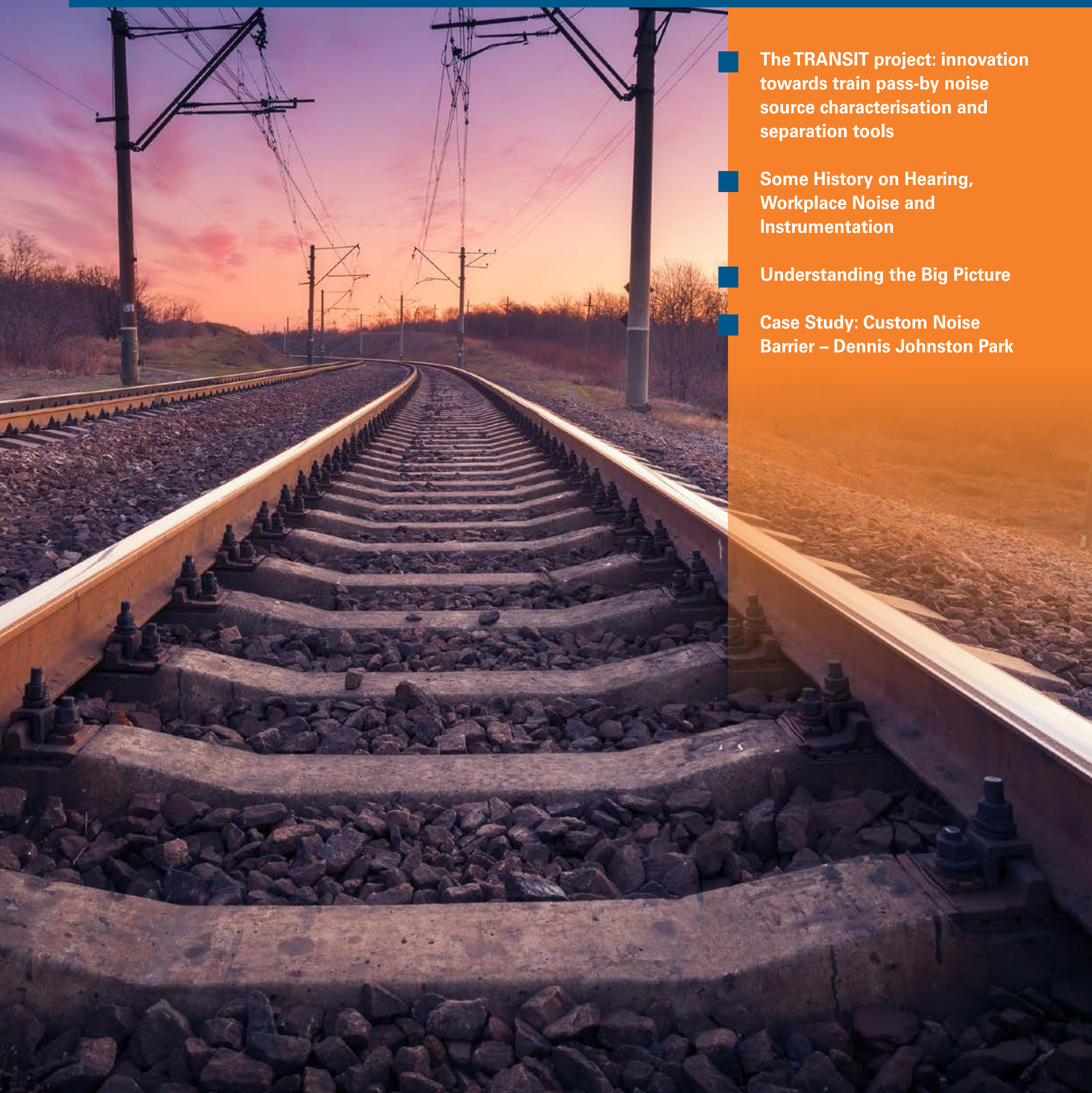
NOISE/NEWS INTERNATIONAL

Volume 29, Number 3
2021 September

A quarterly news magazine and online digital blog published by I-INCE and INCE-USA



- The TRANSIT project: innovation towards train pass-by noise source characterisation and separation tools
- Some History on Hearing, Workplace Noise and Instrumentation
- Understanding the Big Picture
- Case Study: Custom Noise Barrier – Dennis Johnston Park

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Cover Image courtesy of the TRANSIT project.

A quarterly news magazine in PDF format with an Internet supplement published by I-INCE and INCE-USA

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Produced by
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Reston, VA 20191-4371
USA

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NOISE/NEWS INTERNATIONAL

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The International Institute of Noise Control Engineering (I-INCE) is a worldwide consortium of societies concerned with noise control and acoustics. I-INCE, chartered in Zürich, Switzerland, is the sponsor of the INTER-NOISE Series of International Congresses on Noise Control Engineering, and, with the Institute of Noise Control Engineering of the USA, publishes this quarterly magazine and its blog. I-INCE has an active program of technical initiatives. It currently has fifty-one member societies in forty-six countries.

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The Institute of Noise Control Engineering of the USA (INCE-USA) is a nonprofit professional organization incorporated in Washington, DC, USA. The primary purpose of the Institute is to promote engineering solutions to environmental noise problems. INCE-USA publishes the technical journal *Noise Control Engineering Journal* and with I-INCE publishes this quarterly magazine and its blog. INCE-USA sponsors the NOISE-CON series of national conferences on noise control engineering and the INTER-NOISE Congress when it is held in North America. INCE-USA members are professionals in the field of noise control engineering, and many offer consulting services in noise control. Any persons interested in noise control may become an associate of INCE-USA and receive both this magazine and *Noise Control Engineering Journal*.

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From the President of I-INCE: INTER-NOISE 2021 and the Future of Congresses

Bob Bernhard

As I write this article, we have just concluded INTER-NOISE 2021, the 50th INTER-NOISE meeting. First, I want to thank the Organizing Committee of the Congress and its President, Raj Singh, for their hard work and adaptability in response to all of the challenges of 2021. The congress was described to me by several participants as "the best virtual conference they've attended". This is a credit to the innovation and effort of the Organizing Committee. In particular, I know that authors and attendees appreciated that all sessions were live and timed for participation by authors regardless of time zone. The networking sessions and posters were also a feature of this congress that helped us to achieve some connection with old friends and the ability to discuss issues with our colleagues. To the Organizing Committee, well done. And to all of the participants, thank you for your contributions.

One of the disappointments of the congress was the downsizing of our plans to celebrate the 50th INTER-NOISE. The original plan for the congress was to revisit the site of the first congress in 1972 in Washington DC and use this as an opportunity to look both backward and forward. That first congress in Washington was truly an international congress and was well attended. It occurred at a time of emerging noise control policy mandates. In fact, the delegates at INTER-NOISE 1972 interacted with the White House and the US Congress during the meeting. The US Noise Control Act of 1972 was passed later that year. Other countries were also developing policy at this same time. Those mandates launched quite a bit of the foundation that serves as a basis for global noise control policy and practice that persists to today. It was our hope at this congress to celebrate that history. We did, but only modestly.

One of the highlights of this congress for me were the projections of the future of noise control engineering. If you haven't seen them, I recommend that you view the plenaries and keynote speeches in particular. It is clear that emerging technologies such as materials, information technology and sensing (internet of things) will have a profound impact on the tools and techniques we have available. If I project even farther to the future based on my "day job" as a Vice President for Research, I expect to see impacts to our community from emerging areas of research in neuro-science and quantum technology. But, with all of these tools, will our world be less noisy? Real progress in making our world more pleasant and our environment more harmonious with our activities, depends on the will of the citizenry and policymakers. Where there is such a will, noise control engineers must step up to the opportunities and show what is possible and persist in implementing the solutions that achieve a more pleasant environment. I hope you will all look for these opportunities.

Another highlight was the Latin American Symposium and associated activities that ran through the congress. I caught only brief glimpses of these activities but I was very impressed and pleased with the participation of a large number of delegates who normally have not joined us. It was good to see. Thank you to the organizers and participants from Latin America.

In conclusion, thank you to the INTER-NOISE 2021 Organizing Committee for a job well done. And onward to INTER-NOISE 2022 in Glasgow!

Bob Bernhard
President, I-INCE

Editor's View

Welcome to the September 2021 issue of *Noise/News International*.

In this issue we continue our series of showcasing some EU funded research projects related to noise control, with the spotlight falling on the TRANSIT project – a project whose goal is to provide the railway community with a proven set of innovative tools and methodologies to reduce the environmental impact and improve interior acoustic comfort of railway vehicles. We also feature another article from Walter Montano, who writes a very informative article on the history of hearing, workplace noise and instrumentation. This is another article written as a special celebration on the occasion of the 50th International Congress and Expo on Noise Control Engineering (INTER-NOISE), that took place in August – and what a great conference that was!

The usual features like Noise/Notes and Book Reviews return, and, fresh from his keynote presentation at INTER-NOISE 2021, we sat down for a quick 'Getting to Know You' session with Dr. Jian Kang, Professor of Acoustics, University College London.

And after a brief break – after the host moved from the US back to Ireland - The Noise/News, our companion podcast, returns. We sat down with our very own living legend, NCEJ editor (and frequent NNI contributor), D.r Jim Thompson to talk all about his career in noise control and where he sees the field going. Its available wherever you get your podcasts. Jim also writes another article for this issue reminding us on the importance of considering the big picture.

I hope you enjoy this issue, and if you have anything you would like to contribute, please feel free to reach out to here at NNI HQ. You can email me at kingea@tcd.ie

Eoin A. King, PhD

Eoin A. King

The TRANSIT project: innovation towards train pass-by noise source characterization and separation tools

Railway transport produces less CO2 and consumes less energy than road and air transport modes; it also requires less space than road transport. However, noise and vibration (N&V) levels in the vicinity of railways are a major environmental challenge for the railway sector. Populations close to railways no longer accept the increasing N&V annoyance and a competitive railway transport system demands better passenger comfort.

Noise reduction is addressed to some extent by the requirement of the Technical Specifications for Interoperability (TSI) for all new vehicles to meet noise limits in both pass-by and stationary conditions. Due to the high cost involved in such tests, it is desirable to develop virtual testing and some progress has been made in a previous project, Acoutrain, towards this.

In Acoutrain, source characterization methods, and exterior noise simulation tools aimed at virtual certification, were developed, and validated for a few cases; however, these were limited in terms of the speed and type of vehicles considered. These tools and models should urgently be further developed to include other practically relevant scenarios. This will require including source integration effects such as the effect of skirts or fairings.

In addition, advanced measurement methods are required that can identify the noise contributions of different sources on an operational train. The relative importance of the various vehicle sources as well as the track need to be better understood.

The overall goal of TRANSIT is to provide the railway community with a proven set of innovative tools and methodologies to reduce the environmental impact and improve interior acoustic comfort of railway vehicles. A summary of the TRANSIT Applications and Impacts is presented in Figure 1, while the main objectives of the TRANSIT project are:

- Reduction of rail vehicle noise certification lead time and costs, and lower operator's track occupation requirement for testing by providing accurate virtual certification tools,
- Reduction of the need for a TSI-compliant track by developing and demonstrating accurate separation and transposition techniques,
- Derivation of a more precise and better-founded definition of acoustic requirements for equipment suppliers, reducing time and cost,
- Improved source quantification for noise mapping and a more accurate assessment of noise abatement measures,
- Enabling lighter vehicles, thus lower energy consumption, while maintaining high levels of interior acoustic comfort.

The TRANSIT consortium integrates members with considerable experience in the railway sector, who have a successful history of collaboration in this field, with expertise from other sectors, such as the aerospace and automotive industries. They bring leading-edge knowledge on topics ranging from best practice in the use of computer aided engineering software tools for virtual prototyping and certification of products, to advanced microphone array technologies for source separation. These advanced methodologies will be transferred to the railway industry to optimise rolling stock and infrastructure design using lightweight metallic and composite structures, passive, and smart

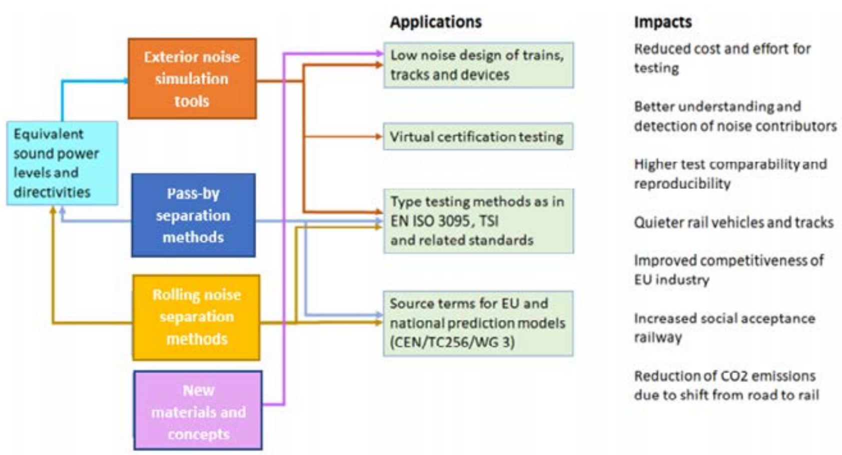


Figure 1: Summary of TRANSIT Applications and Impacts

active materials, thus gathering the key expertise required to realise the innovation sought in Shift2Rail (S2R).

TRANSIT is a project that uses other previous and ongoing projects outcomes in order to successfully analyse all the data. The outcomes used in TRANSIT are based on the past EU and ongoing Shift2Rail Joint Undertaking projects:

- **Roll2Rail:** aimed at developing key technologies and removing already identified blocking points for radical innovation in the field of railway vehicles, as part of a longer-term strategy to revolutionise the rolling stock for the future. The results contributed to the increase of the operational reliability and to the reduction of the life cycle costs. Methods to separate infrastructure and rolling stock noise contributions were developed and tested.

