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Acoustics and NVH case studies



Automotive

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Intake manifold noise

Actran Japan User Meeting 2011, Study of the Noise radiated by an Intake Manifold, Hiroyuki Abe

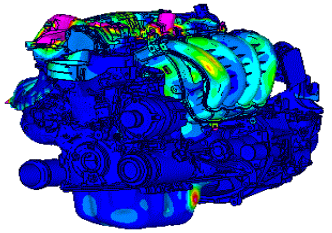
Challenge

- A new resin material used to reduce weight and the fuel consumption leads to a decrease of the acoustic performance of the intake manifold.

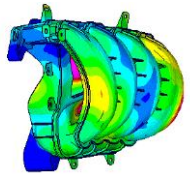


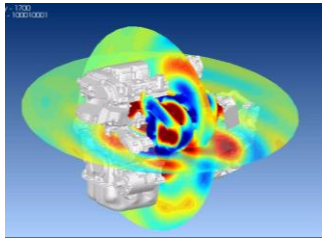
Solution

- Integration of Actran coupled to MSC Nastran in the design cycle to predict the radiation of the manifold. Structure was rigidified by stiffeners to reduce noise radiation



Vibration with Nastran

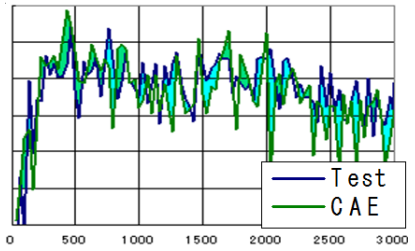




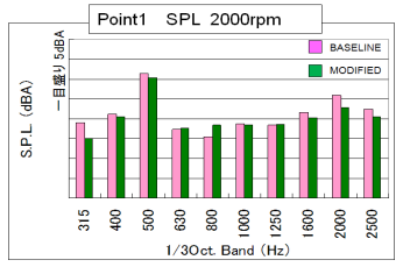
Acoustic Radiation with Actran

Benefits

- Very good correlation with tests.
- Contribution to the definition of new designs with an important noise reduction compared to the baseline.



Radiated noise – dBA Actran Vs tests



Design Improvement – SPL Reduction

BorgWarner

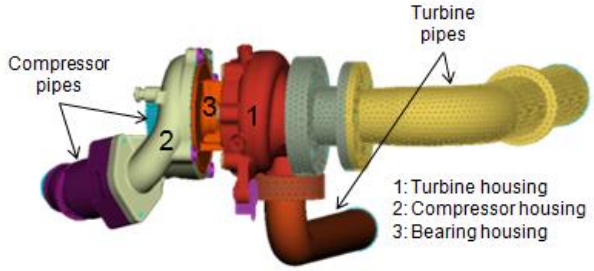
Turbocharger whistling noise

Aachen Acoustics Colloquium 2013, Investigation of turbocharger structure borne noise using multi-disciplinary strategy, Xavier Robin, Nicolas Driot

Internoise 2013, Vibro-acoustic simulation of automotive turbochargers using a finite and infinite element technique, Xavier Robin, Nicolas Driot

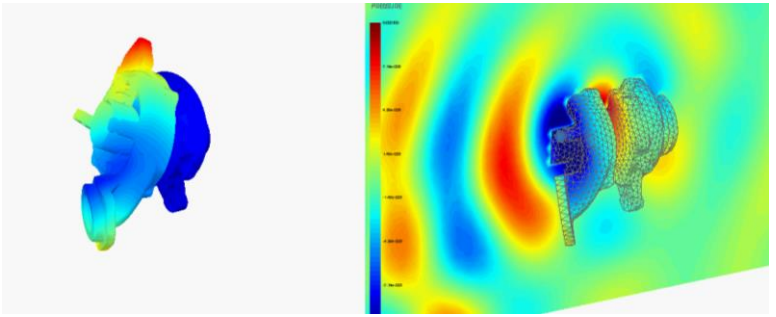
Challenge

- Noise generation in turbochargers is an important source of inconvenience in modern vehicle. The simulation can help to reduce the development time.



Solution

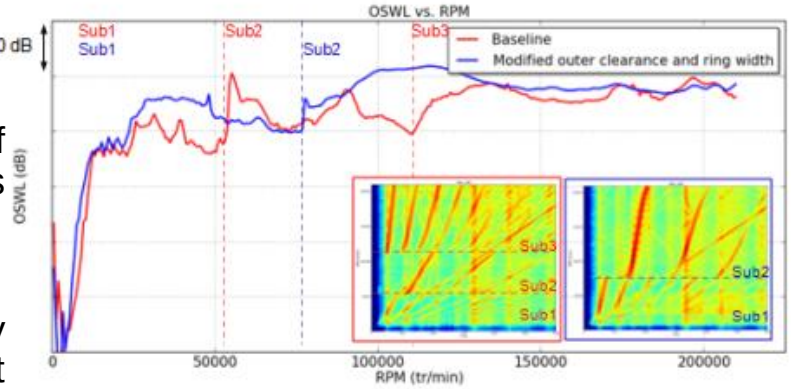
- A simulation chain consisting of Adams, Nastran and Actran was used to analyze the structure borne noise such as the whistling noise from the turbocharger



Benefits

- The established simulation chain allows investigation of noise issues at an early product development phase, thus avoiding expensive prototypes.

- Additional insight is provided by the acoustic simulation by identifying that the most vibrating modes are not the most emitting ones (radiation efficiency).



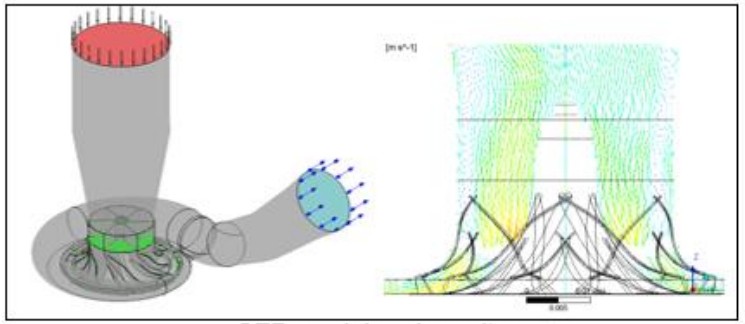
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Turbocharger aeroacoustic noise

FFT Acoustic Conference 2014, Vibro Acoustic and Aero Acoustic of Passenger Car Turbochargers, Xavier Robin, Nicolas Driot

Challenge

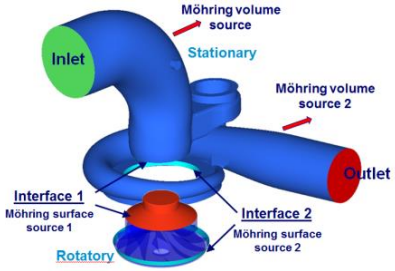
- Aeroacoustic sources and noise propagation are important for turbochargers, but experiments can only identify noise issues and do not provide additional insight on the modifications needed: How can we model the aeroacoustic performance of a turbocharger?



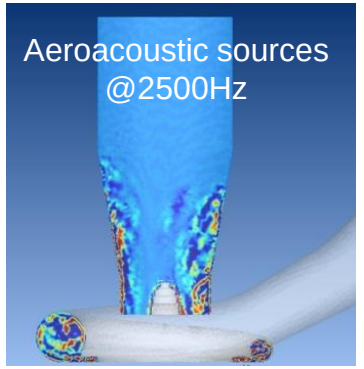
CFD model and results

Solution

- Actran is used to read the unsteady CFD flow information to generate aeroacoustic sources.
- Actran then propagates the computed sources within the turbocharger ducts and on the outside through a vibroacoustic analysis

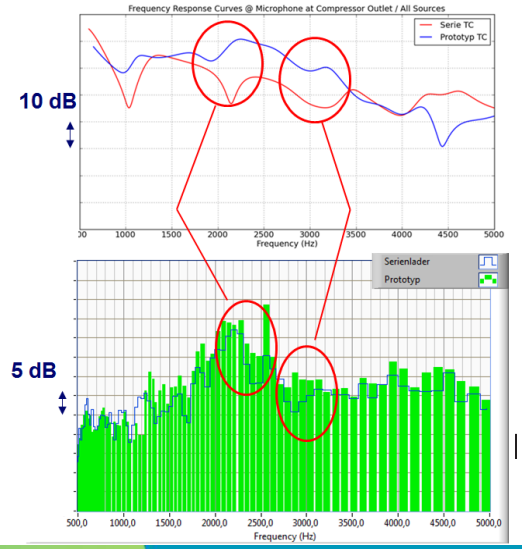


Actran model



Benefits

- The aeroacoustic noise issues of the new prototypes have been identified using an aero-vibro-acoustic simulation which allows to perform virtual prototyping accounting for aeroacoustic phenomena.



PLASTIC OMNIUM

Rear floor acoustic insulation

FFT Acoustic Simulation Conference 2012, Acoustic insulation of steel & thermoset panel, Benjamin Surowiec & Philippe Gilotte, Plastic Omnium

Challenge

- Evaluate road noise transmission at 90 kph on rear floor: the airborne as well as the structure-borne noise must be taken into account.

Solution

- Actran is used to compute the noise radiated by the rear floor for 2 excitations: forces at mounting points of the shock absorbers, a diffuse sound field below the rear floor. The Nastran structural model is imported in Actran.

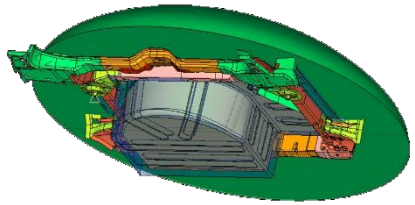
Benefits

- The simulation helps understand how the rear floor design performs. The structure-borne noise is a significant source below 200Hz. A better insulation is obtained with the steel floor.



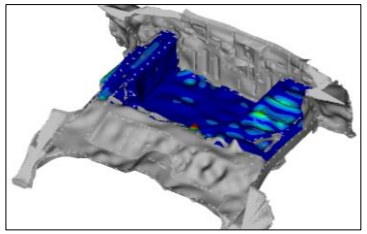
Acoustic (left) and structural (bottom) excitations

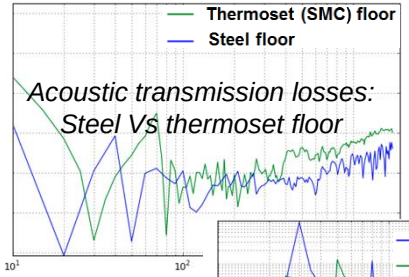




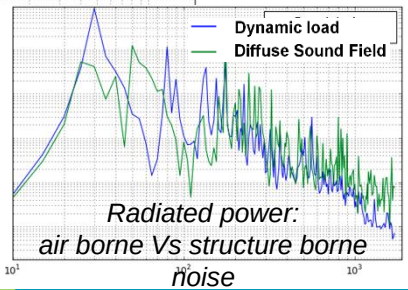
Actran vibro-acoustic model

Rear floor vibrations @590Hz





Acoustic transmission losses: Steel Vs thermoset floor



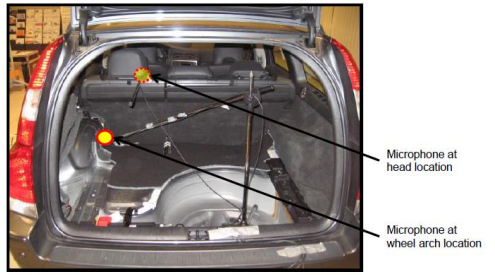
Radiated power: air borne Vs structure borne noise

Wheel arch acoustic treatment

FFT Acoustic Simulation Conference 2014, Road Noise Radiation Outside and Inside a Vehicle, B. Surowiec and P. Gilotte, Plastic Omnium

Challenge

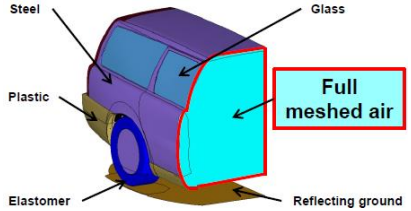
- Vehicles need to meet more and more stringent regulations for pass-by noise.
- Tire noise is one of the most prominent contributors to the noise and adding treatments to the wheel arches can be considered as a means of noise reduction.



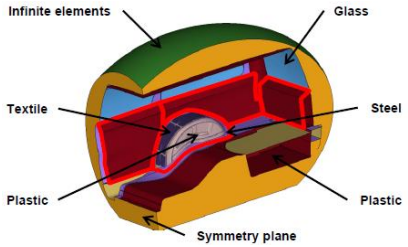


Solution

- Actran is used to study the tire noise propagation and absorption by the acoustic trim components.

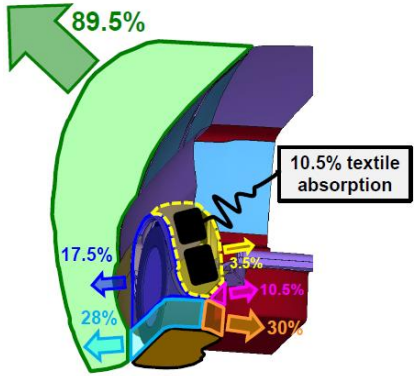


Actran vibro-acoustic model



Benefits

- The textile can reduce the noise in the wheel envelop by 6dB, and absorbs 10% of the acoustic power

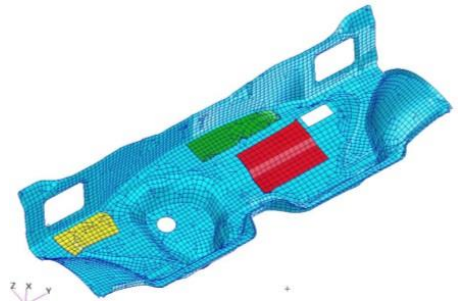


Power balance at 850Hz

Dashboard panel insulation performance

Challenge

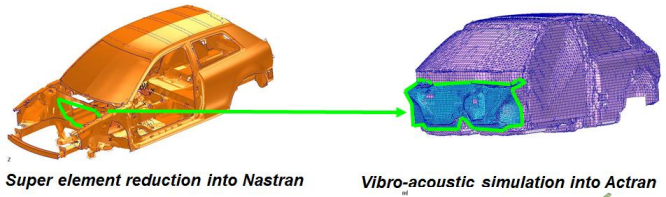
- Estimation of the acoustic insulation capabilities of the dash panel with and without trim materials.



Dash panel with treatments

Solution

- Actran is used for modeling the dash panel, by taking into account its real geometry and including acoustic treatments.
- Nastran SuperElements are used to take into account the effect of the full car structure. A diffuse sound field excitation is applied to obtain the dash panel transmission loss as well as the noise inside the cabin.

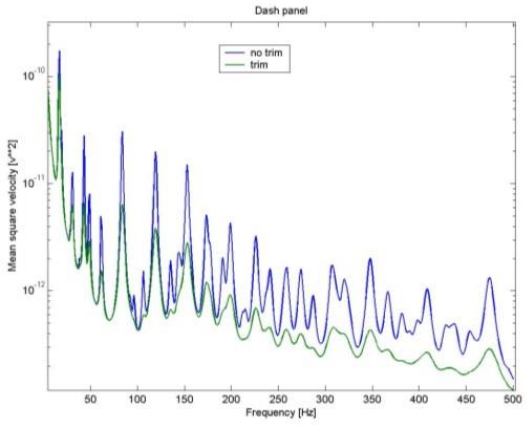




Dash vibration at 28 Hz *Dash vibration at 135 Hz*

Benefits

- Nastran and Actran co-simulations allow to accurately model the case by taking into account the full car structure. Actran considers the real geometry and acoustic treatment's thickness variations.



Dynamic response with and without treatments

Visteon

Air conditioning noise prediction

SAE International conference 2009, AeroAcoustic predictions of automotive instrument panel ducts, J. Manera et al.

Challenge

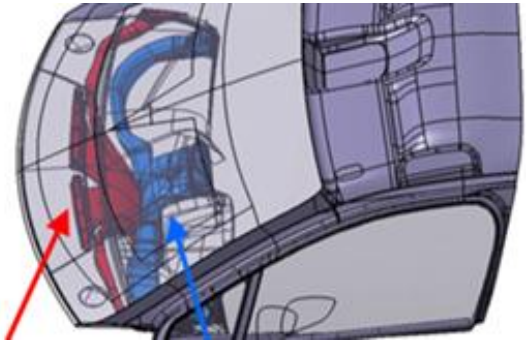
- The noise generated by automotive climate control systems is today emerging as one of the main noise sources in a vehicle interior.
- The origin of the noise is mainly aeroacoustic, meaning that the air flow generates noise

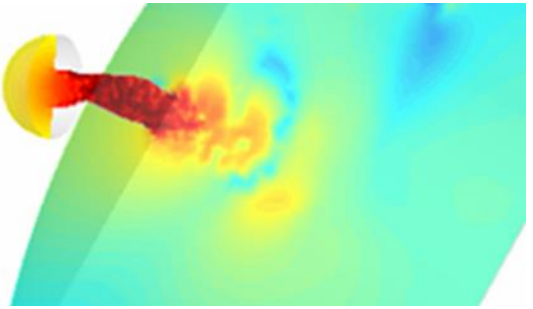
Solution

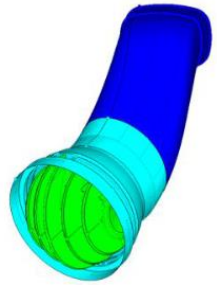
- Actran has been coupled to an unsteady CFD simulation to predict the noise radiated by 3 configurations: a central duct with and without register and a lateral duct.

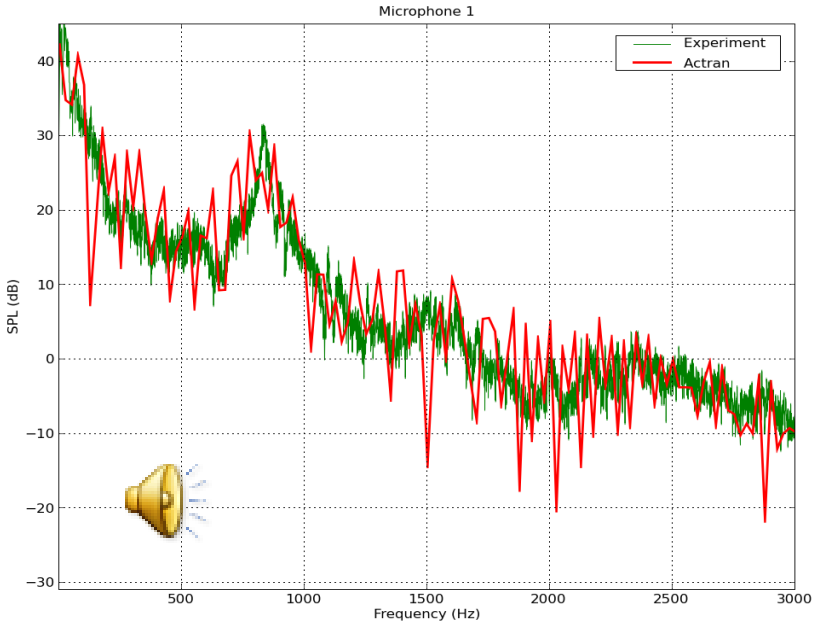
Benefits

- CFD being separated from the acoustic computations, it allows reusing one CFD for many different acoustic computations.
- It is possible to hear the simulation by means of wav files to understand the acoustic quality of a design.









Side windows and windshield wind noise

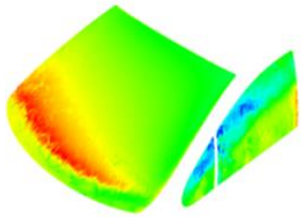
ISNVH conference 2012, Vibro-Acoustic Simulation of Side Windows and Windshield Excited by Realistic CFD Turbulent Flows Including Car Cavity, François Vanherpe , Jonathan Jacqmot

Challenge

- Interior noise due to the exterior aerodynamic field is an emerging topic in the acoustic design of a car. Final objective: improving the products design by reducing this noise source.



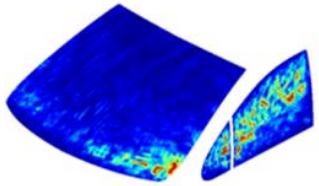
Flow configuration yaw angle = 10°



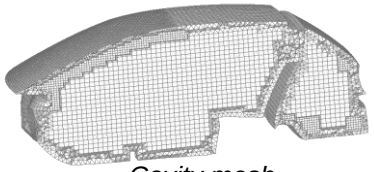
Aerodynamic load on windshield and windows

Solution

- Actran reads the pressure fluctuation on windows from compressible CFD results. The noise is propagated through a 3-layer windshield and side windows with seals to obtain the pressure at driver's ears.



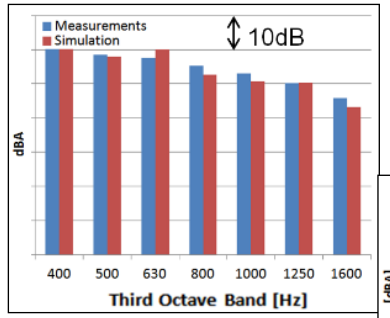
Pressure fluctuation on windshield and windows



Cavity mesh

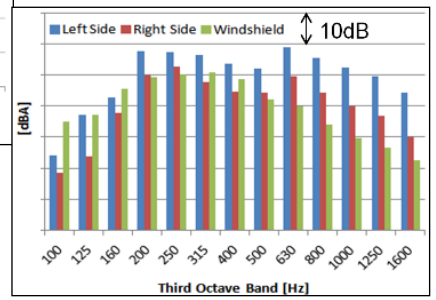
Benefits

- Very good correlation with measurements up to 1.6kHz. Set up of an efficient methodology to predict the noise transmission through windows.



Mean square pressure in the car cavity yaw angle = 10°

Noise at driver's ear Yaw angle = 0°



Wind noise into cabin

SAE N&V Conference 2015, Numerical Simulation of Noise Transmission from A-pillar Induced Turbulence into a Simplified Car Cabin, B. Ganty, J. Jacqmot, Z. Zhou, C.H. Jeong

Challenge

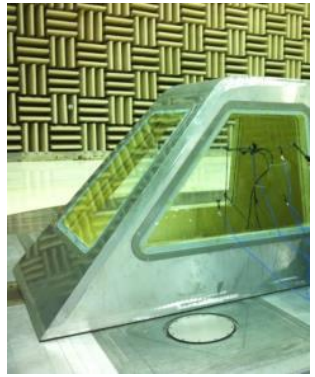
- Prediction of the noise transmission from A-pillar induced turbulent flow into inner cabin.

Solution

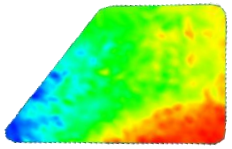
- The wall pressure fluctuation, retrieved from compressible CFD results, is read in Actran. Then the noise is propagated to the interior by modeling the cabin structure, including windows and windshield, sealant, acoustic treatment (damping & porous material) and inner cavity.

Benefits

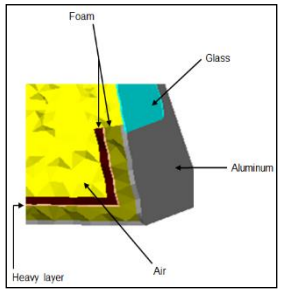
- Good correlation with measurements up to 1.5kHz on four flow conditions: two cruising speed (110km/h & 130km/h) combined with two yaw angles (0o & 10o). Methodology for predicting wind noise was validated.



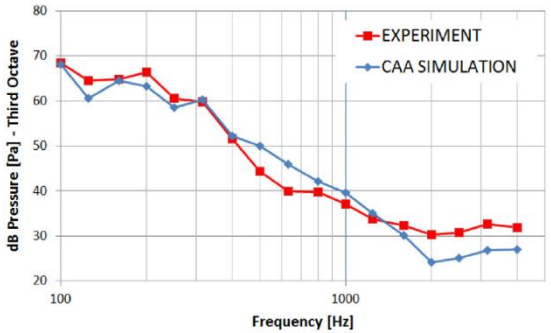
Mock-up



Turbulent wall pressure on side window



Finite element modeling of structural component and foams



Acoustic pressure inside the cabin

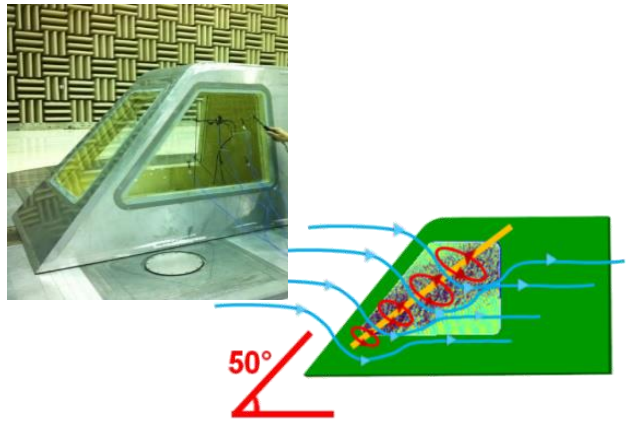


Wind noise into cabin

Internoise 2015, A method to identify the acoustic contribution in pressure fluctuations acting on a realistic car's side window, B. Ganty, D. Copiello, Y. Detandt

Challenge

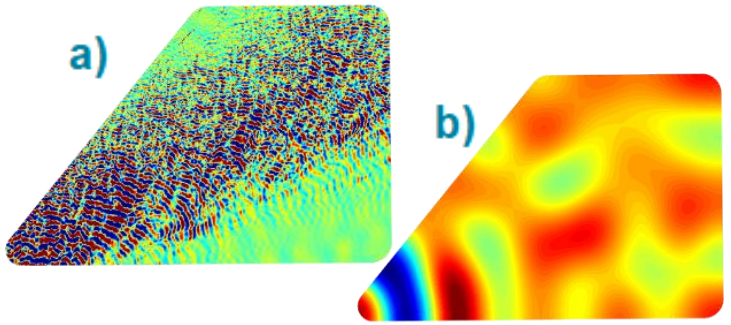
- A-pillar induced exterior pressure fluctuations leads to interior noise.
- The two contributions of wind noise, the acoustic and turbulent contributions, need to be separated in order to properly calculate wind noise



Solution

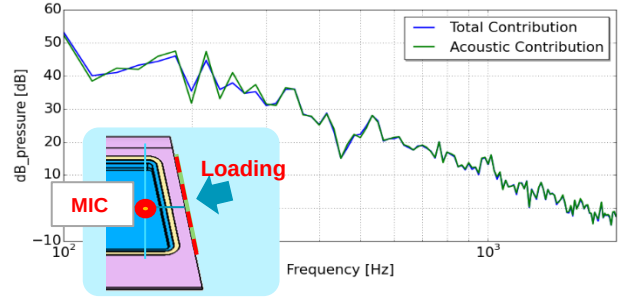
- Actran provides two methods for separating the acoustics from the turbulent contribution:
  - the wave number decomposition (WND)
  - the pellicular mode decomposition (PMD)

Pellicular Mode Decomposition: Side-window total pressure(a) and acoustic load(b)



Benefits

- The interior noise is affected only by the acoustic exterior contribution. Contrary to the WND, the PMD can be applied to any surface (curved and of arbitrary shape) like real side-windows allowing an accurate estimation of the acoustic contribution.



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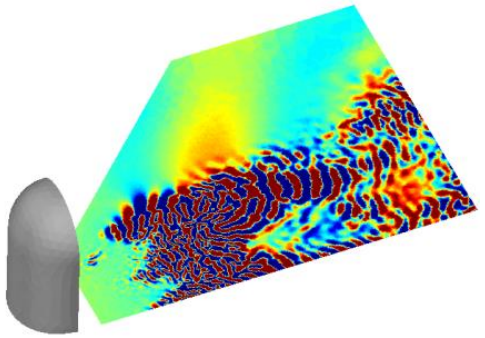


Side-mirror aeroacoustics

European Conf. Thermal Systems and Aerodynamic Solutions for Ground Vehicles 2015, Separating the acoustic from the hydrodynamic pressure on a realistic side mirror configuration. D. Copiello

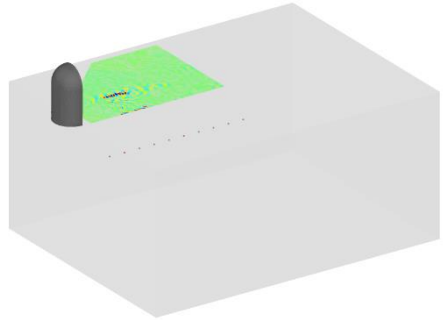
Challenge

- A side-mirror causes pressure fluctuations at the exterior of a side-window. However, reducing these fluctuations does not guarantee a lower interior car noise.



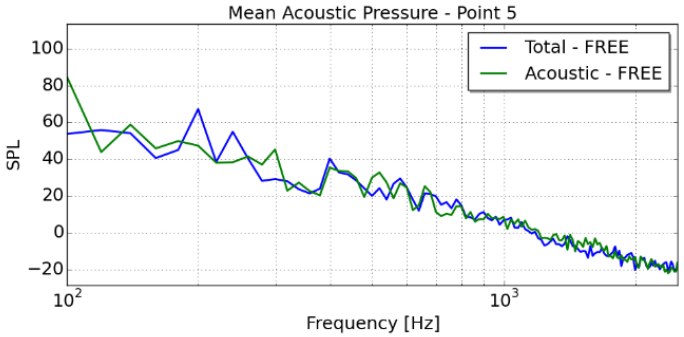
Solution

- Actran provides the wave number decomposition (WND) and the pellicular mode decomposition (PMD) for separating the acoustic from the turbulent contribution.



Benefits

- Contrary to the WND, the PMD can be applied to any surface (curved and of arbitrary shape) like real side-windows allowing an accurate estimation of the acoustic contribution.



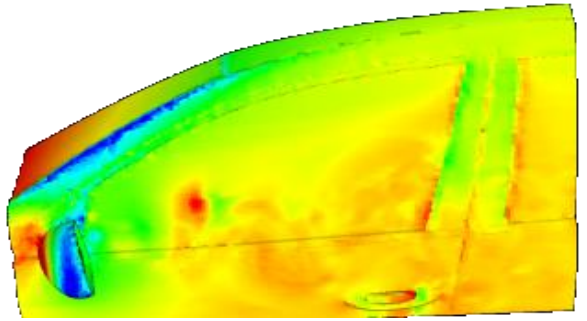
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Side window wind noise

AIAA Aeroacoustic Conference 2012, A comparison between the effects of Turbulent and Acoustic wall pressure fluctuations inside a car, M. Cabrol et al.

Challenge

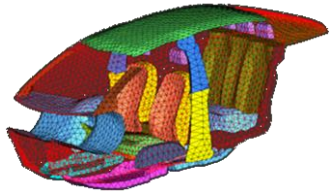
- Predict the side-mirror noise generation and transmission into the car compartment through the side window.



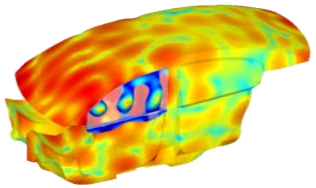
Pressure field on the window

Solution

- Starting from an incompressible flow, Actran is used for propagating the noise produced by the turbulent flow, downstream the side mirror, until the side window surface. The noise is propagated through the side window and to the driver's ears. A trimmed cabin is modeled by impedance conditions.



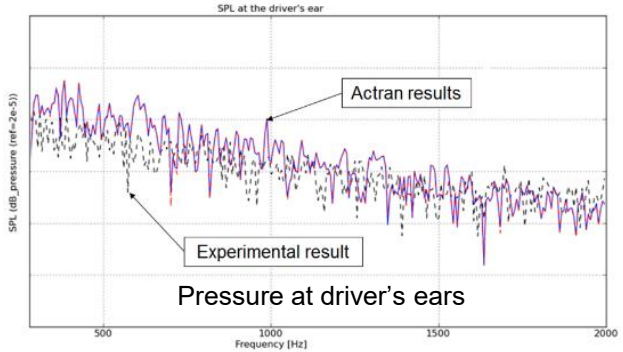
Passat structure and trim components



Vibration mode of the window and interior sound pressure

Benefits

- Good correlation with experiments up to 2kHz
- Improved understanding of noise transmission mechanisms with the ultimate goal of improving the comfort inside the vehicle.



Pressure at driver's ears

HEXAGON

MITSUBISHI MOTORS

Flow noise transmission with the SNGR method

FFT Acoustic Simulation Conference 2014, A validation of acoustic wavenumber component of fluctuating surface pressure calculated by SNGR technique for predicting flow noise transmission, F. Kosaka, Mitsubishi Motors Corp.

Challenge

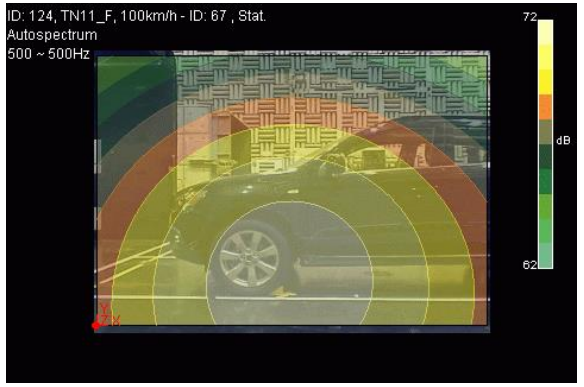
- Turbulence generated by the air flow around the car produce noise that can propagate inside the vehicle.

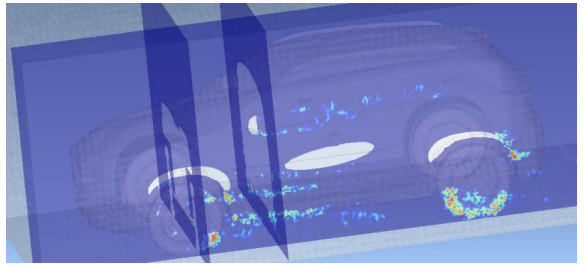
Solution

- Actran is used to perform aeroacoustics computations with the SNGR method based on affordable, steady RANS CFD simulation results.
- The acoustic contribution of the pressure on the window has been retrieved thanks to the wavenumber analysis.

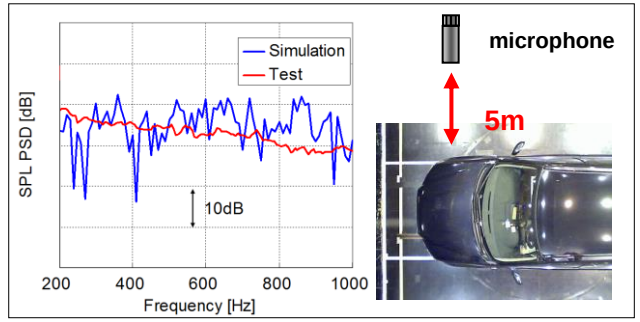
Benefits

- The SNGR method in Actran is validated by Mitsubishi motors. Its fast resolution time allows its integration into the pre-design process





Aerodynamic noise at 100km/h, 500Hz pressure 5dB lower on the rear wheel than on the front wheel



Simulation vs. measurement

HEXAGON

DAIMLER

Rod airfoil aeroacoustics

AIAA 2013 Conference, Validation of a Direct Noise Calculation and a Hybrid Computational Aeroacoustics Approach in the Acoustic Far Field of a Rod-Airfoil Configuration, A. Schell

Challenge

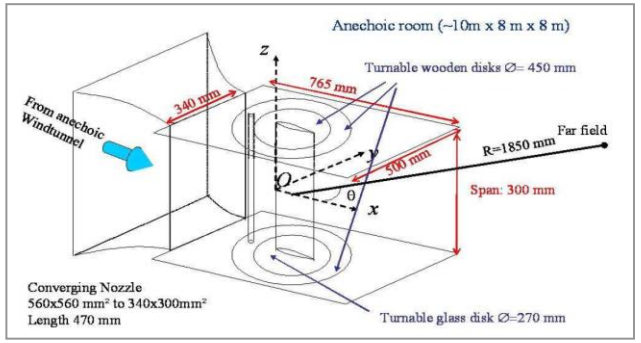
- Set-up accurate and predictive methods for aero-acoustic problems such as wind noise and HVAC noise.
- Validation of industrial cases can be difficult so simpler cases that proxy the physics correctly and are more widely used in industry are employed.

Solution

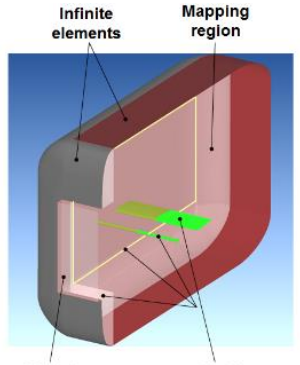
- Actran has been used for computing the aeroacoustic sources from an unsteady DES flow simulation.
- The noise produced by these sources is then propagated in far field.

Benefits

- Excellent correlations with measurements. “On the Fly” source mapping from CFD to acoustic mesh drastically reduces disk storage and computation time.

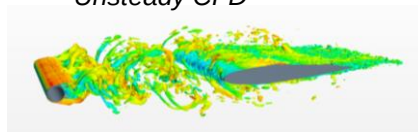


Experimental set-up

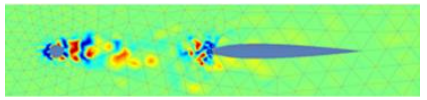


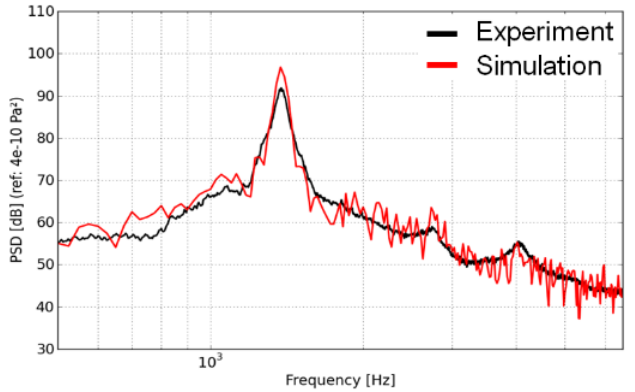
Actran model

Unsteady CFD



Acoustic source in Actran





HEXAGON

HUTCHINSON
IT'S YOUR RIDE

Side window & run channel simulation

FFT Acoustic Simulation Conference 2012, Automotive front side window boundary conditions effect on acoustic performances, C. Barras, Hutchinson Research Center

Challenge

- Improve acoustic performance of automotive lateral windows by evaluating the seal performance
- Validate experimentally the acoustic simulation process



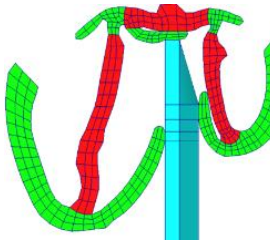
Side window and it run channel



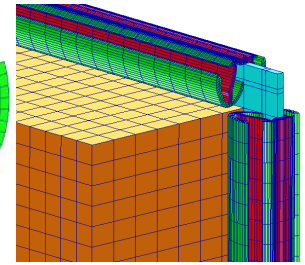
Experimental set up for measuring the acoustic transmission loss

Solution

- The deformed seal and the glass are modeled in Actran.
- The acoustic transmission loss of the side-window is accurately studied by using a diffuse sound field as acoustic load.



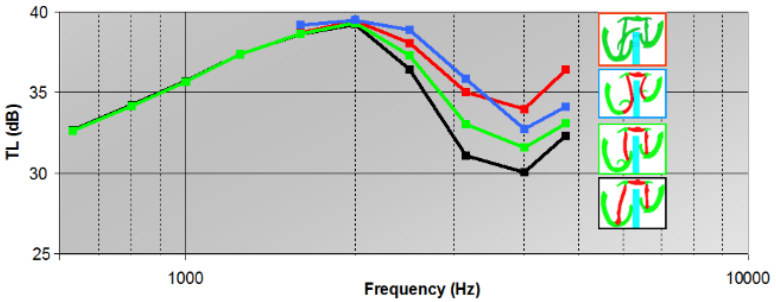
Window and seal model in Actran



Actran model for TL computations

Benefits

- Actran results were experimentally validated
- Diffuse Sound Field is a dedicated boundary condition for transmission loss
- Actran determined the optimum seal design and window thickness allowing a considerable reduction of the number of prototypes and tests.



Acoustic Transmission Loss (TL) for different seal designs

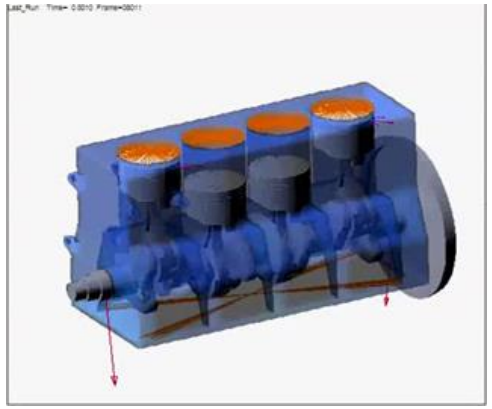
HEXAGON

iSiD
IT Solution Innovator

Piston slap noise

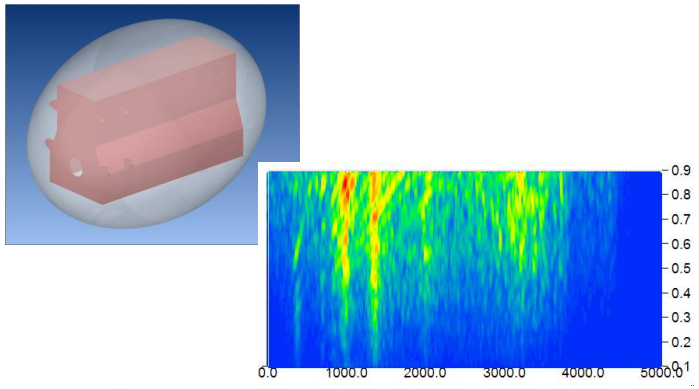
Challenge

- Modeling the engine noise requires to address dynamic and acoustic modeling. The goal is to find a method for easily combining these two fields



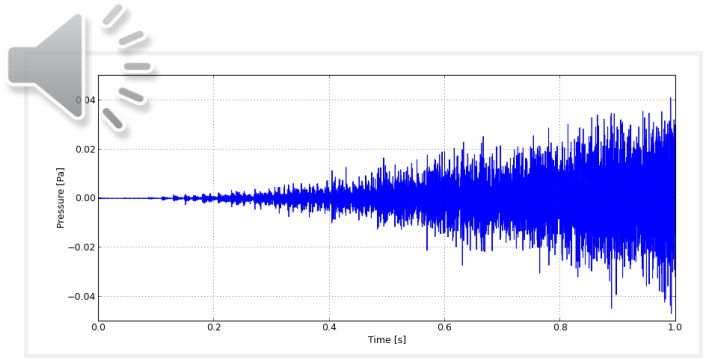
Solution

- Adams is used for the multi-body dynamic modeling as well as vibration computation.
- Actran reads acceleration in time domain on the cylinder block and propagates the noise in far field. Sound files are finally produced.



Benefits

- Prediction the real sound of an engine. The acoustic simulation can thus be integrated at the beginning of the design stage for understanding the acoustic quality of a design.



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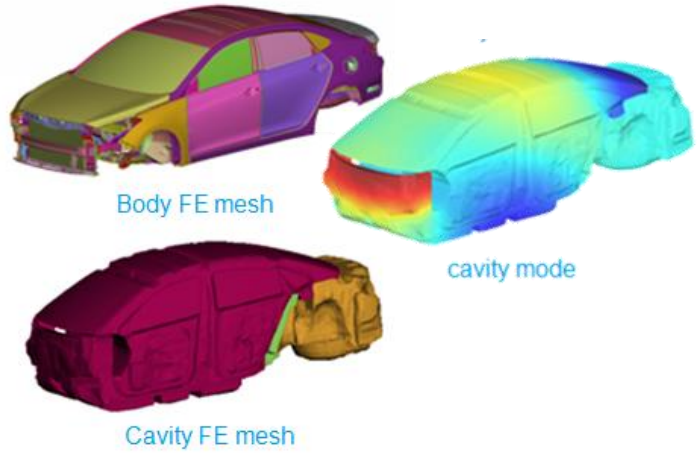
HYUNDAI

Road noise on trimmed body

ISNVH 2014, Evaluation of Trim Absorption to Exterior Dynamic and Acoustic Excitations Using a Hybrid Physical-Modal Approach. Z. Zhou et al. 2014-01-2080

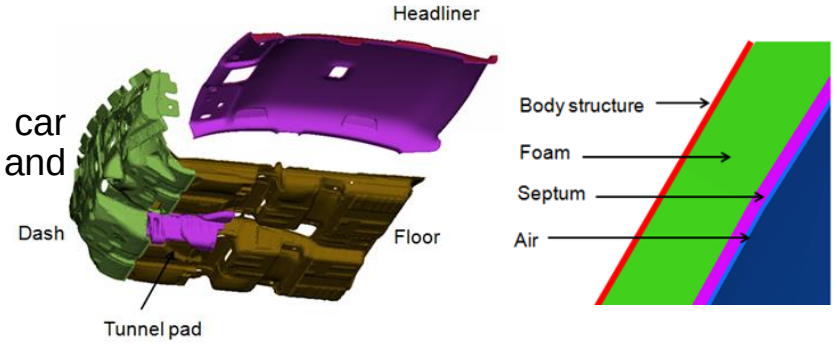
Challenge

- Vehicle passengers are very demanding when it comes to noise and expect a silent vehicle. Road noise is one of the most important acoustic sources, especially below 80km/h.
- Increasing the users comfort requires understanding how this noise is transmitted from the road to the driver/passenger ears.



Solution

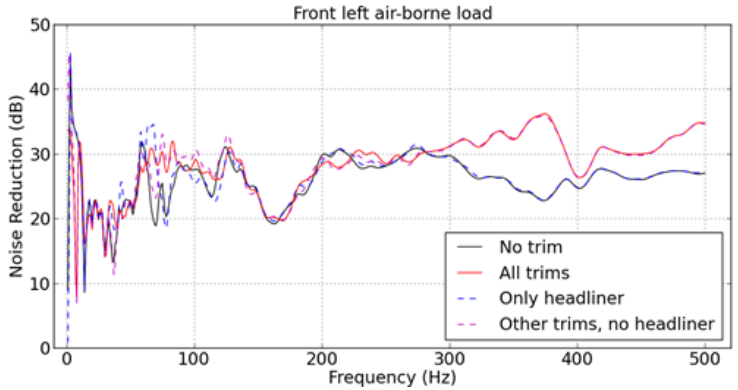
- Actran and Nastran have been used for modeling the car body, including trim components. Both air-borne and structure-borne road-noise were studied.



FE mesh of trim components

Benefits

- The methodology used showed a reduction in road-nois transmission into cabin by means of vehicle trim design



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MITSUBISHI MOTORS

Complete exhaust line simulation

Challenge

- In a traditional development cycle, the product improvement is mainly carried out by prototypes. The goal is to better design products during the concept study phase for reducing the development time and cost.

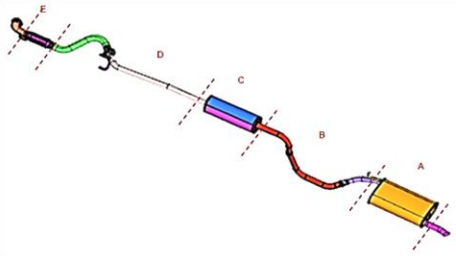
Solution

- Actran is used to model the complete line, taking into account the perforated plates and absorbing material. The exhaust line is divided in subsystems using the Transfer Matrix Method (TMM). The surrounding environment, namely the road and the car, have been added.

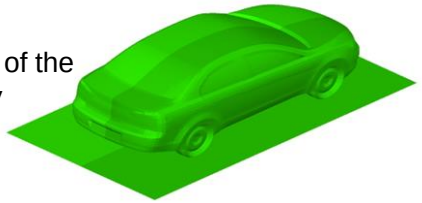
Benefits

- Study a whole exhaust system during short time, leading to a cheaper development cycle with more freedom for the product design.

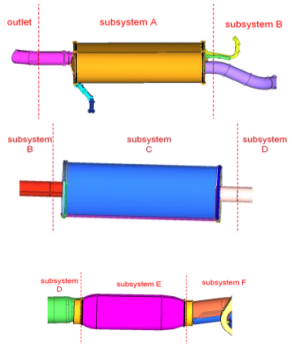
Model of the complete exhaust line



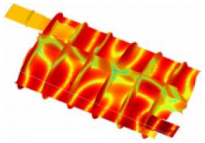
Consideration of the car body

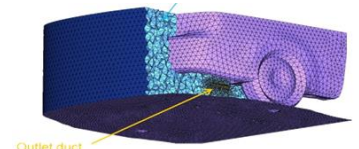


Subsystem modeled in Actran

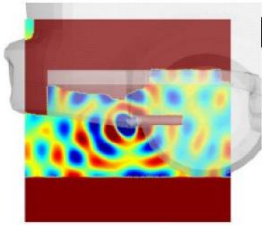


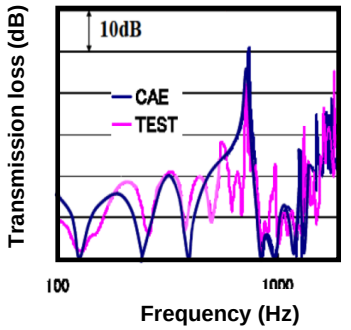
Pressure map (dB)





Pressure map (real part)





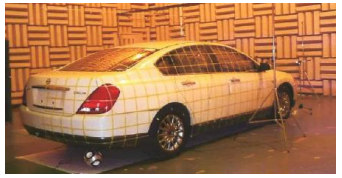
HEXAGON

Trimmed vehicle body modeling

SAE NVH Conference 2011, Numerical Prediction of the Exhaust Noise Transmission to the Interior of a Trimmed Vehicle by Using the Finite/Infinite Element Method. D. d'Udekem, M. Saitoh, B. Van den Nieuwenhof, and T. Yamamoto

Challenge

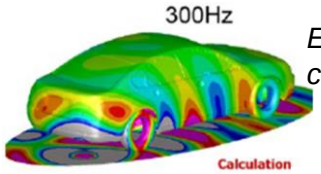
- Controlling noise in the cabin during vehicle acceleration.
- The task requires studying the exhaust noise, its propagation to the driver ear taking account of the sound insulation by trim components.





Solution

- The surface sound pressure on the car body due to the exhaust pipe noise is computed with Actran. Then this pressure is applied on the Nastran body including impedance of trim components.
- The transfer function from exhaust noise to driver's ear is calculated.



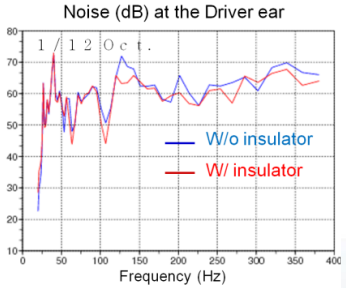
Exhaust noise on the car body

Structure modeling (Nastran)

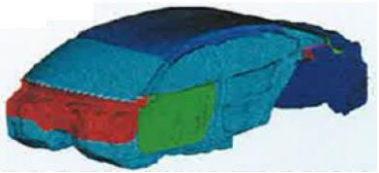


Benefits

- A simulation method was established to study trimmed vehicle body NVH, with noise source from exhaust



Cavity modeling with trim





Active noise control in car cabin

Challenge

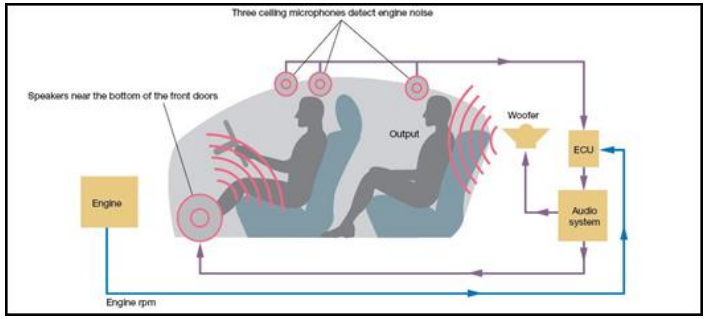
- Active noise control provides new possibility for premium vehicle comfort, which requires modeling noise sources (e.g. HVAC), active units (loudspeakers) and their wave propagation to the driver's ears.

Solution

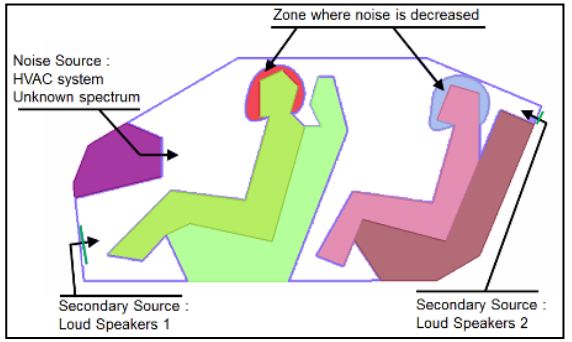
- Actran is used for computing the HVAC noise, from an unsteady CFD simulation, and its propagation in the cabin. Acoustic waves with adapted amplitude and phase are injected through the speakers for reducing the perceived noise at driver's ears.

Benefits

- A methodology has been showcased for active noise cancelling in the vehicle cabin
- Acoustic simulation can be used to identify the best position for the noise-cancelling loudspeakers

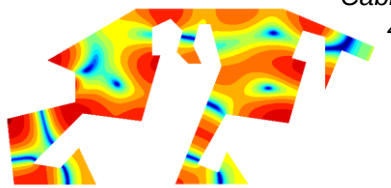


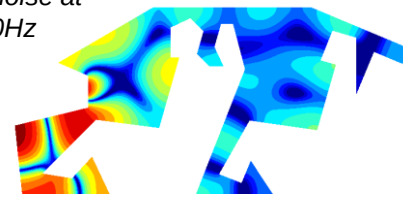
The active noise control principle



Sources modelled in Actran

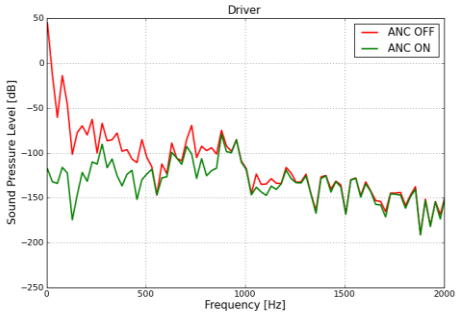
Cabin noise at 400Hz





Without active control

With active control



Noise at driver's ear

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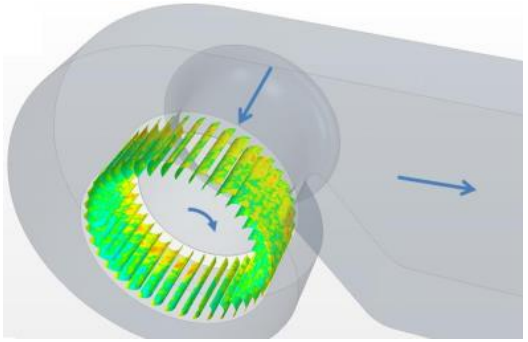
Hochschule für Technik und Wirtschaft Berlin
University of Applied Sciences

Centrifugal fan aeroacoustic simulation

Internoise 2013, Numerical and experimental investigations on the noise of a centrifugal fan with forward-curved blades. M. Darvish, S. Frank

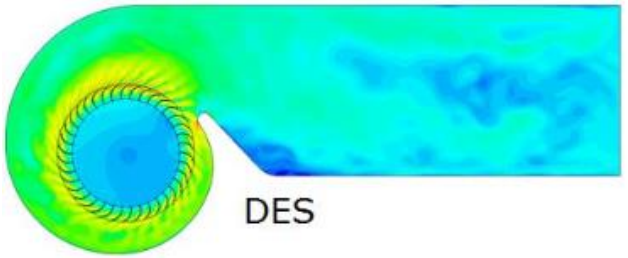
Challenge

- Assess the ability of aeroacoustics simulations to predict the noise radiated from a radial fan with forward curved blades.



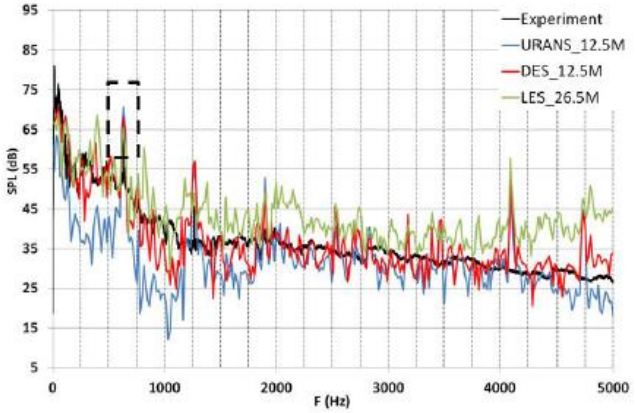
Solution

- Actran is coupled with an unsteady CFD for computing the aeroacoustics noise of a 38 blades fan rotating at 1000rpm



Benefits

- Identification of the best methodology for assessing the aeroacoustic noise by comparing different CFD solutions for computing the noise sources.
- Accuracy of fan noise prediction by Actran has been verified as the tonal and broadband noise predictions match well with measurement.



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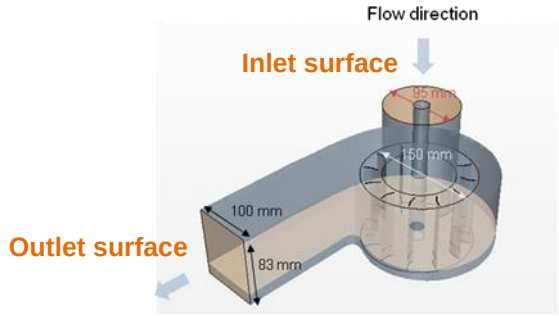


Centrifugal fan aero-vibroacoustic

Fan Noise 2012, Computational aeroacoustic analysis of industrial fan application using a hybrid approach, M. Cabrol et.al.

Challenge

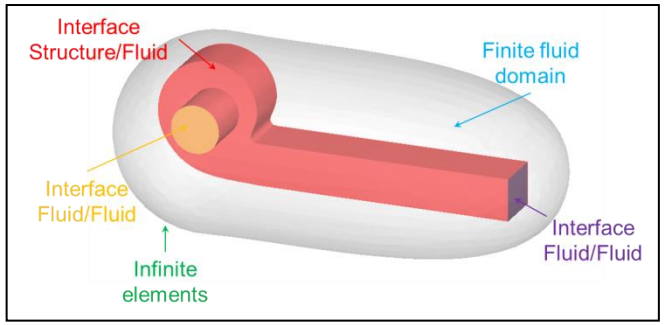
- Industrial fans are an important noise source and reducing noise is an important consideration
- For validation purposes, modeling of a simplified centrifugal fan system representative of an industrial configuration can provide insight
- Assess the influence of the casing design on the acoustic response and the shell noise radiated in far field



Fan Geometry

Solution

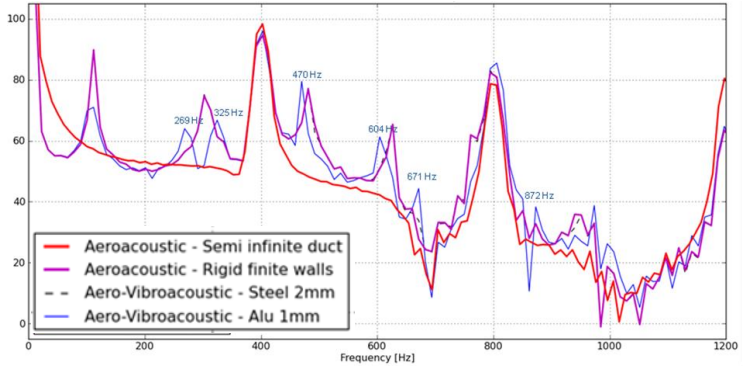
- A hybrid aero-acoustic method based on the Lighthill analogy in the finite element context is used to evaluate noise
- Unsteady CFD data are used to generate the noise sources from the fan
- A finite element model is used to propagate the noise within the system and on the outside



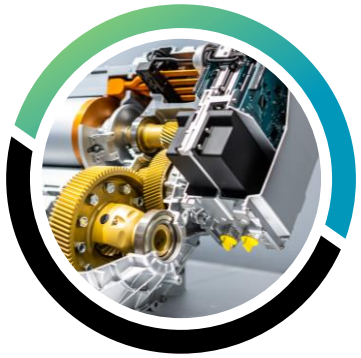
Aero-Vibro-Acoustic Model

Benefits

- Fully-coupled aero-vibroacoustic analysis in the interior and exterior of a fan
- Easily perform acoustic analyses with the same aeroacoustic excitation to evaluate different structure designs and materials



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Electric motor acoustic noise prediction

Challenge

- Several electric motors can be found in a car or inside a house. The noise generated by an electric motor is due to the interaction of electromagnetic field with the resonant frequencies of stator core or teeth.

