SOUND AND VIBRATION NEWS

WAVES

ISSUE# 02

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SOUNDS LIKE A FERRARI

CUTTING-EDGE BLADE MAINTENANCE

TRIAL BY COMBAT

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Brüel & Kjær

BEYOND MEASURE

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FRONT COVER IMAGE
As beautiful as they look, some would say that sports cars from Ferrari sound even better.

Brüel & Kjær
BEYOND MEASURE

LETTER FROM THE MANAGING DIRECTOR

SOLVING SOUND AND VIBRATION CHALLENGES TOGETHER

Welcome to this second edition of Waves. We are happy to hear that so many share our passion for sound and vibration and we want to thank you for the positive response to the first edition of the new Waves.

Sound and vibration affect us every day, from the smartphones we use and the cars we drive, to the aircraft we fly in and the environment in which we all live. We are all committed to solving sound and vibration challenges during all phases of a product's life cycle – from initial design and development, to manufacturing, deployment and operation – and this is reflected in the interesting articles in this issue.

You can get a glimpse into the world of designing a Ferrari and read about the hallmark Ferrari sound – a big part of the Ferrari experience. A Brüel & Kjær NVH simulator helps Ferrari fine-tune that sound with virtual prototyping that helps to achieve engine sound targets rapidly and cost-effectively.

Moving into the deployment phase, with a focus on safety, an article about the Apex Tool Group (ATG) explains how they ensure their tools live up to the standards for human vibration exposure, using the state-of-the-art noise and vibration testing lab in Michigan.

The operation phase of a product's life cycle is illustrated in our article about how the Technical University of Denmark (DTU), Vattenfall, Bladena and Total Wind collaborated with Brüel & Kjær to reduce operational costs and detect and localize damage to wind turbine blades, using structural health monitoring.

We are excited about this issue of Waves and to share this selection of articles with you. But, as always, we would very much like to hear your stories and experiences with sound and vibration – so don't hesitate to contact us at waves@bksv.com. Happy reading!

LARS RØNN
MANAGING DIRECTOR

SOUNDS LIKE

Ferraris are distinguished by an unmatched combination of beauty, power and responsiveness – and a unique sound that is as carefully tuned as a piece of music.

A FERRARI

FRANCESCO CAROSONE

- Senior Acoustic Engineer, responsible for exhaust and overall sound quality
- Joined Ferrari in 1999
- Worked in NVH testing department and moved to the NVH Concept department four years ago
- Also a musician, playing classical piano and composing pop and theatre music
- On his bedside table, "The Physics of Musical Instruments", a book with acoustic theories that can be used in his work with sound in Ferraris
- Graduated from La Sapienza University, Rome, in 1994

The sound is a big part of the Ferrari experience. With their V12 and V8 engines and carefully crafted intakes and exhausts, they emit an explosion of sound that resonates with Ferrari's statement of purpose – to provide the driver with the ultimate experience in every moment of his journey. The first time you drive a Ferrari and hit the throttle, several things happen to you. Firstly, your head is snapped back by the sudden power of the unleashed engine. At the same time, you are completely engulfed by a huge explosion of beautiful sound that is unlike any other car – it is like nothing you have ever experienced before. Then, at the end of the straight, the feel of the brakes is so good that you have more confidence to bury the throttle pedal again and again.

The importance of the Ferrari sound to customers is borne out by chat on the Ferrari website and by customer surveys that show that the vast majority of customers are excited about it. "It's a major part of our brand image," says Francesco Carosone, Senior Acoustic Engineer. "The Ferrari sound is an immediately recognizable trademark. Ferraris are sporty, extreme cars and the sound needs to embody that. Our goal is to give all our cars the sound that is expected from them."

It's not unusual for car companies today to artificially modify engine sounds in their cars with amplifiers or loudspeakers, an option that Ferrari is not considering. "We have the authentic sound that other car companies want to create artificially, and we intend to keep it that way," says Francesco. This commitment to the purity of the sound creates significant challenges for the company. One of the largest is complying with noise regulations, both at racetracks and on public streets. Virtually all countries have legislation to limit noise from cars, especially in cities where it can be a major problem. Legislation also imposes rules on racetrack noise, and racetracks themselves often impose additional regulations. An additional challenge is delivering such levels of exciting sound, while also making the car comfortable on a long journey.

> "THE NVH SIMULATOR WAS A GROUNDBREAKING SOLUTION FOR US."
>
> FRANCESCO CAROSONE
> SENIOR ACOUSTIC ENGINEER

Brüel & Kjær's Desktop NVH Simulator enables you to evaluate, modify and design NVH data interactively, by driving in a virtual scenario using authentic car controls and feedback. The scenario, shown on desktop monitors, allows quick changes between different vehicles, systems and components

VIRTUAL PROTOTYPING OF SOUND TARGETS

"Our customers want a loud sound, a high decibel level," says Francesco, "and this means you can't hide – it has to be beautiful. We need to tune the sound quality carefully, usually by balancing the intake and exhaust." It can, however, be time-consuming and expensive to swap different components of the car's intake and exhaust system and listen to the difference. In 2013, Ferrari streamlined the process by installing a Brüel & Kjær NVH Simulator that allows virtual prototyping to achieve engine sound targets rapidly and cost-effectively. This enables vehicle design and development teams to make the best possible use of customer preference and satisfaction input, set accurate NVH targets, design with specific differentiations to competitors, and work efficiently with all NVH data throughout the development process.

According to Francesco, "The NVH Simulator was a ground-breaking solution for us. It is becoming an integrated part of our NVH product development, and we are spending ever-increasing time using the simulator to fine-tune the results we want to achieve. In the concept phase, we can change the shape of different components of the intake and exhaust systems, and we can use the simulator to hear the sounds of the different design concepts directly from the CAE (computer aided engineering) model without prototyping. This makes it possible to evaluate and exploit components that would have been too time-consuming or even impossible to test before."

Ferrari has also installed a hexapod in their test lab, which is a cockpit simulator for cars built on hydraulic actuators to simulate the experience of driving a new vehicle. The hexapod features additional actuators to provide more rotation, which

THE FERRARI COMPANY

Ferrari S.p.A. is based in Maranello, Italy. Founded by Enzo Ferrari in 1929 as Scuderia Ferrari, the company sponsored drivers and manufactured racing cars before moving into production of street-legal vehicles as Ferrari S.p.A. in 1947. Throughout its history, the company has been noted for its continued participation in racing, especially in Formula 1, where it has had great success. Ferrari road cars are one of the world's best-known brands, generally seen as a symbol of speed, luxury and wealth. Ferrari produces around 7,000 cars a year, and there is typically a one- to two-year waiting list for a car. Ferrari has approximately 3,000 employees, 500 of them within the Formula 1 division.

"THE FERRARI SOUND IS AN IMMEDIATELY RECOGNIZABLE TRADEMARK. FERRARIS ARE SPORTY, EXTREME CARS AND THE SOUND NEEDS TO EMBODY THAT. OUR GOAL IS TO GIVE ALL OUR CARS THE SOUND THAT IS EXPECTED FROM THEM."

FRANCESCO CAROSONE
SENIOR ACOUSTIC ENGINEER

improves realism in hard cornering. A 180-degree widescreen visually simulates the racetrack while the Brüel & Kjær NVH Simulator provides fully accurate sound. The hexapod system allows test drivers to experience and evaluate a car's handling and sound together in a highly authentic context.

THE SOUND OF THE FUTURE

Even though Ferrari focuses heavily on performance, their use of sound simulation is part of a larger trend driven by environmental concerns, as the automotive market moves towards smaller engines, and electric and hybrid vehicles. The challenge for the entire industry is to create cars with strong performance that are at the same time environmentally acceptable, and yet maintain their brand sound. "Ferrari has developed hybrid technology," says Francesco, "that combines internal combustion and an electric engine and is currently in production. Ferrari is always aiming to get the best from new technology; we always have to produce better cars, better performance and that special sound."

TAKING THE STING OUT OF VIBRATION

Hand-held tools are tested according to specific ISO standards

Human vibration can be a nasty thing. Too much exposure to certain frequencies can lead to hand-arm vibration syndrome (HAVS) or even whole-body vibration syndrome – both of which damages nerves.

Hand-arm vibration syndrome results from prolonged exposure to vibration specifically to the hands and forearms, while using vibrating tools. It starts with a 'pins and needles' feeling in your fingers, but can eventually lead to permanent numbness and an inability to do fine tasks, such as fastening buttons. Whole-body vibration has negative effects on general health and comfort. Alert readers will recall that the previous issue of this magazine carried two articles related to the topic of human vibration, one about a Japanese expert in the field and another about fine-tuning the equipment used in bowhunting. This is indicative of increasing attention to the subject of human vibration, which will also be an important focus area at Inter.noise 2014, the premier international conference on noise and vibration control, to be held this November in Melbourne, Australia.

TESTING TO MEET VIBRATION REQUIREMENTS

Andrea Frey, Project Engineer for Brüel & Kjær North America, confirms this growing interest: "We have seen more emphasis on safety in our engineering services in the past few months," she says. "We've written quotes to measure the high-frequency noise emitted by automatic timers for office lighting. We have done minimum noise-level testing for electric vehicles. And in the past year, we have performed testing of vibration levels transmitted to humans during operation of different kinds of vehicles and construction equipment. We've also conducted tests of various hand-held tools this year to help manufacturers meet requirements for vibration transmitted to the operator's hand during use. Most of these tests were carried out in collaboration with Sound Answers, our services partner." All testing takes place at the ARC (Application Research Center) testing lab near Detroit, Michigan, which houses a one-of-a-kind noise and vibration solution centre with a wide array of state-of-the-art NVH testing capabilities.

> "WE HAVE SEEN MORE EMPHASIS ON SAFETY IN OUR ENGINEERING SERVICES IN THE PAST FEW MONTHS."
>
> ANDREA FREY
> PROJECT ENGINEER
> BRÜEL & KJÆR NORTH AMERICA

The tool tests were done in accordance with the standard 'ISO 28927 Hand-held portable power tools – Test methods for the evaluation of vibration emission'. For these tests, a triaxial accelerometer was placed at the location where the operator grips the tool, and a tachometer was used to monitor the speed of the tool to ensure that the actual rotational speed matched the rated speed.

