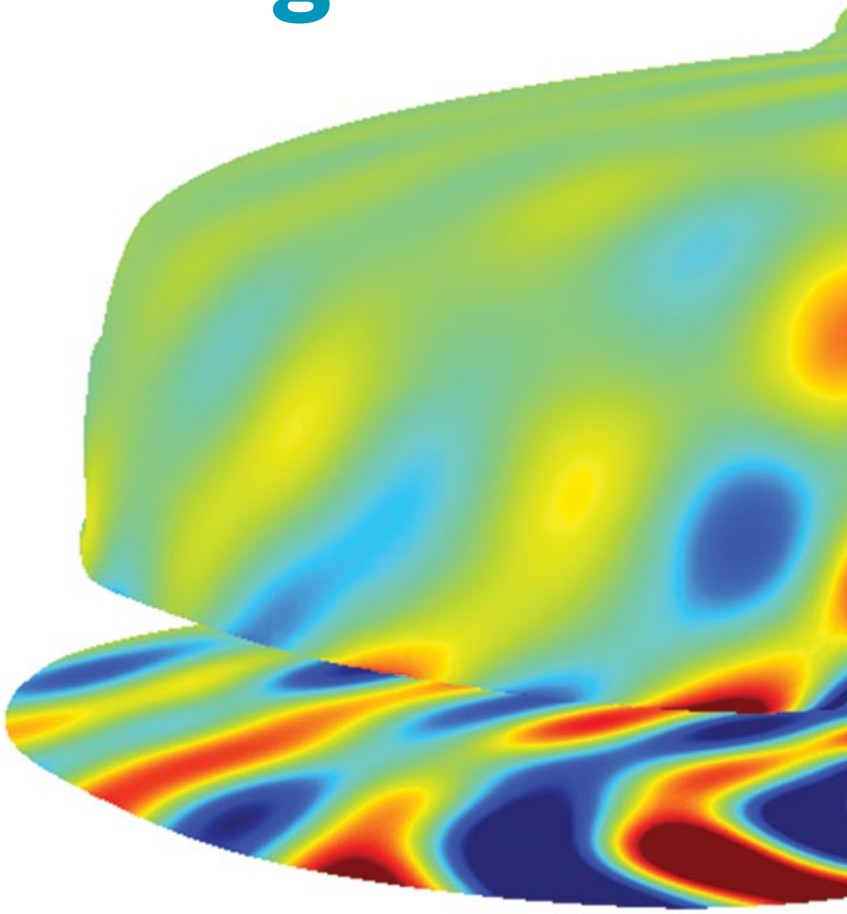
Introducing Hexagon's Acoustics Centre of Excellence