Solution

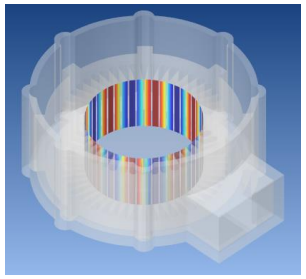
- The structure and the air are modeled in Actran. Forces are applied on the stator teeth with a sine function. Actran computes structural displacements. Then the noise radiation induced by the housing vibration is calculated.

Benefits

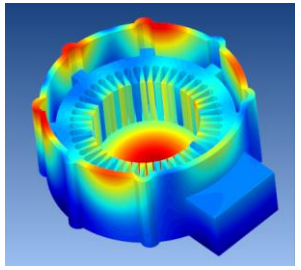
- The noise generated by an electric motor can be efficiently calculated with Actran.



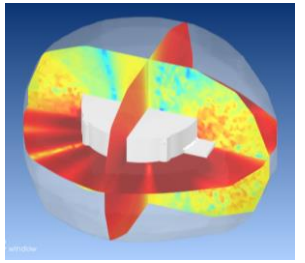
Model based on the 2004 Honda Prius electric motor



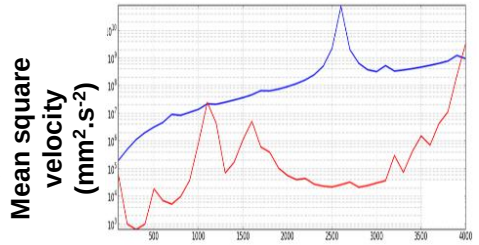
Excitation: radial forces of the 8 poles motor



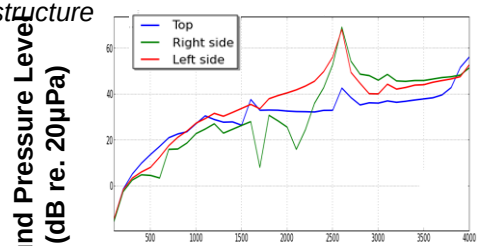
Displacement map



Noise map



Mean square velocity of the structure



Noise level at 3 microphones

Electric motor noise prediction

Numerical methodologies to address electromagnetic noise at each phase of development of electric machines, G. Fritz, Renault, H. Mechmeche, Laboratoire d'Electrotechnique et d'Electronique de Puissance de Lille, SIA 2014 (Le Mans, France)

Challenge

- End-users expected electric vehicles to be very quiet. Therefore, in the development of a new electric powertrain, Renault had guaranteed NVH requirements of new motors before physical prototyping

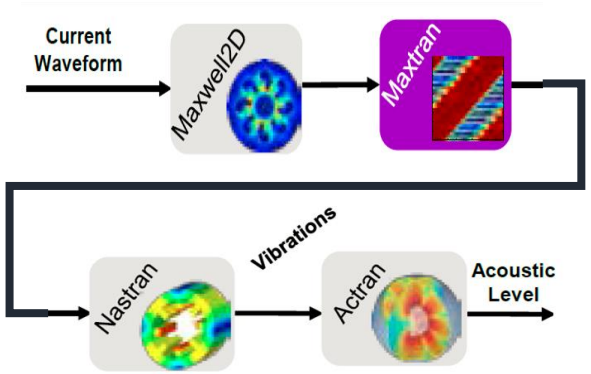
Solution

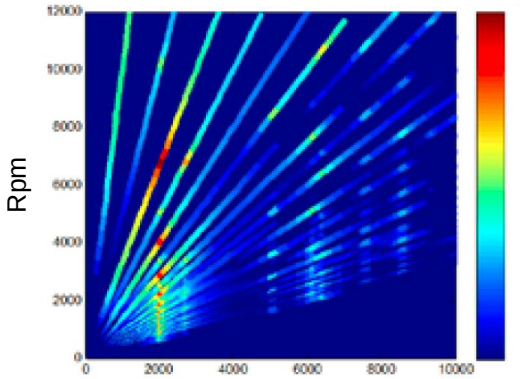
- Nastran read electromagnetic forces, and calculated the vibration levels
- Then, the vibration is inputted in Actran for predicting the radiating noise.

Benefits

- Actran and Nastran were used for performing virtual prototyping validation at the end of the design cycle

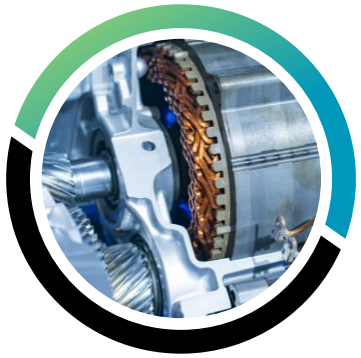






Noise at each engine order (with the Waterfall diagram output by Actran)

HEXAGON



Electric motor noise prediction

Challenge

- With the emergence of electric vehicles, the noise of electric motors is becoming more and more perceived and needs to be evaluated at early design steps.

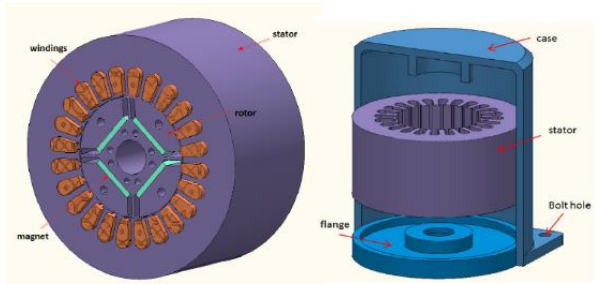
Solution

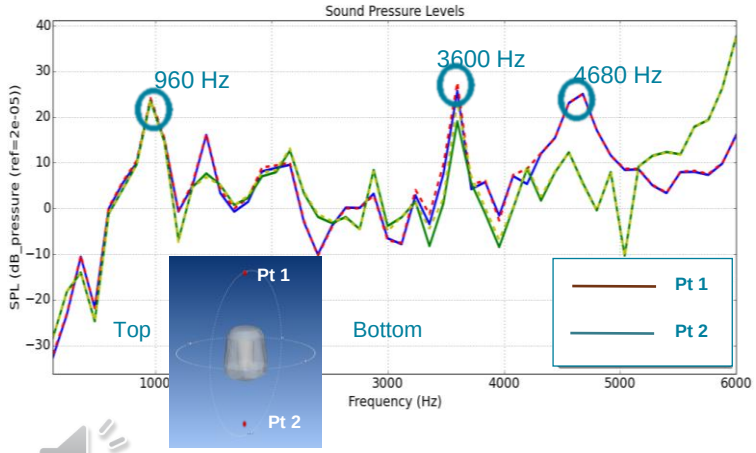
- Different tools from Infolytica MagNet to Actran and Nastran can be chained to perform this simulation.

Benefits

- Electric motors acoustic radiation can be computed at early design stages by means of Actran. This simulation allows to assess both the acoustic performance and listen to the noise generated.







Sound Pressure Level surrounding the motor

HEXAGON

DAIMLER

MITSUBISHI MOTORS

Two layers trim systems (RTC3) validation

SAE conference 2005, Vibro-acoustic FEA modeling of two layer trim systems. C. Y. Glandier, R. Lehmann, T. Yamamoto Y. Kamada

Challenge

- Modeling multilayer trim with one heavy layer and two different poro-elastic materials: one foam and one fibrous material.

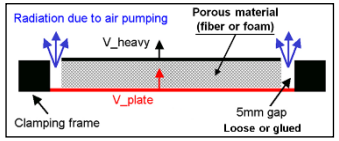


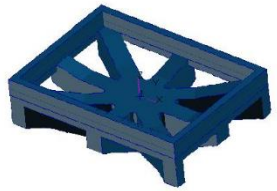
Test Rig

Solution

- The Actran vibro-acoustic model considers:
  - The carpet as a porous material
  - The frame as a Nastran superelement

Multilayer material surrounded by a frame



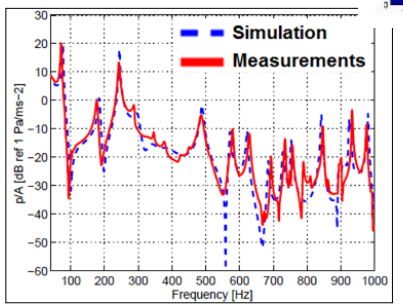


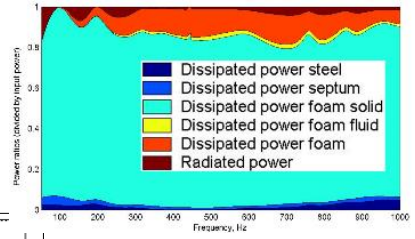
Frame reduced into a Nastran superelement and read by Actran

Benefits

- Experiments and simulations are in excellent agreement. The numerical model is validated and provides useful post-processing information. The method is replicated insulated panels.

Mean pressure at 1 meter





Power balance: Radiated & Dissipated Power

HEXAGON

HONDA

Sloshing noise

SAE 2015 World Congress & Exhibition, Complete Multi-Discipline Simulation for Sloshing Noise. Douglas Marriott, Takeshi Ohtomo, Tohru Wako

Challenge

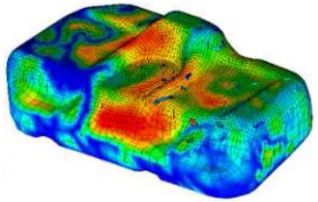
- Growing desire from fuel tank manufacturer to predict the sloshing noise as early as possible during the design process as the demand for quieter vehicles increase.

Solution

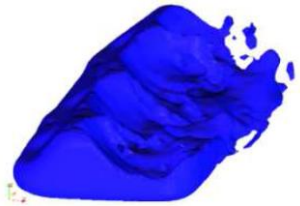
- Dytran is used for computing the fuel movement and the interaction with the tank flexible structure (time domain explicit non-linear analysis).
- Actran then reads tank vibrations for computing the radiated noise in time domain, during 2.5s

Benefits

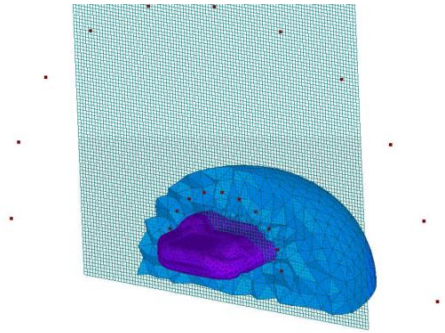
- Combining Dytran and Actran, we can perform a multi-discipline time-domain simulation for sloshing noise.
- Suppliers can build products at a lower cost and shorter timeframe.



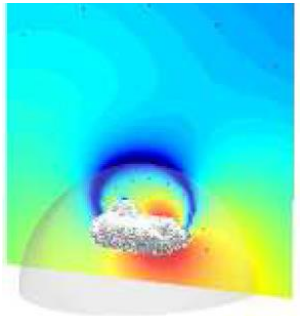
Tank vibration at t=0.75s



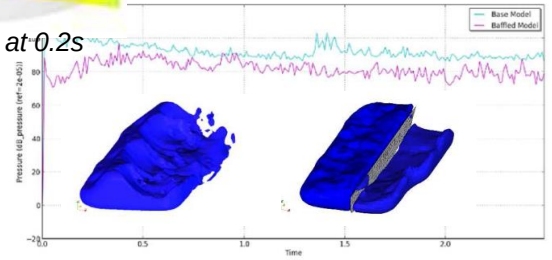
Fuel at t=0.75s – without baffle



Acoustic model with automatic meshing



Noise (dB) at 0.2s

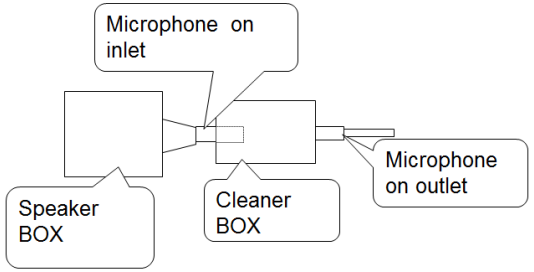


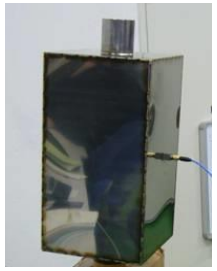
Radiated noise with and without baffle

Motorcycle air box noise prediction

Challenge

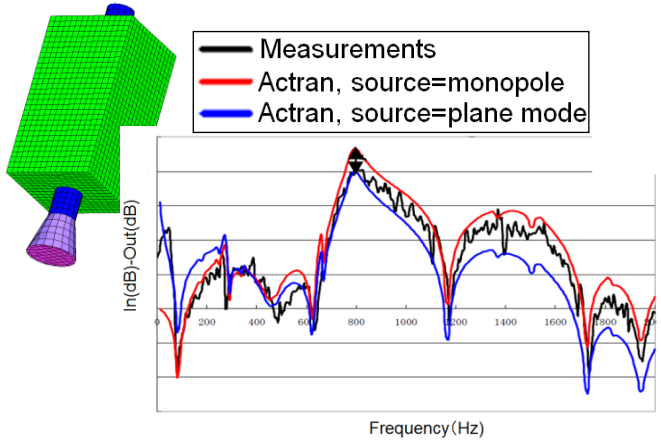
- Prediction of the acoustic propagation in a motorcycle air box.





Solution

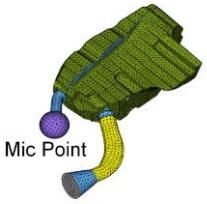
- Actran is used for modelling the experimental acoustic source with a plane mode, and then for propagating the noise through the air box, by taking into account the air filter.



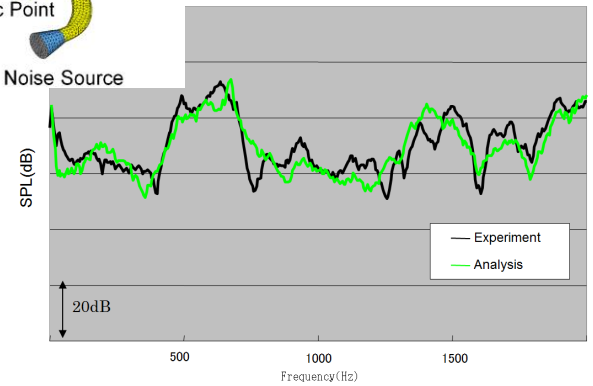
Pressure inlet – Pressure outlet: Actran Vs Tests

Benefits

- Good correlation with experiments have been obtained on a simple box (validation case) and on the real air intake.



Actran vs. tests

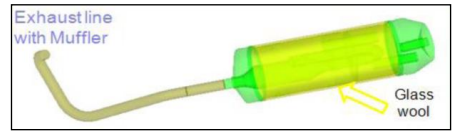


Motorcycle muffler noise attenuation

Challenge

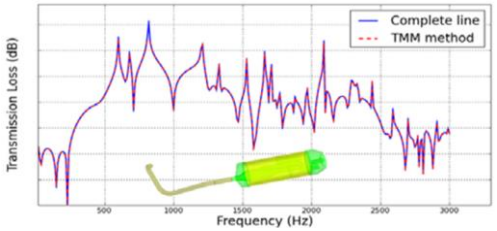
- Motorcycle mufflers are commonly used for noise attenuation of the exhaust of the motorcycle
- It is important to evaluate the sound attenuation and the flow noise contribution on a motorcycle exhaust line.





Solution

- Actran is used for predicting the acoustic Transmission Losses (TL) of the muffler by the effect of glass wool and the catalytic converter.
- Then the flow noise has also been computed using data from an unsteady CFD simulation.

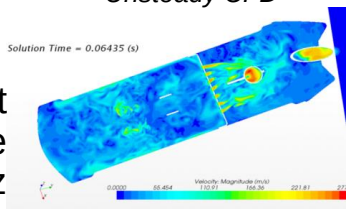


Transmission Loss: Validity of the TMM Method

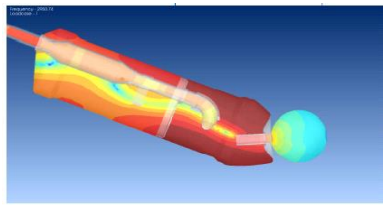
Benefits

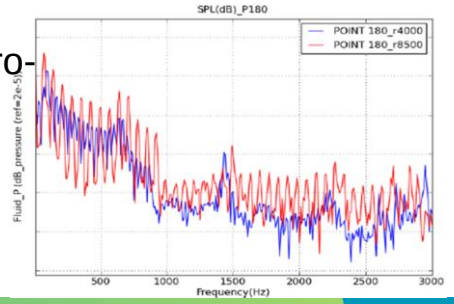
- Actran has been successfully applied to predict the exhaust pipe noise radiated by a motorbike. The complete calculation has been performed in 2.5hours (10Hz resolution) up to 3000 Hz.
- The next step is to take into account the shell noise (vibro-acoustic).

Unsteady CFD



Flow noise in the muffler





Flow noise at the muffler outlet:
At 4500rpm and 8500rpm



TMM for exhaust noise at high frequencies

SAE/JSAE 2014 SETC, Acoustic Simulation of Vehicle Exhaust System using High Order Transfer Matrix Method Coupled with Finite Element Method, D. Copiello, Z. Zhou, G. Lielens

Challenge

- TMM (Transfer Matrix Method) is efficient to ease acoustic simulations on exhaust lines and speed their optimization by dividing the entire line into subsystems.
- Current methods are only available at low frequencies because they only take into account the plane mode (1D) at the connections between subsystems.

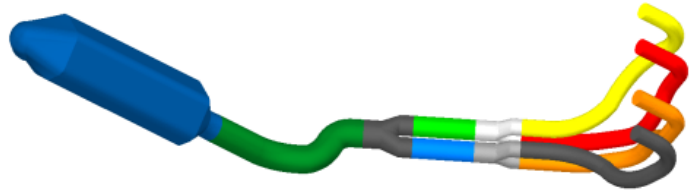
Solution

- Actran now gives the possibility to use the TMM method by taking onto account high order duct modes between subsystems

Benefits

- Optimizing efficiently exhaust lines thanks to the TMM method is now possible at high frequencies

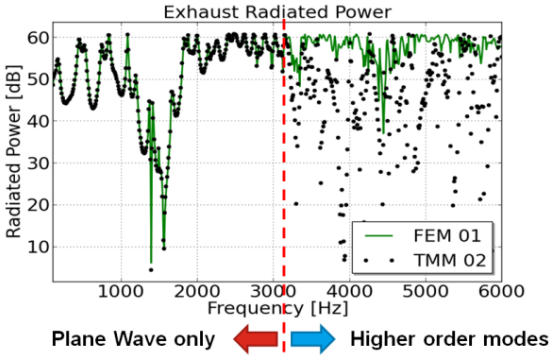
Awarded at the SAE conference:
Top Five Best Presentations
Top Ten Best Papers



Exhaust lines in 6 parts with bifurcations

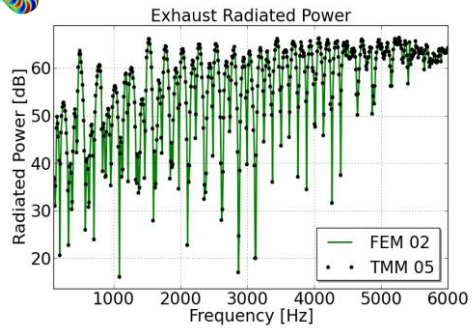


On one part of the line:
Above 3kHz the classic TMM method is not valid





On the complete line:
The new advanced TMM method is valid even at high frequency



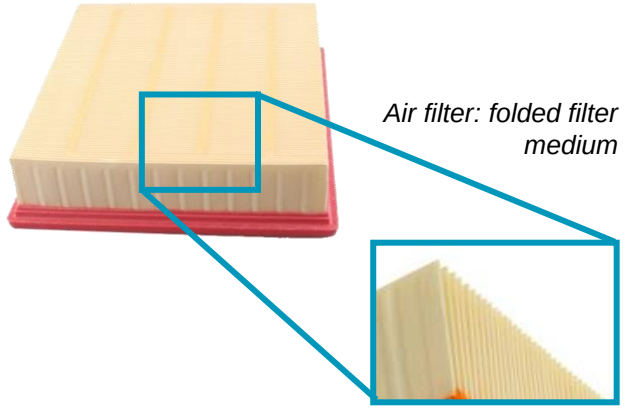


Automotive air box simulation

Fahrzeugakustik Aktuelle Entwicklungen in der NVH-Berechnung 2015, Advanced FEM Modeling Techniques for Vibro-Acoustic Studies on Automotive Air Intake and Exhaust Components, D. Copiello

Challenge

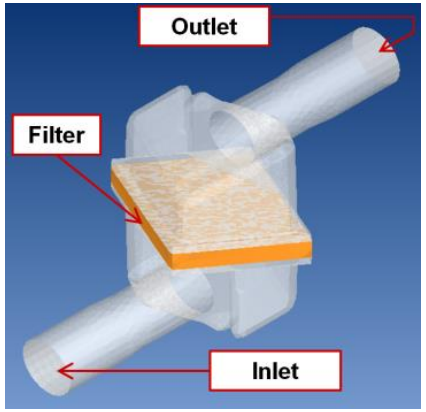
- An automotive air filter is made by a folded porous layer which leads to an anisotropic behavior.
- The filter plays an important role in sound absorption, so it is crucial to properly model its behavior



Air filter: folded filter medium

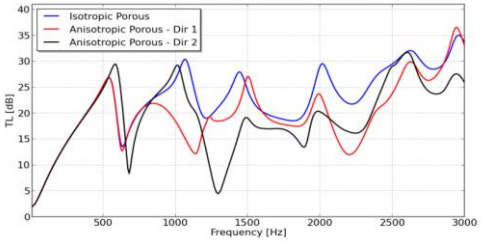
Solution

- Actran is used to model the filter as an equivalent porous element with anisotropic Biot properties. This allows to take into account all the dissipation mechanisms occurring in the filter



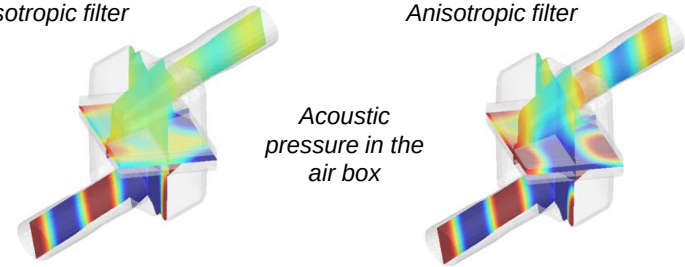
Benefits

- Taking into account the anisotropic nature improves the prediction of the absorption since the isotropic approximation overestimates the absorption.
- It is also easy to define the optimal orientation of the filter plies from an acoustic perspective.



Isotropic filter

Anisotropic filter



Acoustic pressure in the air box



Catalytic converter simulation

Fahrzeugakustik Aktuelle Entwicklungen in der NVH-Berechnung 2015, Advanced FEM Modeling Techniques for Vibro-Acoustic Studies on Automotive Air Intake and Exhaust Components, D. Copiello

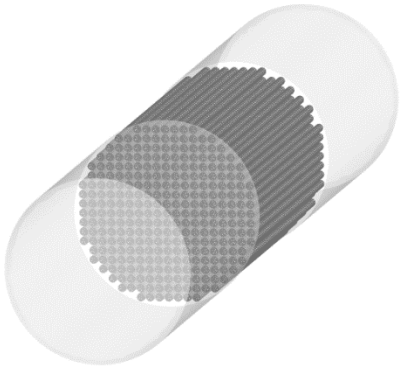
Challenge

- In some intake and exhaust components, visco-thermal dissipation is not negligible. For example, in catalytic converters the visco-thermal dissipation in the presence of a mean flow requires specific modeling techniques.



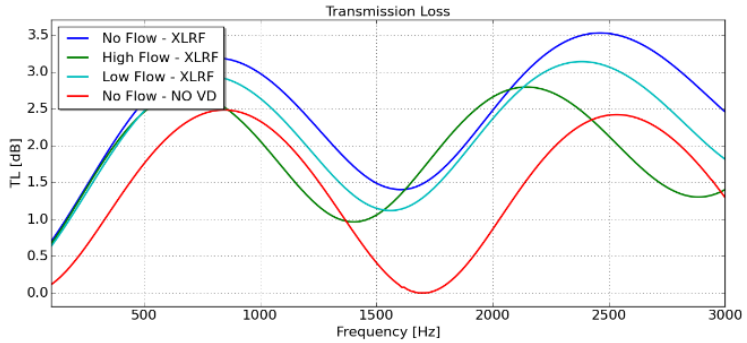
Solution

- Actran is used to model the catalytic converter. The eXtended Low Reduced Frequency Model, which extends the classic LRF model, is used to include the effect of the mean flow.



Benefits

- By using the eXtended Low Reduced Frequency Model, the mean flow is considered, and the effect of different mean flow speed can be evaluated.



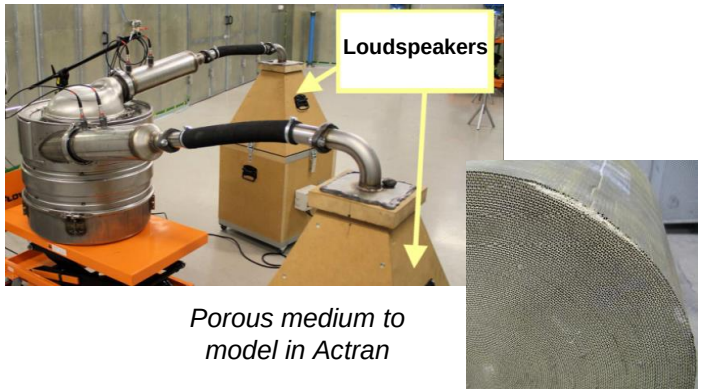
HEXAGON

Air filter transmission loss

MSC Germany User Conference 2012, Actran use in the acoustic development of exhaust systems, J. Voillequin

Challenge

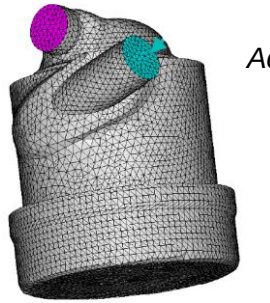
- 1D simulation software leads to bad correlation with experiments. A more detailed modeling technique is required to properly assess truck catalyzers.



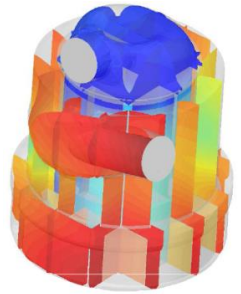
Porous medium to model in Actran

Solution

- Actran is used for modeling accurately the catalytic converter, including the porous medium inside.



Acoustic model

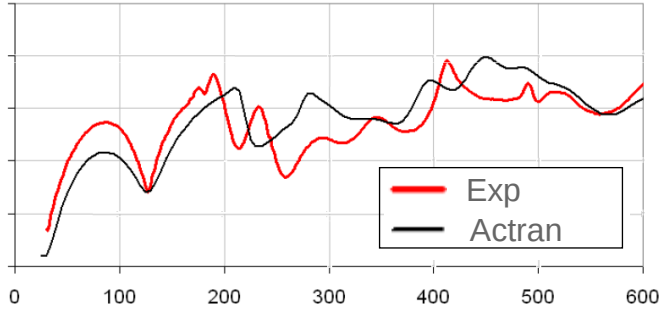


Pressure map @ 215Hz

Benefits

- The acoustic transmission loss is computed and compared with experimental results.
- Correlation between Actran predictions and experiments are in good agreement.
- This allows the implementation of an accurate virtual prototyping methodology in an industrial context.

Transmission Loss: Actran Vs tests

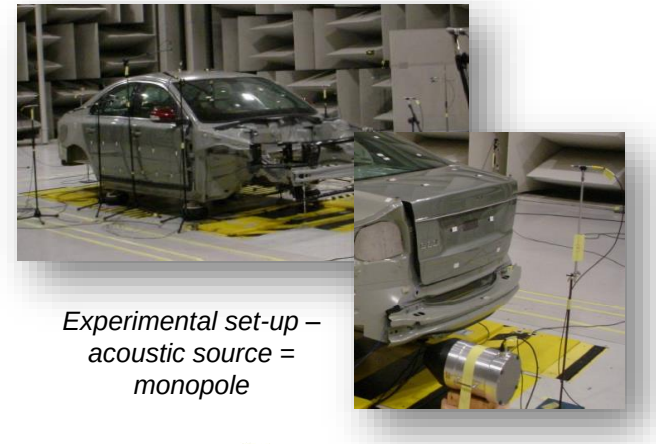


Airborne exhaust noise for a body-in-white

SAE NVH Conference 2015, Prediction of airborne sound transmission into the passenger compartment, A. Pietrzyk

Challenge

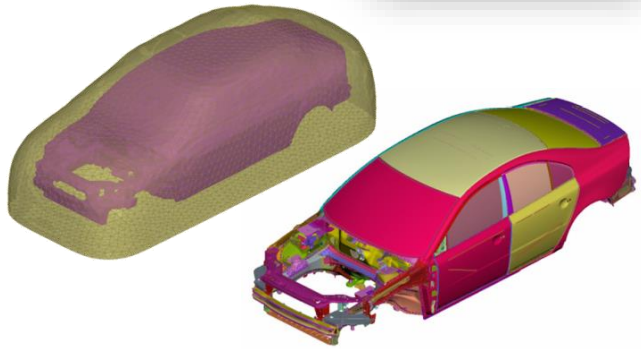
- Compute the noise inside the cabin, due to the exhaust and take into account the trim components.



Experimental set-up – acoustic source = monopole

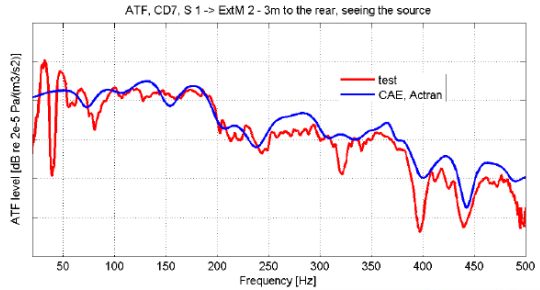
Solution

- Nastran is used for modeling the car body. Actran computes the acoustic pressure coming from the exhaust till the car cabin exterior surface by using a monopole.
- In a second step this pressure is used by Actran to load the car body (Nastran modal component imported in Actran) and propagate the noise to the driver's ears.

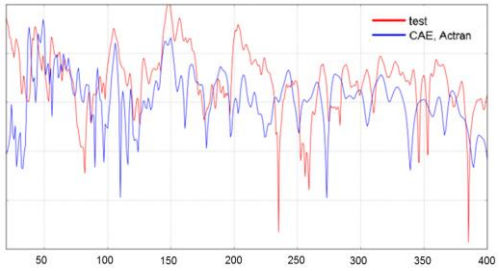


Benefits

- Get the exhaust noise inside the cabin thanks to the efficient coupling of two MSC products.
- Results accuracy is linked to the accuracy of the structural model.



Noise around the car body: Actran Vs tests



Noise inside the cabin: Actran Vs tests

Loudspeaker performance and integration

FFT Acoustic Simulation Conference 2016, Applications of Actran in Volvo Cars, Andrzej Pietrzyk

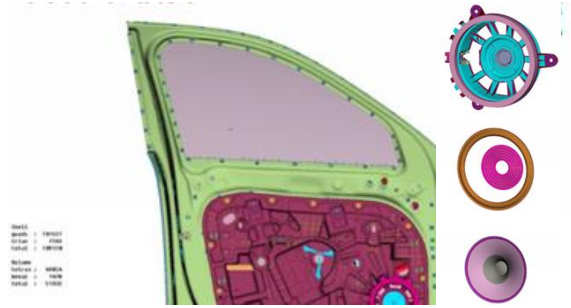
Challenge

- The integration of the loudspeaker on the vehicle door affects the performance of the system
- It is important to assess the audio system performance and integration, and this can be done using CAE methods
- An efficient multiphysics approach is needed including electric, structural and acoustic inputs.



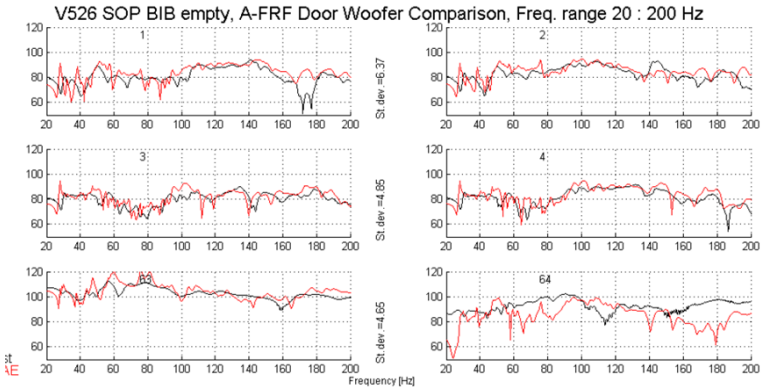
Solution

- MSC Nastran is used for the vehicle door model which is then coupled to the loudspeaker model in Actran, including the interior car door cavity
- Actran's capabilities allow to drive vibro-acoustic model with electric voltage input.



Benefits

- Accuracy of simulation results with respect to measurements.
- Possibility to rely on simulation to improve loudspeaker design and integration at lower cost



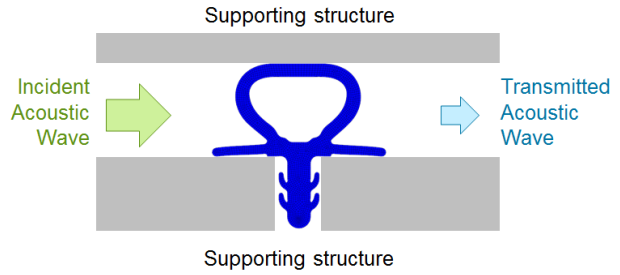
CooperStandard

Door seal acoustics

AAC 2015, Development of acoustic STL simulation methodology for automotive door seals: Correlation between simulation and Testing results, I. Iovtchev, J. Jacqmot

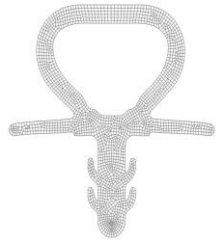
Challenge

- Vehicle door seals have a contribution in isolating the interior of the car from exterior noise, especially wind noise which is transmitted through the windows
- The goal of this study was to improve the acoustic performance of automotive door seals.

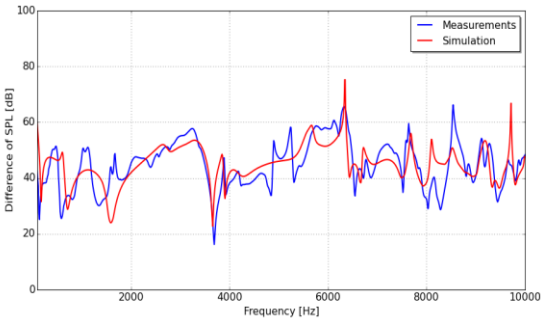


Solution

- The **deformed seal** is modeled in Actran in order to detect the vibro-acoustic performance. The **material properties** of the rubber can be modeled using accurate **frequency-dependent information**.



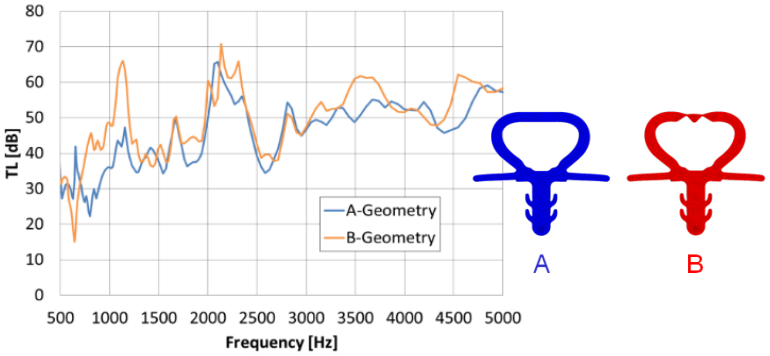
Deformed Seal mesh



Actran Experiment Validation

Benefits

- Actran results are experimentally validated.
- Detection of the key ingredients for finite element modeling of a rubber automotive seal.
- Actran determines the optimum seal design.
- Full confidence in the simulation process for defining and selecting new seal design.



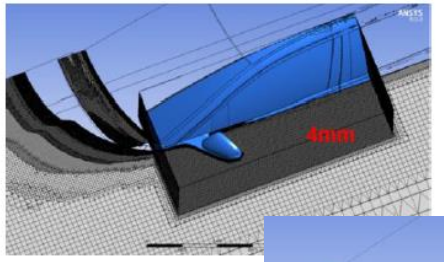
HEXAGON

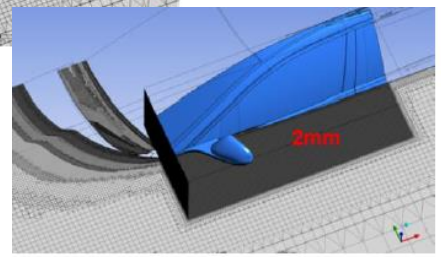
Car side mirror noise

ICSV22, Passenger Car Side Mirror Exterior Noise Simulation And Validation, A. Pietrzyk, D. Beskow and D. Moroianu, M. Cabrol, Y. Detandt

Challenge

- The A-pillar and the side-mirror generate complex aeroacoustic sources. Car manufacturers aim at reducing these sources to reduce the exterior pass-by noise level. This is also a prerequisite for interior noise reduction.

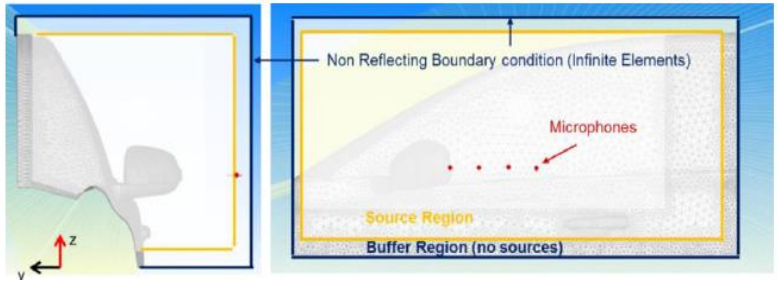




CFD meshes in the source region

Solution

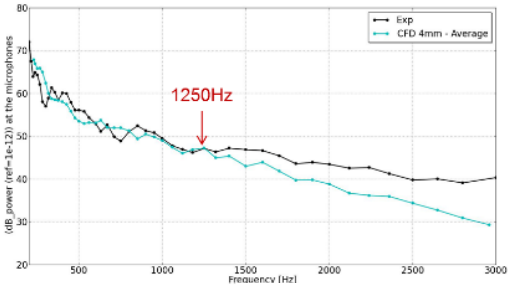
- Actran computes the noise sources from the pressure fluctuation computed by means of unsteady CFD results.
- The noise is then propagated up to a number of external virtual microphones.

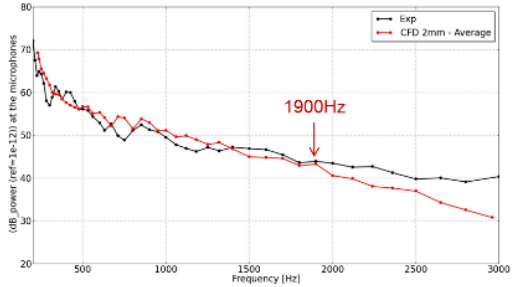


Actran analysis set-up

Benefits

- Actran has been used to validate the simulation procedure for exterior noise prediction. A method to determine the validity of a CFD mesh (vs frequency) has been developed





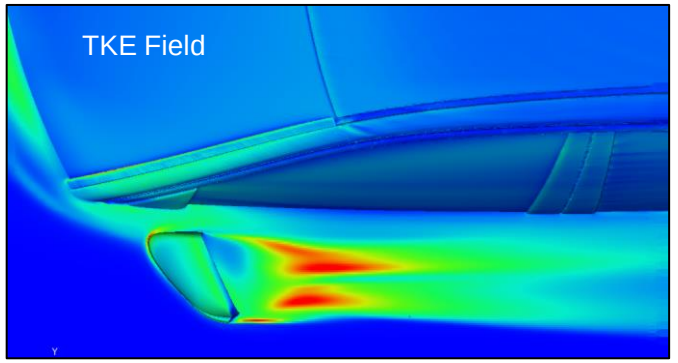
Actran results for the two different CFD meshes – Comparison with experiment

Car side mirror noise at high frequency

ICSV24, Efficient Method for Car Exterior Noise Prediction based on Steady CFD input, M. Cabrol, Y. Detandt & A. Talbot

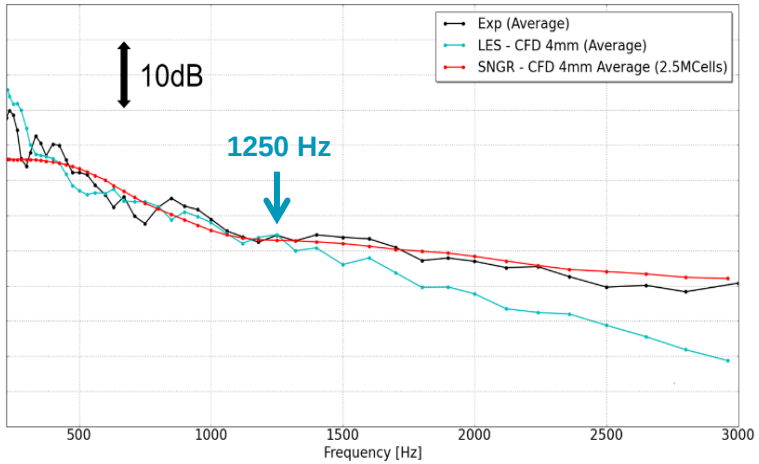
Challenge

- Unsteady CFD simulation is commonly used to study side mirror noise. This method becomes extremely computationally intensive when high frequencies are of interest



Solution

- Actran computes the noise sources from the mean flow results of a CFD analysis using SNGR.
- With this method the computation time needed to compute the aeroacoustic sources is independent from the frequency and reduced by orders of magnitude when comparing to the classic approach



Benefits

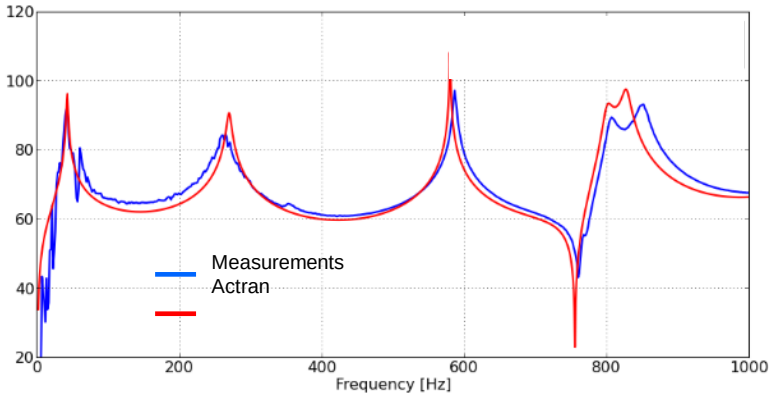
- Actran SNGR complements the classic aeroacoustic approach to reach higher frequencies with reasonable computation time. Results show very good agreement with the experiment

Leak effects on muffler acoustic performance

Advanced Simulation for the Ground Vehicle Industry Conference 2014, Acoustic Analysis of a Muffler with ACTRAN, A.Ciacci et al

Challenge

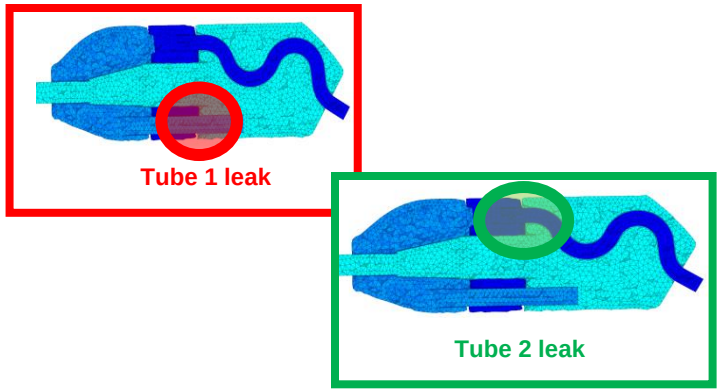
- A muffler optimization can be done by means of 1D tools at first stage with inherent limitations which needs to be overcome with 3D tools



Experimental Validations on a simple case

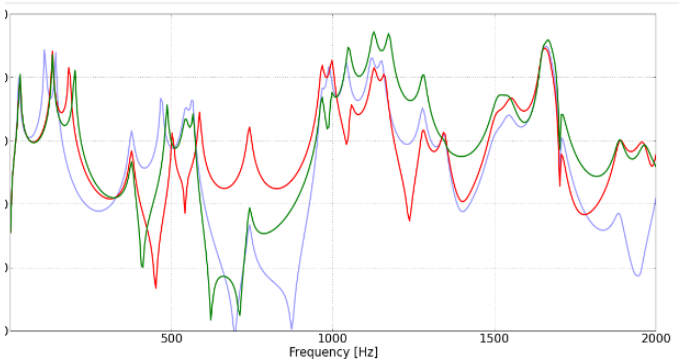
Solution

- Actran can perform 3D muffler design with advanced modeling capabilities for reducing the computational effort in order to be implemented into an optimization loop.
- The model takes also into account spatial dependent temperature and mean flow



Benefits

- Actran as been first experimentally validated on a basic configuration. A complete muffler model is then considered.
- To improve the computational efficiency the catalytic converter has been approximated by an equivalent anisotropic porous material.
- The effect of leaks have been also assessed.



Assessment of leaks effects on the muffler response

Air filter shell noise

Challenge

- Predict the acoustic radiation of an air filter submitted to interior acoustic excitation



Solution

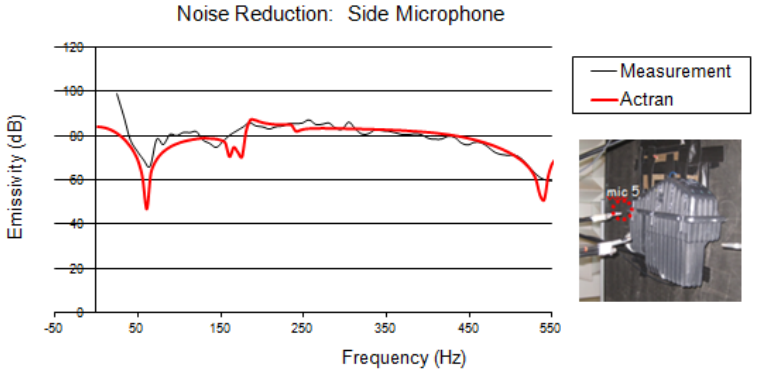
- A hybrid modal-physical model is created to predict the shell noise of an Air Filter box using Nastran for modeling the structure and Actran for the interior and exterior acoustic parts



Mode at 86Hz | Mode at 115Hz | Mode at 217Hz

Benefits

- Acoustic radiation of the air filter box accurately predicted over the complete frequency range of interest



Injection duct pipe noise

SAE 2009, "Vibro-Acoustic simulation of diesel injection ducts", J-L. Bourachot, J-P. Leandre, A. Walbott, B. Bouvier, B. Van Antwerpen, D. d'Udekem

Challenge

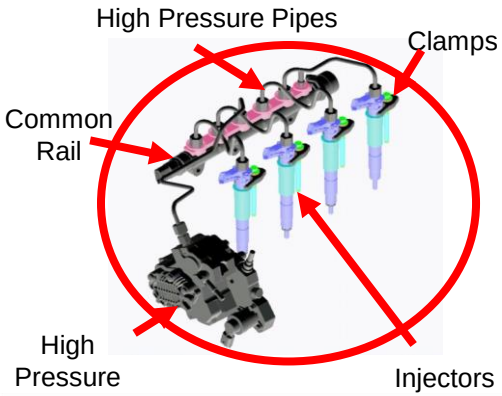
- Common rail engines suffer of pan and hooting noise at cold start and hot idle

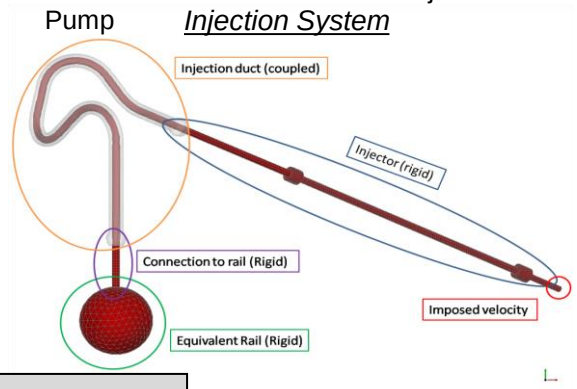
Solution

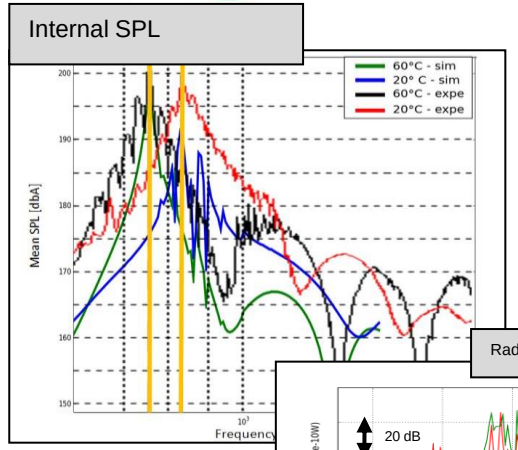
- Nastran is used to model a realistic boundary condition for Actran vibro-acoustic model of injectors duct
- Velocity condition applied to model engine excitation
- Temperature effects on flue viscosity and dissipations considered

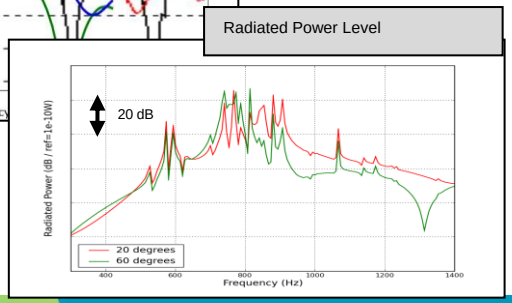
Benefits

- Actran results are able to capture hydraulic resonances
- Inside duct visco-thermal dissipations are properly modeled
- Radiated power levels are predicted











Door closing sound

Challenge

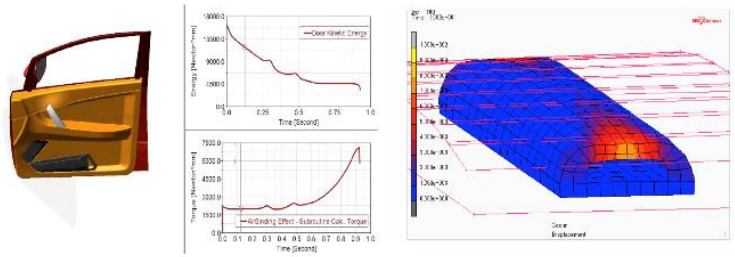
- The door closing sound is an important parameter for positive “showroom effect“. It is important to design door structures and seals according to the sound they will generate when closing

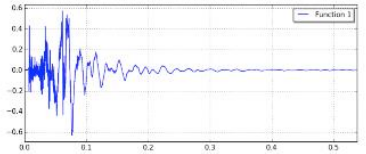
Solution

- Marc computes the non-linear deformation and contact of the door seal.
- Adams computes the door mechanism and vibration and Actran the acoustic propagation

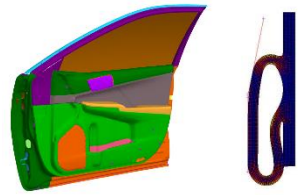
Benefits

- The door closing sound is simulated and can be optimized according to specifications. Subjective evaluation can be done based on simulation results





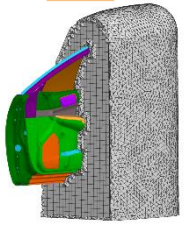
Ad Adams + Ma Marc



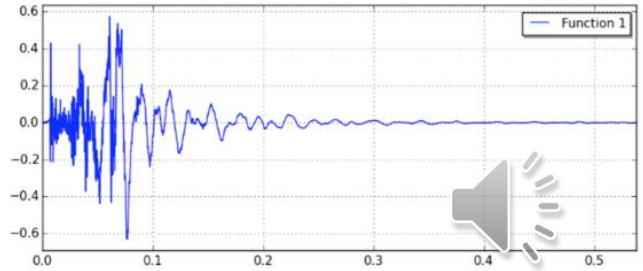
Door closing motion computed with Adams using flexible bodies

Rubber seal highly non-linear behavior computed by Marc

Ac Actran



Acoustic radiation computed using Actran



HEXAGON

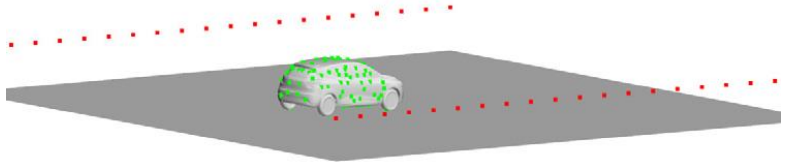
Car pass-by noise prediction

“ We were thinking we would reach a limit in the size of the problem we wanted to address, both in terms of dimensions and frequency. Finally, thanks to Actran’s methodology and HPC, we were able to achieve our goal.”

– Philippe Mordillat, NVH CAE Expert, Methodology Development at Renault

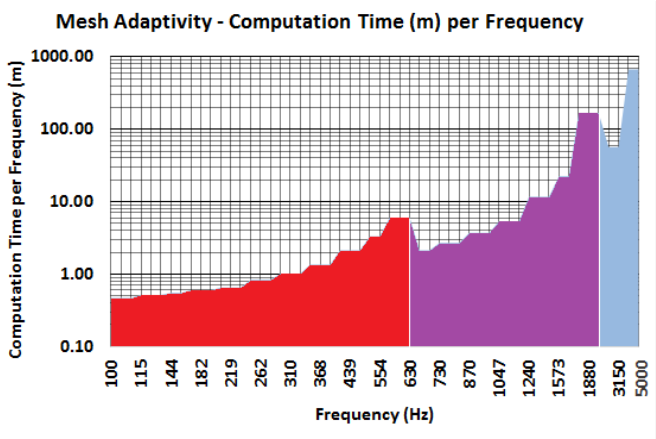
Challenge

- Predict Acoustic Transfer Functions between sources and pass-by noise microphone location as early as possible in the design phase.



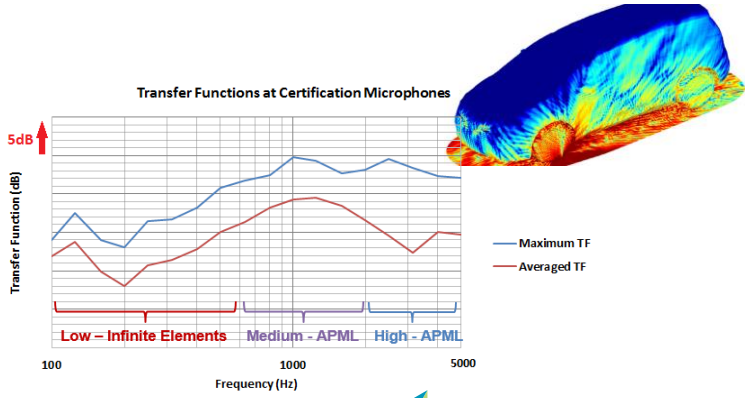
Solution

- MSC’s Actran performs adaptive exterior acoustic radiation calculations including multiple loadcases to compute the Acoustic Transfer Functions around a complete car in a single fast run



Benefits

- The influence of a change of design on the different acoustic transfer function is assessed without tests.
- The effect of different acoustic insulation packages can also be evaluated.



HEXAGON

Exhaust flow noise

FFT Acoustic Conference 2016, Exhaust flow noise simulation in the Automotive field, S.Vizzini

Challenge

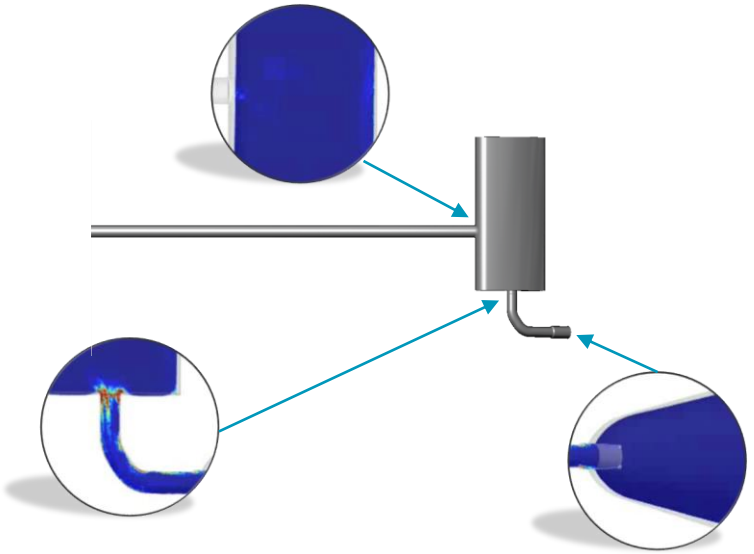
- Muffler are very useful devices from an acoustic point of view
- Due to the high-speed flow within the muffler, flow noise appears
- The goal of this study is the computation and validation of the flow noise of a car muffler

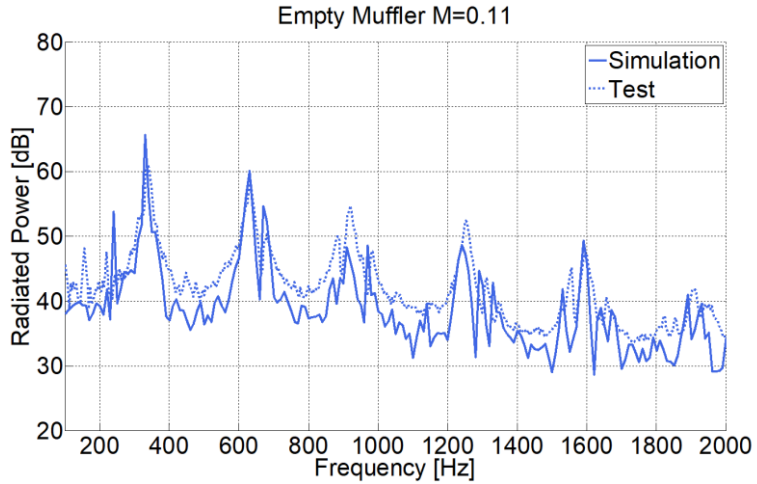
Solution

- Actran predicts the noise created by turbulent flow in the exhaust line. The Lighthill analogy is used to compute acoustic sources based on unsteady CFD data
- The computed sources are then propagated

Benefits

- Actran has been successfully applied to predict the exhaust pipe noise due to turbulent flow. The complete calculation was performed in 12 hours up to 2000 Hz.
- Actran SNGR was also used to predict the relative performance of several designs.





Catalytic converter transmission loss

FFT Acoustic Simulation Conference 2016

Challenge

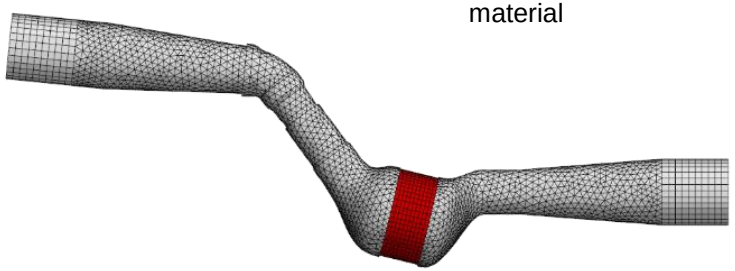
- Catalytic converters are used by car manufacturer to cope with engine particulate emissions regulations and have non-negligible acoustic footprint when they are integrated in the exhaust line

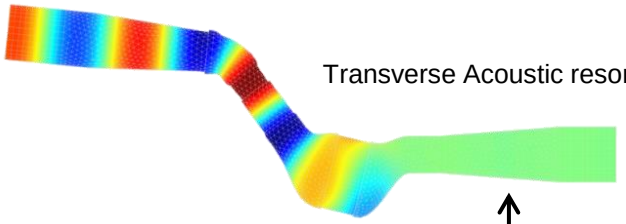


Substrate modeled as anisotropic porous material

Solution

- Actran predicts the Transmission Loss of a catalytic converter by using **an anisotropic porous** material to model the substrate

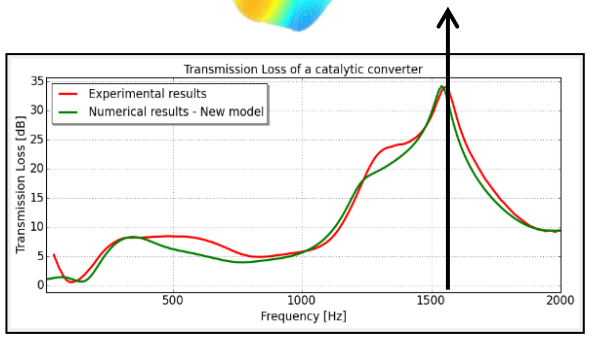




Transverse Acoustic resonance

Benefits

- Actran was successfully applied to predict the TL of a catalytic converted.
- Actran is able to model complex 3D resonances occurring in the system.