After this basic set-up, the ISO standard has specific sections that deal with different tools. "We operated each tool according to the ISO standard," says Andrea. "Three different operators performed the same test so that we could understand how variation in grip affected the transmitted vibration, and each tool is tested under a variety of conditions, such as different speeds and different loads. For example, one of the tools tested was a die grinder, which requires a workpiece that you actually grind during the test. Some of the ISO sections specify a particular drill bit, or a simulated response force – it just depends on the tool. In one case we had to verify that the workpiece didn't have any natural frequencies in the range that we were measuring." The official results of the tests are 'declared vibration emission values', which can be used by manufacturers to rate the tools. ▶

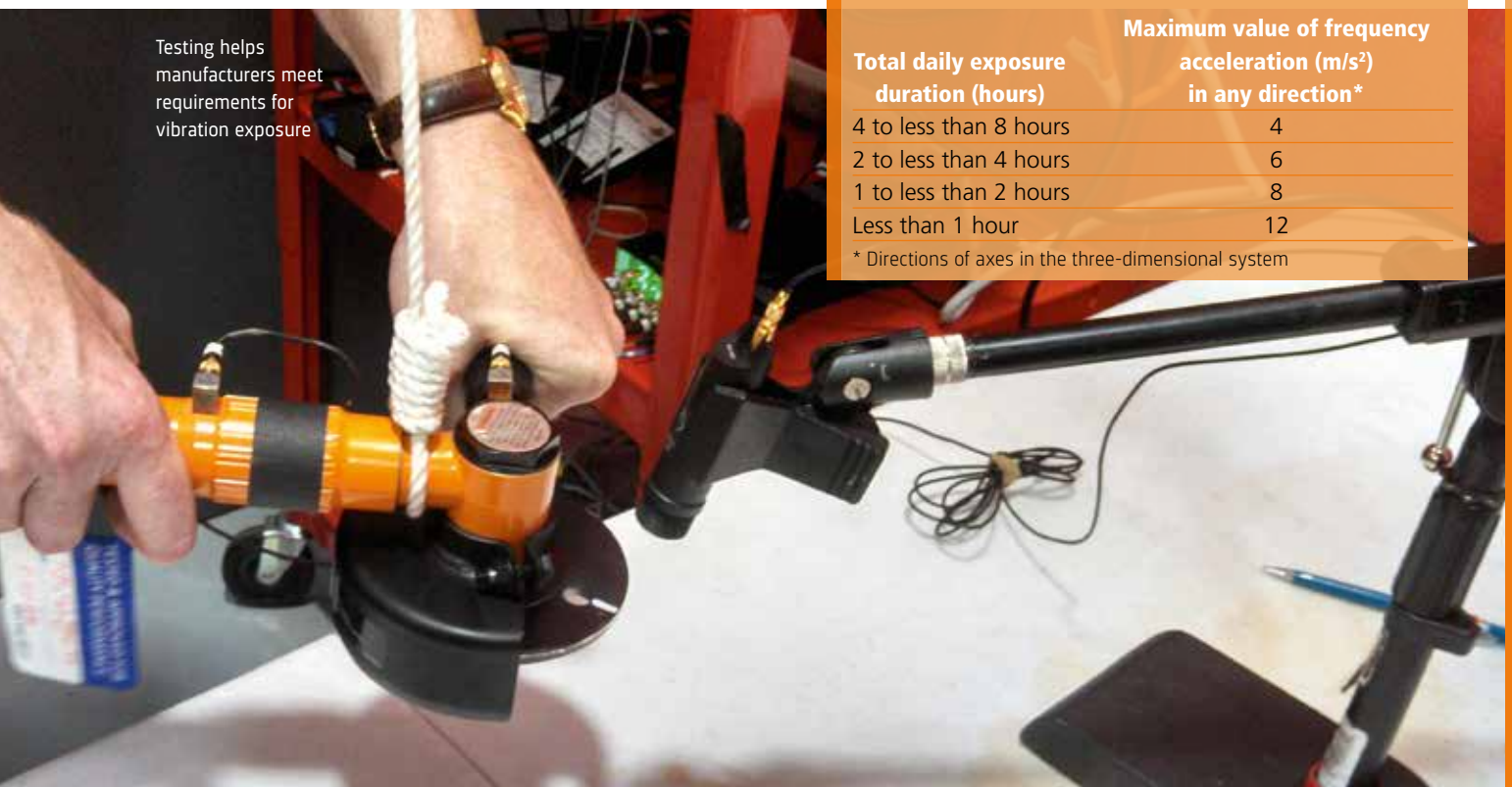
STANDARDS FOR MAXIMUM VIBRATION EXPOSURE

The standards vary from country to country. In the United States, for example, the Occupational and Safety Health Administration (OSHA) does not set standards for maximum human vibration, but does recommend that manufacturers and employers follow the guidelines of the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH has developed Threshold Limit Values (TLV) for vibration exposure from hand-held tools, which depend on the total daily exposure: if you'll be using the tool for less than one hour, you can be exposed to 12 m/s^2; for one to two hours, it's 8 m/s^2, and so on.

THE ACGIH THRESHOLD LIMIT VALUES (TLVS) FOR EXPOSURE OF THE HAND TO VIBRATION IN X, Y OR Z DIRECTION

Total daily exposure duration (hours)	Maximum value of frequency acceleration (m/s^2) in any direction*
4 to less than 8 hours	4
2 to less than 4 hours	6
1 to less than 2 hours	8
Less than 1 hour	12

* Directions of axes in the three-dimensional system



Testing helps manufacturers meet requirements for vibration exposure

TAKING THE STING
OUT OF VIBRATION

> "USING THE ARC ENSURED THAT WE WERE DOING IT RIGHT. I WAS CONFIDENT OUR PRODUCT WOULD BE IN COMPLIANCE."
>
> JOHN STEWART
> CHIEF ENGINEER
> APEX TOOL GROUP

EQUIPMENT AND EXPERTISE IN ONE LOCATION

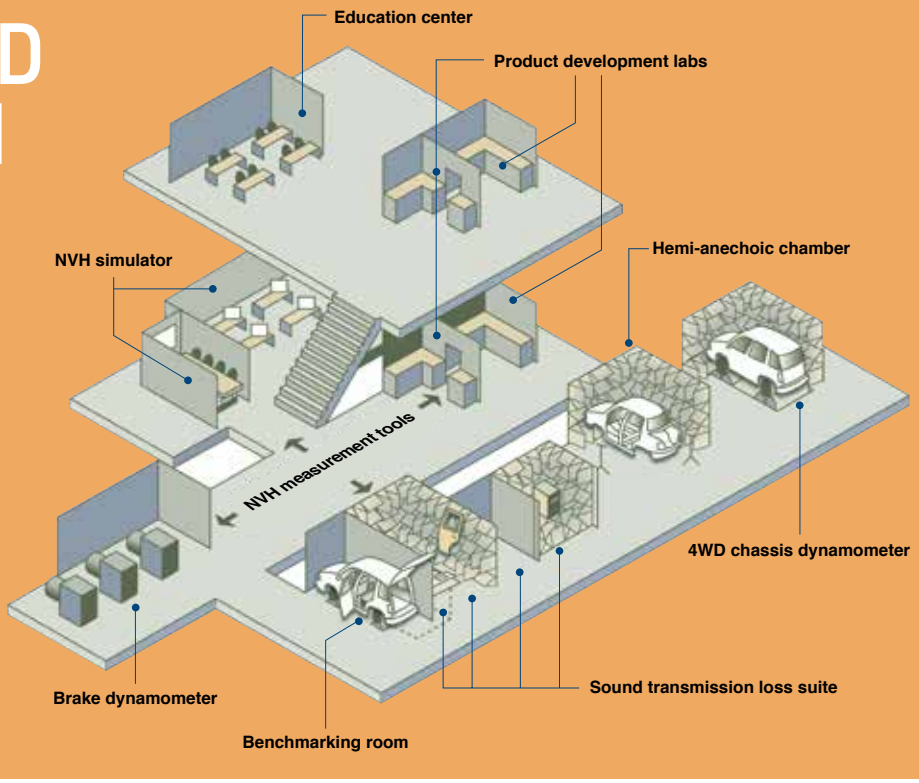
Apex Tool Group (ATG), one of the largest manufacturers of professional hand and power tools in the world, came to the ARC to run tests on a hand-held pneumatic grinder. According to John Stewart, Chief Engineer, Components, Technology and Intellectual Property for Apex, time and confidence were two of the main reasons for using the ARC's facilities and expertise. "We simply didn't have the time or manpower to run the tests ourselves," he says, "and it certainly would have taken us longer to complete the tests. Also, using the ARC ensured that it would be done right. Their engineers are very knowledgeable, and I was confident our product would be in compliance with the necessary international standard. The bottom line is that the ARC enabled us to finish our programme efficiently."

"I see several advantages to customers using the ARC for this type of testing," says Andrea. "First, Brüel & Kjær actually makes the testing equipment, which means not only that it is accurate and reliable, but also that we have all the equipment we need right here and ready to go. Second, the ARC offers dedicated facilities. Something small like a hand tool could in theory be tested in an office, but it's very noisy and messy and disruptive to other employees. For something larger that needs to be affixed to a bedplate, or driven on a dynamometer, or tested for noise at the same time as the vibration test, we can accommodate all those kinds of tests, too. Third, we have all the people right here. Brüel & Kjær has four application engineers at the ARC, and our services partner, Sound Answers, is right down the hall with 11 more engineers. That's a lot of knowledge and experience all in one location, and it means that we can support just about any noise- or vibration-related request that might come up during testing." ■

THE APPLICATION RESEARCH CENTER – 'THE ARC'

SOUND AND VIBRATION SERVICES

- Customization
- Equipment rental
- Material testing
- Noise source identification
- NVH simulation
- Production line testing
- Sound quality
- Source path contribution
- Structural vibration
- Training
- Troubleshooting
- Vehicle pass-by testing
- Vibration testing ■



FROGS SCORE AUDIO VICTORY

Not everyone agrees on what beauty is, but they desire and compete for it. In fact, competitions to find the 'most beautiful' example of a certain theme happen every week at the website BeautifulNow.is. These samples can be anything that contributors have written, painted, designed, directed, photographed, filmed, composed or concocted. Then the Beautiful Now community shares and votes for their favourite.

CAN YOU THINK OF A MORE BEAUTIFUL SOUND? HEAR THE WINNER HERE.

When the website held the 'most beautiful sound in the world' competition, audio fans got their chance to submit hundreds of recordings of soundscapes that featured anything from decaying bridges to mothers with their babies.

Standing out among many nature recordings, the winner was the sound of 'Dusk by the Frog Pond' by Marc Anderson, a sound recordist and photographer based in Sydney, Australia.

Wallace's Flying Frog (Rhacophorus nigropalmatus).

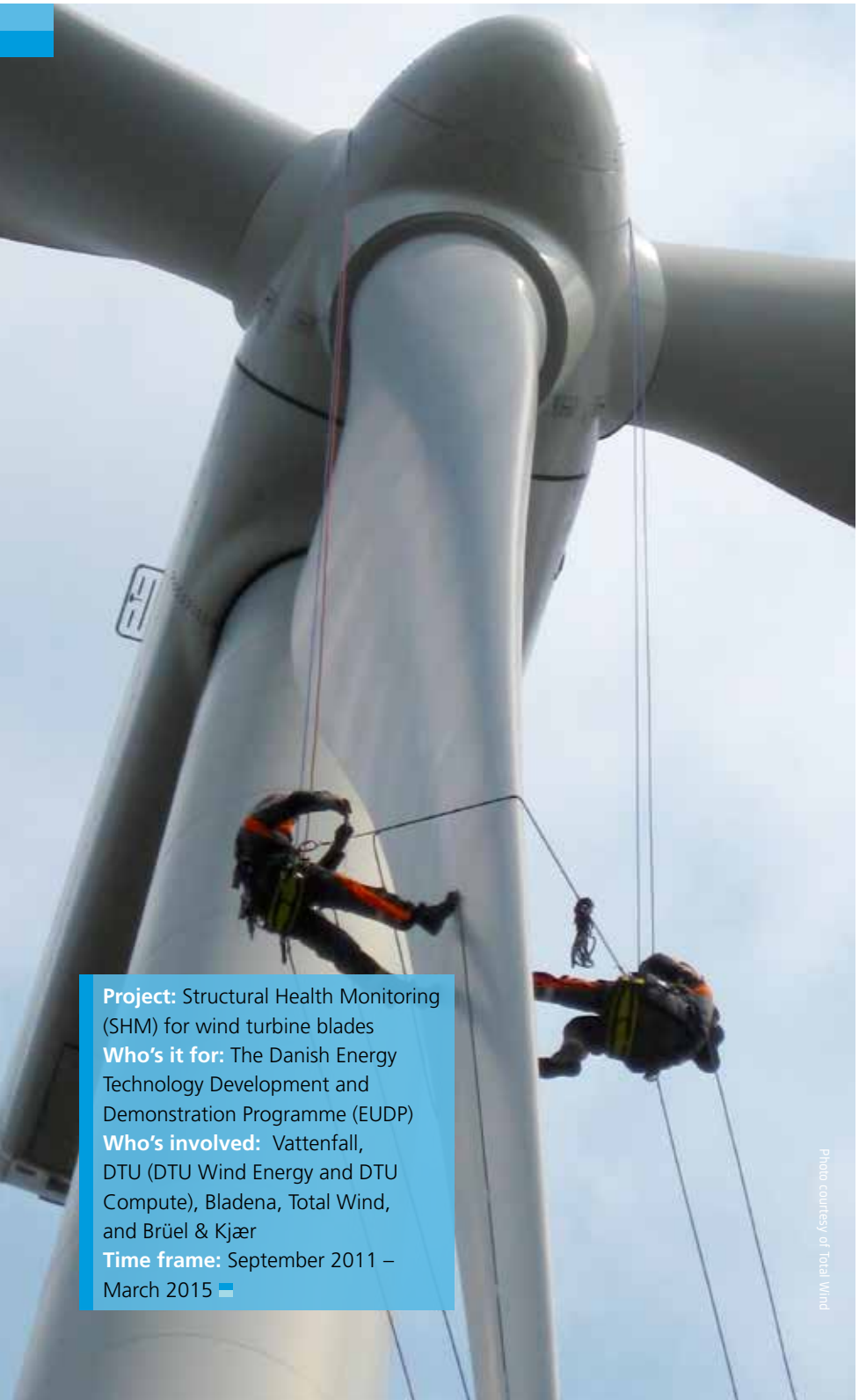
DO YOU KNOW YOUR UNITS?