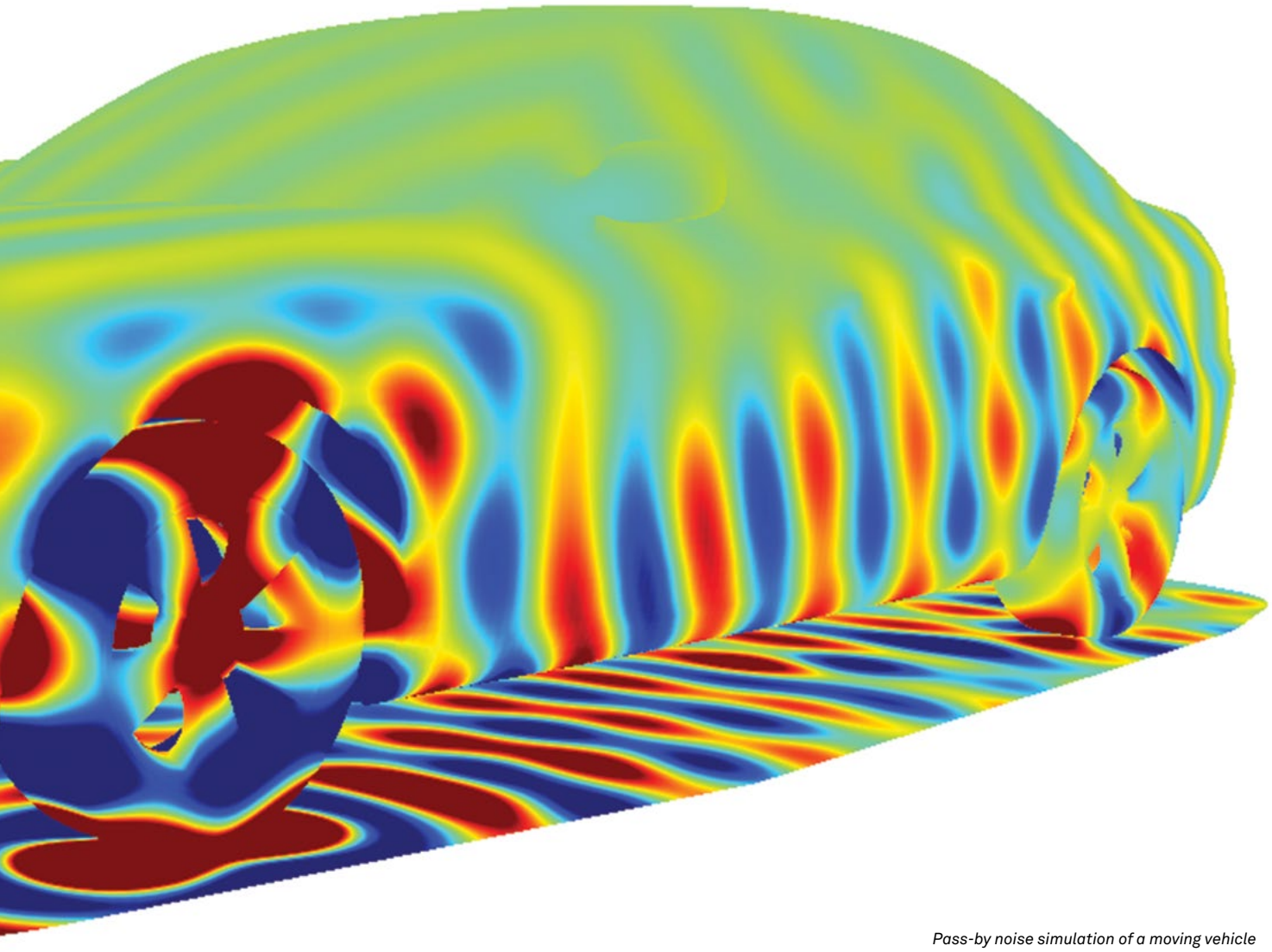
Delivering state-of-the-art acoustic simulation for a quieter, better-sounding world

By Jonathan Jacqmot, Head of Acoustics CoE, Design and Engineering business unit, Hexagon's Manufacturing Intelligence division

Noise is affecting everyone in their day-to-day life. From noise within our homes and offices, to noise from cars on the streets or aircraft flying above us, noise has a significant impact on our health and well-being. On the other hand, sounds such as music and speech allow us to communicate, evoke emotions and experience our world. Physically, both sound and noise are pressure waves which our ears have evolved to capture on a large frequency spectrum with a fine resolution. Whether they evoke positive emotions (sound) or stress (noise) depends on our perception but engineers in general want to enhance sound performance and reduce noise. From a sound perspective, CAE simulation enables engineers to optimise their product's performance and provide an unparalleled experience to listeners with fuller, clearer sound. From a noise perspective, while not a lot of attention was given to noise pollution in previous decades it is now considered as a major factor in social, environmental, and manufacturing sustainability. As our cities and industrial facilities get bigger, denser, and more complex, noise pollution becomes critical to the quality of life of many inhabitants.

CAE simulation is one of the main tools used to improve acoustic performance for vehicles, airplanes, and other noise generating industries to help build a quiet, pleasant, and sustainable environment.

