (ICEs), but these new EVs and HVs rolling down the roads can be very quiet before they're moving fast enough to generate that wind and tyre noise. It has therefore become necessary to enforce minimum noise requirements to ensure the safety of pedestrians in traffic, so in addition to the current noise level requirements for all vehicles, new standards, specifically for EVs and HVs, have been introduced: Federal Motor Vehicle Safety Standard (FMVSS) 141 and United Nations (UN) Regulation No. 138 (UN 138), and more regional and national standards are in various stages of approval.

A LOGISTICAL SOLUTION TO THE EVERY-DAY WORLD

It turns out that these vehicles are so quiet that ambient noise can be an issue when testing. Travelling at 10 km/h vehicles must produce a minimum of 50 dB(A), at 20 km/h, 56 dB(A) and for the reverse test at 6 km/h, the minimum is 40 dB(A). These levels are sufficiently loud to alert nearby pedestrians, but they are not exactly deafening, which can present some problems in testing. Test tracks performing minimum noise testing outdoors may be influenced by external noise from surrounding areas, and this ambient noise can be present around the vehicles' target levels. ►

“THE STANDARD WAS A NECESSARY FURTHER STEP TO IMPROVE THE SAFETY OF PEDESTRIANS AND THE MOST VULNERABLE ROAD USERS.”

IRENE ARROYO CHAO
APPLUS+ IDIADA

SOMETHING QUIET THIS WAY COMES



This makes it very difficult for the testers to determine if the vehicle is complying with the standard, or if they are measuring the surrounding environment. While the software has the tools needed to identify the data they need, Irene's team elected to adopt a simpler solution. They shifted the test times to the early morning hours, negating the need for the additional post-processing.

THE NEEDED NOISE COMES FROM...

Along with minimum noise levels, FMVSS 141 includes stipulations for a shift in the amplitude (dependent on changes

In the European market, all new types of quiet vehicles must be equipped with an AVAS and comply with UN 138 by 1 July 2019, and all new vehicles must comply by 1 July 2021. ■

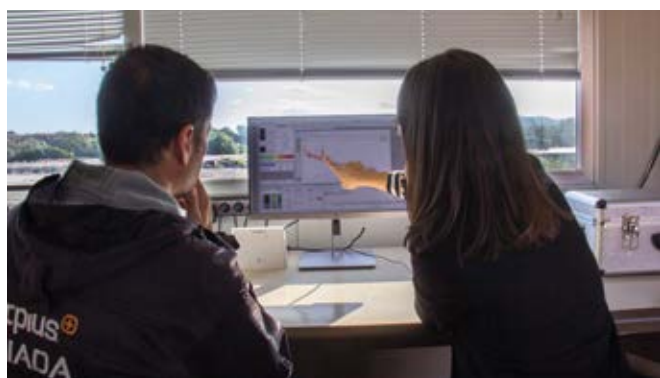
in velocity) of specified frequencies. Similarly, UN 138 defines minimum noise levels, but requires a shift in the frequency (dependent on changes in velocity) of specified frequencies. And because, of course, quiet vehicles (such as EVs and HVs, when not using their ICE) cannot inherently meet those requirements, they must be equipped with an Acoustic Vehicle Alerting System (AVAS). Vehicles must meet the requirements of FMVSS 141 (the US standard) or UN 138 (the European standard), depending on where they will be sold. IDIADA can test for either standard, and additionally provide design and system development, at the customer's request.

INSIDE OR OUT?

Another option their customers can request is indoor pass-by testing. While indoor pass-by testing can provide some advantages, some manufacturers find that they need to increase the volume of their AVAS because their initial evaluations may have included additional vehicle noise source paths, such as tyre noise. IDIADA currently works with a range of vehicles, from cars to buses and trucks, and in particular, in the moving scenario, buses and trucks are more likely to be above the noise limits based purely on the physics of vehicle contributing source paths.

PASS OR FAIL

In the end, the results come down to a pass or fail. Irene's team tests the vehicles and processes the data. The data provided by the system enables the homologation department to provide an easy go or no-go for sale in Europe/Spain or the US, which – in turn – results in a safer world for the public. ■



"WE'VE HAD A GOOD EXPERIENCE WITH THE PASS-BY SYSTEM. THE GUI AND WORKFLOW MAKE THE SYSTEM EASY TO USE AND DERIVE THE RESULTS WE NEED."