Among thousands of different units used for measuring, English units include many unusual names – thanks to their long history and agricultural origins. But are any of these actual English length units?

UNIT	TRUE	FALSE
Ell		
Fathom		
Loaf		
Furlong		
Cable		
Button		
Poppyseed		
Nail		
Claph		
Shaftment		
Twig		

Find the answers in a handy diagram on page 29, where you can read about the complicated origins of measurement units.

CUTTING-EDGE BLADE MAINTENANCE



Project: Structural Health Monitoring (SHM) for wind turbine blades
Who's it for: The Danish Energy Technology Development and Demonstration Programme (EUDP)
Who's involved: Vattenfall, DTU (DTU Wind Energy and DTU Compute), Bladena, Total Wind, and Brüel & Kjær
Time frame: September 2011 – March 2015

Photo courtesy of Total Wind

Since September 2011, an exciting EUDP project has been underway to develop a practical way to detect, localize and predict damage to wind turbine blades. The associated cost of maintaining and repairing blades is a very real issue for wind farm operators and so far no remote inspection method has offered a viable solution. Thanks to the project, the best answer could lie in sophisticated algorithms using vibration measurements with considerable potential above and beyond the wind industry.

Reducing the costs associated with wind energy is essential to becoming competitive and attracting investors. The industry is faced with various challenges in this regard, especially as the turbines (and their blades) become bigger. Wind farms are placed offshore, new materials and designs are introduced, transportation issues arise due to sheer size, and manufacturing defects occur – to mention just some of the challenges.

SEE MORE

Watch an SHM prototype demonstration at

www.bksv.com/video1

SEE MORE

Read the conference paper 'Effect of a damage to modal parameters of a wind turbine blade' at

www.bksv.com/whitepapers

By **DMITRI TCHERNIAK**
PhD, Research Engineer,
Brüel & Kjær

and **JENS J. HANSEN**
Global Key Account Manager,
Brüel & Kjær

WHAT IS THE EUDP?

The EUDP is a Danish organization that supports the development of energy technologies that create growth, secure supply and enable Denmark to become independent of fossil fuels. With a budget of roughly EUR 250 million each year, the EUDP has been instrumental in helping Danish businesses to create world-leading solutions to both local and global energy issues.

As the use of wind turbines has become more widespread, so has our understanding of the stresses and strains they endure over prolonged exposure to nature. A wind turbine is made up of thousands of components integrated into a finely balanced piece of engineering; any defect can result in a significant drop in performance, leading to costly structural failures, safety issues and system downtime.

Even though some parts of a wind turbine are monitored, such as the gearbox and main bearing, there is currently no viable means to check the integrity of the blades beyond expensive manual inspections, typically once a year. OEMs and major industry operators such as DONG Energy, EON and Vattenfall are researching this, but so far any ideas to automate the process have met with limited success. For this reason, the EUDP initiated a major project with Vattenfall, DTU Wind Energy and DTU Compute, Bladena, Total Wind, and Brüel & Kjær to find a solution.

BLADE MAINTENANCE – A NECESSITY, NOT A LUXURY

Even though they are designed to last for 20 years, damaged or faulty wind turbine blades can reduce overall productivity and have to be repaired. By carrying out a thorough yearly inspection, the operator reduces the risk of a catastrophic failure by highlighting issues and taking action before it becomes a serious problem that could result in costly repairs and lost revenue.

Blade damage is due to wear and tear from the natural elements and because of manufacturing defects and transportation. The most typical damage appears in the form of cracks and delamination. Wind turbine blades can be damaged or degraded by several factors. Over time, sand, ice, rain, sun and lightning constantly strike the moving blade and have serious adverse effects on its leading edge and structure. Worse still for off-shore installations, salt crystals can be a major cause of erosion and cause moisture diffusion within the blade structure. As a result, regular inspections and ongoing maintenance are not simply a luxury, they are a necessity.

MANUAL INSPECTION SHORTCOMINGS

The wind industry is growing fast – turbines and their blades have increased in size and numbers, and as a result, the industry demands greater equipment reliability. Consequently, wind farm operators and OEMs have been searching for a condition monitoring system capable of detecting adverse conditions and predicting failures, in order to help minimize risks and prioritize repairs.

Currently, there is no real-time health overview of blade fleets. For many operators, manual inspection continues to be the method of choice to determine the health of a blade. However, for many reasons this is not an effective solution. Manual inspection involves a hands-on, visual check of the rotor blades that must be conducted by highly qualified technicians hanging from ropes or using special working platforms.

> "THE MAIN CHALLENGE IS DETECTING DIFFERENT TYPES OF BLADE DAMAGE WHILE DEALING WITH THE NOISY AND CHANGING ENVIRONMENT IN WHICH THE MEASUREMENTS ARE BEING MADE."
>
> LASSE LOHILAHTI MØLGAARD, PHD, M.SC.EE
> SENIOR RESEARCHER, DTU COMPUTE

CUTTING EDGE
BLADE MAINTENACE

A triaxial accelerometer mounted on the leading edge of a blade

A 34 metre wind turbine blade in the test facility at DTU's Wind Energy department's test facilities, Roskilde

In both cases, the methods not only require specialists well trained in both blade engineering and rope climbing (who are few and far between), but they also depend entirely on the ability to spot damage with the naked eye.

This means that the inspection process is limited to the surface of the rotor blade or tapping the blade to get an idea of its structural integrity, both of which are widely open to human error. Furthermore, damage can occur before or right after inspections and each blade has to be checked individually, which is time-consuming, costly and dependent on weather conditions.

This kind of maintenance is also an expensive process due to system down-time. During inspections, the wind turbine has to be withdrawn from service for up to a full day and the process can only be performed under certain conditions (such as wind speeds of less than 10 m/s) by industrial climbers – in groups of three, due to safety rules.

Worse still, these issues are magnified for the off-shore sector, where wind farms are considerably larger and the use of lifts and platforms is very difficult due to the swell of the sea. The marine environment itself makes working conditions psychologically and physically stressful and often the turbines are up to 200 km from land, so the timeframe for working on location is limited, and workers must be transported there by boat or helicopter every day.

TAKING UP THE AUTOMATION CHALLENGE

As a result, a variety of automated methods and technologies – known as structural health monitoring (SHM) – have been tried and tested in an attempt to find a better approach. SHM is a relatively new field, and there are only a few projects already running in other industries, such as monitoring bridges and buildings in seismic areas. Some of the techniques used for SHM elsewhere have been adapted for wind turbines with limited success, including strain gauges, acoustics, lasers and thermography.

The EUDP project to develop an automated solution included partners with specific skills and qualifications:

- Vattenfall, Bladena and Total Wind: overall problem formulation, blade expertise, maintenance expertise
- Total Wind: damage repair
- DTU Wind Energy: mathematical modelling, access to a test wind turbine and test facilities
- DTU Compute: statistical models, decision-making algorithm, robustness to noise, and changes in environmental conditions
- Brüel & Kjær: overall project design and management, measurement equipment, long-term monitoring, damage detection algorithms and prototype design and implementation

Working together, the teams behind the EUDP project developed a novel approach to the problem. This led to an effective potential solution for SHM of wind turbine blades that also has considerable potential above and beyond the wind industry. The approach was based on the premise that any structural change to the wind turbine blade (i.e., damage) will cause a vibration pattern that deviates from normal. This results in unusual vibrations that can be detected by sensors

WIND – A GROWING INDUSTRY

During the first six months of 2014 alone, Europe grid-connected 224 offshore wind turbines in 16 commercial wind farms (there are also 310 wind turbines awaiting connection). The increasing use of wind farms isn't limited to Europe, with annual worldwide market growth of almost 10% and cumulative capacity growth of about 19%, as indicated by 2012 figures.

> "ADAPTIVE FILTERING METHODS IN COMBINATION WITH POWERFUL STATISTICAL LEARNING MODELS ENABLED US TO BUILD A SYSTEM THAT PROVED VERY ROBUST TO THE NATURAL NOISE SOURCES THAT ARE PRESENT IN A REAL WIND TURBINE."
>
> LASSE LOHILAHTI MØLGAARD, PHD, M.SC.EE
> SENIOR RESEARCHER, DTU COMPUTE

on the blade and measured; any deviation from the norm would suggest that damage has indeed occurred.

Initially, operational modal analysis (OMA) appeared to be an excellent tool for measuring these changes. However, tests showed that the process was not sensitive enough to detect and localize where the damage had occurred, and an alternative method was developed. In this new method, mechanical energy is introduced into the blade by means of an electro-mechanical actuator and the resulting vibrations are measured using accelerometers placed along the blade. This technique proved so effective it allows for an opening as small as 20 centimetres to be detected on a blade 34 metres long, even in the presence of environmental noise. Algorithms form the heart of the new method. To distinguish between actual damage and merely the effects of environmental noise, these algorithms are based on statistics collected from hundreds of careful measurements taken when the blade was in an undamaged state, during as many different weather and operating conditions as possible (a process known as 'model training').

WORKING TOWARD AN INTELLIGENT, ACCURATE SOLUTION

This method points the way to a future solution that will enable vibration data to be gathered, pre-processed and transmitted wirelessly to the 'cloud', which allows for quick data transfer, storage and processing. Based on advanced algorithms, several levels of analysis take place in the cloud, and if damage is detected, a report is issued to the wind farm operator via a Web-based interface that details which turbine blade is affected and to what extent.

Blade health monitoring will optimize the inspections and maintenance schedules, by providing the owner/operator with a unique ability to get a daily updated overview of the health of its asset, and constantly assess which blades need maintenance and when. This results in the ability to optimize a scheduled maintenance programme that decreases the cost of energy due to: ▶

CUTTING EDGE
BLADE MAINTENACE

An electro-mechanical actuator introduces mechanical energy into the blade. Here, the actuator is mounted inside the blade, on the inner surface of the spar cap, about 4 metres from the blade's root

The suggested technique is able to detect the shown damage: a 20 cm opening on the blade's trailing edge, which is relatively small compared to the 34 metre length of the blade

- In-time inspections
- Ability to optimize schedules in both peak and off-peak seasons
- Technicians arrive ready to inspect blades already identified
- Crane and/or vessels are mobilized for multiple inspections and sites
- Repair of problem before compounding
- Report/documentation/complete maintenance record in database, which improves knowledge and understanding of fleet health
- Daily detailed assessment view that provides insight and ability to react to changes in health before damage compounds and becomes catastrophic

GOING A STEP FURTHER

Typically, damages are categorized according to guidelines which determine the necessary follow-up, for example, in one category repairs must be immediate, while in another within a three- or six-month period. In order for the operator to categorize the detected damage and make a decision regarding the follow up, he needs to know where on the blade the damage is located and if it is progressing or stabilized. In effect, the new method constantly monitors the overall health of the blades and alerts the operator when a fault occurs, enabling them to prioritize repairs and schedule a maintenance plan before it becomes a more serious problem.