Acoustic simulation, unlike structures simulation or computational fluid dynamics (CFD) was not widely used in industrial contexts until the late 90s. The predominant technology of the time was based on boundary elements; a method that required large computational resources to tackle industrial-size problems. This



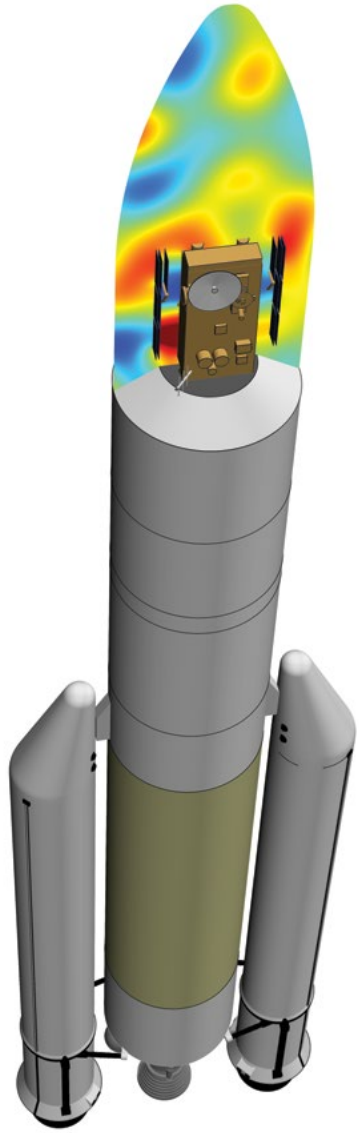
Pass-by noise simulation of a moving vehicle

methodology suffered stability issues while lacking capabilities for modelling important effects such as convection. This gap was identified by the original founders of Free Field Technologies, Jean-Louis Migeot and Jean-Pierre Coyette, professors at Université Libre de Bruxelles and Université Catholique de Louvain respectively, started the company in an attic at Louvain-la-Neuve, a small university city in the heart of Belgium.

With their past experiences in acoustic numerical simulations, they selected a completely different approach by implementing their solution based on a finite element framework. The access to efficient 3D meshing tools significantly improved in the past two decades and their implementation of acoustic infinite elements – an highly innovative way to solve free field conditions – was the key to convince large companies to create a consortium to fund their software under development. The consortium was defined by 10 companies, leaders in the aerospace, automotive, glass, chemical and shipbuilding sectors starved of more accurate and more efficient acoustic simulation software.

The result of this consortium, Actran, is now used by hundreds of companies across the globe for creating products that not only make the world around us quieter but also more pleasant sounding.

With the acquisition of Free Field Technologies by MSC Software in 2011 and the subsequent acquisition by Hexagon in 2017, Free Field Technologies is reorganised into the Acoustics Centre of Excellence (CoE) inside the Design and Engineering business unit of Hexagon's Manufacturing Intelligence division. The new centre of excellence



Vibroacoustic analysis of rocket launcher payload

structure allows each CoE to focus on their key strengths to develop and deliver innovative multi-physics simulation technologies. This reorganisation further enables each CoE to solve end-to-end challenges in particular industries and work toward a common goal. Hexagon provides customers with comprehensive solutions to the industry's biggest challenges facing modern manufacturing and digital transformations in the coming century.

The Acoustics CoE is one of seven in the Design and Engineering unit; focusing on delivering world-class acoustic and NVH simulation that enables engineers across various disciplines to build quieter and better-sounding products. Working together with the other CoE teams in integrating acoustic solutions within their products have allowed a combined leveraging of tools such as the Romax Spectrum or Adams2Actran workflows for powertrain and system dynamics NVH analysis. Additional workflows such as Nastran PEM for the inclusion of poroelastic material for trimmed body simulation and scFLOW to Actran for streamlined aeroacoustics simulation further demonstrate the benefits of these relationships. The Acoustics CoE is operating across the automotive, aerospace, renewable, space, machinery, electronics and consumer products industries, aiming to empower the best companies in the market to conduct CAE-led design, development, and optimisation of their complex products. Leveraging on the best software solutions, the expert team of the CoE is supporting many research and development programs directly inside many companies not yet familiar with acoustic simulation but also in funded large scale programs with dozens of participants.