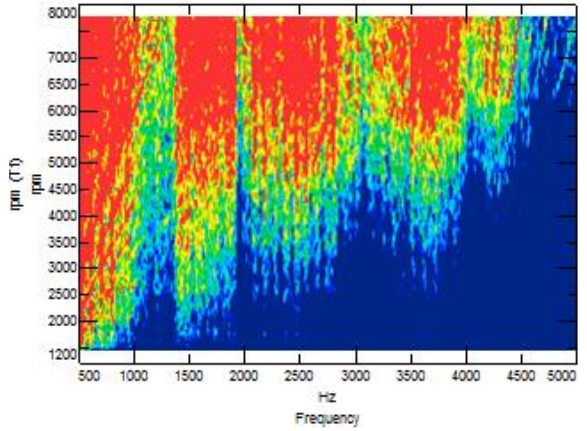
HEXAGON

Optimization of coaxial muffler for harshness

FFT Acoustic Conference 2016, Ferrari Sound Design, F. Carosone

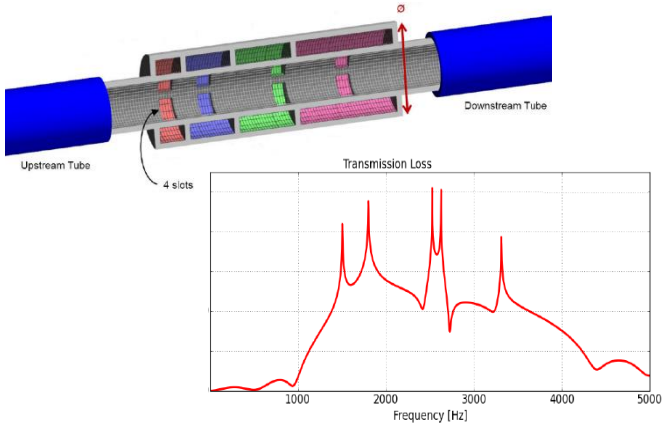
Challenge

- The noise from the exhaust is a fundamental component in the sound of a sports car and must be carefully designed to deliver the desired acoustic footprint.



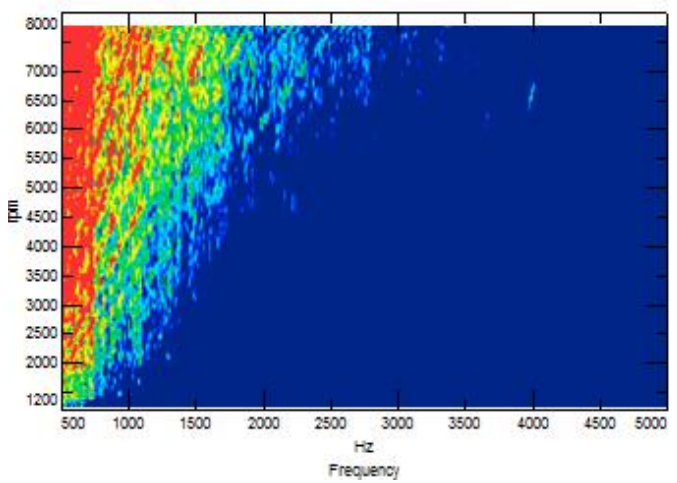
Solution

- Actran and its embedded optimization solution are used to optimize the Transmission Loss of a multi-chambers coaxial muffler in order obtain a low-pass filter and drop the unwanted component of the sound



Benefits

- Measurements of the geometry optimized by Actran confirmed the performance of the design.
- The resulting car sound offers the driver the targeted sports car experience driven by low frequency acoustic content

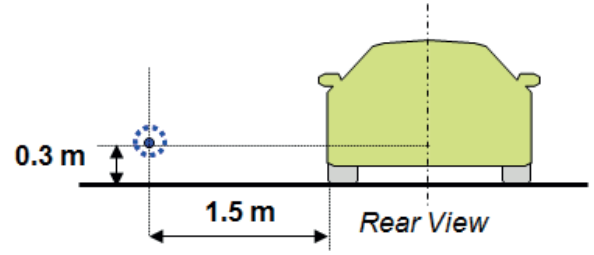


Engine encapsulation

ATZ Conference on Vehicle Acoustics 2017, On the role of simulation in accounting for the design complexity of engine encapsulation, R. D'Amico & al

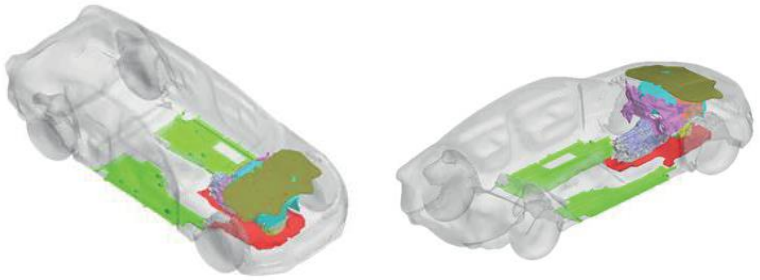
Challenge

- Increasing need for advanced engineered acoustic treatment in the engine bay for CO2 and noise emission regulation



Solution

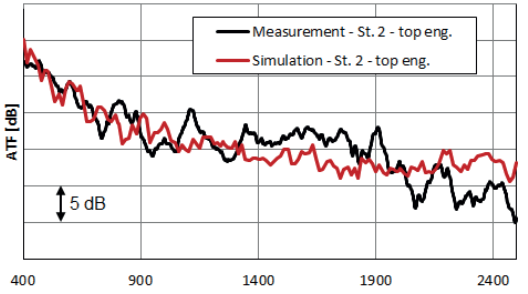
- Actran is used to compute engine noise radiation including complex acoustic treatments



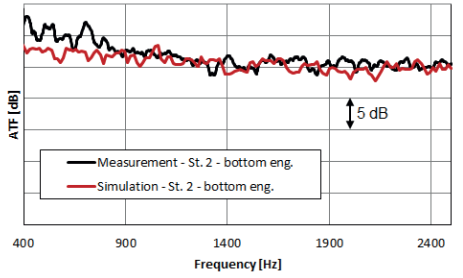
Actran model including acoustic treatments

Benefits

- Accurate prediction of the effect of engine mounted and body mounted engine encapsulation on the acoustic propagation around the complete vehicle



Acoustic transfer function from engine to near field microphone



Firewall panel transmission

FFT Acoustic Simulation Conference 2016, Modular NVH – from complete vehicle NVH demands to detailed part design, F. Bissardella et al.

Challenge

- System break-down to part and module level is necessary in order to understand the physics, troubleshoot weaknesses and identify optimization potentials

Solution

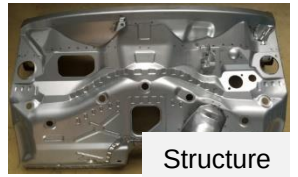
- Detailed vibro-acoustic simulation with Actran are performed to study the acoustic transmission of insulated panels

Benefits

- The numerical model provides accurate results and is easily changed to study optimize the part performances



Firewall in reverberant room



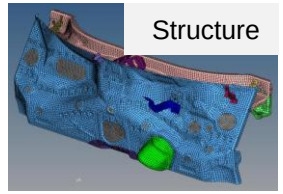
Structure



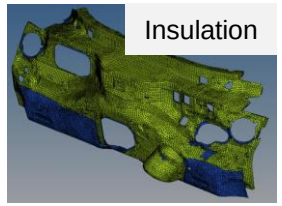
Insulation

Firewall in reverberant room

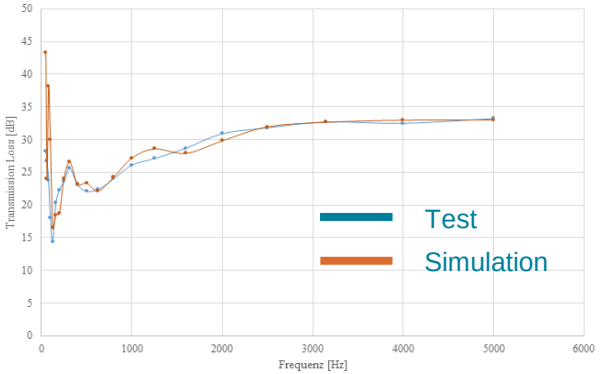




Structure



Insulation

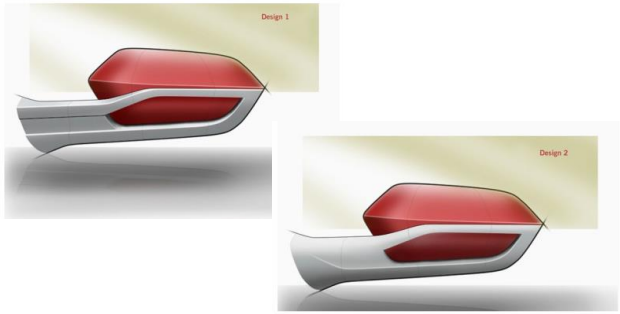


High frequency side mirror noise

Aachen Acoustic Colloquium 2017, Efficient Method for extending Car Wind Noise Prediction Frequency Range based on Steady CFD input, F.Bissardella, A.Talbot, Y.Detandt, T.Cordaro

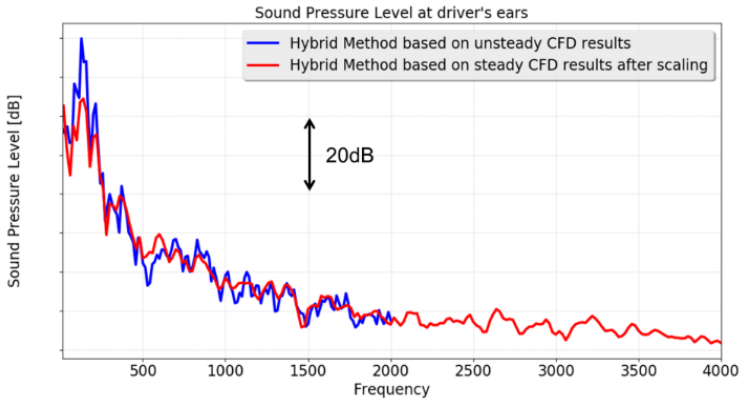
Challenge

- Accurate side mirror noise prediction can be achieved using an unsteady CFD simulation and Actran aeroacoustics. The maximum frequency is limited by the CFD mesh refinement
- Design comparison is costly using unsteady CFD simulations



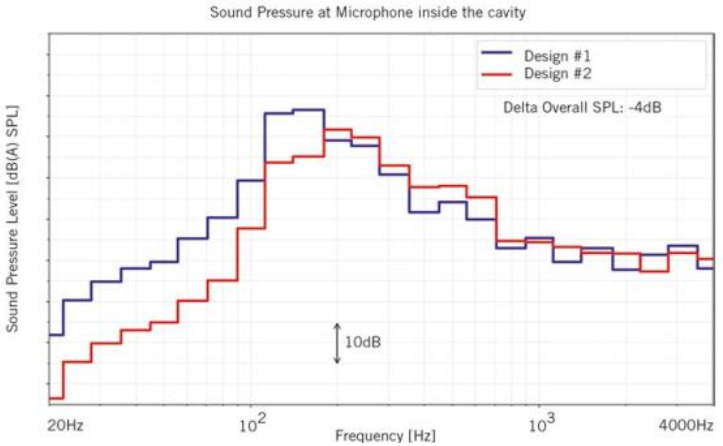
Solution

- Actran SNGR is used to extend the frequency range using steady CFD results
- Results are obtained in a larger frequency range without any modification in the CFD calculation



Benefits

- At early stages, simulations must be fast and provide information on the relative performance of different design candidates.
- Aero-acoustic simulations based on steady CFD simulations and the SNGR method are used to establish a ranking according to acoustic performance.





Acoustic Transmission through emission control devices

DAGA 2018, Acoustic modeling of a Diesel Particulate Filter using a double equivalent fluid homogenization approach, G. Lielens, M. Brandstetter, A. Talbot

Challenge

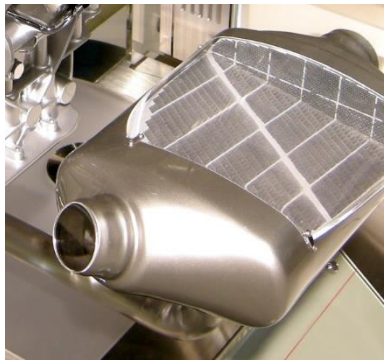
- Catalytic converters and particulate filters (DPF/GPF) are present in vehicle exhaust systems to reduce pollution emission.
- These devices have non-negligible impact on the acoustic behavior of the exhaust line

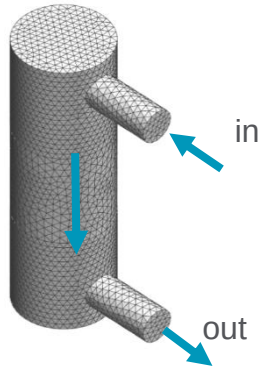
Solution

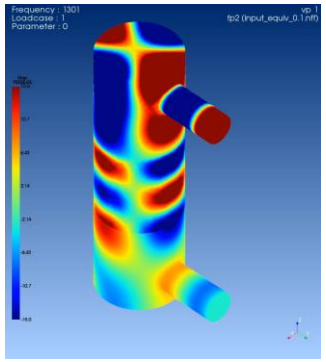
- These complex devices are modeled in 3D with an equivalent approach without the need to mesh the holes

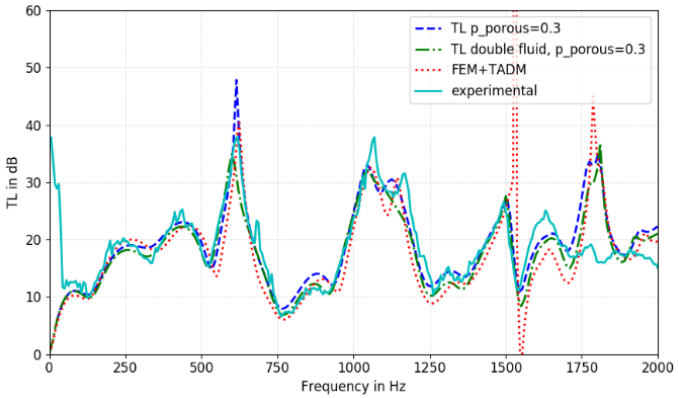
Benefits

- Acoustic transmission through emission control devices is evaluated accurately with minimal meshing requirements









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Full Vehicle Wind Noise

Internoise 2018, Broadband noise prediction of stochastic sources based on the linearized Euler equations, C.Legendre et al

Challenge

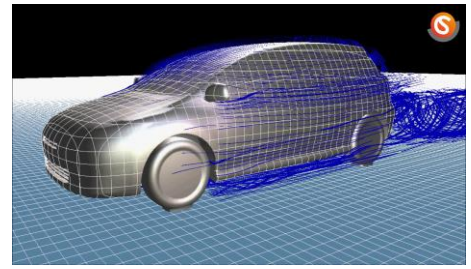
- Wind Noise can have significant contribution to both interior and exterior vehicle noise.
- Computing wind noise on a complete vehicle is challenging because of size limitations

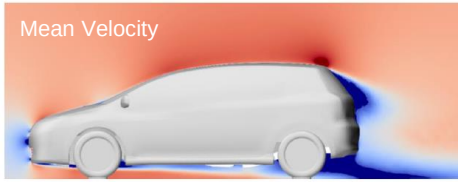
Solution

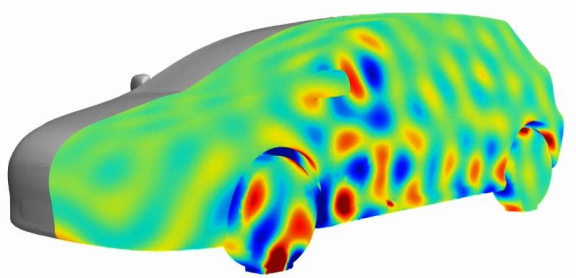
- Based on steady CFD analysis results, the SNGR method is applied to compute aero-acoustic noise sources which are propagated using the Actran DGM solver

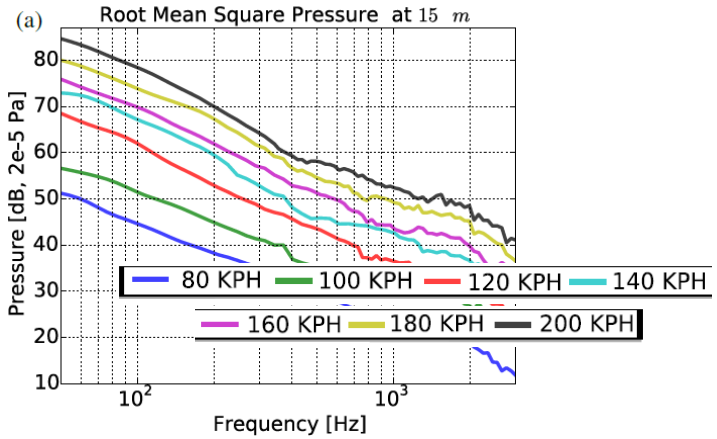
Benefits

- With the combination of SNGR methodology and Actran DGM solver, the exterior wind noise and the aero-acoustic loading on the vehicle is computed leveraging on GPU acceleration.
- The effect of design change or vehicle speed change is assessed quickly









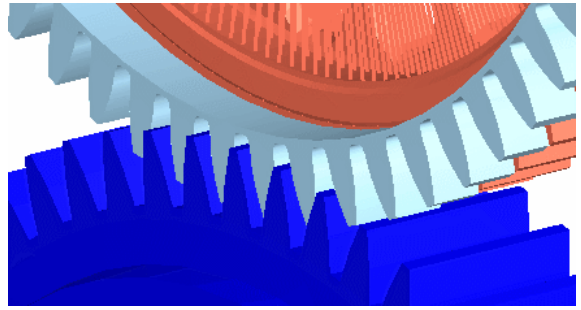
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Assessment of engine gear rattle and whine noise

CAASE18, Vibration and Radiated Noise Simulation of Engine Gear Rattle and Whine, M. Moetakef, A. Zouani, M. Felice, E. Pesheck, R. Baudson, M. Cabrol, J. Baumann, B. Campbell

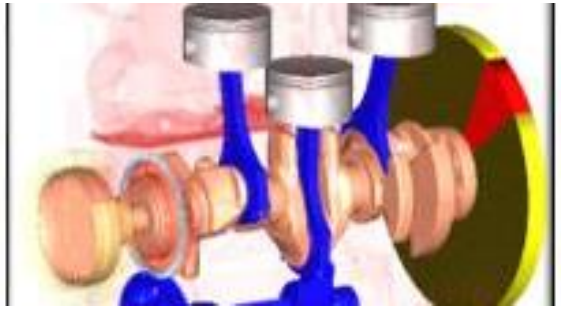
Challenge

- Develop a noise risk assessment methodology for engine gear noise
- Predict transmission error factors impact on induced vibrations and noise emission



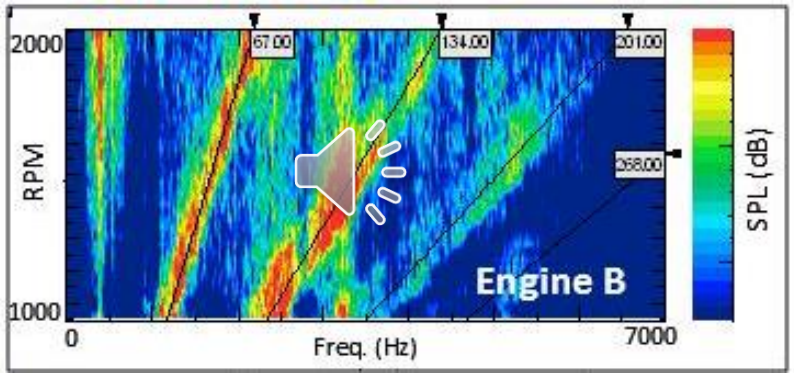
Solution

- Integration of MSC's Nastran, Adams and Actran in analytical methodology to provide directions for robust NVH design
- Objective and subjective evaluation of noise performance by generation of sounds files



Benefits

- Assessment of key NVH factors to consider in engine gear design
- Structural weak point assessment via structure path analysis



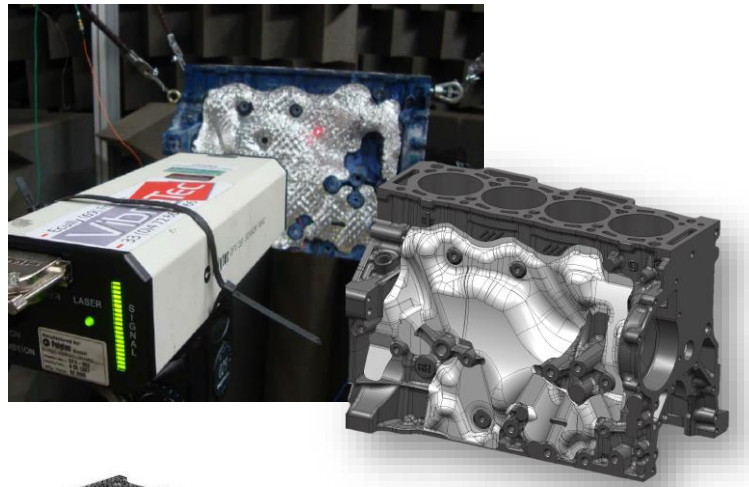
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Engine encapsulation design comparison

HxGN Live Design & Engineering 2021, Direct poroelastic encapsulation modelling method for engine radiated noise reduction purposes, Cedric Dumont

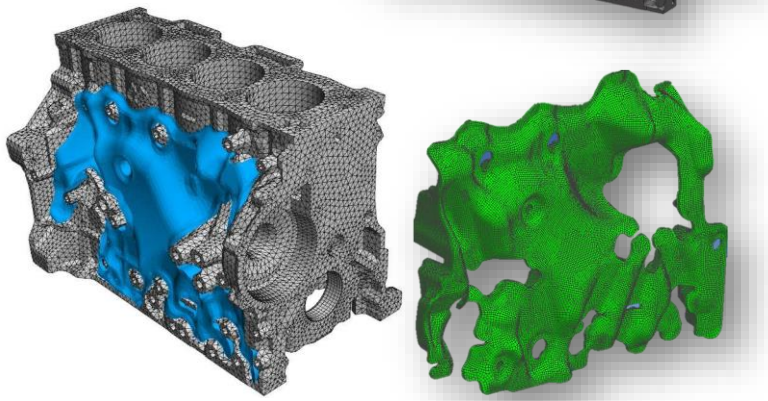
Challenge

- Assess the acoustic radiation of ICE powertrain with in-contact absorbing treatment
- Comparison of encapsulation material layout and properties (porous and elastomer)



Solution

- Actran reads MSC Nastran vibrations results
- Modeling of in-contact absorbing treatments and impact on acoustic radiation thanks to FE approach



Benefits

- Mesh creation and post-processing done in ActranVI with dedicated tools
- Consideration of in-contact engine encapsulation
- Direct access to acoustic radiation directivity and total sound power



Robust design of powertrain cover

FFT Acoustic Simulation Conference 2018, Philippe Mordillat, Cécile Dutrion, Sandra Forget

Challenge

- Focus on powertrain-generated noise in a context of **stricter regulations** and **improved comfort**
- **Robust design of treatments** (optimization and variability analysis) is more challenging as it implies **multiple acoustic radiation analyses**

Solution

- **FEM-based** numerical modeling has been **extensively validated and is easy to set-up**
- Perform a **static condensation** on interfaces of selected acoustic surface allows to **solve** and **optimize a smaller residual problem**

Benefits

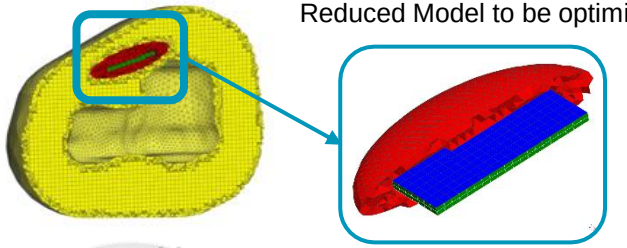
- **Computational gain** of static condensation is good at **higher frequencies**
- **Mesh adaptivity** further improves performances

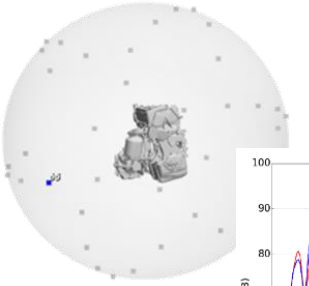


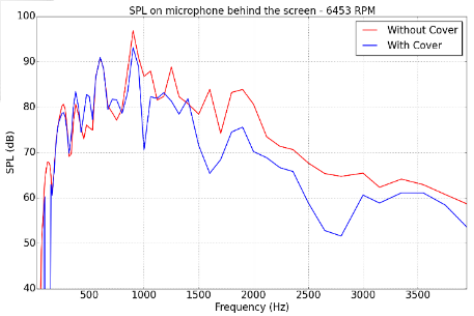
Serial production - Full Engine Encapsulation (~3kg)

Initial Global System

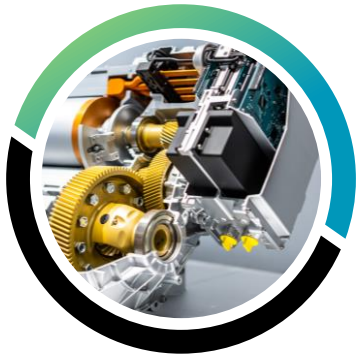
Reduced Model to be optimized







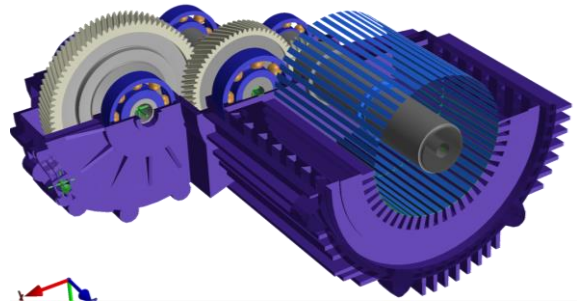
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Electric motor gear noise prediction

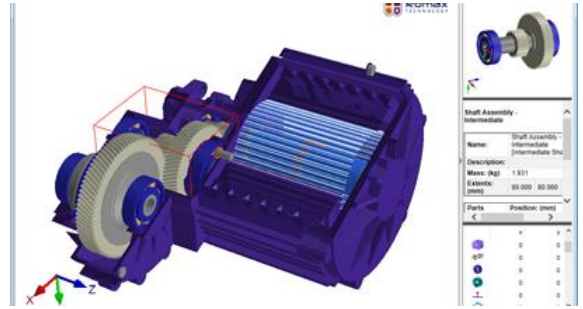
Challenge

- Allow non-experts to assess the effect of design changes on noise performance targets
- Accelerate development processes by reducing design time and minimizing prototyping and testing
- Cope with consumer expectations of quality



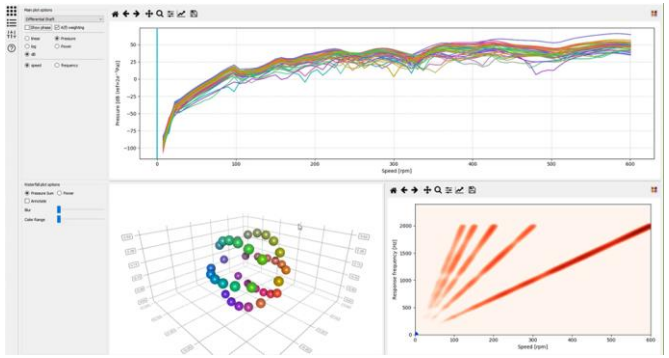
Solution

- Electric machine modelled structurally as FE model with electro-magnetic forces imported from EM FE tools (Dassault Opera, MDL Motor-CAD, Ansys Maxwell, Altair Flux)
- Frequency domain Actran solver calculates pressure at microphone locations



Benefits

- Post-process acoustic results while remaining inside Romax environment
- Possibility to reuse created analysis inside Actran for more complex acoustic environment modeling



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HONDA

Automotive tailpipe flow noise prediction

FFT Acoustic Simulation Conference 2018, Steve Eich, Ryan Quern, Adam Miller & Shira Katz

Challenge

- Flow-induced noise is an important contribution of noise in exhaust systems
- Jet noise generated inside the exhaust line should be mitigated

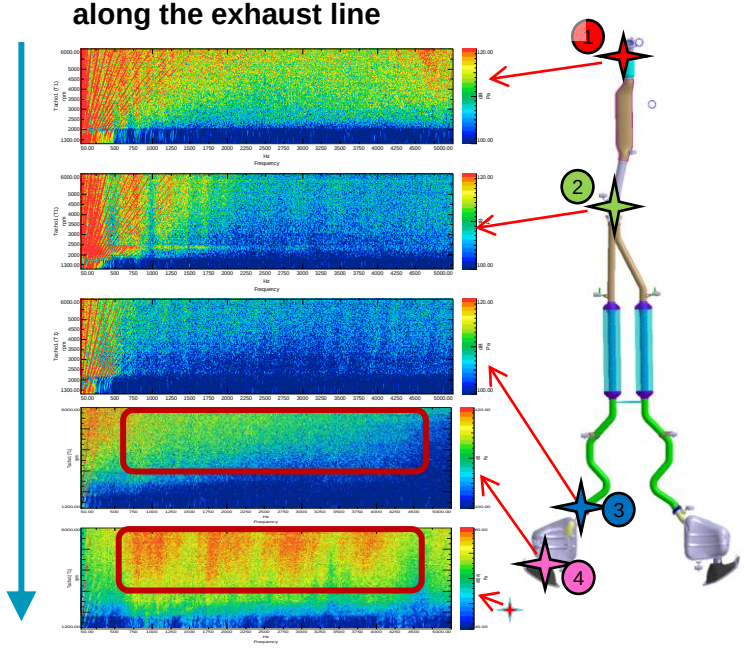
Solution

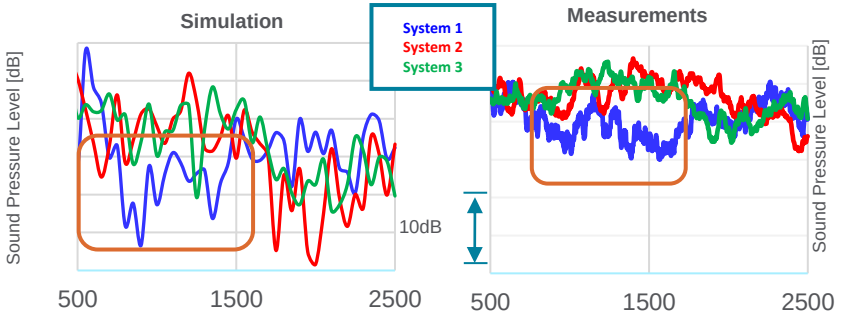
- MSC's Actran is coupled to Cradle CFD results for aeroacoustic prediction inside exhaust line
- The unique SNGR method is applied to quickly compare exhaust line designs

Benefits

- Fast and efficient **design comparison** thanks to **SNGR** method
- Accuracy of simulation results
- Possibility to distinguish acoustic and turbulent contribution thanks to specific post-processing capabilities

Increase of aeroacoustic noise along the exhaust line





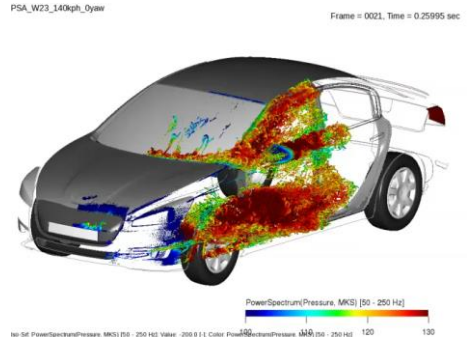
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Wind noise assessment

FFT Acoustic Simulation Conference 2018, François Van Herpe

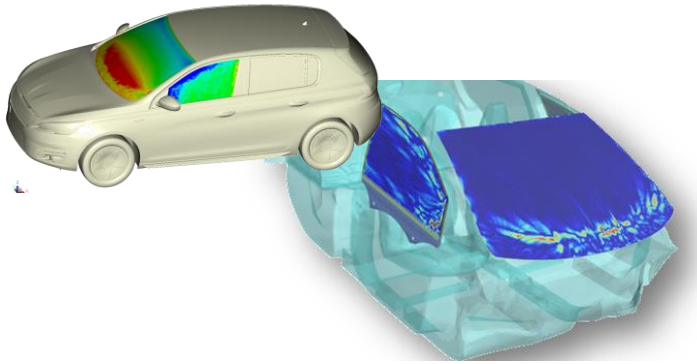
Challenge

- Improve passenger acoustic comfort driven by aerodynamic loads at mid- and high-frequencies above 100 km/h.
- Reduce experimental measurements
- Include aeroacoustic modeling in early design phase



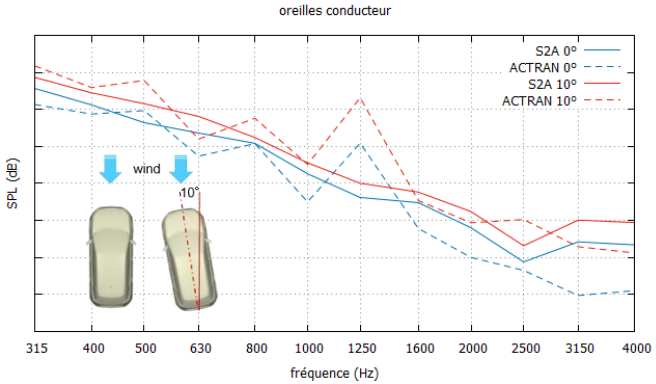
Solution

- MSC's Actran is coupled to CFD results for interior vibro-acoustic prediction
- Advanced CFD results processing reduces solution computation and efficient loading comparison



Benefits

- Fast and efficient computations together with ease of use thanks to specific MSC's Actran solution capabilities
- Accuracy of simulation results
- Possibility to distinguish acoustic and turbulent contribution thanks to specific post-processing capabilities



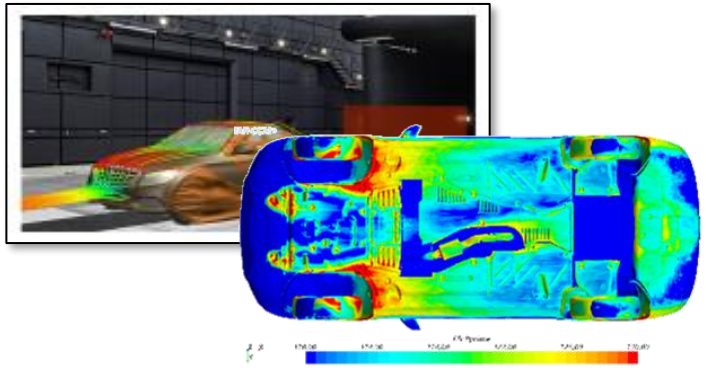
DAIMLER

Trimmed Underbody Acoustic Transmission

FFT Acoustic Simulation Conference 2018, Georg Bettinger

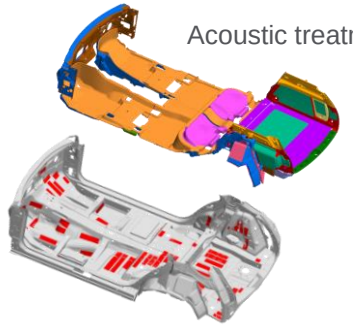
Challenge

- Wind flow generates underbody pressure loading inducing vibrations that have a significant contribution to the interior sound level
- Reduction of interior sound thanks to underbody optimization and exterior/interior acoustic treatments

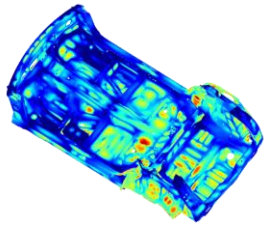


Solution

- Underbody acoustic insulation performance prediction
- MSC's Actran is coupled to Nastran structure model
- Modeling of exterior and interior damping pads and acoustic treatments



Acoustic treatments

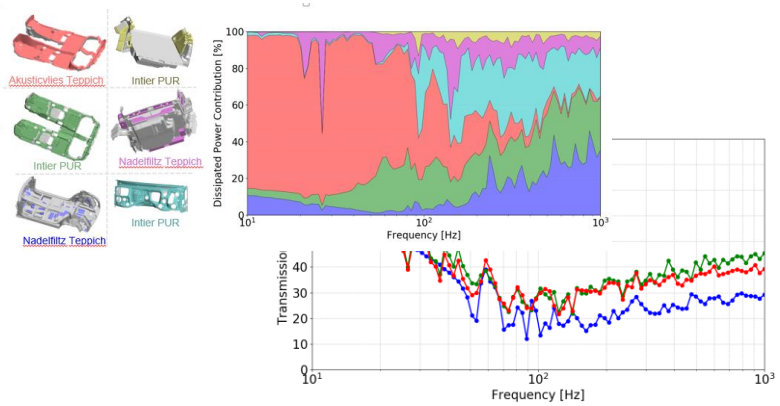


Structure vibrations

Structure with damping patches

Benefits

- Fast and efficient computations together with ease of use thanks to specific MSC's Actran solution capabilities
- Accuracy of simulation results



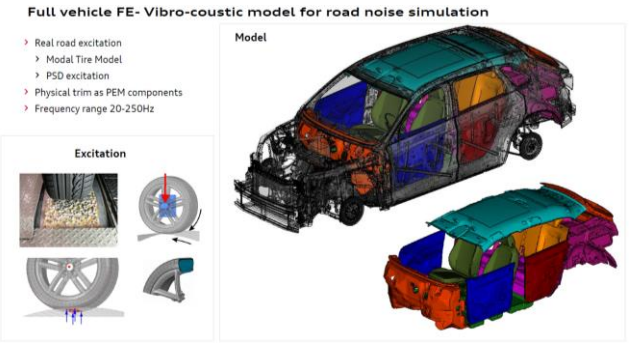
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Structure and Trim Mass Optimization

ISNVH 2018 SAE Technical Paper 2018-01-1547, Optimization of Trim Component and Reduction of the Road Noise Transmission Based on Finite Element Methods, Guellec, A., Cabrol, M., Jacqmot, J., and Van den Nieuwenhof, B.

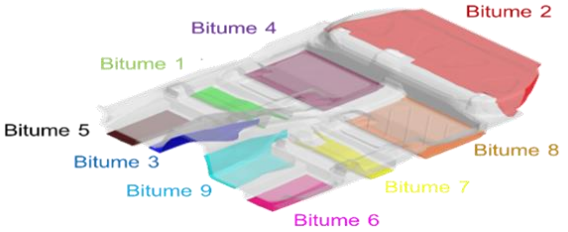
Challenge

- Find the optimized trim package solution to meet interior noise levels while respecting restrictive weight and new space constraints due to batteries



Solution

- MSC Nastran PEM topography optimization of the structure considering trim component effects.
- Trim components material properties optimization with Actran.



Benefits

- The structure is optimized considering accurately the trim component effects thanks to MSC Nastran PEM.
- Sound pressure level reduced inside the cabin with a trim component mass reduction compared to initial design.



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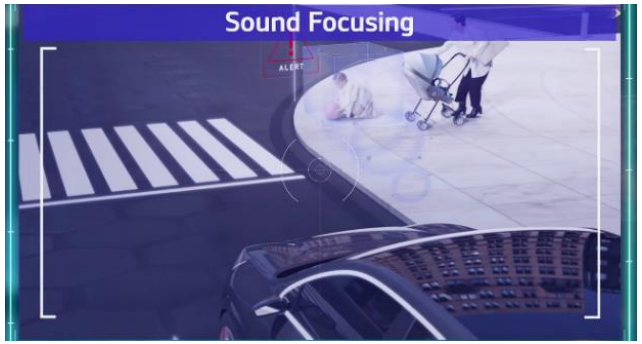
Optimization of Active Pedestrian Alerting System

"The simulation results provided by Actran were much more comprehensive than information generated by physical testing, which helped Hyundai engineers quickly iterate to an optimized design in about half the time that would have been required using traditional build and test methods."

– Jinmo Lee, Senior Research Engineer, Hyundai Motor Company

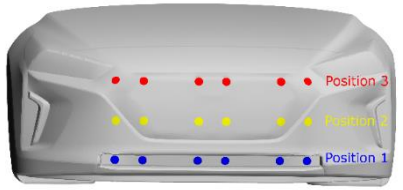
Challenge

- Satisfy government regulations and enhance safety features of Evs
- Avoid emissions of excessive sound reducing passenger comfort
- Design sound focusing technology emitting alerting sound only to pedestrian in danger

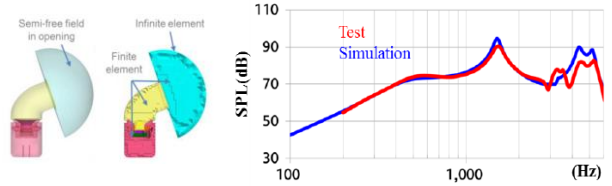


Solution

- Actran is used to optimize speaker array design and vehicle integration of an Active Pedestrian Alerting System (APAS)
- Study the impact of speaker enclosure and location to ensure optimal sound emission

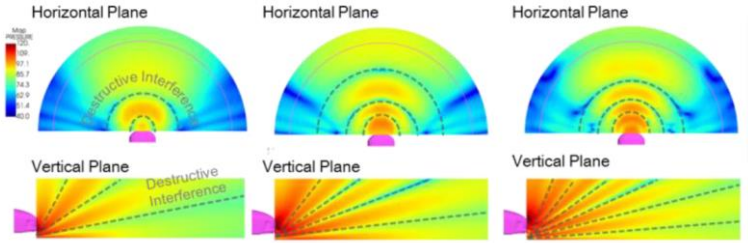


Loudspeaker Model Validation



Benefits

- Find appropriate design speaker enclosure and location to both respect APAS targets and driver's noise comfort.
- Reduction of speaker size and power consumption
- Reduction of time to optimize by 50 %





Ultrasonic Sensors in Self-Driving Cars

Challenge

- Ultrasonic sensors will come to have a much wider range of uses as autonomous driving systems develop
- Increase ultrasonic sensors detection distances and angle view of obstacles
- Vehicle integration (see through metal/plastic parts, aesthetic, …)

Solution

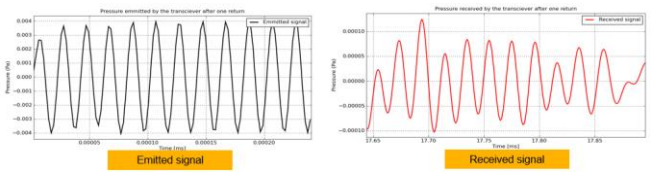
- Actran DGM is used to compute the transient signal emitted by piezo-electric transducers
- The strong coupling between the sensor and the structure is taken into account
- The sensor is designed for optimized detection efficiency

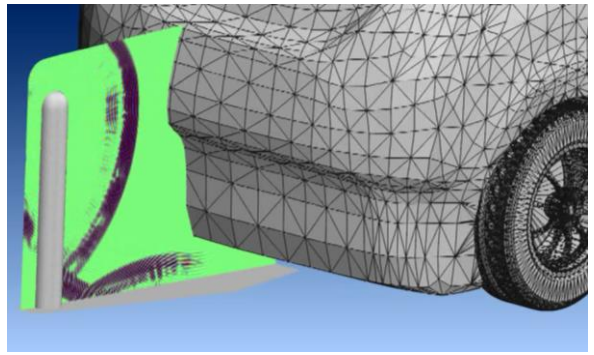
Benefits

- Actran is providing acoustical information to engineers working on signal processing
- The transducer is designed for optimized efficiency considering its car integration (different locations, materials and purpose)









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Headrest Loudspeaker Integration

FFT Acoustic Simulation Conference 2018, A History of Actran at Bose, Sarah Heile

Challenge

- Address the need of individual listeners
- Create individualized experience
- Account for the various seats and the car environment in general

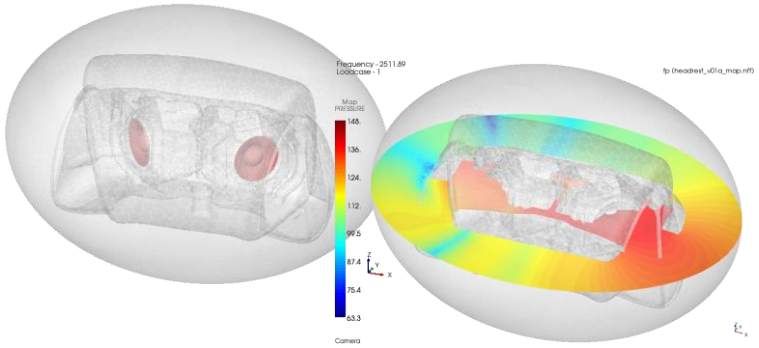




automotive.bose.com

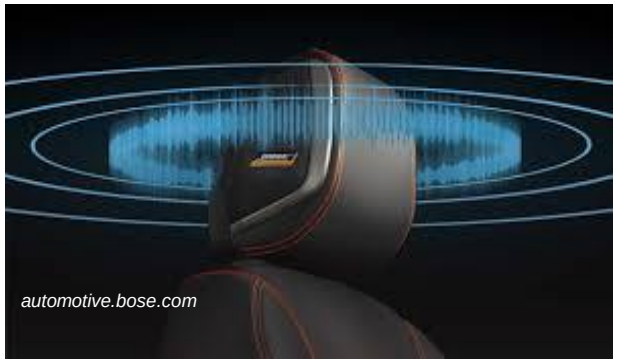
Solution

- Actran’s vibro-acoustic capabilities offer accurate loudspeaker modeling and consideration of real environment assessment
- Direct access to directivity performance and phase-shift optimization



Benefits

- Accuracy of simulation results with respect to measurements.
- Possibility to rely on simulation to improve loudspeaker design and integration at lower cost.

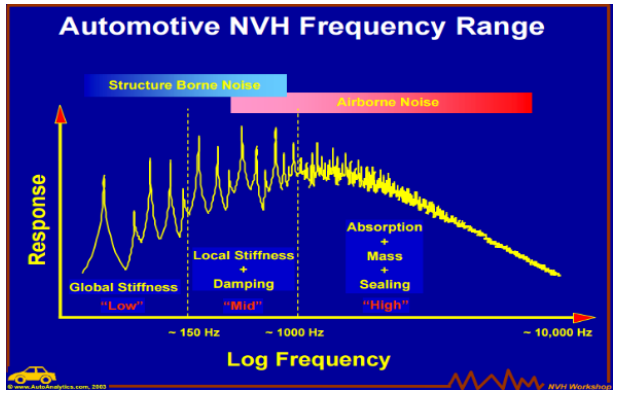


Full car TPA analysis based on SEA modeling

Aachen Acoustics Colloquium 2018, SEA Modelling and Transfer Path Analysis of an Extensive RENAULT B segment SUV Finite Element Model, M. Brandstetter, C. Dutrion, P. D. Antoniadis, P. Mordillat, B. Van den Nieuwenhof

Challenge

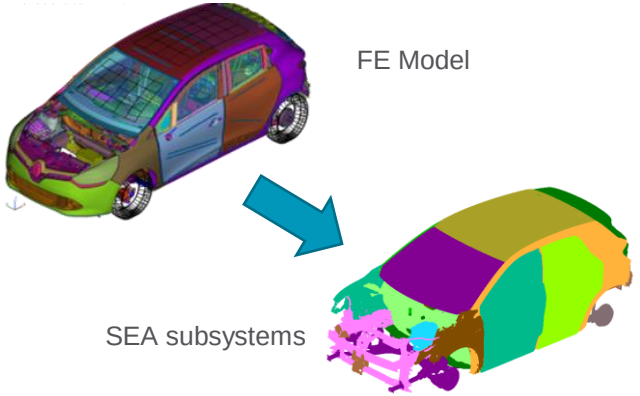
- Extend structure-borne noise prediction to mid and high frequencies
- Rely on existing validated low frequency FEM models
- Build valid SEA models



Reference: SAE 2003 NVH Conference

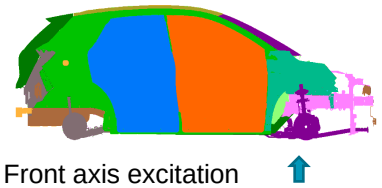
Solution

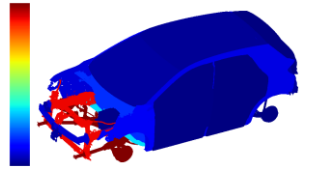
- The Actran SEA module uses an existing MSC Nastran low frequency FE model to build the SEA model based on the Virtual SEA approach

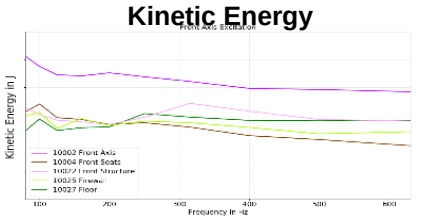


Benefits

- Ensure smooth transition in-between low, mid and high frequency model
- Virtual TPA analysis thanks to energy levels and flux transfer analysis







Full trimmed body vehicle simulation

SAE Technical Paper 2019-01-1511, 2019, Extensive Correlation Study of Acoustic Trim Packages in Trimmed Body Modeling of an Automotive Vehicle, Yoo, J.W., Brandstetter, M., Jeong, C., Jacqmot, J. et al.

Challenge

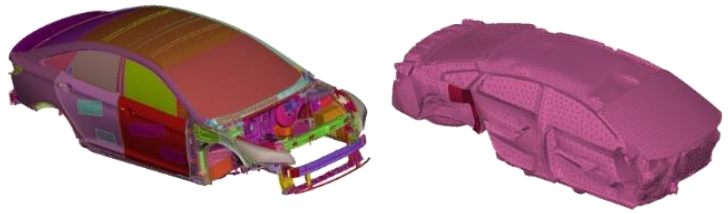
- Define **predictive** and **efficient** simulation methodology framework to assess **acoustic trim package efficiency** at low and mid frequencies



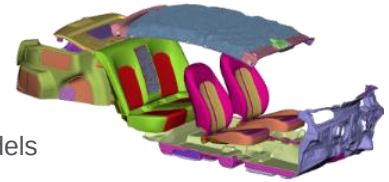
Solution

- **MSC Nastran PEM** based on the **Actran** Reduced Impedance Matrix method is able to efficiently and accurately **predict all acoustic trim effects (insulation, absorption and damping)**

Structure and Cavity FE Models

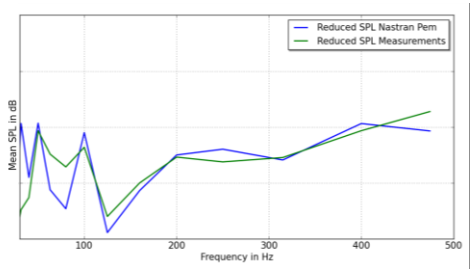


Trims FE models



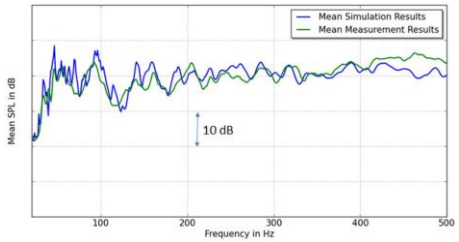
Benefits

- **Accurate** acoustic trim effects prediction **with respect to measurements** compare to impedance surface trim modeling over 200 Hz
- Possibility to **rank acoustic trim configuration** performance



Mean acoustic trims effect on SPL – methods comparison vs. measurement

Local SPL Simulation vs. Measurements



Truck trimmed cabin acoustic transfer function

FFT Acoustic Simulation Conference 2018, Noise Transfer Function of a Truck Cab Using Actran for Trimmed Body, Florence Brefort, Fabien Acher

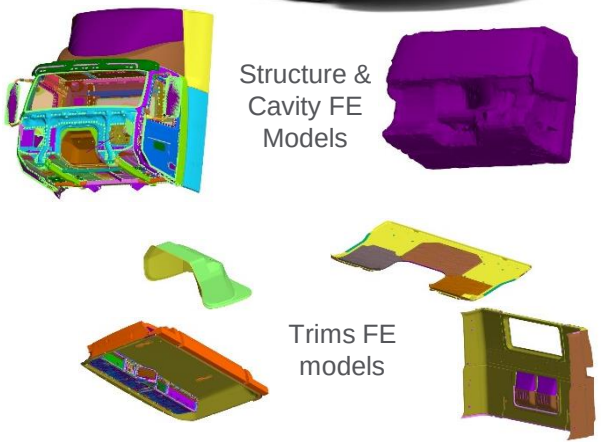
Challenge

- Estimation of **noise transfer functions** at low frequency in **early design phases** to reduce noise in truck cabs



Solution

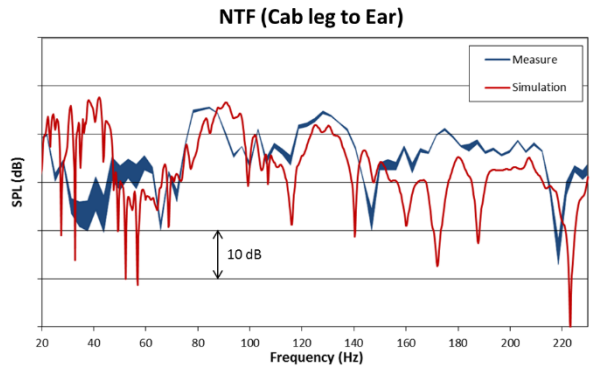
- **MSC Nastran PEM** based on **Actran** Reduced Impedance Matrix method is able to efficiently and accurately **predict all acoustic trim effects (insulation, absorption and damping)**



Benefits

- Actran for Trimmed Body provides an **efficient method to capture trim behavior** at low frequencies (50-230 Hz)
- An **analytical trim capability** enables fast concept studies for trims

Noise Transfer Functions

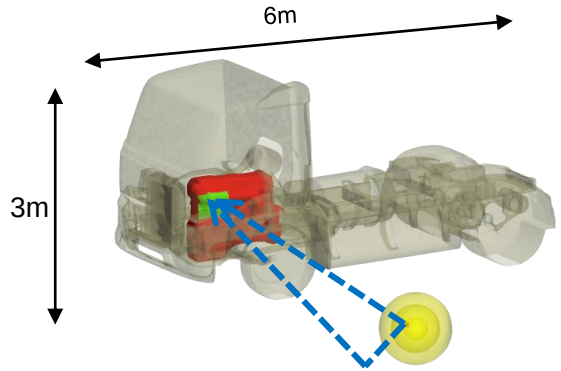


Truck engine contribution to pass-by Noise

FFT Acoustic Simulation Conference 2018, Computation of Acoustic Transfer Functions between Pass-by Noise Certification Microphones and Engine Surface, Sophie Girolami

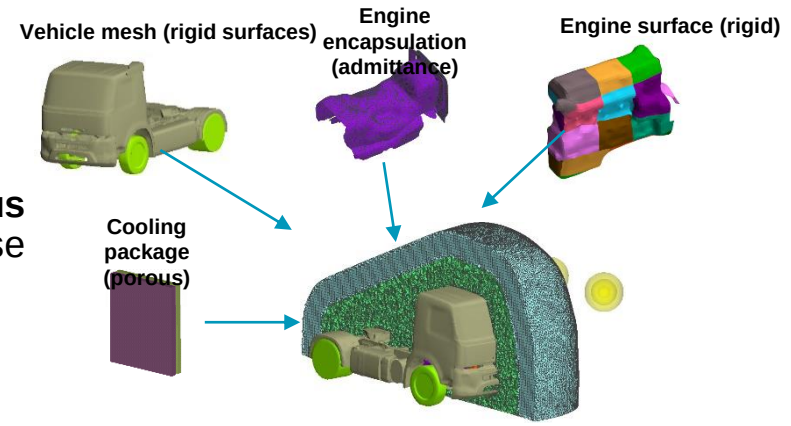
Challenge

- Understand **engine contribution** to final **pass-by noise** test including complete engine encapsulation treatment and cooling radiator effects



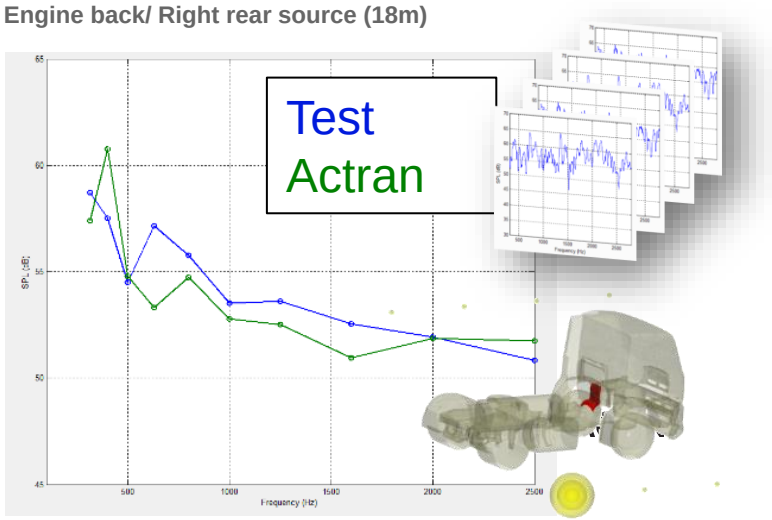
Solution

- Actran's efficient **multiple source handling**, **porous** modeling and **acoustic mesh adaptivity** allow precise reproduction of static Pass-by noise test



Benefits

- **Good correlation** between test and Actran results.
- **Flexibility** allows **parametric studies** on encapsulation concepts
- **Multiple noise sources handling** in one computation and possibility to **rank transfer path functions**



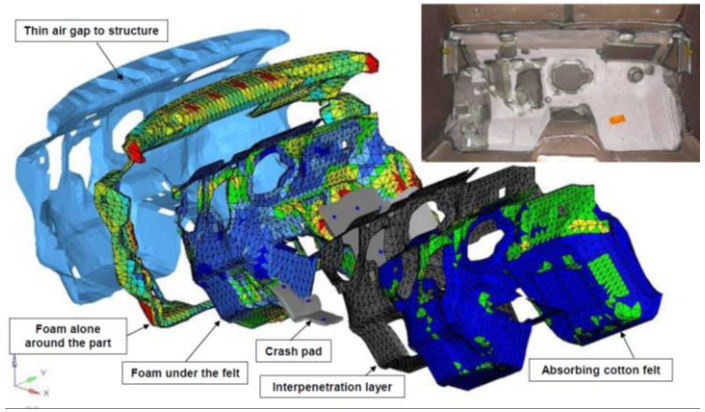
faurecia

Acoustic study of dash insulator and instrument panel

FFT Acoustic Simulation Conference 2018, Enabling innovative concepts for complete front vehicle unit through numerical assessment of acoustic insulation, Ludovic Dejaeger, Minh-Tan Hoang

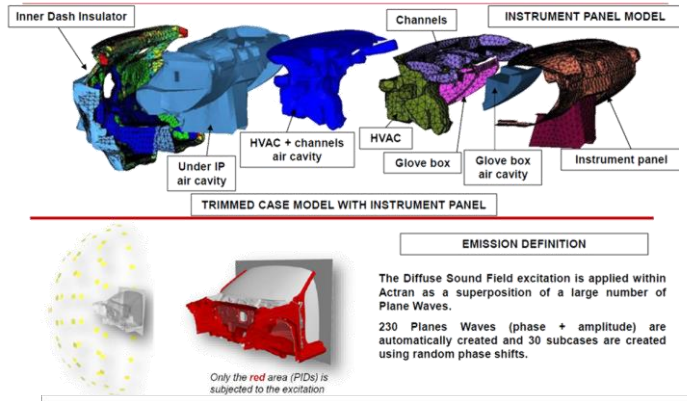
Challenge

- Assessing the acoustic insulation efficiency of complete dashboard insulator and instrument panel