IRENE ARROYO CHAO
APPLUS+ IDIADA

ACOUSTIC CAMERA GETS DOWN TO WORK AT **WAVE ENGINEERING**

The most recent addition to consultancy Wave Engineering's acoustic measurement toolbox is a state-of-the-art BK Connect® Acoustic Camera. It's already been put to good use distinguishing problem noise sources from other noise sources at industrial facilities, successfully finding leaks in modular wall systems and investigating sound isolation problems.

A consultant's work is never dull, as Wave Engineering's noise experts can attest. Their projects vary tremendously, ranging from reviewing and interpreting LEED (Leadership in Energy and Environmental Design), ANSI, ASTM, and ISO acoustic standards to evaluating and designing electronic sound masking systems for speech privacy and providing expert witness and forensic engineering services.

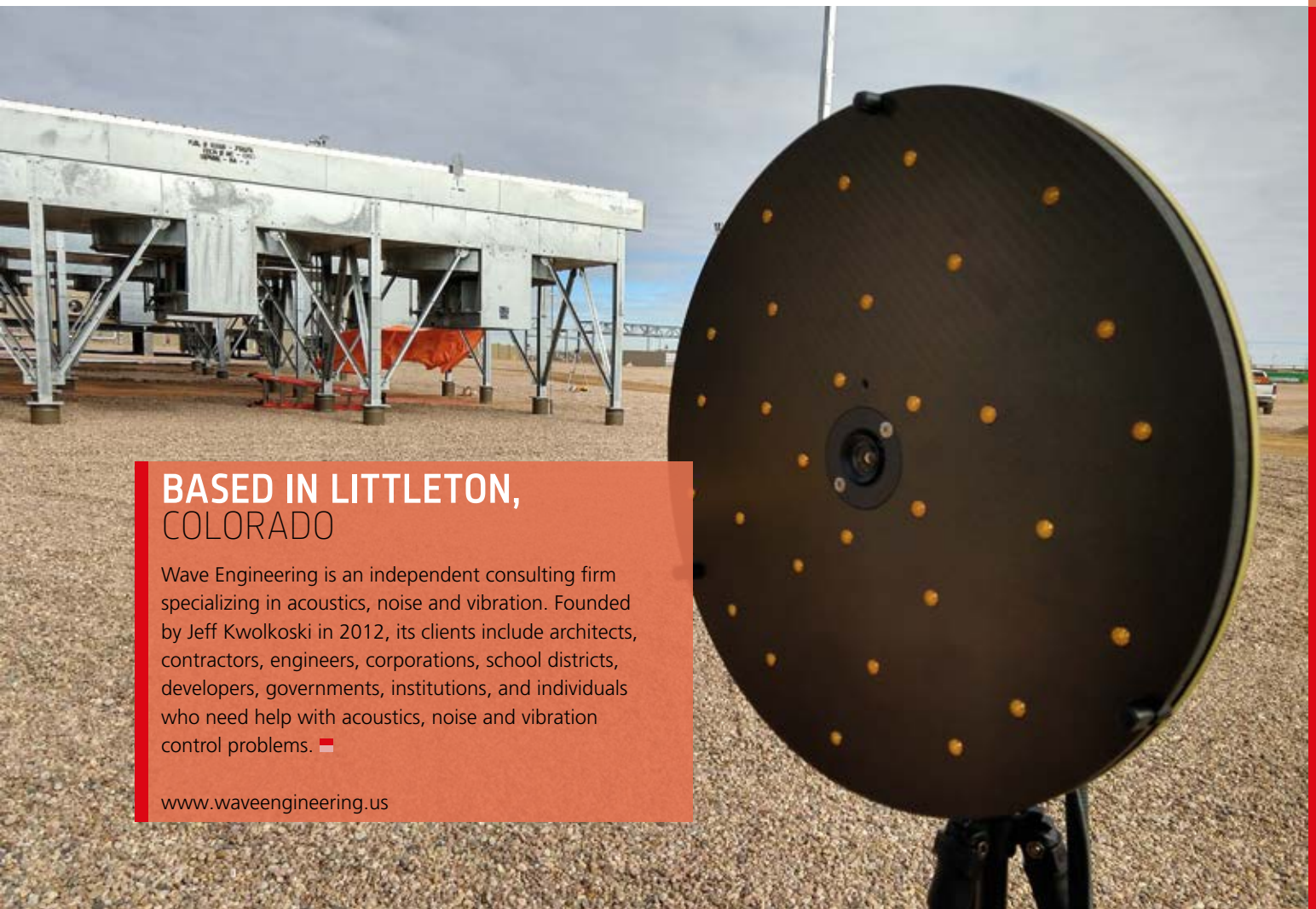
LATEST ADDITION TO THE TEAM

The noise experts at Wave Engineering were recently joined by a Brüel & Kjær Acoustic Camera – a portable solution that is used to locate and view transient sound sources on site using an aim, shoot and measure procedure. ►

BASED IN LITTLETON, COLORADO

Wave Engineering is an independent consulting firm specializing in acoustics, noise and vibration. Founded by Jeff Kwolkoski in 2012, its clients include architects, contractors, engineers, corporations, school districts, developers, governments, institutions, and individuals who need help with acoustics, noise and vibration control problems. ■

www.waveengineering.us



ACOUSTIC CAMERA GETS DOWN TO WORK AT WAVE ENGINEERING

Wave Engineering President and Senior Acoustical Engineer, Jeff Kwolkoski says, "The camera allows us to actually see sound radiation and leaks. Originally designed for aerospace and automotive noise applications, we are using it for industrial, environmental, manufacturing, architectural, and other innovative noise applications."

With its 30 microphones, sophisticated signal processing and software to identify the loudest noise source among a host of other noise sources, the Acoustic Camera allows Wave Engineering's team to pinpoint sound leaks in walls, doors and floors, and to target the required noise mitigation. It is also used to find transient and intermittent noise sources on equipment or machinery, and to identify which components

of large equipment are causing excessive noise. Acoustic treatment can then be applied only where necessary.

PINPOINTING NOISE SOURCES