Currently, the algorithm provides a rough damage localization. The next stage of the project is therefore to develop even more advanced localization algorithms that can deduce exactly where the damage has occurred, even in its inner substructure. When done, this will help to give a more detailed overview of the blade's health and enable operators to design the repair and maintenance strategy in a more cost-efficient way.

INSIDE THE ALGORITHM

The algorithm that determines whether or not the blade has become damaged compares the current vibration pattern against those of an undamaged blade. If the results are the same, all is well and we can be sure that the blade is fine; in contrast, if the measured states differ, we can suspect that damage occurred and that blade is in need of closer inspection and repair. ■

HEALTHY BLADES, HAPPY OPERATORS – AND BEYOND

The outcome of the project represents a great step forwards for the industry and offers an invaluable new technique that will help operators maintain wind turbines at far lower costs and with improved reliability and efficiency. The solution fits all the criteria for an ideal SHM system, which is able to detect, localize and immediately alert the owner of damages in the blades. The system can be incorporated in new blades, or retrofitted into existing ones.

At this stage the project has produced a working prototype that is currently being tested on a real turbine. Further testing and development is required together with either an OEM and/or owner to make the working prototype into a commercial application.

In principle, the technique is directly transferrable to other industries such as aircraft, satellite and space. Other potential areas could be hydro-electric and high-speed rail. Of course, the future will reveal its true operational and commercial potential, but for now we'll have to wait and see which direction the wind blows. ■

THE FATHER OF DOLBY TECHNOLOGY

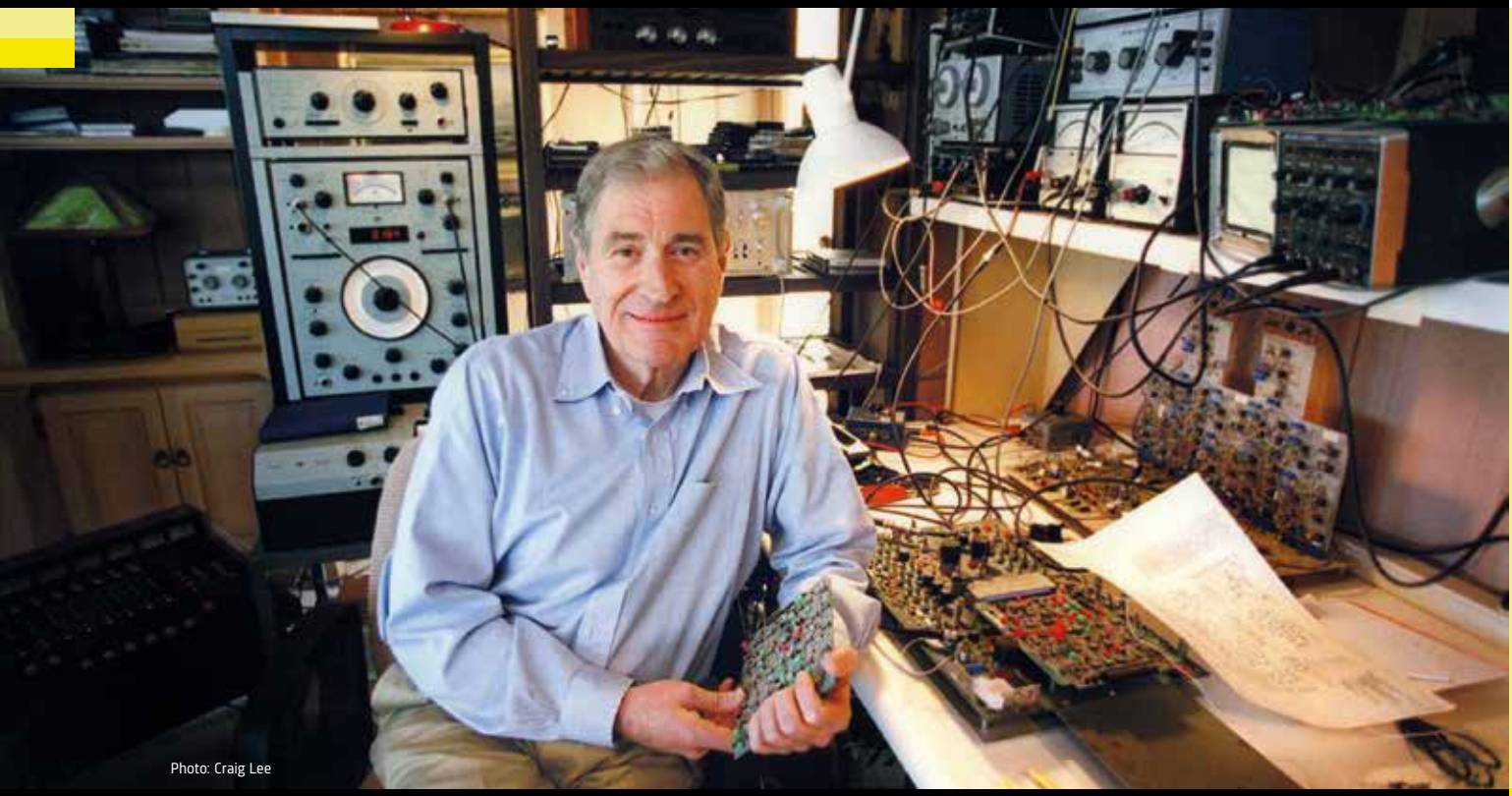


Photo: Craig Lee

DR RAY DOLBY 1933 – 2013

A pioneer who revolutionized the recording industry.

Born in Portland, Oregon, the inventor and founder of Dolby Laboratories made his name by reducing the background hiss on magnetic tape recordings. His analogue noise-reduction system used an electronic filter to boost the volume of low-level, high-frequency sounds during recording. Then, by reversing the process during playback, it removed most of the audible hiss.

The first 'Dolby A' production unit was bought by Decca Records, London, and by the late 1970s, the legendary 'Dolby B' technology (a less costly and less complex filtering system) was standard on virtually every hi-fi cassette player.

With the coming of the digital era, Dolby turned his attention to improving cinema sound. In 1977, George Lucas' Star Wars and Close Encounters of the Third Kind were the first films released in Dolby Stereo® – a significant milestone that changed movie sound forever.

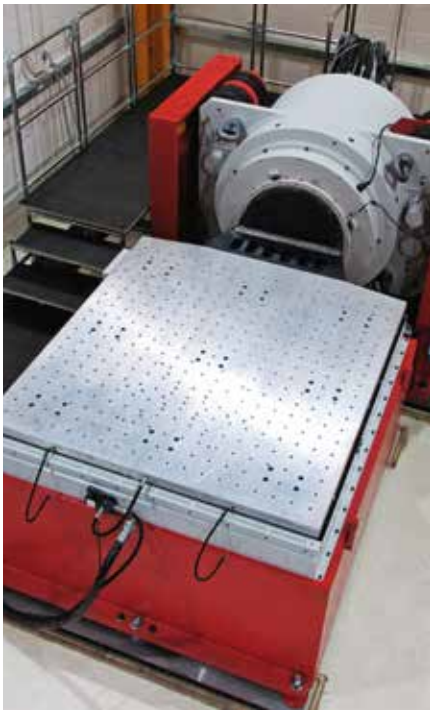
Yet Dr Dolby's heart actually lay with machines. "I love machinery. I would have liked to have been in a position to make a better steam engine, or to invent the first internal combustion engine; to work on the first car. I just regret that I was born in a time when most of those mechanical problems had already been solved, and what remained were electronic problems." ■

> "YOU COULD DIVIDE FILM SOUND IN HALF. THERE IS BD: BEFORE DOLBY, AND THERE IS AD: AFTER DOLBY."
>
> WALTER MURCH
> OSCAR-WINNING FILM EDITOR

For a combination of environmental conditions like vibration, dust and extreme temperatures, simultaneous testing in environmental chambers reduces test time

TRIAL BY COMBAT

Military equipment failing in battle or aircraft components breaking under pressure are nightmare scenarios that require punishing test regimes. And as quality standards intensify, test houses are guaranteeing more hardware is ready to survive.



TRaC's three LDS V984 shakers test objects weighing up to 4 tonnes like bridge-laying equipment, which will experience severe vibration levels in use

There are good reasons the testing business is booming in the UK. In the export-led markets of aerospace and defence, test houses like TRaC Global offer a great deal of value: a one-stop shop where manufacturers can achieve standards compliance for many different countries. But aside from final certification, much of TRaC's recent growth comes from helping manufacturers to navigate the whole journey to compliance, bringing the design and durability of their products up to the exacting specifications of end-users.

HARDWARE IN THE PIPELINE

Market demands are pushing customers into TRaC's safe hands. In the UK aerospace sector, numerous Airbus programmes are undergoing efficiency upgrades, while new aircraft from other manufacturers like Mitsubishi Heavy Industries and Bombardier are on their way.

Nowadays more new parts and revisions to original designs must be rigorously tested to the demanding Radio Technical Commission for Aeronautics (RTCA) standard than ever before. And whenever retrofitted components must be adopted on aircraft, they need certifying before rigid flight safety deadlines. For sub-suppliers, tighter deadlines mean OEMs are less forgiving of errors or delays, and pass down to them the associated costs and liabilities – which can be millions of pounds.

SQUEEZING OUT EFFICIENCY

But not all the pressure comes from regulators. Quality demands from the end-users of defence and aerospace equipment have become more exacting. Meanwhile, supplychain efficiency programmes like the UK's SC21 are forcing more suppliers to fulfill design requirements 'right the first time'. In the defence industry, the UK's Future Force 2020 programme means that all military equipment must meet tighter specifications than just the hot, dry and remote conditions for which they were procured. For TRaC, these factors have led to test enquiries doubling over the last five years. With more quality rejections, suppliers have needed quick help to pass tests. As TRaC's CEO Mark Heaven says, "We might get called in when a product has failed in-house testing. Or when a supplier realises they don't have the understanding of the applied environment required. Or if testing has taken place at another external facility with little support to then fix the failures they have found. So our consultancy services are essential."

CERTIFICATION TEST DEMANDS

Test specifications come from legislation or customers themselves – either self-developed or the result of contractual demands imposed on them. "Once they come to TRaC, we begin with product classification, which determines the route through the compliance and submission process, taking into account which country the product will be marketed in," says Mark. Everywhere the story is similar though: to achieve better quality, suppliers must test to tighter tolerances, which requires more from the testing regime. ▶

RTCA
Global (US) aerospace test procedure standard.

SC21
UK supply chain efficiency programme that encourages continuous improvement to increase yield.

TRIAL BY COMBAT

Lives depend on it: testing to incorrect specifications can mean in-service failures like military vehicles breaking down on the battlefield

"Overall, the trend is that vibration test levels are increasing, with larger forces and wider frequency ranges," says Mark.

WINDMILLING ENGINES

As standards cover more components, vibration testing for large objects has increased. At the low frequencies, 'windmilling' tests simulate the effect of a jet engine losing a blade – normally due to impact damage. With an unbalanced engine, significant low-frequency vibration surges throughout the aircraft. "The majority of components we test for Airbus have windmilling requirements, from interior doors to flap actuation systems," says Mark.

At the most demanding end of the testing spectrum, frequency, force and acceleration levels dictated by RTCA are intense. TRaC's large shakers test objects weighing up to 4 tonnes that will experience severe vibration levels, like bridge-laying equipment. "We have three of the four (160kN thrust) LDS V984 shakers available at independent test houses in the UK," says Mark, "so we specialize in large and challenging tests that other laboratories are unable to handle."

Still, TRaC's large systems are being pushed to the limit, at close to 100% operational time. With such a high demand, they need a broad range of vibration systems – nine in all. "We do over 500 vibration tests per year, so the flexibility of the range keeps lead times down, by keeping the big shakers free for the tests only they can do. And selecting appropriate shakers keeps costs down for our customers," says Mark.

TRaC GLOBAL

TRaC Global has been testing for over 65 years. Its six UK sites help 2500 organizations per year with electromagnetic compatibility (EMC), safety, environmental, telecoms and radio testing, and secures certification and approvals for 140 national markets.