- **Acoutrain:** introduced virtual certification with a reliable simulation approach; Established measurement procedures for new running conditions, specifically braking and curving; Developed procedures to obtain inputs for the European Noise Directive

- **FINE-2:** This is the ongoing S2R Members project aiming to reduce the annoyance and exposure to noise and vibration by developing future methods for predicting overall noise and vibration performance of trains. Moreover FINE-2 aims at ensuring that the research & innovation activities dealing partially or entirely with energy, noise and vibration.

Most of the activities in TRANSIT are focused on the experimental characterisation, modelling and separation of railway noise sources (at standstill and during pass-by) as well as the further development of the Acoutrain external noise prediction tool to account for installation effects in the transmission paths. New test methods are also developed to quantify noise transmission paths from sources on rail vehicles to the standard microphone positions accounting for installation effects.

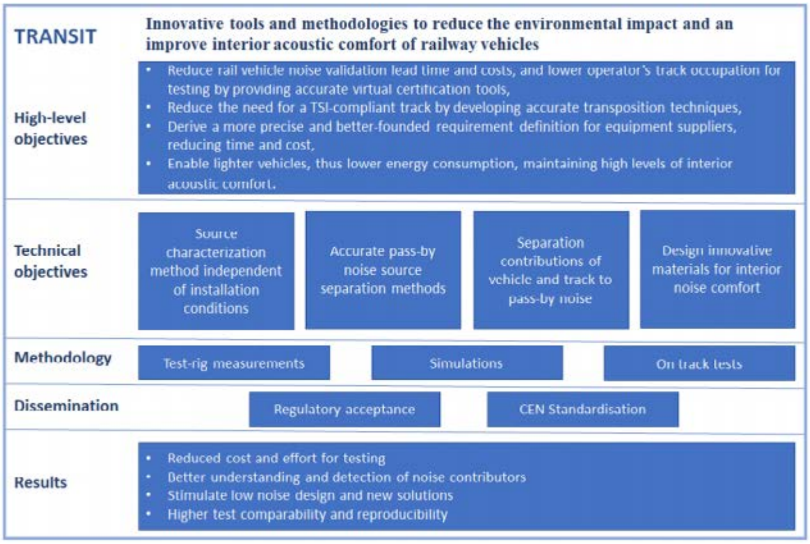


Figure 2: TRANSIT – from objectives to results

In addition, the project is also investigating innovative materials and methods for improved acoustic comfort. New and innovative approaches will be used to improve the design of the interior acoustics of future rolling stock. Several possible approaches are being considered, including optimal sound absorption at the source, damping along ducts for air conditioning systems and innovative use of meta-materials for the car-body parts.

Figure 2 represents the global approach of the TRANSIT project, in particular the translation of the high-level objectives into technical objectives. It also shows the methodology implemented within the project.

The main expected impacts of TRANSIT arise from the methods and tools that will give a better understanding and quantification of the contribution of the different sources to the total pass-by noise. That will, in turn, lead to innovations in low noise design of vehicles and tracks, virtual certification testing, and the derivation of source terms for EU and national prediction models, among others.

TRANSIT will provide an accurate description of sound power levels and directivities of individual noise sources, which is the key to future breakthrough developments in railway design and (virtual) certification testing. The expected impacts include a reduction in cost and effort required for certification testing, greater comparability and reproducibility of test results and ultimately improved competitiveness for the EU rail industry and increased social acceptance of railways leading to modal shift.

There are four work streams, each of which has already obtained specific technical achievements, as described in the following:

1. Source and transmission characterization for exterior noise

A method of source characterization based on equivalent monopoles has been developed from an earlier method developed in Acoutrain, by introducing a new simplified procedure assuming uncorrelated monopoles. The simplified procedure is based on sound power data determined via an ISO procedure e.g. ISO

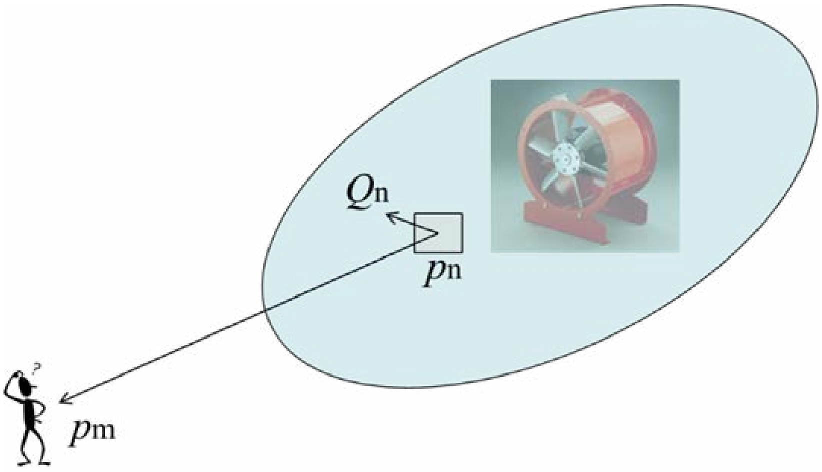


Figure 3: System may be described as a black-box model

Errors (dB)	100-500 Hz	630-5000 Hz
Mean original REF.BOX	1.8	0.2
Mean original REF.BOX no K-factor	2.8	0.2
Std original REF.BOX	3.0	1.8
Std original REF.BOX no K-factor	3.0	1.8

Table 1: Summary of errors based on all tests for the three generic source types tested. Std stands for Standard deviation and K-factor is a correction for a reflecting floor.

Figure 4: Sound power measurement (VibraTec & MicrodB) with an acoustic array on a power converter. Measurements carried out in cooperation with FINE-2 (ALSTOM)

3744 or 9614. The simplified procedure uses a calibrated monopole source to also characterize the transmission and has been validated for generic sources in the report (D1.1): "Validated procedure for source characterization based on equivalent monopoles and tests involving generic sources".

The method developed is based on the assumption that the source is a time-invariant acoustical system. The system can then be described using a black-box model or as a multi-port as illustrated in Figure 3. For the acoustic case the state variables are often taken as force & velocity (F,u) or pressure & volume flow (p,Q). In this case when air-borne sound is of interest the best choice is to use p and Q. If we enclose a machine by a control surface which is divided into "small" areas and associate each area with a port defining p_n and Q_n , we get a multi-port source model for the machine.

The model can then be formulated in terms of a matrix equation in the frequency domain, which can be written in the form of a source cross-spectrum matrix which when multiplied with a frequency response ("Green's") matrix gives the acoustic spectra p_m at given receiving positions. For more details please refer to the full task report D1.1.

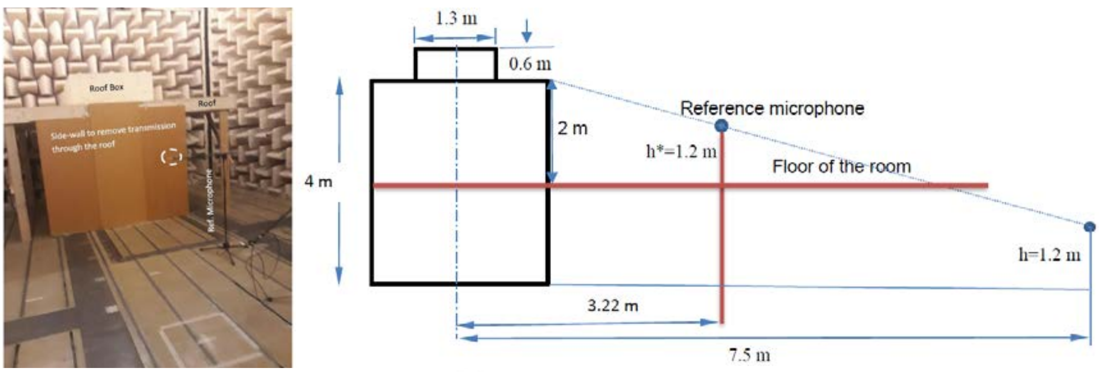
To summarize, the work in TRANSIT for the source & transmission is based on two approaches:

- The full model (correlated monopoles) uses an acoustic array and assumes the Green's matrix is known (Figure 4). To improve the prediction iterative Bayesian focusing (IBF) is used.
- In the simplified model sound power data W_i in frequency bands is first determined based on an ISO standard. It is then assumed that each side of a machine represents an uncorrelated monopole with a corresponding monopole source strength auto-spectrum.

To validate the simplified model generic source tests at KTH have been carried out. Figure 5 shows some examples of the tests conducted.

In conclusion, source characterization based on equivalent monopoles has been presented, with a new simplified procedure assuming uncorrelated monopoles. The simplified procedure is based on sound power data determined via an ISO procedure e.g., ISO 3744 or 9614. The simplified procedure uses a calibrated monopole source to also characterize the transmission.

The simplified procedure has been validated for generic sources (Table 1), see the task report D1.1 for more details.



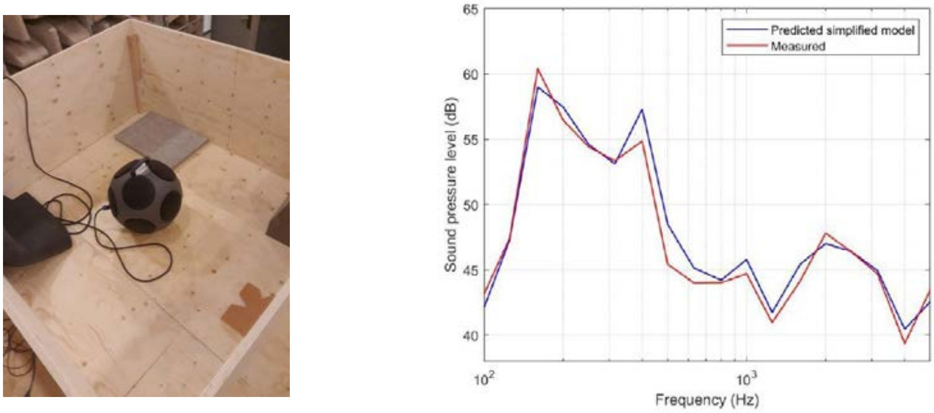


Figure 5: Some examples of tests conducted at KTH.

2. Pass-by noise source separation

The aim here is to obtain the sound power level and directivity of noise sources on a moving train during pass-by at constant speed. The main sources considered (Figure 6) are aerodynamic noise, traction noise, equipment noise and rolling noise. Two different methods are investigated: i) with a microphone array and ii) with a single microphone and rail-mounted accelerometer (PBA-based).

The PBA-based method (Figure 7) uses measured operational rail acceleration to assess indirect combined wheel/rail roughness levels. A vibro-acoustic transfer function is derived from combined roughness and track-side sound pressure levels.

The rolling noise transfer function can be assessed from the operational pass-by of vehicles with dominating rolling noise, (parts of) the vehicle without traction noise or low-traction noise, a high-speed train at medium speed; vehicles with high wheel roughness; stationary measurements on track and vehicle by hammer impact or reciprocal measurements using an artificial sound source.

Non-rolling noise sources will show up as deviations from the rolling noise transfer function; and the pass-by level of "rolling noise only" estimated from the sum of indirect roughness level and rolling noise transfer function.

The source separation methods based on a microphone array (Figure 8) consist of measuring train pass-by noise with an arrangement of microphones (at least 64 channels) and the application of acoustic imaging techniques for source separation (beamforming, advanced spatial filtering deconvolution, inverse methods).

To this end, beamforming state-of-the-art methods consisting of delay-and-sum beamforming in the time domain (with moving focus) and de-dopplerization of source signals, only provide relative comparison between noise sources (no information about directivity and absolute source strength).

In addition, a CLEANT deconvolution method is applied as well as the Iterative deconvolution method - de-dopplerization of source signals using a time domain approach that can be used to estimate source strength via sector integration (See Figure 9).

3. Separation of track noise and vehicle noise:

TRANSIT is working in the development of enhanced methods for separating vehicle and track contributions to rolling noise. The Technical Specifications for Interoperability Noise specify noise limits for new vehicles. These have to be measured on a track with low contribution to the noise, specified in terms of track decay rate and rail roughness level. But the track noise (and roughness) is still an important contributor to the overall level, meaning it is difficult to compare results from different sites; it is important to be able to separate the contributions of vehicle and track, to identify and promote low noise design.

In TRANSIT, promising techniques from the Roll2Rail project are being further developed (simplified and/or enhanced). The aim is to provide estimates of the contribution of the vertical and lateral rail vibration, the sleeper vibration, and the wheel vibration. The methods should also be able to ‘transpose’ pass-by data measured on one track to another track; wheel and rail roughness separation should also be achieved. The methods are being validated using field measurements in collaboration with FINE-2 project.

The proposed innovative separation methods to be considered and further developed are:

- **TWINS model (Track-Wheel Interaction Noise Software):** the TWINS model for rolling noise was developed and validated in 1990s. It includes a series of engineering models for vibration and noise radiation of wheel, rail and sleepers and excitation by combined surface roughness.

  For source separation TWINS is used with measured rail vibration. The approach effectively only uses the noise radiation part of the model (which has less uncertainty than the vibration part).

  Improvements in TRANSIT are based on recent developments in modelling rail radiation and sleeper radiation. The need to include the effect of reflections from the underside of the vehicle is being investigated, by using 1:5 scale models and boundary element calculations to verify these effects (Figure 10). The final aim is to develop a set of ‘standard’ vibro-acoustic transfer functions for the track so that track noise can be estimated simply from measured rail vibration.

