NEW ZEALAND ACOUSTICS

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ACOUSTICS 2022 CONFERENCE – WELLINGTON

NEW DATES: 31 Oct-2 Nov 2022

The Acoustical Society of New Zealand (ASNZ) and Australian Acoustical Society (AAS) Joint Conference will be held at Te Papa Tongarewa Museum in Wellington New Zealand, from 31 Oct – 2 Nov 2022.

Acoustics 2022 will provide engineers and scientists in all fields of acoustics the chance to share their work with colleagues. Six plenary/keynote lectures, a full and interesting programme covering a wide range of topics, and some excellent social functions, will give attendees the opportunity to exchange views and share experiences. There will also be a unique opportunity for manufacturers and suppliers to showcase the latest developments in acoustic instrumentation, software and noise and vibration control products.

Surrounded by nature and fuelled by creative energy, Wellington is a compact city with a powerful mix of culture, history, nature and cuisine. Fuel your visit with strong coffee and world-class craft beer – Wellingtonians are masters of casual dining, with plenty of great restaurants, night markets and food trucks.

On the waterfront itself you'll find Te Papa Tongarewa Museum, New Zealand's national museum. Te Papa, as it's colloquially known, means 'our place' and is one of the best interactive museums in the world. It is an iconic New Zealand building, right in the heart of the capital city. It is easily accessible by international and domestic flights into Wellington airport, which is only a short 15 min drive from the venue.

The Acoustics 2022 Organising Committee looks forward to welcoming you to Wellington in November. We hope that the conference gives you an opportunity to strengthen your existing networks and that you leave with great memories, fresh ideas, and new friendships.

Keep up to date with the latest conference information by visiting: www.acoustics2022.com

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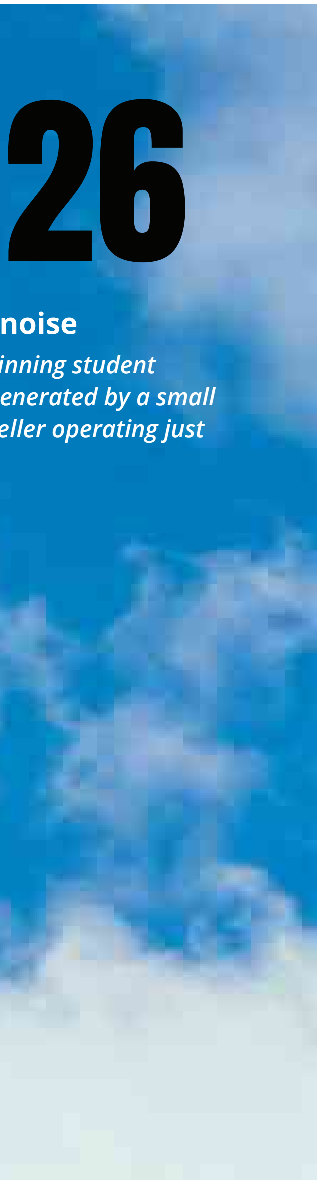
NZ Classrooms have a new acoustic design standard – DQLS v3.0

An overview of the comprehensive rewrite of the previous standard to improve readability and clarity for designers of school buildings, and to update best practice guidelines in response to complaints and feedback about the previous version



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Greetings fellow acoustic enthusiasts!

As your new ASNZ president, I must say it is an absolute honour to be appointed to this prestigious position, in a society that I feel deeply passionate about. I would like to extend many thanks to those who nominated and supported me for this appointment.

Well, what a...shall we just say, interesting...year 2021 turned out to be. 93 days in lockdown and counting. I'm glad the rest of the country has managed to largely carry on as normal, and I'm personally grateful that my field of acoustical consulting work has not really been affected. If anything, things seem to be busier than ever!?

Looking back on 2021, ASNZ managed to achieve some pretty great things, most notably the Conference in June. This was our best attended ASNZ (solely NZ) conference ever. I'd like to say a big thank you to the organising committee for their tireless efforts in pulling it all together. Fortunately, we have much the same people involved in organising the upcoming 2022 joint ASNZ/AAS conference at Te Papa, Wellington, so I'm sure we will all be keenly anticipating that as well.

The ASNZ Council consists of 13 enthusiastic members – welcome to you all. I'm looking forward to getting plenty done with you over the next couple of years. Here is a quick snapshot of some of the things the Council & Society members have been/are, currently working on:

- University research projects were recently judged with the award of prizes to three student groups for excellence.
- The Council are aiming to strengthen ties with the Association of Australasian Acoustical Consultants (AAAC.org.nz).
- Discussions have been held on the interpretation and application of the New Zealand Building Code clause G6 and the construction noise management process, with the aim of producing guidelines/practice notes to assist Councils and acoustic consultants, alike.
- Due to popular demand, the Cafe and Restaurant Acoustic Index (CRAI) is being reinvigorated as a cross-platform mobile App.

With so many things on the go I'm sure we are all looking forward to the Christmas break and having the opportunity to relax, unwind, and maybe even do a bit of travel (at least around our fine country).

Cheers,

Tim Beresford

President of the Acoustical Society of New Zealand

Welcome to the third and final edition of New Zealand Acoustics for 2021.

We are coming to the end of another busy and turbulent year which has included additional restrictions and lockdowns, which one can only imagine is even more of a challenge to our colleagues, family and friends based in Auckland. We hope you are all keeping safe?

Tim Beresford, our new elected President has his first President's Column in this edition and it would be a good time to thank Jon Styles (retiring President) and the past committee members who are stepping down for their past service to the Society. A new Council team was voted in at the ASNZ conference (see page 7).

We have a full edition, ranging from news through to the quiz and everything in between. Our feature is a piece by Head Environment Court Judge Kirkpatrick on expert witnesses in court. We also have some fantastic papers on 'Designing Quality Learning Spaces (DQLS)' – the acoustics document the MoE uses as their blueprint for the design of new and renovated classrooms in New Zealand. We recommend you read not only the paper but also the DQLS guidelines.

We have a paper by Yan Wu. Yan was awarded the Acoustical Society of New Zealand Student Paper Prize at the 2021 conference. His paper investigates the noise generated by a small unmanned aerial vehicle (UAV). Again, the paper is well worth the read.

Lindsay Hannah & Wyatt Page

Principal Editors

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NEWS

ASNZ Committee 2021

Acoustic Society of New Zealand 2021-2022 Council

A new committee was elected during the AGM at Five Knots in Auckland. The committee is:

President: Tim Beresford

Vice President North Island: Mike Kingan

Vice President South Island: Tracy Hilliker

Secretary: James Whitlock

Treasurer: Siiri Wilkening

Council Members:

Lindsay Hannah; Mathew Legg; Hedda Landreth; Victoria Rastelli; Askhan Ghane; Matthew Bronka; Christian Vossart

Retiring President: Jon Styles

ASNZ Conference 2021 Report

The conference of the Acoustical Society of New Zealand was recently held at the Tamaki Yacht club, overlooking the beautiful Hauraki Gulf, on Monday the 28th and Tuesday the 29th of June. This was following a last-minute postponement in February due to the Covid-19 lockdown in Auckland, and followed on from the postponement of the joint ASNZ-AAS conference, which was to be held in Wellington in 2020. Despite the conference being run under the shadow of the Covid-19 pandemic, the conference was attended by a record number of delegates and received record support via sponsorship.

The theme of the conference was 'The Sound of a Changing World'. This theme was intended to focus contributions towards discussing changes in the field of Acoustical Engineering and also to encourage contributions which emphasised how the importance of sound in society is changing. The Covid-19 pandemic served to emphasise the importance of the latter objective with a number of presentations and discussions noting the effect of the lockdowns on the acoustic environment. These included a fascinating talk from Matt Pine on the reduction in anthropogenic underwater noise in the Hauraki Gulf during the Covid-19 lockdowns, and a presentation from James Boland introducing the concept of soundscapes and discussing the effect of the lockdowns on the perception of the local soundscape.

Matt and James' presentations were two of 30 technical presentations and 3 keynote talks which were delivered over the course of two very long days.

The first keynote talk was given by the Chief Environment Court Judge, David Kirkpatrick, who gave a description of the court process and the role of the expert witness in that. He provided suggestions as to how Acoustical Engineers presenting expert witness testimony might best present their evidence. In particular, he suggested that the Acoustical Engineering profession might want to explore whether using qualitative approaches to assess noise impact might be appropriate in some instances.

Marion Burgess gave the second keynote presentation via video recording in which she introduced the International Year of Sound (IYS). This was followed by a panel discussion featuring Marion (via Zoom from Sydney), local Acoustical Engineers James Whitlock and Victoria Rastelli, Professor Peter Thorne from the University of Auckland, and Tom Hamill from the Auckland Philharmonia Orchestra. This discussion covered a range of topics related to the IYS and has resulted in a motion to establish a new role on the Society's council for an 'engagement officer' who will identify and implement outreach activities for the purpose of raising the profile of the Society and to advertise the importance of sound in the wider community.


Out going president Jon Styles and in coming president Tim Beresford

The final keynote presentation was delivered by Professor Peter Thorne who talked about how hearing loss was a public health issue of global significance. He discussed the public health approaches advocated by the WHO and the opportunities for these to be implemented in New Zealand. Without exception, all of the technical presentations given at the conference were of a very high standard and we were particularly grateful to Yulia Yagunova and Lindsay Leitch who could not attend because of the Covid-19 scare in Wellington, but provided high quality video recordings of their presentations instead.

The Society's AGM was held just after the final technical presentation on Monday. At this it was announced that Tim Beresford would take over from Jon Styles as president of the Society, James Whitlock would continue as secretary and Siiri Wilkening as treasurer. We welcome Matthew Bronka, Ashkane Ghane, Hedda Landreth, Victoria Rastelli, and Christian Vossart who are joining the Society's council which includes returning members Lindsay Hannah, Mathew Legg, Jon Styles, Michael Kingan and Tracy Hilliker.

The GIB conference banquet was held later on Monday evening and was attended by the vast majority of delegates and sponsors' representatives. Entertainment was provided by local band Tribus, featuring Andrew Hall as lead singer, saxophonist and in various other roles. Unfortunately, Andrew did not use one of the 3D printed saxophone reeds he helped develop which were discussed in a presentation by Jonathan Everett on the second day of the conference. The last formal event of the evening was the presentation of a fellowship of the Acoustical Society of New Zealand to Keith Ballagh. The presentation included a citation made by Chris Day which emphasised the hard work which Keith had done for the Society over many years and the impact that his technical work has made on the acoustical engineering community both in New Zealand and abroad.

The second day of the conference contained 18 high quality technical presentations including the majority of the student talks. Grant Emms and Mark Poletti assisted Mathew Legg in judging the prize for the best student paper, which was awarded to Yan Wu. Yan presented a paper describing the physics of the noise generated by a UAV propeller mounted close to a strut. The conference ended at 5:30 pm with a closing address in which it was noted that, everything going to plan, the next Acoustical Engineering conference to be held in New Zealand will be the joint ASNZ-AAS conference in Wellington on the 31st of October to the 2nd of November 2022. We are looking forward to seeing you all there!

Michael Kingan and Tracy Hilliker

Keith Ballagh Encomium

It is an honour to be asked to deliver the Encomium for the conferring of a Fellowship of the Acoustical Society of NZ to Keith Ballagh. As well as an honour, it is also slightly awkward because Keith hates this sort of attention. Anyway, it is one of those important things that need to be done so I will start with a short history of Keith's career.

Keith Ballagh graduated from the University of Canterbury in 1974 with first class honours in Mechanical Engineering, joining the Acoustics Section of the DSIR as a Scientist. For you youngsters, the DSIR was the Department of Scientific and Industrial Research - now called ERL - well I think that's what it's called this week. In 1981 he was appointed Section Leader.

Later in 1981 he worked at the PTB (Physikalisch - Technische Bundersanstalt) in Braunschweig, Germany, one of the world's leading acoustic research centres.

Keith joined Marshall Day Acoustics in 1987 and became a partner in 1995. His work has included the full range of acoustical consulting work, from room acoustics to industrial noise control. A couple of highlights include;

- University of Waikato - Gallagher Concert Chamber – a beautiful space that is regarded as the best 'chamber music' venue in NZ
- Air NZ engine test cell Christchurch – very large high velocity hot gas silencers with residents in close proximity

It is Keith's technical expertise that really stands him head & shoulders above the rest. Keith has been the technical backbone of MDA for 35 years. He has developed various software packages that we sell internationally. INSUL sound insulation prediction and Zorba for predicting absorption performance of systems. Both of these have sold in more than 30 countries and are in use by universities, consultancies and manufacturers. INSUL has sold around 3000 copies. If you don't have INSUL you can't regard yourself as a serious acoustic consultant.