GUIDANCE THROUGH THE MINEFIELD

Keeping testing costs down is a key to TRaC's value. For large OEMs and suppliers alike, TRaC guarantees safe and timely navigation through the many approval procedures. "Regulatory compliance for global markets is without doubt complicated and increasing, so achieving certification can be a complex and daunting task," says Mark.

Testing incorrectly or to the wrong specifications could leave manufacturers open to in-service product failure like military vehicles breaking down while in use, resulting in danger to troops, and expensive recalls and warranty claims. So an essential aspect of running a successful test house is knowing, selecting and applying the most relevant standards and regulations, and future-proofing product compliance.

OUTSOURCING TRUST

Considering timescales is an important theme for TRaC, whose expertise is steadily entering earlier in the development process. This is initially as a development tool to make bespoke tests on prototypes for customers, and finally to prove robustness in the final design. "It is significant because it means more suppliers and OEMs are

New military vehicles were needed urgently to protect troops from roadside bombs in Afghanistan, but the vehicles need tighter retesting as they return to different climate and standards regimes

"OVERALL, THE TREND IS THAT VIBRATION TEST LEVELS ARE INCREASING, WITH LARGER FORCES AND WIDER FREQUENCY RANGES."

MARK HEAVEN
CEO

outsourcing more development testing to us, rather than maintaining expensive laboratories and engineers that are seldom used," says Mark.

With blue-chip companies relying more on the robustness of their hardware, TRaC depends on reliability. Understanding its systems' capabilities, and maximizing uptime are critical. Planned, regular servicing of its vibration test systems and a stockpile of genuine spare parts minimize any downtime for the customers depending on them.

THE EARLIER THE BETTER

But uptime is also critical because the 'On Time, Right First Time' philosophy of modern aerospace OEMs means that suppliers need help fast if something fails qualification. Such occurrences are frequent. Customers come for qualification and discover they need development testing, so a two-week programme extends into months of redesigning, remanufacturing and retesting. TRaC can add value through earlier involvement with the customer, encouraging them to invest more of their budget up front in development testing.

"Many of our customers tend to use our finite element analysis team after a product has already failed testing," says Mark. "But with our expertise engaged earlier, we can help them steer products away from compliance pitfalls and achieve first-time success. Experience proves that testing earlier is better, when the cost of change is lower. So it's a trend we want to continue."

EXPERT PROFILE

FROM ATOMIC PHYSICS TO AEROACOUSTIC CONSULTING

PAUL MURRAY
BSC, PHD, CPHYS

Location: Sussex, UK, and Rolls-Royce University Technology Centre (UTC) in Gas Turbine Noise, Southampton University, UK
Position: Principal Research Fellow, Institute of Sound and Vibration Research
Expert in: Aeroacoustics and acoustic engine liner design
Mission: Reducing exterior and interior aircraft noise

1985: Physics and Applied Mathematics degree from Queen's University Belfast
1989: PhD in Atomic Physics
1989: Aerodynamicist, BAe Systems, New Projects
1994: Acoustics Engineer, Bombardier Shorts,
1997: Acoustics Engineer, NASA AST programme, Boeing
1999: Acoustics Consultant, Alenia Aermacchi, Italy
2007: Rolls-Royce UTC, Southampton University (research in aero engine acoustic liners and noise sources/ propagation).
Morrisbrand acoustic consultancy (aircraft interior noise, underwater noise, environmental noise)

Paul Murray is at the peak of a career that has taken him throughout the western hemisphere: from wind tunnel testing the Joint Strike Fighter to acoustic liner research on both sides of the Atlantic. Now based in Sussex and Southampton in the UK, he told us about his fascinating experiences so far.

How did you get into aeroacoustics? During my PhD in atomic physics, I quickly realized I needed to get into the 'real world', with targets and deadlines. British Aerospace (BAe) gave me a job looking at space vehicles. After moving home to Northern Ireland, I commissioned a wind tunnel for testing acoustic liners at nacelle supplier Bombardier. That got me into noise, and I've stayed there ever since. It's definitely a passion now!

What are your best work experiences? There are many. At BAe, I had a phenomenal start. Apart from the space vehicle work, I spent four months in their low-speed wind tunnel in the early days of the Joint Strike Fighter (now F35). We tested the aerodynamics of every combination you can imagine of wings, tails and body shapes. When I went to Boeing, I was fortunate to work on the NASA Advanced Subsonic Transport programme on acoustic liner research. After that, I worked on the EC SILENCER aircraft noise programme, where I had the chance to attend an A320 flight test. More recently, I have worked on the noise transmission characteristics of the A350's interior trim, while in the last couple of

ON PLANES, DO YOU ASK FOR A VIEW OF THE ENGINE?

"Well, it's a bit sad, but, if I can, I like to sit in front of the engine to hear the extent of low-frequency, buzz-saw noise, which is a really big issue. Also, I always have a look at the engine liners as I board!"

years I have been working on underwater noise, a portable impedance meter, and on engine noise sources. Plenty of variety!

How is working with interior and engine noise different?
Engine noise is mainly about what gets to the ground, while interior noise primarily involves optimizing the fuselage walls and trim. There is some limited read-across, though. I recently helped design an engine liner to reduce the low frequencies arriving on the fuselage, because these get through to the cabin relatively easily. But interior and engine noise are almost two separate communities.

How about the international community? Is there much sharing? I'm lucky to have worked in aircraft noise research on both sides of the Atlantic. When the Boeing 747X programme was cancelled, I came back to the EC and started working on noise research there. I could see how everybody was doing many of the same things in slightly different ways. But the level of collaboration has increased with time. ▶

"AN ADVANTAGE OF SUPPLYING NACELLES TO DIFFERENT COMPANIES IS THAT YOU CAN GET INSIGHTS INTO HOW DIFFERENT PEOPLE DO THINGS IN DIFFERENT WAYS, AND LEARN FROM THEM ALL."

PAUL MURRAY

FROM ATOMIC PHYSICS
TO AEROACOUSTIC CONSULTING


Image courtesy of NASA

Separate aerospace development programmes are organized and funded by the EC, UK and USA.

Is it common to have contracts cancelled? That was rare. The 747X cancellation meant over 2,000 engineers had to leave. I was devastated, as I was very happy in Seattle. Everybody knows that contracts come and go, but that was a shock. At least I got six weeks: time to sell my car! I ended up in Italy designing acoustic nacelle liners at Alenia Aermacchi, so it wasn't all bad!

What were your challenges making nacelles? You can easily produce an acoustic panel that looks okay but doesn't perform. Drilling and bonding can easily go wrong and affect the acoustic performance of a nacelle liner. So we tried to tightly control all of the design and manufacturing processes, and we ensured that all the people on the production line understood the impact of their work on the final result. They really bought into the whole thing, and we had a brilliant team spirit. Our Guinness-and-croissant celebrations helped too!

How does it compare working for a nacelle supplier, as opposed to an airframer? Interesting! You have to keep the customers happy at all times. But an advantage of supplying nacelles to many different companies is that you get insights into how different people do things in different ways. If you're working for Pratt & Whitney, for example, you'd do it the Pratt & Whitney way, and you wouldn't necessarily see what other manufacturers do. So you can learn a lot by moving around.

What have your biggest lessons been? There are many. The value of friendships, and persistence! Regarding acoustic liners, everybody's model for acoustic impedance was different – even for the simplest panel – and there's only one right answer.

What are your goals in liner design? There's always a trade-off between cost, weight and acoustics. For engine liners, you have different frequencies and impedance targets to consider for take-off and landing. But you've only got one liner, so you have to prioritize, and get the optimum liner construction. With better modelling, and high-quality manufacturing processes, you can ensure the best performance. So that's been my focus.

What does the future hold for aircraft acoustics? The biggest step in noise reduction was moving from pure jets to engines with large bypass ratios. That provided massive reductions in jet noise. Improved airframe and engine designs, and improved liner design and manufacturing processes, have also played their part. For example, the noise footprints of the Boeing 787 and Airbus A380 are much smaller than previous-generation aircraft of a similar size. But the ultimate goal is to achieve 'silence' outside airport boundaries. The only way to make substantial design gains towards this is to use noise-driven airframe layouts, using the fuselage or other surfaces to shield sound away from the ground.

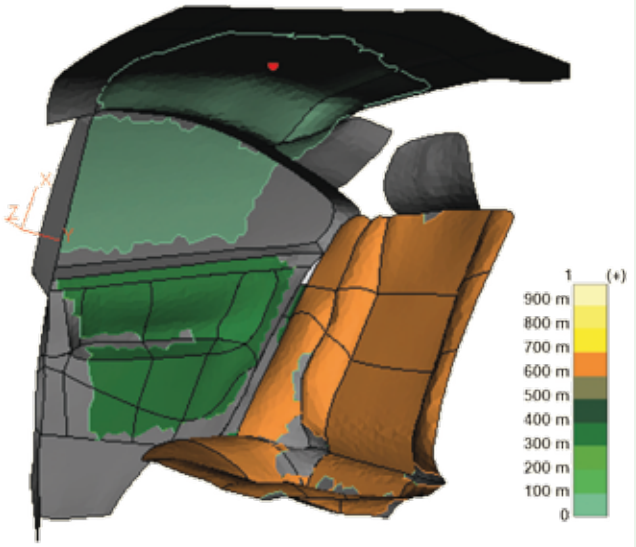
BYPASS RATIOS

In early jet engines, all of the air flowed through the centre of the engine. But in modern designs, an increasing proportion is split from the main airflow and ducted around the edge, separate from the main airflow.

A NEW WHITE PAPER FROM THE STACKS

Svend Gade, Jesper Gomes, and Jørgen Hald from Brüel & Kjær Sound & Vibration Measurement A/S, Skodsborgvej 307, 2850 Nærum, Denmark

USING HAND-HELD ARRAYS FOR AUTOMOTIVE NVH MEASUREMENTS



Microphone arrays help engineers develop sound quality on vehicles, giving fast and effective noise source identification. Now, advanced new techniques improve the insights possible.

One of the challenges for the automotive engineer is understanding the cause of a noise problem. Simple measurements, such as those done using a single microphone, can reveal the frequencies at which the sound pressure level is dominant, but cannot provide insights into the location of the sources. Positioning the microphone at different locations close to the presumed source can help, but this approach can lead to faulty conclusions because it depends heavily on the locations selected, and on the engineer's interpretation of the data.

Microphone array techniques can help engineers to make the right decisions more quickly by visualizing the sound field on the surfaces of interest. Visually representing the sound field makes it much easier to identify noise issues caused by phenomena such as acoustic leakage from openings or from structural resonances. And rather than displaying only sound pressure levels, microphone array techniques provide more acoustic quantities such as sound intensity, particle velocity, and sound quality metrics – all of which can be necessary to understand the noise-generating mechanisms.

This paper describes a family of array techniques that can provide even more sophisticated insights. One such is intensity component analysis, which can extract the sound intensity coming from in front of the array while suppressing sound from behind – making an effective tool for vehicle cabins, which have very diffuse fields. Another method presented is panel contribution, which separates the contribution of individual panels to, for instance, the driver's ear position inside a car. The in situ absorption method can be used to calculate and visualize the absorption coefficients of the ceiling of a vehicle, rather than having to perform the measurement on a material sample in an impedance tube.

All these methods use the same small, hand-held array, which is easy to move around inside a cabin environment and fits easily in narrow spaces. And because the array has two layers of microphones it is effective in conditions with sources or reflections that come from behind the array, which is typically the case inside cabins.

SEE MORE
Read the full white paper at
www.bksv.com/whitepapers

JET ENGINE KNOW-HOW HELPS **VOICE STUDIES TAKE OFF**

A model that simulates our voice-production capabilities facing a microphone array, which determines the acoustics inside the vocal tract using acoustic holography

Taking principles used to analyze jet engines, researchers are studying the mechanisms that generate the human voice. With precise sound mapping, they seek to understand the specific contributions of all the biological components to sound quality, pitch and strength, and find the origins of specific speech problems.