A culture of innovation

Since its beginning in the late 90s, the Acoustics CoE has been driven by a culture of innovation. From the finite element method used as an efficient radiation condition or Actran for trimmed body for faster and more accurate evaluation of trim performance to the pellicular mode formulation, the acoustic team has always strived to solve the most advanced industrial problems with novel methods, going along with the most renowned industrial experts. The development of these methods allowed the solution to be applicable in new industries, help more companies and tackle new challenges that seemed impossible before. Actran has evolved from solving acoustic transparency problems to becoming the premier acoustic simulation software suite. Solutions for acoustics, vibroacoustics and aeroacoustics have been brought together, supplemented by an intuitive graphical user interface and powerful solver implementation. Actran is the standard tool in the automotive industry – currently being used by 18 out of the top 20 major automotive OEMs – and aerospace industry – considered the de facto standard for simulating aircraft engine noise, as well as being the reference for aeroacoustic simulation.

The human auditory spectrum ranges from 20 Hz to 20,000 Hz. Reaching the high end of this spectrum has always presented a challenge for acoustic simulation, especially in the context of the finite element method. This is due to the discretisation required to accurately model these frequencies which makes simulation mostly unfeasible. While for most adults the maximum audible frequency decreases with age, designers are interested in the theoretical limit and strive to achieve high performance at these very high frequencies.
The standard approaches used for acoustic simulation have historically been unable to overcome such a challenge and it is time to explore new methods and technologies. For acoustic propagation of pressure waves through air, the DGM method offers an efficient and scalable solution. Utilising high order elements and bringing the number of degrees of freedom to the order of billions, the DGM approach is able to produce results and insights within a few hours. For vibroacoustic NVH models where the structure vibration must be considered as part of the problem, the Actran SEA approach allows to refactor existing finite element models and extend them to higher frequencies. This has enabled the automotive and space industries to consider not only the low frequency spectrum but also to push the envelope to consider higher frequencies that could lead to better acoustic performance and/or vibration comfort for passengers. The innovations in the methods and technologies are not the only reason why these challenges are now within the engineers' reach. By taking advantage of the increase in computing power of modern CPUs and optimised solvers, larger models in size and frequency can be solved faster. Such time savings result in shorter turnaround times and reducing the cost of product development, enabling more iterations and resulting

in better optimised products. Further to the advances in modern processors GPUs have emerged as the next big enabler of computational gains in large physical simulation systems. Complex computing tasks can be subdivided and distributed across very large numbers of computing units efficiently. GPU computing has already been implemented in Actran DGM since 2016, making Actran the only code utilising GPU acceleration for acoustic simulation. GPU acceleration is now available in a much wider part of the Actran capabilities.

Acoustic simulation is not only about reaching higher frequencies and tackling larger models, but also about providing tools that can help designers and engineers find out what the problem is, where it originates and how to mitigate it. Acoustic measurements tend to focus only on what the sound or noise is at one location (or microphone) and thus they do not provide easy or affordable ways of identifying the issue and providing insights about what can be done to mitigate it. Furthermore, they tend to be expensive to perform requiring highly specialised equipment, the presence of a prototype and the use of specialised test chamber such as an anechoic room. Acoustic simulation can provide an affordable way to evaluate noise issues early in the design process, provide direction as to where an intervention is needed and quickly iterate through design changes to identify the best mitigation solution. It allows engineers to make informed engineering decisions early in the process and produce higher quality, innovative products at shortened development times and ultimately at reduced cost.

A vision of sound

Besides the culture of innovation which characterises the centre of excellence, the development focus has always placed the final user at the centre of attention to make sure Actran solution is developed towards the needs of industry. Thanks to this close collaboration between users and developers, a vision has been created for the next few years and rests on three pillars: to enable engineers to simulate increasingly complex models faster; to democratise acoustic simulation by making it accessible to everyone; and to build a simulation ecosystem which allows for a connection between the virtual world and the physical world.

Standing on the first pillar is the ability to model more complex physics by developing, implementing and industrialising methods that push the envelope of what is currently possible in acoustic simulation. In recent years, we have industrialised Actran SEA for high frequency NVH, implemented new methods for tyre noise and fan noise in addition to new capabilities in turbomachinery and combustion noise. At the same time, the CoE has participated with industry partners to develop numerous publications which showcase ground-breaking methods such as machine learning for real-time simulation. The goal of this research is to empower non-specialised individuals to take informed decisions earlier in the design process without the need to learn new tools.