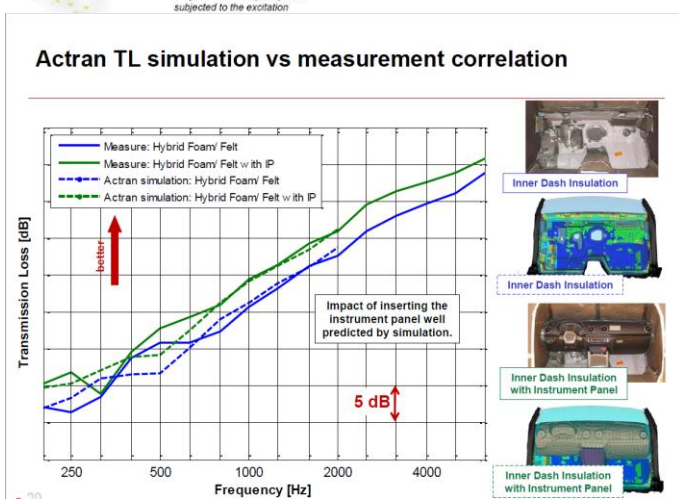
Solution

- Complete FE modeling of multi-layered acoustic treatments
- Nastran FE structural model of front car efficiently re-used in Actran model



Benefits

- **Good correlation** between test and Actran results.
- Access to **main contributor** to acoustic insulation thanks to power balance



Exhaust sound quality tuning

FFT Acoustic Simulation Conference 2018, Tuning an exhaust for sound quality by subjective assessment of acoustic CAE data, Mudassir Farooq

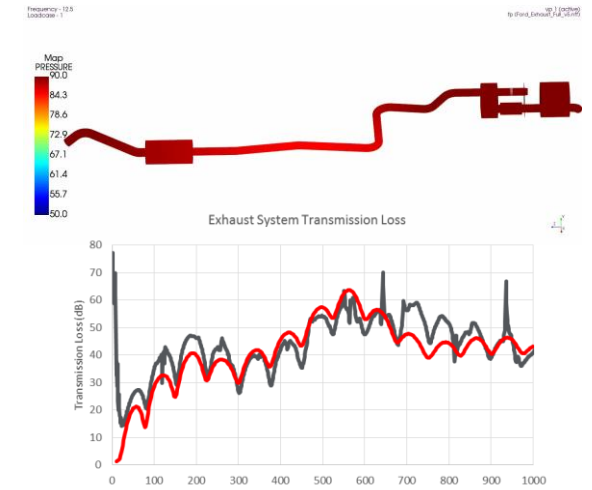
Challenge

- Very often, vehicle sound is associated with the car brand so it's important that a vehicle sounds consistently.
- A process for conducting **CAE analysis** of exhaust systems need to be created as well as **sound quality tuning** based on NVH simulator conclusions



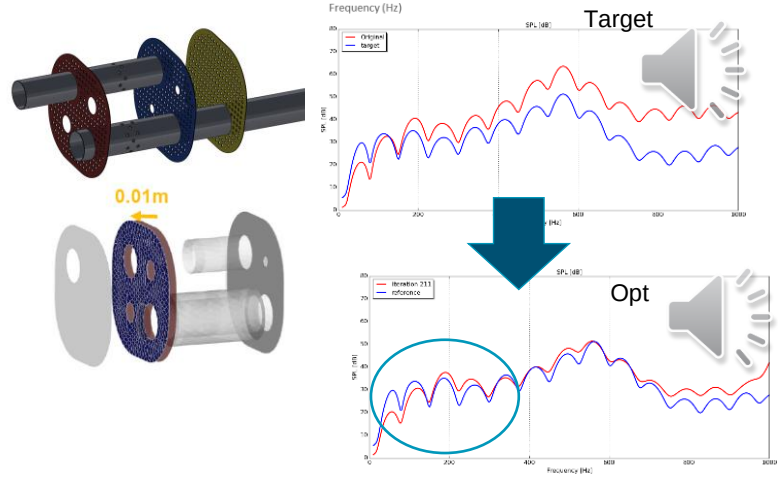
Solution

- Modeling of **entire exhaust line** including **particle filter**, **temperature** and **flow effects** is done in Actran



Benefits

- **Good correlation** between test and Actran results for initial configuration
- Use of **integrated optimization** library to modify **muffler geometry and materials** and reach **sound quality objective**
- Possibility to **listen to numerical results**



Optimization of door sealing

FFT Acoustic Simulation Conference 2018, Trade – off Between Acoustic and Closing Effort Performance of Door Sealings, Orçun Saf, Serkan Çakır

Challenge

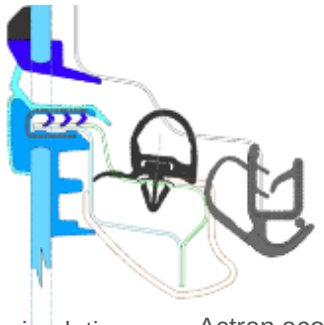
- **Reduce cost** for door sealing design validation
- Find a **trade-off** in-between increase of **acoustic performance** and minimum of **reaction forces** to ease door closing

Solution

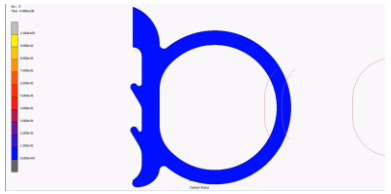
- A **non-linear** Marc model is used to calculate the **seal deformation**
- The non-linear deformation is then used as the input for the **vibroacoustic model** solved by Actran

Benefits

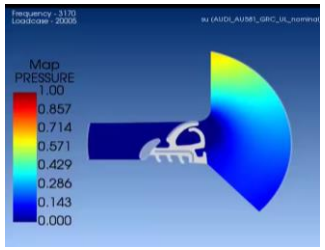
- **DoE** to assess material, thickness and shape effects on noise reduction index and reaction forces
- **Robust part design and optimization**
- Increase of Noise Index with reasonable Reaction Force increase



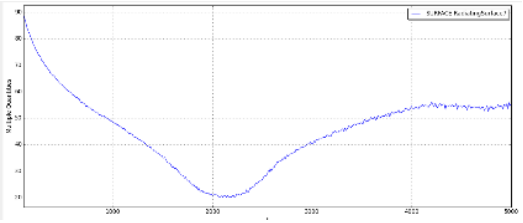
Marc deformation simulation



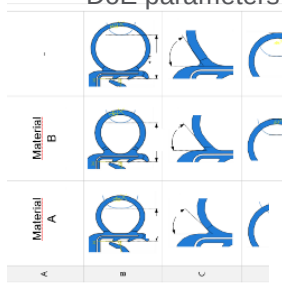
Actran acoustic simulation



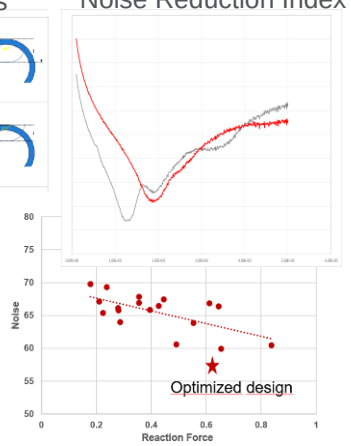
Noise Reduction Index



DoE parameters



Noise Reduction Index



Motorbike Pass-by Noise

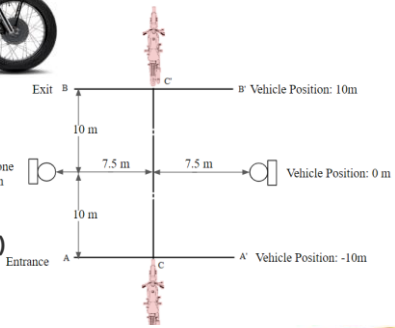
"By providing a fairly accurate insight into expected noise levels even at early design stages, Adams, MSC Nastran and Actran software enabled us to adhere to project delivery timelines, while helping us maintain our stringent quality standards and meet regulatory requirements easily"

Rod Giles, Lead CAE&CAD, Royal Enfield

Challenge

- To design a variety of bikes meeting, the pass-by noise regulation standards in European markets while maintaining Royal Enfield's signature rumble

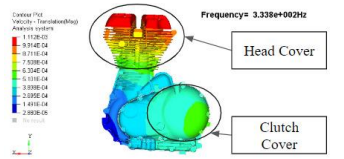




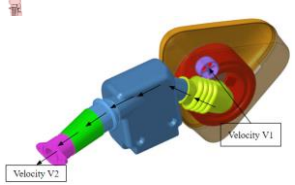
Pass-by Noise Measurement (ISO 362-3)

Solution

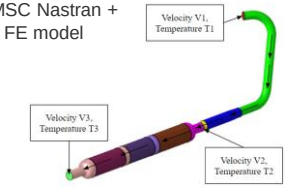
- A combined simulation of Adams Car, MSC Nastran and Actran is performed to help predict noise levels from three dominant noise sources (air intake, engine, exhaust line)



Engine block
Adams + MSC Nastran + Actran FE model



Air Intake
MSC Nastran + Actran FE model

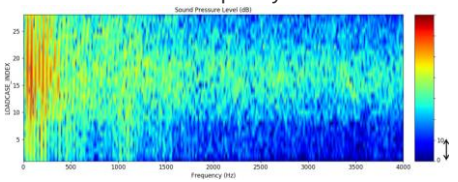


Exhaust Line
MSC Nastran + Actran FE model

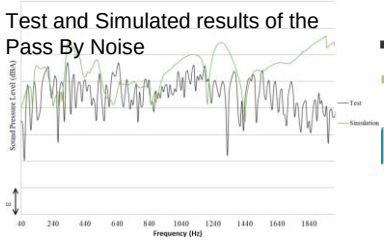
Benefits

- Greater predictability to their new vehicle launch cycles
- Identification of major noise source contributors
- Savings in cost and time in entire design to launch process

Pass By Noise – Evolution of frequency content with vehicle position



Test and Simulated results of the Pass By Noise



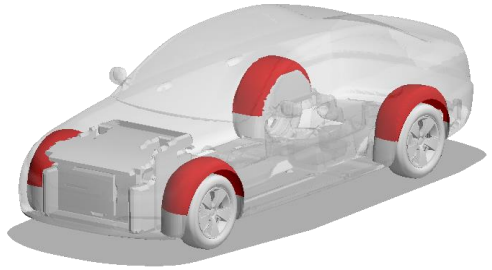
SAE Technical Paper 2019-32-0593, 2020, Pass-by Noise Prediction of a Vehicle, B., R., Gannu, S., M, A., Krishnamurthy, G. et al.

Wheel Arch Acoustic Treatment

Automotive Acoustics Conference 2019, Parametric Analysis of an Automotive Wheel Arch Acoustic Treatment, Baudson R., Lafont T., Balaramraja V.S., Ronzio F., Van den Nieuwenhof B.

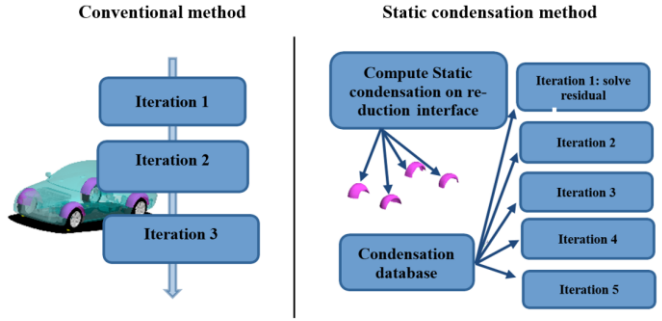
Challenge

- Recent evolutions in terms of regulations for pass-by noise force Automotive OEMs to build more silent cars than before.
- Tire noise sources are dominant contributors to the exterior sound emitted by vehicles.
- Definition of optimum acoustic treatment location and physical properties.



Solution

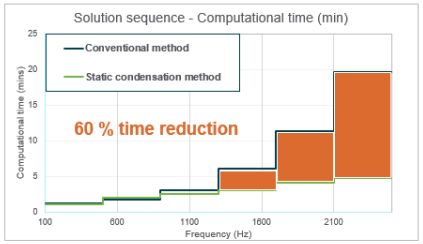
- Actran unique **acoustic superelement** strategy based on a static condensation approach offers efficient technique for material performances comparison and selection.
- Embedded Pass-by Noise output.



Benefits

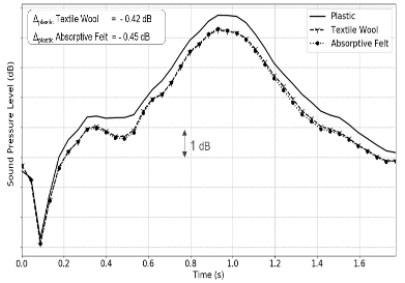
- Significant computational time reduction during design iterations.
- Direct output of pass-by noise performances at the end of computation offers efficient design comparison.

Computation gain



Pass-by Noise simulation

Comparison of material performances



Optimization of Foam Microstructure Parameters

2019 JSAE Congress Autumn, Acoustic Modeling Technique of Internal Structures of a Sound-Absorbing Foamed Resin by Homogenization Method, Keisuke Yamakawa, Daiji Katsura, Takashi Yamamoto

Challenge

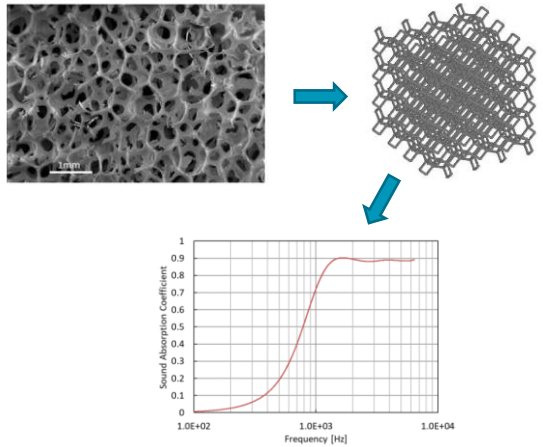
- Develop methodologies to **design sound-absorbing material with desired performance** optimizing mass and volume properties

Solution

- Homogenization method correlating microstructure and macro structure behaviors.
- Sound-absorbing properties optimized based on Actran virtual Kundt's tube tests

Benefits

- Development of more efficient automobile engine cover made of foam resin material by controlling the foam cell size.



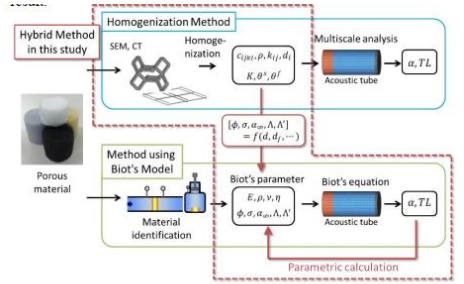


Fig.1 Process to design sound-absorbing poroelastic materials with desired performance.

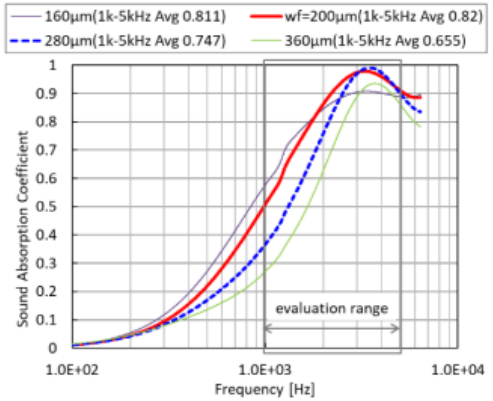


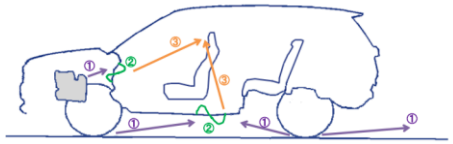
Fig.2 Calculated sound absorption coefficient of foam resin material based on parametric calculation.
Unit cell size w_f = 200μm maximizes performance.

Pass-by Noise & High Frequency Interior Noise

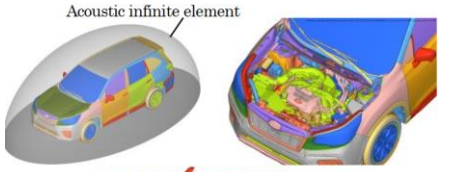
2019 JSAE Congress Autumn (20196286), Development of pass-by and high-frequency interior noise prediction techniques by FEM analysis, Takahiro Minezaki, Kimitoshi Yoshikawa, Kosuke Kanesaki

Challenge

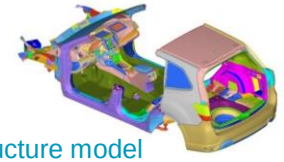
- Need to assess engine and tyre noises sources contribution to pass-by and interior noise levels



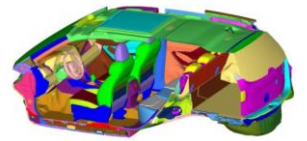
Outline of pass-by and interior noise propagation mechanisms



Exterior acoustic model



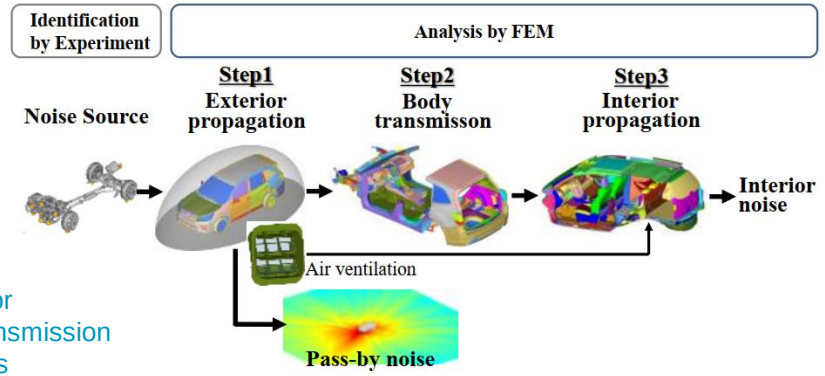
Structure model



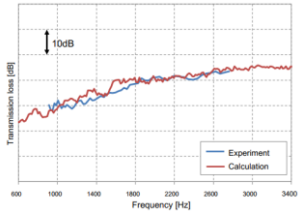
Interior acoustic model

Solution

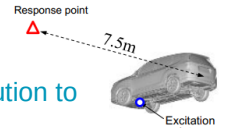
- 4-step approach coupling measurements with Actran and MSC Nastran FE models.
- Efficient system to components level analysis, prediction of both exterior and interior levels based on same models.

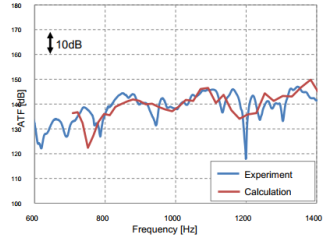


Floor Transmission Loss



Contribution to pass-by microphone

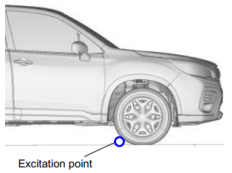


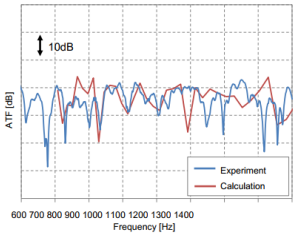


Benefits

- Development of process able to make qualitative predictions during vehicle development stage offering at the same time countermeasures performance effects.

Passenger sound pressure level due to front tyre excitation





北京汽车 BAIC MOTOR

How BAIC optimized car-body damping by simulation

"Thanks to simulation-based optimization and test verification, the materials installed on a certain car model were reduced by more than 25%, cutting the cost by more than RMB10 per vehicle"

- Wang Zhiwen, Director,Lightweight Tech. Dept., Beijing Automotive Technology Center

Challenge

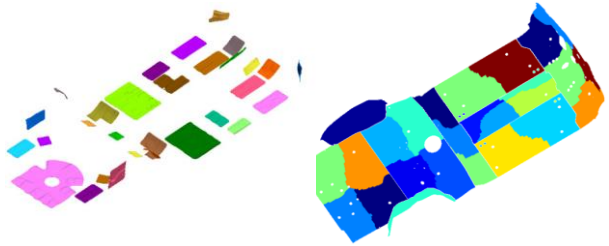
- Damping materials are widely used to reduce vibration and noise.
- Previously, rules of thumb and the maximum strain energy method were the only approaches toward floor damping design.



"To meet ever-increasing competition on the automotive market, we are in urgent need of a CAE method to accurately simulate the NVH performance of damping materials" – Wang Zhiwen, Director,Lightweight Tech. Dept., Beijing Automotive Technology Center

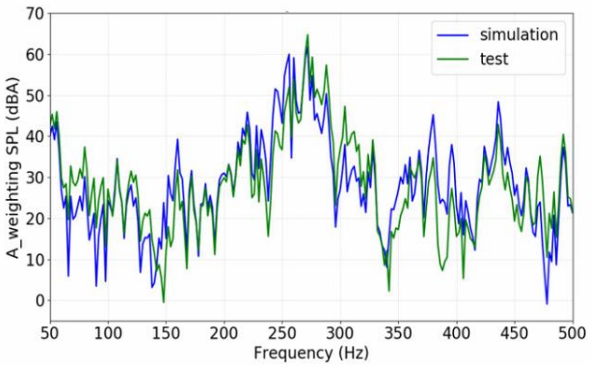
Solution

- Actran Energetic Analysis coupled to embedded NLopt optimization library to develop a simulation-based method to optimize materials in response to the physical load.
- Actran accurate modeling of frequency dependent damping materials properties



Benefits

- Quick analysis of interior noise car sensitivity to damping under real-life load.
- Optimization of material location and thickness to ensure the best acoustic and control cost.



HEXAGON

Increase commuter comfort, from FEM to SEA

“With the Actran Virtual SEA approach, our existing FE models can be re-used, this is the best situation for us.”

***Per-Olof Berglund**, Senior NVH CAE Engineer at Scania Bus*

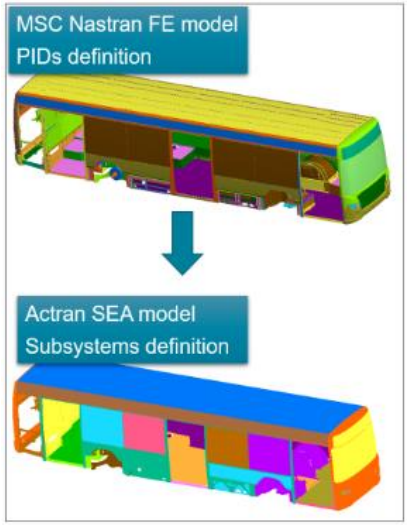
Challenge

- Designing electric and autonomous vehicles is a challenge for the NVH design
- Engineering teams need to cope with increasing acoustic comfort expectations while dealing with new noise sources and structural designs.



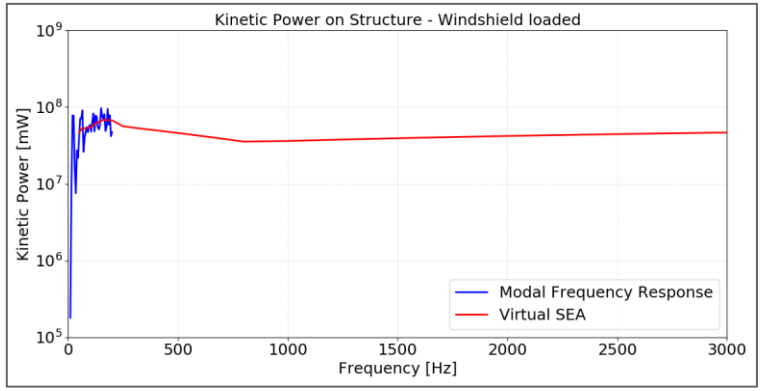
Solution

- An Actran SEA model is built to tackle the size of the bus for the frequency required
- Actran SEA relies on existing low frequency Finite Elements models
- MSC Nastran is used for the structural model, where mode shapes are extracted



Benefits

- The calculation team at Scania Bus decided to use the new capabilities of Actran Virtual SEA approach to assess the vibro-acoustic performances of their design at mid- and high frequencies.



Maintaining acoustic performance of tire spare hub

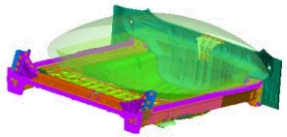
Challenge

- **Light weighting** is becoming a primary objective in vehicle design while ensuring vehicle performance parameter such as crash, **NVH** and durability
- Dura Automotive was looking at **replacing** the vehicle's existing tire tub with a hybrid tub (plastic/metal) component while maintaining its acoustic performances

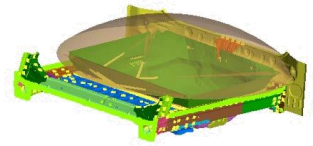


Solution

- MSC Software helped Dura team create a simulation model that would help compare the acoustic transmission loss for the base and hybrid version using Actran
- Actran helped Dura to evaluate effect of different materials on spare tire tub's NVH performance
- Numerical Transmission Loss (T.L.) analyses were carried out in Actran



Baseline design



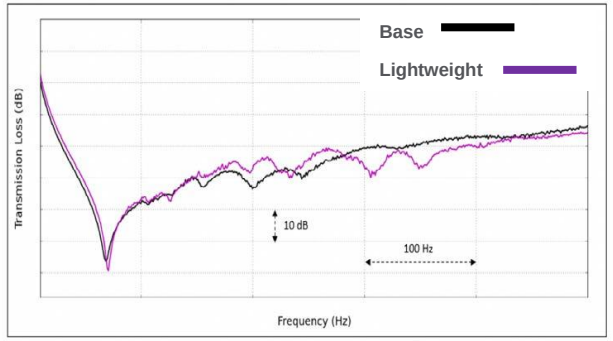
Lightweight hybrid design



Base Tire Tub



Lightweight Tub



Benefits

- The simulation using Actran helped identify weak regions for the hybrid tub and make necessary design modifications to accomplish an equivalent base tire tub
- The design changes were determined using simulation as opposed to physical experimentation which resulted in considerable savings in cost and time

Maintaining acoustic performance of car windows

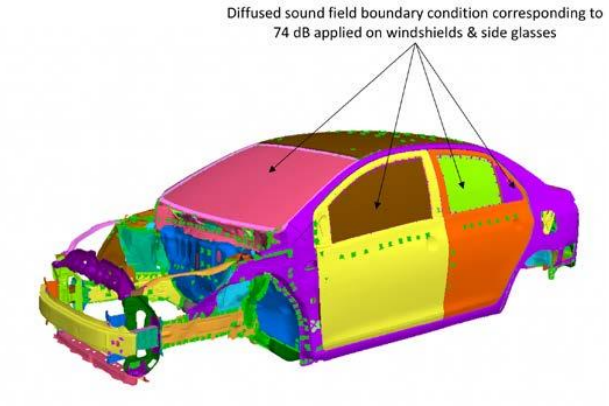
Challenge

- **Light weighting** is becoming a primary objective in vehicle design while ensuring vehicle performance parameter such as crash, **NVH** and durability
- Light weighting not only **includes** the metals but components like **windshields and side glass** as well.
- Dura Automotive was looking at replacing the material for the side glass window of a vehicle with Acrylic and assess its acoustic performances



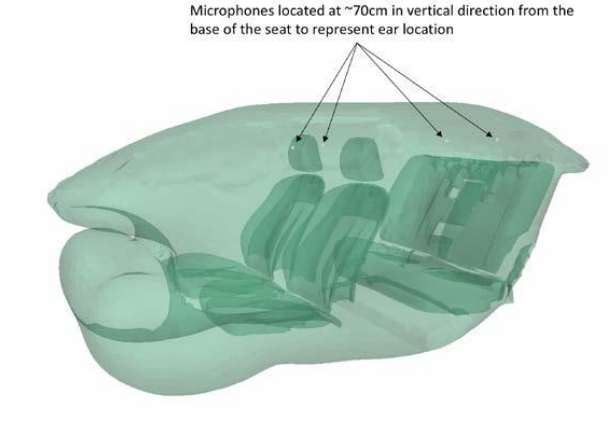
Solution

- Actran’s vibroacoustic capabilities helped Dura Automotive to quickly build a representative FE car mock-up out of an open-source model
- Efficient Actran random load modelling is used to assess the insulation capabilities of the window material and predict the relative interior noise levels



Benefits

- Efficient material ranking and prediction of interior noise level
- Optimization of material percentage replacement thanks to numerical scenarios comparison



Tire acoustic signature – Noise source reconstruction

NOVEM 2018, Modeling tire noise in FE simulations for pass-by noise predictions, T. Lafont et al.

Challenge

- Exchange of tire acoustic signature information in-between tire manufacturer and OEMs
- Reconstruction of the overall noise source of an isolated tire from experiments or simulation
- Provide more complex noise propagation simulations with a noise source obtained experimentally or numerically

Solution

- Tire acoustic signature mimicked by using 2 monopoles placed at the sides of the contact surface at the distance **d**
- Optimization loop in order to minimize the difference between reference pressure (from experiments or simulation) and the radiated pressure at a given sampling surface

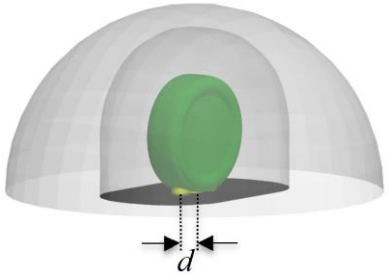
Benefits

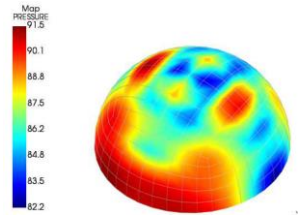
- Optimization set-up with Actran embedded NLOpt libraries
- Equivalent monopole information can be easily exchanged with third-parties
- Integration with Actran pass-by noise vertical inside Workflow Manager for target settings

From tire designs to in-situ performance assessment



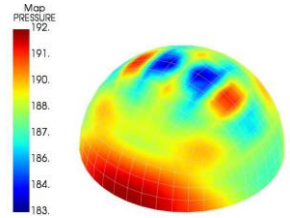
Actran model for equivalent source characterizations





Reference pressure surface (from exp. or simulation)

Equivalent signature radiated by 2 monopoles

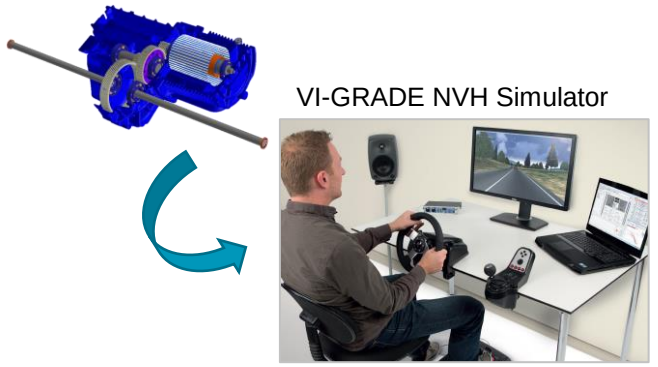


ePowertrain – Interactive Sound Quality assessment

InterNoise 2020, Interactive Sound Quality Evaluation of an EV Virtual Prototype, R. Hadjit, T. Histed, S. Joshi, A. Talbot & J. Charbonneau

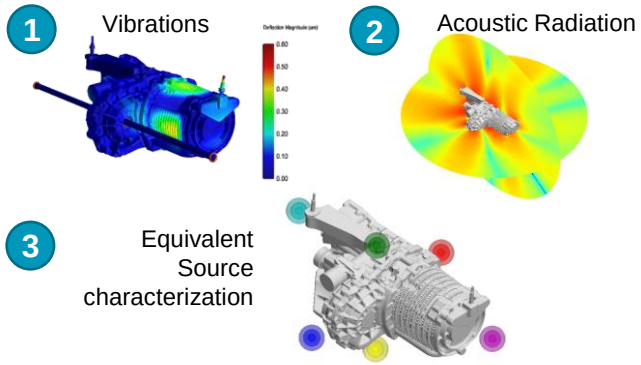
Challenge

- Powertrain Sound Quality (SQ) is an important attribute for automotive vehicles designs.
- Need to develop workflow of interactive SQ evaluation for virtual prototypes, starting from numerical designs to sound perception



Solution

- Complete design of virtual EV Powertrain using Romax and Actran solutions.
- From gear-to-hear workflow assesses both acoustic signature and mounting forces responses.
- Definition of powertrain equivalent sources to feed Interactive SQ Evaluation in **VI-GRADE NVH Simulator**



Benefits

- The CAE-led design approach allows problems to be identified and resolved well in advance to achieve a “virtual NVH sign-off” of the powertrain.
- Interactive comparison between engine configurations
- Identification of loudness responsible mechanisms



Accelerating truck pass-by noise through HPC

MSC Taiwan User Conference 2020, Numerical estimation of noise sources and validation, K. Zhengxiang

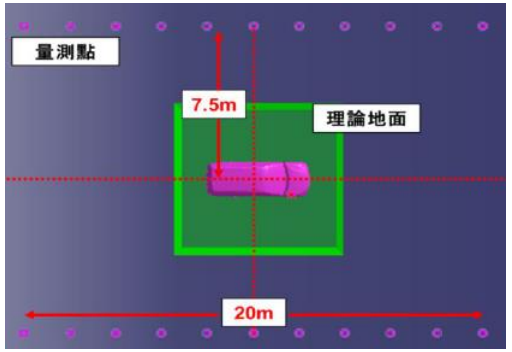
Challenge

- CMC, in order to comply with regulations, has been using simulation for pass-by noise for the last years, but computations take too much time even for 2000 Hz
- The goal is to perform pass-by noise simulations up to 4000 Hz



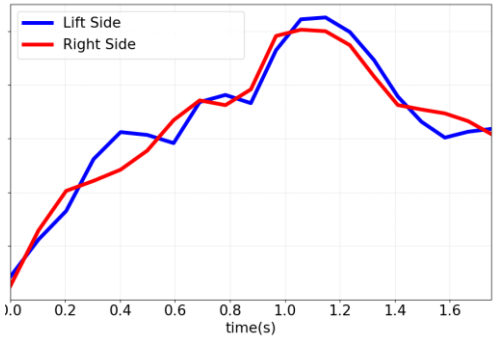
Solution

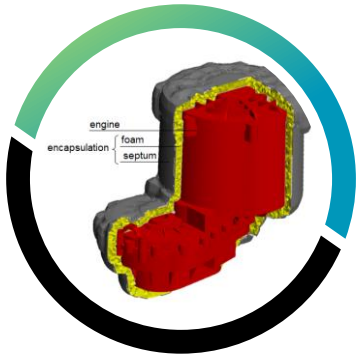
- Actran provided the perfect mix of methods:
  - FEM instead of more expensive BEM
  - HPC capabilities
  - Adaptive mesh
- All these allow to reduce the calculation time significantly



Benefits

- The calculation time was reduced by 98%, from 100+ hours to 2 hours, up to 2000 Hz
- Very good correlation between measurements and simulation → confidence in the solution





Predicting radiation efficiency for vibrating objects

Challenge

- Due to different structure bending and fluid wavelengths, the structure's ability to radiate is often weakly related to its vibration level
- Improving the noise performance of a design cannot rely on the structural analysis and Equivalent Radiated Power alone

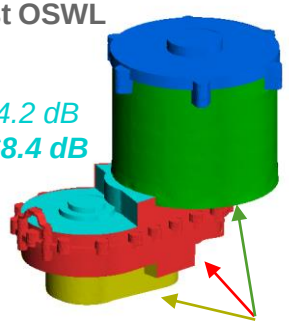
Solution

- Actran inherently considers the radiation efficiency of a structure to the surrounding fluid
- The contribution of different panels to the global propagated solution can easily be outputted

Benefits

- Radiation efficiency and acoustic propagation can be analyzed for each panel across the frequency range
- Easier optimization of the acoustic design based on the most contributing radiating panels

The panel with the **largest OERP** has the **lowest OSWL**



OERP: 75.9 dB
OSWL: 66.3dB

OERP: 74.2 dB
OSWL: 68.4 dB

OERP: 76.2 dB
OSWL: 65.1 dB

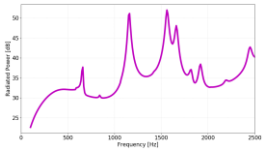
OERP: 76.3 dB
OSWL: 62.0 dB

OERP: 76.1 dB
OSWL: 65.7 dB

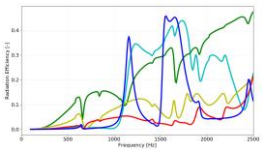
Highest **Overall Equivalent Radiated Power (OERP)** up to 2500Hz

Total OERP: 82.75 dB
Total OSWL: 73.2 dB

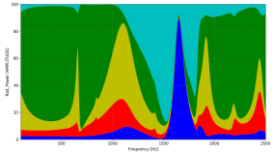
Radiation power spectrum



Radiation efficiency per panel



Radiated power contribution (%)





Adding stiffeners

-0.85dB OSWL
Good result for a first iteration

HEXAGON

Lowering cabin noise for comfort in GM electric vehicles

"The recent inclusion of Actran in our toolkit has improved our ability to predict mid-frequency issues and confidence that we can develop solution sets and vehicle level performance that will delight our customers."

Kevin Miller

Director - Virtual Body Systems, Interior & N&V
General Motors

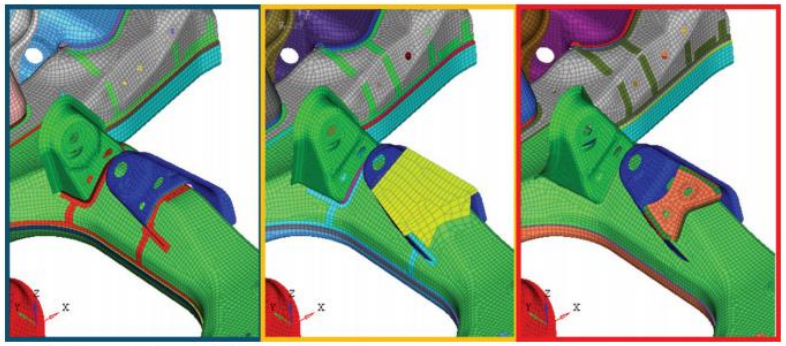
Challenge

- Higher customer expectations for eV vehicles, in terms of interior noise and vibration comfort
- With new body architectures, different types of noise and vibration sources, dynamic interior design requirements and electric vehicles brought many new challenges in terms of passenger comfort



Solution

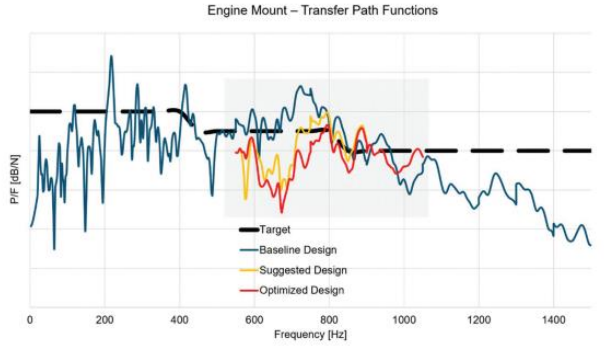
- Implementation of Actran acoustic treatments component modeling capabilities alongside existing FE models
- Build ability to break down component contribution to interior sound level for identification of best leverage



Cadillac LYRIQ show car - Image Courtesy of Cadillac - Cadillac Pressroom

Benefits

- Meet NVH targets of new EV design for engine structure born noise
- Improve interior speech intelligibility by optimization of interior acoustic treatments



Engine Mount Optimization - Transfer Path Functions – Courtesy of General Motors

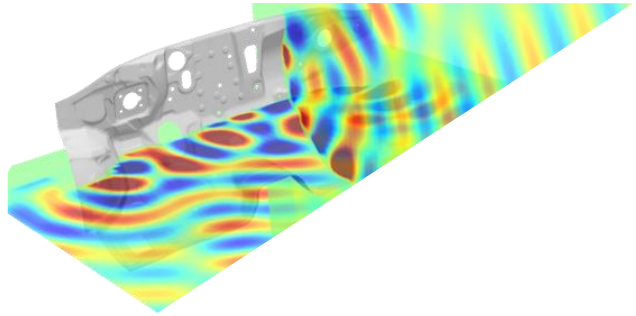
HEXAGON



Machine learning-accelerated transmission loss of a firewall panel

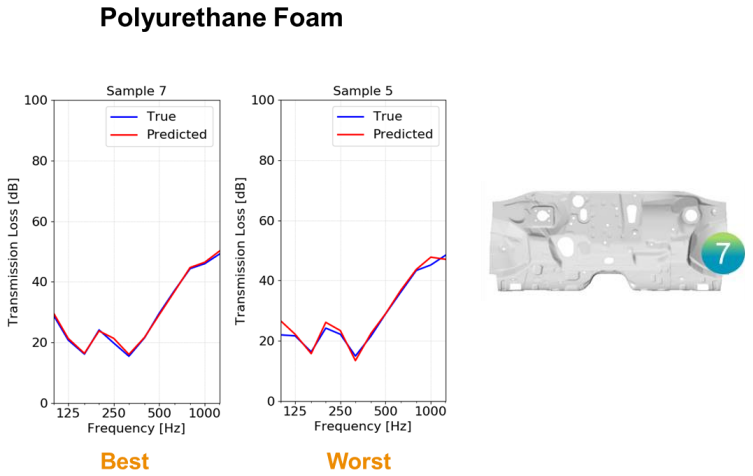
Challenge

- Acoustic treatments are an important part of noise mitigation strategies in vehicles.
- A large number of different porous materials exist for acoustic treatments and finding the combination of materials that work best can be challenging.



Solution

- Actran is for the acoustic simulations used for training the reduced model and for cross-validation while ODYSSEE CAE is used for the creation of the reduced order model based on material and geometry parameters



Benefits

- Acceleration of noise transmission loss of acoustic treatments via the use of machine learning. It allows to get fast and accurate results without having to run a simulation.
- Possibility to use the image-based prediction order to improve the results

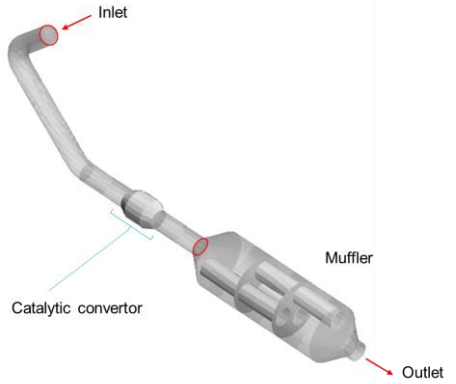
HEXAGON



Optimization of the transmission loss of a motorcycle exhaust

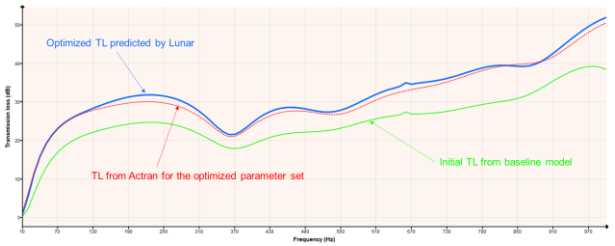
Challenge

- Exhaust systems are important for the attenuation of the engine noise in motorcycles.
- The sound transmission loss is used to measure the sound attenuation through the system
- Transmission loss needs to be maximized across the frequency spectrum in order to ensure quieter operation



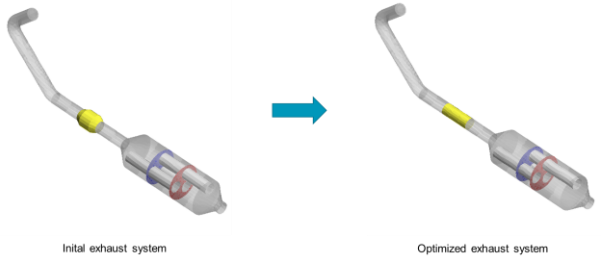
Solution

- Combining acoustic simulation with Actran with ODYSSEE CAE for creating the reduced model and performing the optimization allows to maximize the transmission loss of the exhaust system
- The geometric parameters of the muffler and the catalytic converter are used for the optimization



Benefits

- Optimization of a motorcycle exhaust system via the use of a reduced model, thus accelerating the optimization process.
- The process allows to optimize a system faster as no simulation is needed for the evaluation of the system during the optimization process



HEXAGON



Reduced order modeling for HVAC duct aeroacoustics

Challenge

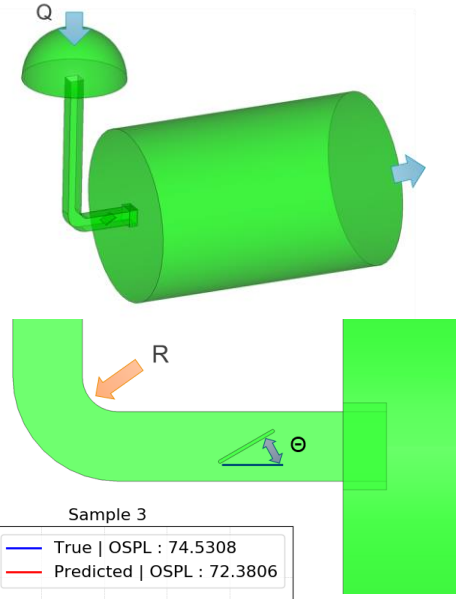
- Heating, Ventilation and Air Conditioning (HVAC) ducts need to be designed with both aerodynamics and acoustics in mind
- In terms of aerodynamics, a proper flow distribution needs to be ensured.
- In terms of acoustics, HVAC ducts contribute to broadband noise experienced by the passengers

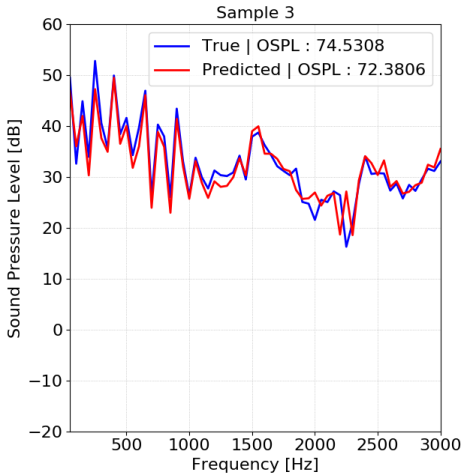
Solution

- MSC Apex is used for the geometry generation
- Cradle CFD and Actran are coupled with scFLOW2Actran for simultaneous simulation of flow and aeroacoustics
- The SNGR method based on a steady RANS simulation is used for aeroacoustic source generation
- ODYSSEE CAE for creating the reduced model
- The whole process is automated with the Cradle CFD and Actran APIs

Benefits

- The reduced order model allows accurate instantaneous predictions for aeroacoustics across the whole spectrum
- Performing automated aeroacoustics while staying within the same portfolio is possible with the combination of MSC Apex, Cradle CFD, Actran and ODYSSEE CAE.





Sample number	OSPL difference
Sample 1	3.6dB
Sample 3	2.1dB
Sample 5	0.8dB

HEXAGON

Trim modeling in the mid-frequency range

ISNVH 2020, Extended Solution of a Trimmed Vehicle Finite Element Model in the Mid-Frequency Range, David Sipos et al.

Challenge

- Finite Element (FE) analysis is an established approach for modeling trimmed NVH models, providing high quality results in early design phases.
- These analyses are typically done in the low range of the frequency spectrum because of the size of the models
- There is increasing interest for tackling the mid-frequency range for trimmed models

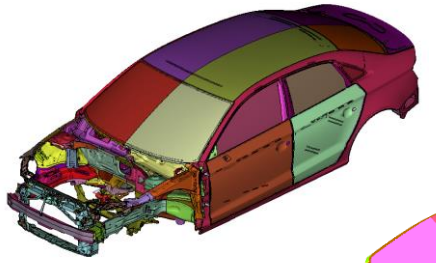
Solution

- The Actran SEA approach takes an existing FE model valid of the low frequency range and extend it to the mid-frequency range
- In Virtual SEA, the necessary information required to build the SEA system is extracted from the FE models
- Trim effects can be taken into account through an analytical trim approach based on an equivalent transfer admittance

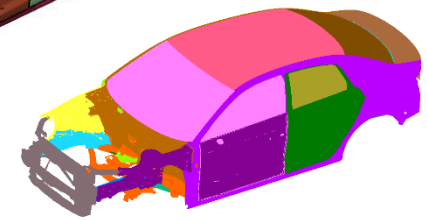
Benefits

- Good correlation between measurements for both microphones and accelerometers in the mid-frequency range
- Trimmed models can be solved in an industrial timeframe for higher frequencies
- Actran SEA models can be easily set up with an existing finite element model



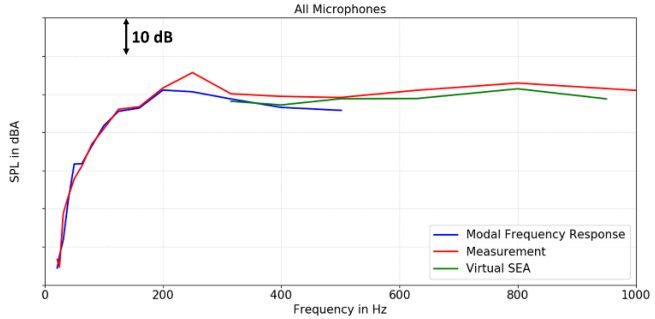


Structure FE model



Virtual SEA model

Comparison of mean sound pressure level for the various methods





Speaker transfer function calculation up to 20,000 Hz

SIA NVH Comfort 2021, A novel GPU accelerated numerical process for automotive loudspeaker design and integration studies, T. Costes et al.

Challenge

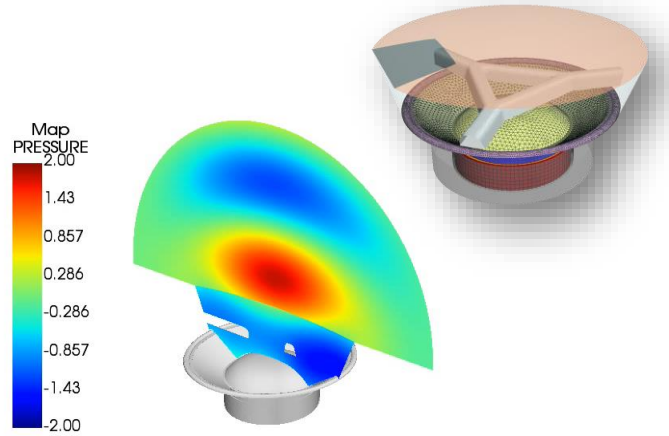
- Car designs bring new challenges to (re)define and ensure sound quality, intelligibility and comfort of vehicle compartment
- Superior audio system performances require in-situ prediction and speaker positioning optimization.
- Numerical methodology needs to assess accurately the behavior of the speaker within the cabin

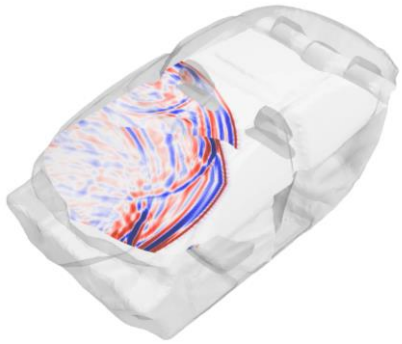
Solution

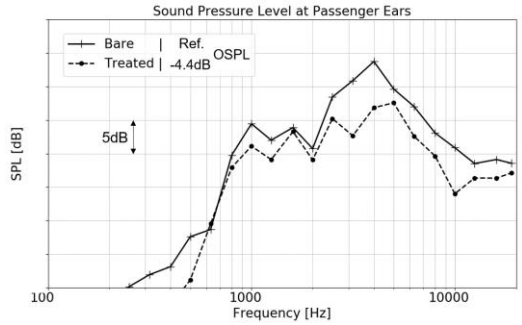
- Speaker level simulations are run to assess the influence of specific features (shape, structure and back cavity coupling, grill…)
- Transfer functions between speaker and passenger ears are computed up to 20kHz efficiently using Actran DGM and GPU computing
- With the help of GPU computing, a simulation up to 20 kHz can be completed within an hour

Benefits

- Accurate and fast prediction of speaker integration
- Reduced need for costly well-finished prototypes to fine tune the audio system







HEXAGON

High Frequency vibroacoustics of a battery EV

"Simulations results were compared to experiment and a good correlation was found in most of the cases in mid and high frequencies"

Lucas Epperlein

Project Leader CAE-NVH

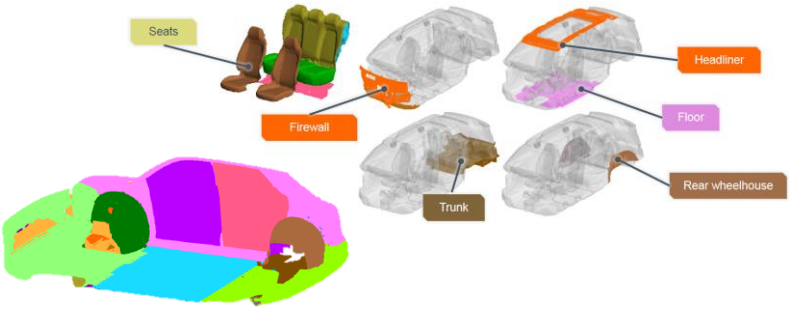
Challenge

- Performing virtual noise and vibration analysis at early design stage for the full vehicle
- Realistic conditions need to considered, such as the presence of trims
- Most common analyses are done in the low frequency spectrum (<500 Hz), but a larger part of the spectrum needs to be evaluated.



Solution

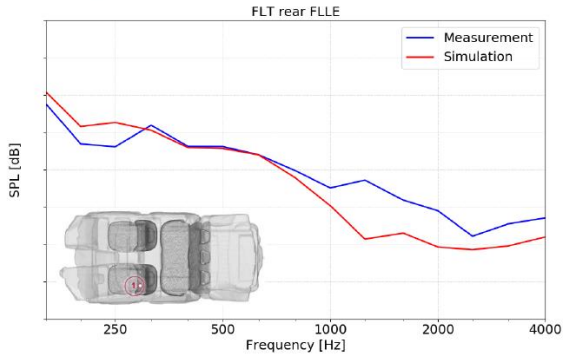
- Actran SEA provides a methodology for solving high-frequency vibroacoustic problems for full vehicle response
- The response to passenger ears was modeled up to 4000 Hz due to road/tire noise including trim evaluation
- A methodology including Actran Frequency Response and Virtual SEA and Nastran (SOL 103, SOL 108) is used to model the full vehicle





Benefits

- A good correlation is achieved, including in the mid and high frequencies
- Easy and fast calculation of the Virtual SEA model for trim modifications
- Actran SEA provides an alternative to experimental and analytical SEA, being able to handle complex geometries without the need for junction modeling early in the design and development process as no prototype is required.



enedym

Noise from switched reluctance electric motors

“By using the proposed numerical approach, we’re able to reduce the simulation time significantly with Actran without sacrificing the accuracy”

Jianbin Liang

Senior Principal Engineer

Challenge

- While switched reluctance are simple in construction and low in cost, acoustic noise modeling is critical for their design
- Noise sources include electromagnetic noise, electrical and mechanical noise due to eccentricity, mechanical noise from bearings and aerodynamic noise from the fan and rotor
- Electromagnetic noise contributes most to the total noise and needs to be reduced

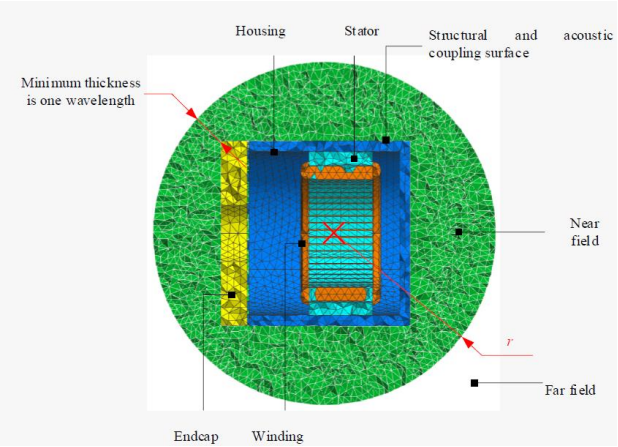
Solution

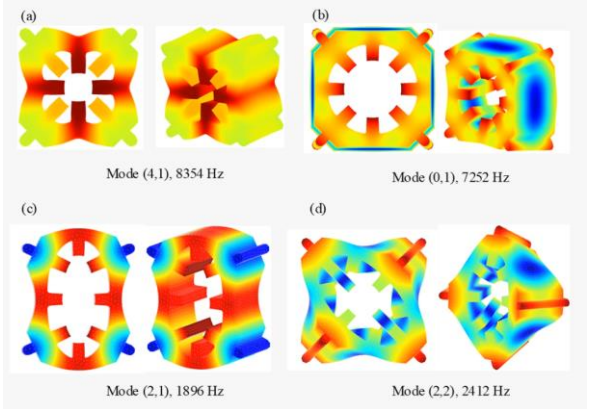
- Actran is used as part of a simulation chain that allows for fast numerical estimation of noise, suitable for the early design phases
- The excitation coming from the electromagnetic forces is mapped onto the rotor and propagated into the near and far field.
- Actran’s adaptive mesh capabilities allow for reaching high frequencies at a low computational cost

Benefits

- Very fast and lightweight process, calculated in a typical workstation within minutes for high frequencies
- Good correlation with measurements, even for reduced models, that solve the most important harmonics and structure modes







HEXAGON

Truck side mirror aeroacoustics

25th AIAA/CEAS Aeroacoustics Conference, Application of SNGR Method to Compute Aero-Vibro-Acoustics of Heavy-Duty Rear-View Mirrors, B. Mazeaud, Z. Chroneer, M. Karlsson, H.D. Yao, B. Petit, Y. Detandt

Challenge

- Flow-induced noise inside cab interior is nowadays perceived as a key factor when assessing the quality of heavy-duty vehicles
- Evaluation of wind noise early in the design process is challenging due to the complexity and time required to run accurate simulations
- In order to satisfy the turnaround time required for current product development, a simplified hybrid numerical approach is needed



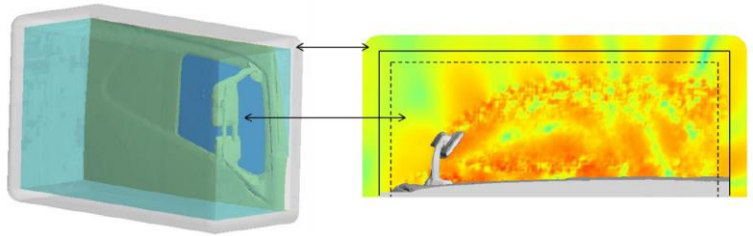
Solution

- Actran's SNGR method can take data from an affordable steady (RANS) CFD analysis to generate aeroacoustic sources
- These sources are then propagated around and inside of the truck cabin.
- SNGR enables affordable comparisons between different side mirror design configurations



Benefits

- Valuable insight on side mirror aeroacoustics early in the design phase at a low cost
- Acoustic maps show the physical mechanisms of wind noise and point out regions that can be improved.
- All-in-one aero-vibro-acoustic workflow for interior noise comfort due to wind noise



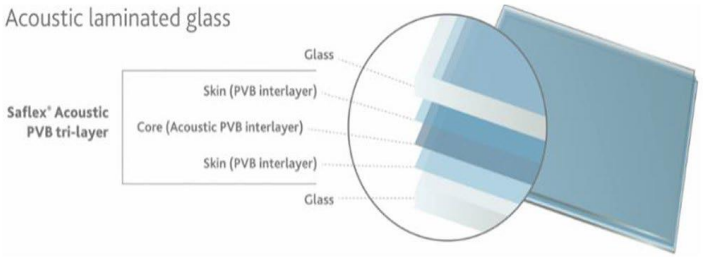
EASTMAN

Evaluation of an acoustic interlayer for glass panels

SAE Noise and Vibration Conference 2021, Performance Evaluation of Eastman's Saflex® E Series Acoustic Interlayer, D'Haene P., Van de Vyver S., Poulos A., Robin X.

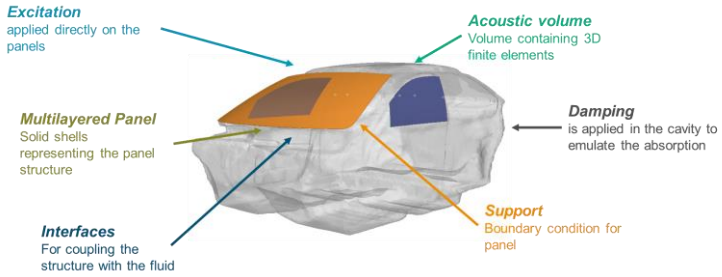
Challenge

- Glass panels in vehicles serve multiple purposes, including providing noise isolation
- To provide noise isolation, special acoustic interlayers are placed between the glass panels that reduce vibration and noise transmitted from the outside to the inside
- To evaluate different materials early in the design, a simulation approach is used



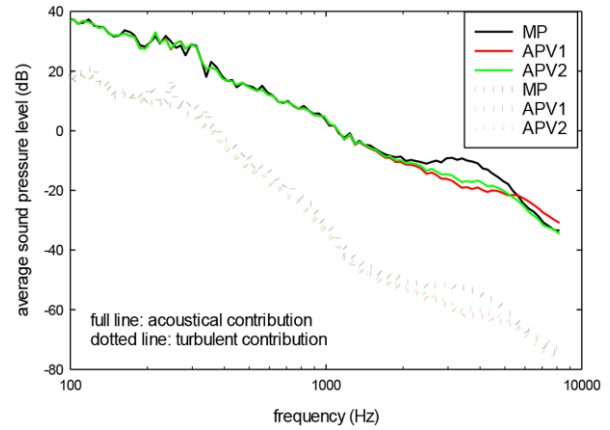
Solution

- A vibro-acoustic simulation approach in Actran is used to model the materials in the windshield and side windows of a vehicle
- Diffuse sound field and turbulent boundary layer condition with custom profiles are used to model the different wind noise contributions
- Frequency-dependent material properties are easily considered by Actran



Benefits

- Easiness to interchange materials for evaluating performance
- Accurate results for transmission loss and interior propagation
- Possibility to use custom frequency-dependent material properties and excitations



HEXAGON

Optimization of transfer path analysis

“Based on this research we could build up a full chain of simulation that can be used for auralization purposes as well. The obtained auralized results were validated against measurements and were found to be reliable.”