Iris is our 3D room acoustic measurement system. Keith initiated and supervised this project and Daniel Protheroe implemented it. A number of international auditorium acoustic firms now use Iris as their room acoustics measurement tool.

When I meet people at International conferences and they see I'm from MDA - they don't register where I fit in but say - "oh Marshall Day - you must work with Keith Ballagh - he is amazing ....etc." He has an enormous international reputation.

To become a Fellow involves a combination of his status in the field of acoustics and his contribution to ASNZ. It turns out the ASNZ history has not been well documented. However, Keith was secretary of the society during the 70s and during that time he organised to have the Society made an 'Incorporated Society'.

He also developed the original Logo (of which the current logo is an evolution) - not sure that his graphic design skills are as outstanding as his acoustical talents, but the logo is certainly better than the first MDA logo which I designed.

He was the principal organiser of the early Wellington conferences. However, by far his largest contribution was organising the technical programme for InterNoise 98 (in Christchurch) including arranging the keynote speakers etc. This is the largest acoustics conference ever to be held in NZ and the Society has run on its profits for decades.

All this praise could lead you to believe Keith is perfect. However, there have been one or two 'counter balances'. One of the funniest was during one of our regular morning tea times, Keith was engrossed in a deep philosophical discussion when the phone in the room rang asking for Keith. "Oh I'm really, really sorry – I'll be there in, ah, 30 mins". Turns out Keith had forgotten about a site noise measurement where he was meeting the client. He raced downstairs grabbed a sound level meter case and jumped in the car. He made it to the site in 30 mins and offered further embarrassed apologies. He then opened the sound levels meter case – and the cupboard was bare – no SLM !!

One other time he flew down to Wellington for a meeting and arrived at the client's office to find out he had arrived exactly one week early.

Keith is probably the most intelligent person I have met. His knowledge in everything from Bessel Functions to world affairs continues to astound me. However, in addition and more importantly - he has a wonderful social conscience. Keith has influenced generations of MDA youngsters (and oldies) - community before self (he probably contributed significantly to the Labour landslide victory at the last election).

Keith started the Marshall Day interest in Te Reo many years before it became trendy.

All of us at Marshall Day are privileged to have worked with, and learnt from, this outstanding human being.

I think I have embarrassed him way more than he is comfortable with - but as I said earlier - this had to be done.

Ladies and gentlemen, I give you - Keith Ballagh - Fellow of the Acoustical Society of NZ.

(This encomium was given by Chris Day from MDA)

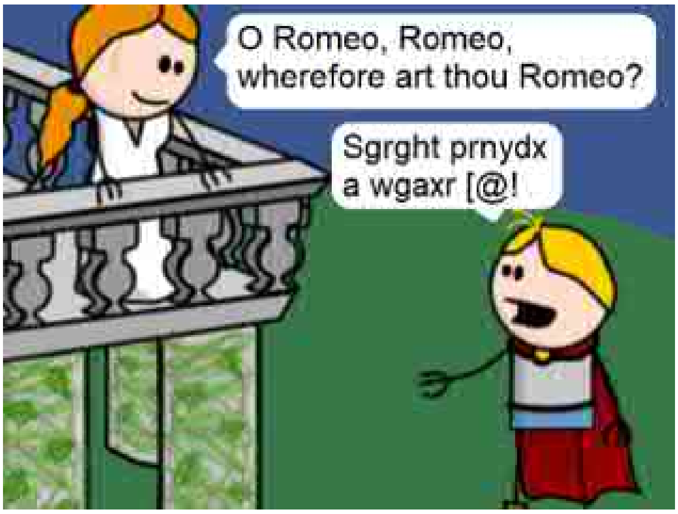
Chris Day conferring on Keith Ballagh a Fellowship of the Acoustical Society of New Zealand

Journalists cock-a-hoop over pun opportunities presented by Rooster noise case

Kiwi journalists have seized on a recent Dunedin court case involving a rowdy Rooster and several sleep-deprived neighbours to squeeze numerous puns into their articles reporting the case. The case resulted in the judge imposing an enforcement order to silence the fowl noise between 10 pm and 7 am. Following the verdict, Rob Kidd from the Otago Daily Times reported that the owner's 'chooks have finally come home to roost', while Hamish McNeilly from Stuff.co.nz noted that the neighbours now had 'something to crow about'. Further puns are available in the links below.

Sources: https://www.nzherald.co.nz/nz/cock-a-doodle-dont-dunedin-woman-convicted-for-noisy-roosters/QCSR724NCDGAE2SSRGSZEDZWSQ/ and https://www.stuff.co.nz/national/crime/300403680/crowing-roosters-fall-fowl-of-the-law-after-owner-fails-to-keep-them-quiet

'Science: "women more intelligible than men". '



A study recently published in the Journal of the Acoustical Society of America has confirmed what women have known since time immemorial – that, on average, their speech is more intelligible than that of men. The study also showed that women who speak more clearly were perceived to be more 'vocally attractive'. On the contrary, the attractiveness of a man's voice was found to be unrelated to the intelligibility of his speech. This finding may well partially explain the popularity of several well-known male public figures!

Daniel A. Stehr, Gregory Hickok, Sarah Hargus Ferguson, Emily D. Grossman. Examining vocal attractiveness through articulatory working space. The Journal of the Acoustical Society of America, 2021; 150 (2).

Sources: https://asa.scitation.org/doi/10.1121/10.0005730

Controls needed to protect animals from underwater noise

Radio New Zealand has reported that The Cawthron Institute says a lack of rules controlling underwater noise is putting at risk some of our most endangered mammals. The institute has been monitoring increasing amounts of noise created by pile driving, ports and recreational boats, and found it can cause temporary or even permanent deafness in whales and dolphins.

Dr Simon Childerhouse a biologist with the Cawthron Institute, said noise pollution got in the way of them communicating with each other and could cause stress, leading to declining birth rates.

"Loud noises have the potential to physiologically injure them and their hearing either temporarily or permanently, which obviously has big implications for survival. Some of the really loud noises

like seismic surveys or military sonar can also actually directly kill marine mammals."

Childerhouse said there were lots of things ports and boaties could do to reduce their impact but, at the moment, this was mandated through the RMA (Resource Management Act 1991) and done in a piecemeal way.

The Department of Conservation, which was responsible for protecting mammals such as endangered Hector's and Māui dolphins, should bring in a set of regulations for everybody to abide by, he said.

"The European Union has some excellent underwater standards. The USA also has some standards and even Australia has some guidelines in some states. So New Zealand's a bit behind."

Underwater acoustic expert, Dr Matt Pine, a past contributor to New Zealand Acoustics said it's normally hard to gauge if things were getting noisier underwater because the sound made by boats was almost always there.

That was until last year's lockdown when boaties were forced to stay moored for almost two months. Dr Pine couldn't believe his ears when he pulled up the five hydrophones that had been recording right through the period.

"It was pretty amazing, sort of going back to what it would have been like you know before [Captain James] Cook and hearing seal calls and whales and dolphins and fish, and waves rolling on a distant beach."

With the base pre-industrial level established, Dr Pine was now able to predict how much louder it was likely to get in the gulf over the coming years, especially from recreational boats which created most of the noise.

With ownership forecast to increase 38 percent in the next two decades, it may eventually become too noisy for marine mammals or even the fish the boaties were looking to catch, he said.

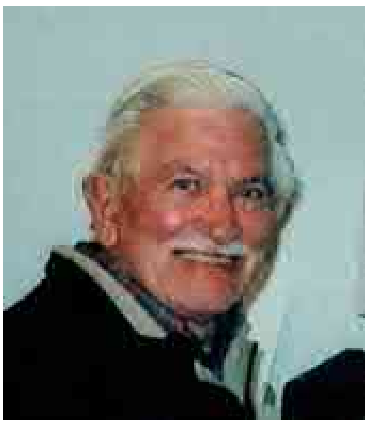
"Sound impacts fish right down to the larvae where they orient towards sounds like reef sounds and, if they can't hear the reef sounds, they won't swim in. So they'll end up in areas that are not in the Hauraki Gulf."

A DOC spokesperson said addressing the problem would require an amendment to the Marine Mammals Protection Act. This would involve a "substantial piece of work" and would need to be weighed against "other priorities."

For now it would continue to use the RMA to help protect them.

Source: https://www.rnz.co.nz/news/country/442462/controls-needed-to-protect-animals-from-underwater-noise

Francis John Quedley (1934 - 2021)



There could not be a truer friend, supporter and worker for the Acoustical Society of New Zealand than John Quedley who passed away on 13 August this year.

John was one of its founders (New Zealand Acoustical Society as it was) in the early 1970s. John and co-workers from the Auckland Industrial Development Division (a division of the then DSIR) together with Sir Harold Marshall from the University of Auckland organised and ran the first meetings in 1973.

At that time, it existed mainly as a *friendly society* providing presentations and discussions (usually held at the AIDD premises in Albert St) for anyone with an interest in acoustics. Later it became an incorporated society and eventually made its transition to the fully-fledged professional Society that we know today (except that we changed to our present name to avoid a clash of initials with the New Zealand Audiological Society).

Throughout all that early period John was Treasurer for the Society, the Advertising Manager, the Newsletter Editor and its publisher (with much help from his wife Sue).

He was the undoubted champion of the Society organising annual conferences and monthly meetings. He was, as a friend commented recently, "the glue that held the Society together"!

Personally, John was a quiet, unassuming man who did not compete for attention or prominence in the male-dominated professional environment in which he served but he was very firm and frugal when it came to financial matters. The newsletters – in the era before word processors and laptop publishing – were cut and paste jobs put together, photocopied, addressed and posted by John and Sue. Later when the original A5 bulletin moved to A4 format and then into the present-day NZ Acoustics, the revenue he raised as advertising manager meant that the Journal was produced and printed without cost to Society funds.

John was born in Auckland and lived in Manurewa until leaving school. He did military training in the NZ Air Force after which he worked for NZ Broadcasting in Auckland and Wellington. In 1955 he went to do his OE in England and worked in London as a TV technician. Later his work took him to Nottingham where he met Sue. After marrying in 1959 they left to live in Canada.

John was a keen supporter of the St. John's Ambulance Assn and was a weekend volunteer which he did first in NZ then in UK and Canada. He was active in a number of hobbies including Ham Radio, photography, bee keeping and keeping canaries.

When John and Sue returned to NZ in 1962 John built his own dark room at home to develop his own photographs for exhibition at the Camera Club. This earned him numerous awards over the years.

John and Sue regularly had a trade stand at the NZ Society conferences and, because he was the trade display organiser, John was often teased about 'having the best' stand site! In addition to ASNZ conferences John and Sue were regulars at Environmental Health and overseas Acoustics conferences too. Sometimes these came with unexpected experiences. Whilst at an Inter-Noise Conference in Budapest John decided to travel back to the hotel by tram. While actually on the tram he was attacked and robbed of his wallet which contained all his money and credit cards. Fortunately, other passengers on the tram were very helpful and took him to the Police Station to help him describe what had happened!

After his career in DSIR John decided to set up his own agency, Machinery Monitoring Systems, which as well as serving as local agent for a number of major manufacturers of sound and vibration equipment also provides a machine health monitoring service. For industries running large machines, regular vibration signature recordings is a regular feature of their preventative maintenance schemes. After his retirement the agency has been run and operated by John's son Jeff.

John retired from being treasurer of the Society in 2004 and at the AGM in November of that year he was appointed a Fellow of the Society in recognition of his vast contribution and value to the Society – only the 5th Fellowship awarded by the Society in its 30-year history to that date.

We also say a big thank you to Sue for all that she has given and extend our condolences to her at this sad time.