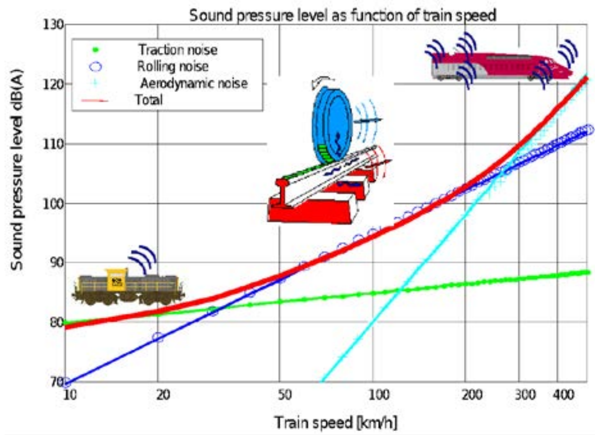


Figure 6: Notional examples of the main sources of noise on a moving train

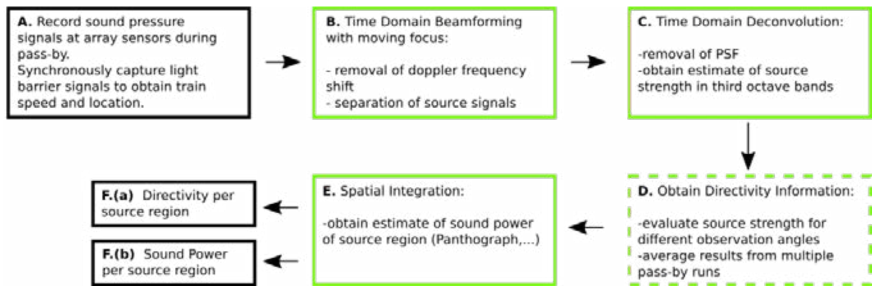


Figure 7: Strategy for microphone array

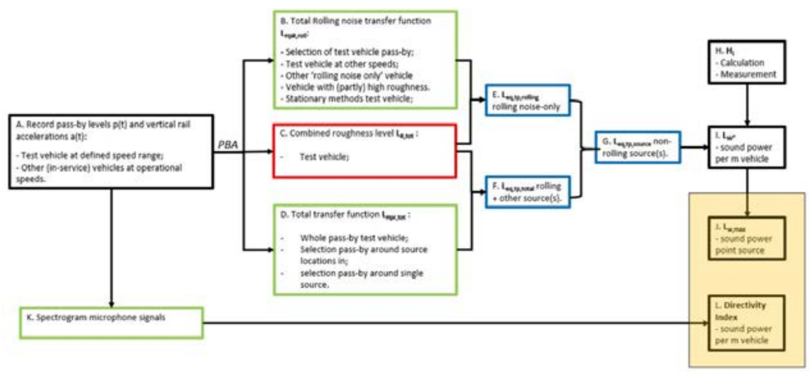


Figure 8: Strategy for PBA-based method

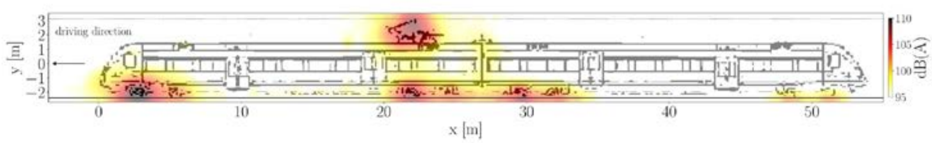


Figure 9(a): Example of beamforming result

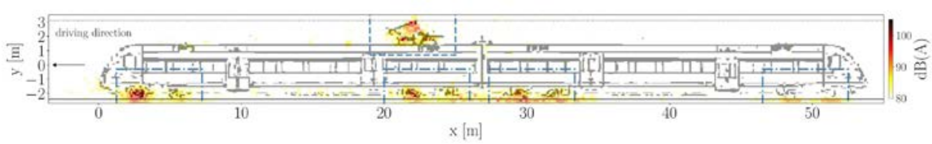


Figure 9(b): Example of deconvolution result

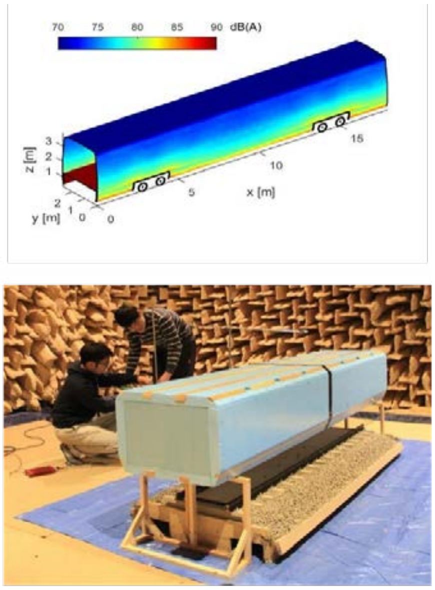


Figure 10: Investigations of the effect of the vehicle on rolling noise. Upper: boundary element model; Lower: 1:5 scale model tests (ISVR)

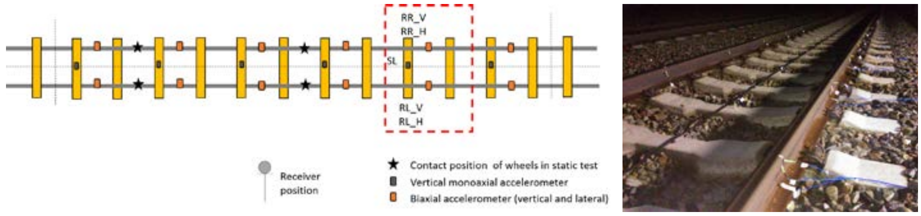


Figure 11: ATPA: (left) diagram of the instrumentation setup and (right) experimental campaign carried out in Roll2Rail project (ICR).

- **Pass-By Analysis** with input based on microphone signals, and vertical rail acceleration signals of multiple pass-bys at different speeds. The outputs are the track decay rate from rail vibration, combined effective roughness levels and combined vibro-acoustic transfer function. Consequently, the results are the separation of roughness excitation and response (combined vehicle and track) and wheel/track separation is still needed.

  Separation of vehicle and track components is considered in the project, based on PBA combined transfer functions that can be combined with separately measured transfer functions p/F for vehicle and track (static measurements). For these, two different methods are compared: the direct method (excite with hammer) and the reciprocal method (excite with loudspeaker). This results in separated contributions of: rail (vertical/lateral), wheel (axial/radial) and sleeper. Separation of wheel and rail roughness will be performed through PBA, obtaining a combined effective roughness with the proposed method to identify rail roughness. This involves monitoring of mixed traffic, identifying minimum combined roughness levels in each wavelength band and providing an upper bound for rail roughness.

- **Advanced Transfer Path Analysis (ATPA)** is an experimental method for obtaining noise contributions from different parts of a system (subsystems), by decomposing the sound pressure at a target location as the sum of the noise contributions considered. To apply ATPA to rolling noise separation the relevant track section is divided into subsections (Figure 11). Both static measurements (with hammer excitation) and dynamic (pass-by) measurements are carried out and combined. Each subsection (red dashed box) includes a vertical accelerometer on each rail, horizontal accelerometer on each rail, and vertical accelerometer on one sleeper. Four wheels of one bogie are instrumented in radial and axial directions.

  TRANSIT project will work in the simplification of ATPA in terms of equipment, time and resources. Simplifications may come from different approaches: measuring a reduced set of static functions and deducing the rest from calculation, assessing the use of reciprocally measured static functions or measuring the static functions without the train present on track and applying some corrections coming from FEM-BEM models.

4. Innovative designs in materials and methods for interior noise

Finally, the TRANSIT project is exploring innovative approaches and material designs for improved interior sound comfort. This started with a feasibility study for a number of potential solutions to proposed case-studies and is continuing with an in-depth analysis of the two most promising solutions. The feasibility is studied of innovative designs and methods, focusing on meta-structure designs and other tailored material design, acoustic performance characterization of baseline and new designs through simulation or small-scale measurements and validation of acoustic performance of new designs in near-realistic conditions. The potential for interior noise reduction is assessed based on the existing literature and additional simulations based on Finite Element (FE) and analytical models. The two most promising solutions have been chosen for further development.

Designs related to increasing sound absorption are being developed in two steps: first the designs will be optimized for small samples that can be validated in an impedance tube and the final design will be implemented in a real scale prototype to be tested in the lab. In the case of designs related to increasing sound transmission loss (STL)

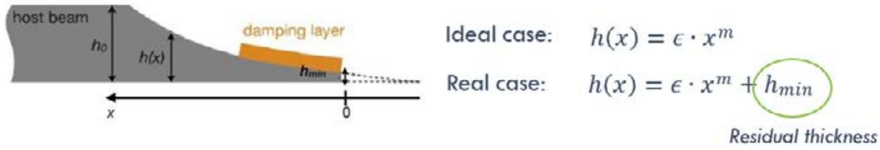


Figure 12: Effect of residual thickness in an ABH. Schema from Pelat et al. / Journal of Sound 22 and Vibration 476 (2020) 115316

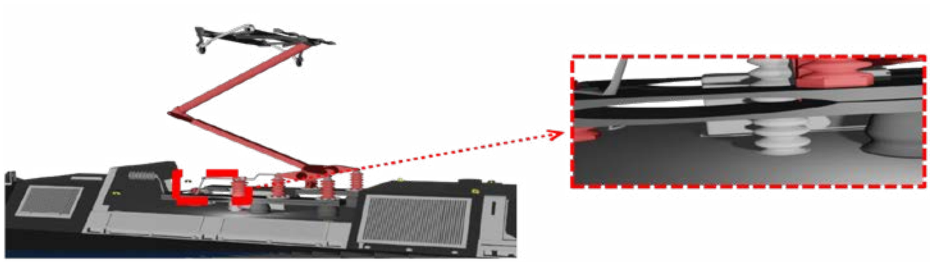


Figure 13: Frame design example

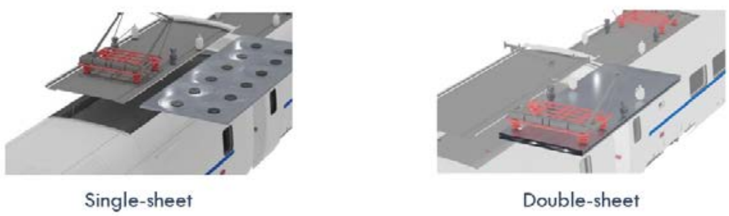


Figure 14: Roof plate design: single sheet and double-sheet examples.

and reducing vibration transmission, designs will be simulated based on FE and analytical models and prototype plates will be built and tested at the Marcus Wallenberg Laboratory at KTH. Different components and materials are being analysed in the TRANSIT project.

For example, noise reduction in a HVAC duct system has been analysed. Simplified ultra-thin low frequency (UTLF) resonators array, were employed in a feasibility study for application in HVAC ducts with the result that a high number of single UTLF would be needed. The simplification proposal of the TRANSIT project is that of a membrane with an array of small masses and a perforated plate. In addition, the optimization of design through Cremer impedance has been considered in order to create optimal damping of a certain acoustic modes in a duct.

Moreover, pantograph area design solutions based on the so-called acoustic black holes (ABH) have been investigated, with reflection-free terminations. The velocity of the reflected flexural wave is reduced to zero, provided that the thickness vanishes at the tip of the wedge. For m≥2 (Figure 12), the flexural wave never reflects back. Some considerations are outlined:

Residual thickness (Figure 12) reduces the absorption, but the addition of a thin strip of damping material significantly reduces the reflection coefficient.

Frame design (Figure 13): Structure-borne (SB noise) can be controlled through the design of a dedicated frame for pantograph supports based on ABH to reduce vibration transmission from the pantograph to the roof. It is composed of a double – layer beam with one-dimensional ABH.

Roof plate design (Figure 14): SB and AB noise, based on ABH to potentially reduce both air-borne and structure-borne noise caused by the pantograph. A characteristic length about 18-28 cm was chosen considering the frequency of interest and typical car body materials.

Horn directivity (Figure 15) – acoustic antennas are being analysed with fundamental frequencies of about 370 Hz and 660 Hz. The horn directivity is modified by means of resonant antennas, directing the sound in a cone around the travelling direction, hence reducing the sound level in the driver's cabin. Considering the space constraint and the relatively low frequencies involved, designs with sub- wavelength scale dimensions are a potentially promising alternative.

Horn cover (Figure 16) – locally resonant metamaterials attached or embedded in the panels and/or covers to increase the sound transmission loss from the horn to the driver's cabin.

Advances and innovations in TRANSIT

With all these analyses and through the development of the above-mentioned methods, TRANSIT aims at enabling future low noise railway vehicles with a reduced environmental impact and an improved interior acoustic comfort. This is achieved by developing accurate and robust source characterization and separation methods and techniques, and exterior noise simulation tools that will make virtual testing and more cost-effective vehicle certification and homologation methods possible. For interior noise control, innovative material designs to increase sound transmission loss and absorption will be developed, leading to an improved interior sound quality within the weight constraints.

Installation effects and refraction in the transmission paths

The Boundary Element Energy Method (BEEM) successfully applied in the prediction of automotive exterior noise will be used to model the sound radiation of bogie-mounted sources and other sources under the vehicle, and combined with ray-tracing techniques to predict railway exterior noise. This combined methodology has recently been applied to estimate the contribution of engine noise to pass-by noise in cars and will be adapted to trains in TRANSIT. Furthermore, diffraction effects for a roof-mounted source, a source mounted on the underframe and a source in the bogie will be studied using a 2.5D boundary element method, analytical diffraction models and a ray tracing approach. The results will be compared with experimental results and the energy BEEM method. The most promising approach(es) will be implemented in the global exterior noise modelling tool.