BY: **LIRAN OREN**
Ph.D., Research Assistant Professor
Department of Otolaryngology – HNS
University of Cincinnati, USA

Despite Tweeting, Facebook and texting, our voice remains our primary tool for communication, and many of us seek to improve it. Singers need to recover from vocal cord strain, business professionals want to project sound better, and hospital patients deal with post-operative damage to vocal cords. Most of us would like to have better vocal power, sound more resonant, or sing better.

UNDERSTANDING VOICE ACOUSTICS

Our voice is generated by vibrations of the vocal folds. These folds are found in the larynx, which is located in the middle of your neck. The vibrations of the folds generate sound at a frequency that determines the pitch of your voice. The sound then propagates to the articulators, the organs located above the vocal folds such as the tongue, uvula, cheek, or lips, which filter the sound through a series of acoustic resonances. This filtering process transforms sound into a series of vowels and consonants, thus creating the final output – intelligible speech.

Even with marked progress in science and medicine, we lack detailed understanding of how the voice is generated. Voice and speech are integrated outcomes, yet scientists often separate them to understand the specifics of each, and to determine what mechanisms are important. But both outcomes can be affected by distortion. For example, breathiness or hoarseness are disorders that are related to voice, while stuttering is a disorder that is related to speech. Using modern engineering and the latest acoustic techniques, we are cutting a new path in the study of the human voice.

JET ENGINES AND VOICE BOXES

Our lab is researching voice mechanisms and its various disorders by bridging the fields of medicine and engineering. It was founded by Drs Sid Khosla and Ephraim Gutmerk. Dr Khosla is a laryngologist and an airway surgeon who has received several grants from the US National Institutes of Health to investigate causes of voice disorders, and best ways to treat them. Dr Gutmark is an Ohio Eminent Scholar and distinguished professor of aerospace engineering who studies the noise mechanisms in jet engines and best ways to reduce them.

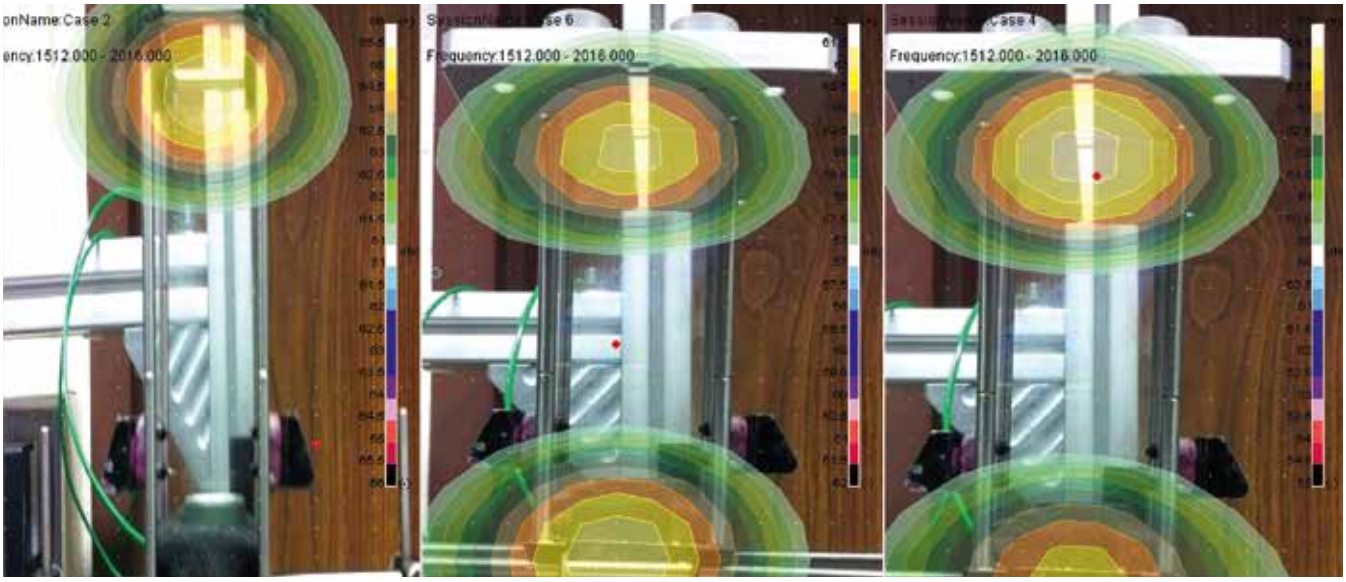
Our voice lab's unique approach is in taking existing knowledge about jet engines from aerospace engineering and using it to study the voice. Understanding how airflow patterns affect sound in a jet engine (aeroacoustics) helps us determine how we can reduce jet noise. So we are applying the same physical understanding of aeroacoustics to study normal and abnormal cases of voice. Once you understand how the structure of the airflow produces acoustics, you can work on either making the acoustics quieter – for jets – or making them stronger, for voices.

VOCAL CORD VORTICES

Our lab was the first to observe that vortices form in the airflow that passes between the vibrating vocal folds. A tornado is an extreme example of a vortex that is created by the airflow. Using an advanced laser imaging technique that is well established in ▶

JET ENGINE KNOW-HOW HELPS
VOICE STUDIES TAKE OFF

Near-field acoustic holography measures the acoustic modes, whose location and intensity changed as the testers varied parameters for the articulators



aerospace engineering to measure airflow – particle image velocimetry (PIV) – we found that small vortices are formed between the folds. We know that vortices in a flow can have a marked effect on its acoustics, but we do not yet understand how these vortices might affect voice or speech.

The next stage of studies will focus on speech evaluation and measurement of nasalance

However, one of our findings shows that the vortex strength weakened or disappeared when we simulated an abnormal voice condition.

MAPPING THE ACOUSTIC DISTRIBUTION

Recently, our voice lab used near-field acoustic holography (NAH) to study the sources of sound in the vocal folds and the articulators. With the help of Tony Frazer and Dave Bush from Brüel & Kjær, we set up an experiment that simulated sound propagating from the vocal folds to the articulators. We then used NAH to identify how the modes of the acoustics changed as we varied the parameters in each experiment. The images showing the set-up give an example of the sound modes that we observed in the model. Our findings were well received at the 2014 International Conference on Voice Physiology and Biomechanics in Salt Lake City, Utah.

TOWARDS TREATING DISORDERS

As we continue to use NAH to study voice, and potentially speech, we hope to take our established method of measuring the airflow between the vocal folds (PIV) and pair it with spatial distribution measurements of the acoustics (NAH). By coupling these two methods, we will better profile the aeroacoustic attributes such as vortices that exist in the human voice. Discovery of these additional sources that affect sound may open up a whole new way to treat voice disorders.

FEET, THUMBS AND BARLEYCORNS

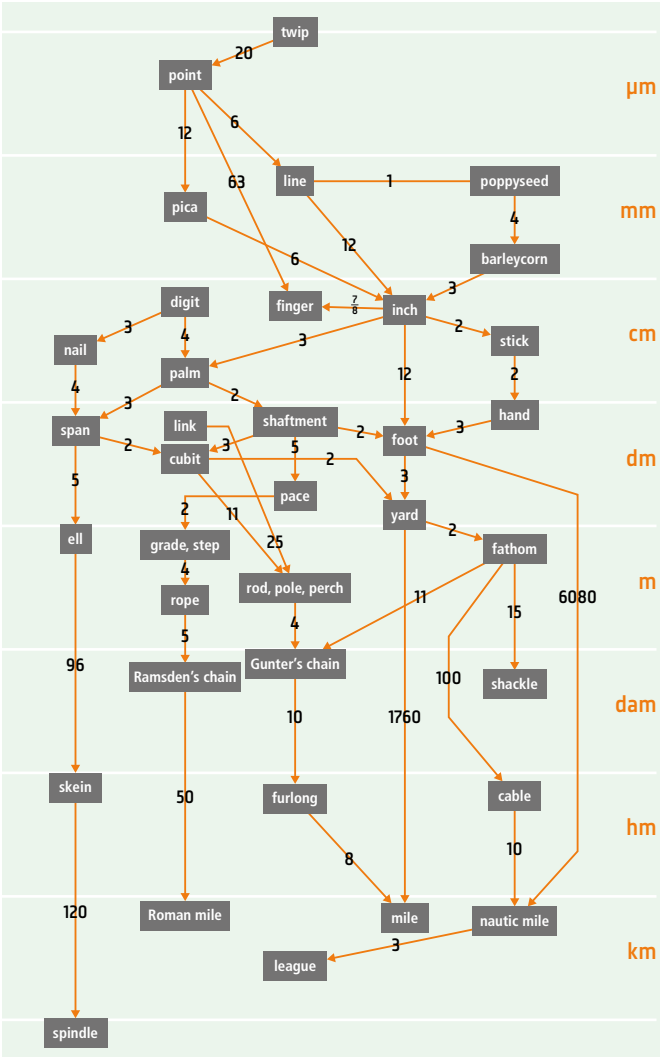
Where do inches come from, and how did medieval Europe affect American shoes?

Before the Romans imposed their measurement system on Britain in the 1st century CE, very little is known about British measurement units. But it's clear that the Anglo-Saxon age (450 – 1066) saw a blending of units, as the North Germanic tribes brought with them a larger standard foot of 335 millimetres (13.2 inches).

Units evolved by using items that were common in pre-scientific, agrarian times, so the foot was divided into 12 thumbs. These became inches, which were further subdivided into barleycorns – themselves divisible by poppyseeds.

History is filled with minor adjustments including after the Norman conquest of 1066, when 1 inch became standardized as 3 barleycorns, and in Magna Carta of 1215.

The 1824 'Weights and Measures Act' defined the Imperial System of Measurement that Britain imposed on much of the world through its global empire. But by then, the USA had become independent and continued on its own path. With little coordination between the parallel systems, units with the same name – like gallon – evolved to mean different quantities.