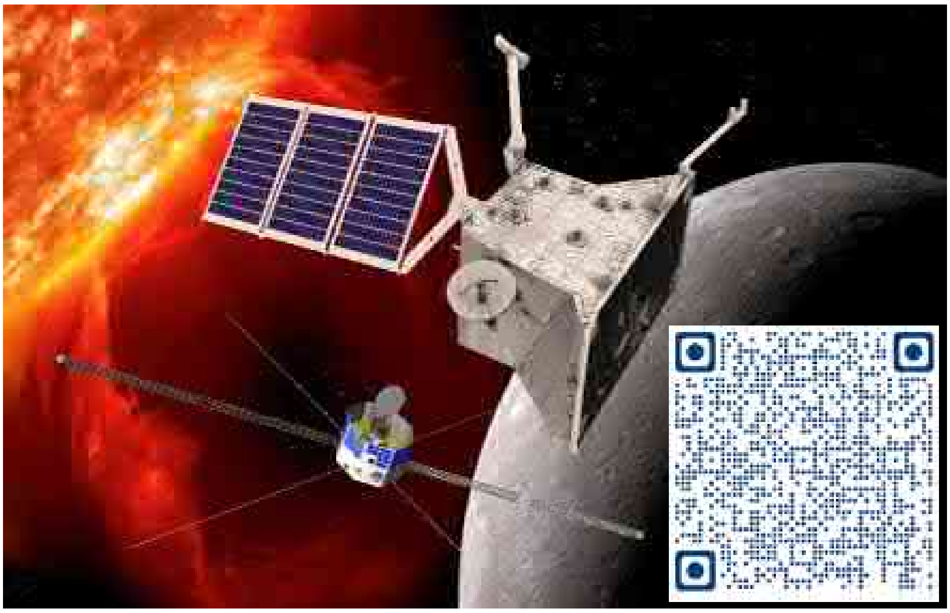
'You bloody fool': Duck mimics human sound during mating display

An Australian musk duck has been recorded saying "*You bloody fool*" in the first documented instance of the species mimicking human speech. A hand-reared male named Ripper was recorded imitating the phrase during a courtship display, according to a study published Monday. The authors said he could have learned it from his caretaker. Do you agree the Duck is saying 'you bloody fool'? To listen to an audio recording scan the QR code in the photo above.

Source: https://edition.cnn.com/2021/09/07/australia/australia-musk-duck-imitation-scli-intl-scn/index.html

Scan the QR code below to find out more.

Sound of solar wind at Venus



Space.com has reported that the Mercury-bound BepiColombo spacecraft listened to the sound of the solar wind at Venus as it flew just 550 km above the planet's surface during a maneuver designed to adjust its path. BepiColombo, a joint mission by the European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA), recorded the audio with its magnetometer instrument, providing a rare glimpse into the interaction between the stream of charged particles flowing from the sun, known as solar wind, and the thick carbon dioxide-rich atmosphere of Earth's closest planetary neighbour.

Scan the QR code to find out more.

Foreign Accent Syndrome (FAS): Brisbane woman wakes up with Irish accent after tonsil surgery

Brisbane woman Angie Yen had her tonsils removed. Ten days later, the 27-year-old woke up speaking in a “funny” voice which was a foreign accent. When Angie Yen woke up on April 28, it felt like just another morning. But when the 27-year-old dentist got in the shower and started singing — something she always did — she was shocked by the sound she heard. Instead of her normal Aussie accent, Ms Yen was stunned to hear a “foreign accent” that “sounds very Irish”. “When I started singing, I was singing in a different sound and also talking words in a funny accent,” the Brisbane woman told news.com.au.

Scan the QR code to watch the 60 Minutes documentary about Ms Yen.

Road and rail noise linked to dementia

The Guardian has reported that a study found that exposure to rail or road traffic sounds was linked to an increase in the risk of dementia by more than a quarter. The Danish researchers estimated that as many as 1,216 out of the 8,475 cases of dementia in a single year could be attributed to it.

Researchers investigated the association between long-term residential exposure to road traffic and railway noise and the risk of dementia among two million adults aged over 60 and living in Denmark between 2004 and 2017. The level of exposure at the most- and least-exposed sides of buildings was estimated for every residential address in the country. After taking account of potentially influential factors related to residents and their neighbourhoods, the study concluded that as many as 1,216 out of the 8,475 cases of dementia registered in Denmark in 2017 could be attributed to transport noise.

Source: https://www.theguardian.com/society/2021/sep/09/transport-noise-linked-to-increased-risk-of-dementia-study-finds

Scan the QR code above to find out more.

The secrets of owls' near noiseless wings

Owls have the uncanny ability to fly silently, relying on specialized plumage to reduce noise so they can hunt in acoustic stealth. Owls are known as silent predators of the night, capable of flying just inches from their prey without being detected. The quietness of their flight is owed to their specialized feathers. When air rushes over an ordinary wing, it typically creates a “gushing” noise as large areas of air turbulence build up. But the owl has a few ways to alter this turbulence and reduce its noise.

Owls possess no fewer than three distinct physical attributes that are thought to contribute to their silent flight capability: a comb of stiff feathers along the leading edge of the wing; a flexible fringe at the trailing edge of the wing; and a soft, downy material distributed on the top of the wing. For conventional wings, the sound from the hard trailing edge typically dominates the acoustic signature.

A research group working to solve the mystery of exactly how owls achieve this acoustic stealth presented their findings at the American Physical Society's (APS) Division of Fluid Dynamics meeting, held on Nov. 24 – 26, in Pittsburgh, Pa. This important work may one day help bring "silent owl technology" to the design of aircraft, wind turbines, and submarines.

Source: https://www.apsdfd2021.org/

Scan the QR code below to find out more.

Exposure to road traffic noise and air pollution may raise heart failure risk

Exposure to air pollution and road traffic noise over the course of many years may be associated with an increased risk of developing heart failure, and the correlation appears to be even greater in people who are former smokers or have high blood pressure, according to new research published today in the Journal of the American Heart Association, an open access journal of the American Heart Association.

The study, including more than 22,000 female nurses in Denmark, evaluated exposure over 15-20 years to air pollution and road traffic noise to evaluate the impact on heart failure.

Exposure to small particulate matter and road traffic noise over three years was associated with an increased risk for heart failure.

The risks were greater among women who were former smokers or women who had high blood pressure.

Source: https://scitechdaily.com/exposure-to-road-traffic-noise-and-air-pollution-may-raise-heart-failure-risk/

The pandemic made cities quieter, but not less stressful

A University College London (UCL) study confirms a distinct phenomenon: During last year's lockdowns in th Unite Kingdom, average noise levels did indeed drop across London. There was also a dramatic change in noise complaints—but not in the way you might expect. They went up more than 47%, according to an analysis by the same UCL researchers, and were overwhelmingly occasioned by neighborhood noise.

Much of the time, simply reducing the volume of noise in a space, as the experience of lockdown suggests, doesn't in itself make people more at peace with their surroundings.

If we're going to promote an acoustic environment where citizens can coexist happily—and we have to believe they can—we should change our approach. In place of the tendency to fixate on the quantity of sound in our environment, we should think a lot more about its quality.

According to Francesco Aletta, a researcher at UCL's Bartlett School of Architecture, assessing an acoustic environment solely as loud or quiet is like "judging a soup only by its temperature. Of course, if it's too hot, you need to know," he says. "But if you want to think about spices, flavor, you need a different approach."

Moving away from simple volume, soundscape researchers might ask whether an environment is "eventful" or "uneventful" and whether people in that space find it pleasant or not. These two axes—pleasant/unpleasant and eventful/uneventful—more closely describe the actual lived experience of sound. A quiet park on a sunny day is an "uneventful" soundscape that's almost universally perceived as pleasant, while a deserted nighttime street, equally uneventful, may feel unpleasant because it seems unsafe.

Source: https://www.bloomberg.com/features/2021-covid-city-noise/

FEATURES

How expert witnesses can help the Environment Court

David Kirkpatrick

Original presentation transcript

Chief Environmental Court Judge, David Kirkpatrick was appointed Head of the New Zealand Environment Court on 8 July 2020. Prior to his appointment to the Court in February 2014, he had been a Barrister sole since July 2004. He specialised in administrative and public law generally, and resource management law in particular. He appeared regularly before consent authorities, the Environment Court, and the High Court. He also appeared before the Court of Appeal, the Privy Council, and the Supreme Court. From 1994 to 2004 Judge Kirkpatrick was a partner in the Local Government and Environment practice area of Simpson Grierson. In that role he was the primary legal advisor to a number of local authorities in the Auckland region in regard to public administration, the regulation of public utilities and resource management. He has also acted for a wide range of corporate clients, incorporated societies and individuals in those fields.

Abstract

This is a presentation on the nature of the court process and judicial decision-making in the context of environmental matters. With a particular focus on acoustic issues, I will speak about how expert witnesses can give the greatest help to the Environment Court. This will include how technical evidence might be best presented from the Court's viewpoint and how expert witnesses in different disciplines should work together.

The opinions expressed are the author's own.

The Courts

Why do we do what we do?

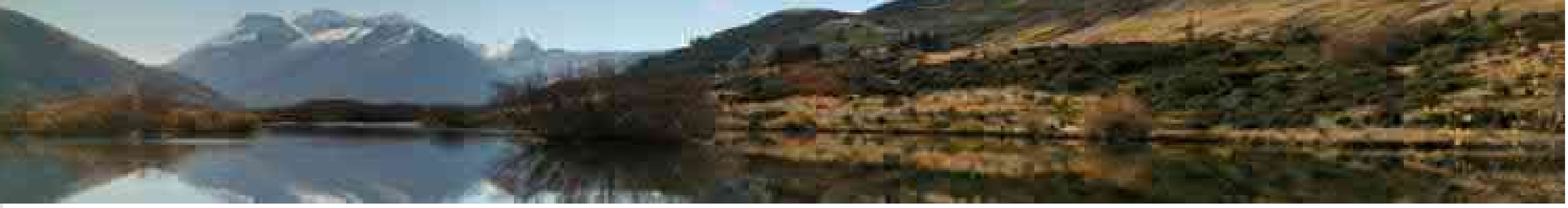
We have laws so that people can order their affairs with some certainty. We have judges in courts to resolve disagreements about the application of the laws and to try and, if proven, sentence those who break the laws.

In resolving disagreements, a judge listens to what the parties say and does not advance their own issues. Sometimes a court has to take steps to help the parties identify what the issues actually are, but the court must not substitute its own concerns for those of the parties. This is sometimes referred to as the principle that judges should not descend into the arena. This is crucial to maintaining the independence of the courts and to doing justice between the parties.

It is also not the Court's job to fix a problem if that is beyond the scope of the issues that are properly before the Court. It is not the Court's role to advise people what to do or otherwise counsel them. Perhaps resolving the disagreement or clarifying the application of the law will help do those things, and the Court will not shy away from saying something to the parties because of that, but that is not the Court's job.

I don't say these things because judges are lazy or because we don't care or otherwise don't want to help people. Sometimes we can get quite upset that we have to remain so separate from the parties. Sometimes we will say things in the course of a hearing, or perhaps in a decision, which are intended to assist the parties, or one of them, to understand something that we think they do not fully understand. We do so in the hope that this may point them towards resolving an underlying issue for themselves where it is not properly before the court. From my experience both as counsel and as a judge, that is risky business for a court.

I say these things so you can better understand why judges do what we do. I hope that a clear understanding of that may assist you when preparing something to present to us. If you have a clearer idea of what we can do, you are likely to present a better case or at least a better statement of evidence. That will then assist us better. Whether it will help us to resolve the case is a



separate and more complicated issue that I will return to later.

The Environment Court

The jurisdiction of the Environment Court is quite unusual. Most courts resolve disagreements about things that have already happened – breaches of contract or motor vehicle accidents or allegations about offences that have occurred. Such cases involve evidence being given about what has occurred and who is or ought to be responsible for that. So, in most civil and criminal cases the view is almost always retrospective.

The Environment Court handles cases of that kind in its enforcement role, dealing with appeals against abatement notices and applications for enforcement orders, and also Environment Judges hear criminal cases where the charges have been laid under the RMA.

But a very large proportion of the work of the Environment Court falls into two categories involving appeals from decisions:

- of planning authorities about the content of policy statements and plans and
- of consent authorities about the grant or refusal of resource consents and the terms and conditions of them.

This work considers what may happen and how we should plan for it, so the view is prospective and involves prediction of likely effects of activities that are being planned for or for which consent is being sought.

This range of jurisdiction, from planning to applications to enforcement, means that the members of the Environment Court see a full range of activity under the RMA. We may see how a proposed plan provision is developed, what applications are made based on it and perhaps what enforcement issues arise from it. So, while the Court's jurisdiction is narrow in the sense that we operate within a limited statutory ambit and mainly under the RMA, it is broad and extensive in terms of how the resource management regime in New Zealand is implemented.

In that context, even though we focus as a court on the dispute before us, we can often see back to the policy origins of the relevant plan provisions and forward to the effects of those plan provisions in action. One would like to think that this enables the Court to pursue an integrated management approach to the RMA, much as the legislation seeks to promote an integrated management approach to the effects of activities on the environment.

The reasons why I am taking some time to tell you this are:

1. To help you to understand the Court's approach to its role both for its own sake and so you can see how the case you may be involved in fits into what we do; and
2. As a basis on which I might suggest that you too might think about your role in resource management, particularly as an expert witness before a consent authority or the Court.