Serafima Anisovich

Research NVH Engineer
HEAD acoustics

Challenge

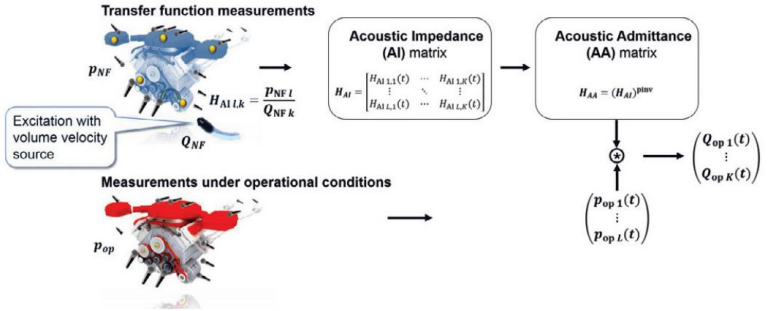
- The precise characterization of sound sources is critical, as the major challenge for manufacturers is to identify the main contributors to the sound emission.
- In the world of mechanical equipment, if the vibrations of a flat structure cause sound emission, the main contributors (sound source components) are spread over the structure and their quantity and positions vary with frequency, complicating their localization.

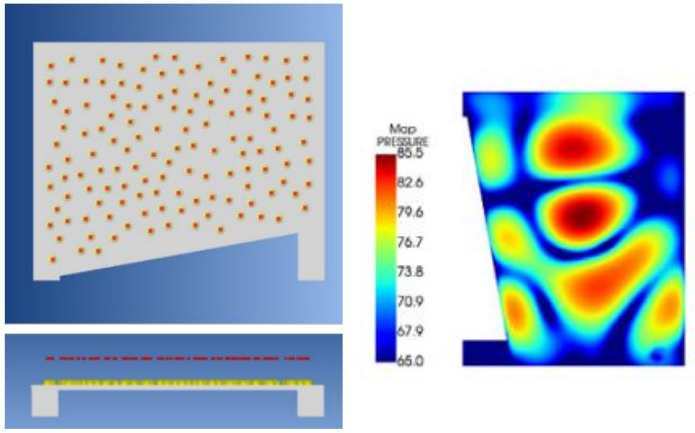
Solution

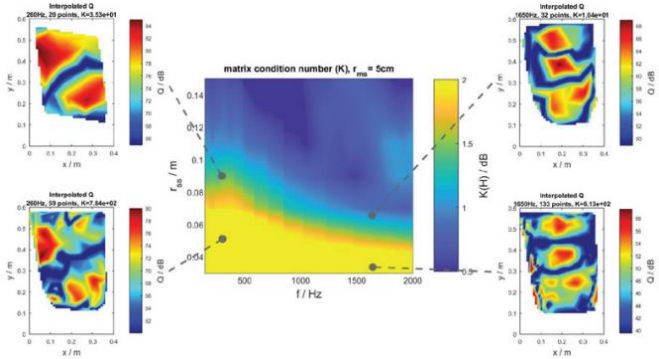
- This new method allows characterizing the source components in a wide frequency range and requires only customary limited sound field measurements.
- To accomplish the vibro-acoustic evaluation of the model, researchers chose MSC Software portfolio solutions MSC Apex, MSC Nastran and Actran

Benefits

- A clean numerical process including MSC Apex for CAD and meshing, MSC Nastran for fast and reliable structural analysis and Actran for its dedicated acoustic capabilities allows for seamless simulations
- Actran’s solver-based meshing and single precision solvers provide fast and accurate results
- Sound files can be created which were reliably validated against measurements







Read the case study here.

Reduction of cabin noise in trucks

“I found that the integration between Nastran and Actran was very good. It was the perfect tool to choose for the simulation, especially for representing the acoustic load and for trim modeling. It’s a perfect companion to Nastran.”

***Per-Olof Berglund**, Senior NVH CAE Engineer at Scania Bus*

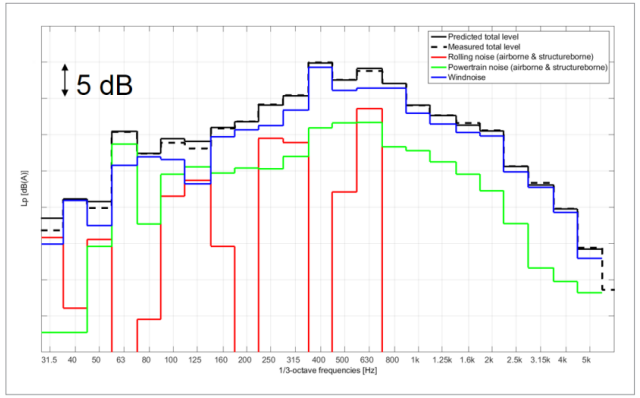
Challenge

- High noise levels or unpleasant sounds in a working environment are known to cause excessive fatigue and health problems.
- Engineering teams need to understand what the different noise sources were and identify how they directly affected cabin noise



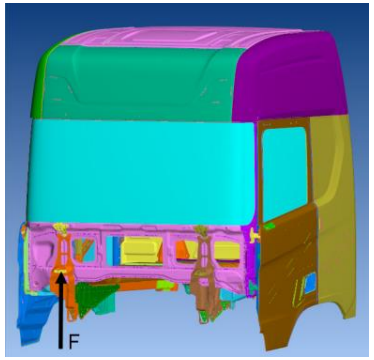
Solution

- MSC Nastran is used for calculating structural dynamics and structure-borne noise in the cabin
- Actran extended these capabilities by including trims, calculating airborne noise from the powertrain and simulation wind noise based on CFD data



Benefits

- Hexagon’s portfolio capabilities can simulate all interior noise contributions at component and system levels.
- Actran’s auralization capabilities helped power subjective evaluation sessions where the environment of driving a truck is replicated.





Optimization of Electric Motor Drive Design

"Once the mode shapes of the motor and the natural frequencies are determined, we can predict which radial force harmonic is causing the most acoustic noise and go back to electromagnetic design to work on reducing that radial force harmonic."

Dr. Berker Bilgin

Chief Engineer of Canada Excellence Research Chair in Hybrid Powertrain program
McMaster University

Challenge

- In order to develop efficient architectures for electric motors meeting the expectations both in terms of performance and acoustic comfort, engineers need to access new methods and tools
- Electric motor noise early in the design process as it is very difficult to reduce noise from the motor once the design is finalized
- Reduction of prototypes created during the motor design process

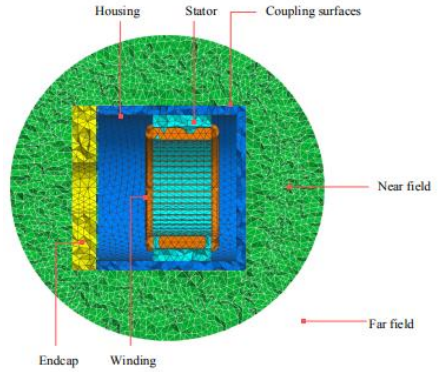
Solution

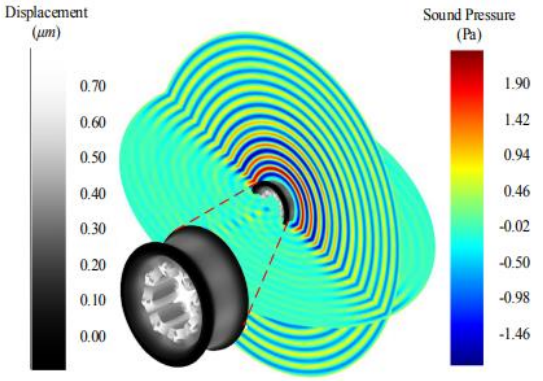
- Actran is used to analyze vibrations and acoustic noise of electric motors over a wide variety of frequencies and motor speeds
- Actran can deal with complex 3D geometries where it is more challenging to calculate mode shapes, especially for the analysis of axial mode shapes

Benefits

- Accurate results that cover any frequency range and rotation speed
- Precise prediction of structural mode shapes and the acoustic response
- Identification of the radial force harmonics which contribute the most to acoustic noise and to know whether they can be reduced without affecting the torque
- Significant reduction to prototyping cost





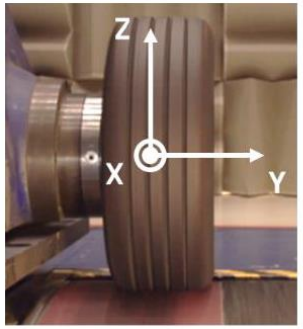


Tire air cavity noise effect to interior comfort

Chassis Tech Plus 2021, Tire Model to Feature Multi Body Simulation Based NVH Assessment of a Car Including Air Cavity Effects, P. Kindt et al.

Challenge

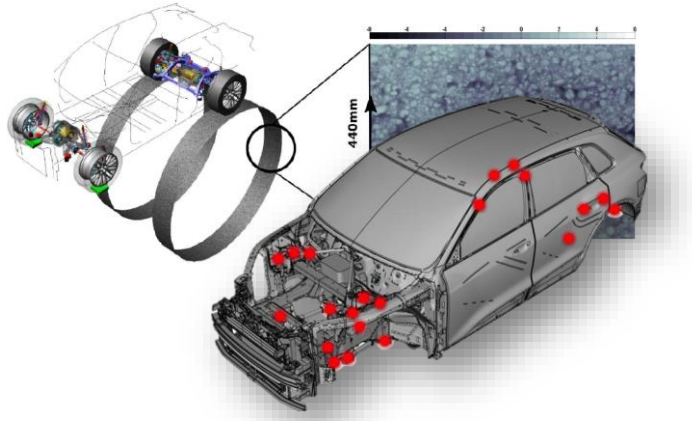
- Structure-borne noise induced by the tire/road contact requires more focus absent the masking noise in electric cars.
- The tire air cavity resonance noise is increasingly impacting the vehicle interior noise perception





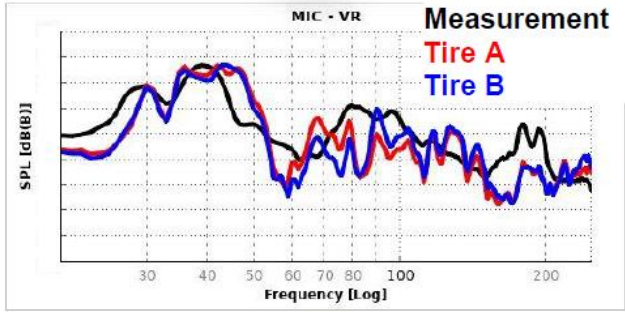
Solution

- A coupled finite element and multi-body full vehicle simulation approach is used for predicting structure-borne road noise
- Flexible body files are exported from a non-linear, time domain simulation in Adams to Nastran PEM for interior noise evaluation, with the excitation coming from a tire simulation with CDTire/3D



Benefits

- Good correlation of simulation with measurement data
- A couple Adams/Nastran PEM approach with non-linear effects for early-stage development can lead to accurate predictions
- Easy connection with CDTire model:
  - it can be applied to assess handling, durability, ride comfort and structure-borne interior noise
  - CDTire model allows for the tire supplier and vehicle manufacturer to collaborate efficiently at an early development stage to optimize and adjust the tire and suspension characteristics.



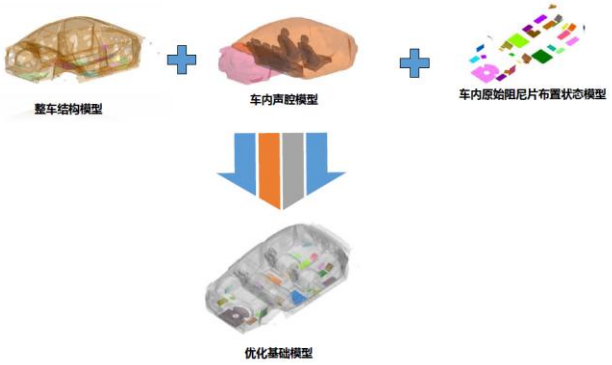
北京汽车 BAIC MOTOR

Damping optimization on the car floor

MSC China User Conference 2019, Modelling and optimization of damping pads on the FE car body. Miao Yuping

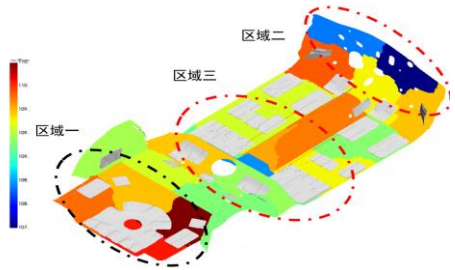
Challenge

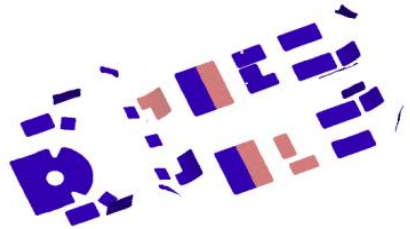
- Mass reduction is interesting to the OEMs. If the designer can remove the unnecessary damping pads, the cost will be reduced for the OEMs.
- The fuel efficiency will be raised for the consumers. Modelling the damping materials precisely is important for the designers.



Solution

- Nastran has been used for modeling the car body and cavity. Actran is used for modelling the damping components and coupled the vibro-acoustic model.
- Actran EA is used to evaluate the sensitivity of cavity response to the location of the damping on the floor
- Reduce the size or remove the low-ranking damping pads

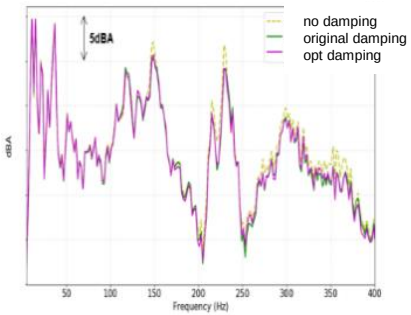




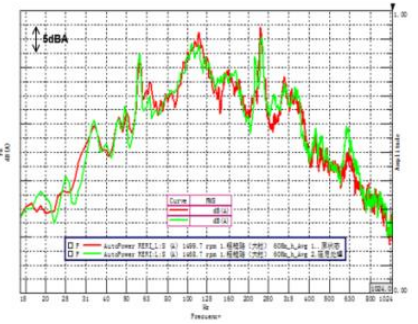
Benefits

- Reduction of the mass of damping on the floor up to 20%, with the same acoustic behavior inside the cavity@60km/h road noise load. Save more than 8 RMB per car.

simulation



test



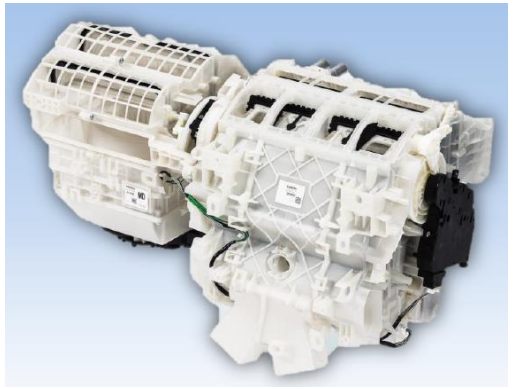
DENSO

Light Computational Aero-Vibro-Acoustics in HVAC systems

HxGN Live Design & Engineering 2021, Light Computational Aero-Vibro-Acoustics in HVAC systems, Antonio Baiano Svizzero

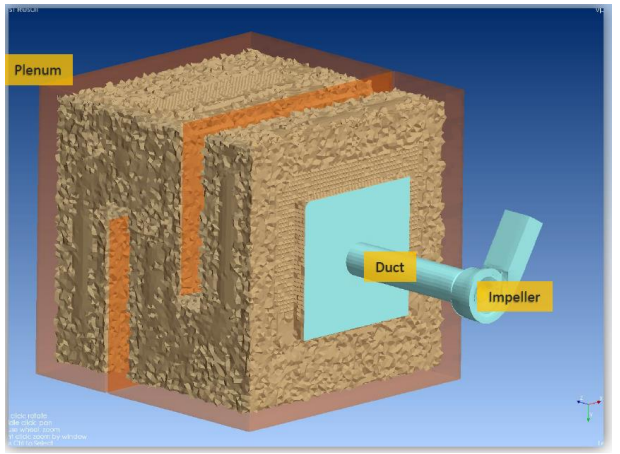
Challenge

- HVAC systems are important for cooling engine components and providing thermal comfort to the passengers
- There are important considerations for noise in order to ensure acoustic comfort as well
- Identifying and predicting the noise is challenging due to the high cost of performing aero-vibro-acoustic computations



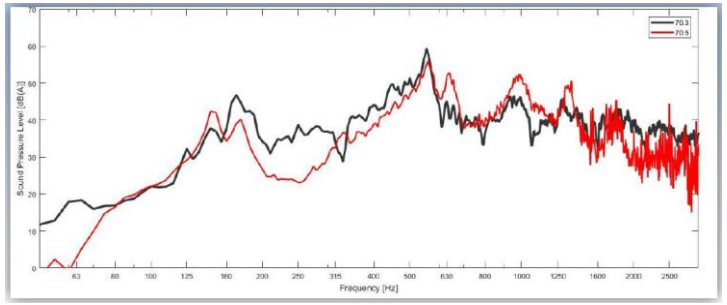
Solution

- A transfer matrix method (TMM) is used to perform the vibroacoustic analysis, taking into account the structural response based on aeroacoustic sources
- Actran is used for solving the acoustic problem with the TMM method after the computation of the aeroacoustic sources



Benefits

- Reduced time for solution from 21h to 20 min
- Results available early in the design process with possibility to do multiple iterations
- Good correlation with fully coupled FEM solutions and measurements



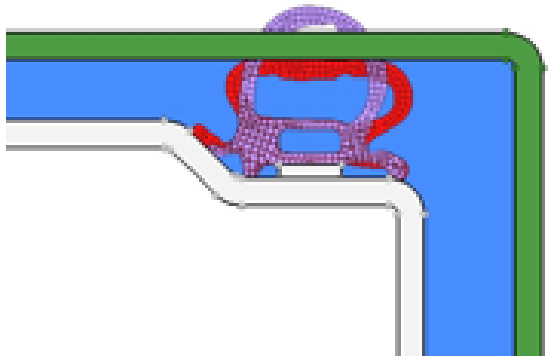
HEXAGON

Transmission loss across a door seal

HxGN Live Design & Engineering 2021, Modeling and prediction of Sound Transmission Loss across a Door Seal, Abdellah Bedrouni

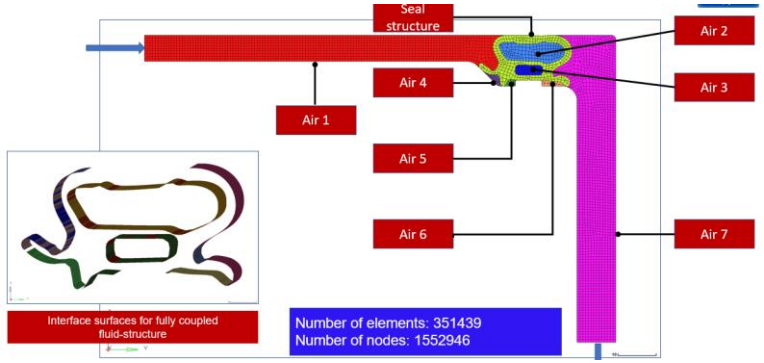
Challenge

- Inadequate seal design prior to the construction of the first prototype can leads to unacceptable vehicle wind noise performance and error states
- It could delay launch, increase costs, and significantly impact a customer's subjective impression of the wind & road noise performance



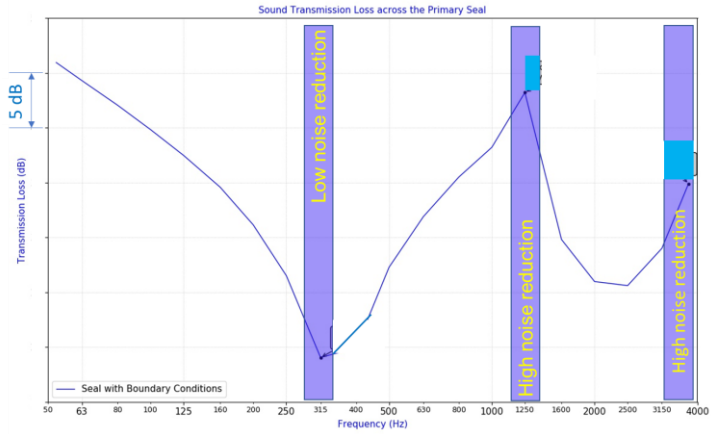
Solution

- The structural analysis is performed with Marc to get the non-linear deformation of the seal
- Actran is then used to calculate the acoustic characteristics of the seal and get the transmission loss information



Benefits

- A more robust understanding of the acoustic behavior of the seal can be established using simulation
- The effects of the material characterization, boundary conditions, and material properties on the transmission loss can be evaluated
- Using a dedicated acoustic software that integrates all the modeling and post-processing capabilities to predict the sound transmission loss for better user experience



Auralization of Road Noise CAE Simulation Results

HxGN Live Design & Engineering 2021, Auralization of Road Noise CAE Simulation Results for Interactive Sound Quality Evaluations, Rabah Hadjit

Challenge

- Sound Quality (SQ) is an important attribute for automotive vehicle designs.
- Need to develop workflow of interactive SQ evaluation for virtual prototypes, starting from numerical designs to sound perception for road noise

Solution

- Evaluation of vehicle behavior for road noise with Adams and Nastran
- A streamlined workflow can evaluate acoustic signature and force responses.
- A set of transfer functions is provided to perform interactive SQ evaluation in **VI-GRADE NVH Simulator**

Benefits

- The CAE-led design approach allows problems to be identified and resolved well in advance to achieve a “virtual NVH sign-off” of the powertrain.
- The results can be compared to targets and evaluated subjectively.
- If risks of NVH issues are identified, CAE simulations are used for troubleshooting and design countermeasures during the very early stages of vehicle development.

VI-GRADE NVH Simulator





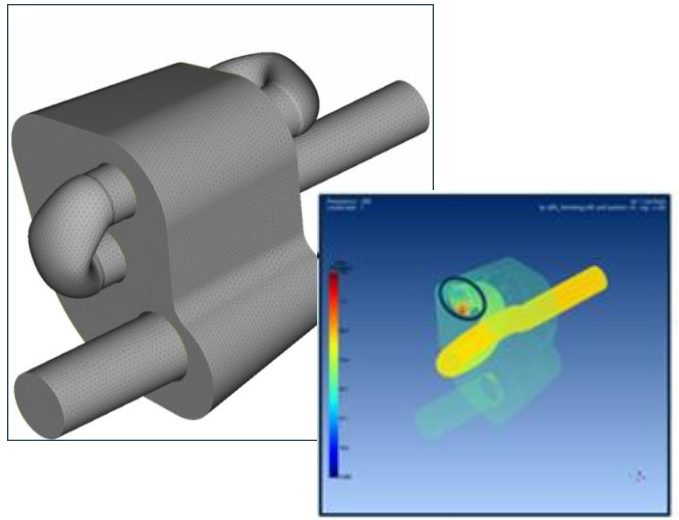


Aeroacoustic analysis of exhaust system

HxGN Live Design & Engineering 2021, Research and Improvement of Muffler Acoustic Characteristics with regard to Thermodynamic Characteristics of Exhaust Gas Flow with Aeroacoustics Sources, Rakhmatdzon Rakhmatov

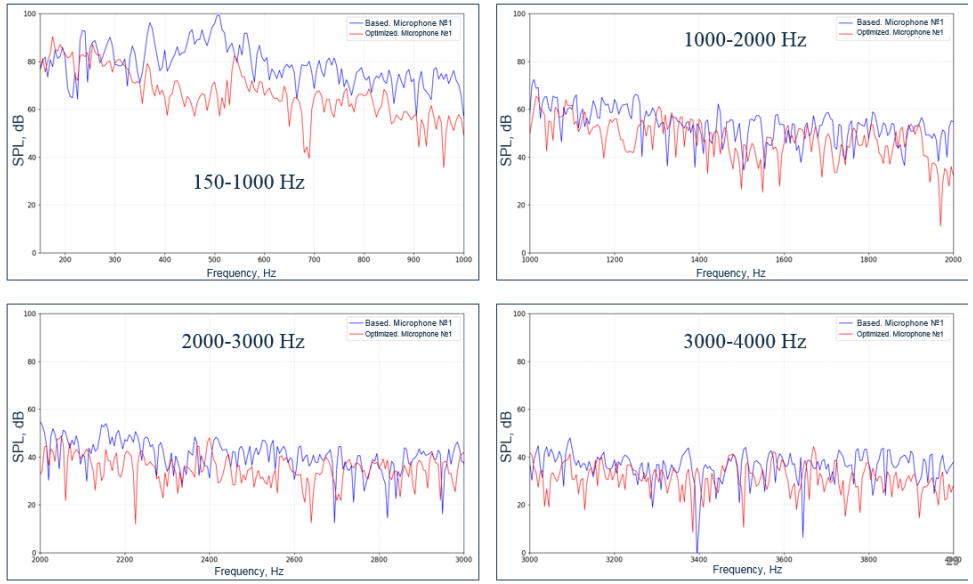
Challenge

- Exhaust systems very often require a compromise between efficiency of the flow and efficiency of the acoustic behavior
- In order to properly model the exhaust muffler, complex flow effects and the acoustic sources due to the flow need to be taken into account
- An optimization process is then use to improve the behavior of the muffler



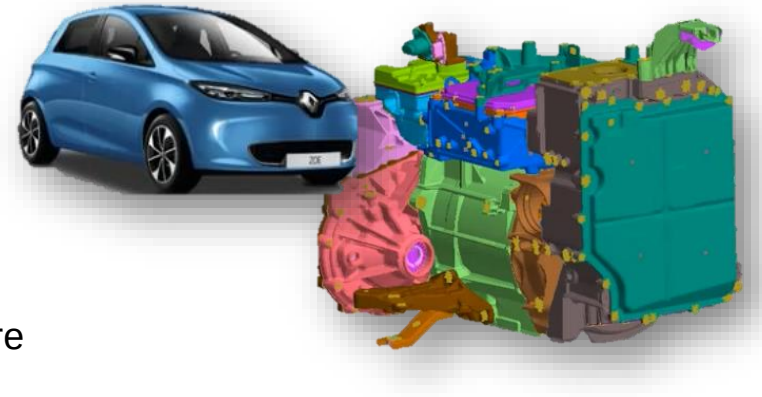
Solution

- A simulation-based approach using Actran's Mohring aeroacoustic sources is used to evaluate the aeroacoustic performance of the muffler
- Complex flow effects are also taking into account in the propagation simulation



Benefits

- A measurement campaign identified a 10 dB reduction in sound pressure level for the optimized exhaust system
- The impact of thermodynamic characteristics of the flow with aeroacoustic sources on the transmission loss was evaluated.



Electric motor noise control

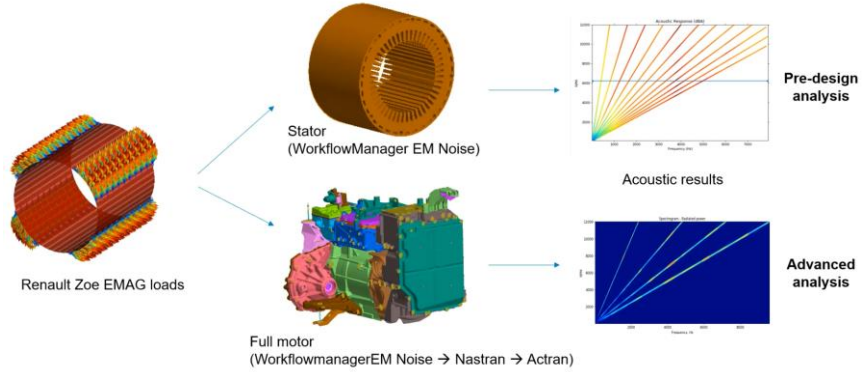
HxGN Live Design & Engineering 2021, Actran for e-motor noise control, Philippe Mordillat

Challenge

- Passengers expect electric vehicles to be very quiet.
- Therefore, in the development of a new electric powertrain, Renault had guaranteed NVH requirements of new motors before physical prototyping

Solution

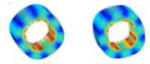
- MSC Nastran reads electromagnetic forces, and calculates the vibration levels
- Then, the vibration is provided to Actran for predicting the radiating noise.
- Pre-design evaluation and advanced analysis is performed within the Actran Workflow Manager



Benefits

- The Actran Workflow Manager's Electric Motor Workflow is an all-in-one tool for EMAG/FE coupling and noise radiation
- Non-simulation engineers can use this tool to more effectively analyse electric powertrain noise





(4,0) mode
~3840 Hz

Engine encapsulation acoustic simulation

HxGN Live Design & Engineering 2021, Engine encapsulation acoustic simulation, Mehdi Zerrad

Challenge

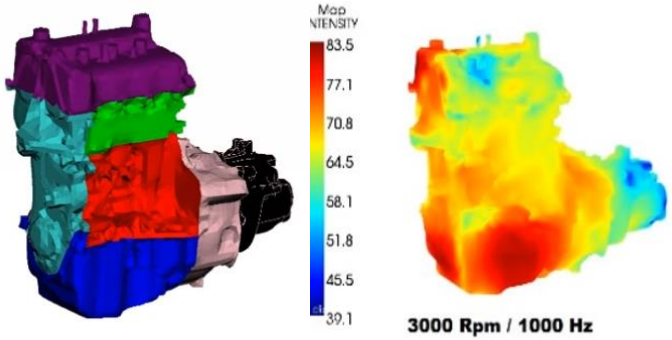
- Engine noise contributes a large amount to the overall pass-by noise of a vehicle
- Regulations are becoming stricter and need to be fulfil in order to avoid penalties
- Pass-by noise needs to be evaluated before physical prototyping
- Engine encapsulation can provide a way to significantly reduce noise from the motor

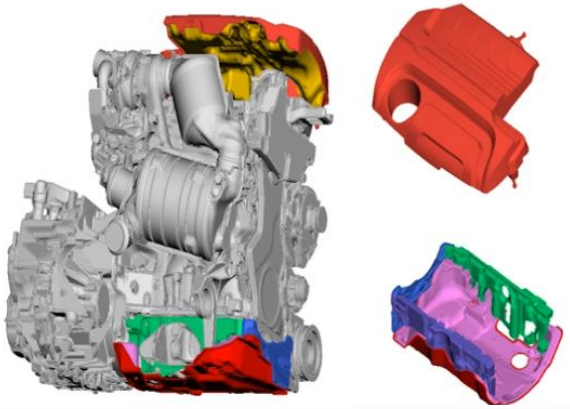
Solution

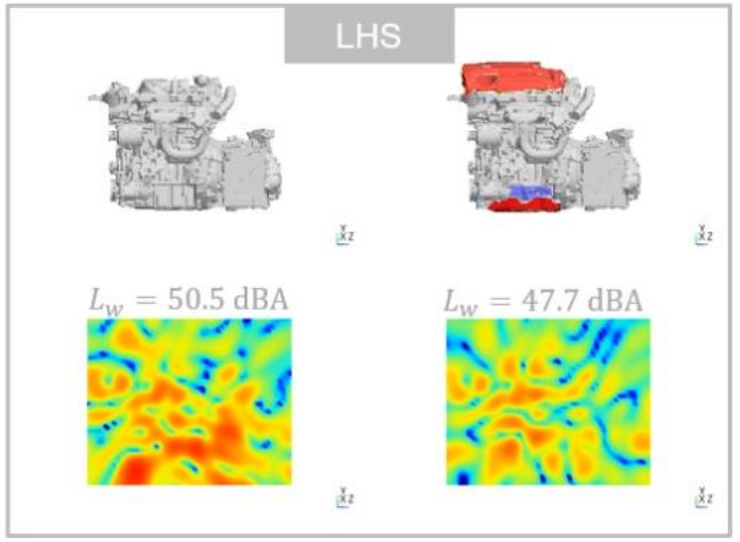
- A hybrid modal/physical approach is used within Actran to efficiently model the motor, porous encapsulation and the radiated field
- The excitation comes from AVL Excite, modes are generated by MSC Nastran and Actran solves the vibroacoustic encapsulation simulation

Benefits

- “Numerical methods provide recommendations in a short time frame and with reduced cost”
- Good correlation with measurements where the proposed encapsulation reduced noise by 0.7 dB(A)







Optimization of damping pad distribution on car structure

Journal of Vibroengineering, 2022, Optimization of damping pad distribution on body-in-white car structure, David Sipos et al.

Challenge

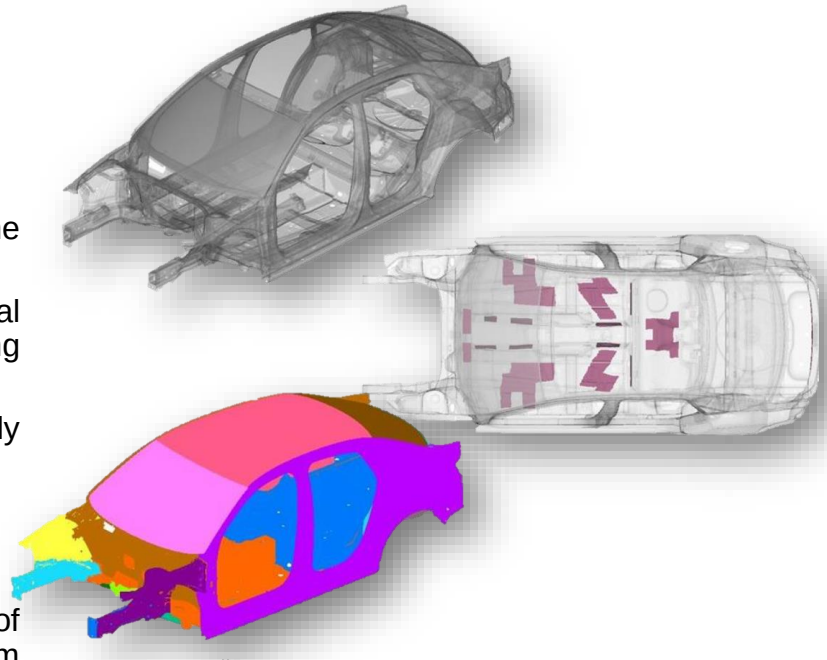
- Structure-borne noise is one of the most important contributors to the interior noise in a vehicle cabin.
- This can be effectively reduced by placing damping pads with special material properties along the chassis and on the large, radiating panels.
- Optimizing their distribution and properties can lead to significantly lower noise and vibration

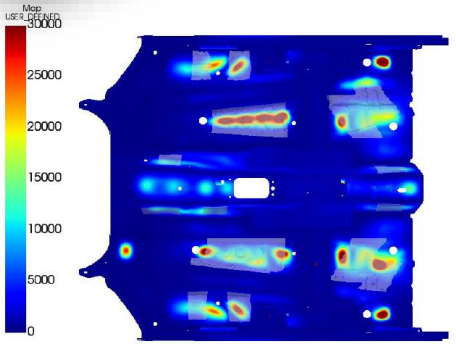
Solution

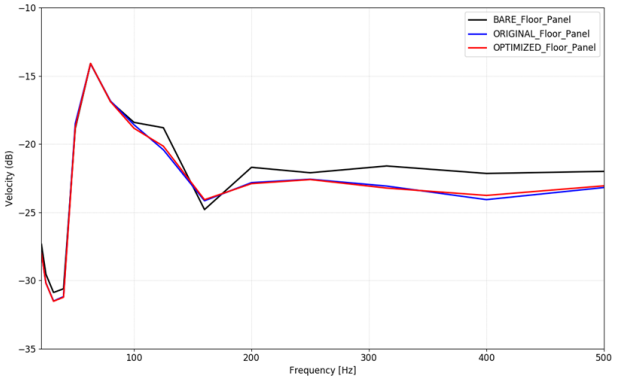
- Actran's Virtual SEA approach is used to calculate the behaviour of the car structure with the damping pads, using mode shapes from MSC Nastran
- Local information from the Virtual SEA analysis is retrieved using an auxiliary scalar output field

Benefits

- Reduction of the weight among of damping pads on a real car structure by 33 % while keeping the same acoustic performance.
- The local field is obtained as part of the Actran SEA simulation, no extra computation is required







Evaluation of exhaust aeroacoustic designs

SAE Technical Paper 2021-24-0091, 2021, Assessment of Flow Noise Mitigation Potential of a Complex Aftertreatment System through a Hybrid Computational Aeroacoustics Methodology, Federico Millo et al.

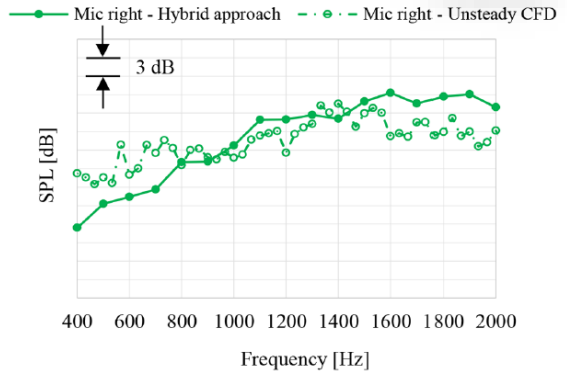
Challenge

- One of the main sources of noise in a heavy-duty vehicle is the turbulent flow of the engine's exhaust gases, generated within the exhaust line
- Direct aeroacoustic methods are generally not affordable in the development phase of an automotive engine and its subsystems.
- More affordable techniques are needed for design exploration early



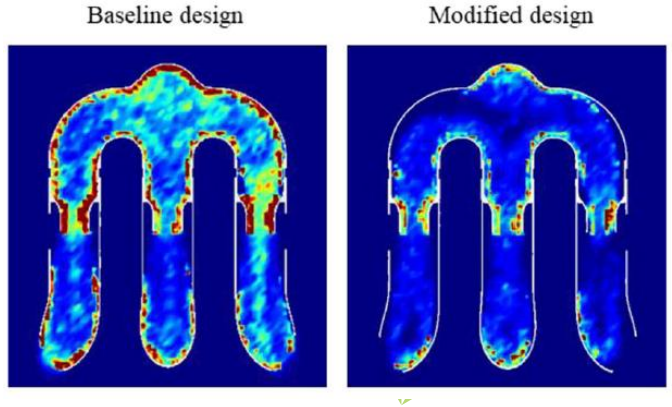
Solution

- Actran's SNGR method for affordable aeroacoustics is used to evaluate the noise from an exhaust system comprising of a catalyst, a muffler and a three-tailpipe diffusor
- Two versions of the diffusor are evaluated with results compared to a direct method for the baseline design



Benefits

- Good correlation with higher fidelity simulations
- Very effective in evaluating the aeroacoustic performance of different designs
- SNGR could be considered as a cost-effective numerical tool compatible with the limited time available for the development of a new product in the automotive industry.



formfleks

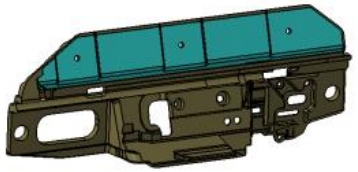
TOFAŞ

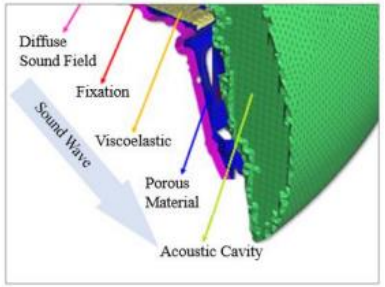
Sound Transmission Loss of Inner Dash Insulator

International journal of science, technology and design, 2021, Obtaining Sound Transmission Loss of Inner Dash Insulator via Numerical Methods, Mustafa Ceyhan et al.

Challenge

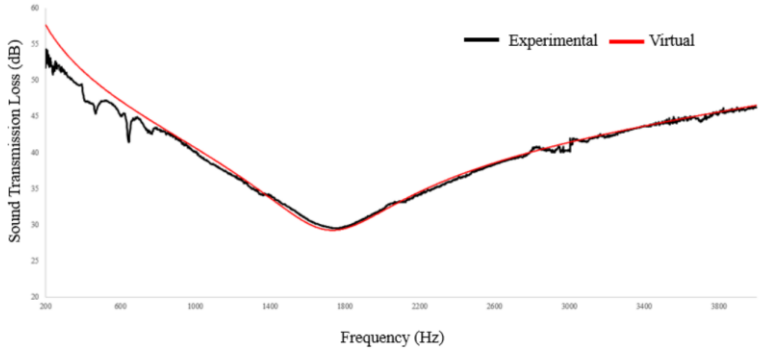
- The airborne and structure-borne noise of the engine can be reduced by the inner dash insulators and the acoustic comfort in the cabin can be improved
- Continuous development studies are carried out for insulators and numerical simulation can help keep up with the dynamic environment of designing them.





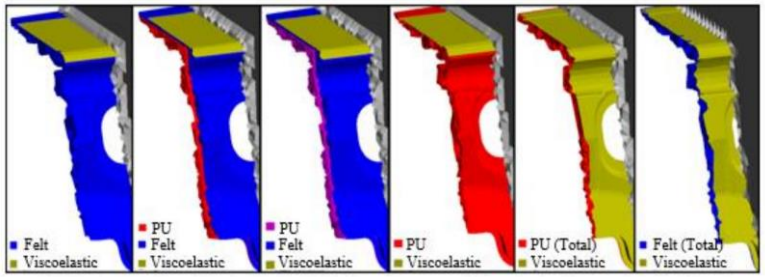
Solution

- Actran is used for calculating the transmission loss of the materials of the dash, including various porous and viscoelastic materials
- A diffuse sound field condition is used to model a reverberant room and a free field condition for the anechoic room
- The software was first validated with a Kundt's tube and then was used to perform the dash simulations



Benefits

- Critical insight was provided in terms of the use of the appropriate materials, especially when it comes to weight and acoustic performance
- Due to the simulation-enabled virtual development, no prototypes were created and that results in savings of time and cost



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Evaluate NVH Performance as Manufactured

Challenge

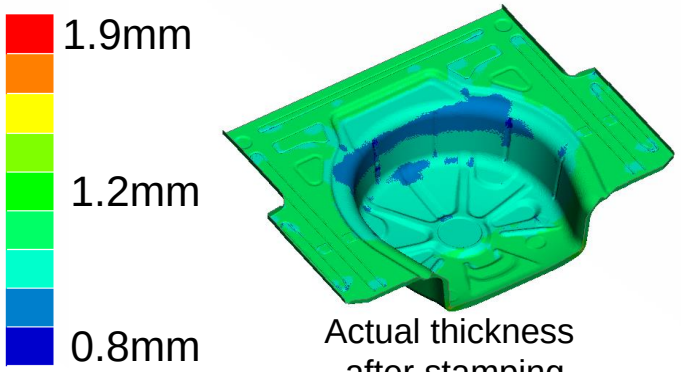
- NVH performance is affected by manufacturing process such as welding, stamping, etc.
- Final product may not comply with targets during homologation process while simulation predict the opposite
- Stamping the spare wheel panel results in a non-uniform thickness from 0.8mm to 1.9mm while starting from a 1.2mm steel sheet.
- **How is this affecting the NVH performance ?**

Solution

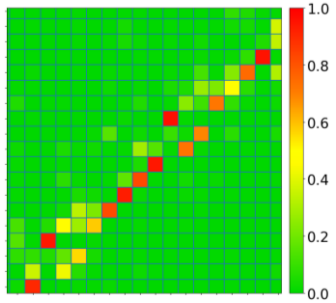
- FTI, Nastran & Actran are coupled to evaluate performance **as manufactured** and compared to performance as designed
- Structure Modes are different in shapes and natural frequencies.
- Noise insulation of the panel is affected by the material repartition. Predicted Acoustic insultation (TL) is **0.3dB lower** considering manufacturing process compared to as designed.

Benefits

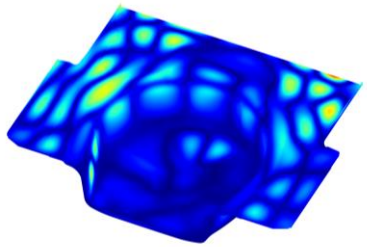
- More accurate simulation allows better design decision
- Safety margin can be reduced to further optimize design
- Simulating product performance as manufactured requires almost zero additional time compared to simulation as designed



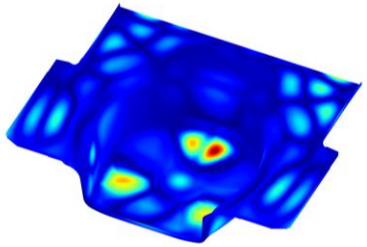
Actual thickness after stamping



MAC Correlation around 400Hz



Mode at 437Hz **as designed**



Mode at 437Hz **as manufactured**

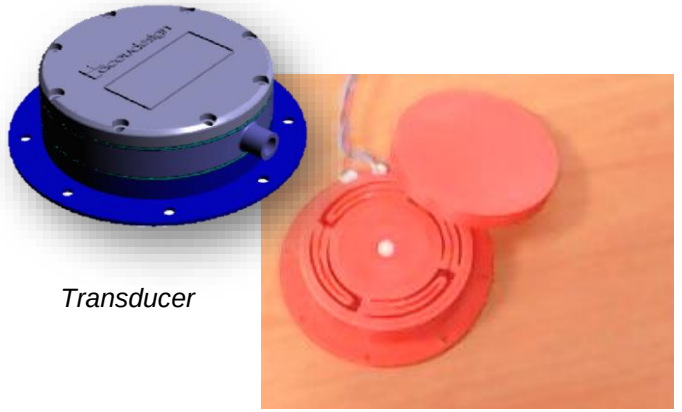
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Audio system within trim parts

International Styrian Noise, Vibration & Harshness, 2022, An alternative solution to vehicles audio system using inertial transducers integrated in trim parts: advanced development, J-Ph. Thome et al.

Challenge

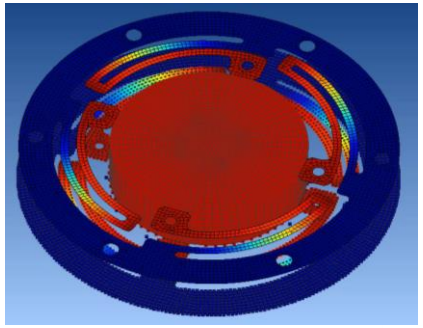
- Transducers integrated in trim parts can provide a way to bring a more important surround effect in the vehicle
- They can also be used to reduce the mass and volume of the audio system
- The challenge is to have a transduce with perfect piston movement to avoid distortions in the radiated sound signal



Transducer

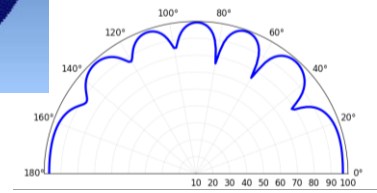
Solution

- Actran's extensive loudspeaker modeling capabilities were used to first examine the isolated transduced component and then the embedded component on the trim
- Necessary ingredients available:
  - Input data of voice coil (magnetic force, inductance, electric resistance
  - Electrical signal as the excitation
  - Impedance with Thiele & Small parameters



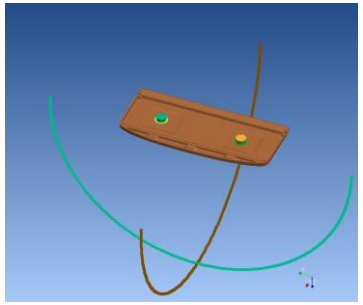
Isolated transducer model

Directivity at 2000 Hz

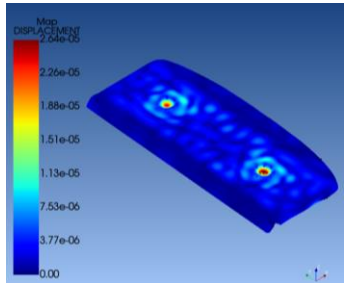


Benefits

- Innovative configurations can be modelled and evaluated easily with simulation
- Inertial transducers with double antagonist suspension allow a perfect piston movement, which improves drastically the linearity and thus prevents from distortions in radiated noise signal.
- Integrated in semi-structural inserts or trims, themselves embedded in decoupled soft trims leads to invisible "smart trim" equivalent speakers with very good immersive sound quality as well as a strong weight (-50%) and package reduction (-80%).



Transducers on trim



Displacement at 1360 Hz



Leakage in firewall transmission loss

DAGA 2022, Hybrid method to predict sound transmission loss for vehicle insulation considering component measurement data in finite element models, M. Brandstetter et al.

Challenge

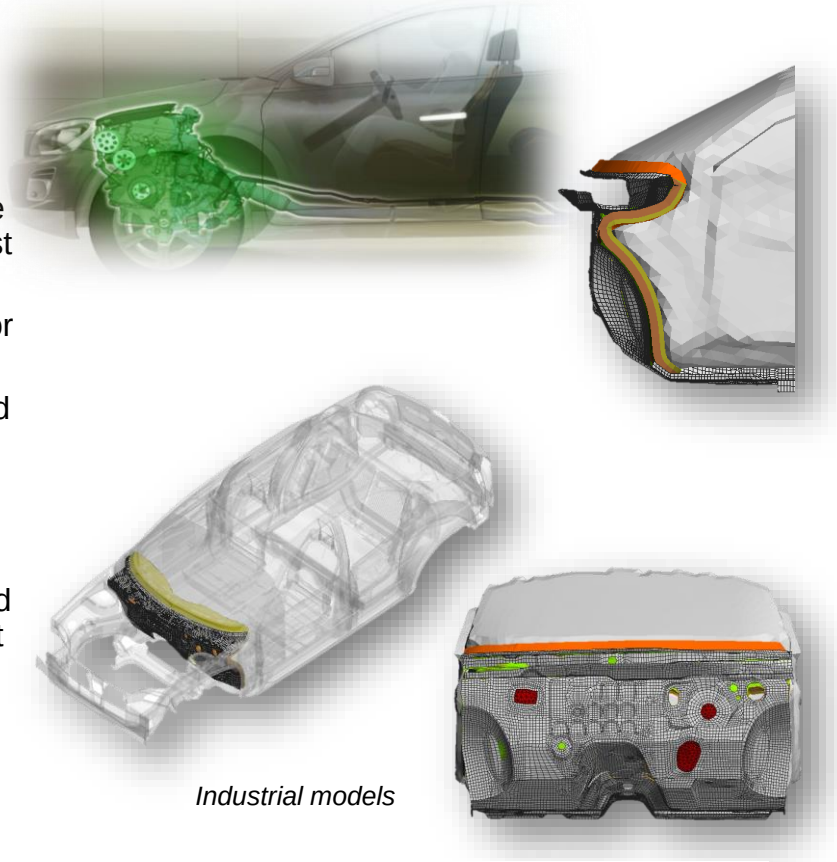
- As electric vehicles, which have a different sound and noise signature than ICE-powered vehicles, becomes more popular, NVH design must adapt to the different requirements
- Different firewalls are required for proper sound insulation of the motor noise
- More accurate evaluation is needed, taking into account leakages and grommets

Solution

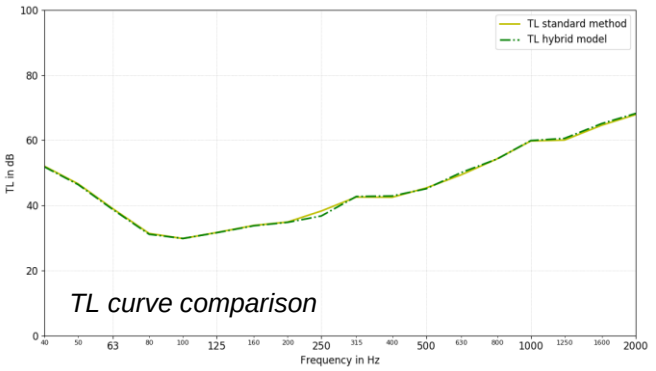
- A new hybrid modeling method combining finite element modeling and the transfer admittance method is used to produce accurate results at a reasonable computational cost
- It also allows to consider additional parts in the form of measured TL data
- The method is validated on an isolated firewall as well as on an installed industrial case

Benefits

- Imperfections and local behaviors can be considered in the model by adding TL values in form of admittance values.
- Time for material data analysis for grommets or other parts that might be time demanding when modeling everything in FE can be significantly reduced



Industrial models



TL curve comparison

HEXAGON

Driveline Clunk NVH

SAE Noise and Vibration Conference 2021, CAE Analysis and Auralization of Driveline Clunk NVH, Kelby Weilnau et al.

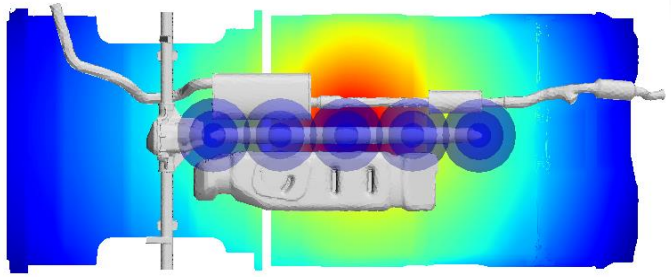
Challenge

- Noise and vibration evaluation of driveline clunk can be challenging as it is the result of driver input conditions and is transient in nature.
- A hybrid approach of physical test-based measurements and CAE analysis can be used to leverage the advantages of CAE in a comprehensive evaluation including the total vehicle noise, vibration, and harshness (NVH) performance.



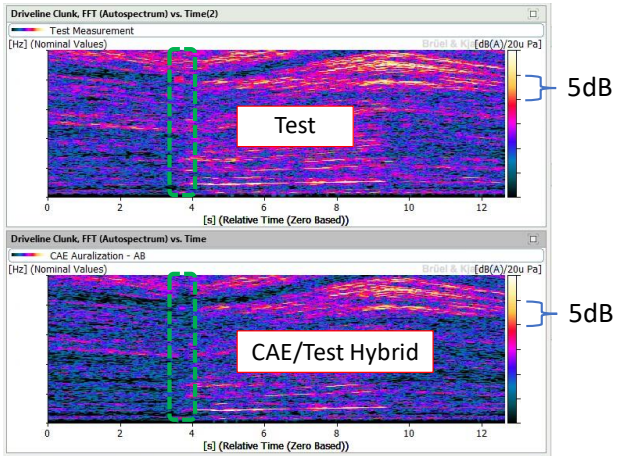
Solution

- Test measurements are used to characterize the source and transmission path in terms of structure-borne and airbone noise
- A time-domain multi-body analysis in Adams is combined with an Actran time-domain simulation to calculate the acoustic radiation
- The data are combined to auralized for objective and subjective analysis of the clunk noise



Benefits

- Auralization of combined simulation and test data for capturing a clunk noise event
- The data can be used within an NVH simulator for objective and subjective noise analysis





Affordable alpha cabin simulation

NAFEMS World Congress 2021, Simulation of Alpha Cabin reverberant room to estimate absorption coefficient under diffuse sound field, Eleonore Richard et al.

Challenge

- For evaluating trim acoustic properties, OEMs require suppliers to provide the absorption coefficient information up to 10 kHz
- This very expensive measurement is typically done by placing a sample in cabin that creates a diffuse sound field called alpha cabin
- Simulation could help reduce costs, but models tend to become large due to the size of the cabin and the demanding frequency characteristics

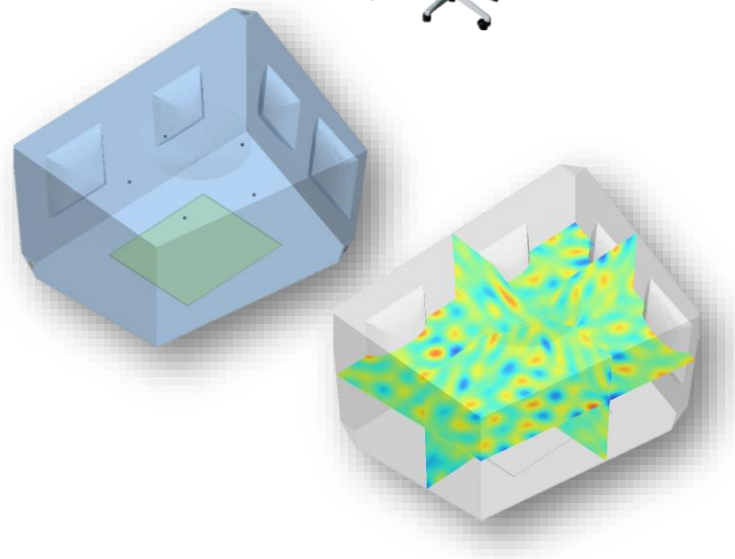
Solution

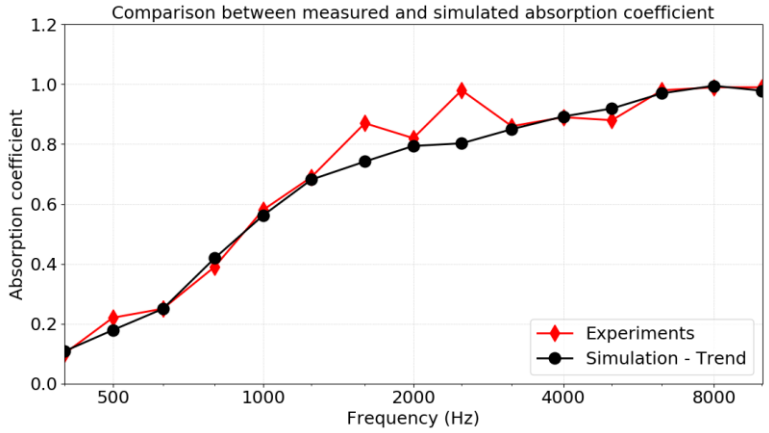
- A three-step process based on the finite element method is used to calculate the absorption coefficient between 400 and 10 kHz
- The method takes advantages of the unique quantities that simulation can provide such as energetic quantities
- A scaling law is found for the cabin that enables using smaller models without loss of accuracy

Benefits

- An alpha cabin simulation can be performed end-to-end within 7 hours!
- Comparison with measurements show strong agreement with the simulation method
- Reduced costs for suppliers when characterizing material samples for noise absorption







HYUNDAI

Road Noise on Trimmed Body

Challenge

Car buyers are very demanding for silent cars. Road noise is one of the most important noise sources, especially below 80km/h. Increasing the users comfort requires understanding how this noise is transmitted from the road to the driver/passenger ears.

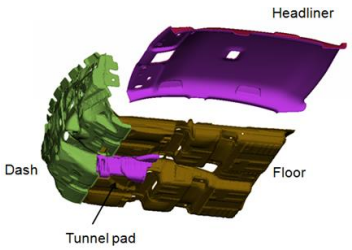
Solution

Actran and Nastran has been used for modeling the car body, including trim components. Air-borne and structure-borne road-noise were studied.