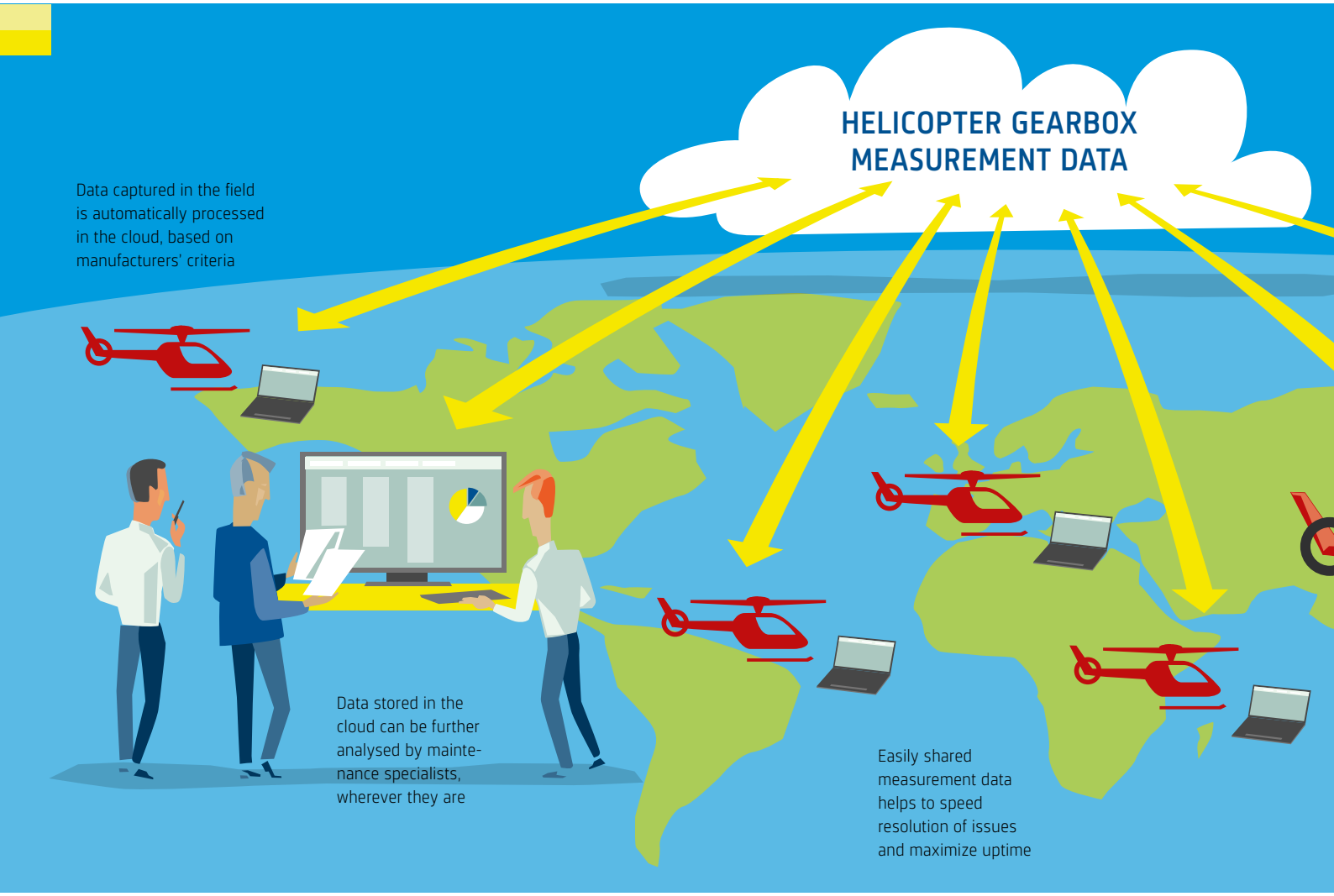


Answers to the quiz on p. 11.
True: ell, fathom, furlong, poppyseed, shaftment.
False: loaf, cable, button, nail, cloth, twig.

HOW MANY CORNS IN YOUR SHOES?

Originally, the maximum shoe size was set at 13, which was exactly 13 inches, and all other sizes were determined by counting backwards from 13 in barleycorns. So a size 4 would be 9 barleycorns less than 13 inches: 10 inches (25 centimetres). So barleycorns are still used today as the basic unit of shoe size in the UK and the USA.

CLOUD COMPUTING BRINGS TEST DATA DOWN TO EARTH



From helicopters to medical screening CT machines, air-conditioning units and cars, manufacturers depend on accurate sound and vibration measurements to assess quality and confirm correct operation. These measurements need to be accurate, repeatable and easy to obtain. Organizations also need a straightforward way to share these measurements with experts around the world, to get good diagnostic results and quickly resolve any issues.

How do you take precision vibration and noise measurements of a helicopter gearbox in a remote location? Companies can't have experts everywhere to take these measurements, but the data needs to be captured and analyzed wherever the helicopter is located and decisions and action taken based on the results.

Using simplified instrumentation and a globally networked data management solution makes it easy for non-specialized technicians to take measurements in the field and then share this data with experts anywhere in the world, who can decide the best course of action.

STRAIGHTFORWARD MEASUREMENT

It all starts with accurate, repeatable measurements that are easy to perform using instrumentation in the field, so that regardless of where your equipment is, technicians can get reliable data, without having to be skilled in noise and vibration measurements.

Being able to take reliable measurements is just the first step. The information is useless if it simply sits on someone's computer and cannot be shared with others who need it.

So, rather than storing it locally, the data is transmitted to a cloud-based system using the Internet. In the cloud, Brüel & Kjær looks after the measurement data in a form that means authorized people can access it.

AUTOMATIC DIAGNOSTICS OF PRODUCT QUALITY AND PERFORMANCE

Once measurement data is captured in the field and sent to the cloud, it is automatically processed to determine a pass/fail result, based on specific criteria validated by the original equipment manufacturers (OEMs).

If a measurement result fails this initial screening, then companies have various options, depending on the specific equipment. For the gearbox in the helicopter, for example, a detected problem could mean the helicopter is grounded until the issue is solved.

DATA ANYTIME, ANYWHERE, ACCESSIBLE TO ANYONE

But how do companies solve problems that have been detected? If you do get a failure, then often the measurements need to be referred to a specialist (for example, a specialist in helicopter gearbox maintenance) who can determine what needs to be done. By reviewing and analyzing the sound and vibration data further, an expert can decide if the failure can be overridden or how to rectify the condition.

Working together with the OEMs, Brüel & Kjær makes it easy for the essential data needed for assessing and resolving an issue to be shared with specialists, wherever they are.

Via the database in the cloud, this solution is a reliable way to share measurements so that you can concentrate on cost-effective operations and avoid downtime due to equipment failure. ▶

CLOUD COMPUTING BRINGS TEST DATA DOWN TO EARTH

Cloud-based data management can significantly improve helicopter gearbox field maintenance

An efficient operation based on accessible information is crucial for business profitability, whether it's a helicopter gearbox, a generator in a powerplant, or a CT machine in a hospital. A cloud-based data management system can significantly improve field maintenance – regardless of where your products are in relation to your headquarters or technical specialists.

PRODUCTION LINE MEASUREMENTS

The same data management solution can also be used to establish and monitor product quality on production lines during manufacture. For example, in the case of medical CT machines, the performance of the bearings used in the machines can be measured as they are released from the production line at the manufacturer. This confirms that the parts meet stated quality criteria. Similarly, data is sent to the cloud where it can be accessed remotely. Manufacturing facilities are routinely located away from the equipment design facilities, in different countries and different time zones.

Often manufacturing is outsourced to different companies. Cloud-based data management enables the production test data to easily be shared with the OEMs in real time.

The benefits of this include:

- OEMs can obtain early warnings of any changes in component quality before they start to fail quality criteria. This allows action to be taken without yield dropping or production stopping
- Saving time and money because production quality issues can be resolved remotely, avoiding having to send experts from the OEM every time a problem is detected at the manufacturing plant

Obtaining measurement data from the production line and being able to easily share this information with experts anywhere in the world helps to maintain quality levels and manufacturing throughput.

Noise and vibration maintenance check results for CT machines can be recorded and stored in the cloud

AVOID OPERATING FAILURES AND COSTLY DOWNTIME

Continuing the example of the bearings, once they are manufactured, they are installed in CT machines, which are then delivered to hospitals around the globe. During the operating life of the machine, maintenance technicians can use Brüel & Kjær's instrumentation to carry out easy-to-run, routine, noise and vibration maintenance checks, and the results can be recorded and stored in the cloud.

In the event of problems or concerns over operation, the OEM can access this information in a centralized database and advise on any problems and on how to resolve them. Because the data gets to the experts quickly, the fault can be diagnosed and resolved quickly, which reduces downtime and provides a better result for the hospital and, ultimately, the patients who need a CT scan.

SAFE STORAGE, SIMPLE RETRIEVAL, LONG-TERM DATASETS

Because all the measurements are securely stored and are easy to access and analyze, you can look at trends in the noise and vibration data going back many years. For the CT machines, for example, you can see when the performance of the bearings is degrading. Over time, you can look at aggregates of your data and can anticipate when failures might occur. For example, perhaps failures start to happen when the bearings show a particular vibration characteristic. This might suggest preventative maintenance procedures can be adapted to change bearings less regularly, based on how much the machine is used, which optimizes costs and minimizes downtime.

Many diverse organizations and manufacturers can use a cloud-based data management solution to improve the routine maintenance of different types of equipment out in the field. The testing is easy to perform, so reliable measurements can be taken by non-specialized technicians. You can quickly obtain pass/fail results and, because you can easily share this data with your equipment specialists and experts, you can get good diagnostics and a quick resolution of any issues.

Ultimately, accurate vibration measurements in the field, with easily accessible results, help to maximize uptime, optimize preventative maintenance cycles, and facilitate a quick resolution of issues. And the secure, long-term storage of data also means that the solution can be used to generate insights that positively influence maintenance procedures, for the long-term benefit of businesses.

BRÜEL & KJÆR'S WEB TEST ADVISOR

The Web Test Advisor is a new development from Brüel & Kjær that couples sound and vibration test equipment with cloud processing and storage, to share data between stakeholders around the globe.

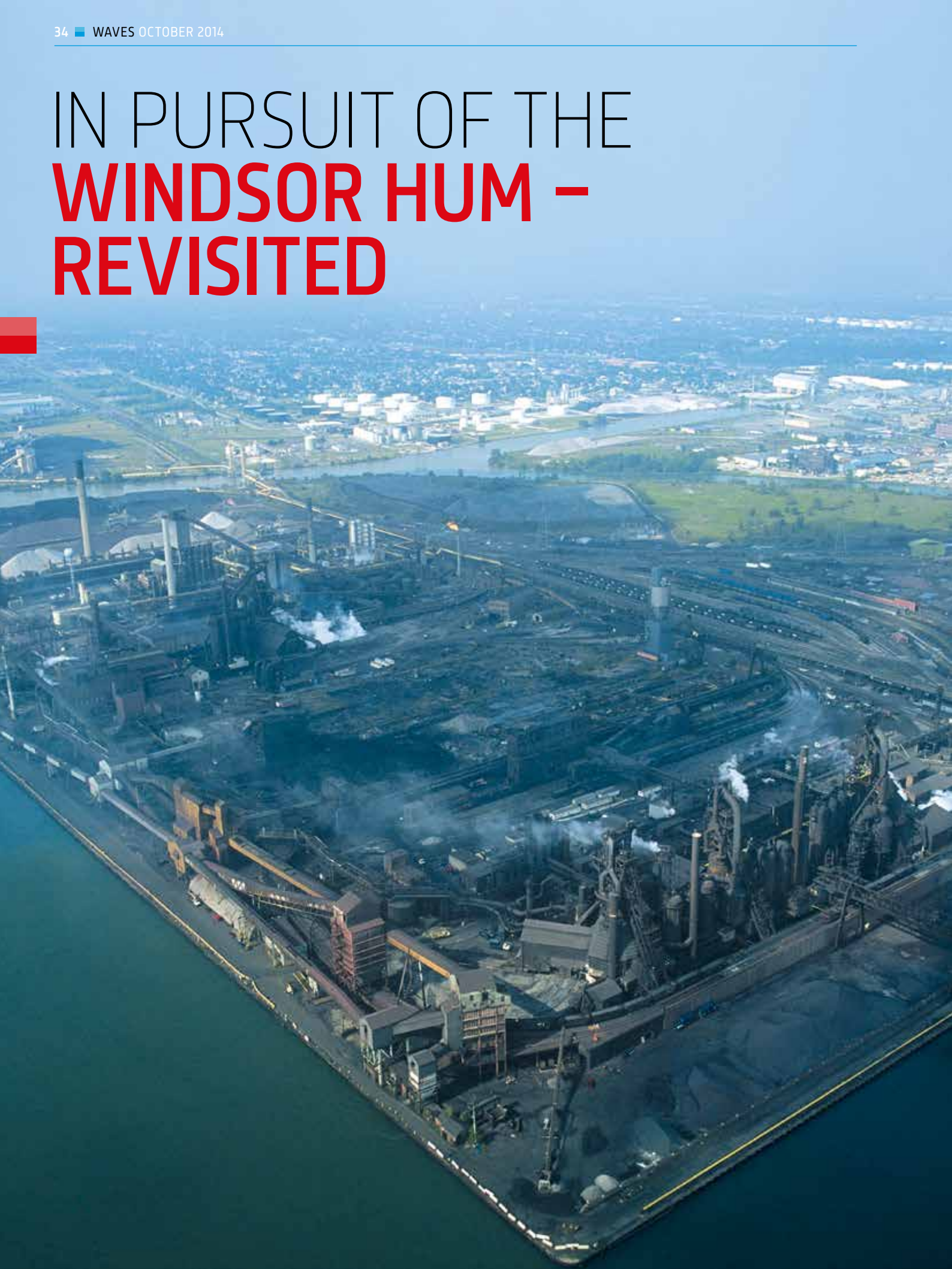
Data is captured in real-time from PULSE production line test systems, or from hand-held devices like Hand-held Analyzer Type 2250 and transmitted to the cloud for secure storage. Data can be automatically processed with diagnostics results transmitted immediately back to site, or alerts sent to other parties to take immediate action.