Evidence

As I have said, the Court does not make up the cases that it wants to hear. The Court also does not want to hear made-up cases from others. The key to every case is in the evidence. The law only exists to be applied to the facts, and the best legal argument almost always depends on the facts for its success. A crucial fact can beat any number of higher court decisions.

The presentation and testing of evidence is therefore at the heart of a court's process. The rules which govern the evidential process in our courts have evolved over hundreds of years. They are akin to the scientific method, even if the artificial laws of the legal system are not as sure as nature's laws. The common features of science and the law are contestable inquiries into propositions which are capable of being falsified by the presentation and testing of evidence.

While the Environment Court enjoys some latitude in receiving material which might not be so readily accepted in other courts[1], the rational and contestable framework of the law of evidence still applies.

The legal rules of evidence have been forged in the crucible of the criminal law and tempered by innumerable cases, within the strict requirements of the presumption of innocence and the requirement for proof beyond reasonable doubt before a verdict of guilty can be given. That origin places great emphasis on evidence from witnesses who were present at the relevant events and can give direct evidence of what they saw, heard, touched, smelled or tasted. Opinions are generally not admissible:[2] it is for the court to reach a view from the direct evidence put before it.

That rule against the admissibility of opinions has been relaxed over time, first to the extent that anyone can give evidence containing their opinion if that opinion is necessary to enable the witness to communicate, or the fact-finder to understand, what the witness saw, heard, or otherwise perceived.[3] A further relaxation is that an expert witness can give evidence of an opinion subject to certain rules.

The longstanding fundamental rules of expert evidence can be expressed as questions in the following terms:

1) Is the evidence relevant?
2) Does the witness have knowledge and experience sufficient to entitle them to be considered as an expert who can assist the Court?
3) Is the witness' field of knowledge and expertise recognised as credible by others and capable of having its theoretical and empirical foundations tested and verified?
4) Is the information to be provided by the expert really something on which the Court needs assistance, or can the Court rely on the application of general knowledge and common sense to the facts?
5) Will the expert's opinion supplant the arbitral function of the Court to decide the case?
6) To what extent can the expert's opinion be based on hearsay or matters not directly within the expert's own observations?

Many of the rules are now codified in the Evidence Act 2006. For ease of reference I set out the key provisions of that Act here, with some underlining to assist readers in identifying important elements:

Evidence Act 2006

4 Interpretation

(1) In this Act, unless the context otherwise requires,—

1 Section 276(2) RMA.
2 Section 23 Evidence Act 2006.
3 Section 24 Evidence Act 2006.

expert means a person who has specialised knowledge or skill based on training, study, or experience

expert evidence means the evidence of an expert based on the specialised knowledge or skill of that expert and includes evidence given in the form of an opinion

7 Fundamental principle that relevant evidence admissible

(1) All relevant evidence is admissible in a proceeding except evidence that is—
(a) inadmissible under this Act or any other Act; or
(b) excluded under this Act or any other Act.

(2) Evidence that is not relevant is not admissible in a proceeding.

(3) Evidence is relevant in a proceeding if it has a tendency to prove or disprove anything that is of consequence to the determination of the proceeding.

8 General exclusion

(1) In any proceeding, the Judge must exclude evidence if its probative value is outweighed by the risk that the evidence will—
(a) have an unfairly prejudicial effect on the proceeding; or
(b) needlessly prolong the proceeding.

25 Admissibility of expert opinion evidence

(1) An opinion by an expert that is part of expert evidence offered in a proceeding is admissible if the fact-finder is likely to obtain substantial help from the opinion in understanding other evidence in the proceeding or in ascertaining any fact that is of consequence to the determination of the proceeding.

(2) An opinion by an expert is not inadmissible simply because it is about—
(a) an ultimate issue to be determined in a proceeding; or
(b) a matter of common knowledge.

Also relevant to the preparation and presentation of evidence before the Environment Court are the requirements of the Court's Practice Note. I expect most of you are well aware of that and in particular Section 7 of the current version, which sets out the Code of Conduct for expert witnesses. I strongly suggest that you re-read it before every occasion on which you give evidence. I will recap some of its important requirements, that every person presenting expert evidence before the Environment Court:

a) Must comply with the Code of Conduct;
b) Must include in any evidence the matters required to be presented by the Code of Conduct;
c) Has an overriding duty to impartially assist the Court;
d) Must not behave as an advocate;
e) Is expected to treat the evidence of other experts with collegial respect;
f) Must appropriately qualify any evidence;
g) Must identify any opinions that are not firm or concluded for any reason; and
h) Must communicate to all parties any change of opinion without delay.

I am also aware that your Association has established a code of ethics for you which, as far as I can see, appears to be fully consistent with the Court's Code of Conduct. It is not for the Court to tell your Association how to run its affairs and what standards one must meet as a member. However, the Court will expect members of professional organisations which have established codes of conduct to adhere to them. An allegation that an expert witness in acoustics is not complying with the Association's Code of Ethics will be regarded by the Court as seriously as an allegation of non-compliance with its own Code of Conduct.

These ethical and other behavioural requirements all contribute to the Court's sense of the reliability of your evidence and whether it deserves to be admitted as expert opinion evidence.

It is notable that both the Court's Code of Conduct and your Code of Ethics place a great deal of emphasis on your dealings with your peers. This is not just so that everyone gets along. To establish a field of study as one that can be called professional and whose practitioners can be called experts requires high standards of behaviour between its members as well as with clients or the public. From the Court's perspective, the increasing reliance on processes of conferencing among experts and the production of joint witness statements to the Court makes such high standards of behaviour essential to an effective and efficient evidential process.

Once the hearing has commenced, the most important aspect of that effectiveness and efficiency is your duty to present evidence of your opinions that is likely to provide substantial help to the Court. You share that duty with all other expert witnesses before the Court. I say all other experts – not just the others giving acoustic or noise evidence, but also any who give evidence which may bear some relationship to the particular issues that the Court has to decide. A case is rarely resolved on one issue alone, or even within a single field of evidence. Usually, the Court has to draw together key pieces of evidence in order to resolve the issues before it. So while you must ensure that your evidence is within your field of expertise, there is a need for you, and other experts, to recognise that the Court will have to undertake an integrated assessment of all the relevant evidence and to do what you can to provide substantial help to the Court in that undertaking.

Acoustics

I have always had an interest in sound – making it with various instruments and manipulating it: tape, volume and gain, reverb and distortion, filters and synthesis.

I note that the Oxford English Dictionary offers two main meanings of "*acoustics*":

1. The sense of hearing; the characteristics or ambience of sound; and
2. The branch of physics concerned with sound.

The distinction between these two meanings is at the heart of the main point I want to make in this paper. The first meaning relates to the subjective sense while the second relates to a science which is capable of a more objective analysis.

Importantly, while they are capable of being distinguished, the two meanings are directly related to the point of them being two sides of the same coin. That is, people's sense of the character of sound can be understood in physical terms.

Equally, the physical nature of sound can be expressed in terms of human responses to it.

With that in mind, the two senses of acoustics open up many dichotomies in the overall field, including:

- Signal versus noise
- Consonance versus dissonance
- Distortion – bad versus good

Often these dichotomies are generated or informed by what an individual or group is used to as compared to what they find unusual or strange, or what is expected compared to what is unexpected. Importantly, there is more to these senses of acoustics than measurements and comparisons of amplitude and frequency.

It seems to me that people's reactions to sound underlie what in the RMA is given the compendious name of "amenity values":

> ***amenity values*** means those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes

For present purposes, the point is that a landscape or a cityscape includes its soundscape. Note that these amenity values are about what people appreciate, and not an expert assessment. Note also that the values may involve a synthesis of factors, rather than some sort of item-by-item analysis. My general experience is that people tend not to break their responses down into separate elements, and certainly not according to the way in which technical matters are routinely organised in the presentation of a case before our Court: traffic, geotechnical, landscape, ecological, noise and so on. People tend to form a whole view. That view may highlight certain elements, but it does not normally do so to the exclusion of all other elements.

As someone once said, on being asked their opinion of the bagpipes: Well, at least there's no smell. I quite like the sound of the bagpipes, but what I like to think of as my eclectic taste in music as been described by a much more knowledgeable friend as a lack of discernment. The point is that what we like or don't like is rarely arrived at by a process of separate analyses of individual factors.

In 1958, David Ogilvy came up with the famous advertising headline: At 60 miles an hour the loudest noise in this new Rolls-Royce comes from the electric clock, to which the chief engineer of Rolls-Royce responded: It is time we did something about that damned clock. In 1982 Warren Pfaff adapted Ogilvy's idea by using the line The loudest noise in a new Rolls-Royce is the beating of your heart. I never thought that you might be so scared just riding in a Rolls-Royce.

From the opposing camp in relation to vehicle noise, I want to play a short video excerpt of a review of a Ferrari:

> *A Tesla model S also accelerates very quickly but does not have . . . the sound.*
>
> (Revs the engine) *Ha ha ha. Why would you listen to the audio system?*
>
> (Tom Voelk, NY Times, test driving a Ferrari 488 GTB, 12 August 2016[4])

There is what I consider to be a general myth that an objective approach is innately superior to a subjective one. To the extent that objectivity tends to be associated with rationality and seeks to minimise bias and capriciousness, while subjectivity connotes a personal view rather than a general one, the legal system does tend to favour objective approaches. But it is also generally useful to bear in mind that all human thinking is both underpinned and influenced by a host of subjective factors, many caused by the inherently subjective nature of our perception.

Even within an objective field focussed on the science of acoustics, the context is what can be heard, so the physical framework must include adjustment for subjective human responses. I am aware that you regularly debate issues relating to perceived loudness, weighting of frequencies in the audible part of the spectrum, and the assumptions inherent in the statistical methods used to analyse or model the acoustic environment based on samples.

I acknowledge that I am not qualified to comment specifically on your field, but as someone trained and experienced in another professional field, I can offer a general view based on the common elements of rational inquiry. Recognising and respecting the sophistication of the science and the advances in the state of the art, an expert in a field must keep in mind the weakness in both the science and the art and consider the subjective elements that may affect both empirical measurements and theoretical projections. No-one should ever kid themselves that there is nothing more to learn. You may reflect on the state of your field 50 years ago and contemplate what may be achieved in the next 50 years and so approach your work mindful of both how far you have come and how far there is to go.

So, while we appreciate that standards for measurement and assessment are based on careful science, I want to ask a question about the extent to which that is sufficient to deal with subjective reactions to acoustic effects in the context of resource management.

Qualitative Assessment

I have now gone well beyond my comfort zone in offering the thoughts of an over enthusiastic amateur to a room full of experts. Back in my lane this may be better put by me to you in the context of the evidential process and the methods of laying a foundation for a case of whatever kind.

The key lies, in my view, in identifying what the expert witness can present that is most helpful to the decision-maker. In resource management proceedings, that will be what best advances the resolution of the particular issues before the Court in accordance with the purpose of the RMA to achieve the relevant objectives of the applicable plan in a manner consistent with its policies.

I did not include the rules of the plan in that summary, not because they are irrelevant but because their importance may be secondary to the policy framework. This is often so in appeal hearings before the Court. Once a case has reached that stage it is likely to have developed beyond any issue relating merely to the application of rules. More likely, the case will involve the assessment and weighing of various policy factors, probably based on policies which, at least on their face, are in tension with each other, and possibly which are found in different policy documents.

As the Court has noted[5], a complex regulatory system is not always best implemented simply by rules. While one may intuitively think that rules can be more precise than objectives, policies or other statements of principle, it is the conclusion of at least one expert in the theory of regulation that *the iterative pursuit of precision in single rules increases the imprecision of a complex system of rules*.[6] In simple stable systems, rules can regulate the system with greater certainty, but in complex dynamic systems, principles may be more likely to enable certainty. This is generally because the interaction of multiple factors leads to less certain results, especially where the factors are themselves inherently complex.

The activity classification framework of the RMA, as typically implemented in plans, reflects this by:

- reliance on rules and standards for permitted and controlled activities; and
- relatively greater reliance on objectives and policies in assessing applications for consent for discretionary and non-complying activities.

So, in that context, what is likely to be helpful to the Court? I suggest to you that an expert witness can best provide help

4 https://www.nytimes.com/2016/08/12/automobiles/autoreviews/review-ferrari-488- gtb.html at 2.28.

5 *Edens v Thames-Coromandel District Council* [2020] NZEnvC 13 at [53].