Jeff Kwolkoski describes a recent project, "We were contacted by an industrial facility concerned about noise that was causing complaints from nearby neighbours. There were many sources producing noise and contributing to the noise radiating from the facility. By testing and making computer-based models of the facility, we were able to predict which noise sources were the most significant noise contributors."

However, many of the sources were complex and included multiple sources such as compressors, motors, piping and valves. Jeff continues, "Enter the Acoustic Camera. We first looked at the facility from the property line and used the camera to verify where the most significant noise was coming from." Next, the Acoustic Camera was used to further narrow down the sources of noise at each piece of equipment. "Without the camera," says Jeff, "it would have been necessary to acoustically treat multiple noise sources to make sure that the noise was sufficiently reduced. The camera allowed us to pinpoint which parts of the equipment required noise mitigation thus reducing the overall cost to the owner."

SPEECH PRIVACY IN THE OFFICE

The Acoustic Camera was quickly in use again when Wave Engineering were called to investigate complaints of poor sound isolation and a lack of speech privacy between offices in a new commercial office space. Office occupants complained of being able to overhear and follow conversations from adjacent offices, conference rooms, and corridors. However, some partitions seemed to perform better than others even though the designs were identical.

The offices were constructed from a combination of conventional drywall and modular walls. The drywall extended to the deck above and the modular walls only extended up to the lay-in ceiling. Most of the complaints were from offices with modular construction.

Jeff explains, "Our first task was to determine if the walls were performing as they should. The Noise Isolation Class (NIC) was measured using pink noise generated with powered loudspeakers and measured with an integrating sound level meter. Overall, the



rooms seemed to be performing as well as should be expected.” Nonetheless, Wave Engineering was tasked to develop ways to improve sound isolation between offices. “We first wanted to know where the strongest noise paths were in or around the modular wall system that contributed to complaints. The Acoustic Camera was the perfect tool to identify sound leaks,” says Jeff.