Estimation of uncertainty on predicted noise levels

The sensitivity of the global model predictions to uncertainties in the source strengths, directivities and installation effects will be studied in a number of scenarios and the propagation of uncertainty will be quantified. The methodology will be further developed, paying special attention to the accurate definition of the uncertainties in the input source strengths. Additionally, the application of IBF, an inherently statistical

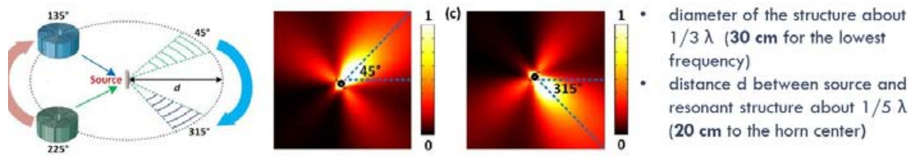


Figure 15: Effect of Horn Directivity

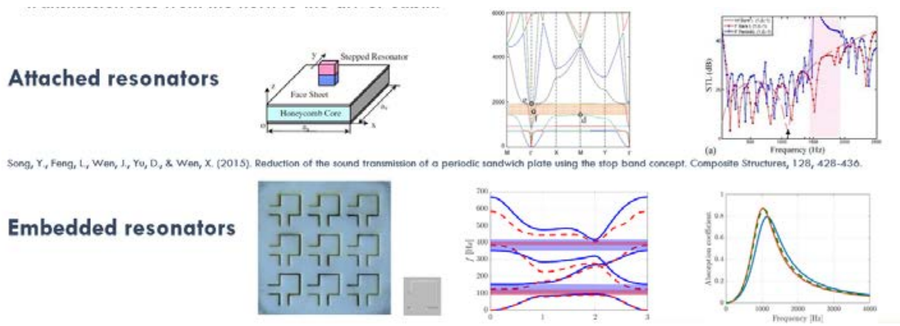


Figure 16: Locally resonant metamaterials with the design panels

method, will provide built-in tools to estimate the uncertainties of source strength measurement.

Validated exterior noise simulation tool

The global exterior noise simulation tool will be experimentally validated for a stand-still vehicle for at least two of the most relevant sources. This result will be a consequence of the advances in modelling of installation effects and characterization of source sound power and directivity.

Definition of strength and directivity of sources

Advancements along two paths will be sought. The first is to take the next step along the line started in Acoutrain and characterize the source based on sound power measurements according to ISO3744 (instead of using a calibrated monopole source). The second path is to apply the IBF method,\ based on microphone array measurements, to the characterization of source strength and directivity of railway sources (e.g, a traction motor, a HVAC fan unit and a transformer). The tests should be conducted at a supplier in the test rig or environment which normally is used. An advantage of IBF is that it can be used for in-situ source characterization, which could potentially allow for validation of installation effects on the source strength and directivity.

Equivalent source models to represent strength and directivity

Models based on equivalent elementary sources (e.g. monopole, dipole) will be developed. The effect of reducing the number of equivalent monopoles on source strength and directivity condition will be analyzed, by comparing sound radiation in free field with the full and reduced sets of equivalent sources.
In particular, a correlation with the 5 equivalent monopoles derived from measurement according to the ISO3744 standard will be done (search of an optimized set of 5 equivalent monopoles that reconstruct as precisely as possible the source directivity and comparison with the 5 sources derived from ISO 3744 measurements).

Improved pass-by source separation including source strength and directivity

Methods based on microphone arrays successfully applied in other fields such as rotating machinery, aerospace and automotive will be extended or adapted to the needs of railway pass-by source separation measurements. Separation of aerodynamic noise sources, traction and equipment noise sources will be achieved, including estimation of sound power for the sources in third-octave bands and information on the directivity of sound radiation. Two promising methods are CMF and SODIX. The source models for the CMF method will be enhanced with information from the source models and transfer functions developed in source and transmission characterization for exterior noise field in the TRANSIT project. It is expected that this will improve the resolution and the accuracy of the source strength calculation. Regarding the source directivity, the SODIX method will be explored. Regarding methods not involving the use of microphone arrays, the PBA-based approach described above will be improved and adapted using the total rolling noise transfer function and combined roughness to separate out the contribution of other sources.

Validation and uncertainty assessment

Uncertainty estimation methods based on error propagation and Monte-Carlo approaches will be developed and the source separation results will be validated by comparison to the exterior noise simulation tool developed and validated in source and transmission characterization for exterior noise.

Enhancement and simplification of separation methods

Three families of separation methods will be enhanced and simplified: PBA, ATPA and TWINS-based. PBA methods provide the combined effective roughness and total transfer function from combined effective roughness to sound pressure. Source separation will be achieved by splitting the total transfer function into a track and vehicle part, based on stationary measurements. For the ATPA method simplifications of the method will be explored in terms of the number of measurement transducers and the number of static measurements required. Regarding TWINS-based separation methods, a set of 'standard' vibro-acoustic transfer functions for the track will be developed, so that track noise can be estimated simply from measured rail vibration. Recent improvements to acoustic radiation models for track components will be incorporated into these estimates.

Separation of wheel and rail roughness

A method will be developed for separation of combined roughness into wheel and rail contributions starting from the combined roughness of the whole train or parts of the train, and applying either known rail roughness at the site with a contact filter or assessing multiple pass-bys from trains with different wheel roughness, or from individual wheels within the same train. This will result in an absolute level and a threshold level of wheel or rail roughness, depending on which is lowest.

Separation of vertical and lateral rail vibration contributions

The PBA, ATPA and TWINS-based methods make use of vertical and lateral rail vibration measurements during pass-by to establish the track contribution. The developments to enhance these methods described earlier will lead to separating the contributions of vertical and lateral rail vibration (and sleeper vibration) to the total track noise.

Transposition methods

Transposition of pass-by rolling noise from one track to another will be investigated building on work done in Acoutrain, which illustrated some limitations when converting between widely different track types such as ballasted track and slab track. A better understanding of the physical factors involved will be sought, supported by TWINS simulations. The feasibility of developing a method for transposition using the ATPA method will be investigated as well.

Feasibility study of innovative solutions

A comprehensive feasibility study for design solutions concentrating at different parts of the interior noise generation chain will be produced. Solutions to increase sound absorption at the source, increase sound attenuation in ducts and through panels, reduce structure-borne transmission through the carbody structure and increase acoustic absorption in the car will be proposed and assessed against criteria established by the associated project FINE-2.

New designs for improved interior noise comfort

New designs based on (meta)-structures tailored to maximize attenuation at selected frequency regions will be proposed and optimized. Hybrid constructions potentially combining light metal alloys and composite materials that can be manufactured with 3D printing technique will be explored, in line with other expected developments within Shift2Rail (S2R-OC-IP1-01-2019). Inspiration will be sought in successful designs from other application areas, such as liners for aero-engines. The designs will be experimentally validated in laboratory tests.

Concluding Remarks

The key to predicting overall noise levels accurately for stand-still or in the vicinity of the track during pass-by is an accurate separation and characterization of the main contributing sources and this is the core of the research work in TRANSIT: to identify the sound power and directivity of the main sources of railway noise and establish their contribution to the total measured levels. These results are the input to the exterior noise simulation tool that will be developed taking the Acoutrain-tool as the starting point. Furthermore, although not included directly in TRANSIT, the source models are a valuable input for the interior noise simulation models developed in previous S2R projects Fine1 and Destinate. In TRANSIT, new material designs and their corresponding absorption and transmission loss properties will be modelled, that can subsequently be introduced in the interior noise simulation models to assess their performance.

The main obstacle for current vehicle certification methods is the fact that the track is a main contributor to pass-by noise in combination with the inability to accurately separate vehicle and track contributions. TRANSIT will target this problem by developing methods to identify the contribution of vehicle sources and to separate the vehicle and track contributions to rolling noise, based on the most promising approaches from Roll2Rail. Furthermore, an operator experienced in EU research projects (Metro de Madrid) will provide practical guidance and availability of rolling stock to test and validate, if necessary, the methodologies developed within TRANSIT.

TRANSIT is firmly based on the results from past EU projects Acoutrain and Roll2Rail and relies on the inputs from S2R Member projects FINE1 and FINE2 to set the next steps towards virtual certification. Furthermore, a key aspect to maximize the visibility, impact and acceptance of the TRANSIT results is the interaction with relevant stakeholders such as the steering committee of the Shift2Rail Cross-cutting Activity (CCA) Noise, the EU Agency for Railways (ERA) and TC256/WG3 of the European Committee for Standardization (CEN).

For further information about the project and partners, please, visit the project website: https://transit-prj.eu/home.aspx


Live level reporting and alerts.
NTi Audio Demo (active)
Map
50.3 dB
34.2 dB
Locations
Residential West
Residential South

The Noise News Podcast

Living Legends: Dr. Jim Thompson

For 20 years, NNI has served as the leading source of news for noise and vibration specialists. It informs the growing international body of professionals who work to control noise and vibration. As part of this mission, we have started a companion podcast, The Noise/News, to give readers an inside track for even more developments in noise control.

In the latest episode of The Noise News, host Eoin King is joined by Dr. Jim Thompson. Dr. Thompson is the current editor of the Noise Control Engineering Journal and Past President of INCE-USA. Dr. Thompson shares his 40 years of experience with us, and shares career advice to those on planning to join the industry.

The Noise/News is available wherever you to your podcasts. Alternatively you can click on the direct links below:

- The Noise/News on Apple
- The Noise/News on Spotify
- The Noise/News in INCE-USA

Book Reviews

A Guide to U.S. Aircraft Regulatory Policy

Sanford Fidell, Vincent Mestre
Springer, (2020), 144 pp., hardbound, 109 USD, ISBN 9783030399078

This volume provides a concise chronological discussion of the history of US Aircraft noise regulations, up to and including the 1996 Revocation of the FAA Charter to promote civil aviation and the eventual FAA Act of 2018 and its potential influence on future aircraft noise regulations.

The book also provides a handy review on several closely related topics of interest. These include a review of the effects on individuals and communities of aircraft and airport noise (a topic for which Dr. Fidell is especially well known, and easily the most detailed chapter of the book). Other less rigorous chapters include aircraft noise measurement and modeling, airport land use planning and other airport noise mitigation strategies, and potential future changes to airport noise policy.

I did find the discussion of related topics to be useful and easy to follow for someone who is not a dedicated aviation noise specialist. However, I think that one additional topic that might have been useful to include would be a comparative analysis between US aviation policy and aviation noise policy around the world. For example, the European Union is known to be much more progressive in terms of noise control requirements for everything from consumer products to public projects. It would have been interesting to better understand how their aviation noise policies differ from those in the US.

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Why You Hear What You Hear: An Experiential Approach to Sound, Music and Psychoacoustics Eric J. Heller

Princeton University Press, Princeton, NJ, USA (2013), 590 pp., Hardbound, 120 USD, ISBN 978-0-691-14859-5

There are numerous proofs of the Pythagorean theorem. Euclid provides one of the more interesting in his Elements where he uses only the geometry axioms he originally proposed. No algebra or trigonometry is needed, and the proof is remarkable because he gets there with a limited set of tools.

I appreciate Eric Heller's Why You Hear What You Hear: An Experiential Approach to Sound, Music and Psychoacoustics in much the same way. Heller goes about introducing the science of acoustics with a substantial handicap. Namely, calculus and differential equations are not welcome. Yet, Heller's accomplishment is more impressive because he teaches with a set of limited mathematical tools. Heller compensates by using intuition and pulling in similar phenomenon from fields outside acoustics where appropriate.

For instance, he explains impedance by aligning coins on a table. He gives the reader a conceptual understanding of autocorrelation by looking at temperature variations in Fairbanks. He describes vibrational modes using beads on a string. Along the way, Heller adds color to the discussions by mixing in historical anecdotes and quotes from well-known personages like Aristotle and Galileo. Even Napoleon plays a role in the history of acoustics. He recounts how the sound of bells was apparently heard by a ship 100 miles away at sea. That would seem to be impossible, but he goes on to show how it just might be plausible. In an amusing aside, he recounts how Sabine's frequency in getting haircuts affected the reverberation time in his room and that one of his students surmised that hair might be a very good sound absorber.

I found the book as entertaining as it is informative. It is lucidly written, and the explanations and rudimentary mathematics can be understood by first year undergraduates. The text is inviting because the volume is nicely illustrated and attractively laid out. Where illustrations are not enough, Heller relies on Paul Falstad's physics applets that are freely available online. I was not aware of these applets prior to reading the book.

The book proceeds in a logical fashion by first discussing sound and wave propagation. It goes on to discuss some signal processing basics such as the Fourier transform and autocorrelation. Heller then describes sources of sound, vibrational modes, damping, and the impulse response. Musical acoustics is next with chapters on wind instruments, the voice, violin, and piano. The book then moves on to discussing psychoacoustics where concepts like loudness, pitch perception, and timbre are explained. The book concludes with discussions on architectural acoustics and outdoor sound propagation.

The text can be used for a myriad of introductory level undergraduate courses in acoustics. However, I suspect that more experienced acousticians and noise control engineers will derive greater pleasure from it. There are surprises in every chapter. This is a book that makes acoustics interesting. Simply put, this is a fantastic book and is highly recommended.

David Herrin, Ph.D.
Professor, Mechanical Engineering,
University of Kentucky
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NOISE/NOTES

Eoin A. King, NNI Editor

NNI is on Facebook and Twitter. We try to keep our readers informed with noise news from all across the globe by highlighting interesting research and projects. Here is a roundup of some of the stories that have been making headlines. Follow @NNIEditor to stay up to date with all noise-related news!

INTERNOISE 2021… the gift that keeps giving.

All registered attendees of INTER-NOISE 2021, have been gifted free access to the INCE Digital Library for three months (September 1 – November 30, 2021). On top of that congress proceedings (written papers) and most video recordings are available online from August 12 to October 5. So, you never have to miss a paper!

Summer Bridge on Noise Control Engineering

The Summer 2021 issue of *The Bridge* was devoted to noise control engineering. The issue is guest edited by George Maling Jr, and Eric W. Wood, and addresses what the role of engineering practice, education and standards in mitigating human-generate noise. In 2007 the subject was first covered in *The Bridge* during the early stages of an NAE consensus study that led to the report *Technology for a Quieter America (TQA)*, published in 2010. This issue of The Bridge is a key follow-up to this work.

Noise and Seagrass

EcoWatch reports that human-created noise pollution is altering seagrass beds on a cellular level and causing them to uproot themselves. This could have dire effects on marine ecosystem health, water quality, shoreline stabilization and the climate crisis. The report considers an article published in *Communications Biology* by researchers from the Polytechnic University of Catalonia, in Spain. The study monitored morphological and ultrastructural changes in seagrass, after exposure to sounds in a controlled environment.