6 *Rules and Principles: A Theory of Legal Certainty*, John Braithwaite, (2002) 27 Australian Journal of Legal Philosophy 47

by seeing the broader context in which their evidence will be received and providing evidence which is responsive to the two fundamental questions that the legislation requires the Court to consider:

- What advances the process to resolve the issue in dispute?
- What does so in a way that is most in accordance with the purpose and principles of the RMA and the relevant plan?

These should not be considerations which you treat as being the responsibility of only the planners and lawyers. Beyond the planning purpose and its associated policy structure and the corresponding statutory considerations, you should be asking yourselves:

- What is the purpose of what you do?
- Why do we have noise assessment standards and related controls?

I strongly doubt that it is simply to have standard methods for predicting the sound pressure levels generated by particular activities and practicable mitigation measures to reduce the perceived levels. There is a greater purpose in resource management.

Your colleagues in the field of visual assessment are grappling with similar issues. They have been called landscape architects, but I think it is increasingly apparent that this name does not fully cover what they do and what the Court expects them to do.

A particular complication in the field of visual assessment is to understand what is meant in s 6(a) and (b) of the RMA by the word "natural" when applied to features and landscapes and to the character of an area[7]. The apparent dichotomy between *natural* and *artificial* or *human-made* led to a lengthy period in the 1990s during which avoidance and mitigation of effects was considered only to be feasible by full screening of an activity or reduction in size or some form of quasi-natural decoration.

More recently, the Supreme Court's confirmation in the King Salmon case of the directive meaning of a requirement to *avoid* an effect[8] has generated a similar discussion around the claimed binary nature of avoidance and permissiveness. This is not an appropriate occasion on which I might delve deeply into what I regard as a widespread misunderstanding of the majority opinion in that case. For present purposes it is sufficient to repeat the Court of Appeal's subsequent explanation that much turns on what is sought to be protected[9]. An outstanding natural landscape or an area of outstanding natural character should be protected from a rezoning which would permit an intensive farm to be located in it, but it may not be inappropriate to locate a hiking track or a small hut in such an area to enable people to enjoy what is being protected. The issue is not simply whether to avoid or permit but a more detailed consideration of what character, intensity and scale of human effects may be appropriate in a particular context.

While the senses of hearing and vision are distinct, they may be susceptible to at least some common analytical methods which could assist the Court in the integrated assessment and management of the effects perceived through them.

In very broad terms, a qualitative approach to effects which are heard would therefore start with an identification of the purpose of the assessment and the focus of analysis. This would include the characterisation of the existing environment and a preliminary summary of the resource management conflicts or tensions that either exist in this environment or may exist if a proposed activity occurs.

7 *Western Bay of Plenty District Council v Bay of Plenty Regional Council* [2019] NZEnvC 110 (Interim decision) and [2019] NZEnvC 167 (Final decision).

8 *Environmental Defence Society Inc v The New Zealand King Salmon Co Ltd* [2014] NZSC 38.

9 *Man o'War Farm Ltd v Auckland Council* [2017] NZCA 24 at [65].

Adapting the visual assessment framework, a qualitative sound assessment might then be conducted under three broad headings:

a) Biophysical – in acoustics, this might involve some form of noise mapping and predictive modelling of likely new sources of sound to understand their physical effects.
b) Sensory – the subjective responses of the local population to the existing sound environment and to the new sources of sound to understand the human reactions to them.
c) Associative – the social, cultural and spiritual aspects of sound in the environment to understand any issues of appropriateness.

These broad headings should probably be further sub-divided to enable more detailed contextual assessment. Some guidance might be obtained from the list of factors routinely used in visual assessments but, of course, the factors should be based on the sense of hearing and the physical phenomenon of sound. The areas and factors overlap in visual assessments and are likely to do so in acoustic assessments too. Some care must be taken to avoid double-counting or other potential confusion, especially if the assessment method goes on to require scores to be awarded for each factor.

Another approach would be to consider the method used in the assessment of odour. While the mechanism of odour in terms of the presence of chemicals in the air is generally well understood and certain odours are known provoke strong reactions generally among people, we do not have any general measurement system for odour or, even if we did, suitable meters to perform any measurements. Part of the reason for this is the complex chemistry that produces odours.

The current methodology devised to provide a framework for assessing odours requires consideration of five distinct factors:

- Frequency – occurrence of exposure to the odour
- Intensity – perceived strength of the odour
- Duration – length of exposure to the odour
- Offensiveness – the character or "hedonic tone" of the odour
- Location – the context in which the odour occurs

Each factor must be assessed individually and then all are considered together to determine whether the odour is offensive or objectionable and the severity of the odour's effects in terms of people's expectations for the context where the odour occurs.

These assessment frameworks offer ways in which the subjective experience of what a person may see or smell can be analysed so as to provide a more objective sense of whether the particular visual or odorous effect is appropriate in the circumstances.

Ultimately, I think such approaches might be a basis on which to investigate whether a similar approach to what people may hear could be a useful addition to the methodology in the current standard for the assessment of noise. Such an approach could be developed as a basis for identifying the character of different sounds and the different effects they may have on people, both intrinsically and comparatively with other sounds. It could provide a more rigorous analytical framework than the rather more generalised categorisation of a sound as intrusive or disruptive, whether with a special audible characteristic or not.

In this way, for example, while a dripping tap and a babbling brook may result in the same sound pressure levels or frequency spectra to a receiver, the differing character of the sounds might be identified and assessed better in their contexts. I think that this would be more helpful to the Court in making decisions about managing change in the environment.

David Kirkpatrick - Chief Environment Court Judge , June 2021.

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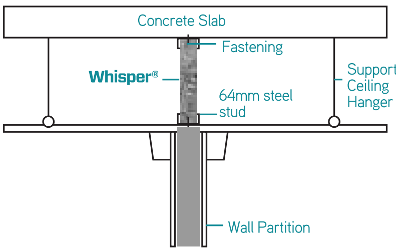
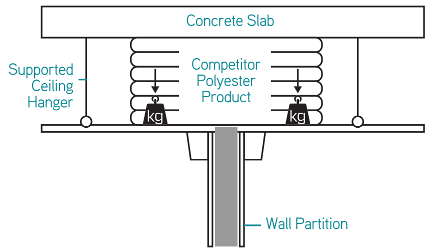


Old Method



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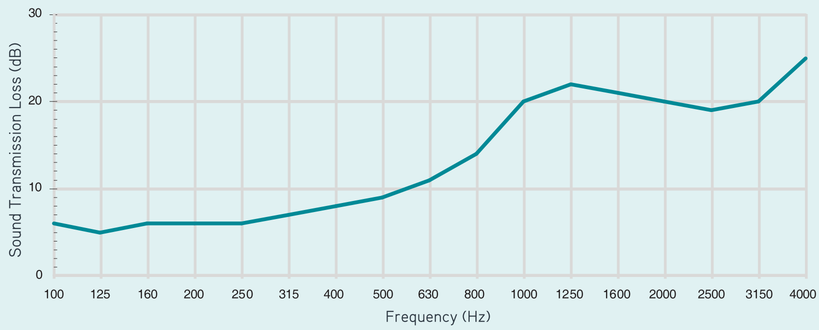

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NZ Classrooms have a new acoustic design standard - DQLS v3.0

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Original peer-reviewed paper

Abstract

The Designing Quality Learning Spaces – Acoustics document (DQLS) is the Ministry of Education's blueprint for the design of new and renovated classrooms in New Zealand. It sets mandatory requirements for reverberation times, sound/impact insulation and indoor noise levels in all types of learning spaces.

We were engaged by the Ministry to prepare the latest DQLS revision (v3.0). It's a comprehensive rewrite of the previous document. The primary objectives were to improve readability and clarity for designers of school buildings, and to update best practice guidelines in response to complaints and feedback about the previous version. Our paper explains the main differences in the new version, and our reasons for making them. One notable change is with rain noise, which now refers to approved solutions for roof-ceiling designs rather than requiring compliance with NC 45.

1. Introduction

Good acoustic design supports all students and creates a better place in which to learn and teach. The Ministry of Education (the Ministry) owns 30,000 learning spaces in about 2,100 schools, and as part of their School Property Strategy (Te Rautaki Rawa Kura, 2020) it aims to ensure that they are all quality and fit for purpose. The 'Designing Quality Learning Spaces' suite of documents sets out mandatory design parameters and best practice guidelines for acoustics, lighting and visual comfort, and indoor air quality and thermal comfort.

Last year we were engaged by the Ministry to prepare the third version of the Acoustics document (DQLS, 2020). It builds on the previous versions, but improves its readability, explanation of acoustic concepts and ease of navigation. There are a few key changes, which may be of particular interest to the NZ acoustics community, which we describe in this paper.

2. DQLS v3.0 has an new format and is easier to read

In addition to a refreshed look (refer to Figure 1), which brings it into line with other documents in the DQLS series, the layout has changed compared to previous versions.

The target audience for DQLS is architects and acoustic engineers involved in the design of the Ministry's school buildings – especially learning spaces. But the document has been written using plain speech and active sentences so it can be easily understood by schools, teachers and parents too.

It is to be used for new builds, including extensions, pre-fabs and any new contracts for modular buildings, and refurbishments of existing school buildings, including significant alterations.

It has four main sections:

1. Introduction, scope, and a discussion of the importance of good acoustics for learning
2. Acoustic concepts and mandatory requirements
3. Acoustic design guidance - to explain concepts in more detail and give handy rules of thumb
4. Acoustics verification - methods for testing and signing off completed spaces when carrying out Post Occupancy Evaluation (POE).

In the previous version 2.0 (DQLS, 2016), the mandatory requirements and 'key information' were sprinkled throughout the document in red text, and 'recommendations and other key concepts' were in blue text. This made the requirements difficult

to find and caused some confusion and ambiguity, as some of the red and blue text conflicted with each other. In the updated version, we have consolidated all of the mandatory requirements into one section. This is located near the start of the document just after the important concepts section.

3. The important concepts are up front and easy to understand

The important concepts page sets out five key acoustic concepts that are used in the DQLS (see Figure 2 below). This is largely targeted at architects and other lay readers, who often get confused between sound absorption and sound insulation (for example).

Each concept has its own colour so when readers see that colour throughout the document, they are clear on its meaning and can easily refer back to the diagram.

We also made a point of defining 'connected spaces'. Connected spaces are adjacent learning spaces physically connected by a door, corridor or opening (i.e. you can walk between them without going outside), and are part of the same general space in which learning activities are coordinated. Sound travels more easily between connected spaces, but this is okay provided activities are acoustically compatible, e.g. all quiet or all noisy at the same time. We expect that teachers will manage connected spaces so activities are compatible. Walls between connected spaces are permitted to have lower STC ratings (refer Section 5.2).

4. Mandatory requirements are still the cornerstone of the DQLS

Since v2.0, the DQLS has had mandatory requirements rather than just guideline values. This has had a massive positive impact on classroom design because acoustic design can no longer be sidelined. Acoustic requirements are now itemised in documents that are submitted to the Ministry during the design process, and commissioning can be required by the Ministry once the building is complete to confirm its acoustic performance.

The mandatory requirements address four key issues:

- Reverberation Time (RT)
- Sound transmission between learning spaces (STC)
- Impact insulation between floors (IIC)
- Indoor ambient noise levels, including HVAC noise and rain noise

Important concepts

Figure 2 shows the key acoustic concepts. Each concept's colour is applied throughout this document to provide a clear distinction between different acoustic concept. For example, pink text is about sound absorption.