The second pillar is the democratisation of acoustic simulation. Simulation in general remains an expert tool requiring training, not only for using the different physical models but also for operating the graphical user interface. Our goal is to make acoustic simulation accessible to everyone by developing a modern visual interface, supported by state-of-the-art technologies with the best user experience in mind. This is further complemented by creating better, clearer documentation which can be understood by newcomers and acoustic experts alike and by

Listen to the sound of your product before it's even built

making our wealth of knowledge available to all engineers. Guidelines are created from our experience and demonstration cases are continuously being developed which help engineers start solving a new application easily and accurately. Furthermore, vertical solutions such as specialised wizards and workflows have been developed and implemented to provide the expert users the flexibility to create their own custom solutions; fitting the needs of their team and organisation. The future also holds more automation in the creation of models as well as a more unified platform for all the simulation steps; from generating the model to post-processing the simulation results.

On the third and final pillar, the centre of excellence is striving to build an ecosystem that connects the virtual, simulation world with the physical world. As part of Hexagon, we are uniquely positioned to enhance Hexagon's vision of a complete digital thread that follows a product through its complete lifecycle; even into recycling in the emerging circular economy of the 21st century. Further to that, we are investing in augmented and virtual reality technologies that will allow engineers to not only see how much noise their product will produce through a spectrum, but to also experience their product's acoustic signature by listening to the sound generated by the simulation and view the acoustic field. This immersion will aid the user's understanding of where changes are required to decrease the noise generated.

By following this vision, our goal is to empower every engineer with ground-breaking acoustic simulation to design a quieter and more sustainable world.

Opening up to the future

With acoustic simulation, it is easy to evaluate different fundamental noise sources. For more complex environments the excitation is most often simulated in a different platform such as structural vibration, fluid flow, multibody dynamics and non-linear dynamics. As such, we have over the years built strong connections with the six other CoE groups, including synergies with the Structures CoE for structural vibration with Nastran and non-linear dynamics with Marc, with the System Dynamics CoE for multibody dynamics simulation with Adams and powertrain dynamics simulation with Romax and with the Computational Fluid Dynamics CoE on aerodynamic simulation, among others.

In the CoE we pride ourselves on strong multi-fidelity, multi-physics workflows that often feature products from other class-leading technologies under the Hexagon umbrella. We are looking to expand our links to other areas of Hexagon as well that have enormous amounts of sensor and software technologies built up over the last 20 years.

Beyond Hexagon, the Acoustics CoE has been nurturing a powerful open partner ecosystem for many years. From the beginning of the consortium, a large number of partners has been involved in the development and the promotion of Actran. A non-exhaustive list would include academic institutions, acoustic measurement companies and acoustic treatment manufacturers such as Autoneum and Hottinger, Brüel & Kjær, among others. Furthermore, over the years, the number of interfaces to other software has always grown with all the leading FEA and CFD software packages, counting up to more than 30 interfaces and file formats, which has provided a great benefit to our customers, who can enjoy seamless workflows and integrated processes between the very best specialist tools available. It is also tremendously beneficial to us, as we tap into the very best knowledge and embedded expertise that the market has to offer and expand our own solutions.

Looking into the future, we are in the process of establishing further collaborations and partnerships and reinforcing our solutions for tackling large-scale future challenges such as urban air mobility, electric vehicle NVH and safer space launches.

We're very excited to be embarking on this the next chapter of our journey with you and cannot wait to explore how we can work together to further improve the landscape of engineered systems and create CAE for smart manufacturing and a more sustainable future for us all.

Jonathan Jacqmot holds a mechanical engineering degree (equivalent to MSc) from Université Libre de Bruxelles (Belgium).

Jonathan has 15 years of experience in acoustic CAE with Free Field Technologies (FFT Hexagon). At the beginning of his career, he performed a 1-year assignment on-site at Airbus Acoustic department as NVH CAE consultant.

Over his career, Jonathan evolved from application engineer position to project manager and then to technical manager responsible for all engineering and support operations at FFT. He is now the head of the Acoustics Centre of Excellence of Hexagon's Manufacturing Intelligence division.