ANIMA Project Final Event

The ANIMA project, as previously featured in NNI, will be completed at the end of 2021, and they are holding a final event, which will take place on 16 December, in Brussels. The ANIMA consortium will present the results generated by the project after over four years of activity. More information is available here.

Some History on Hearing, Workplace Noise and Instrumentation

Walter Montano, Technical Department, Arquicust, Gualeguaychu, Argentina

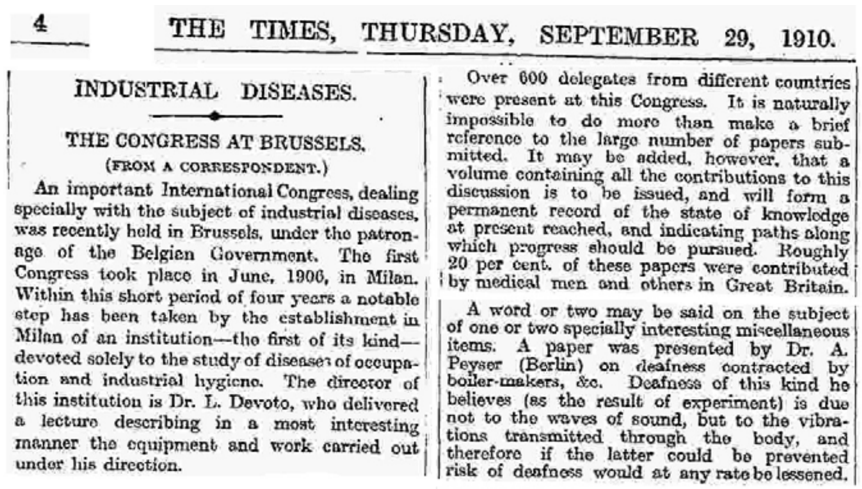
Introduction

This is the third in a series of articles published by the author in Noise/News International, dealing with particular historical aspects of concerns about noise. This article will focus on the early concerns about noise in workplaces, a topic first presented in 1910 at a meeting of the International Labour Organization (ILO). A century later the author was able to obtain a digital copy of the first encyclopedia published by ILO and which identifies noise problems for workers at workplaces and the early treatments by an Italian doctor. As for the previous articles, this article provides a summary of the technological advances over the decades.

The International Commission on Occupational Health (ICOH)

The International Commission on Occupational Health was founded in 1906 in Milan as the Permanent Commission on Occupational Health, and *"ICOH is recognized by the UN as a NGO and has close working relationships with ILO and WHO"* (ICOH, 2020), according to its official website. Also: *"The International Commission on Occupational Health (ICOH) is an international non-governmental professional society whose aims are to foster the scientific progress, knowledge and development of occupational health and safety in all its aspects."*

There is little information on the 1st ICOH conference but *The Times*, September 29, 1910 reported on the 2nd ICOH congress, held in Brussels. Dr. Alfred Peyser (1870-1955), in his paper on *"Industrial diseases and injuries of the auditory system"* (in German) proposed that the *"Congress should instruct a commission to systematically study occupational diseases of the hearing system and present a report at the next session."*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THE TIMES, THURSDAY, SEPTEMBER 29, 1910.

INDUSTRIAL DISEASES.

THE CONGRESS AT BRUSSELS.

(FROM A CORRESPONDENT.)

An important International Congress, dealing specially with the subject of industrial diseases, was recently held in Brussels, under the patronage of the Belgian Government. The first Congress took place in June, 1906, in Milan. Within this short period of four years a notable step has been taken by the establishment in Milan of an institution—the first of its kind—devoted solely to the study of diseases of occupation and industrial hygiene. The director of this institution is Dr. L. Devoto, who delivered a lecture describing in a most interesting manner the equipment and work carried out under his direction.

Over 600 delegates from different countries were present at this Congress. It is naturally impossible to do more than make a brief reference to the large number of papers submitted. It may be added, however, that a volume containing all the contributions to this discussion is to be issued, and will form a permanent record of the state of knowledge at present reached, and indicating paths along which progress should be pursued. Roughly 20 per cent. of these papers were contributed by medical men and others in Great Britain.

A word or two may be said on the subject of one or two specially interesting miscellaneous items. A paper was presented by Dr. A. Peyser (Berlin) on deafness contracted by boiler-makers, &c. Deafness of this kind he believes (as the result of experiment) is due not to the waves of sound, but to the vibrations transmitted through the body, and therefore if the latter could be prevented risk of deafness would at any rate be lessened.

Fig. 1: News about the 2nd ICOH congress (Extracted from The Times), 1910.

His study was on deafness contracted by boilermakers, with statistics from experimental data, demonstrating that *"Continuous noises of medium intensity, transmitted exclusively through the air, have a harmful influence on the hearing apparatus, or at least this influence is weak."* He also added *"Short and loud noises or noises of a very high pitch produce, particularly when repeated, temporary or lasting damage to the hearing system;"* and the most important finding of his investigation was *"The propagation of noise through skeleton, especially through the ground, ends up creating very serious damage to the hearing system"* (Peyser, 1910).

At the end of this article by Peyser a summary in French, condenses his entire proposal for actions intended to protect people from injuries due to noise exposure:

Prophylaxis of hearing damage in industry: 1. Exclusion of workers with lesions of the ear, nervous system, anemia. 2. Introduction of rest time with noise suppression, or reduction of working hours. In jobs that pose the greatest threat to the hearing system, rotate workers from 15 to 15 to 30 to 30 minutes. 3. Construction of workers' houses away from all noise. 4. Placement of devices intended to muffle noise and reduce trepidations. 5. Periodic otological inspection of workers. (Peyser, 1910)

THE EVENING STAR, WASHINGTON D. C., FRIDAY, MAY 17, 1929.

Noise As Noise Cure Is Novel Prescription

BY E. E. FREE, PH. D.

Making more noise to cure the nervous effects of some noise is the paradoxical prescription offered by Dr. L. Carozzi in a report on the harmfulness and control of noises in offices or factories, presented recently to the League of Nations in Geneva, Switzerland. Dr. Carozzi agrees with other experts that the harmful effects of noise on human beings are complex and are not measurable by the mere intensity of the noise.

THE TIMES, TUESDAY, FEBRUARY 12, 1929.

NOISE AND HEALTH.

A LEAGUE REPORT.

TO THE EDITOR OF THE TIMES.

Sir,—The extensive Encyclopædia of Hygiene, Pathology and Social Welfare, studied from the point of view of labour, industry and trades, that the International Labour Office of the League of Nations has for some years been engaged on, has recently been enriched by an article on Noises by Dr. L. Carozzi (I.L.O.), revised by the Correspondence Committee on Industrial Hygiene of the International Labour Office, Geneva (Brochure No. 129), thereby enhancing the importance of an epoch-making contribution to the science of hygiene that will have far-reaching and beneficent effects throughout the industrial world.

Yours, &c.,
HENRY J. SPOONER.
Royal Societies Club, S.W.

Fig. 2: Articles extracted from: The Times and The Evening Star, 1929.

International Labour Organization and Noise

The International Labour Organization (ILO) *"was created in 1919, as part of the Treaty of Versailles that ended World War I, to reflect the belief that universal and lasting peace can be accomplished only if it is based on social justice;"* the constitution of the ILO was a *"process resulted in a tripartite organization, the only one of its kind, bringing together representatives of governments, employers and workers in its executive bodies,"* finally in 1946 the ILO became a specialized agency of the United Nations (ILO, 2020).

According to internal documents, ILO started to prepare to publish an encyclopedia of industrial hygiene around 1925. Dr. Luigi Carozzi was one of those responsible for developing the content. The sections were written by many collaborators and were presented separately to the Board. ILO then published the first version of "Occupation and Health - Encyclopaedia of Hygiene, Pathology and Social Welfare" in two volumes: Volume I A-H, in 1930; Volume II I-Z, in 1934.

Luigi Carozzi and his work about occupational noise

In 1929, an Italian doctor, Luigi Carozzi (1880-1963) chief of the Hygiene service at ILO (also a member of ICOH board), presented an original text which described several diseases at workplaces, including the noise problems, however there are no official documents at the ILO archive on his early notes.

Unfortunately, there are only a few isolated articles available on the Internet about Carozzi's work on noise problems. Two comment and explain the Carozzi's Report so-called "Correspondence Committee on Industrial Hygiene of the ILO (Brochure No 129)": **(a)** The Times of London of February 12, 1929 in "Letter to editors" written by Henry J. Spooner (1856-1940). In this he highlights some of Carozzi proposal *"it is a consolation that long last the devastating effects (both hygiene and economic) of harmful noise are receiving international attention,"* adding *"These and many other considered opinions of the distinguished author, fathered by the correspondence Committee, cannot fail to command the serious attention of the authorities and others responsible for the health of workers of all nations;"* **(b)** The Evening Star of Washington on May 17, 1929, published an article "Noise as noise cure is novel prescription" written by Edward Elway Free (1883-1939).

Some background on Spooner who reported Carozzi's work (Fig. 2): He was a worldwide well-known English mechanical engineer and acoustician who had a strong sense of the problem of noise on people's health. He said *"and a careful perusal of the comprehensive brochure referred to should inspire them to energize in tackling the manifold problems of noise reduction in all activities, in the great cause of humanity; realizing that mechanical noise connotes wicked waste, and too often unskillful design and construction; also that ignorance of the harmful effects of noise and vibrations on the human machine is the most general cause of inaction."* As an example of his beliefs, Spooner helped the "Manufacturing Grocers" Union of Australia, in 1924 to a demand on employers that *"All mills and machines shall be run with as little noise as possible,"* as the States Secretary quoted (Recorder, 1928). Spooner suggested in January 1922 having a 'Day of silence,' being this the first time that an acoustician proposed a social activity to promote the problems for human health resulting from noise.

The section "Noises" in the first ILO Encyclopedia

The second volume of the *"Occupation and Health - Encyclopaedia of Hygiene, Pathology and Social Welfare"* included the diseases starting with I-Z was published in 1934. The introduction of the five pages of the chapter *"Noises,"* written by Carozzi, is a clear declaration of the importance of noise control at workplaces:

The influence of noises on the health of workers is one of the most important problems of industrial pathology, for it *concerns nearly every modern industry. As a matter of fact, there are few industries to which the introduction of machinery has not brought, in addition to radical changes in methods of work, more or less serious disadvantages from noise and vibration. The study of industrial noises is of comparatively recent date, and the increasing interest which it arouses is accounted for partly by the increase in industrial noises, and partly by a better realization of their harmful effect, and of the waste of energy which they cause.* (ILO, 1934, p.365)

He uses Peyser's research (the one presented at 2nd ICOH) about the classification of the different sources of noise in workplaces and also discusses that vibration transmitted through the body could cause deafness (depending on the amount of the mechanical energy). It is interesting that Carozzi put emphasis on young workers because *"they are more exposed to get deafness"* and *"The age of the sufferer must be taken into consideration with the increase of lesions..."* (ILO, 1934, pp.366-367). He proposed rational efforts to diminishing the harmful effect of noises, by suppression or diminution of noises and vibrations at the source, and suggested *"the use of acoustic material to reduce the airborne sound transmission,"* and to put *"bases of special materials or on special foundations, independent of the floor used by personnel, or enclosing them in special rooms"* (ILO, 1934, p.370).

Although the encyclopedia was published in 1934, when discussing the technology that should be used to analyze the noise inside the workplaces, the methods and acoustic instrumentation that he proposes are those available prior to 1925. For example he does not mention the noise meters that was used worldwide from 1926 and he proposes to use Edison's phonograph, tuning forks and oscilloscopes, and even Low's "audiometer".

Section "Industrial noise (Physio-pathology)" in Supplement of the ILO's Encyclopedia

In 1938 ILO published an updating supplement for the Encyclopedia which included a ten page chapter on *"Industrial noise (Physio-pathology)"* was written by Dr. Raoul Caussé (1892-1949) (ILO, 1938, pp.107-117).

The first chapter *Definition, measurement, and analysis of noise* presents the metrological definitions from "The first international acoustical conference" held in Paris in July 1937 under the auspices of the International Electrotechnical Commission (IEC), with the co-operation of the Comité Consultatif International Téléphonique (CCIT), and also the Federation of National Standardising Bodies known as the International Standard Association (the former ISO) (Nature, 1937). This is important because the ILO adopted the use of standardized sound meters. Caussé also mentions the use of the Barkhausen noise meter as a possible analyzer of noise levels in workplaces and it was being used for this purpose in Germany (Beck & Holtzmann, 1929).

The second chapter *Influence or noise on the system* explains the harmful effect of noise on the ear, presenting a short time-line of the history of what physicians have discovered. The third chapter, *Types of occupational deafness*, offers a scientific justification about the existence of occupational deafness can no longer be doubted, and presents an analysis of one survey made in New York in 1930 into the effect of noise on the hearing of industrial workers. Chapter four on *Noisy trades* states that *"there were no classifications of industries based on an objective phonometric study of noise,"* and so provides a ranking of noisy trades. Chapter five on *Prophylaxis* presents some observations on occupational deafness. *Legislation* is the last chapter where a complete summary of policies on workplace noise from different countries; Caussé presents his view that although *"For some years past public interest has been directed to what is known as the campaign against noise, and regulations which are often extremely stringent have been issued in an effort to restrict noise,"* he adds *"It should, however, be observed that industrial noise or harmful noise is not in question here, but solely street noises or noises inside buildings, which are merely of a disturbing character."* In conclusion, Caussé highlighted the importance of the compensation for deafness: *"Age must be taken into account, since it contributes, especially after the age of 50, to the production of deafness"* (ILO, 1938).