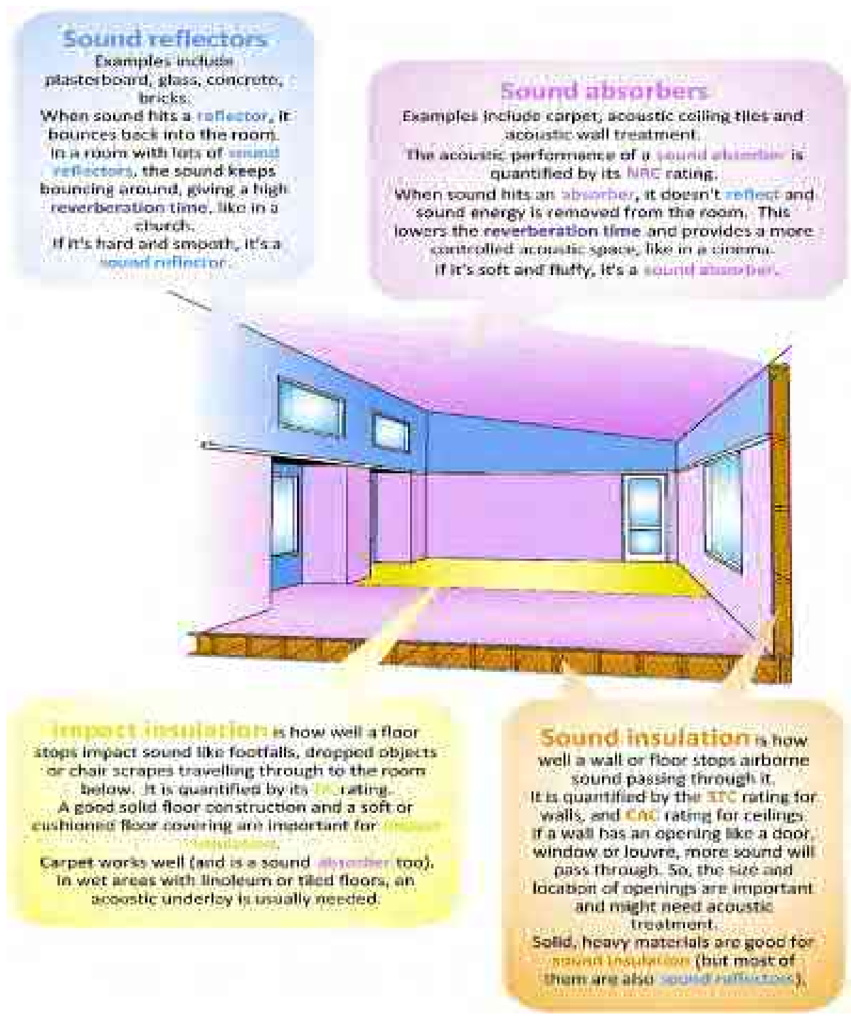

Figure 2: Important acoustic concepts and their colour codes used throughout this document (*Source*: Figure 2 Designing Quality Learning Spaces – Acoustics (DQLS 2020))

5. Notable changes and reasons for making them

In addition to the reformatting, colour coding and move towards plain speech and active sentences, we made some changes to the acoustic requirements. We describe the most notable changes in the following sections.

5.1 RTs have been kept in line with AS/NZS 2107

We have updated the RT requirements to bring them in line with the latest Standard (AS/NZS 2107:2016) which was updated since DQLS v2.0. They are generally the same, but large spaces (learning spaces with volumes greater than 300 m^3, assembly halls, auditoria and gyms) are now dealt with in a figure that shows their required RT in relation to its volume (see Figure 3).

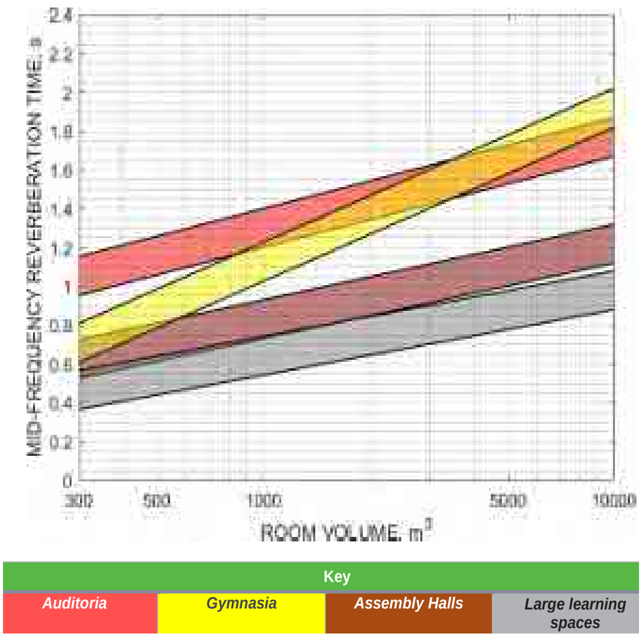

Figure 3: Mandatory reverberation time ranges for large spaces (*Source*: Designing Quality Learning Spaces – Acoustics (DQLS 2020)).

We have removed the NRC 0.85 mandatory requirement for ceilings. This is still a good rule of thumb, but is not necessary for all learning space types, and can make it difficult to achieve a balanced RT.

We have also provided a definition of the mid-frequency RT (arithmetic average of the RTs in 500 and 1000 Hz octave bands – which is in line with AS/NZS 2107:2016) and provided a definition for a 'balanced reverberation spectrum' to ensure good outcomes.

5.2 Openings in STC-rated partitions have been clarified

In version 2.0, the STC rating of a partition was independent of whether there were any openings such as doors or windows in it. For example, a wall with an STC 50 requirement still had to be STC 50 even if it had an STC 25 door within it. There is no practical benefit – and extra cost – of having such a high wall rating, as the noise through the door would dominate. Therefore, in v3.0, we responded to feedback from acoustic engineers who said the requirements for doors and glass elements in v2.0 needed to be improved.

The STC of a door or window in an STC-rated partition now depends on the type and size of the opening. We made sure that the resulting STC requirements for fixed glass could be achieved with standard solutions like 10.38 mm laminated glass, and the requirements for opening could be achieved by standard perimeter seals.

Table 1 below explains the new requirements for openings. In general, the mandatory STC ratings of partitions (without openings) remain similar to v2.0, with additional requirements for some administration spaces.

Table 1: Requirements for doors, glazing and openings in acoustic walls and floors (*Source*: Table 5, Designing Quality Learning Spaces – Acoustics (DQLS 2020)).

Opening type	Requirement
Fixed windows between separate spaces	Windows must have an STC rating within 5 points of the wall
Fixed windows between connected spaces	Windows must have an STC rating within 10 points of the wall
Hinged door/ openable windows	Door/windows must have STC rating within 15 points of the wall If the combined door/openable window area > 15% of the entire partition area (to ceiling height), the wall STC may then be reduced by 5 points. The door/window STC remains within 15 points of the original wall STC
Sliding door	Sliding doors must not be used in > STC 45 walls. This means that they can only be used between connected spaces. All sliding doors between learning spaces must be minimum STC 25 (refer to Section 2.3 for more guidance) If the combined door/window area > 15% of the entire partition area (to ceiling height), the wall STC may be reduced by 5 points. The door/window STC remains within 15 points of the original wall STC

5.3 Minor changes to indoor ambient noise level requirements but HVAC now separated out

The mandatory requirements for indoor ambient noise levels are largely in line with the previous version. But, we have updated the noise levels with reference to corresponding updates in AS/NZS 2107:2016 and added requirements to a few more types of learning spaces.

The main change in v3.0 is that we have removed HVAC system noise from the indoor ambient noise level section, and it is now addressed separately. We did this for two main reasons:

- It allows the designer to separate out HVAC and ambient noise, streamlining the design process (Note that the verification methods give some leeway to account for commissioning measurements, where HVAC and ambient noise may both be present)
- To provide more clarity for heat pumps, which are very common and can generate considerable noise in learning spaces

The requirements for heat pumps now depend on whether they can be controlled by the user. Building management systems (BMS) systems are increasingly common for heat pumps, so they operate according to pre-programmed schedules and sensor inputs. This means that a teacher can't change a heat pump's settings when they want to, so may not be able to control how much noise they generate. The rules for heat pumps in DQLS v3.0 now say:

- Heat pumps must not be specified in spaces with ambient noise limits of 35 dB or less

- User-controlled heat pump indoor units must comply with the relevant ambient noise levels when operating at their design speed
- BMS-controlled heat pump indoor units must comply with the relevant ambient noise levels minus 5 dB when operating at their design speed

5.4 Rain noise is a big change – now design-based rather than performance-based

In the previous version 2.0, designers were "required to achieve a roof and ceiling sound performance of NC 45 or less". Reading between the lines (because the statement is technically incorrect), this meant that during a nominal rainfall rate of 20 mm/hr, the rain noise level inside a learning space must be NC 45 or less.

At the last ASNZ Conference, a paper on rain noise (Schmid & Kingan, 2018) prompted a lively discussion about the difficulties of testing rain noise according to the applicable standard (ISO 10140-1:2016). Other experts in the field have noted that "*prediction methods have been developed but the results are poor and unable to be improved until more test data and laboratory inter-comparisons are available.*" (Donahue & Pearse, 2020). Several other recent papers have noted the shortcomings of the Standard (Yu & Hopkins, 2020 and Schmid et al., 2021).

Because of this uncertainly of the validity and repeatability of the ISO rainfall noise test method, we wanted to avoid a performance-based rain noise requirement. Instead, the mandatory requirement for rain noise in v3.0 is based on approved design solutions.

Figure 4 shows the three approved solutions we have provided in v3.0. They differ depending on what region the school is located within. We have split the country into three categories (high, medium and low) based on regional rainfall rate. This allows the roof-ceiling design to be more appropriate for the likely rainfall rates, as opposed to having a blanket requirement for the country.

Approved solution for high rainfall rate areas
(Northland, Auckland, Bay of Plenty, Taranaki, and West Coast)

- A profiled steel warm roof system including a mass layer
- 150 mm ceiling cavity with insulation batts and CAC 35+ ceiling or 150 mm ceiling cavity with (no insulation) and CAC 40+ ceiling

Approved solution for medium rainfall rate areas
(Waikato, Gisborne, Hawke's Bay, Manawatū-Whanganui, Wellington, Nelson, Tasman, Otago and Southland)

- A profiled steel warm roof system including a mass layer
- 150 mm ceiling cavity with insulation batts and CAC 25+ ceiling or 150 mm ceiling cavity with (no insulation) and CAC 30+ ceiling

Approved solution for low rainfall rate areas
(Marlborough, Canterbury)

- A profiled steel warm roof system including a mass layer (No acoustic requirement for ceiling or cavity)

Figure 4: Approved solutions for rain noise (*Source*: Pages 16-17 Designing Quality Learning Spaces – Acoustics (DQLS 2020))

Figure 4 also shows the colour themes for key acoustic concepts in action (refer Figure 2), and we note that the terms CAC and mass layer are defined in the glossary.

Other roof-ceiling designs can be accepted, but they must be confirmed as acoustically equivalent by an acoustic engineer – also defined in the glossary (which notes that ASNZ is the professional body for NZ acoustic engineers).

6. Summary

We were engaged by the Ministry of Education to revise and update the Designing Quality Learning Spaces – Acoustics document. We have done so, focussing on making it easier to read and navigate, and more relevant in terms of its requirements and best practice guidelines.

It will be reviewed again at regular intervals, and we encourage feedback from ASNZ members to ensure it continues moving in a positive and constructive direction. Classroom acoustic design is important for so many reasons, and we have this ongoing opportunity to make positive change and ensure good outcomes for young learners throughout New Zealand.

Acknowledgements

We would like to thank Ministry of Education personnel involved in creating DQLS v3.0, in particular Anie-bietabasi Ackley, Craig Cliff and Renelle Gronert. Also, Shaun King, Javier Sans Soriano and those members of ASNZ who provided feedback and proposed improvements to the previous version.

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Propeller-strut interaction noise

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Original peer-reviewed paper

The lead author of this paper, Yan Wu, was awarded the Student Paper Prize at the 2021 conference of the Acoustical Society of New Zealand. The paper below is a shortened version of that paper. Yan is in the third year of his PhD at the University of Auckland. Prior to coming to New Zealand to study, Yan completed a bachelor's degree in mechanical engineering at The Arctic University of Norway (UiT) in 2017. He then obtained an MSc in Aeronautical Engineering from The Hong Kong University of Science and Technology (HKUST) in 2018 and then spent a brief period as a research assistant investigating propeller noise in the Aerodynamics Acoustics & Noise Control Technology Centre (AANTC) at HKUST.

Yan Wu (right) and Michael Kingan (left) just after the presentation of Yan's Prize.

Abstract

This paper reports a study investigating the noise generated by a small unmanned aerial vehicle (UAV) propeller operating just upstream of a circular strut. Such a configuration is common on quadcopter UAVs and the unsteady loading on the propeller and strut can produce high levels of impulsive noise in some configurations. In order to investigate this noise generation mechanism, a series of experiments were conducted in the anechoic chamber at the University of Auckland. Acoustic measurements were performed close to the propeller using a traversing probe microphone and in the acoustic far-field using an array of microphones. These measurements show that the propeller-strut interaction produces impulsive noise which is highly directional. It was also observed that increasing the distance between the strut and the propeller can significantly reduce the magnitude of this impulsive noise. Unsteady computational fluid dynamics / aeroacoustics simulations were also undertaken and the results of these show reasonable agreement with the experimental data. The numerical results also show that the unsteady loading on both the propeller and the strut generate impulsive noise which can constructively or destructively interfere at different observer locations.