Benefits

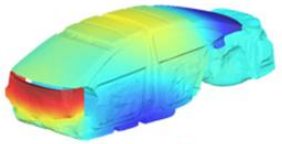
- Reduce road-noise transmission into cabin through vehicle trim design

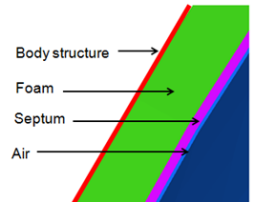

Body FE mesh

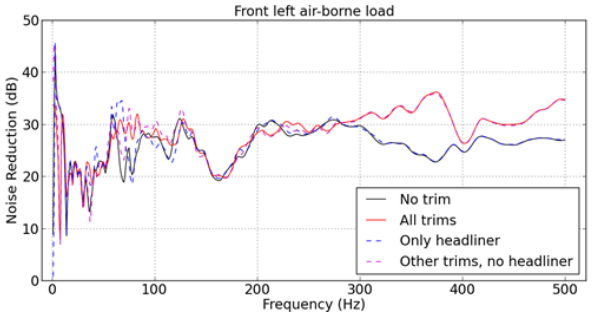


FE mesh of trim components

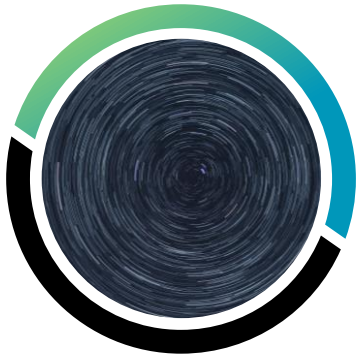

Cavity FE mesh


cavity mode





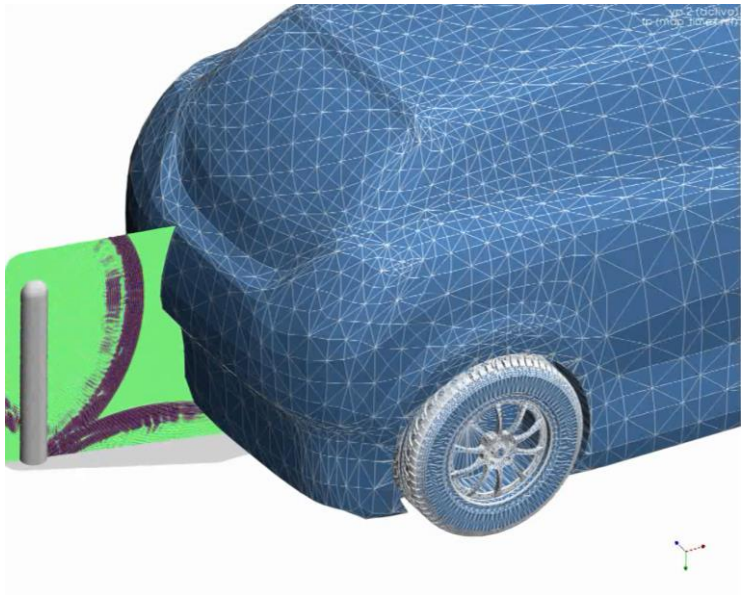
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Complex Doppler Effects

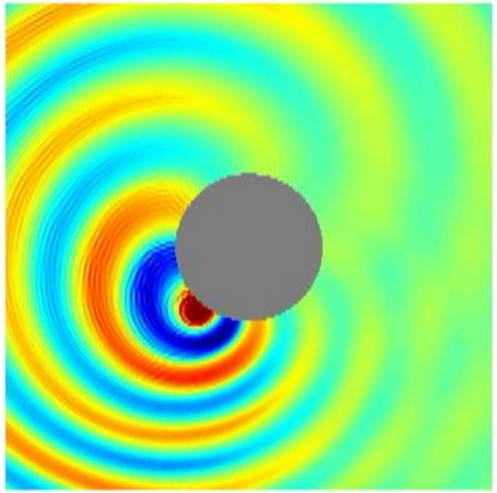
Challenge

- In several applications complex acoustic phenomena are exploited such as in ultrasonic parking sensors to discriminate spurious reflections



Solution

- Actran’s time-domain solvers (Actran VA time-domain & Actran DGM) are used to compute complex acoustic phenomena including Doppler effects or transient behavior at very high frequencies.



Benefits

- Actran allows the analysis of transient acoustic phenomena not easily and efficiently detectable with frequency domain codes.

HEXAGON

FKFS
RESEARCH IN MOTION.

LAMBORGHINI

Side mirror noise

28th AIAA/CEAS Aeroacoustics 2022 Conference, An efficient hybrid computational aeroacoustic process: validation and applications for vehicle development, Carlo Alberto Perugini, Gilberto Arzilli et al.

Challenge

- Automotive OEMs are expected to fulfil demanding requirements with respect to the safety and comfort of passengers.
- Wind mirror noise is an important issue in high speeds.
- The implementation and application of numerical methodologies for aeroacoustic analysis becomes more and more essential for car manufacturers in order to optimize the effectiveness of vehicle development.

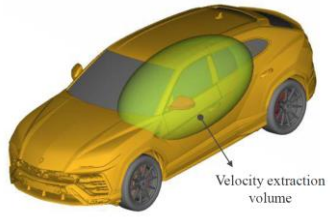
Solution

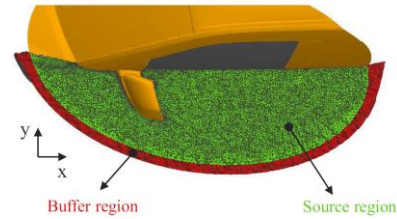
- Actran is used to propagate the noise calculated with the acoustic perturbation equations based on a compressible flow simulation
- A vibro-acoustic model has been used to simulate the transmission of the acoustic pressure fluctuation into the cabin.

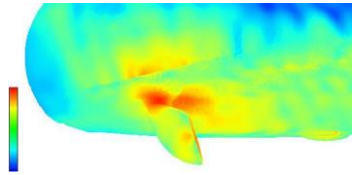
Benefits

- Great correlation between simulation and measurements up to 2.5 KHz for side mirror interior noise propagation
- The simulated acoustic contribution to the pressure fluctuation, calculated by using the acoustic perturbation equations (APE), has been validated against exterior microphones and beamforming measurements

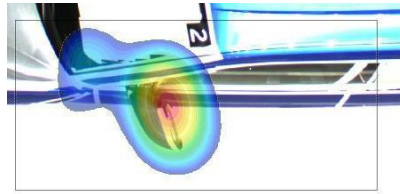




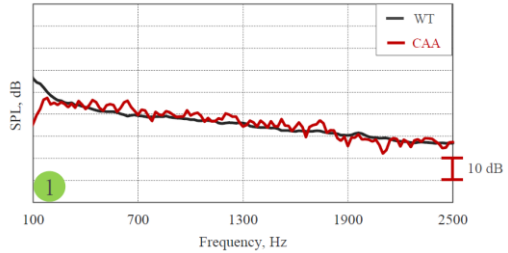




CAA (Top view)



Standard Beamforming (Top view)



Sound pressure level (SPL) measured by the exterior microphones: Wind Tunnel measurement (WT) vs Computational Aeroacoustics (CAA)

HEXAGON

Wind buffeting noise of vehicle rear window

Study on hybrid LES–LAA method for wind buffeting noise control of vehicle rear windows, 2017, H. Guo, Y. S. Wang, X. L. Wang, N. N. Liu and Z. Y. Yin

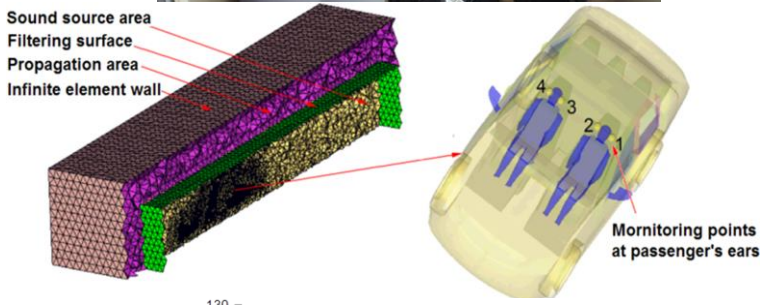
Challenge

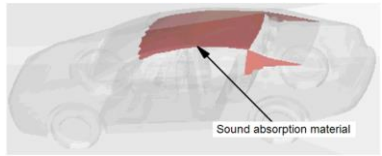
- Vehicle wind buffeting noise consist of fluctuations caused by aerodynamic turbulence, irregularities of the air flow, cavity resonances, aspiration leaks, and low-frequency beating noise caused by open windows, sunroofs, and gusts of winds.
- The low frequency and high intensity of the buffeting noise of a vehicle rear window may make the driver tired and irritable, which thus affect the comfort and safety.
- Rear-window wind noise specifically comes from the cavity resonance and has been a challenging topic for OEMs.

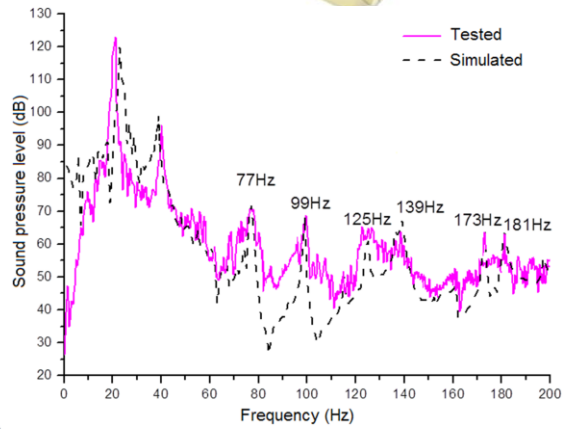


Solution

- Based on LES simulation, Actran is used to generate noise sources and propagate them inside and outside of the car cavity.
- Sound absorbing materials can be easily introduced in the acoustic simulation to evaluate noise reduction techniques.

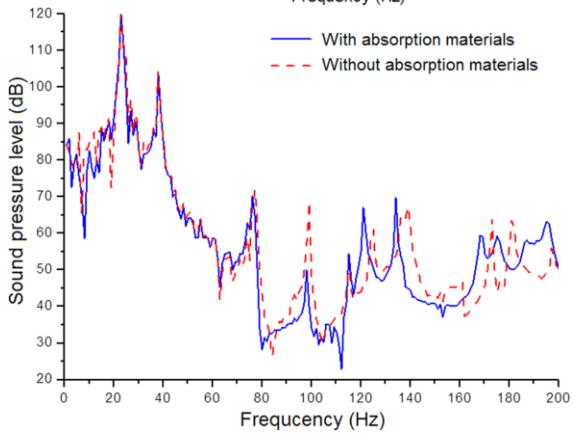






Benefits

- Good correlation between the simulations and real vehicle road tests.
- The simulation error of sound pressure level with the hybrid LES-LAA method is less than 2%.
- The validated method is used as part of an optimization process for noise reduction.
- A sound pressure level reduction of 27.26dB was achieved.



Flow noise generation in a pipe bend

SAE 2018-01-1525, Flow noise generation in a pipe bend, S. Vizzini, M. Knutsson, M. Dybeck, M. Abom

Challenge

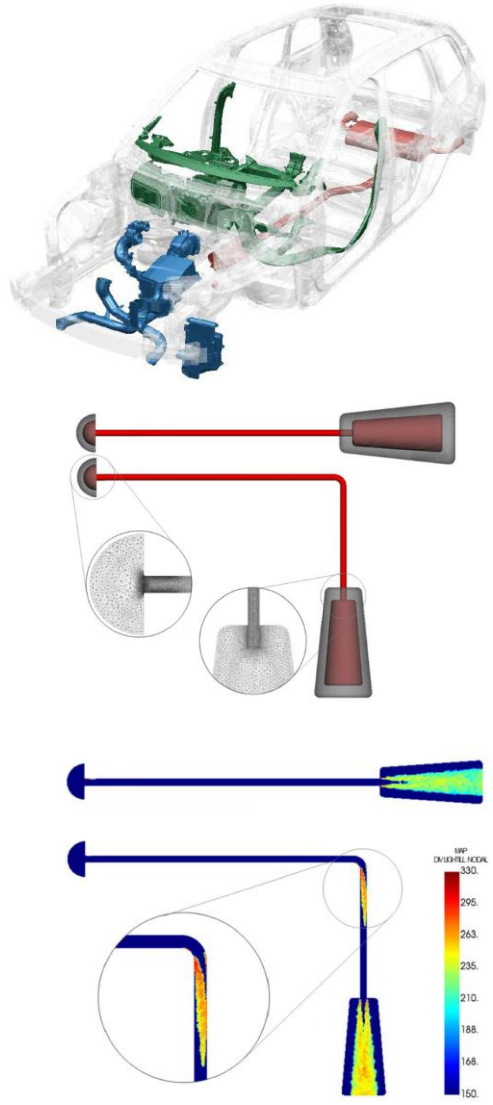
- Noise generated by low Mach number flow in duct network is important in many industrial applications.
- In certain cases, the traditional way to make the design, which is based on the rule-of thumb and scaling law methods can become highly inaccurate and uncertain unlike numerical solutions.

Solution

- Actran uses a SNGR numerical model, to predict flow noise generation.
- A hybrid computational aero acoustic approach, based on steady RANS and Lighthill analogy has been used in Actran.

Benefits

- Optimization of duct geometry of the exhaust system can be done more efficiently.
- SNGR can provide valuable insight in the form of acoustic source maps and location of the noise-generating areas.



Straight and bent duct SNGR Lighthill source strength

Full-vehicle road noise

Journal of Physics, 2020, Prediction and Optimization of Full-Vehicle Road Noise Based on Random Response Analysis, C. Cao, D. Meng, et al.

Challenge

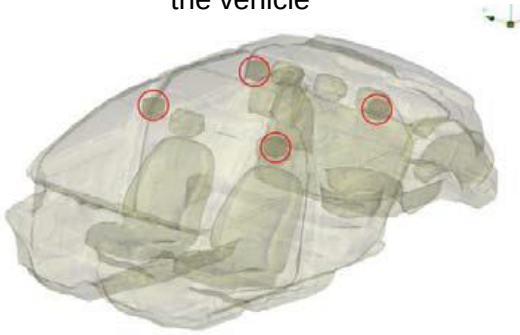
- With the new tendencies in the automotive industry, wind noise has become more prominent, which seriously affects the comfort of the passengers
- Interior road noise is mainly caused by road surface excitation, which is transmitted to the vehicle body trough tires and suspensions, causing body panel vibration and interior noise response.



Finite element model of sound-structure coupling of the vehicle

Solution

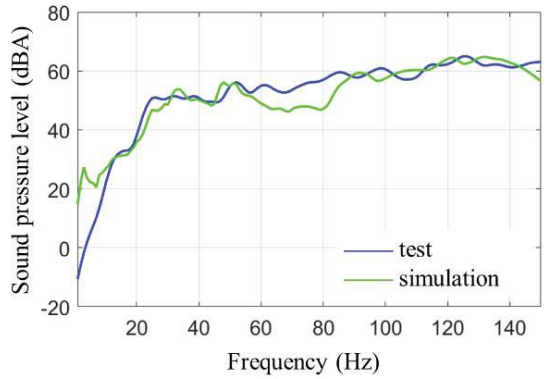
- A finite element model for the entire vehicle, including the suspension, is established and solved in MSC Nastran
- A road noise prediction method is established based on the theory of random response analysis.



SPL measurements points

Benefits

- Good correlation between the simulation of the sound pressure level results and the measurements.
- This process determines optimization measures to reduce sound pressure level
- A decrease of the average sound pressure level near the driver's ear of 0.81 dBA was achieved.



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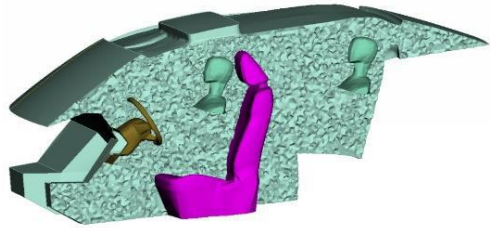
Flow-induced vehicle interior noise

2020 International Conference on Applied Physics and Computing, AN EFFICIENT METHOD FOR PREDICTION OF THE FLOW-INDUCED VEHICLE INTERIOR NOISE, Y. Liu, W. Lu, et al.

Challenge

- Wind noise is an important attribute for vehicle interior quietness.
- High costs of wind tunnel measurements have made numerical solutions an impending method in the process of vehicle development.

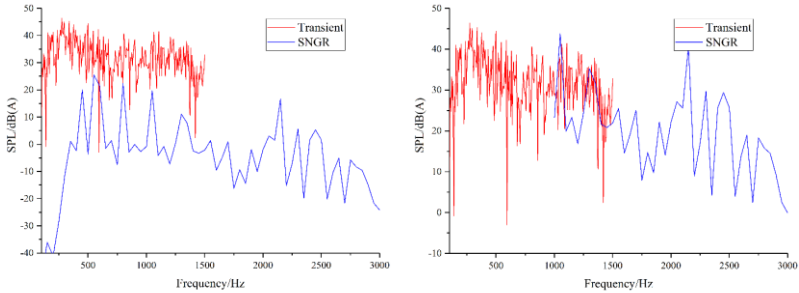




Internal acoustic model

Solution

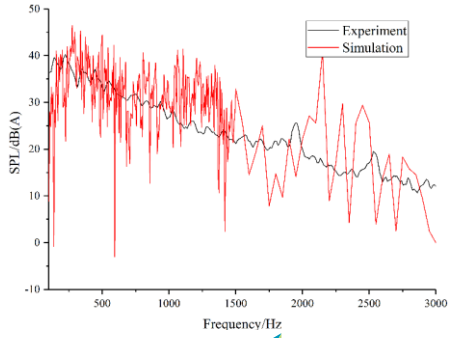
- Actran uses a hybrid method composed of a transient solution, based on the LES model, for low frequencies and a SNGR method for the medium and high frequencies for wind noise simulation.
- The SNGR results are corrected with a correction coefficient and the two results are combined.



Comparison before and after correction

Benefits

- Good correlation between simulations and experimental data for interior wind noise in a frequency range from 100 Hz to 3000 Hz.
- The process used can be applied to optimize the shape of vehicle's rearview mirror and A pillar.
- The hybrid method allows to improve computational efficiency.



HEXAGON

Sound transmission loss

Applied Acoustics, 2020, An Investigation of the Sound Transmission Loss for Elastomeric Vehicle Door Seals, O. Saf, H. Erol, et al.

Challenge

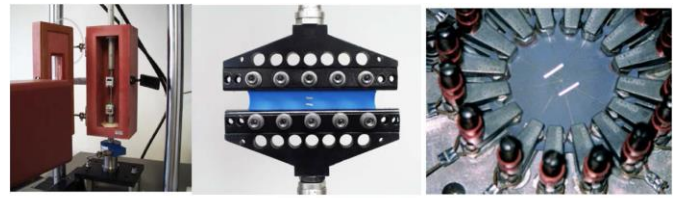
- In the new generation of vehicles, wind noise has become to most dominant part of interior noise.
- Understanding the sound transmission loss through a seal system is essential to reduce interior wind noise level.

Solution

- An impedance tube model is created and solved to perform a FEM-model material validation in Actran.
- After validation of the model, Actran was used to calculate the sound transmission loss of the sealing sections.

Benefits

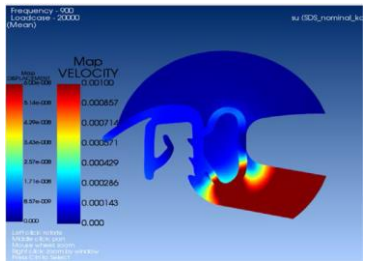
- Excellent correlation between measurements and FEM for resonance and high frequencies.
- This perspective will bring new insight for the acoustic design of the sealing sections.
- Numerical solutions can be practical for the early development of sealing sections.



Hyperlastic test setup

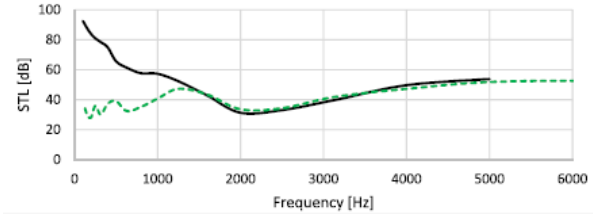


Impedance tube FEM model

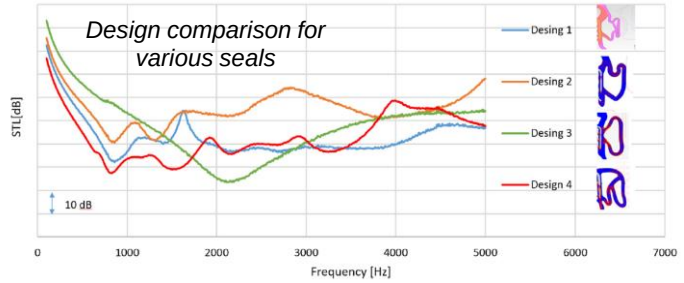


FEM model

Comparison of the numerical and experimental results obtained for the sealing section



Design comparison for various seals

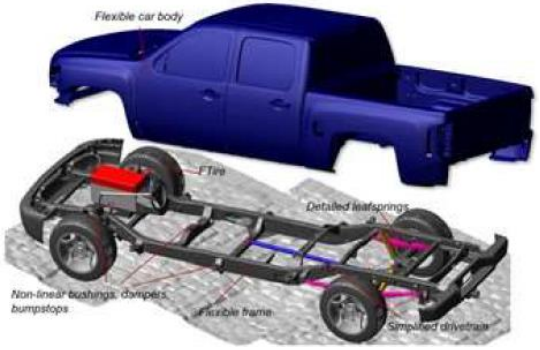


Auralization of road noise

2022 JSAE Annual Congress, Auralization of Road Noise CAE Simulation Results for Interactive Sound Quality Evaluations, R. Hadjit, F. Sjogren, A. Poulos, et al.

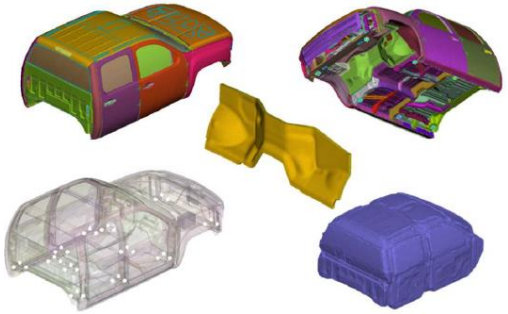
Challenge

- Road noise is the dominant contribution to a vehicle interior noise when cruising below highway speed.
- Simulations are essential to accelerate the development process.



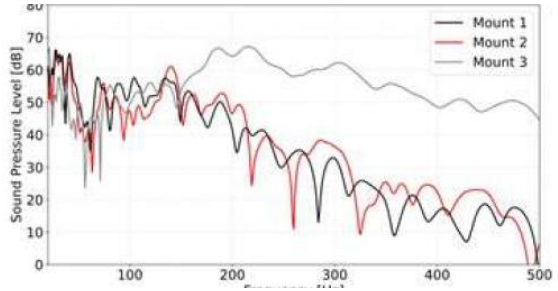
Solution

- The road vibration is calculated based on an Adams model
- A vibroacoustic finite element model is built in MSC Nastran PEM to compute the transfer functions between the mounting points and two virtual microphones.
- The sound pressure level is found by combining the transfer functions with previous body simulations.



Benefits

- These simulations can be generated in a very early stage of the design process even before physical prototypes are available.
- This process is effective in minimizing the risks of late NVH issues and support the definition and evaluation of design countermeasures if necessary.
- All information can be entered to the NVH Simulator to subjectively evaluate noise and sound quality



Transfer function



Acoustic trim results recovery

SAE Technical Paper 2022-01-0309, 2022, Efficient Acoustic Trim Components Results Recovery for Industrial Finite Elements Models, de Walque, C., Brandstetter, M., Corveleyn, S., and Van den Nieuwenhof, B.

Challenge

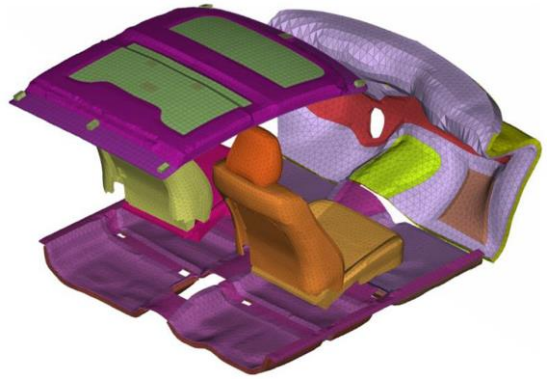
- The Reduced Impedance Matrix (RIM) method, which is most widely used to solve vehicle trim models, cannot solve for the behaviour of internal trim components
- Understanding the behaviour of internal trim components can help to optimize its acoustic damping and reduce mass

Solution

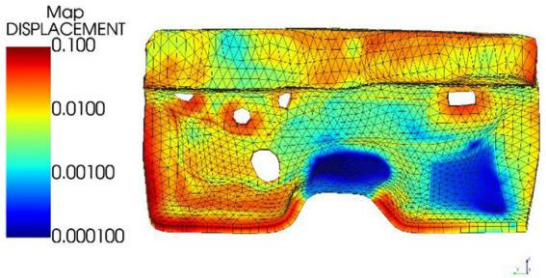
- An additional facultative step was used in addition to the RIM method to recover the trim internal results in an Actran model
- Results were compared with that of a direct approach in Actran, on the basis of Noise Transfer Functions (NTF) at the driver ear location
- From the comparison, design changes were made to the trim

Benefits

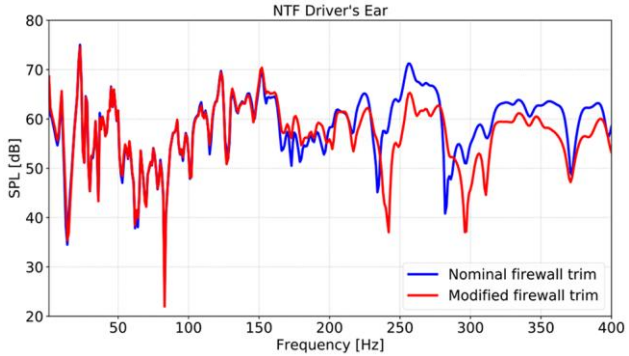
- Good correlation between RIM with facultative step and the direct approach
- Time taken for additional step was less than 10% of total runtime, and negligible memory consumption
- Modification of nominal trim resulted in a 6dB reduction of sound at 256 Hz at driver ear location



Actran model of acoustic trims in Neon Dodge



Displacement map of firewall acoustic trim at 256 Hz



Noise transfer function at driver's ear for nominal and modified trim configurations

SZÉCHENYI EGYETEM
UNIVERSITY OF GYŐR

Validation of Actran Virtual SEA for different types of connections

Journal of Vibroengineering, 2022, Validation of finite element connection modeling by comparison of experimental and virtual power injection methods, D. Sipos, M. F. Treszkai, and D. Feszty,

Challenge

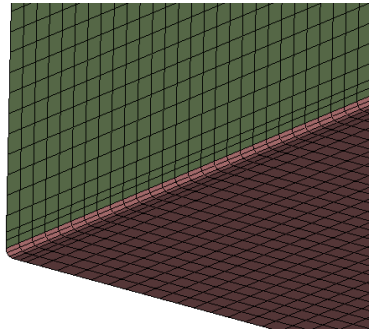
- For a Statistical Energy Analysis (SEA) model, the damping loss factors and coupling loss factors need to be evaluated by experimental or analytical methods, but are challenging to obtain
- Due to the mesh size, the finite element method is not feasible in high frequency ranges

Solution

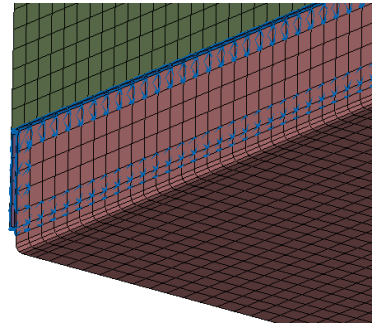
- Power Injection Method (PIM) was applied virtually on a coupled plate model using Actran Virtual SEA
- Four connection types – bent, line welded, superglued and spotwelded
- Two cases considered – constant value global damping and global damping using values from experimental PIM
- Loss factors were evaluated experimentally for comparison

Benefits

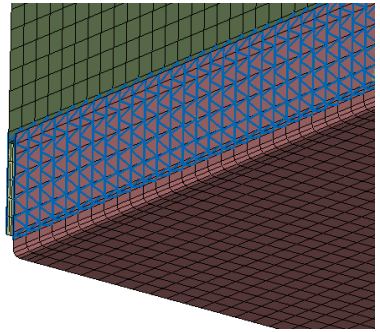
- The simulated loss factors matched with experimental values for bent, line welded and superglued connections
- For spotwelded connections the exact dimensions of experimental model are required to accurately match the results



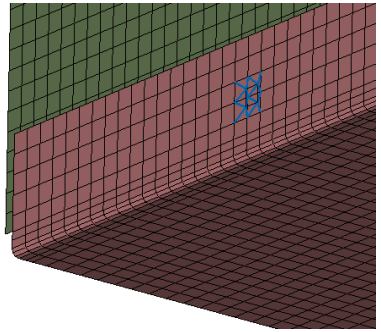
Bent connection



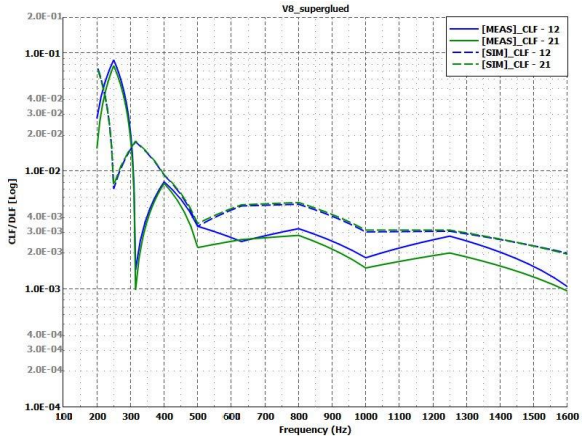
Line welded connection



Superglued connection



Spotwelded connection



Coupling loss factors for superglued connection

MARQUARDT

Acoustic simulation of automotive switches

"We need to understand how to effectively modify things, which is something that would be very possible with Actran"

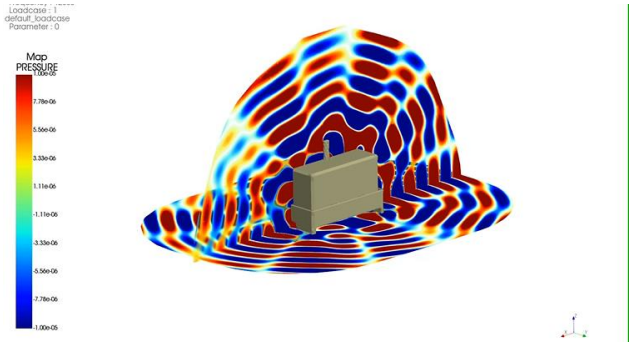
- Michael Stiefel

Functional Lead for CAE Mechanics

Challenge

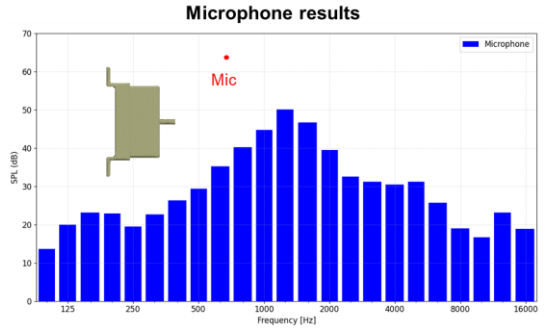
- "As automotive OEMs pay more and more attention to acoustics, the acoustic development of switching components is getting increasingly important.
- How do they sound and how do they feel? What kind of click or not click do they produce?"

Michael Stiefel,
Functional Lead for CAE Mechanics



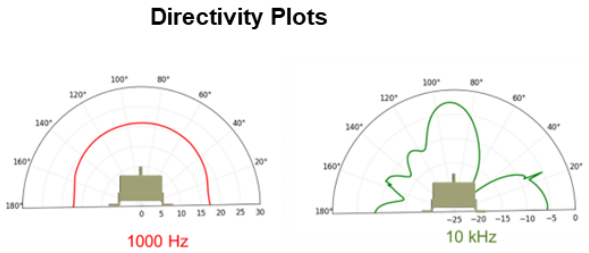
Solution

- A model of the switch box is created and solved in Actran.
- The model includes a representation of the vibrating structure, the interior acoustic cavity and the exterior acoustic propagation
- Different configurations can be efficiently tested and compared



Benefits

- Impact of design changes can be assessed in concept phase
- Both objective (sound pressure level and psycho-acoustic) and subjective evaluation (auralization) can be performed



HEXAGON

Sound Directivity Pattern of AVAS Speaker

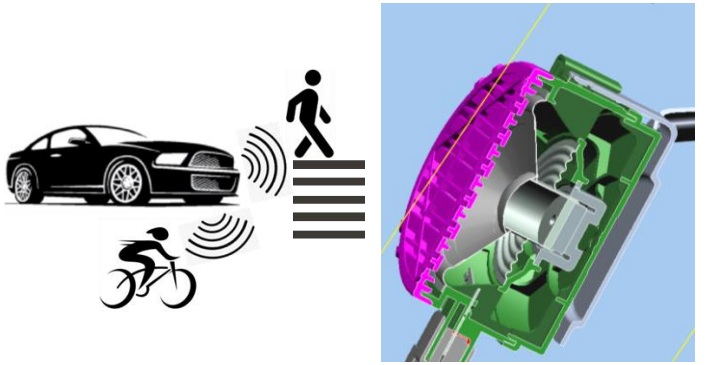
"With this project, we set out to develop a methodology to consider the acoustic directivity pattern of an AVAS speaker in a full vehicle model as well as develop a virtual speaker model that has the same sound properties as the physical speaker"

- Wenlong Yang

Noise and Vibration CAE Engineer General Motors

Challenge

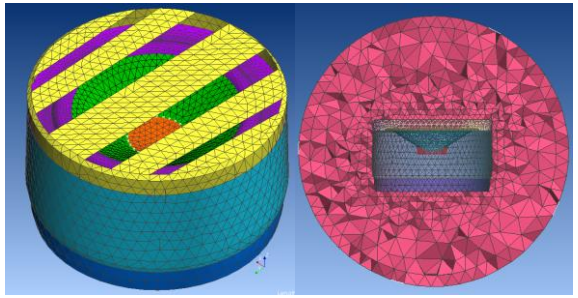
- An acoustic vehicle alert system (AVAS) is required to be present in all electric vehicle to alert pedestrians in low speeds, when the vehicle is silent
- The AVAS speaker generates sound fields that are very directive which makes it difficult to evaluate them and optimize them as part of the system
- A methodology is required to develop a virtual speaker model to represent the physical speaker in full vehicle conditions



AVAS speaker definition and cross-section

Solution

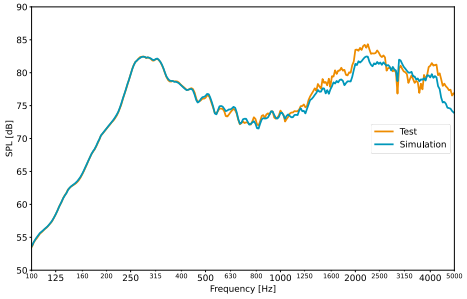
- A methodology is proposed based on validating the physical speaker with Actran against measurements and then extracting the necessary information with a pellicular analysis
- The recovered acceleration of the virtual speaker is then inserted into the full vehicle, reducing the computational cost



Actran model

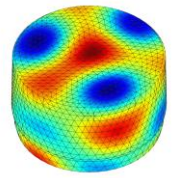
Benefits

- Excellent correlation of the speaker representation against measurements
- Easy way to extract equivalent source information with the inverse pellicular analysis
- Easy application of the extracted field in a different model



Comparison with measurements

2500 Hz



Surface vibration from pellicular analysis

HEXAGON

Lightyear

Tire noise and in-wheel motor noise for Pass-By Noise predictions

SAE Noise and Vibration Conference 2023, Tire noise and in-wheel motor noise in FE simulations for Pass-By Noise predictions, A. Lysak, A. Kocsis, X. Robin

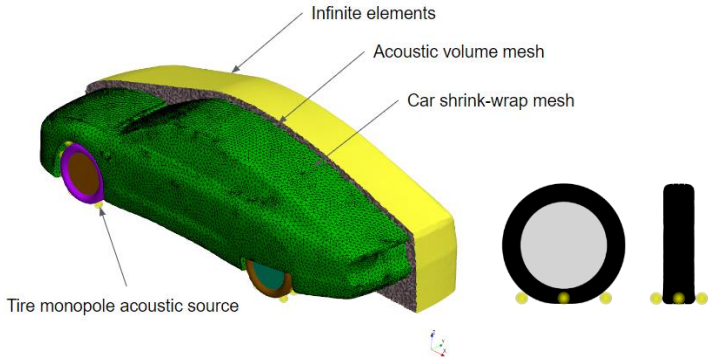
Challenge

- Pass-by noise of electric vehicles is mainly driven by tire and e-motor noise
- Some electric car companies, like Lightyear, use in-wheel electric motors
- These types of noise need to be thoroughly understood, but especially tire noise is difficult to simulate before then being used in pass-by noise simulations



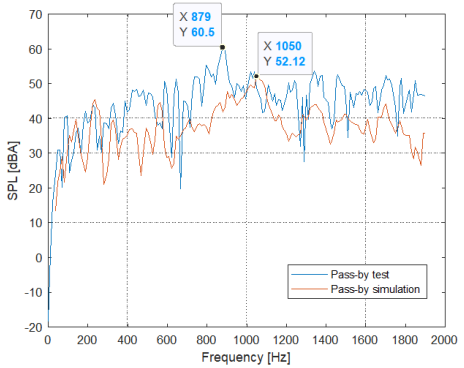
Solution

- A methodology to reduce tire noise to monopole sources based on test data is used, and the e-motor vibration is calculated with finite elements
- Both these excitations, as well as wheel treatments are then used in the complete car model for pass-by noise simulations



Benefits

- Good correlation with measurements, proving the monopole reduction methodology
- Fast full vehicle pass-by noise simulation, reaching easily 2000 Hz
- Complete solution for evaluating electric motor noise as a standalone or as part of the vehicle



HEXAGON

Interior noise from side mirror excitation

SAE Noise and Vibration Conference 2023, An Efficient Hybrid Computational Process for Interior Noise Prediction in Aeroacoustic Vehicle Development, Carlo Alberto Perugini et al.

Challenge

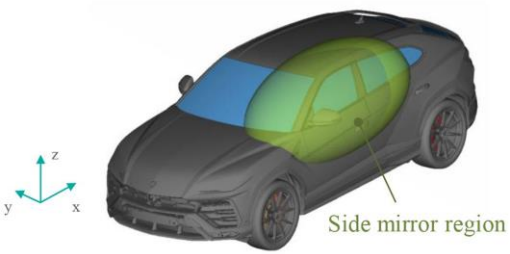
- Wind mirror noise is an important issue at high speeds, especially for performance and luxury vehicles, where expectations of acoustic comfort are higher
- The interior noise needs to be evaluated to properly apply treatments to reduce noise and increase comfort
- Numerical methodologies for aeroacoustic analyses are increasingly crucial for car manufacturers to optimize the effectiveness of vehicle development.

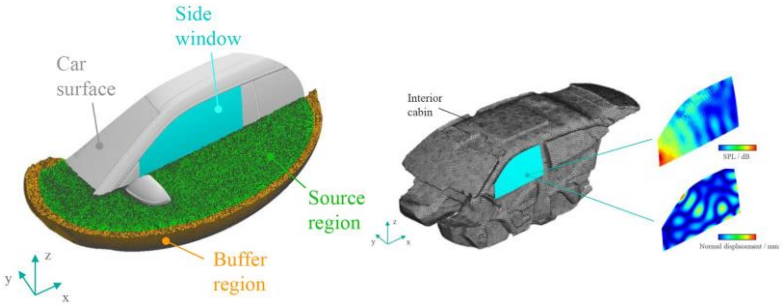
Solution

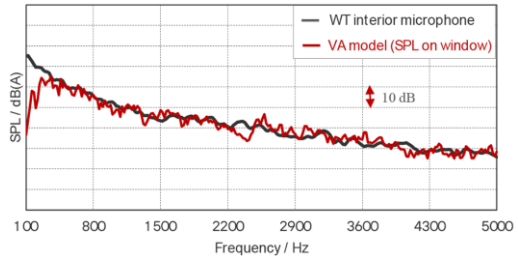
- A hybrid aeroacoustic simulation approach is used to model side mirror noise in the interior, based on CFD and Actran, reaching 5 kHz in frequency
- A comparison is also performed when loading the window only with the acoustic contribution or with both the acoustic and the hydrodynamic contribution of the sources

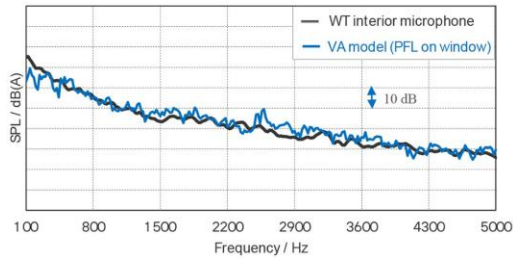
Benefits

- Excellent correlation with measurements for both the exterior noise and the interior noise, reaching frequencies of 5000 Hz
- Efficient and flexible methodology for modelling aeroacoustic excitations, even for large vehicles and high frequencies
- The process is a suitable tool for combined analyses with wind tunnel experiments and is effective for both exterior and interior acoustic analysis in vehicle development











Electric Powertrain Noise Treatment Evaluation with Machine Learning

SAE Noise and Vibration Conference 2023, Machine-Learning-Based Modelling of Electric Powertrain Noise Control Treatments, A. Kocsis et al.

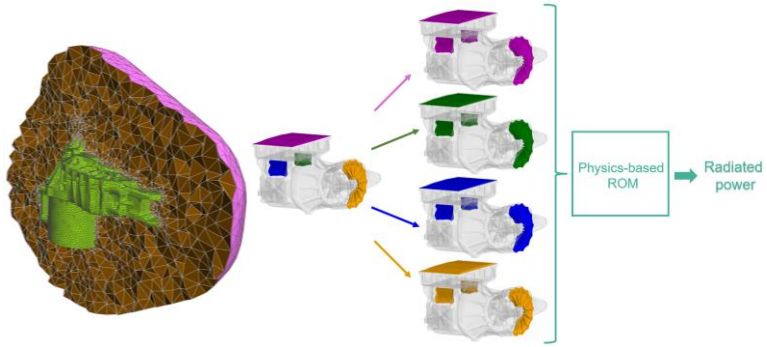
Challenge

- Acoustic treatments can be used to improve NVH performance of (electric) motors
- Choosing the appropriate materials and correct positions could be tricky as there is a huge number of possibilities
- Simulating all these possibilities could be cost-prohibitive



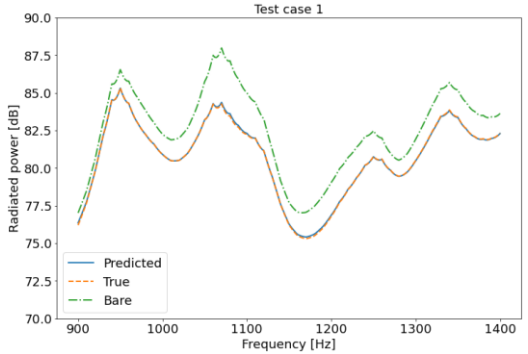
Solution

- Two types of reduced model approaches are used to accelerate the evaluation of treatments
  - A physics-based model that recovers the total radiated power as the sum of the contributions from the untreated part and the treated regions
  - A machine learning model for evaluating instantaneously any treatment configuration



Benefits

- Massive reduction of the required simulations to cover the whole design space, from billions of simulations to just 256 for 4 treatments
- Excellent performance of both reduced models in terms of accuracy
- Instantaneous prediction of any configuration with the machine learning model



Machine learning model accuracy on a random configuration

HEXAGON

EASTMAN

Evaluation of an acoustic interlayer for glass panels for wind noise

Internoise 2023, Evaluation of the PVB interlayer type on the interior noise level using a finite element approach, D. Hodder, M. Johnson, P. D'Haene, V.S. Balaramraja

Challenge

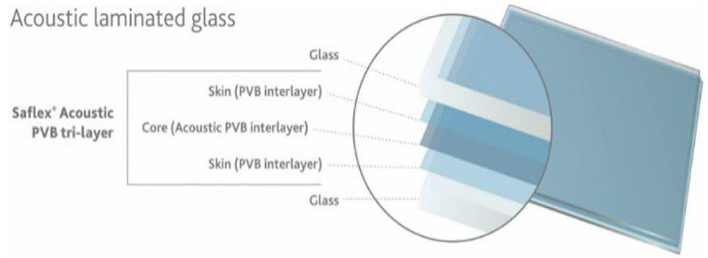
- Glass panels in vehicles serve multiple purposes, including providing noise isolation using special acoustic interlayers
- To evaluate different materials early in the design, a simulation approach is used
- For wind noise, due to the computational cost of the process the required frequency (> 10 kHz), it's often difficult to perform

Solution

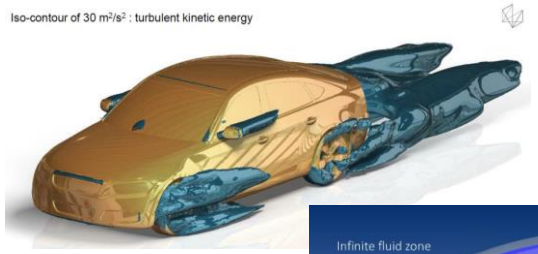
- A vibro-acoustic simulation approach in Actran is used to model the materials in the glass and side windows of a vehicle
- An SNGR approach based on Cradle CFD flow results can provide aeroacoustic sources fast for relative comparisons.
- The sources are then mapped onto the windows and roof, and they are propagated within the cabin in frequencies up to 10 kHz

Benefits

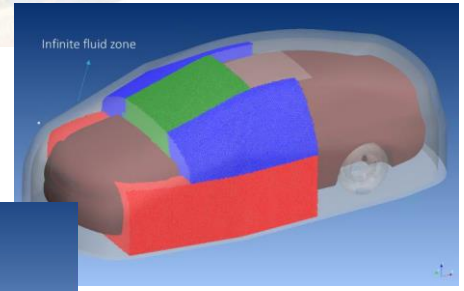
- Easiness to interchange materials for evaluating performance
- Affordable evaluation of wind noise with limited required expertise, with high-frequency noise being taken into account
- Availability of psychoacoustics metrics such as intelligibility can provide further insight for OEMs and suppliers



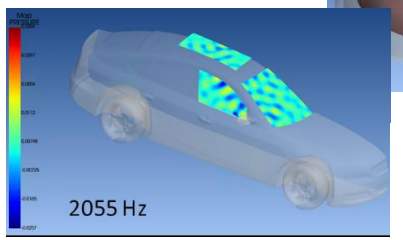
Laminated glass



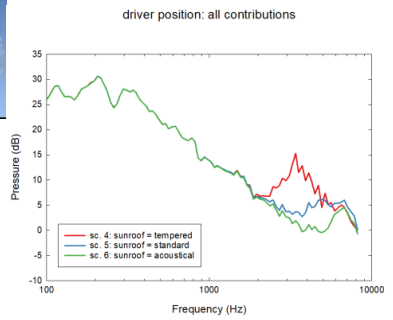
Turbunent kinetic energy isosurfaces



Exterior acoustic model



Aeroacoustic noise source mapped onto glass surfaces



Comparison of different glass compositions (lower is better)

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Aerospace

HEXAGON

AIRBUS

Silent but powerful aicraft engine

"Airbus has confirmed the accuracy of Actran predictions by comparing them with engine static testing results. Actran is the only simulation tool able to accurately model the main physical phenomena for engine nacelle radiation."

Jean-Yves Suratteau
Head of Numerical Methods, Acoustics & Environment Dept., Airbus

Challenge

- To reduce jet noise-to-noise radiation by an aircraft at takeoff
- Acoustic liners presented a major design challenge because they addressed many conflicting design requirements

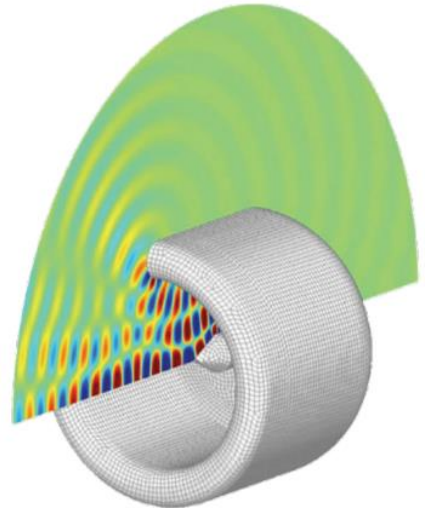
Solution

- Airbus had been working to achieve more accurately simulate noise radiation from the nacelle. Actran was the only simulation tool able to accurately model the main physical phenomena for engine nacelle radiation
- Simulation with Actran and other numerical tools helped reveal the substantial impact of splices on forward fan noise and those simulations were confirmed with physical testing

Benefits

- Actran helped Airbus design and deliver best-in-class acoustic solutions that saved aircraft weight with a huge financial impact for airlines operating Airbus aircraft
- Actran also helped Airbus reduce product development costs by avoiding expensive post-design changes
- Airbus is now in the process of expanding its use by developing new applications such as auxiliary power units for ramp noise and counter-rotating open rotor engines for community, cockpit and cabin interior noise





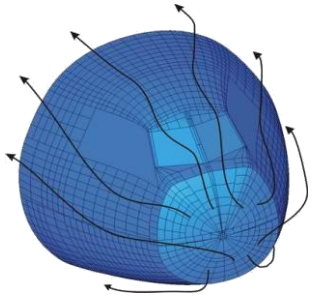
HEXAGON

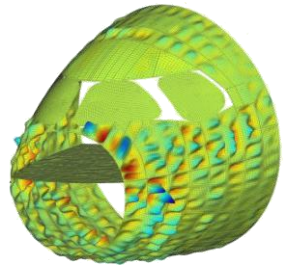
AIRBUS

Aircraft cabin noise

Challenge

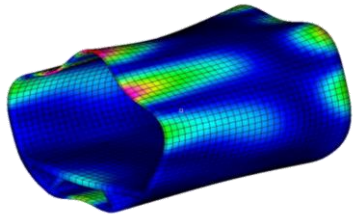
- Aircraft noise is not only important in terms of the exterior but also in terms of the interior of the aircraft.
- It is important to reduce the noise transmission through an aircraft fuselage or cockpit in order to increase comfort for passengers and crew alike

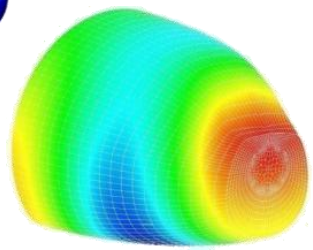




Solution

- Actran's vibroacoustics module is able to account for the complex structure (composite fuselage and multi-layered windows), the interior cavity, the insulation materials and the pressurization effect
- It provides a holistic view on the transmission of noise to the cabin





Benefits

- Acoustic simulation enables Airbus to understand the effects of various parameters such as the excitation type, the presence of the floor and the variable thickness on the interior noise levels

HEXAGON

AIRBUS

ONERA

THE FRENCH AEROSPACE LAB

Aircraft interior noise

CRESCENDO European project

Challenge

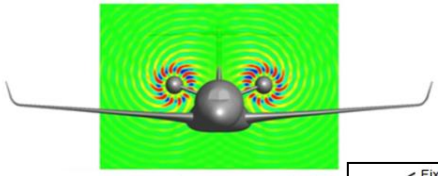
- New engine concepts can provide better noise performance to align with new regulations
- The **Counter-Rotating Open Rotor (CROR)** is a very promising concept where two counter-rotating rotors are used to propel the aircraft
- Considering noise issues at design phase of an aircraft equipped with CROR engines is important for advancing the concept

Solution

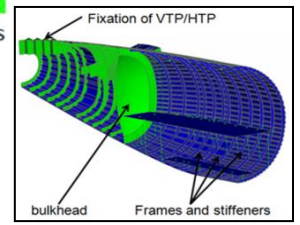
- SimXpert: Nastran structure modeling
- Nas2Act: conversion of Nastran model into an Actran model
- Actran: enrichment of the Actran model with fluid, foam materials and non-uniform pressure excitation on the fuselage

Benefits

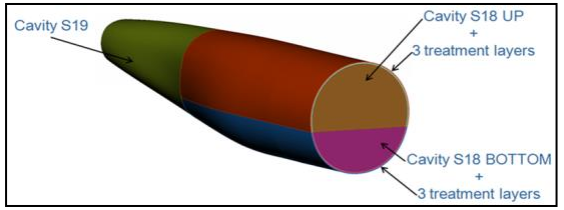
- Compute **sound pressure level in the cabin** due to airborne excitation of **synchronous** and **asynchronous engines**



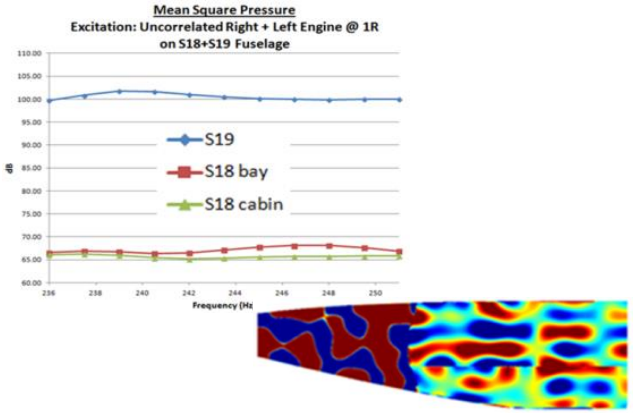
Acoustic Pressure fields



APU composite tail cone – Acoustic transmission losses



APU composite tail cone – Acoustic transmission losses



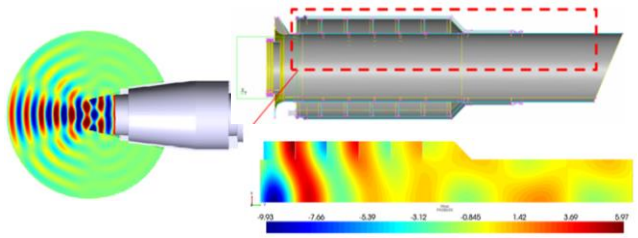
HEXAGON

Aircraft composite tail cone

ADVITAC European project

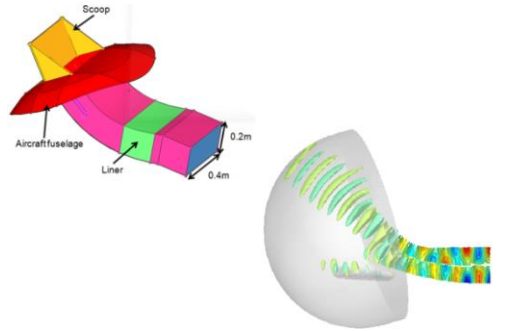
Challenge

- Reducing aircraft ramp noise coming from tail cone, the rear part of aircraft containing the Auxiliary Power Unit (APU)



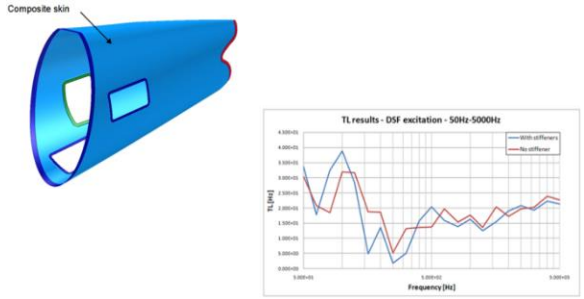
Solution

- Actran TM: APU noise radiation in presence of complex flow, splitters, scoop, porous material, perforated sheet and cavities.
- Actran Vibroacoustics: composite structure modeling, with shell, omega-shaped stiffeners and diffuse sound field excitation on applied on the fuselage.



Benefits

- Reduce APU inlet and exhaust radiation
- Improve tail cone muffler insulation in order to meet the ICAO certification standards



APU composite tail cone – Acoustic transmission losses

SAFRAN Turbomeca

European project on rotorcraft engine noise

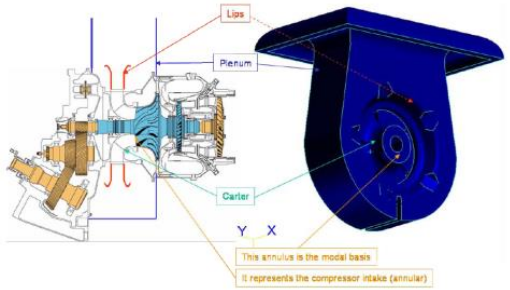
Challenge

- Reduce helicopter engine noise in order to comply with increasingly stringent acoustic norms



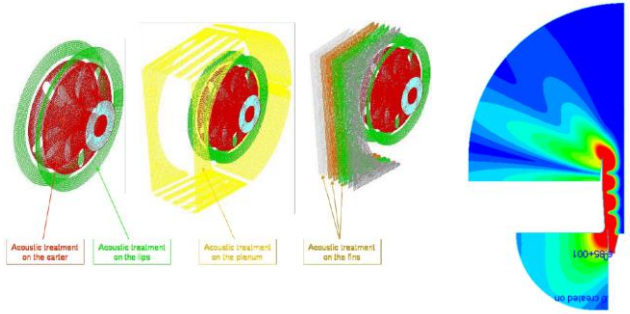
Solution

- Actran TM is used to simulate sound radiation from engine inlet and exhaust.
- Realistic conditions such as complex flows, temperature gradients and acoustic liners are all accurately accounted by Actran.



Benefits

- Based on simulation results, the intake and exhaust geometries have been modified to optimize the noise reduction.
- Intake noise was reduced by more than 10dB and exhaust noise reduced by 6dB



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AIRBUS

CROR engine noise

FFT acoustic conference 2014, Simulation of installation effects of aircraft engine rearward fan noise with Actran DGM, J-Y. Suratteau

Challenge

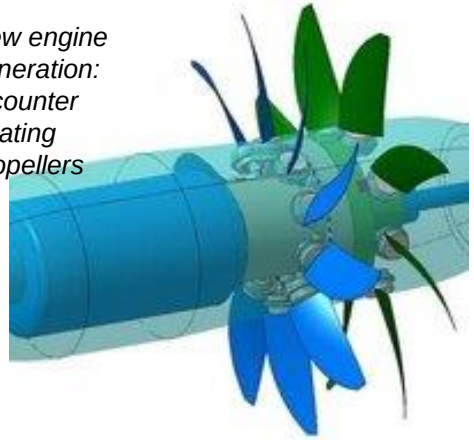
- Evaluate the noise radiated by a new engine generation, the Counter Rotating Open Rotors (CROR).

Solution

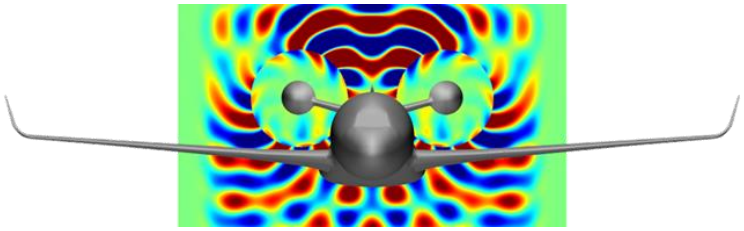
- Actran is used to calculate the aeroacoustic behavior with sources from unsteady CFD results
- Modeling of the refraction of acoustic waves due to the boundary layer on the fuselage

Benefits

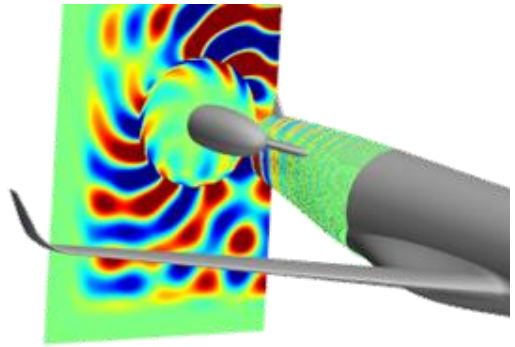
- Addressing industrial aeroacoustic problems for large domains and complex flow



New engine generation: 2 counter rotating propellers



Near field noise due to a CROR engine



CROR engine propagation over the fuselage taking into account the boundary layer

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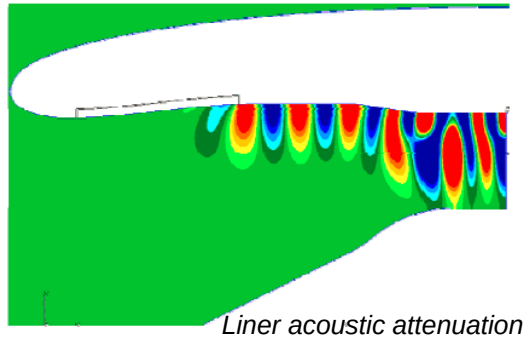
Honeywell

Turbofan engine noise

AIAA 2010-3824, Optimization of a Seamless Inlet Liner Using an Empirically Validated Prediction Method, B.Shuster, L. Lieber - Honeywell Aerospace. A.Vavalle - GKN Aerospace.