Test results are accessed through a Web-based dashboard by authorized users from anywhere connected via the Internet. The dashboard enables individual tests to be accessed through simple metadata searches. The results can be displayed and downloaded locally for further analysis in a variety of applications. Data remains securely stored and accessible for as long as the service subscription is active.

As well as test results, the dashboard shows performance data. On a production line, this can be a real-time display of throughput, yield and failure modes aggregated across multiple production lines and manufacturing facilities in different countries. For in-field product maintenance, this could be the number of units tested, failure rate and, for example, the number of failed cases still open for resolution.

Web Test Advisor
wta@bksv.com

IN PURSUIT OF THE **WINDSOR HUM – REVISITED**



"THE NOISE MONITORING TERMINAL WAS A VIRTUAL EAR, TUNED TO RECORD THE HUM 24/7."

COLIN NOVAK, PROFESSOR, PHD, PENG
UNIVERSITY OF WINDSOR, CANADA

A mysterious noise has long plagued the residents of the City of Windsor in Canada. Since the Canadian government engaged the University of Windsor to investigate its origins, there have been concrete developments in the case of the Windsor Hum.

In January 2013, the government earmarked funding for two research projects to find the Windsor Hum's origin. This was followed by an announcement in February 2013 when Professor Colin Novak was chosen to lead a group of fellow scientists and researchers from Windsor and London's Western University to set up a Brüel & Kjær noise monitoring terminal in a wood in the western part of Windsor. Using 3G communications, the team was able to monitor the noise data from the terminal in real-time from anywhere in the world as long as they had access to the web. Other equipment included microphone arrays used to try to pinpoint the origin of the elusive rumble.

Finally, in May 2014, the Canadian government released the two-part report prepared by the research teams at a highly anticipated press gathering next to the Detroit River, overlooking the industrialized side of the Detroit skyline. The Member of Parliament who led the press announcement stated that while the Western University report was inconclusive, the University of Windsor team was able to confirm scientifically that the Windsor Hum does exist and that it emanates from the industrialized Zug Island on the US side of the border, with the U. S. Steel operations being the likely cause.

"Unfortunately, we weren't able to find the smoking gun," Prof. Colin Novak said following the press event. Novak said he and his partners needed more time and US cooperation to pinpoint the source. "The study time just wasn't long enough, especially for a sound like this, one that doesn't manifest itself on a regular, timed interval. It's like chasing a ghost." Novak said there now needs to be cooperation with all levels of the US and Canadian governments as well with the companies on Zug Island. "Our job as scientists, while challenging, is not as difficult as the task that the politicians now have in front of them."

WHO SAYS **WHAT?**

"TONES SOUND, AND ROAR AND STORM ABOUT ME UNTIL I HAVE SET THEM DOWN IN NOTES."

LUDWIG VAN BEETHOVEN
(1770 – 1827)

German composer and pianist Ludwig van Beethoven was a crucial figure in the transition between the Classical and Romantic eras in Western music, and he remains one of the most famous and influential of all composers.

Although Beethoven never heard a 12-cylinder symphony, perhaps he would have enjoyed a visit to Ferrari, where some of the most passionate engine designers in the world compose overtures with roaring, hot metal.
See pages 4 – 7 for more.

CAE PARTNERSHIPS
MAKING DESIGN PROCESSES MORE EFFICIENT

Brüel & Kjær has teamed up with the best-in-class computer-aided engineering (CAE) suppliers to improve processes and optimize communication between the virtual and physical domains in the sound and vibration test world.

The cooperation focusses on three areas: structural correlation, NVH simulation and load/source determination for model excitation.

For the aerospace and automotive industries, this means Brüel & Kjær's customers can correlate, visualize and audition their simulation and test data.

The ability to define and apply more accurate source excitation to their models allows more precise and comprehensive results earlier in the design cycle.

For the automotive industry in particular, these CAE partnerships allow customers to drive, hear and feel their automotive simulations in a context that is close to a real driving experience.

Brüel & Kjær products and solutions can be used with any CAE solution, however, the close collaboration with CAE partners and their customers allows Brüel & Kjær to optimize work processes, minimizing the manual manipulation and editing of data.

This close dialogue with CAE suppliers is bridging the gap between the virtual world and the physical testing world, enabling more precise results earlier in the design cycle, reducing the number of design iterations, and ultimately helping customers to reach their targets earlier – reducing time to market.

Short-term noise monitoring made simple

Noise consultants with short-term projects such as surveys, complaint assessment or compliance monitoring no longer need to purchase expensive equipment – they can subscribe to a need-based service: Noise Sentinel – On Demand.

Subscribing to the service is easy. Consultants simply order the equipment they need online. During monitoring, the data is stored in the cloud, where it is immediately accessible from anywhere. Once the project is complete, the equipment is returned, but the measurement data continues to be maintained in the cloud.

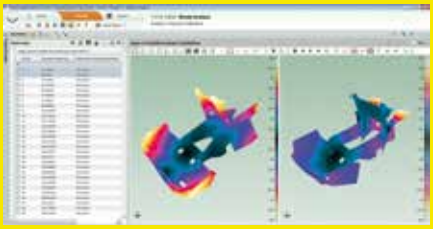
Noise Sentinel – On Demand is based on Brüel & Kjær's award-winning Noise Sentinel for long-term noise monitoring.

Speech intelligibility measurements for room acoustics go wireless

The new battery-powered Echo Speech Source Type 4720 allows you perform speech intelligibility measurements quickly and easily without messy cabling. Used in combination with DIRAC 6 Room Acoustics Software, this stand-alone tool offers five built-in calibration channels that measure a range of speech intelligibility parameters in accordance with IEC and ISO standards.

Users can measure the intelligibility of a system using a signal played directly from DIRAC through the sound device output as well as external devices such as MP3 or CD players. The Echo/DIRAC combination copes well with background noise and is an invaluable tool for acoustic engineers measuring room acoustics.

PULSE Reflex data capacity enhanced with 64-bit



Large data capacity is a reality with the latest release of PULSE Reflex, which introduces native 64-bit support for the PULSE Reflex structural dynamics suite, and for standard PULSE Reflex Core applications. The update enables you to easily handle projects containing large amounts of data on both Windows® 7 and 8. With structural analysis, 64-bit support allows larger finite element (FE) models for test planning, test validation and test-FE model correlation. This update also brings significant new feature enhancements and a fresher, cleaner GUI.

Easy acoustic material testing for aircraft

Ever-stricter environmental regulations mean the acoustic materials that reduce aircraft noise must perform precisely as designed. This can be assured through quality checks on acoustic material constructions, such as engine nacelle liners, after all manufacturing processes are complete.

Brüel & Kjær's Portable Impedance Meter System Type 9737 uses high-pressure sound, up to 155 dB, to quickly spot-test materials at levels found in aircraft engine ducts. An automated pass/fail routine allows production line operators to simply hold the lightweight instrument in contact with the in situ test article, and then receive a clear go/no go signal from an LED.

CUSTOMER NEWS

Healthy gearboxes mean peace of mind at Airbus Helicopters

Gearbox failure is Airbus Helicopters' worst nightmare, even surpassing engine failure. It is vital that gearboxes are constantly monitored to ensure they are healthy and to detect potential failures. And as their helicopters fly demanding missions in hostile environments, it is essential to eliminate false alarms that could lead to unnecessary forced landings.

Airbus Helicopters worked closely with Brüel & Kjær to develop a solution for permanently monitoring vibration levels with health usage monitoring (HUMS) accelerometers. Robust and flight certified, these hermetically sealed accelerometers now perform long-term monitoring on all EC175 helicopters and on the EC225 Super Puma.

Arup Acoustics awarded for 3D train auralisation

Arup Acoustics, an independent firm of designers, planners, engineers, consultants and technical specialists, has won the ANC Environmental Acoustics award category, sponsored by Brüel & Kjær, for their work on the High Speed 2 – Sound Demonstrations (HS2) project.

The HS2 London-to-Birmingham train connection is a nationally significant project with a high level of public awareness. To overcome concern about its potential noise impact, Arup Acoustics used state-of-the-art 3D auralization to demonstrate to residents and government officials what it will sound like in their community.

This is the first time state-of-the-art 3D auralization has been used on such a large infrastructure project to engage with stakeholders, inform design, and aid decision-makers – allowing them to decide for themselves what the impact of the proposals might be.

Eindhoven Airport engages with local community over noise levels

When Eindhoven Airport in the Netherlands wanted to expand while continuing to maintain good relations with its neighbours, it turned to Brüel & Kjær's WebTrak MyNeighbourhood technology. The result was an interactive website that provides the local community with accurate information about the airport, answers to their frequently asked questions, and a better understanding of the airport's operations.

This deployment of WebTrak MyNeighbourhood is the world's first. WebTrak MyNeighbourhood enables the public to investigate noise and flight information, including long-term trends and seasonal changes, for themselves. Drill-down capabilities reveal further information about flights and noise, and WebTrak also provides an easy way for people to lodge complaints.

ENGINEERING STUDENTS JOIN THE CROWD AT ROSKILDE FESTIVAL

The Roskilde Festival is northern Europe's largest music festival, attracting over 100,000 people who come to see such diverse groups as Metallica, Bruce Springsteen and Pearl Jam. This year, as the crowds jammed to the Rolling Stones and Arctic Monkeys, engineering students from the Technical University of Denmark (DTU) joined the unwashed masses for the fifth year running, conducting a series of projects ranging from a simple and flexible urinal made of plastic sheeting to beer cans cooled by cycle power.

Four of the projects this year concerned acoustics. Armed with Brüel & Kjær sound level meters, DTU students tested the sound levels on the main stages, as well as in neighbouring areas. Working with festival organisers, students got a rare opportunity to develop solutions in a real-world setting. This collaboration has led to the set-up of three startup companies since 2010, Volt, DropBucket and Kubio.

Photo courtesy of Tuala Hjarnø

Snecma to test new state-of-the-art LEAP engines

Snecma, one of the world's leading manufacturers of aircraft engines, is developing its state-of-the-art LEAP engine to replace the CFM56. The plan is to manufacture over 1,700 of the new engines in 2019.

To meet the challenge of producing a high-tech engine in such record numbers, Snecma has partnered with Brüel & Kjær, who will be providing 30- and 90-channel (portable) and 300+ channel rack-mounted LAN-XI/PULSE test systems that can be flexibly combined for specific test needs. The workflow and user-interface were designed in close collaboration with Snecma test engineers, to create a flexible test system that can be easily expanded, as required.

FIVE QUESTIONS FOR NISHIKUBO-SAN

49-year-old Takeshi Nishikubo is Country Manager for Brüel & Kjær Japan. He has accumulated immense experience of sound and vibration in the automotive industry, as well as fatigue and durability testing. In his spare time he likes playing golf, sightseeing, driving cars, exploring audio, enjoying wine, beer and sake – and reading Kotaro Isaka's book 'Audubon's prayer'.

MOTTO:
"DO YOUR BEST AND YOUR BEST HAS TO BE FIRST CLASS"

What are your daily work challenges?
Trying to channel power in one direction. Some like things to stay the same but change is necessary for our future. I like to make short- and long-term targets clear and help my team realise that change can be fun.

Who do you admire most?
Anyone not afraid of failing. Failure is essential to overcome difficulties and achieve success.

What is the best advice you've been given?
Don't hurry. Wait and see what happens, observe your surroundings. This is necessary for making the right decisions.

What irritates you most about your personality?
A Korean friend once told me "you are more optimistic than an American but more aggressive than a Korean". I am not sure if this is good.

With all the money and time in the world, what would you do?
Build a fully sustainable town to demonstrate what the world should be like. To protect the environment I would only use renewable energy.

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