The ability to view video images in real time or save still or video images and data for later analysis makes it much easier for engineers to identify excessive noise sources compared with using a conventional sound level meter or trying to discern by ear. “We suspected that sound was transmitting through the modular wall joint at the exterior wall and glazing,” says Jeff. “The joint appeared to be sealed well, but the Acoustic Camera showed that the joint was clearly much weaker than the wall itself.”

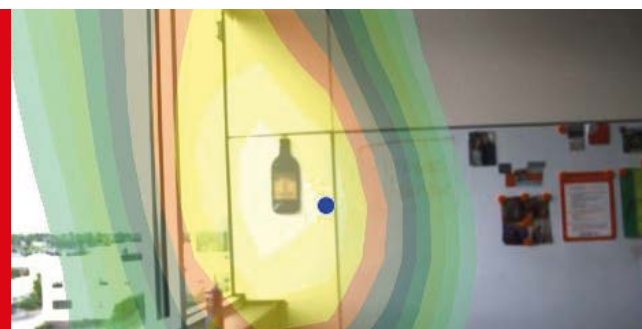
The modular walls of the office had seals intended to maintain sound isolation, but these, it turned out, were imperfect where the walls intersect – Wave Engineering will continue working with the wall manufacturer and installer to identify remedies for this issue. The wall system also included sliding doors that are difficult to seal well. The camera’s images showed strong sound transmission where the office door meets the floor and ceiling.

Finally, a sound “hot spot” was discovered at an electrical outlet and further investigation showed that a cover plate was missing.

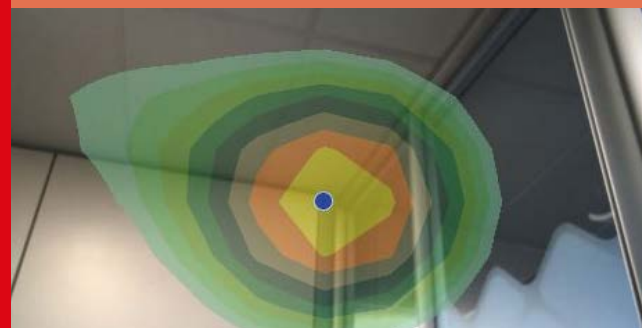
A satisfied client and a way forward to solving the issues was the end of a thorough investigation. Jeff says, “These few examples show how the camera helped identify potential areas for improvement. The images are a very effective tool for communicating the issues to the client. This is a great example of how we work closely with our clients and provide practical solutions.” ■

“WE SUSPECTED THAT SOUND WAS TRANSMITTING THROUGH THE MODULAR WALL JOINT AT THE EXTERIOR WALL AND GLAZING.”

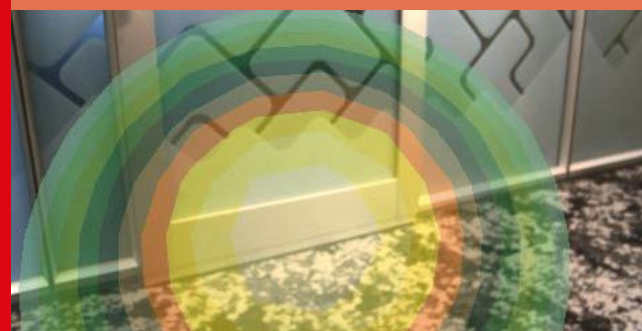
JEFF KWOLKOSKI,
WAVE ENGINEERING PRESIDENT AND
SENIOR ACOUSTICAL ENGINEER



Wall at exterior glazing



Wall intersections



Door seals



Hot spot found – in this case an electrical outlet

SOUNDS GREAT



Customers care about the audio quality of the loudspeaker systems in their cars; it's one of the key factors affecting a car purchasing decision.

For most car drivers and passengers, listening to music is an integral part of the driving experience. Customers' expectations regarding audio quality are continually increasing – something car manufacturers must pay attention to. However, it's not an easy task to evaluate the quality of delivered audio systems.

THE CHALLENGE

The main validation process normally involves a series of

SOUNDS ABOUT RIGHT...

time-consuming subjective audio evaluations. This means that an exorbitant amount of hours are spent checking and controlling the quality of installed systems, and it is difficult to link the results of subjective evaluations to possible solutions. To help car manufacturers figure out whether the delivered system meets their expectations and, if not, to see which perceptual attributes need to be improved, a new prototype tool has been developed based on a limited set of sound samples.