Challenge

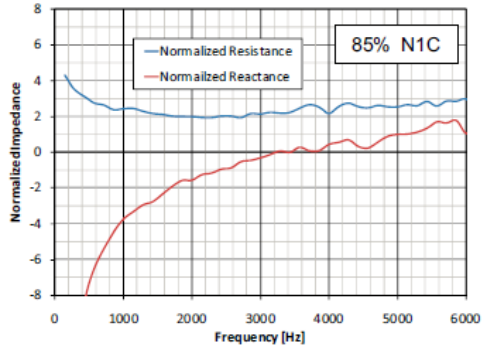
- Aircraft nacelles aim at reducing the noise generated by turbofan engines.
- To this aim reliable acoustic simulation is essential for optimizing the acoustic liner in different flow conditions



Liner acoustic attenuation

Solution

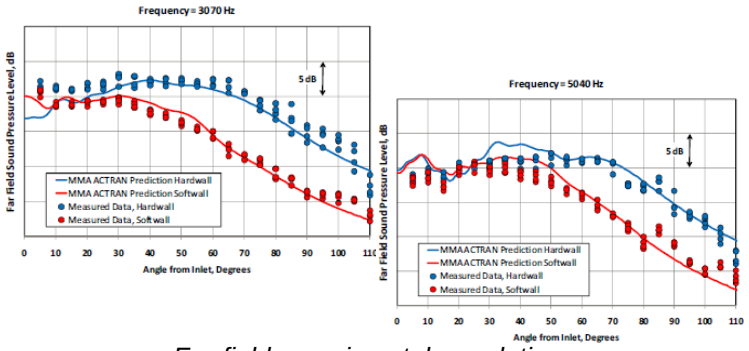
- Actran TM enables the modeling of turbofan engines by taking into account the mean flow both in the near field and far field, the liner effects and complex noise sources at the fan.



Measured Liner impedance

Benefits

- Actran TM is experimentally validated against ground test results with an excellent correlation.
- The simulation takes directly in input the measured noise source and the liner admittance in presence of grazing flow



Far-field experimental correlation

HEXAGON

EMBRAER

Repair effect on aircraft nacelle

ICSV 2015, Numerical Investigations Of Noise Radiation From A Turbo-fan Engine In The Presence Of Hard Patches With Different Geometries, O. Acosta, A. da Silva, J. A. Cordioli, D. Reis

Challenge

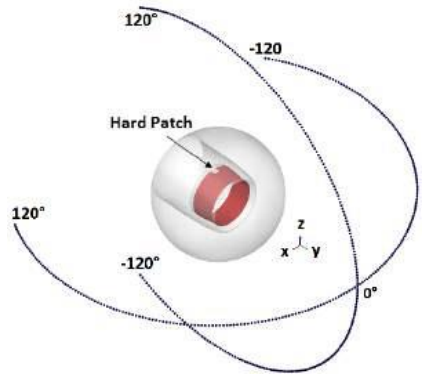
- During engine life-cycle, repairs made in the nacelle liner can result in hard patches acting as discontinuities.
- These discontinuities reduce the acoustic efficiency.

Solution

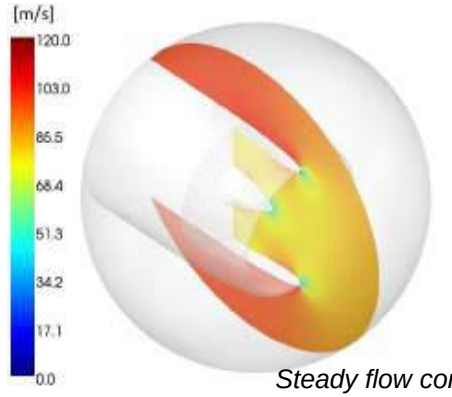
- The compressible flow solver in Actran is used to generate a mean flow to be used in the acoustic model
- Actran TM is used to propagate the noise of the fan in the presence of the flow, taking into account the liner and the hard patches

Benefits

- Actran helped evaluating the acoustic efficiency of liners with different hard patches at different flight conditions.
- At the approach condition the patches have a limited effect, on the contrary at the take-off condition, the hard patches significantly decrease the acoustic efficiency.



Virtual microphones in Actran



Steady flow computed by Actran

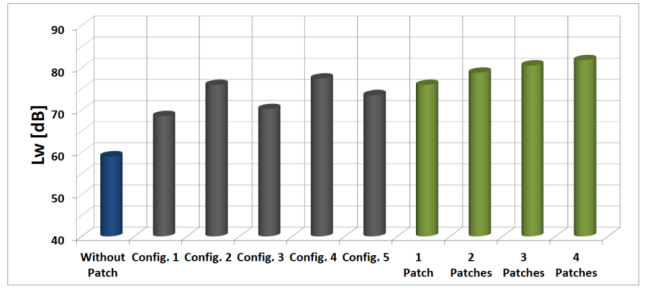


Figure 7: Sound power level. Liner discontinuities. Mode 14.1.

Acoustic power level, for mode (14,1) for several configurations

HEXAGON

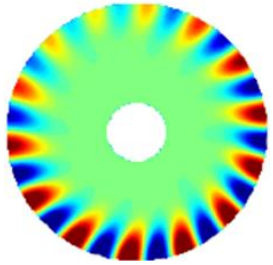
United Technologies

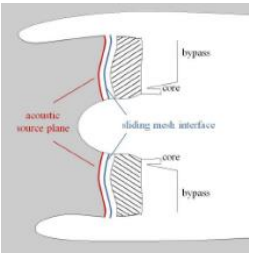
Turbofan inlet distortion noise

AIAA Conference 2014,Turbofan Inlet Distortion Noise Prediction with a Hybrid CFD-CAA Approach , J. Winkler, C. A. Reimann, R. Reba, J. Gilson

Challenge

- In short nacelle designs, the noise is generated by the interaction between fan blades and the mean flow (distortion noise).

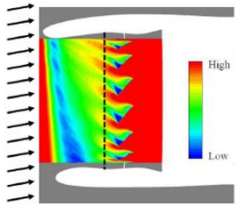




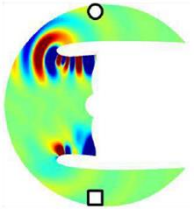
Source plane: acoustic pressure

Solution

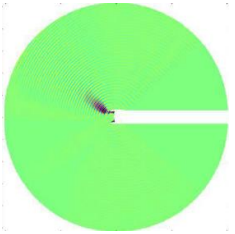
- Actran's Möhring analogy is coupled with a URANS CFD solver for computing and the aeroacoustic sources at the fan face where the surface is non-planar and the flow speed is high (above M=0.3).



Unsteady CFD: velocity



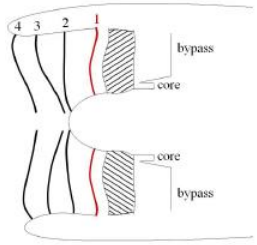
Near field acoustic pressure

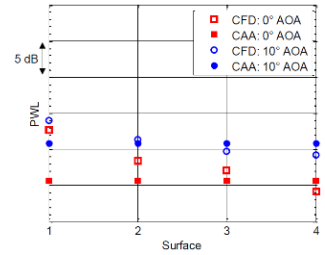


Far field acoustic pressure

Benefits

- Actran offers an alternative method to duct modes which are applicable only to planar surfaces with uniform mean flow
- Compared to the full CFD method, Actran offers both better efficiency (hybrid aero-acoustic method) and better accuracy (no acoustic dissipation or reflections that impact the acoustic pressure quantity)





CFD vs Actran: power level at different surfaces

HEXAGON

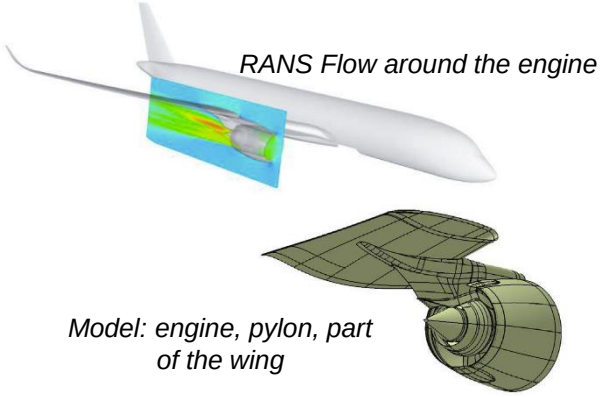
AIRBUS

Installation effects of aircraft rear fan noise

AIAA Conference 2014, Simulation of Installation Effects of Aircraft Engine Rear Fan Noise with ACTRAN/DGM, A. Mosson, D. Binet, J. Caprile

Challenge

- Simulations of large-scale domains including flow effects such as the acoustic radiation from turbofan engine installed on the aircraft

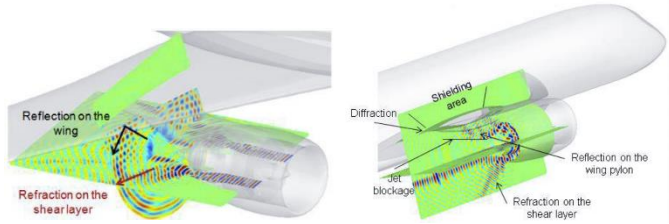


RANS Flow around the engine

Model: engine, pylon, part of the wing

Solution

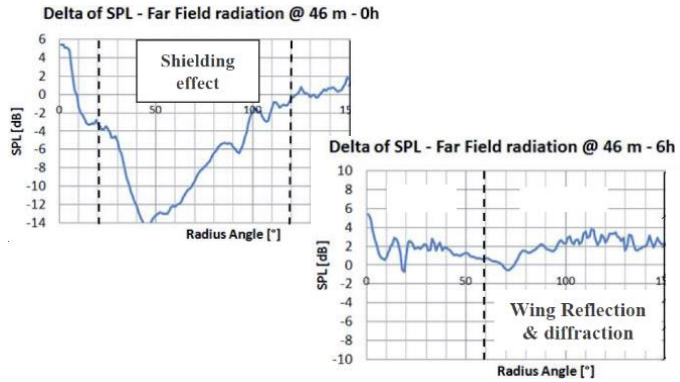
- Actran DGM is used for computing the far field noise taking account of shapes of engine, wing and pylon.
- The acoustic propagation accounts for the mean flow computed by steady RANS simulations.



Main acoustic phenomena to simulate

Benefits

- Good correlation with measurements on a canonical test-case (gaps of 1dB).
- Actran DGM shows a very good computational efficiency and can be used in an industrial context.



Installation effect (wing effect) above the wing (0H) and below the wing (6H)

HEXAGON

LIEBHERR

SAFRAN

Aircraft ventilation system

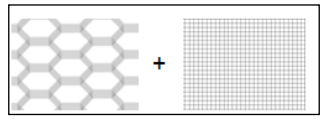
SOFTAIR French project

Challenge

- Define, propose and validate an optimal acoustic treatment for an air conditioning plenum.
- The validation shall be performed between measurements and calculations in flow and no flow condition on a test bench.



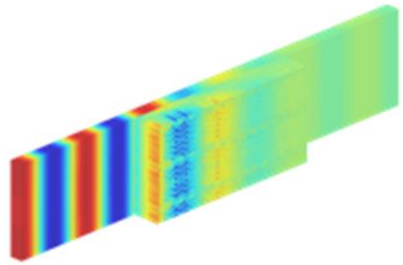
Acoustic treatment modeled in Actran



NIDA and Wiremesh definition in Actran

Solution

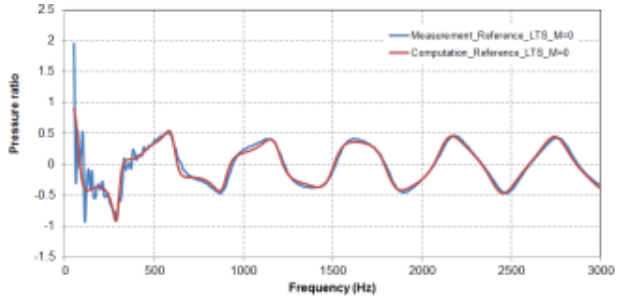
- Actran and Patran have been linked together for defining DOE on several acoustic treatments.



Acoustic pressure calculated in a duct with treatment

Benefits

- Very good correlation with measurements has been achieved.
- Large range of configurations have been simulated to help finding the optimal one.



Pressure ratio (real part) upstream / downstream the treatment:
Measurements Vs Actran

HEXAGON



Aircraft APU noise evaluation

Challenge

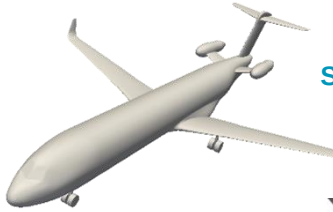
- Prediction of the noise due to Aircraft Auxiliary Power Unit (APU) at ICAO certification points taking into account complex flow due to the APU exhaust and full 3D geometrical effects (e.g. fuselage/ground)

Solution

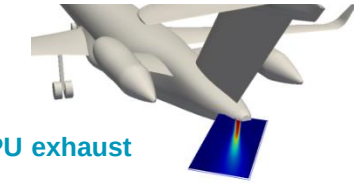
- Actran DGM solves the acoustic propagation in complex flows (high temperature and velocity gradients) and large acoustic domains.
- This makes it suitable for solving problems like ground-fuselage interaction, masking effects and jet refraction

Benefits

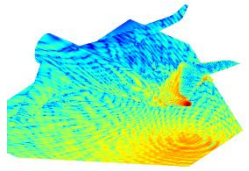
- Actran DGM is a unique tool able to model large acoustic domains (8500 m3).
- The wings, rear fuselage, wheels, ground and VTP/HTP of a single aisle aircraft are modeled.
- Results highlight the strong effect of the flow on the noise prediction at ground.

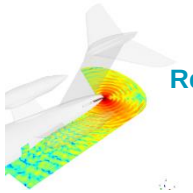


Short range Aircraft*



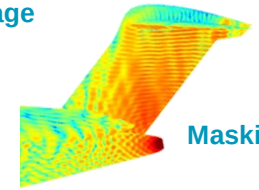
Jet at APU exhaust



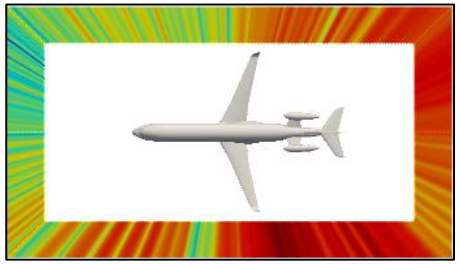


Jet Refraction

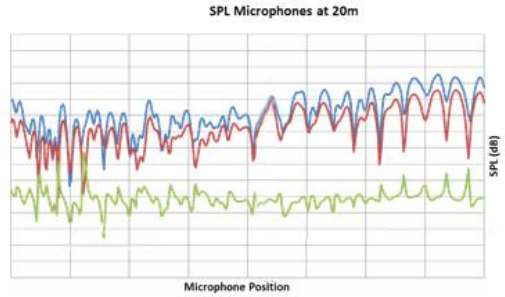
Ground/Fuselage Interaction



Masking Effect



ICAO Norm



SPL at microphones

AIRBUS

Air supply ducts

Noise-Con 2008, Design sensitivity analysis on low-frequency noise radiation of air supply ducts, P. Neple, R. Foret, A. Ramonda

Challenge

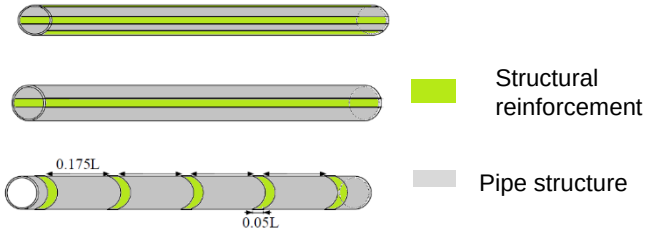
- The air conditioning system of an aircraft is one potential source of interior noise.
- Duct performance is driven by the coupling of the structural modes and the acoustic plane wave: it is needed to study the vibroacoustic propagation through the HVAC duct.

Solution

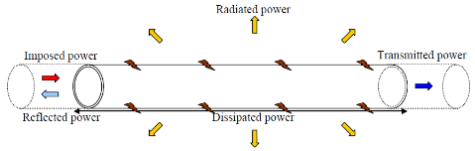
- Actran simulates the noise propagation within the pipe, taking account of the pipe structure.
- Actran is used to compute:
  - the transmitted power through the air outlet
  - the radiated power by pipe structure

Benefits

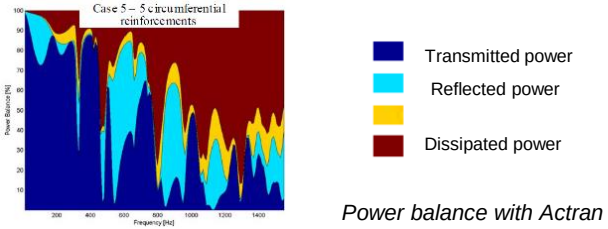
- Coupled vibro-acoustic behavior of the HVAC duct
- Ranking of the different configurations
- The analysis allowed to identify improvements of acoustic transmission loss for the pipes



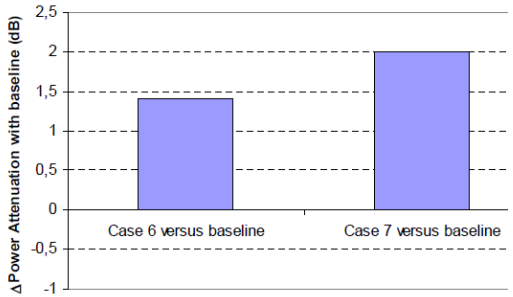
Some studied pipes configurations



Power balance with Actran



Power balance with Actran



Improvement of acoustic transmission losses between inlet and outlet

HEXAGON

AIRBUS

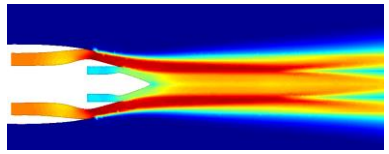
Turbofan engine noise: installation effects

OPENAIR European project

FFT acoustic conference 2014, Simulation of installation effects of aircraft engine rearward fan noise with Actran/DGM, J-Y. Suratteau

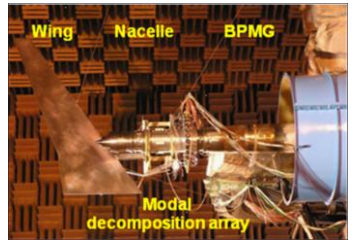
Challenge

- This project aimed at characterizing aircraft exhaust noise of a 1/10 mock-up, in static condition.
- To this aim, both specific measurement techniques and validated acoustic simulations are used.



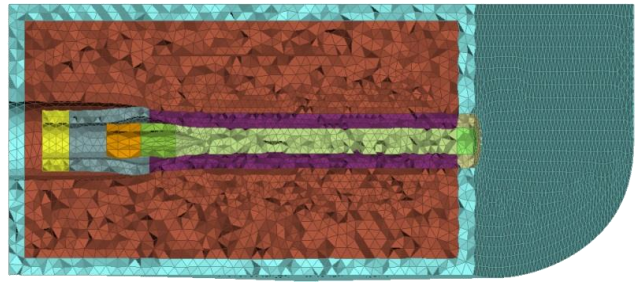
Mean flow imported in Actran: RANS Flow

Experimental set-up



Solution

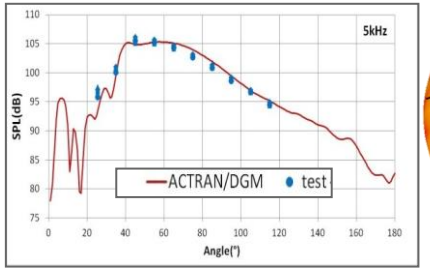
- After a validation on an isolated case, Actran calculated:
  - wing shielding effect on top
  - non-symmetric installation effects on the ground
  - jet blockage effect on the flyover arc
  - interference pattern (reflection and diffraction)



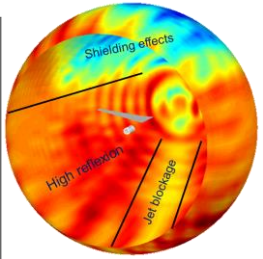
Acoustic mesh use for the Actran model

Benefits

- Actran DGM is able to predict accurately installation effects for aircraft engine exhaust noise
- Good correlation between measurements and simulation is achieved when evaluating very complex acoustic phenomena



Actran Vs tests on isolated case (without wing)



Pressure map calculated by Actran around the engine and the wing

HEXAGON

VTOL compressor flutter phenomenon analysis

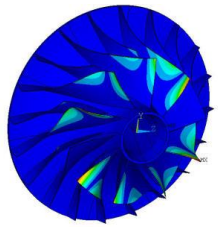
AIAA Conference 2018, Numerical investigations of flutter phenomenon in compressor stages of helicopter engines, A. Vallon, M. Herran, V. Ficat-Andrieu, Y. Detandt

Challenge

- The blade height increase in the compressor of a Vertical Take Off and Landing (VTOL) vehicle engine leads to potential blade flutter issues



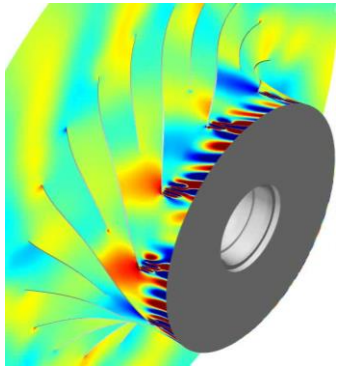
Typical centrifugal compressor wheel



Centrifugal compressor wheel eigenmode

Solution

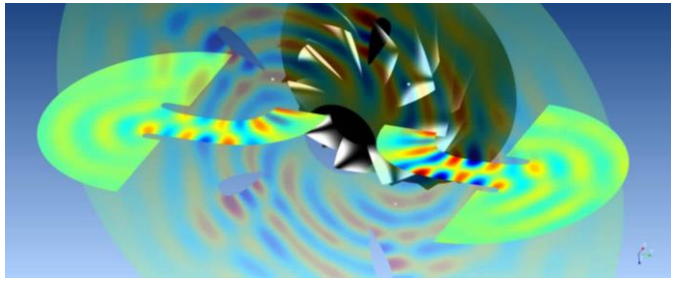
- A vibroacoustic analysis performed with Actran helps to predict operating conditions leading to the flutter phenomenon



Acoustic pressure inside compressor

Benefits

- Better understanding of the parameters impacting the flutter phenomenon.
- Prediction of acoustic noise propagation.



Acoustic pressure and structure displacement map

AIRBUS

Turbofan intake and exhaust noise propagation

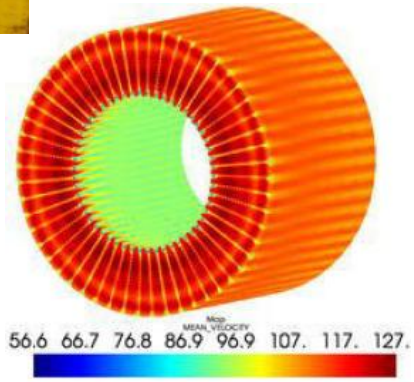
AIAA Conference 2018, CFD/CAA coupling strategies for rearward fan noise, T. Nodé-Langlois, V. Ficat-Andrieu, Y. Detandt

Challenge

- Noise from the fan and exhaust of a turbofan engine is the predominant source of aircraft noise
- To more accurately predict it, an aeroacoustic approach combining fluid and acoustic simulation needs to used.
- In the exhaust, where the flow is extremely complex, a different approach than the fan is needed.



NASA-SDT rig in NASA Glenn 9x15 ft low speed wind tunnel

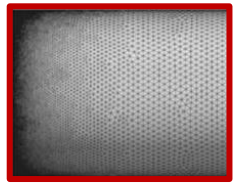


Mean flow in the exhaust duct

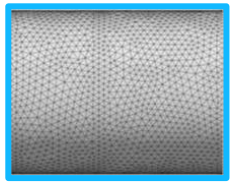
Solution

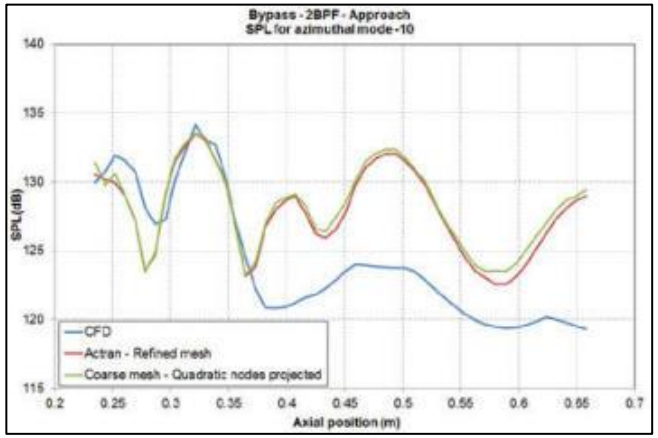
- The aeroacoustic excitation from the flow is provided via a Thompson condition which is then propagated using Actran DGM, a high-order solver.
- A background mean flow is taken into account
- An integration technique is used for mapping the flow to the acoustic mesh which allows for a coarser mesh to be used.

Refined Mesh



Coarse Mesh





Benefits

- Aeroacoustic calculations in the presence of complex mean flows are possible with Actran DGM
- A good correlation has been reached comparing to other methods
- The computational cost was reduced thanks to the hybrid approach utilizing an integration technique for mapping

HEXAGON

Honeywell

Turbo propeller inlet

FFT Acoustic Conference 2014, ACTRAN/TM Analyses of Multiple Acoustic Treatment Concepts in the Inlet Duct of a Turboprop Engine, Lysbeth S. Lieber

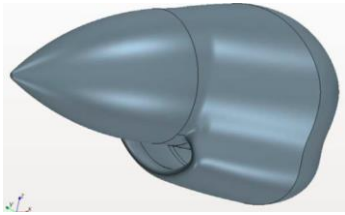
Challenge

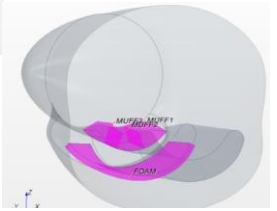
- Turboprop engines suffer from ramp noise at the ground idle operating condition, which affected by high broadband noise levels



Solution

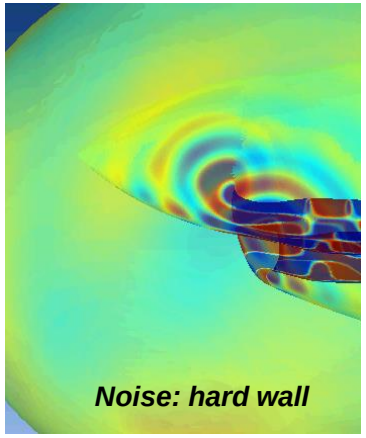
- Actran TM for modeling turbomachinery noise sources of an arbitrary shaped duct
- A muffler is modeled with 3 cavities on the top duct wall covered by a perforated plate. A foam is positioned on the bottom wall covered by a perforated plate.

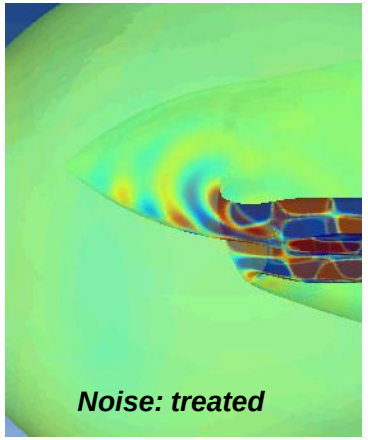




Benefits

- Prediction of the transmission loss index for many configurations to determine the optimal treatment





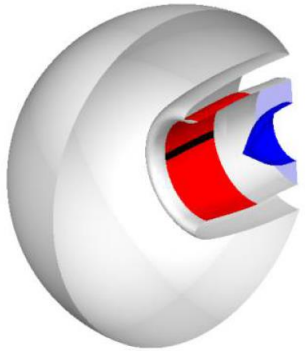
AIRBUS

Acoustic treatment optimization

AIAA Conference 2017, Optimal Design of the Acoustic Treatments Damping the Noise Radiated by a Turbofan Engine, B. Van den Nieuwenhof, G. Lielens, E. Rosseel, V. Dangla, C. Soize, M. Kassem, A. Mosson

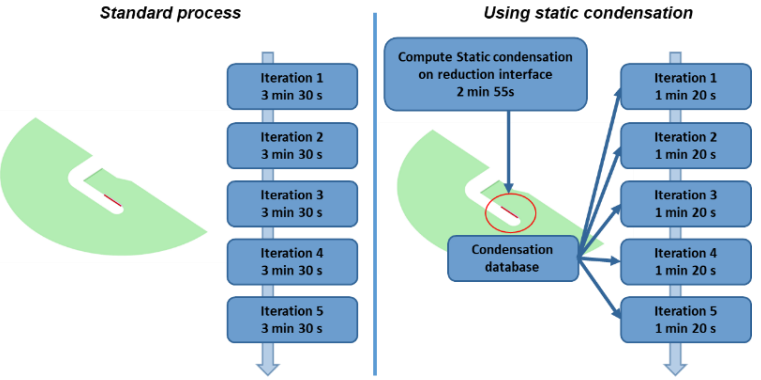
Challenge

- Reduce the computation time associated with aircraft nacelle intake acoustic treatments performances prediction in order to compute more design iterations



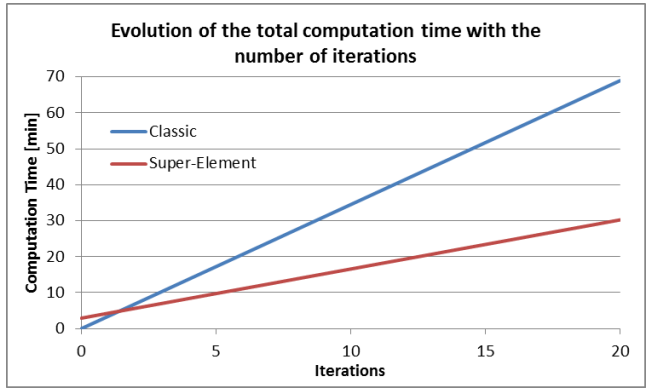
Solution

- The acoustic model is reduced through a static condensation in Actran to be later used as the evaluation part of an optimization process



Benefits

- The total time required to optimize the acoustic treatment is significantly reduced



HEXAGON

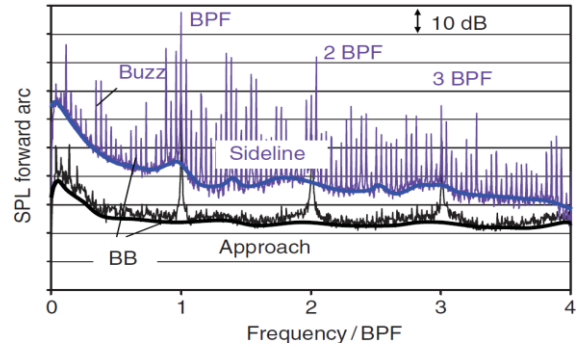
UNIVERSITY OF Southampton

Fan tonal noise propagation and radiation

FFT Acoustics Simulation Conference 2018, Actran numerical study on the effects of intake geometry and length on fan tone noise propagation and radiation, Lei Xiong, Rie Sugimoto and Erika Quaranta

Challenge

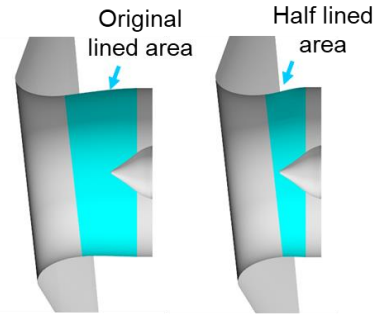
- Buzz saw tones occur at simple multiples of the fan rotation frequency and correspond to azimuthal modes
- Understand and assess the effects of 3D drooped intake geometry with mean flow distortion and intake length on the propagation and radiation of fan tone noise



Typical fan noise spectra (Astley, 2010).

Solution

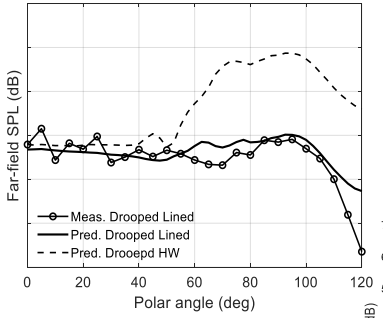
- CFD is computationally expensive while the Actran mean flow and Actran TM analysis are efficient alternatives
- 3D acoustic model allows fast acoustic investigation

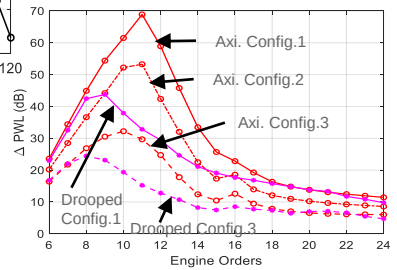


3D models

Benefits

- Accurate prediction of performances for initial configuration
- Efficient method to predict the impact of design changes including complex 3D radiation





Folded spiral-shaped cavities for nacelle acoustic liners

FFT Acoustics Simulation Conference 2016, Folded spiral-shaped cavities for nacelle acoustic liners Impedance, attenuation modelling and comparison to experimental results, Emmanuel Lacouture

Challenge

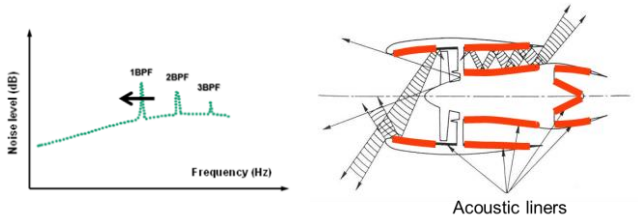
- Airlines desire to reduce their fuel consumption will push the manufacturers towards the development of higher bypass ratio engines, increasing fan diameters
- Rotation speed of the fan will then be reduced thus lowering the blade passing frequency (BPF) requiring thicker liners in a limited space

Solution

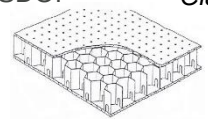
- Possible solution consists in using folded cavities
- Modeling of acoustic behavior is Actran TM to optimize spiral-shaped folder cavity liners

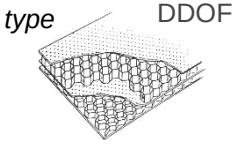
Benefits

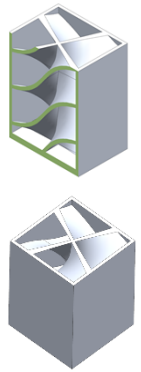
- Excellent correlation between predicted and measured reactance and insertion loss



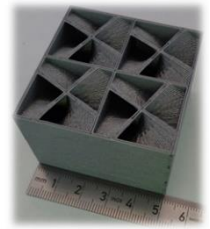
SDOF *Classical liner type* DDOF



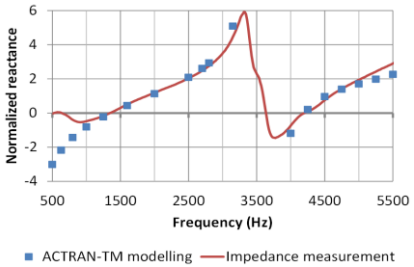




Spiral-shaped folded cavities

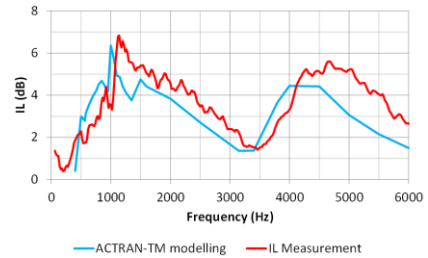


3D printed sample



Reactance prediction

Insertion Loss prediction



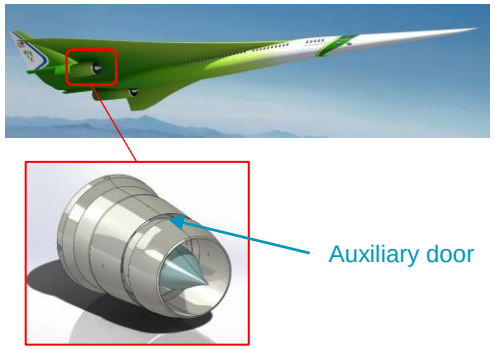
UNIVERSITY OF HARTFORD

Acoustic Radiation of Supersonic Inlet with Auxiliary Door and Mean Flow

AIAA 2019, Acoustic Radiation of Supersonic Inlet with Auxiliary Door and Mean Flow, Jonathan Brown and Paul E. Slaboch

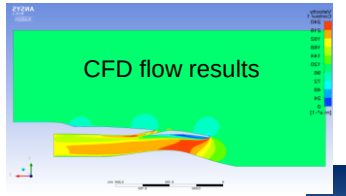
Challenge

- For supersonic aircraft, the propulsion system should also be able to operate at subsonic speeds during take-off and landing operations
- An auxiliary door required to provide a necessary flow rate so the engine can operate at low speed

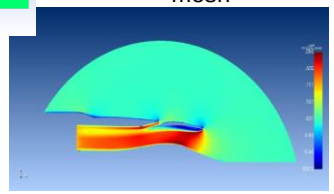


Solution

- Actran TM is the reference solution for turbomachinery noise and acoustic treatment design
- CFD flow results are mapped on acoustic FE mesh



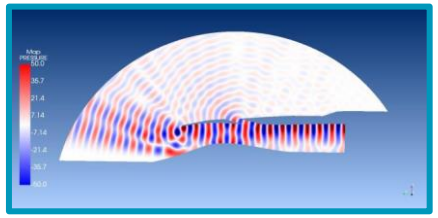
CFD flow results mapped on acoustic mesh

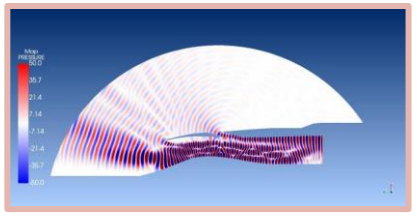


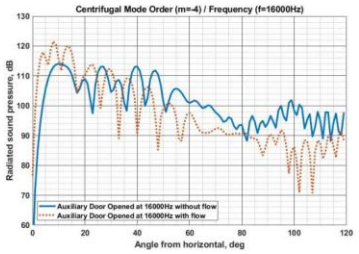
Institute of Acoustics
2017 Peter Lord Award Winner

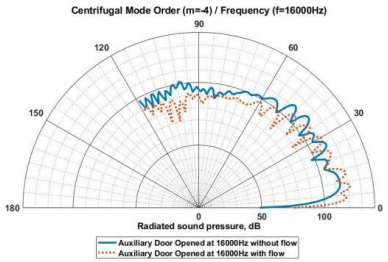
Benefits

- Impact of flow on noise directivity assessed leading to the conclusions that flow must be considered when assessing noise emitted by new engine design and their impact on community noise











Noise level predictions of drones

DICUAM 2021, Computational noise level predictions of small multi-rotor unmanned aircraft systems at different payload conditions, C. Legendre, V. Ficat-Andrieu, A. Poulos, Y. Kitano, Y. Nakashima, W. Kobayashi and G. Minorikawa

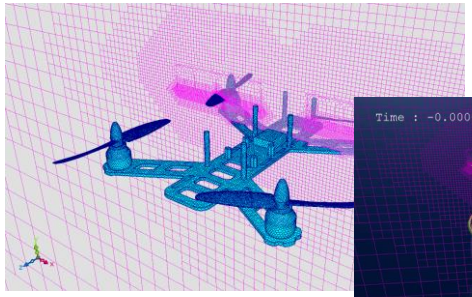
Challenge

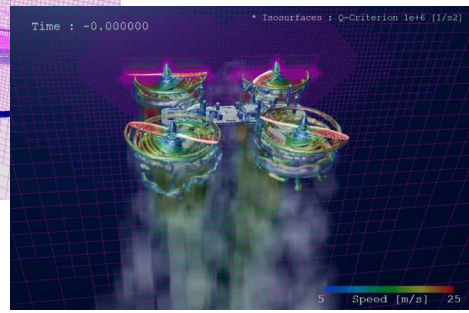
- One of the important aspects of drone operations is noise
- The propellers under a variety of operating conditions are the main source of noise!
- High-fidelity CFD coupled with FWH analogy are too arduous and expensive to predict total noise for all possible operations



Solution

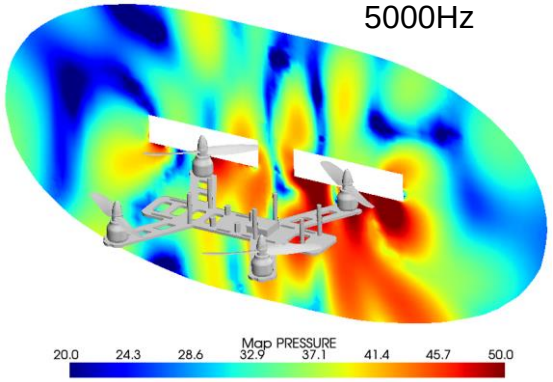
- 3D scan to obtain the blade geometry
- Combination of CFD (Cradle CFD), CAA (Actran) and **machine learning** techniques provide solution in real-time and get insights of any operating conditions





Benefits

- Insights provided by the simulation guide engineers and scientists in the discovery of new strategies leading to quieter drone systems
- The tool allows the engineer to analyze in real time how a parameter affects the acoustic signature of drone



HEXAGON

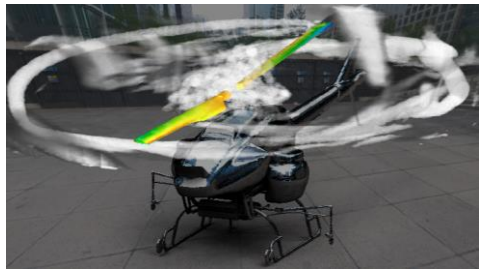
Low noise helicopter motor

"The multi-physics solution enabled by combining Cradle CFD, MSC Nastran and Actran opens up new opportunities to innovate, allowing Yamaha Motor to develop different business scenarios for unmanned helicopters and address them using upstream to downstream design processes."

Mr. Mizuno
Robotics Division
Yamaha Motor Co., Ltd.

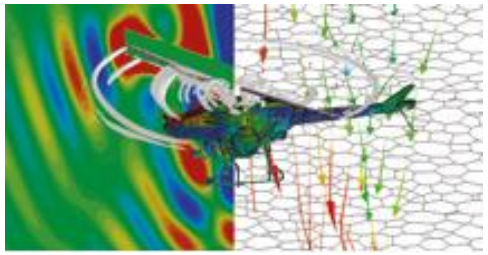
Challenge

- Minimize sound challenges in a helicopter
- Changing blade design combating multiple design trade-offs



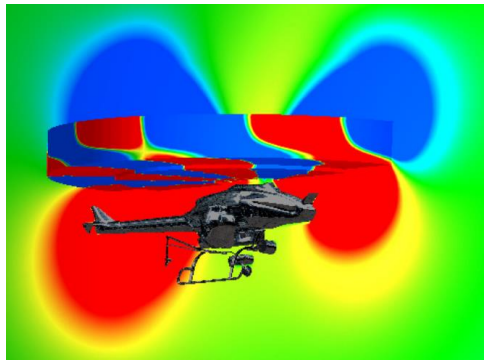
Solution

- MSC CoSim was used to simulated the air flow produced by the rotor, rotor deformation and the propagation of the fluid noise caused by the rotor
- By combining Cradle CFD and MSC Nastran Co-Simulation, and Actran simulation, Yamaha was able to avoid repeating design cycles in fluid, structure, and acoustic areas respectively



Benefits

- Yamaha, by using fluid-structure-acoustic simulation, was able to comprehensively analyse the performance of the main rotor and noise in a single analysis process
- Dramatically shortening design and development lead times



SAFRAN

Determine acoustic performance of VTOL propeller

By using Hexagon solutions, the noise of a virtual propeller prototype has been determined for realistic flight configurations

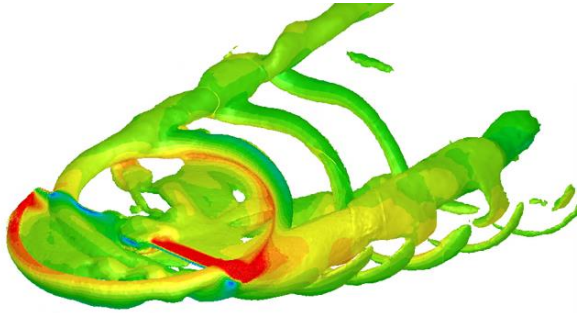
Challenge

- Global eVTOL Aircraft Market is estimated to acquire a market value of USD 4 billion while expanding at a CAGR of 30.30% by 2030.
- This market brings new challenges in terms of noise pollution.
- Different analytical or numerical methods exist to predict noise from a propeller. The challenge is to provide methods affordable for industrials.



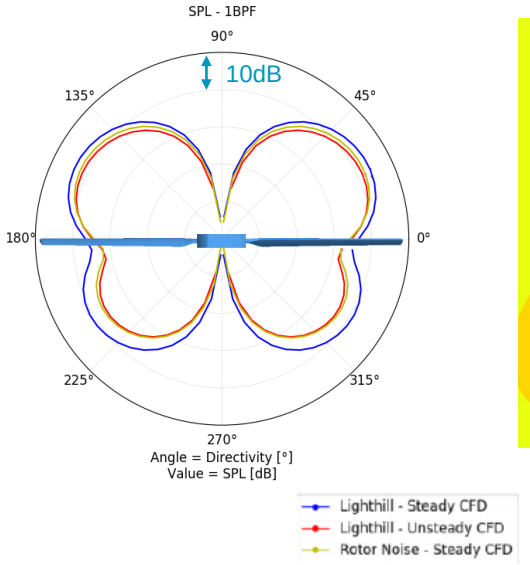
Solution

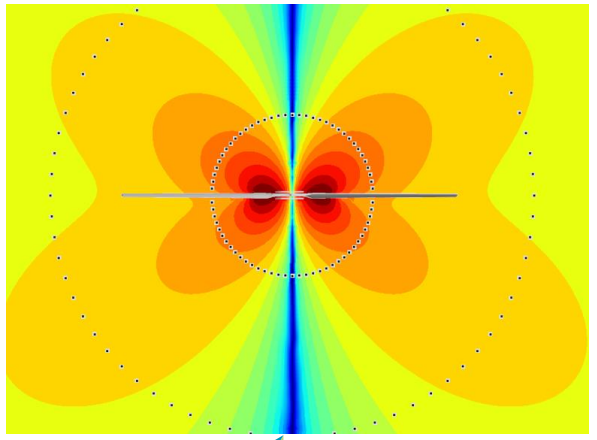
- Actran allows coupling incompressible CFD results for the aeroacoustic sources computation with finite elements approach for the acoustic propagation.
- Cradle CFD allows handling steady, unsteady, incompressible and compressible flow computations. The CFD mesh is built with polyhedral elements and then automatic refinement according to the flow gradient fields.



Benefits

- Several types of aeroacoustic source models are available, based on a steady or unsteady CFD inputs.
- They allow adapting the acoustic computation approach with time/cost constrains and propeller design steps – from low to high fidelity methods.





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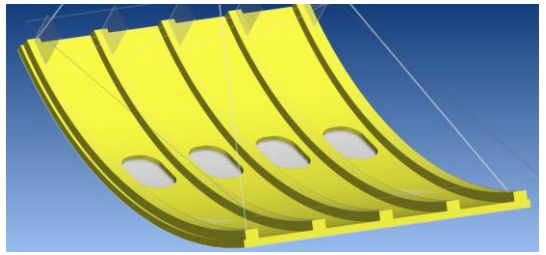
AIRBUS

Sound Transmission Loss through fuselage

Advanced Wizard for aircraft interior noise studies with Actran, Airbus Operations, Fabien Vieuille, FFT users' conference 2018

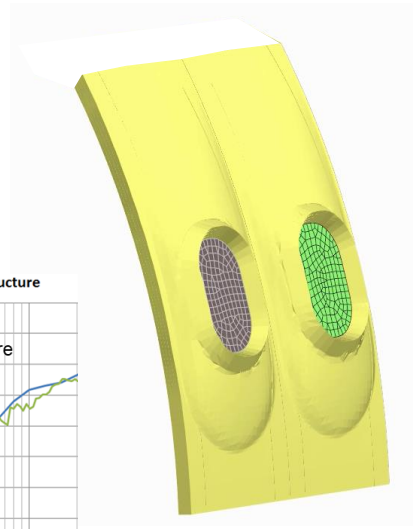
Challenge

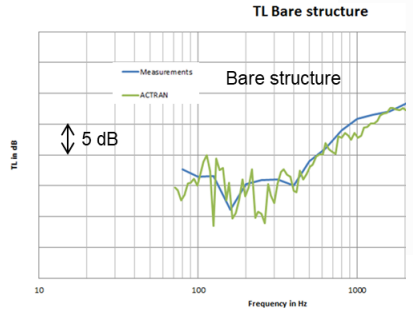
- Aircraft cabin noise is following strict airline regulations requiring manufacturers to design the fuselage taking into account its acoustic insulation

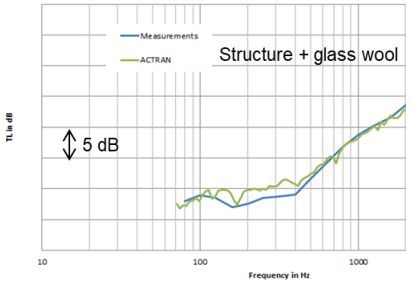


Solution

- Actran is used to compute the sound transmission loss index (STL or Rw) of complex structures composed by multiple layers made from aluminum, composite, plastic, foam, …







Benefits

- Acoustic simulation provides designers with the STL index of any structures allowing to run physical experiments only for final validation

HEXAGON

AIRBUS

Wizards for simulation democratization

“Advanced Wizard for aircraft interior noise studies with Actran”, Airbus Operations, Fabien Vieuille, FFT users’ conference 2018

Challenge

- Aircraft cabin noise is following strict airline regulations requiring manufacturers to design the fuselage taking into account its acoustic insulation
- Modifications to designs are not easy and require expert simulations
- The design would be more efficient if non-experts could perform simulation at the same level as experts

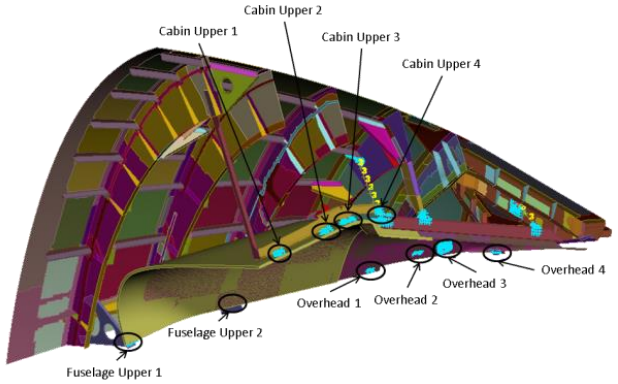
Solution

- A customized wizard chain has been created based on the custom wizard templates in Actran
- The wizard takes a pre-existing model of a panel and applies evolutions requested by the user, creates the Actran model automatically, solves the model and provides specific indicators (TL, path contributions, …)

Benefits

- Acoustic simulation for non-experts based on the experience of experts
- Friendly user interface to guide engineers without acoustic simulation experience through the steps
- Hexagon’s team can guide experts to create wizard and workflows that allow for accelerated design







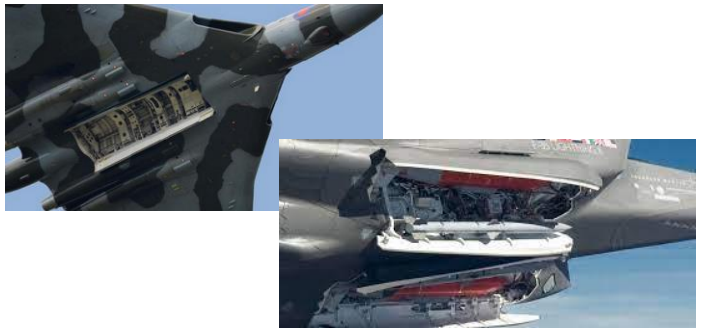
HEXAGON



Weapon Bay Aeroacoustics

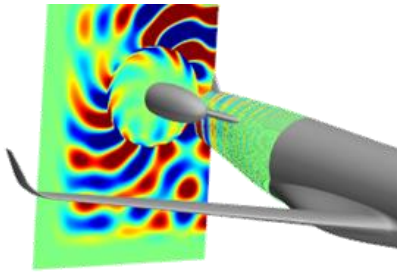
Challenge

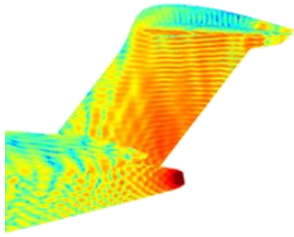
- Fighters are carrying their weapons loads internally.
- Major drawbacks of this design choice comes whenever the bay is opened to release the store.
- The noise generated is capable to damage the payload sensors and generate cracks in the airframe



Solution

- Mitigation of pressure fluctuations inside the weapons bay by using Cradle CFD
- Aero-Vibro-acoustic analysis of the payload and airframe by using Actran





Acoustics pressure on aerostructures computed from CFD data or other acoustics sources

Benefits

- Robust design of the payload and aircraft
- Design of suppression mechanisms



Accelerations and acoustic pressure resulting from an acoustics loading of the structure

HEXAGON

Acoustic Simulations and Commercial Supersonic Flight

HxGN Live Design & Engineering 2021, Acoustic Simulations and Commercial Supersonic Flight, David Stephens

Challenge

- Supersonic flight for commercial aircraft has failed in the past due to high noise from the sonic boom
- New aircraft is being developed that will minimize the sonic boom and will be accepted by the community, with the help of simulation
- Many new OEMs with different engine configurations → Simulation is paramount with little measurement or flight data

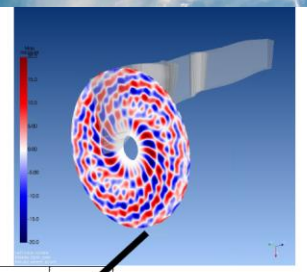
Solution

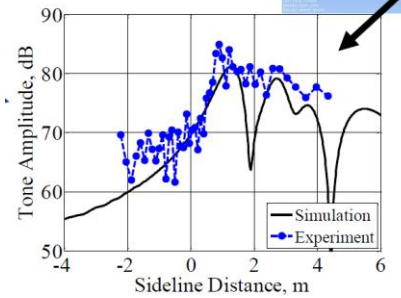
- Actran TM is used to evaluate noise from engines working in supersonic conditions
- Flow information can be used in the acoustic predictions, coming from steady, unsteady or nonlinear harmonic (NLH) simulations

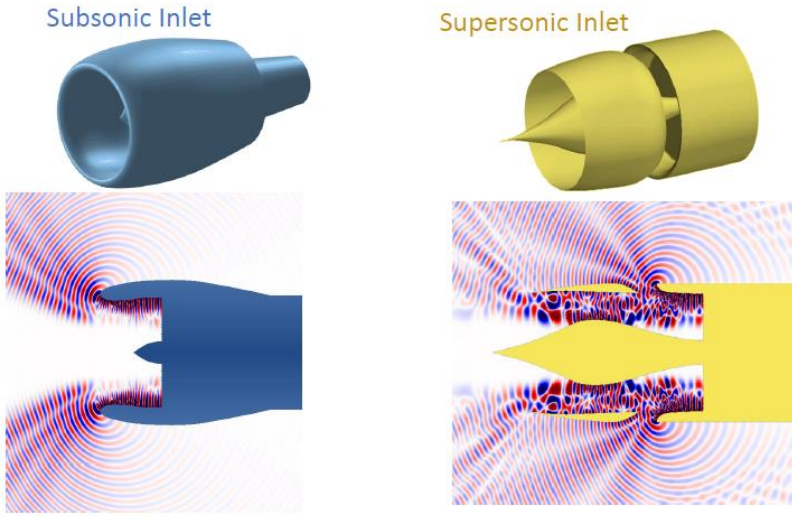
Benefits

- Physics Based Simulations (PBS) are vital when developing new aircraft concepts where little experience is available
- Simulation helps reduce the use of expensive experimental model rig testing









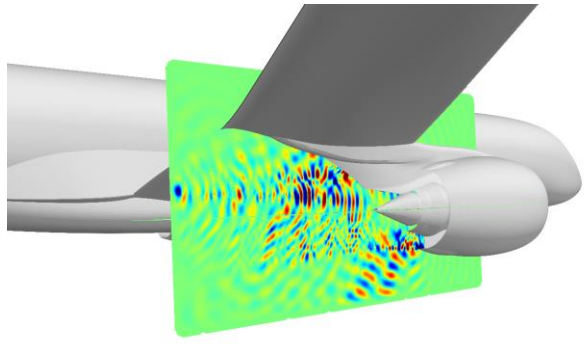
Adjoint method for Jet Aeroacoustics

"Actran's Python API is an indisputable asset of Actran TM opening many possibilities for research"

Étienne Spieser
Post-doctoral researcher
École Centrale de Lyon

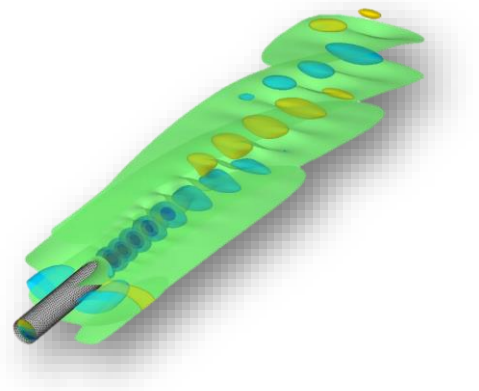
Challenge

- The acoustic radiation of a turbofan engine installed on an aircraft in service, differs greatly from that of an isolated engine.
- A large amount of data is required to solve aircraft engine exhaust noise due to the highly complex, rotational flow
- Predicting the noise spectra by computing the adjoint Green's functions for the Pierce equation could help provide a better model for such problems.



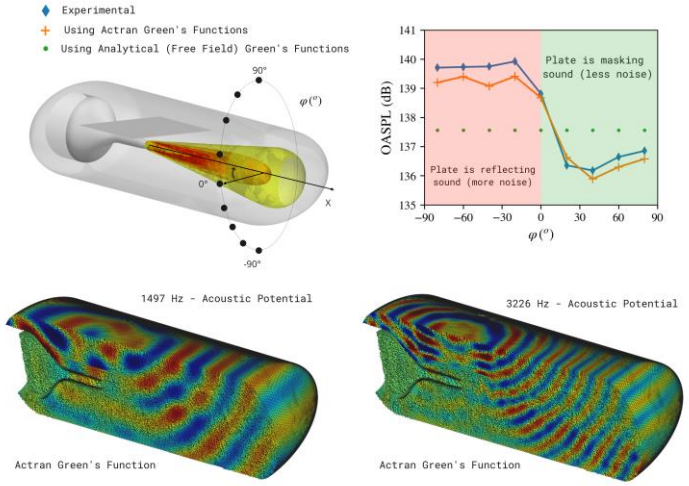
Solution

- The Pierce equation in a finite element context is retrieved using Actran's built-in Python functions that enabled him to manipulate the equations in a finite element context
- Adjoint Green's functions were calculated using the reciprocity principle
- These are finally fed to a Tam & Aurialt model for acoustic propagation



Benefits

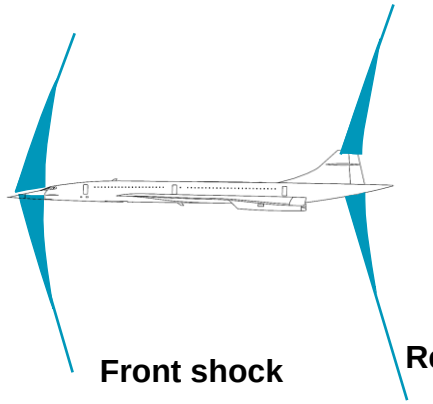
- Actran's powerful Python API can help researches solve acoustic problem faster and more efficiently than academic solvers for complex problems
- Using an industrial solver can have benefits especially when it comes to complex geometry and industry-established conditions such as perfectly matched layers (PML)
- By using Actran TM, the memory requirements were reduced from 43 GB using an academic solver to 1.7 GB



Sonic Boom Noise

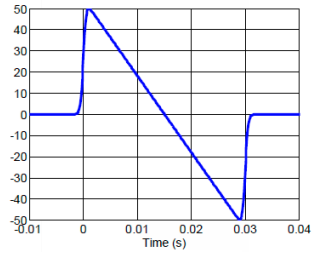
Challenge

- Sonic boom is an intense sound caused by supersonic flights. Affects regions beneath flight path and cause building vibration.

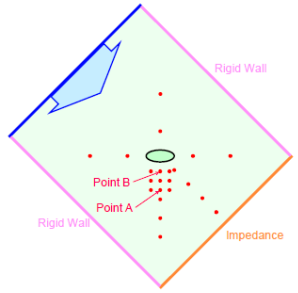


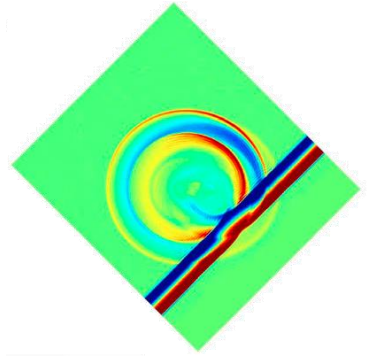
Solution

- Actran's time-domain solver is used to compute the vibro-acoustic interaction of the N-shaped sonic boom noise a blimp.
- The N-shaped boom noise is applied as a user defined pressure wave boundary condition.
- The blimp is modeled by a Nylon membrane filled by helium.