Noise Levels Limits at Workplaces Internationally Discussed

Russia has a long tradition for the study of noise at work, and around 1934 was the first country to provide compensation for deafness of industrial origin (ILO, 1934). Ilya Ilyich Slavin (1912-1959) was an important Russian acoustician in the decade after the WWII. He returned to the Acoustics Laboratory of the "Leningrad Institute of Labor Protection of the All-Union Central Council of Trade Unions" (LIOT), where he became an outstanding specialist into the field of noise control. Slavin conducted several investigations at LIOT and one was focused on the physiology of the inner ear and the human response to different noise levels. The results of this research were:

A great influence on the development of noise control activities could be provided by scientifically sound legislation to limit industrial noise. Work in this direction was conducted by the LIOT laboratory. Based on an analysis of experimental data on the effect of noise on hearing and the general condition of people, as well as special studies conducted by the Laboratory, Slavin developed in 1954 a

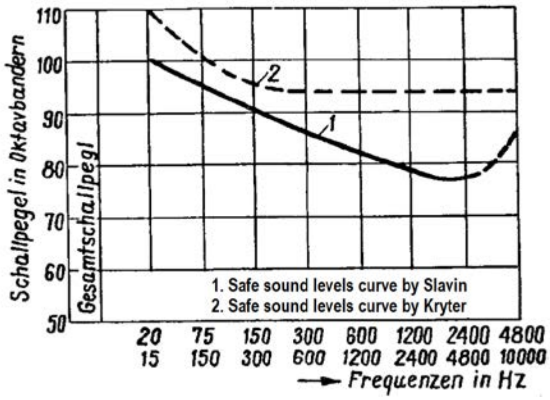


Fig. 3: Slavin's curve presented at 12th ICOH congress, 1957.

Table 1 Permissible Levels in Industry for Various Noises

Description of Noises	Permissible Sound Pressure Level, db re 0.0002 microbar
1—**Low-frequency noises** (produced by non-percussive units of slow operating speed, noises penetrating through sound-proofing barriers, such as walls, ceilings, casings), whose highest levels in the spectrum are situated below a frequency of 300 cps, above which levels become lower (by no less than 5 db per octave)	90–100
2—**Median-frequency noises** (noises produced by most non-percussive machines, mills and plant units), whose highest levels in the spectrum are situated below a frequency of 800 cps, above which levels become lower (by no less than 5 db per octave)	85–90
3—**High-frequency noises** (ringing, hissing and whistling sounds characteristic of percussive units, air and gas streams, and units operating at high speeds) whose highest levels in the spectrum are situated above a frequency of 800 cps	75–85

Fig. 4: Slavin´s 1955 permissible levels in industry for various noises (from ASA 1959).

production noise standardization system, which was introduced in 1956 by the USSR Ministry of Health in as mandatory in the Soviet Union. (Slavin, 1959)

Slavin participated at 12th ICOH congress which took place in Helsinki, 30th June-5th July, 1957, where he presented *"Tentative Standards and Regulations for Restricting Noise in Industry"* written into German. This Congress was very important to Slavin, because his proposal on noise levels limits to workplaces were internationally known and according to him *"Noises allowed by Soviet norms are close in their values to those reported at the Congress in the order of discussion by scientists from the USA (*[Charles R.] *Williams) and Japan (*[Shiji] *Katsuki)"* (Slavin, 1957). Figure 3 (extracted from his paper) compares the Slavin's curve for safe sound levels and the Kryter's criteria, the one suggested for workplaces in US on the same year of 1957.

Slavin's 1955 paper in Russian is not available on Internet yet, so the author has to use the CIA translation into English (CIA, 1959) and one article published in "Noise Control" magazine by the Acoustical Society of America (ASA, 1959). An important contribution by Slavin is that he has defined three frequency intervals (including the low-frequencies band) to establish the industrial noise levels limits, as one can observe in Figure 4.

Despite the widespread use of the single metric dBA it is clear from his writing that Slavin considered it was important to consider at least three separate frequency ranges. The table of Figure 4 was translated to a drawing as noise reference curves (See Figure 5). The curves in Figure 5**(a)** are difficult to understand, taken from CIA document, and they had to have been simplified as one can see in Figure 5**(b)** taken from ASA paper.

Slavin's work was mentioned widely in US technical publications; for example the well-known American acoustician Karl David Kryter (1914-2013) highlighted that *"Slavin states his contours are meant to be a practical balance between hearing conservation and necessary industrial noise conditions"* (Kryter, 1970). According to Slavin, the Russians representatives at ISO presented his work about noise limits in workplaces. It is possible they did it in 1958 during discussions in ISO/TC-43 board but unfortunately, there is no other information available on Internet yet, and his noise curve criterion was never finalized as a proposal.

Slavin died in January 1959, but his work was presented posthumously at Third International Congress on Acoustics held in Stuttgart. Slavin's paper is not in ICA Proceedings but in an issue of Wireless World magazine of October 1959 (Wireless, 1959). Further information about Slavin's work and life in acoustics can be found in a recent investigation published in "Noise Theory Practice" (Montano, 2020).

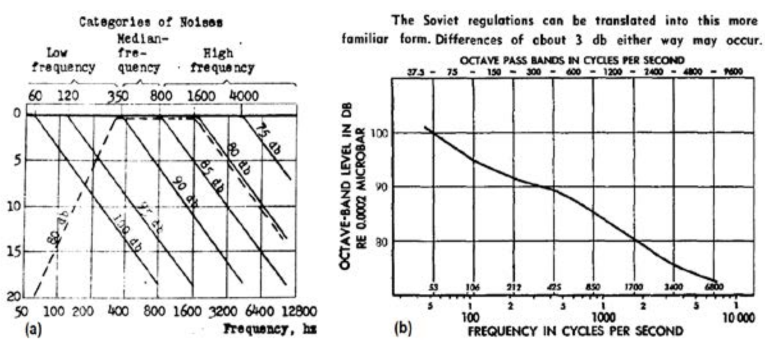


Fig. 5: Slavin´s curves for permissible levels in industry for various noises, 1959 (Slavin reference and the ASA reference).

The Dawn of Sound Level Meters

To be able to implement any controls regarding limits to noise in the workplace it was important to be able to measure the noise accurately and that followed from the development of the sound level meter. Since 1880, with the advent of the telephone, countless devices, which were 100% electro-mechanical, were developed to measure hearing ability. They were generically called "audiometers" but at the time there was mention that audiometers 'measured loudness or intensity,' or "devices that can measure sound level," it has to be kept in mind that before the acoustics terminology standardization in 1937, the term 'intensity' was incorrectly used as a synonym of 'level.' The audiometer in a modified version, evolved technologically to be used as a sound level meter, and the first fully electronic audiometer with valves was developed in Germany in 1919 and was called "Otoaudion" (Griessmann, 1921), but there are no bibliographical references that it was applied for sound measurements that were not related to audiometry.

The firsts reliable microphones for sound measurements

The condenser microphone

Edward Christopher Wente (1889–1972) working at Bell, designed and patented in 1917 the first condenser microphone *"as a uniformly sensitive instrument for the absolute measurement of sound intensity"* with: a wide bandwidth, undistorted and flat response, with real possibilities of calibration, electric circuit stability. The "Wente microphone" measures any kind of arbitrary noise in sound units and was capable of dealing with low levels of sound using an internal valve to amplify the voltage delivered by the membrane;

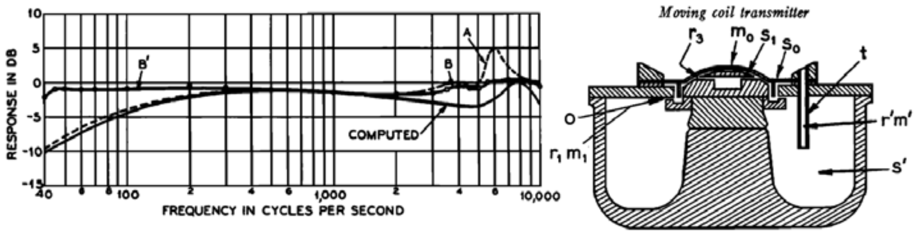


Fig. 6: Wente-Thuras moving-coil microphone frequency response, 1931.

DIE BAUTECHNIK

Preisausschreiben zur Bekämpfung des Straßenlärms. Der großstädtische Straßenverkehr schädigt die Bewohner empfindlich durch seinen Lärm. Mit Hilfe des Schallmessers von Barkhausen ist es möglich, die Stärke der einzelnen Schallquellen zu bestimmen. Eine solche Bestimmung ist auch schon durch unmittelbare Beobachtung möglich. Danach wäre die Aufgabe zu stellen, die stärksten und störendsten Lärmquellen zu ermitteln und Vorschläge zu machen, wie man sie zweckmäßig dämpfen kann. Als Beispiele seien folgende Geräusche genannt: Lärm der Straßenbahnwagen infolge Erschütterung der Wagen, desgl. infolge Radreibung in Gleiskrümmungen; Kraftomnibusse. Erschütterung des Wagens; Kraftomnibusse und Kraftwagen, Lärm durch ungenau arbeitende Motor- und Getriebeteile; Krafträder, Auspuff und Getriebe; Kraftfahrzeuge, Warnungssignale; Müllabfuhrwagen, Umstürzen der Müllkasten; Straßenhändler, insbesondere Zeitungshändler, Ausschreien der Ware.

Bewerbungen sind bis zum 1. Dezember 1928 in deutscher Sprache mit einem Kennwort einzureichen an das Kuratorium der Zusatz-Stiftung zu Zeitlers Studienhaus-Stiftung, La. Stift. II Zeitler, Berlin C 2, Poststr. 16, Zimmer 24. Die Anschrift des Absenders ist in geschlossenem Umschlage mit gleichem Kennwort beizufügen. Als Preis sind 800 R.-M. ausgesetzt.

Offer Prize for Plan To End Street Clatter

BERLIN (AP)—Germany is starting a war against street noises by opening a competition for the best scheme to abolish the nerve-racking clatter and din of the big cities. Naturally, street noises are mostly caused by wheeled traffic. Grinding of street cars around curves, jolting of badly sprung vehicles, banging of garbage cans on pavements and noisy exhausts from old motors are all on the blacklist, as well as street criers and the deafening chorus of motor horns generally.

The Brownsville Herald

Wednesday, May 30, 1928

All these noises are measurable by an instrument called the Blackhausen sound meter. Traffic experts claim that most street accidents are attributable to the nerve-destroying racket which is making city life hideous.

Under the auspices of the Association of German Engineers a prize of $200 is offered for the best solution. The competition is open until Dec. 1.

Fig. 7: The competition announced on the media, 1928.

for the first time, the acousticians had the ability to quantify sound level (Jones, 1931).

The moving-coil microphone from 40 Hz to 10 kHz

E. C. Wente and Albert Lauris Thuras (1888−1945) in 1931 designed a moving-coil microphone. This was aimed at improving linearity of the device at low-frequencies, and they found that by inserting a tube (identified as *t* in Figure 6) between the outside and the cavity behind the membrane (as if it were a Eustachian tube), there was compensation of the pressure difference and, after calibration with a thermophone, an extended frequency response was achieved, as one can observe the curve B' in Figure 6 (Wente & Thuras, 1931).

Another improvement introduced by this development was *"This microphone has important practical advantages over the condenser transmitter in that the amplifier may be at some distance from the transmitter without loss in efficiency and in that no polarizing voltage is required"* (Wente & Thuras, 1931).

European developments of early noise meters

In 1920 Archibald Montgomery Low (1886-1956), an English engineer and prolific writer and inventor, developed an electric/mechanic device to measure the sound intensity so-called "audiometer." This was used in 1920, in a courtroom to measure and compare the noise level from motorcycles (Times, 1920). Its use was overtaken by the emergence of electronic sound meters, but it is possible to find some mentions of it until 1929.

Heinrich Georg Barkhausen (1880-1956) a German scientist designed an apparatus which could measure the sound levels in terms of sensation. In Barkhausen's time, the sound pressure in Europe was measured in 'Wien' and to push this area onto a manageable scale, Barkhausen used the logarithm to base 2 *'I would like to suggest the term 'Phon' for this volume unit,'* later in 1926 it was used in his noise meter (Barkhausen, 1926) and with that,

Fig. 8: Measuring laughing, and the Niagara's noise levels. The Key West Citizen, 1926.

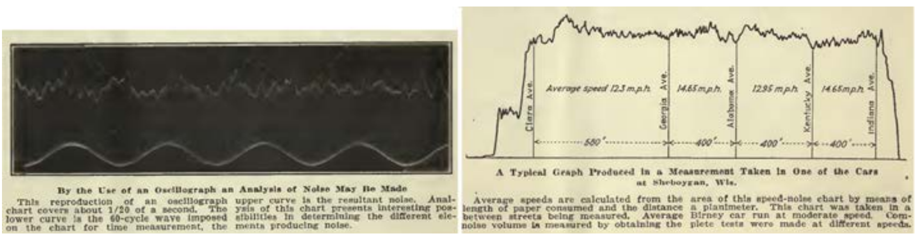


Fig. 9: Wooldridge noise meter charts, 1926.

the 'Barkhausen-Phon' was created. It is important to note that the "phon" concept as is used today is totally different from the Barkhausen-Phon.

This became popular and in 1928, a German engineering magazine held a "contest of ideas" (a competition) to reduce noise in cities using the Barkhausen noise meter (see Figure 7). This idea was replicated in some US newspapers but misspelt Barkhausen as "*Backhausen*".

Following the use of a Barkhausen noise meter to measure occupational noise in 1929 and 1931, an improved version was commercialized under Siemens trademark. Barkhausen was undertaking research for Siemens in a similar way to Fletcher, who was researching for Bell. In 1933 Barkhausen published a paper that defined the concepts of the modern sound meters, this was just a few months before the Fletcher and Munson published the hearing curves (Barkhausen, 1933).

Barkhausen's concept of objective measurement was used for the earliest noise meter designed in England (Kaye, 1937), and in 1929 it was applied to conduct a noise survey of different sources, such as airplanes, car horns, isolation, material absorption, etc. (Times, 1930). There are also a number publications on the use of Barkhausen's noise meter for acoustic isolation measurement in some European countries until the 1950s (Ingerslev, 1952) and Japan (Ohya, 2017). In 1951, the background noise in the Royal Festival Hall, of London, was measured with a Barkhausen meter (Parkin et al, 1952). According to Roland Wittje (2016), Barkhausen visited US and many other countries around the world promoting his meter.