1. Introduction

In recent years, unmanned aerial vehicles (UAVs) have developed rapidly and are used in an increasing number of applications. However, the noise which UAVs generate may have a negative impact on humans and animals. As a consequence, a significant number of studies on the noise generated by small-scale UAV propellers and the electric motors which drive them have recently been conducted (Fattah et al. 2019; Intaratep et al. 2016; McKay and Kingan 2018, 2019; Tinney and Sirohi 2018; Zhou et al. 2019). For most commercially available multi-rotor UAVs, the propellers operate at rotational speeds of between 1500 and 10000 RPM with the exact speed determined by the desired thrust and the size and shape of the propellers. The propeller tip Mach number is normally less than 0.3 and the largest Reynolds number, based on local flow velocity and blade chord-length, is on the order of 105. During hover (or static testing), the noise generated by the propeller typically contains a multitude of tones at integer multiples of the blade passing frequency. The tones generated by a UAV propeller can be thought of as being generated by 'thickness' and 'loading' noise sources distributed over the blade surfaces. Thickness noise is produced by the periodic volume displacement of the air by the rotor blade. Loading noise is produced by the aerodynamic loading on the surface of the blade.

The loading on the propeller blades consists of a steady and an unsteady component. When the propeller interacts with the wake or flow distortion from an upstream or downstream object (such as a contra-rotating propeller or part of the airframe), there will be periodic impulsive loading on the propeller blades which produces periodic impulsive noise. This is a potentially significant noise source for multirotor UAVs which commonly have a circular strut or a support arm mounted upstream or downstream of the rotors. Zawodny et al. (Zawodny and Boyd 2020) showed that the noise produced when a UAV propeller was mounted adjacent to a circular strut has strong directionality. It was also shown that the acoustic pressure radiated from the strut (due to the unsteady loading on the strut itself) can also be very significant – even greater than that radiated from the moving propeller surface (due to the unsteady loading on the propeller surface). Similar results have been obtained by Zajamsek et al. (Zajamsek et al. 2019) who conducted both an experimental and a numerical study investigating the impulsive noise generated by a small-scale fan mounted adjacent to a support tower. Both these studies showed that when the rotor was mounted close to the strut/tower there were a significant number of tones produced, and that the amplitude of these tones significantly decreased when the strut/tower was moved away from the rotor.

In the work described in this paper, a commercially available UAV propeller was tested with a circular strut mounted just downstream. The tests were conducted in the anechoic chamber at the University of Auckland, and acoustic measurements were performed in both the acoustic near- and far-fields respectively using a traversing probe microphone and an array of ½" microphones. Computational fluid dynamics (CFD) simulations were also used to understand the noise generation mechanism. The experimental setup and method is described in section 2. The numerical noise prediction method is described in section 3 and the measurement and numerical results are presented and discussed in 4. Conclusions are given in the last section.

2. Experimental method

A 15" diameter carbon fibre UAV propeller was mounted on a custom-made test rig, as shown in Figure 1. The propeller was driven by a brushless electric motor, and a 21.5 mm diameter circular strut was placed just below the rotor plane to simulate the circular carbon fibre struts commonly used to attach similar propeller-motor systems to a UAV. The strut was positioned such that the distance from the top of the strut to the blade tip in the axial direction was either 20 mm or 40 mm. An optical encoder was used to determine the angular position of the propeller blade. The thrust produced by the propeller was measured using a single-axis load cell mounted beneath the propeller. For the tests reported in this paper, the thrust was between 11.53 N and 11.65 N and the motor shaft rotational speed was approximately 500 rad.s-1.:

Figure 1: Near-field measurement setup

Measurements of the near-field and far-field sound pressure were performed in the University of Auckland's anechoic chamber. A single traversing probe microphone was used to measure the near-field acoustic pressure. The signals from the microphone and encoder were fed to a data acquisition system and data was acquired at a sampling rate of 51.2 kHz for 5 seconds for each measurement. The probe microphone was traversed along a side-line parallel to the propeller axis at a fixed radius and azimuthal location. 401 measurements were made at equally spaced points every two millimetres along the side-line which spanned from 400 mm above to 400 mm below the propeller plane. Measurements were made at locations 100 mm outboard of the propeller tip radius. The traverse was performed using a Dantec 9041T333 traverser. The brushless motor rotational speed was controlled at approximately Ω = 500 rad.s-1 using the signal from the rotary encoder. The acoustic pressure measured by the probe microphone was ensemble averaged over many propeller rotations to produce an ensemble-average acoustic pressure over one complete propeller rotation at each measurement location.

The far-field acoustic pressure was measured using 8 G.R.A.S 46AE ½" microphones. These microphones were attached to a C-shaped support structure as shown in Figure 2. Each microphone was connected to a data acquisition system which sampled at 51.2 kHz for 30 seconds for each measurement. The measured sound pressure was normalised to a distance of 1.5 m assuming spherical spreading from the centre of the propeller. Both the near-field and far-field measurements were performed at 12 different azimuthal angles (the angle that the blade rotates through) starting from φ = 0° to 330° in 30° increments (note that the strut was located at φ = 0°).

Figure 2: Far-field measurement setup. The polar angles (measured from the propeller axis) of each microphone are shown.

2. Numerical noise prediction method

Two CFD simulations of the flow over the propeller and strut were performed. These were for the cases where the strut was located 20 mm and 40 mm below the propeller as per the experiments. The propeller geometry for these simulations was accurately determined from laser scan data. The motor housing was excluded from the simulations because it was expected to have a negligible effect on the flow and would significantly increase the complexity of the numerical model. The CFD simulations were performed using the incompressible, unsteady Reynolds-averaged Navier-Stokes (URANS) solver in the ANSYS Fluent software package. A grid independence study was performed and it was found that the time-average thrust force predicted by the simulations was independent of the number of cells used in the simulation and that these were in good agreement with the experimentally measured values. For each time-step, the pressure on the surface of the propeller and strut was stored. This pressure data was used in a novel 'acoustic analogy method' to calculate the radiated acoustic pressure field. This method is described in more detail in the ASNZ 2021 conference paper.

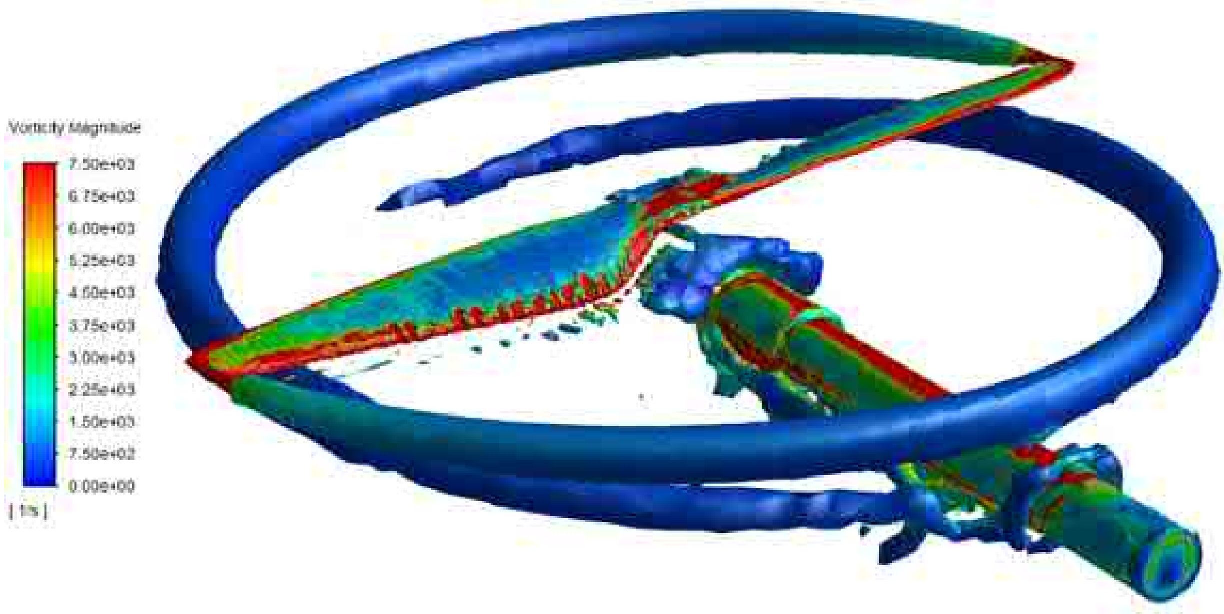

Figure 3: CFD simulation results: iso-surfaces of constant "lambda-2 criterion" coloured by vorticity magnitude (which clearly shows the tip vortices produced by the propeller blades).

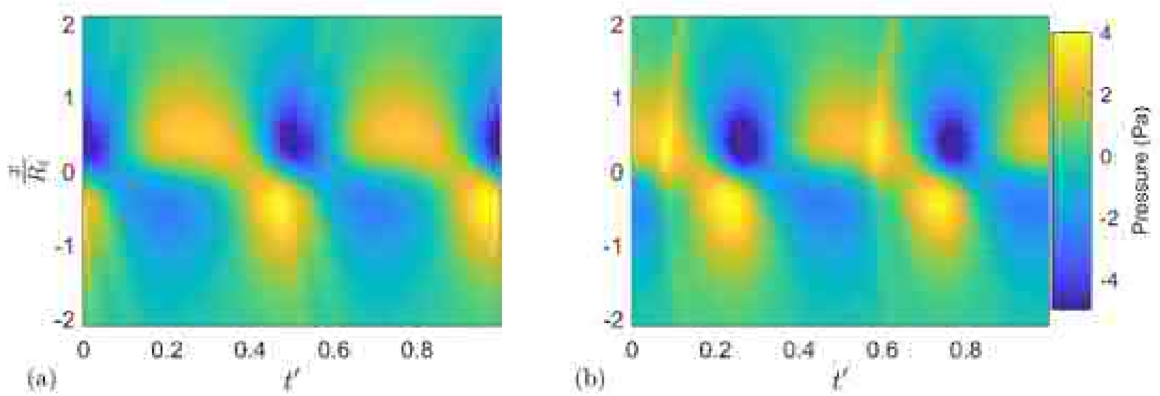

Figure 4: Contours of near-field ensemble-average acoustic pressure, plotted against x/R_t (vertical axis) and non-dimensional time t' (horizontal axis). The strut was located 20 mm below the rotor plane and measurements were made at , a) φ =0°, b) φ =90°.

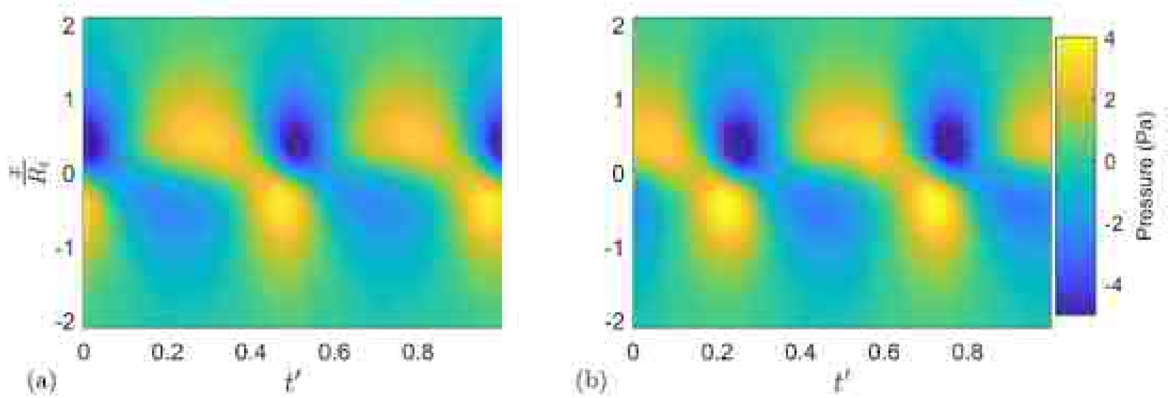

Figure 5: Identical to figure 4, except for this case the strut was located 40 mm below the rotor plane.