NON-INTRUSIVE METHOD

This project developed an audio-quality algorithm for multi-channel audio systems in vehicles. It's a non-intrusive method, which means that the process doesn't use a reference sound sample, which can't be obtained for audio systems in cars. The algorithm is based on spatial metrics, distortion metrics, and sound quality metrics.

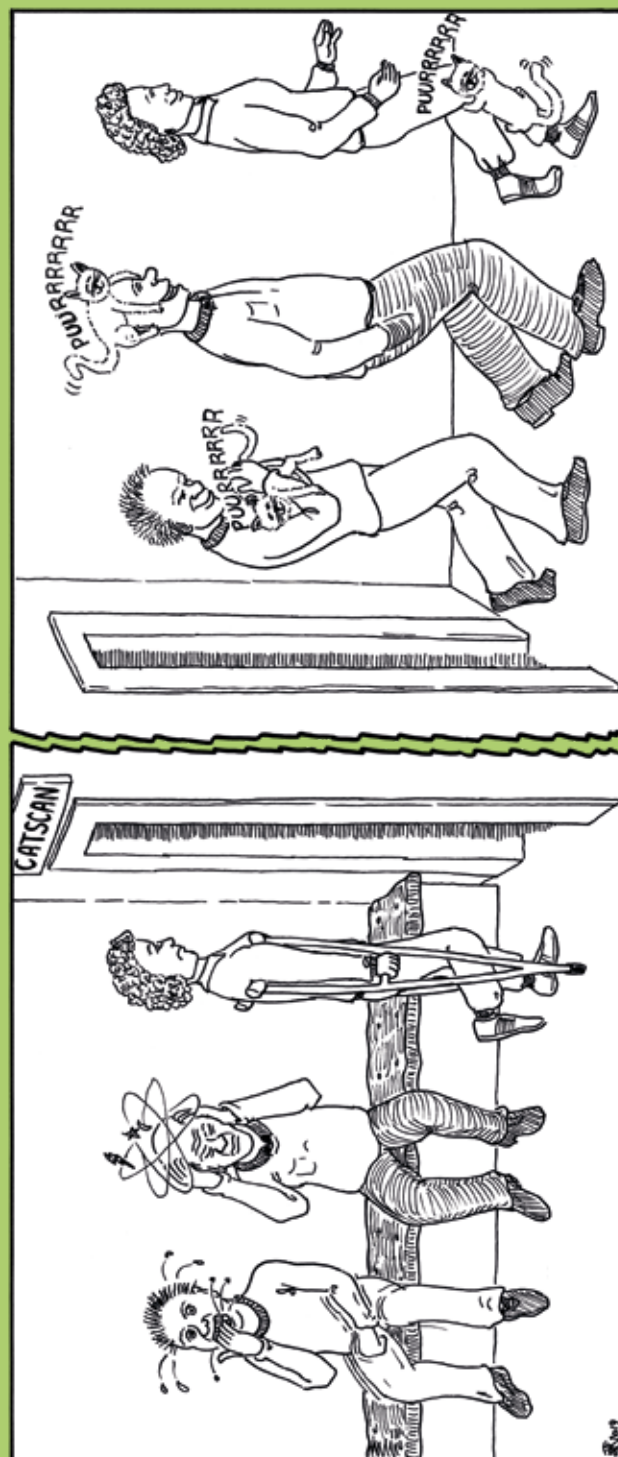
To develop this algorithm, one classical music sample and two pop-music samples were recorded inside vehicles under test conditions, and expert listeners identified six perceptual attributes. The recorded sound samples were then played in a listening room to twenty expert subjects who evaluated the overall quality, as well as the six perceptual attributes.

The tests revealed the overall preference and the perceptual attributes of the recorded sound samples. Subjective results were then predicted by a linear regression involving the principal components of the objective metrics. Furthermore, a new distortion metric was developed to detect and quantify any non-linear distortion generated by the loudspeaker systems, for example, rattling of the panels.