Developments of early noise meters in US

The first attempt to measure the noise levels with no mechanical parts was after the introduction of the full electric/electronic audiometers, in US the portable "Western Electric 2-A" audiometer was sold in 1922 (Mills, 2011).The first mentions of the use of audiometers to measure the sound level for a variety of noise surveys are from 1926, when Edward Elway Free (1883-1939), Hiram Maxim, and other scientists were hired to measure the sound level of different US cities. Images of such measurements in 1926 are shown in Figure 8.

The meter was even used to judge a comedy competition as the joke which won for the loudest laughter was … *"This joke received the largest unit measurement in audiometer test conducted with 26 topics: Jones: 'Sorry, oh! Man, but my hen got loose and scratched up your garden.' Smith: 'That's all right. My dog ate your hen.' Jones: 'Fine. I just ran over your dog'"* (Key, 1926, p. 7).

The develop of experimental noise meters

Kent E. Wooldridge, a graduate student of the University of Wisconsin, was selected by the Electric Railway Section of the Wisconsin Utilities Association to hold their 1925 fellowship. The subject assigned to him was the study of noise in the operation of electric cars and to make recommendations for reducing the cars noise emissions and vibrations to improve the comfort (Rood & Wooldridge, 1926).

Thomas Howell Laby (1880-1946) from Australia with his assistants, R. O. Cherry and R. Fullon (See Figure 10), and under a request by The Herald newspaper of Melbourne, conducted an amazing noise survey at Melbourne's Cathedral Corner in May 1928: The sound captured by the microphone not only was used to measure the noise levels but also was transmitted nationally by 3LO radio station and recorded on gramophone (this pioneering work will be presented in a future article). Figure 10 shows their measuring system being transported from the university's laboratory to the cathedral as well as one of the several charts that they obtained.

Jean-Fernand Cellerier (1870-1936) from France was the Director of Laboratoire d'Essais du Conservatoire National des Arts et Métiers and in 1931, was responsible for building a laboratory to measure the acoustic properties of materials: absorption, impedance, isolation, etc. In December 1931, Cellerier with his technical team presented a "sonde phonique" to measure the sound levels in cities and this was promoted by the Touring-Club de France. In 1935 they conducted a long-term noise survey in Paris with an improved and portable model of their "sonde phonique," where they measured not only the noise emission produced by automobiles (see Figure 11) but also the noise produced by urban electricity distribution, and street noises in general. Figure 12 presents some pictures of noise surveys conducted by acousticians in different cities.

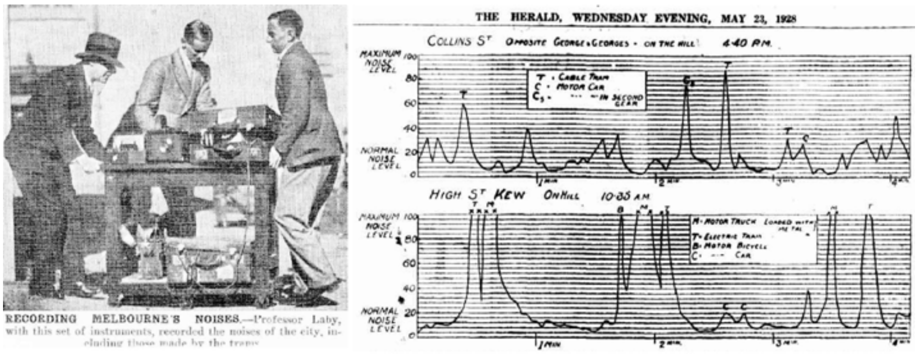


Fig. 10: Prof. Laby (at the center) and his assistants carrying the noise meter, 1928.

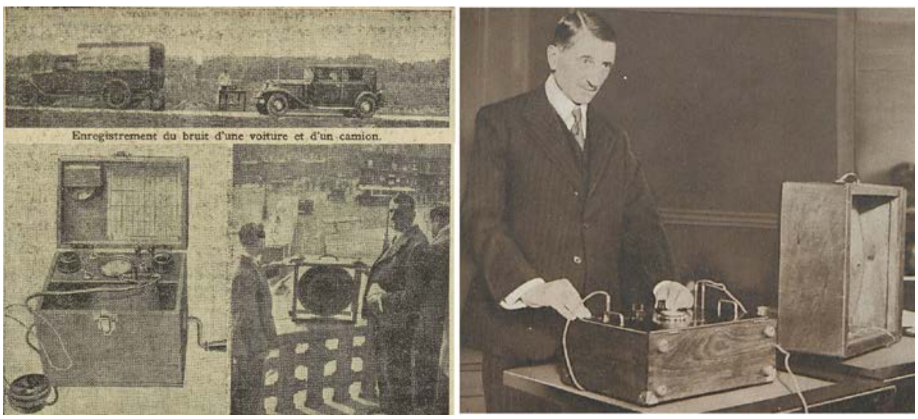


Fig. 11: Cellerier conducting several noise surveys in Paris with his noise meter, 1935.

Fig. 12: Some pictures of different sound surveys.

Acoustic engineer appears in history

The author was captivated as to when the "acoustic engineer" began to be mentioned as a profession, and to date it appears that the first appearance in the media is from 1886 in France. Several articles comment on the work of an "ingénieur acousticien" (acoustic engineer) in developing improvements to a piano (Reyer, 1886), and an 1893 Parisian addresses guide lists to L. Lescuyer as an "ingénieur-acousticien" (Paris, 1893).

As far as could be found to date from searching US newspapers, the first mentions of "acoustic engineers" as a profession was in 1911 and linked to the work of improvements listening in courtrooms of many US cities. Jacob Mazer is the most commonly named as well as Frank E. Morton, who worked for American Steel as an "acoustic engineer." Curiously Morton's discipline comes from being a piano technician.

The new acoustic forensic tool: Sound on films

The first "talkie confession" in the US history of Criminology (and perhaps of the world) took place in a Philadelphia Courtroom in November 1929, just two years after the introduction of films with sound. Director Lemuel R. Schofield, of the Philadelphia Department of Public Safety, developed the idea of using talking motion pictures in a prosecuting case.

Some newspapers in the US (and a few in Europe and Australia) commented on the first confession filmed with sound. Where it did get a lot of coverage was in magazines dedicated to the film industry, and it is there one can find a good explanation of how the recording was technically achieved. Figure 13 show two photographs: one taken from Movie Makers magazine, the other from a Detroit newspaper article *"How film camera and microphone were used to record the self-accused killer's story of his deed"* (Detroit, 1929).

Fig. 13: Pictures in the Courtroom Police witness first "talkie confession," 1929.

The creation of the Acoustical Society of America

The ASA was established in December 1928 and the history is already published (ASA, 2021). The author wondered what media coverage was given to the ASA media at that time. The first mentions that the author was able to find are from March and May 1929 which refers to the first ASA meeting and this news was replicated in dozens of US newspapers. Surprisingly, many of them mention the ASA as an anti-noise group, probably because the most highlighted work in newspapers was Laird's studies on how noise affects people's work productivity and how noise modifies the digestive system functioning.


Quiet May Be More Aggravating Than Loud Noises, Tests Prove

NEW GROUP TO STUDY SOUNDS

Acoustical Society of America to Be Organized.

A temporary organization was formed and a meeting will be in New York April 17 and 18 to establish permanently the Acoustical Society of America. It is proposed that any person interested in acoustics shall be eligible to membership.

REDUCING NOISE MAY AGGRAVATE MAN'S ANNOYANCE

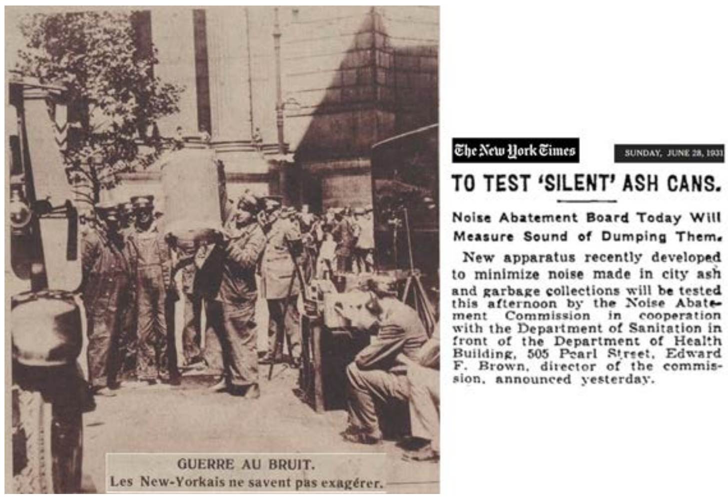
Accoustical Society Finds Pitch Factor; Is Seeking To Combat Deafness

New Acoustical Society Will Attack Problems Of Jazz Age

Fig. 14: ASA first meeting in some US media headlines, 1929.

Abating the New York ash can 'noise evil'

A modified version of Western Electric 2-A audiometer was used in the well-known 1930 New York City noise survey, and as there is much information about this important research and investigation (Thompson, 2002), will be discussed in a later article. One part of that survey focused on identifying the most important urban noise sources. A "silent squadron" was created in July 1930, by the Committee to detect the 'noise evil' (New Britain Herald, 1930), and they undertook a specific investigation on the noise from the ash can and how to diminish it.


GUERRE AU BRUIT.
Les New-Yorkais ne savent pas exagérer.

The New York Times — SUNDAY, JUNE 28, 1931

TO TEST 'SILENT' ASH CANS.

Noise Abatement Board Today Will Measure Sound of Dumping Them.

New apparatus recently developed to minimize noise made in city ash and garbage collections will be tested this afternoon by the Noise Abatement Commission in cooperation with the Department of Sanitation in front of the Department of Health Building, 505 Pearl Street, Edward F. Brown, director of the commission, announced yesterday.

Fig. 15: Picture during ash can noise measurement, 1931.

Different ash can models were proposed and sound level measurements were made as the ash can was banging to the floor. Figure 15 show one picture from "Images" magazine from Cairo, Egypt (Images, 1931; p.2), referring to the New York measurements.

Conclusion

Most of the references in this article are from The Times of London, as well as Australian and US newspapers, because they have a large accessible database. In future years when more historic documents from other countries become freely accessible, maybe this history will be updated. The noise section in the publication of the encyclopedia of the ILO of 1934, written by Carozzi, is possibly the draft that he presented in 1925 as he proposes to use the instruments of that time to analyze the noise in the work places. The update of the encyclopedia written by Caussé in 1938 has the technology that was used at that time, and one of his thoughts was *"It is to be hoped that in the not far distant future the knowledge thus acquired will enable the risk to the worker's health at present arising from industrial noise to be to a large extent reduced, if not entirely eliminated"* (ILO, 1938).

Outside Germany, Barkhausen is more remembered for his research on low level electrical signals and materials magnetic properties (the "magnetic Barkhausen effect" and the "magnetic Barkhausen noise"), than for his contributions to the specialty of sound level measurement. One can only speculate why his noise meter was not used more widely or why his theory on hearing curves after 1939 were not included in the acoustics textbooks.

However this article is a tribute to the memory of I. I. Slavin because of his substantial contributions in the field of human hearing conservation; his scientific research resulted legislation relating to limiting workplace notes that was the first in the world and used as basis for similar legislation in many other countries.

Acknowledgements

The author wishes to thank to Andrea Bauerdorff of Umweltbundesamt from Germany to providing several Barkhausen's papers; to Sonia and Irma of ILO Library; to Iuliia Rassoshenko of the Baltic State Technical University "VOENMEH," for providing information about Slavin; also to Marion Burgess for assisting with the English expression, and to Eoin A. King and the Board of NNI magazine for the opportunity to publish.

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Understanding the Big Picture

Jim Thompson

Often when people ask me what sets people apart in an engineering team, I tell them the ability to see the big picture. They usually ask me what this means. So, I thought it would be good to talk about what I mean by this phrase. Fundamentally, I am talking about the ability to see beyond the current project or work assignment. Ideally, people should be able to see how their work supports the ultimate product and provides value, pleasure, or help to the customer.

However, my definition goes further than this. It is important is to be able to do some things with this understanding. This perspective should allow the individual to assess current practices and procedures and see opportunities for improvement. This person should have the ability to work with others to make improvements and build support for such changes in the organization and/or with clients. Seeing the big picture is more than just seeing. It includes using the knowledge to excel. I am not talking about performing miracles, but I am also not looking for someone who blindly follows instructions doing the minimum possible. I see too many people complaining about how things are but not managing to have the vision and skills to make improvements.

Let me give a couple of examples. In a previous article, I noted how I was able to help to keep my company's tires on a sports car by pointing out to the car's engineers that I could take an on ramp 10 miles per hour faster with our tires compared to the competitors. I could have said my job is noise, and I should not mention this, or the sales engineer should bring this up, not me. However, looking at the big picture, the point was to keep the business, not to worry about roles in my company's organizational chart. In addition, this input only made sense because I knew the business. The competitor's tire was a regular passenger car tire. It was quieter, but it would not perform as well in handling. Pointing out a concrete and easily verifiable example brought this point home to the customer. My input was a reminder that they were comparing apples and oranges, and the two tires were not directly comparable in terms of overall performance.

Another example from my time at the tire company was in the identification of the customer. When first joining the company, I thought the customer was the vehicle driver/owner. I learned that this was not the case for original equipment tires. In this case, tires are tuned for each OE model. This process can take months with tens of different tire designs before a sign-off is received. The final judgement of noise is made by a test driver. They provide a subjective judgement on noise usually using a 10-point scale. Quickly, I realized that the real customer was the OEM test driver. His or her ratings were the critical factor for noise. The big picture view was that this was where our work had to be aimed. If a tire was objectively quieter, it did not matter if the test driver's ratings did not reflect this. The other point was that these test drivers were rating tires on sounds that most customers would never distinguish. One useful result of this understanding was that I had every new noise engineer hired participate on a test drive with our test drivers. All came away having to admit they did not even hear the noises to which the drivers were commenting and rating. At least they could see that in the big picture, the customer was not the vehicle owner. Also, it helped them to respect the subjective capabilities of the test drivers.