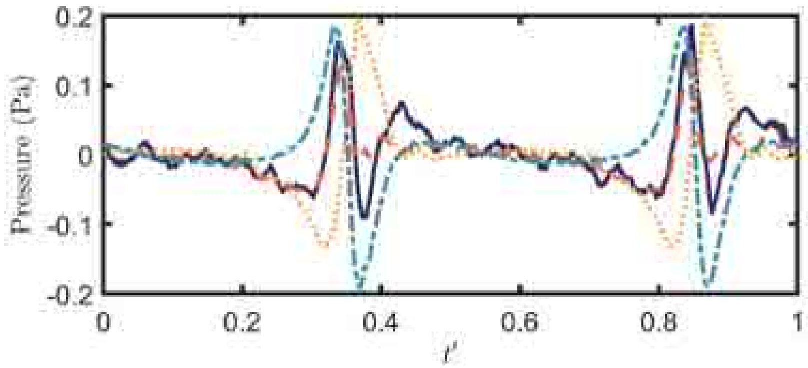

Figure 6: Plots of far-field acoustic pressure versus non-dimensional time *t*' (horizontal axis) for the case where the strut is placed 20 mm below the rotor plane. The ensemble-average of the predicted acoustic pressure from CFD data at observational angle φ =270°, *θ*=5°. Key: measured (purple), numerical prediction total (orange), numerical prediction – propeller sources only (yellow), numerical prediction – strut sources only (green).

4. Comparison of experimental and numerical results

Figures 4 and 5 plot contours of the ensemble-average acoustic pressure against axial coordinate (vertical axis) and non-dimensional time *t*', (horizontal axis) at two different azimuthal angles (φ =0° and 90°) for the cases where the strut is located 20 mm (Figure 4) and 40 mm (Figure 5) below the propeller tip. Both plots clearly show the strong evanescent pressure field which rotates with the propeller blades. For the case where the strut is located 20 mm below the propeller, a pressure impulse, caused by the propeller strut interaction, is clearly visible and the amplitude of this impulse strongly depends on the observer location. This impulse is not clearly visible for the case where the strut is located 40 mm from the propeller. This is because the larger distance between the strut and propeller reduces the unsteady loading on the surfaces of both which reduces the impulsive noise which is produced.

Figure 6 plots the pressure against non-dimensional time at a particular far-field location. The measured pressure is compared with the pressure predicted using the numerical simulations. Also plotted are the pressure time-histories calculated from the numerical simulations using only the sources located on either the strut or propeller. It is observed that the pressure impulse produced by the sources on the strut and propeller interfere with one-another to produce a total pressure impulse which has quite a different shape. This interference effect changes at different observer locations.

5. Conclusions

Propeller-strut interaction noise is a potentially significant source of the noise produced by a UAV. This paper has presented experimental measurements and numerical simulations of the acoustic pressure field produced by a propeller operating in close proximity to a downstream strut. It has been demonstrated that this noise source can be significantly reduced by increasing the distance between the propeller and the strut. It was observed that the impulsive noise generated by the propeller-strut interaction is highly directional. The numerical simulations show that constructive and destructive interference between the impulses from the loading on both the strut and on the propeller can significantly influence the total pressure signal.

Acknowledgements

Yan Wu gratefully acknowledges the financial support of the Acoustics Research Centre at the University of Auckland.

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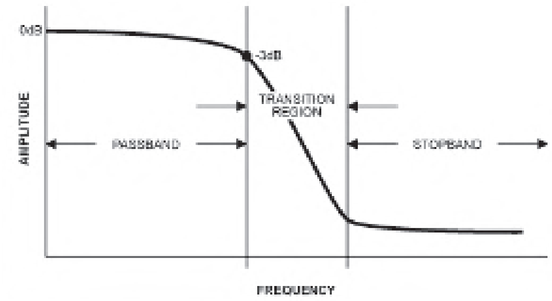
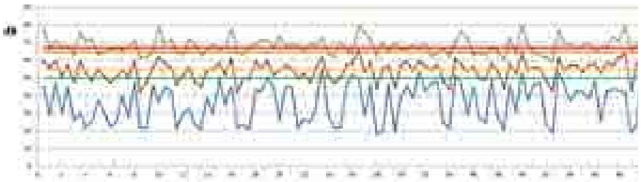
How sound is your acoustics knowledge?

1 What is an ‘anti-aliasing filter’?

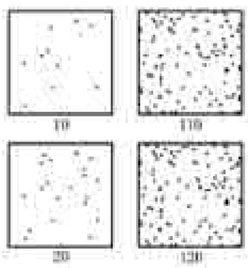


2 Define $L_{evening}$?



3 What does **JND** stand for in psycho-acoustics?

4 What does the Weber-Fechner Law state?

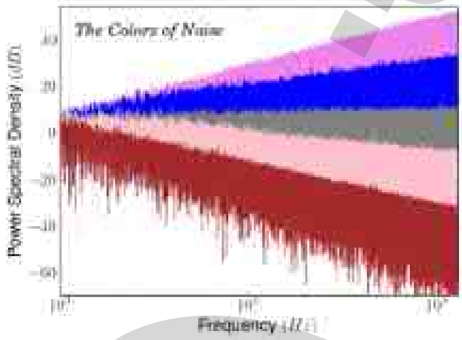


5 What does the angle of view refer to in traffic predictions?

6 What is a dielectric material?

7 Define eVDV?

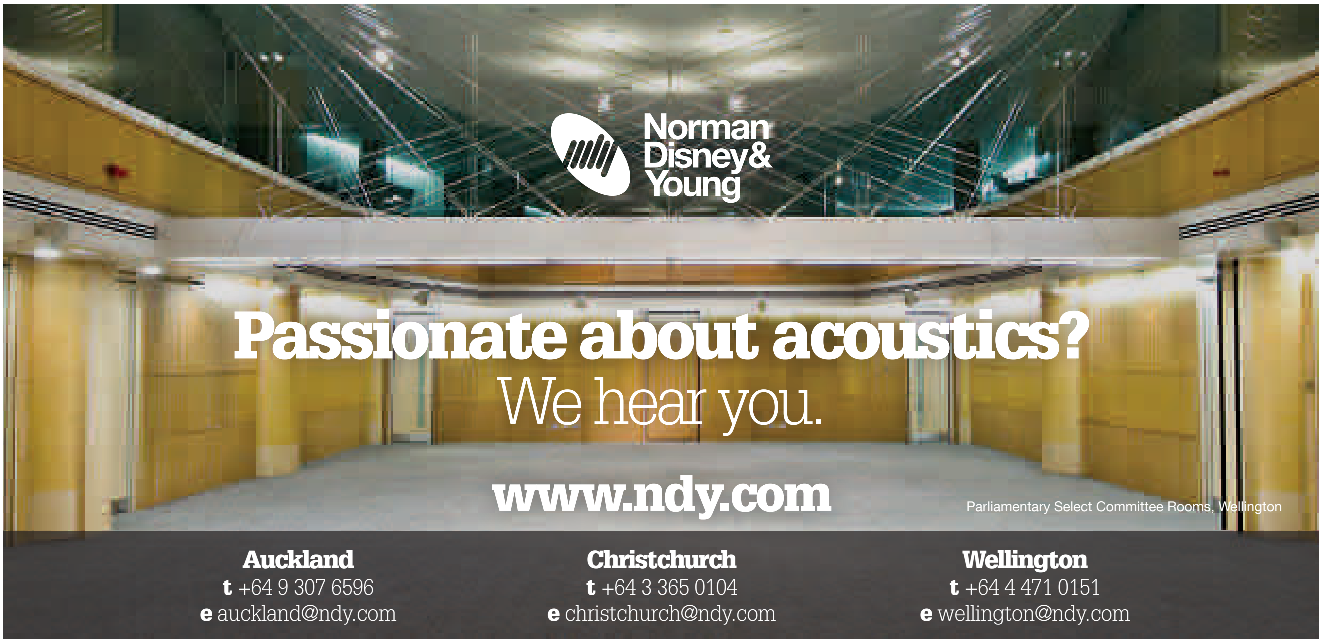
8 What is meant when someone refers to the ‘colour of noise’?



9 **True or False?**
In acoustics ultrasound waves refer to acoustic energy generally between 20 Hz to 20,000 Hz?

10 **True or False?**
Swimmer's ear can also be referred to as otitis-externa?


MARSHALL DAY
Acoustics
N.M Spa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Quiz Answers

1. An anti-aliasing filter is a low pass filter inserted in an instrument before the ADC (analogue to digital converter) in order to prevent aliasing. Aliasing happens when the input signal contains frequencies higher than half the sampling rate (f_s) of the ADC. These higher frequencies get *folded* into the spectrum of the lower frequencies, contaminating it and producing distortion and artefacts in the reconstructed signal that can't be easily removed.

2. In NZ, $L_{evening}$ is the L_{Aeq} over the three-hour period, 19.00 hrs to 22.00 hrs (7:00 pm to 10:00 pm). When combined with L_{day} and L_{night} to calculate L_{den}, a 5 dB penalty is applied to $L_{evening}$ and a 10 dB penalty is applied to L_{night}.

3. **JND** stand for 'Just Noticeable Difference' and is a concept used in psycho-acoustic measurement being the difference between two (Acoustic) stimuli which is just noticeable in some defined condition.

4. The Weber-Fechner Law of psychophysics (a branch of psychology) is a hypothesis that states that the change of subjective response to a physical stimulus is proportional to the logarithm of the stimulus. It applies to stimuli from all senses: vision, hearing, taste, touch, and smell.

5. The angle of view is used in road or rail traffic predictions and is the angle of view of the road or railway corridor subtended at the receiving point.

6. A dielectric material is a material that is electrically non-conductive, an insulator. When an electric field is applied across the dielectric material, it become polarised and charge builds, forming a capacitor. Most current solid state memory devices us this property.

7. **eVDV** = estimated vibration dose value, see https://www.acoustic-glossary.co.uk/vibration-dose.htm

8. When someone refers to the 'colour of noise' they are referring to the shape of the noise frequency spectrum. For example, White noise is a flat frequency spectrum when plotted as a linear function of frequency (e.g., in Hz). In other words, the signal has equal power in any band of a given bandwidth (power spectral density) when the bandwidth is measured in Hz. Whereas pink noise has a low-pass character, with a slopping spectrum at -3 dB per octave (a doubling of frequency).

9. **False.** In acoustics ultrasound waves refer to acoustic energy above 20,000 Hz or 20 kHz?

10. **True.** The other similar sounding condition is OEM (Otitis media with effusion), commonly known as glue ear, when a thick or sticky fluid builds up behind the eardrum in the middle ear due to an ear infection.


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Upcoming Events

World Hearing Day | March 3 2022 | Everywhere

https://www.audiology.org/practice-resources/public-awareness/world-hearing-day-march-3

23 - 27 May, Denver, Colorado, USA

182nd Meeting of the Acoustical Society of America

https:// acousticalsociety.org/asa-meetings/

NOISE-CON 2022 | June 13 – 15 2022 | Lexington, KY | USA

https://www.inceusa.org/noisecon22/

INTER-NOISE 2022 | August 21 – 24 2022 | Glasgow | Scotland

https://internoise2022.org

Joint New Zealand and Australian Acoustic Societies Conference

ACOUSTICS 2022 | October 31 – 2 November 2022 | Wellington | NZ

https://www.acoustics2022.com

All event dates are current as at time of print.

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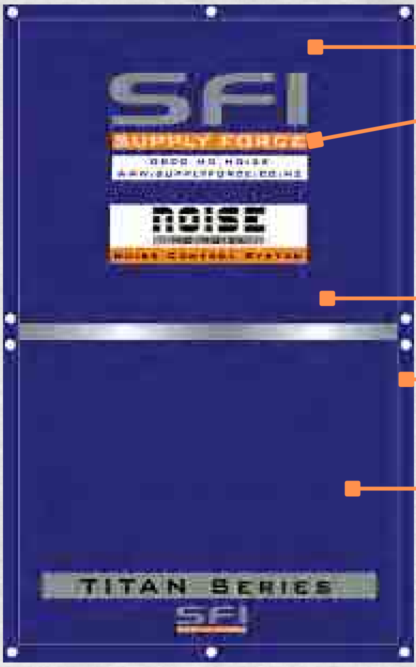

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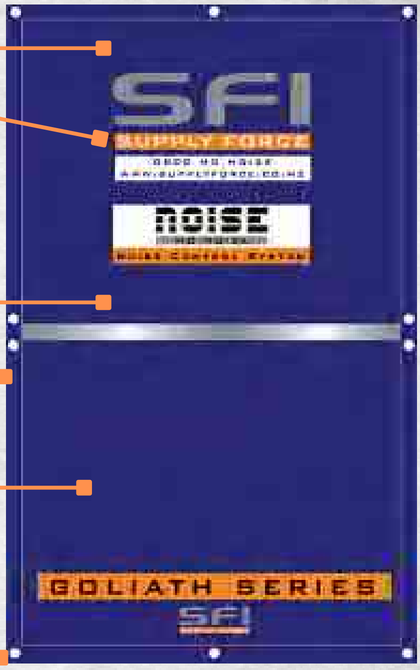

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