TEACHABLE SYSTEM

The result is prototype software that calculates the relevant objective metrics and predicts the perceived attributes. This is a teachable system, so new subjective data can be added in the model to further improve prediction accuracy. Whereas other algorithms require a reference sample (with audio quality close to perfect), this evaluation technique is advantageous for car audio, where it is impossible to know what the perfect system is.

Once there is enough subjective data, the listening test results can be applied to other car audio systems, without performing further listening experiments. This approach allows for more effective evaluation of multi-channel audio in vehicles, without performing time-consuming subjective evaluations. ■



By Lars Kroman

BK CONNECT 2019.0, TEAM SERVER AND SOFTWARE LICENSING PACKS



BK CONNECT 2019.0

The BK Connect 2019.0 software release continues to focus on ensuring that each individual user in the measurement chain has the tools and flexibility they need across the gamut of testing needs in any workflow.

Find out more at bksv.com/bkconnect

TEAM SERVER

Team Server – a new approach to quickly, efficiently finding and securely sharing data amongst a team – takes data management and sharing to a new level.

With traditional database-type data managers, simple requests for data can easily turn into hours of browsing through folders, files and databases – especially if the data was processed years ago and the archive is shared by many. To help solve this problem, Team Server automatically indexes data added to projects, creating a repository of data files to offer advanced

search functionality across the team working on a network of client PCs. Unlike generic document indexing systems, Team Server's indexing makes the most of metadata, based on relevant descriptors and attributes rather than just extracting keywords. This intelligent approach delivers much greater value for teams.

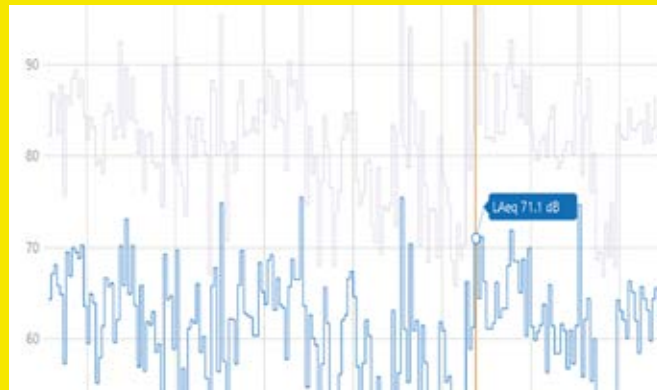
Find out more at bksv.com/TeamServer

BRÜEL & KJÆR ANNUAL SOFTWARE LICENSING PACKS

If you're a single user in a small sound and vibration test department or a domain expert working independently among other domain experts, you will probably need to perform a variety of tests to complete your reports, or you may need several different capabilities to get the data you need to pinpoint problems. If so, buying individual licenses can be cost prohibitive.

BK Connect® license pack leases are a great way to provide access to a wide variety of measurement and analysis capabilities for the flexibility you need to do your jobs. These five domain-specific packs comprise of a selection of tools that cover a wide range of options within a given field of measurement and analysis. ■

Find out more at bksv.com/license-packs





NEW LAN-XI LIGHT MODULE AND LAN-XI OPEN API

NEW LAN-XI LIGHT MODULE WITH GENERATOR OUTPUT CHANNEL

This new LAN-XI Light module is a rugged, portable, stand-alone, four-channel data acquisition unit that supports CCLD transducers and 200 V microphones, including one generator output channel. LAN-XI Light data acquisition modules are perfect for low channel count measurement applications either in the lab or in the field, such as production quality assurance checks, NVH recordings and modal analysis. All LAN-XI Light modules can be used with Battery Module Type 2831 and Wireless LAN Frame Type 3660-A to create a portable, remote recorder.

Find out more at bksv.com/LAN-XI-Light

LAN-XI OPEN API

LAN-XI Open API (Application Protocol Interface) is a lightweight, platform-independent interface for programming your LAN-XI data acquisition hardware from your own (or third party) software.