In some sense seeing the big picture is the opposite of the silos created in many large enterprises. I have found it may be difficult to have a big picture view in some companies. There is often so much competitiveness between groups, teams, or departments that doing something that may be positive for others can be construed as disloyal. I still remember a particular case where I was trying to do what was best for the company and was told I was being disloyal because my

solution promoted work done by a rival group. So, it does sometimes take courage to have this view and sometimes you must be diplomatic in how you express this viewpoint.

Another consideration is that some people do not want to see the bigger picture. Many would rather just focus on what they are doing - their little piece of the world. To me it seems like such common sense to want to see how the parts fit together and how you can take a much larger role. As the old saying goes “the only problem with common sense is that nobody has it”. Unfortunately, my experience has shown that a lot of engineers do not see beyond the current technical problem. They want to stick to their defined engineering role and avoid getting involved in the larger context. While there is nothing wrong with this approach, it is going to limit career opportunities and their ability to contribute. Maybe more importantly, it is going to limit their opportunities to grow and learn. I have found that people who are happy in their work are those who have taken on different roles and challenged themselves to do different things. These challenges may be purely technical, but they involve seeing how developing other technical skills – expanding their technical scope can be helpful to the company and or product. These are the people who have a sense of belonging and contributing to the organization, the product, or the world.

Maybe it is helpful to give a concrete example. When I first went to work for the large tire company, the results of noise tests of tire development candidates consisted of a series of spectral plots with comments about tire A being noisier than tire B in particular frequency ranges. After I had been there a bit, I asked one of the tire development chief engineers how they used these reports. He started laughing and said he just looked at the last page to see which tire was best. I asked about the spectral plots and the differences at defined frequencies, and he said you mean the squiggly lines and the Hertz things? Clearly, most of the content in these reports was useless to the immediate customer.

I talked with the engineers in the group and their attitude was that this was the product development engineers’ problem. Later, I learned this was a common problem in larger organizations – silos. People become detached from the end goal and just want to pass the problem on to the next group or silo.

I spent a lot of time working on a better report format. Using historical data and talking to the tire designers and test drivers, I came up with some categories for tire noise that correlated with frequency ranges, tire subjective evaluation terms, and areas of concern to tire designers. Using these categories, tire designers could see where to improve the design and they could relate the test results to subjective test comments. The tire designers really liked the new format and with discussions about how different categories related to aspects of tire design, we all were more effective in improving tire noise performance. For the first time, I could look at the data and tell a tire designer these are the types of changes that would be effective in improving the noise performance.

To my surprise, some of the engineers in the acoustics group did not like this approach. I got comments like: “The spectral plots have a lot more information in them”, “I don’t want to dumb down my reports”, or “Why should I be doing the tire designers job for him”. Some of these people could not or would not see the big picture. Over the long term these people became more unhappy and left or were let go. Those that embraced this idea and took it much farther became leaders and enjoyed great success in the organization.

I know this is a simple example and the interplay between groups and responsibilities in organizations can be complex. However, I have found the more you see the big picture the more you will be able to contribute and the more your contributions will be recognized. Knowing how the product is made, the major product problems, why this customer likes this or that aspect of the product, etc. may not impact what you do day to day, but it may provide opportunities and perspectives that change your whole career.

So, I always look for people who understand or are trying to understand the big picture. These are the people who will excel, and who will make the right decisions at critical points. I wish I could define this quality better. It is more than being curious. This curiosity must be combined with the skills to utilize the wider knowledge. One way of looking at it is the combination of curiosity, intelligence, and people skills to build an understanding of the wider enterprise/world and how the pieces fit together. There is also the need to have the perspective or maturity to understand how to provide useful input without offending others. Finally, those who see the big picture can use their understanding and skills in decision making to help make the product and system better and the customer happier.

Getting to Know You: Jian Kang, keynote speaker at INTER-NOISE 2021

Quick Stats

Name: Jian Kang

Title: Professor of Acoustics, University College London

Location: London, UK

Years with I-INCE: I have been with I-INCE since I attended the internoise 1987 in Beijing.

Born & Raised: I was born in Shanxi, China in 1964, and raised there until 1979, when I went to University in Beijing.

Education: Bachelor and master degrees from Tsinghua University in China, and PhD from the University of Cambridge in the UK.

Favorite musical group/artist/genre: Holst: Jupiter from the Planets

Favorite pastime/hobby: Hiking, and now also gardening

Job/Career

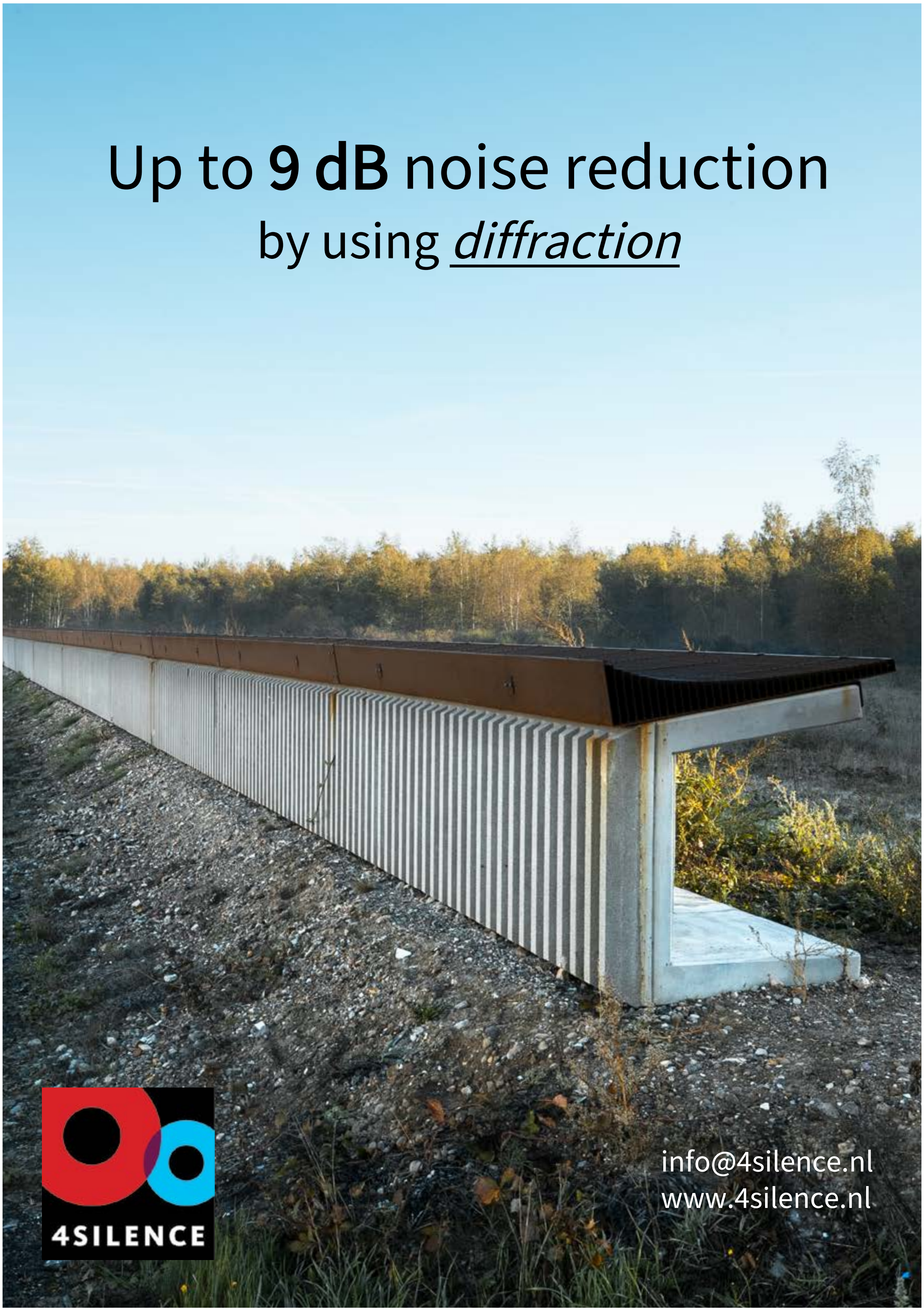
What is the most important part of your job?
Linking research to practice and making real world impact. When carrying out research, I always ask myself and my research students: after this research, what can we tell the practitioners, to help them to do the practical work better?

What's the best part about working with I-INCE?
It is a great platform for researchers and practitioners to communicate with each other.

What do you want people to know about I-INCE?
I-INCE is not only for engineers, but also for people in many other related disciplines and fields, including architecture, ecology, design, human geography, landscape, law, medicine, psychology, sociology, and urban planning. With multi-disciplinary approaches, we can make our sound environment better. Soundscape research and practice is an example, which focuses on perceived sound environment, and promotes the effects of wanted sounds while reduces the effects of unwanted sounds in a harmonic way.

As a child, what did you want to be when you grew up?
Be a teacher.

Best book you've read recently or movie you've seen recently?
Leo Beranek' autobiography, Riding the Waves: a life in sound, science, and industry. When I was asked to review this book by Acoustics Bulletin, I was immediately interested in the book, by his extraordinary achievements outside acoustics, and his enjoyable and healthy life.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Custom Noise Barrier – Dennis Johnston Park

A Durisol Case Study

Durisol was first approached back in March of 2015 to find out how they could work to protect Dennis Johnston Park in Spring, Texas from highway noise from the newly built Grand Parkway which will be the longest beltway loop in the U.S. once completed. One area of the park, the Big Stone Lodge was exposed to the new northbound entrance ramp onto the Grand Parkway.

The park is named after Dennis Johnston, who holds his office is at the park, and the park is a favorite of the Harris County Commissioner. When the Harris County Toll Road Authority announced the new entrance ramp just on the edge of the parking lot of the Big Stone Lodge, the commissioner set out to make sure that the wall would not be detrimental to the park.

He contacted a well-known Houston Area Landscape Architect, Merrie Talley. The commissioner asked that the noise wall be attractive and to "push the science of noise walls" for this project. They were very interested in both absorptive Durisol and SoundStop for their "out of the box" appeal.

Many design renditions came over the next 2 years during the design of the noise barrier system (see figure 1). The goal was to have a unique design that reflected the essence of the park, incorporating the landscape design and custom lighting.

Durisol worked very closely with Merrie Talley to turn concepts into buildable designs, convincing the HCTRA that Durisol was a company with a long history in the noise barrier industry backed with well established products and published test data.

After many meetings and conversations between Durisol, Talley Landscape Architects & HCTRA, a design was finally emerging. The ground mount section would be 18 ft tall, 14 ft absorptive Durisol panels with 4 ft of SoundStop on top. The absorptive Durisol section would have a custom deer mural on the park side and no pattern on the highway side. The SoundStop would have a 'satin ice' color and would be lit by LEDs (see figure 2). The elevated Entrance Ramp section would have 4 ft tall SoundStop mounted to a concrete traffic barrier.

Customer & Owner
Harris County Toll Road Authority

Contractor & Installer
Texas Wall and Landscape

Engineer
Klotz

Landscape Architect
Talley Landscape Architects

Location
Spring, Texas

Absorptive Wall Area (ft2)
8,285

Transparent Wall Area (ft2)
1,884

Figure 1: Design rendering of deer mural

Figure 2: LED lighting

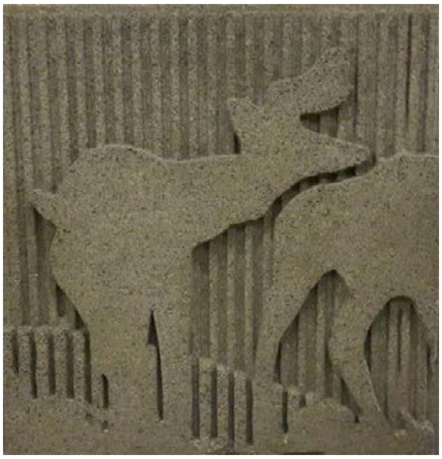

Figure 3: Deer mural sample.

Figure 4: Finished installation.

As Klotz engineering created initial drawings for the project, Durisol worked with them and HCTRA to create specifications for the project. It was determined that there would be a completely custom deer mural shown with detail and depth on the absorptive Durisol panels. Durisol produced a sample from the original artwork created by Merrie Talley for approval in 2017 (see figure 3).

Innovative Lighting was contacted to supply all the LED lighting for this project at Dennis Johnston Park. They had previously completed a very large project in downtown Dallas that involves animating the entire exterior of the Omni hotel, making them a good fit for this project.

In the spring of 2017, the project was awarded to Texas Wall & Landscape. Following the award, Durisol started working with the Merrie Talley to finalize a design for the deer mural panels.

There were very exact and detailed ideas of what was wanted for these panels, and Durisol was up to the challenge to design the moulds and eventually cast the panels.

Production then followed soon after a final rendition of the deer mural panels were approved by all parties involved. Durisol supplied all the custom deer panels, SoundStop transparent sheets, and the fabricated painted steel posts. Installation started in the summer of 2018.

Durisol was actively involved throughout the entire process of this project, from concept to completion. Durisol assisted with various aspects of the project such as engineering, design, renderings and custom product samples. Durisol was very happy and eager to work with everyone involved offering the client a turn-key operation.

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December 6–10, 2021
181st Meeting of the Acoustical Society of America joint with WESPAC 2021 and the Australian Acoustical Society
Seattle, Washington
acousticalsociety.org/asa-meetings/

June 13–15, 2022
Noise-Con 2022
Lexington KY, USA

August 21–24, 2022
Inter-Noise 2022
Scottish Event Campus
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Information on listings in the Directory of Noise Control Services is available from the INCE-USA Business Office, 11130 Sunrise Valley Dr., Suite 350, Reston, VA 20191-4371 Telephone: +1.703.437.4073 email: ibo@inceusa.org.

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