System integrators, test houses, universities and engineers from a broad spectrum of industries and applications, including production testing, now have the freedom to use LAN-XI hardware with both Brüel & Kjær and non-Brüel & Kjær software platforms. ■

Find out more at bksv.com/LAN-XI



ALL-NEW NVH SIMULATOR 2019.0 RELEASED

Sound and vibration, or NVH (Noise, Vibration and Harshness), are amongst the most important elements vehicle manufacturers use to convey character, refinement and a sense of quality to customers. The NVH Simulator software enables automakers to create and evaluate virtual NVH prototypes, saving millions of euros on every vehicle programme and shaving months off development time. Automotive engineers, managers and executives can drive and interact with

these virtual prototypes just like a real car, understand the sound and vibration characteristics of the vehicle long before physical parts are available, and make design decisions with high confidence.

The new NVH Simulator 2019.0 is the most significant and sweeping update ever, including a completely new, modern interface and dozens of new features and efficiency improvements to enable faster model builds and easier usage.

This new release enables easier and faster creation of NVH virtual prototypes from a combination of multiple types of CAE (computer-aided engineering) data and test-based measurement data from multiple sources. These NVH virtual prototypes are then used to ensure that NVH targets, design and content are correct with high confidence, without the need for physical prototypes. ■

Calibration Plus contract

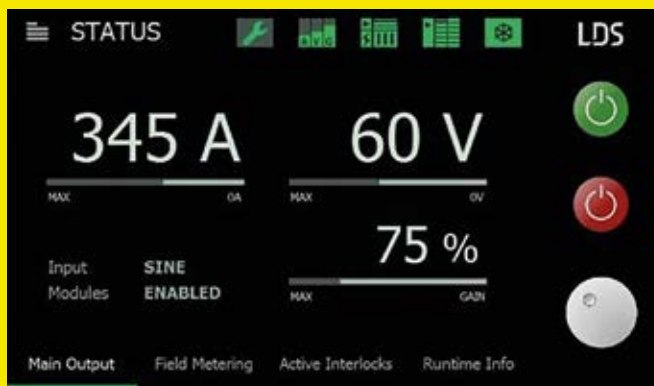
The Calibration Plus contract bundles together the relevant calibration services and extended warranty for your product or products and provides additional benefits to ensure that your measurements are accurate. It also allows for a broader range of calibration and verification services to match your needs including include regular calibration intervals, calibration reminder services and additional online services. ■

Find out more at bksv.com/calibration-plus



XPA-K Remote

Improving the user experience is an important aspect of product design, making user safety and work efficiency key driving factors. XPA-K Remote encompasses both these elements by moving the user away from the shaker through the implementation of a remote amplifier interface on the user's device, keeping it always at hand. With two identical interfaces, XPA-K Remote offers a seamless transition between physical and virtual shaker system operating environments. ■



Introducing Type 4988-A

A new, all-titanium, prepolarized, 1/4-inch pressure-field TEDS microphone with low noise and a frequency range from 20 Hz to 20 kHz, ± 1 dB guaranteed. It is designed to be used in small closed couplers, close to hard reflective surfaces, close to sound ports of audio devices or in flush mountings. ■

Find out more at bksv.com/TheMic



FIVE QUESTIONS FOR RICARDA NERCHE

A native of Dresden, Germany, 37-year old Application Engineer [Ricarda Nerche](#) lives in an old farmhouse with her husband, two daughters, four sheep and a cat. Her passions include, cycling, gardening, Italian food and reading, her favourite book being Lord of All Things by Andreas Eschbach.



MOTTO:

“MOVE FORWARD, LOOK BACK”

[What attracted you to Brüel & Kjær?](#)

I am fascinated by technology and I studied environmental acoustics, that deals with the impact of environmental noise on people. Working for Brüel & Kjær satisfies both these interests.

[What are you passionate about?](#)

I like to do things differently. I like to read about new ideas, think about them and even try them out if I can. For example, I garden unconventionally, and we rebuilt our house with alternative building materials.

[What is the best advice you've been given?](#)

If you don't know the answer, be honest and admit it – a colleague told me that when I started at Brüel & Kjær.

[If you could have two superpowers, what would they be and why?](#)

Understanding all languages – that could solve conflicts everywhere and flying. From the sky you see things from a different perspective.

[If you had all the money and time in the world, what would you be doing right now?](#)

Pushing renewable energy sources to demonstrate that they do work.