Benefits

- Actran allowed to compute the vibro-acoustic behaviour of a blimp subject to sonic boom noise.

FFT Acoustic Simulation Conference 2012, Preliminary study on effects of a blimp in aerial sonic boom measurement

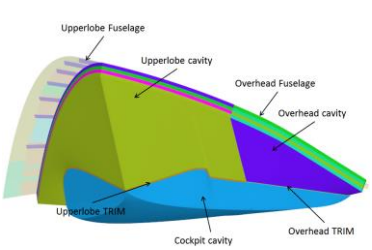
AIRBUS

Airbus – Actran integration into a Virtual SEA process

FFT Acoustic Conference 2016, Local finite elements models for global aircraft predictions, F. Vieuille

Challenge

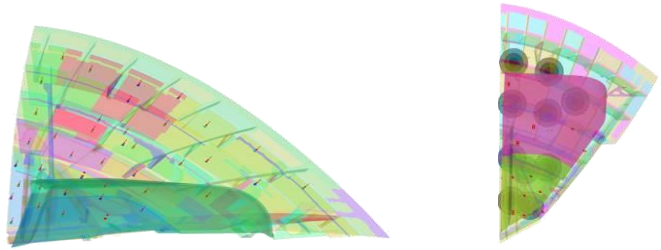
- Airbus numerical synthesis for interior noise is done using energy models (SEA). This requires as input complex coefficients (coupling loss factors and damping loss factors for each subsystem).





Solution

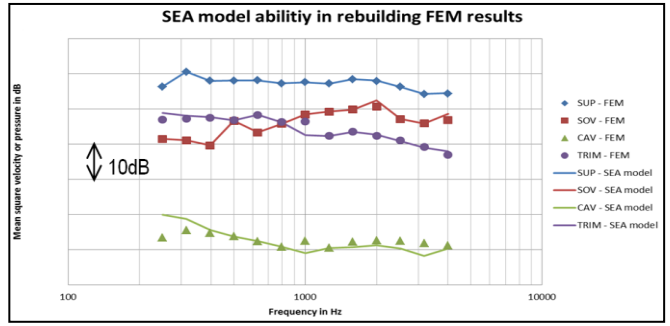
- Airbus A380 cockpit was modeled with Actran FEM vibro-acoustics to extract subsystem CLF and DLF.



Airbus 380 cockpit FEM and SEA model

Benefits

- Adoption of Virtual SEA process for aircraft interior noise relying on Actran FEM models to extract CLF.



SEA VS FEM results

HEXAGON

Noise propagation in porous media

28th AIAA/CEAS Aeroacoustics 2022 Conference, Time-domain simulations of the noise propagation in porous media and its surroundings using the Discontinuous Galerkin Method, Thomas Deconinck et al.

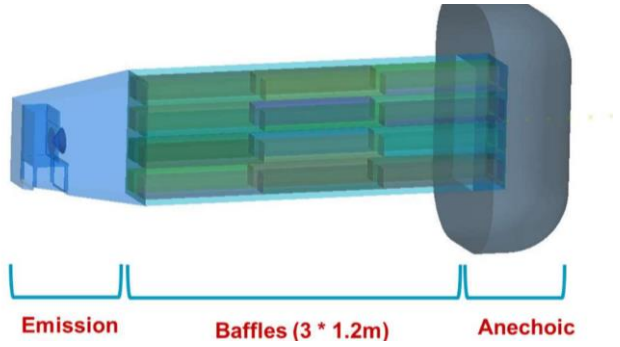
Challenge

- Industrial test benches for noise evaluation of civil jet engines requires effective anechoic terminations which are constructed with porous materials
- Frequency-domain, finite element-based approaches are well established in terms of accuracy and efficiency in the low frequencies but struggle with large models due to the computational cost.
- Time-domain discontinuous Galerkin methods work well for large-size models and high frequencies, but robust porous modeling is missing



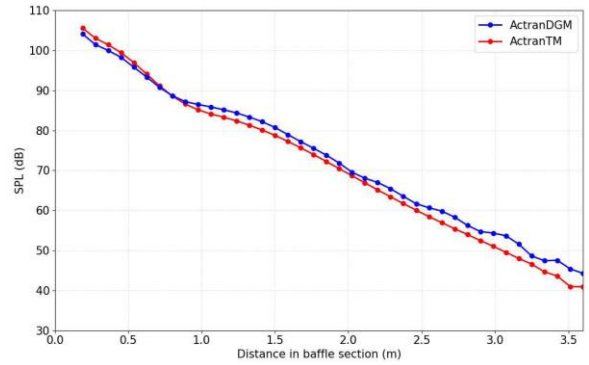
Solution

- A new approach based on a multipole decomposition is introduced to model the porous material behaviour in time domain
- The method is applied on an industrial test bench which contains baffles made of porous materials
- The method in Actran DGM is compared with a finite-element frequency-based approach



Benefits

- Porous materials can now be used in Actran DGM for tackling large models and high frequencies
- Excellent correlation with frequency-based methods
- Potential reduction of computational cost and memory for large models



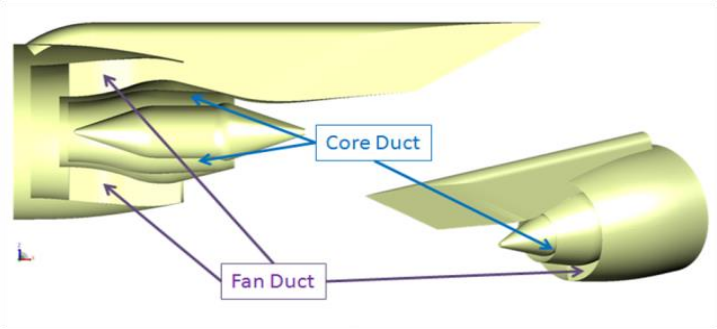
AIRBUS

Exhaust Noise of Turbofan Engine with 3D Effects

AIAA Conference 2009, Exhaust noise prediction of realistic 3D lined turbofans submitted to strong shear layers, FFT: R. Leneveu, B. Schiltz, Airbus France: Y. Druon, A. Mosson,

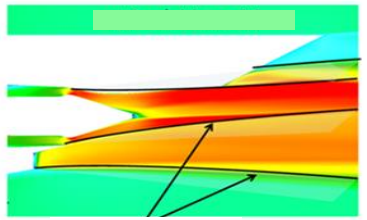
Challenge

- Take into account 3D effect of the turbofan geometry for exhaust noise prediction in take-off condition.
- The geometry of the fan duct is not symmetric due to bifurcations and the pylon.

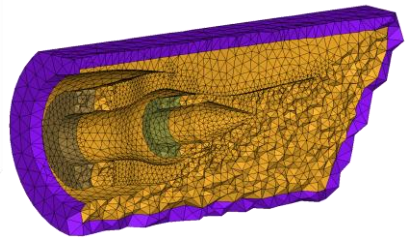


Solution

- Actran DGM is used to perform calculation of a full 3D model.
- Complex flows computed with steady RANS are taken into account including the propagation through shear layers.
- Acoustic treatments are modeled with a surface admittance.

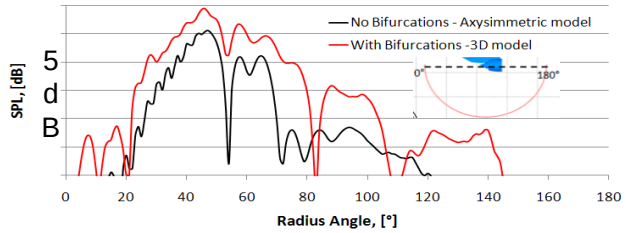


Shear layers



Benefits

- Axisymmetric models are not accurate enough. Bifurcations and pylon must be taken into account for correct prediction.



HEXAGON



Windshield Transmission Loss

Challenge

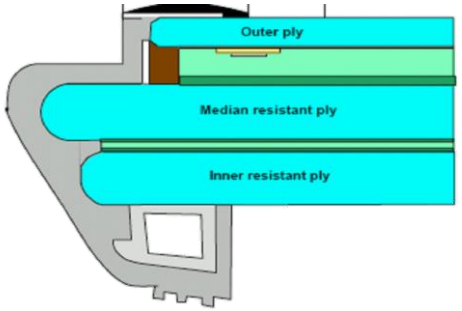
- The windshield vibrates due to the turbulent air flow on its surface. This vibration produce noise that directly radiates on the pilot and co-pilot . The goal is thus to reduce the noise transmission through the windshield.

Solution

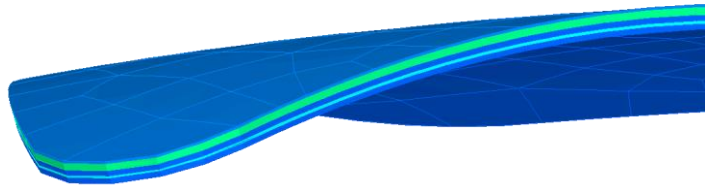
- Actran is used to model the complete windshield with all the plies and the frame. This model is loaded with a turbulent boundary layer, thanks to a random excitation process that does nor required an unsteady flow.

Benefits

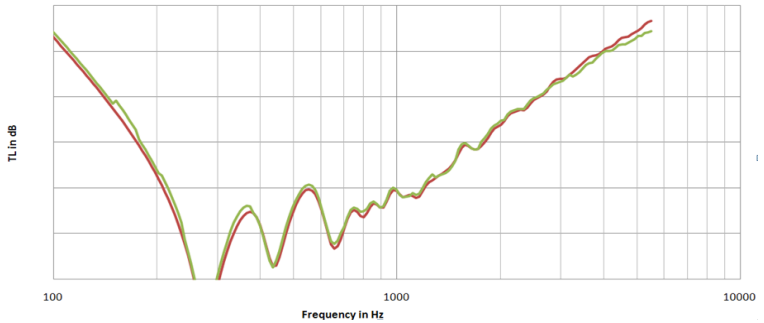
- The Transmission Loss is computed up to 8kHz on different windshield configurations to predict the best one.



Windshield model: frame, seals, several layers



Several windshield layers modeled in Actran



Windshield Transmission Loss (dB)

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Space

HEXAGON

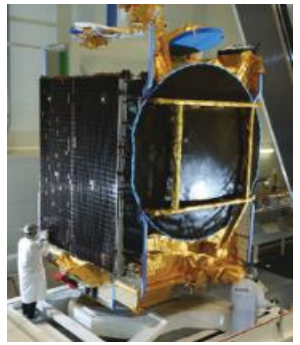
AIRBUS DEFENCE & SPACE

Vibroacoustic response of satellite solar arrays

Challenge

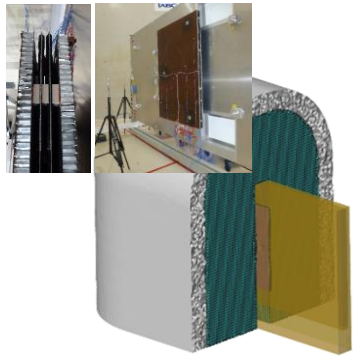
- Develop lightweight solar cell to reduce the weight of the satellite or the space vehicle
- The cost of building prototypes does not allow engineers to conduct design comparisons
- These lightweight devices need their structural response validated to withstand vibrations without residual defects

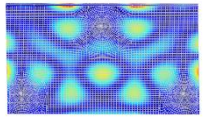


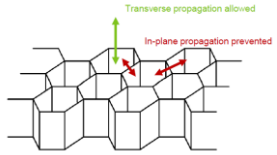


Solution

- Airbus engineers used MSC Nastran and Actran to predict the vibro-acoustic response of solar panels at lift-off
- Mode shapes and related eigenfrequencies of the solar panels structure were computed with MSC Nastran
- Actran was used to enrich the structural model by modelling complex acoustic dissipations and propagation

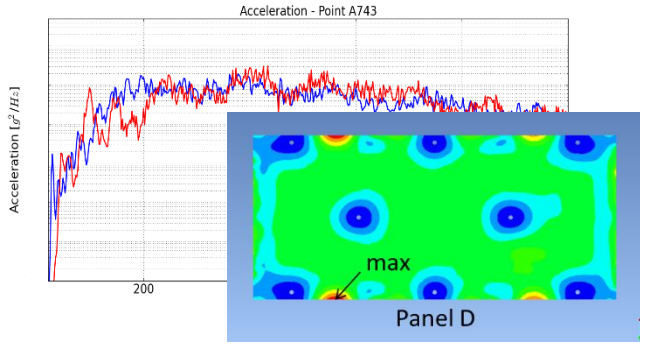




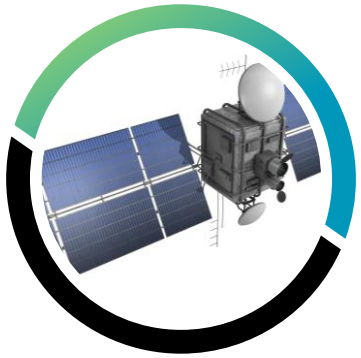


Benefits

- MSC Nastran structural modelling capabilities allowed for the representation of composite material structures accurately
- The effects of a honeycomb structure covered by carbon-fibre face sheets on the acoustic propagation around the solar panel structure were modelled accurately using Actran



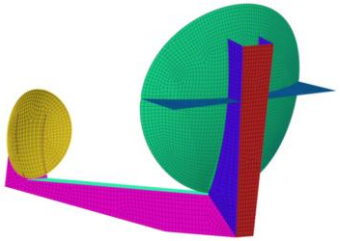
HEXAGON



Satellite antenna

Challenge

- The payload of a rocket is submitted to an intense acoustic load during the lift off.
- The satellite antennas could be damaged during this flight phase, this should be prevented.



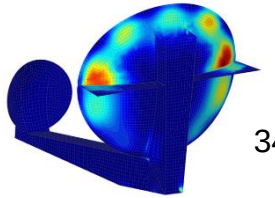
Antenna structural model



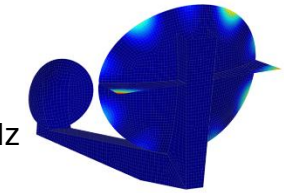
Satellite with 4 antennas

Solution

- A modal extraction is performed with Nastran. An acoustic diffuse field is applied by Actran to model the acoustic load of the test room (IABG).

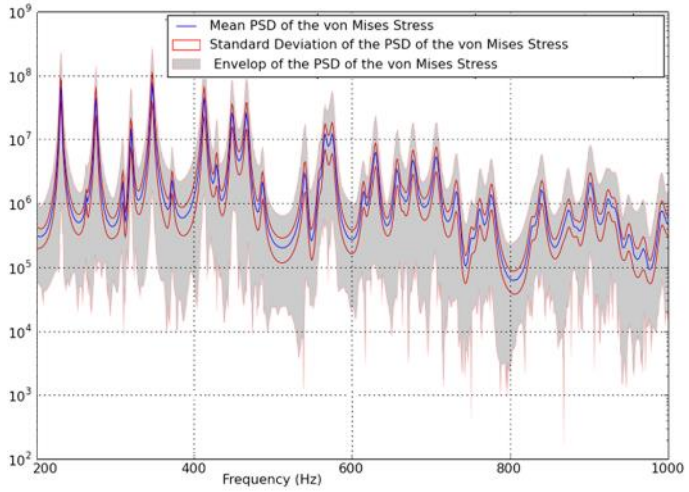


347Hz



PSD of the Von Mises Stress

PSD of the Displacement



Benefits

- Actran computes acceleration, displacement, forces at attachment points and stresses due to the intense noise of the launcher.
- It is possible to perform acoustic fatigue (by coupling with MSC Fatigue or with other post-processing tools)

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AIRBUS DEFENCE & SPACE

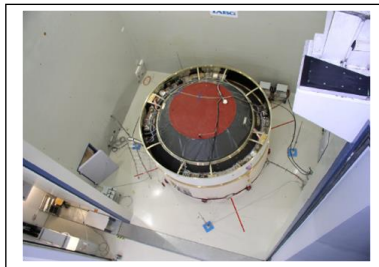
Vehicle equipment bay

ECSSMMT Conference, Prediction of Vibro-Acoustic Responses of ARIANE 5 Vehicle Equipment Bay due to Acoustic Noise Excitation, Published in cooperation with EADS

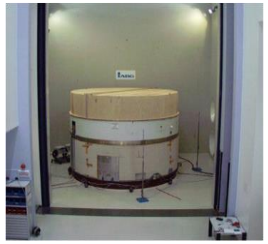
Challenge

- The Ariane 5 equipment bay is the brain of the launcher: it orchestrates from start to end all the systems to control a flight (payload release, separation of boosters…).
- It thus contains electronic systems that can be damaged during the lift-off because of the intense acoustic load.

Tests @ IABG



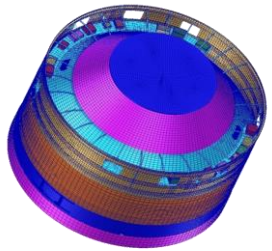
open configuration



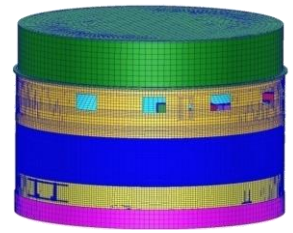
covered configuration

Solution

- A modal extraction is performed with Nastran.
- An acoustic diffuse field is added by Actran for representing the acoustic load of the test room (IABG).



Model without cover

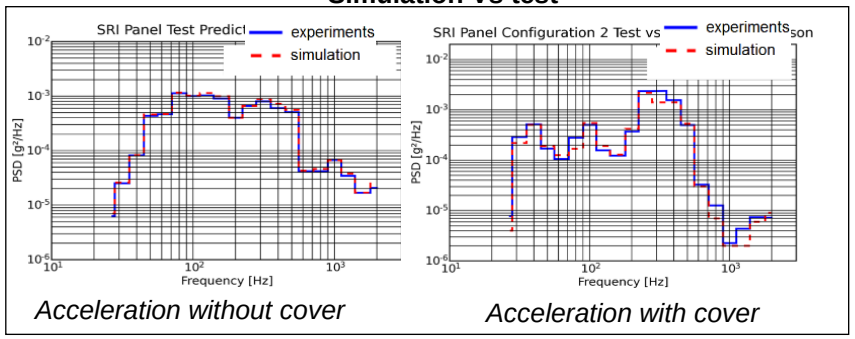


Model with wood cover

Benefits

- Airbus Defense and Space obtained the vibro-acoustic response for each equipment of the Ariane 5 VEB with good correlation with tests.

Simulation Vs test



Acceleration without cover

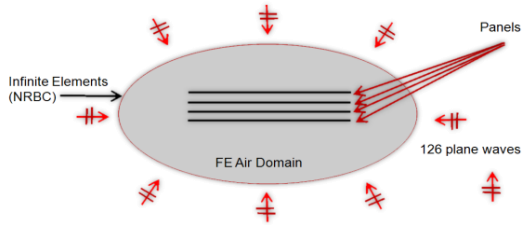
Acceleration with cover

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Folded ATV solar array

Challenge

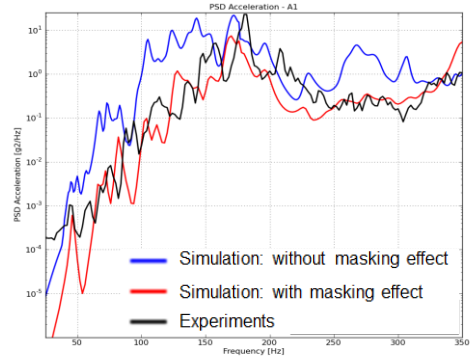
- The cargo ship ATV is developed by ESA for the ISS. It is loaded at the top of the Ariane 5 rocket.
- At lift-off, ATV's solar panels are exposed to an intense acoustic excitation that can damage their structures.



Excitation with diffuse field and masking effects

Solution

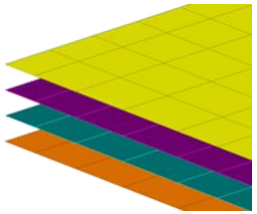
- Combined use of Nastran, for modeling the structure, and Actran for the acoustics.
- The Actran model considers dissipative visco-thermal effects in the air gaps and the diffuse sound field as excitation.



Simulation Vs experiments: Acceleration on the top panel

Benefits

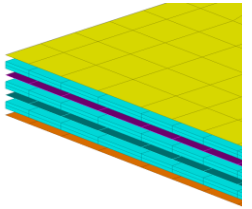
- Actran's visco-thermal models provides higher accuracy of the vibro-acoustic response.
- The masking effect can be simulated using the dedicated diffuse sound field boundary condition available in Actran



Model without air gaps



Solar panels on the cargo ship



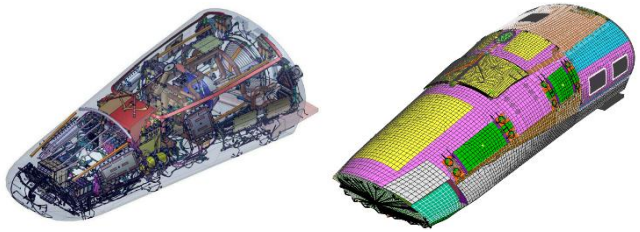
Model with Air gaps

Reusable launcher acoustic fatigue

Starting from a structural model, the acoustic loading is applied to the structure very easily and a predictive structure response is computed within few hours.

Challenge

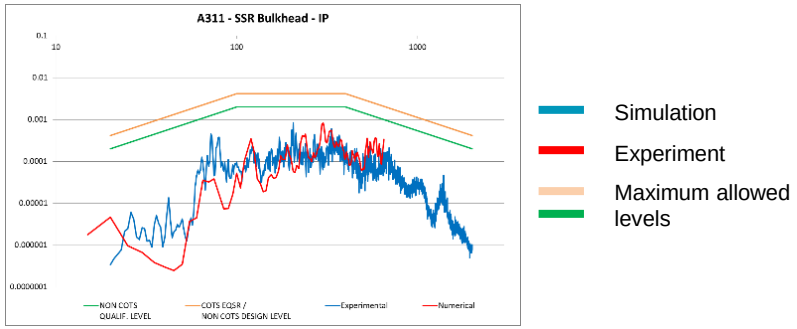
- To make sure that a reusable launcher can be reused, its structure must not be damaged during the launch and landing phases



IXV vehicle global view and structural model

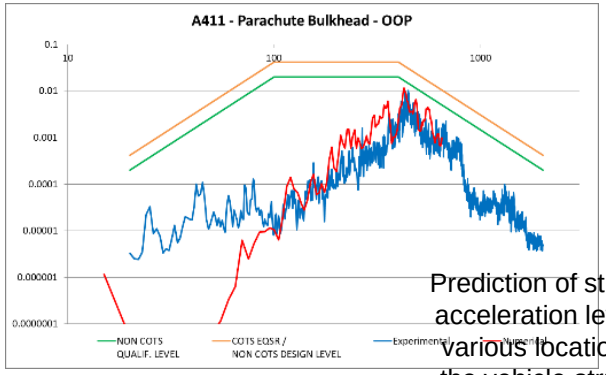
Solution

- Vibroacoustic numerical simulation allows to predict the loading of the structure and anticipate its deterioration due to fatigue.
- Nastran and Actran are used to predict the structure fatigue due to launch acoustic excitation.



Benefits

- Starting from a structural model, the acoustic loading is applied to the structure very easily and a predictive structure response is computed within few hours.



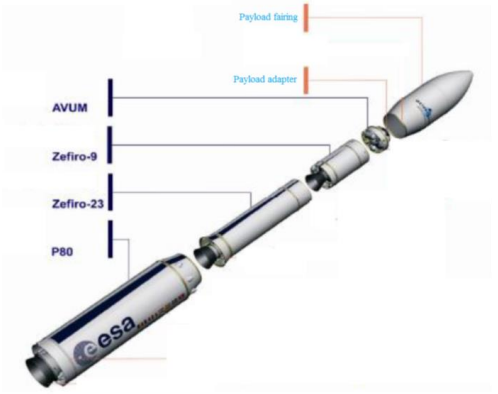
Prediction of structure acceleration levels at various locations on the vehicle structure

Vibro-acoustic analysis of the interstage structures

FFT Acoustic Conference 2016, VEGA Consolidation and Evolution Program (VECEP): vibro-acoustic analysis of the interstage structures, A.De Vivo

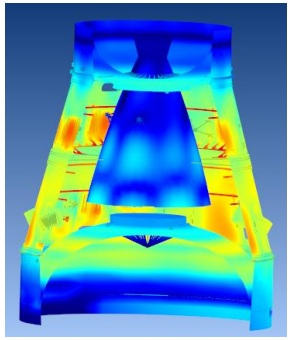
Challenge

- At lift-off, structural vibration and acoustic loading can lead to malfunction of electronic and mechanical components in the vehicle.
- Avio wants to develop a methodology for predicting the vibro-acoustic response of the VEGA launcher structure (in particular, the interstage structures).



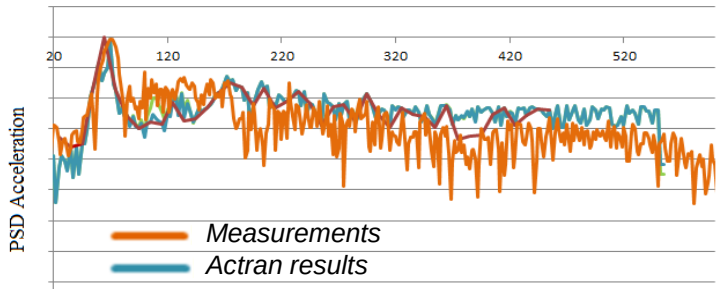
Solution

- A Nastran model of the structure is used to represent the dynamic behavior of the structure.
- Actran is used to load this structure with Diffuse sound field excitation and structure excitation and consider the cavities.



Benefits

- Stress levels and accelerations at key locations on the structure are accurately predicted.



Acceleration on the inner part of the interstage

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Launcher structural integrity

Shaping a Smart and Connected World: Avio to Ensure Spatial Launchers Structural Integrity – MSC Engineering Reality Magazine – Dec 2019

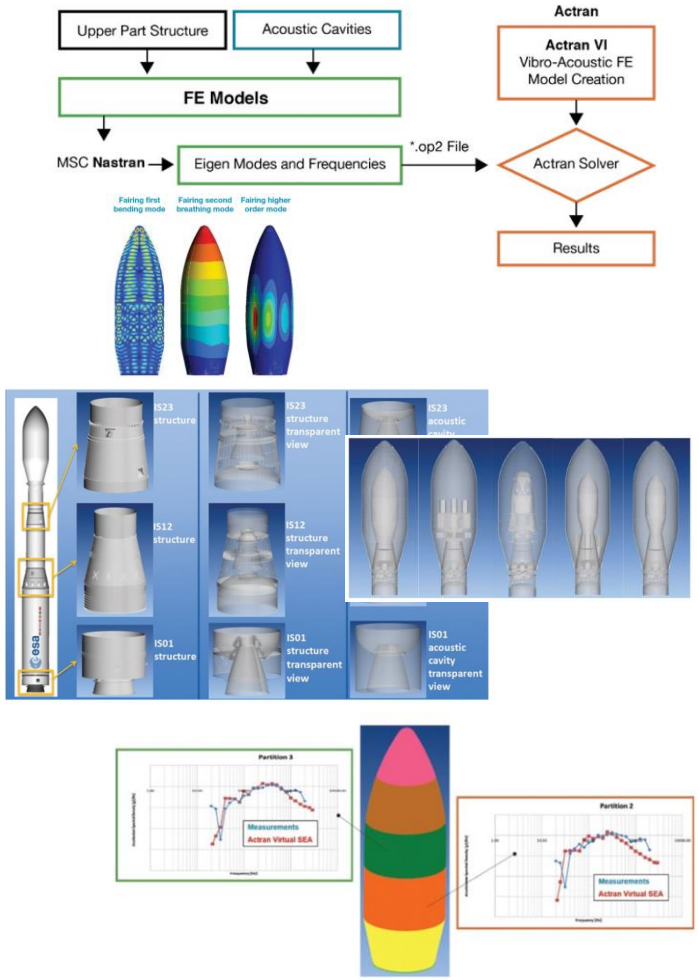
Challenge

- The acoustic load might be critical to the proper function of the vehicle and its components as induced structural vibrations and internal acoustic load can lead to malfunctioning of electronic and mechanical components.



Solution

- Avio engineers used Hexagon CAE solutions MSC Nastran and Actran to predict the vibroacoustic response of the complete launcher structures at lift-off.
- Straightforward computational approach uses MSC Nastran to compute mode shapes and related eigenfrequencies while Actran is used to model both the acoustic environment and acoustic load.



Benefits

- Simple methodology applied on all launcher components.
- Iteration over payload configuration.
- Prediction of high-frequency vibration results using Actran Virtual SEA method.

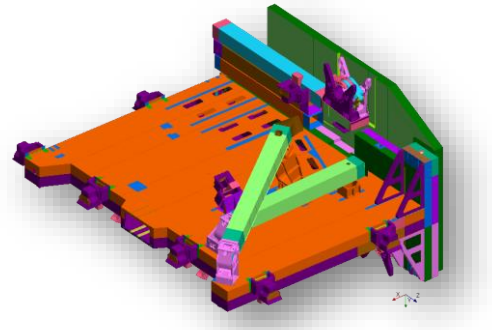
AIRBUS DEFENCE & SPACE

Payload hosting platform

AEC – Bordeaux 2020, Vibro-Acoustic Response Prediction of the Bartolomeo Multi-Purpose Payload

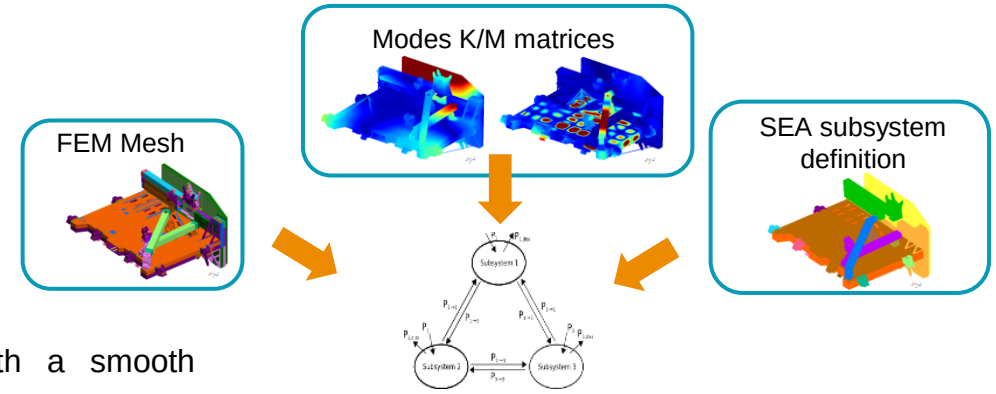
Challenge

- Bartolomeo is a payload hosting platform designed for the ISS (International Space Station) that will be used over 10 years
- At lift-off, high noise levels are capable of damaging payload equipment
- Investigate efficient method for low/mid/high frequency including how to extend the frequency range of the simulation for launch loads



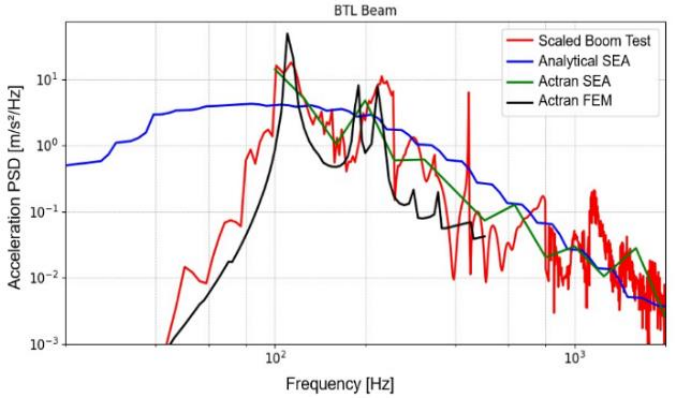
Solution

- Finite Element models for structure integrity:
  - Standard solution
  - Robust and versatile solution
  - Limitation in Low/middle frequency
- **Actran Virtual SEA** → low/mid/high frequency with a smooth transition in middle and high frequency



Benefits

- Actran FEM: standard method for correlation studies and well suited for low and mid frequencies
- Actran Virtual SEA: results are predictive over the whole frequency range, up to 2000 Hz
- Actran is able to predict accurately and efficiently the vibro-acoustic response at low/middle/high frequencies



HEXAGON

Prediction of mechanical shock environments for launch vehicles

"Actran SEA has a lot of potential for shock environments as it allows to extend the suitable analysis frequency range so that even at 10 kHz it is possible to produce fairly reliable results"

- Stefano Destefanis
Vibroacoustic specialist
Thales Alenia Space

Challenge

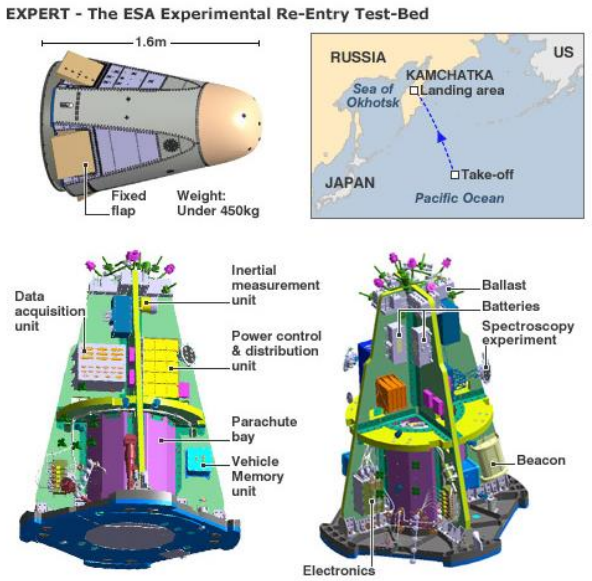
- Various mechanical shocks happening during different phases of a space flight (separation, deployment, hold-down, release, pyrovalves, pyroactuators)
- Shock environments at spacecraft internal locations must be assessed, to properly qualify internal equipment
- Challenges to simulate with other methods (FE up to 10kHz, semi-empirical methods not always accurate)

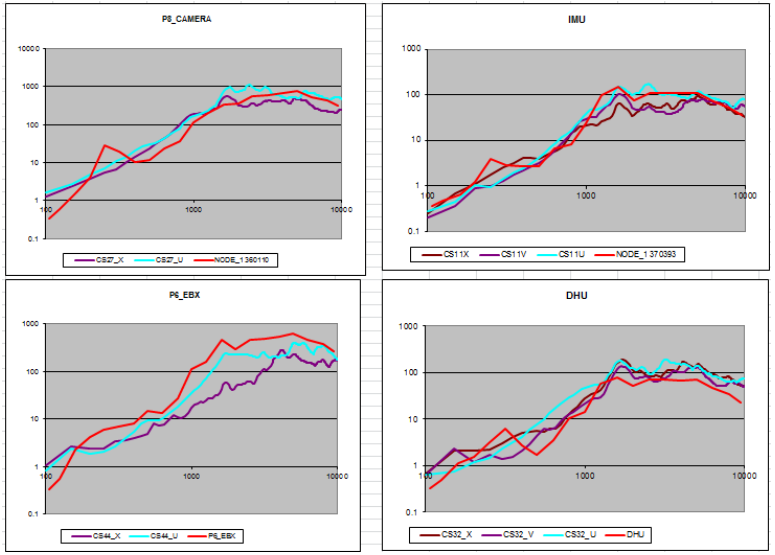
Solution

- Actran Virtual SEA is used to compute the vibro-acoustic response to a shock load up to 10kHz
- Frequency extrapolation provides an efficient way to reach high frequencies with a limited amount of modes
- Specific shock input (SRS) is multiplied by the transfer function to obtain the expected shock environment at target units.

Benefits

- Fast setup: An existing FE model is reused to build the Virtual SEA model using automatic substructuring
- Accurate solution: Allows for definition of frequency-dependent damping, consistent results with FE model





Comparison analysis (red curves) vs shock test data.

UNIFLOW DYNAMICS
NUMERICAL SIMULATIONS

CBK PAN

Vibro-acoustic simulation of spacecraft instrument

HxGN Live Design & Engineering 2021, Vibro-acoustic numerical simulations of spacecraft instrument subjected to diffuse sound field using MSC Nastran and Actran, Zbigniew Rarata et al.

Challenge

- The integrity of space scientific equipment at lift-off is an important consideration
- Both the launcher and the payload are required to withstand specific loads under a diffuse sound field that is present at lift-off
- The Wide Field Imager filter, part of the Athena (the Advanced Telescope for High-Energy Astrophysics) project, ESA's next-generation X-ray astronomy observatory, is one of these components

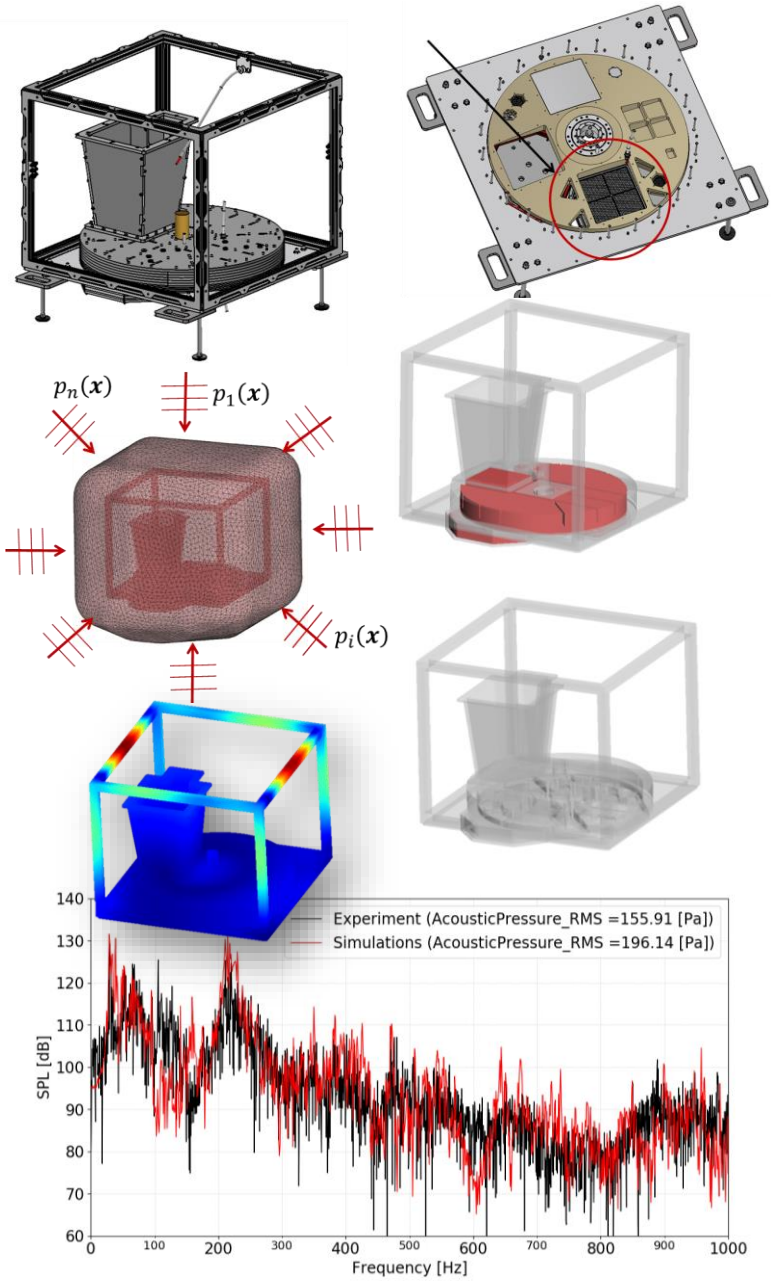
Solution

- A vibro-acoustic analysis with a diffuse sound field excitation with masking effects is used to calculate the response in microphones and accelerometers
- MSC Nastran is used for calculating the modes of the structure up to 1250 Hz
- A modal-physical approach is used for the vibro-acoustic modeling in Actran

Benefits

- Very good correlation between measurements and simulation for microphones
- Reasonably good correlation for accelerometers
- This modal-physical approach allows to investigate in great detail acoustic and vibro-acoustic behaviours of complex mechanical systems

The Wide Field Imager (WFI) filter





Electronics – Audio systems

HEXAGON

Personalized Head Related Transfer Function (HRTF)

FFT Acoustic Simulation Conference 2016, Acoustic Simulations using the Human Head, Sarah Heile

Challenge

- The shape of the head and the face are important when designing sound devices, such as headphones, headsets, as the sound that we hear will depend on how sound waves are propagated and reflected around our face
- It is important to study the impact of the face shape on acoustic transfer functions, which measure how the sound is transferred from the source to the ear



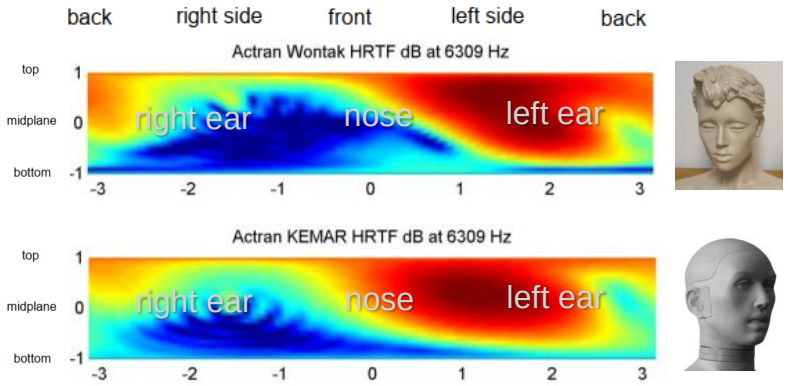
Solution

- Actran acoustic models allows to assess face shape effects on acoustic transfer functions in speaking or listening modes
- Using the acoustic models, it is possible to evaluate a number of different faces fast and efficiently



Benefits

- Ability to listen to personalized head-related transfer function through auralization
- Assess the sensitivity of speakers and microphones designs and position on acoustic transfer functions



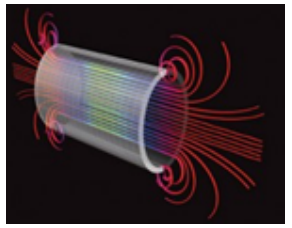
Loudspeaker simulation

Actran is used to model the visco-thermal loss in a loudspeaker port

Challenge

- The visco-thermal loss in the port of the loudspeaker box is a non-trivial effect and needs to be accurately modeled for designing the complete system.

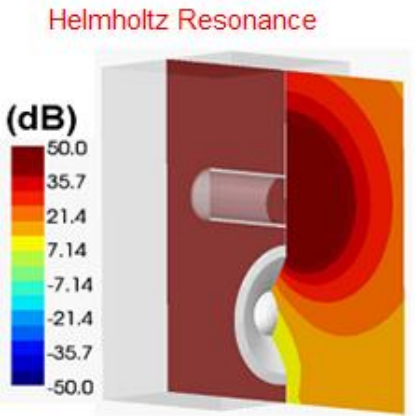




Loudspeaker Port

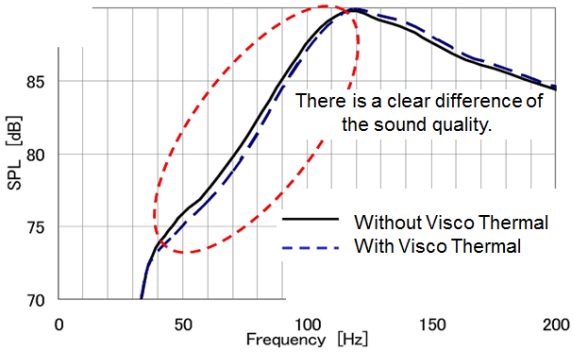
Solution

- Actran can be coupled with a structural solver for modeling the loudspeaker and the vibro-acoustic interactions with the box.
- Visco-thermal losses occurring in the port can be modeled with specific models



Benefits

- The sound quality of the loudspeaker including the installation and specific visco-thermal effects can be efficiently modeled by using acoustic simulation

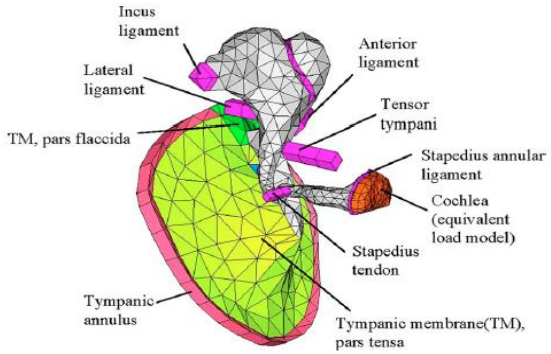


Human ear modeling

Acoustic simulation provides valuable insight by performing human ear modelling for hearing aid development

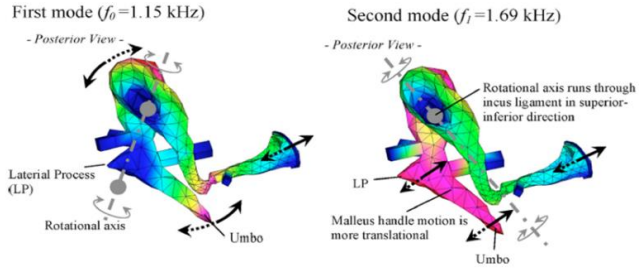
Challenge

- Designing hearing aids requires understanding the noise propagation within the human ear, including air and bone conduction.



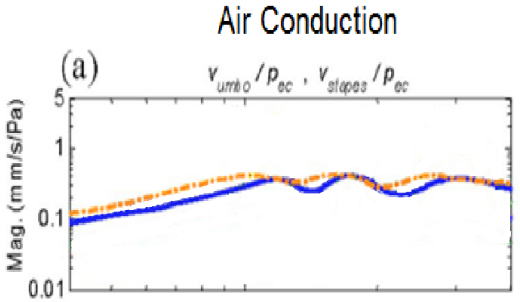
Solution

- Actran is used for the 3D modeling of the middle-ear (ossicles, tympanic membrane, ligaments, tendons and air) using composites, pre-stressed structure, mechanical and acoustical loads.



Benefits

- Hearing aids design can be improved thanks to the knowledge of the middle-ear motions and noise response.
- Actran also helped reveal the 3D dynamic characteristics of the overall middle-ear structure.

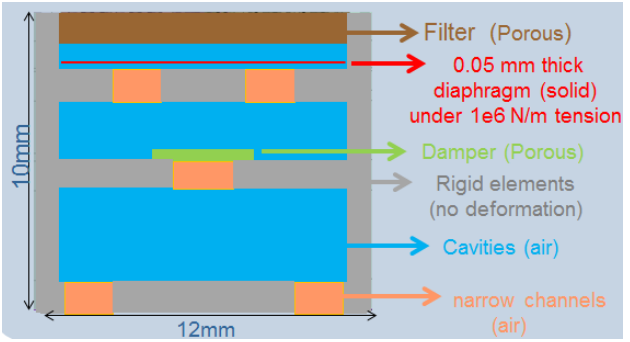




Microphone performance

Challenge

- A microphone is a system that couples electric, mechanic and acoustic phenomena. How to predict microphone characteristics?



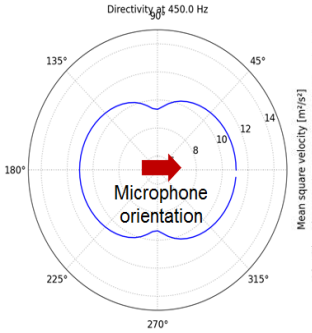
Solution

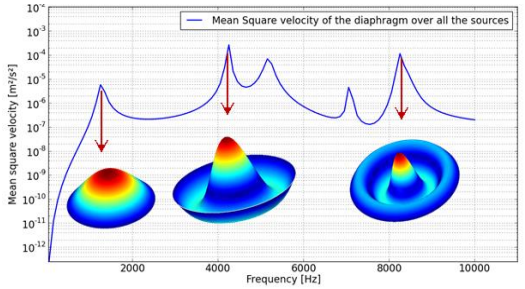
- Actran is used for modeling the filter and the damper (with porous material), rigid components and air cavities.
- This model allows predicting the microphone's mechanical impedance as well as the acoustic transfer function.



Benefits

- The overall microphone behavior can be studied using Actran
- Directivity performance assessment
- Outputs of membrane behavior driving the microphone performances





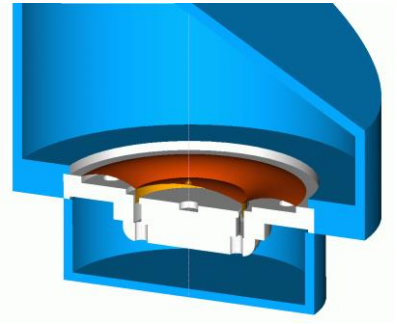
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Headset performance

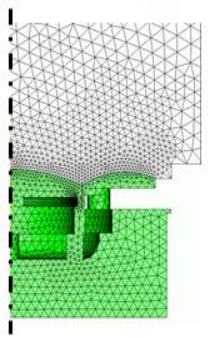
Challenge

- Obtaining from the electric excitation the sound produced at the ear
- Knowing the mechanical impedance and the acoustic transfer function



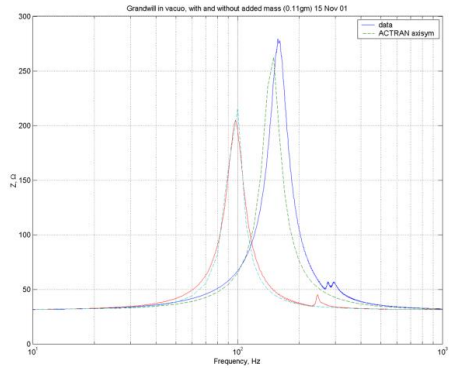
Solution

- Actran has been used for modeling the headset response in free field
- The membrane as well as the air inside and outside the headset have been taking into account, using the fast Actran symmetric computation.



Benefits

- More efficient design cycle thanks to the prediction of the headset acoustic response.



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Brüel & Kjær

Occluded ear simulator

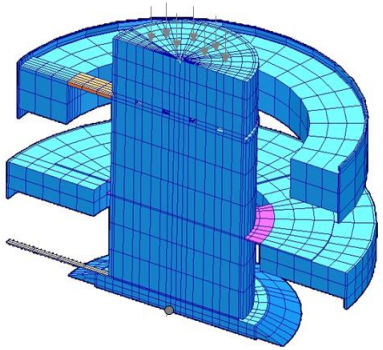
Challenge

- The IEC711 coupler is widely used for calibrating insert earphones.
- The classical modeling of the occluded ear simulator, the Lumped Parameter Modeling (LPM), is not accurate at high frequency range, when acoustic wavelength reduces to the size of the coupler



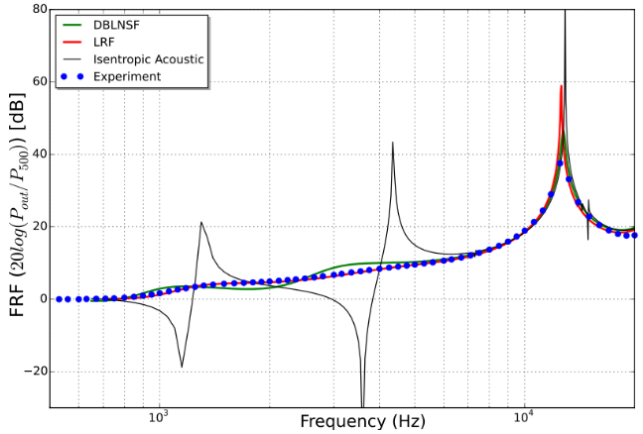
Solution

- Actran has been used for simulating the transfer impedance, taking into account the visco-thermal effects.



Benefits

- The performance of virtual couplers can be evaluated at the very early design stage, especially if the high frequency performance is requested.
- This makes design much more efficient.



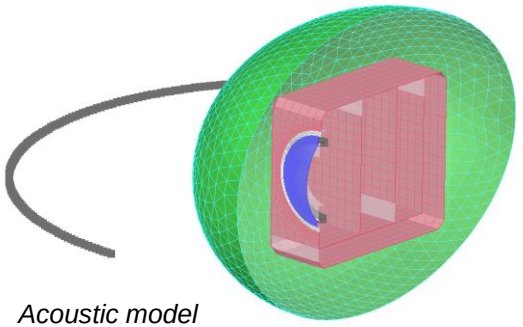
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Speaker box simulation

Challenge

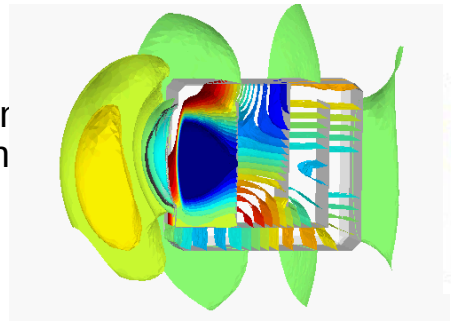
- Transmission lines are used in loudspeaker boxes for redirecting the sound from the back cavity of the front of the loudspeaker.
- Evaluating different transmission lines shapes allows improving the acoustic quality of the device.

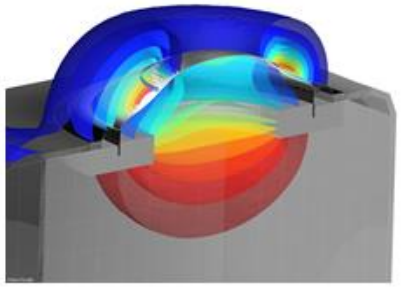


Acoustic model

Solution

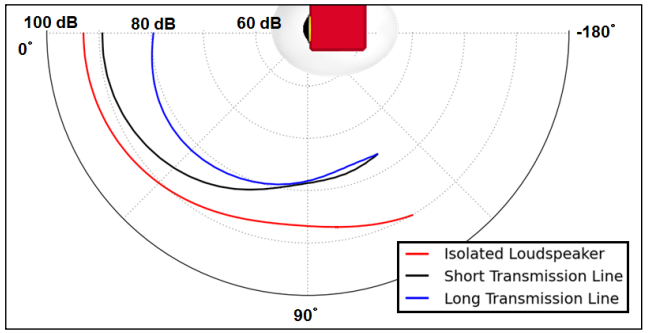
- Actran is used for modelling the vibration of the membrar and the influence of the transmission for the overall soun front of a loudspeaker





Benefits

- Actran can evaluate the acoustic performance of a loudspeaker installed in a cabinet.
- Different configurations are evaluated easily



Far field noise directivity at 1500Hz

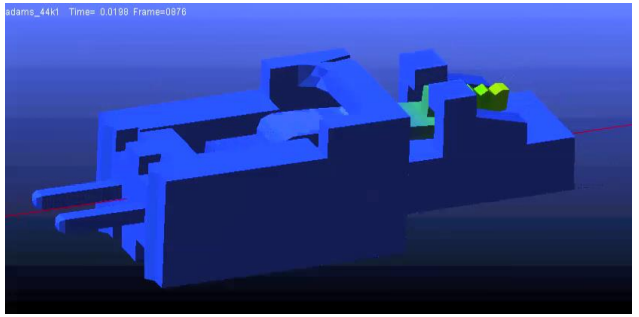
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Connector aligning impact noise

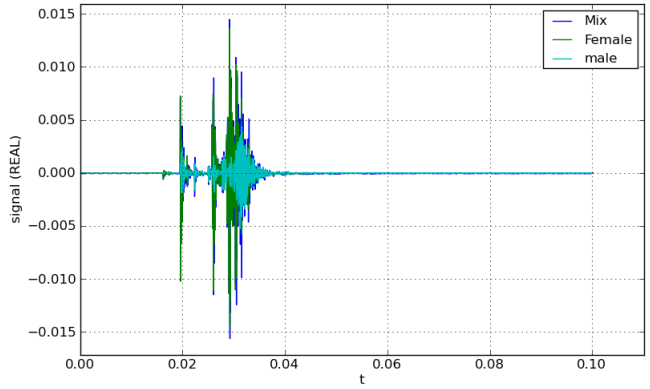
Challenge

- Connectors and switch mechanisms produce specific noise due to impact of the connector parts.



Solution

- Vibrations due to the impact computed with Adams;
- Acoustic radiation computed by Actran time domain solver.

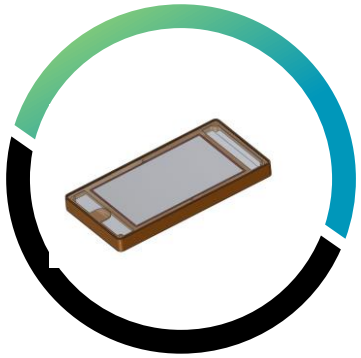


Benefits

- Adams and Actran highly coupled solutions allows to efficiently determine the response of the complete system.
- Microphone time histories and wav files are directly available in the Adams interface enabling MBD engineers to perform preliminary acoustic results.



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Smartphone acoustics and vibration

Challenge

- Acoustic target of smartphone
  - Volume, Sound quality, Sound directivity
- Limited design space for a compact smartphone mechanical design
- Need for rapidly assessing design changes in the development process:
  - Reduce expensive prototypes and testing
  - Shorten time-to-market

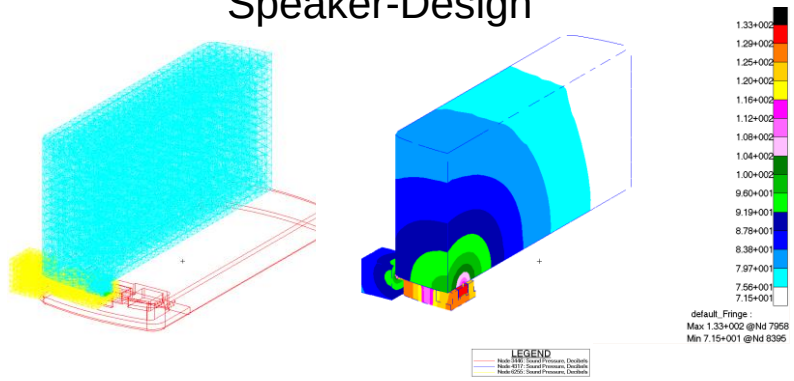
Solution

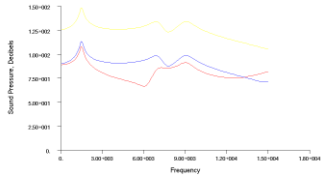
- Actran provides comprehensive acoustics, vibro-acoustic and aero-acoustics simulation capability
- Thiele-Small parameters of a measured speaker performance could be used to study installation effects from various positioning and sound-box designs

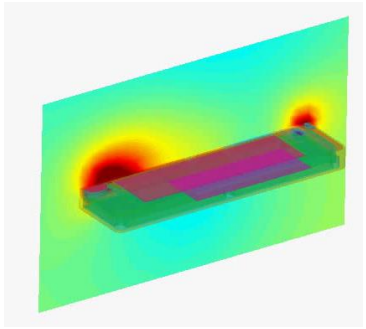
Benefits

- Superior sound performance at lower cost and shorter time-to-market
- Most of the physical prototyping and testing to evaluate the performance for different positioning and sound-box designs of a speaker could be eliminated.

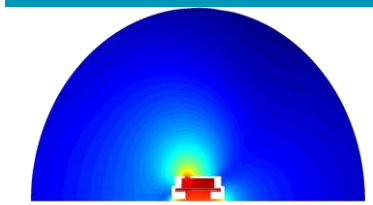
Speaker-Design

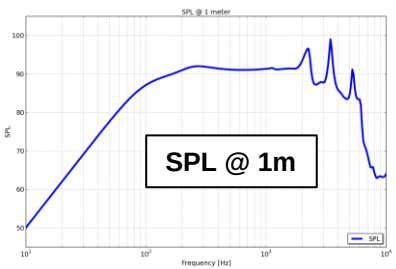


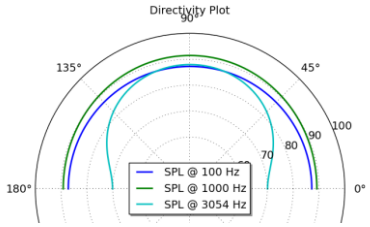




Pressure distribution at 4000Hz







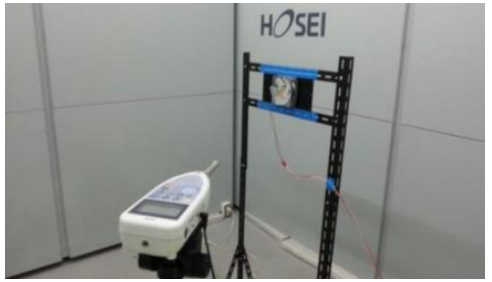
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Electronic fan noise prediction

Challenge

- Cooling fans are important sources of noise and vibration in electronics, from laptops to server racks
- It is important to predict the influence of fan design parameters on aerodynamic performance and generated noise



Measurement setup

Solution

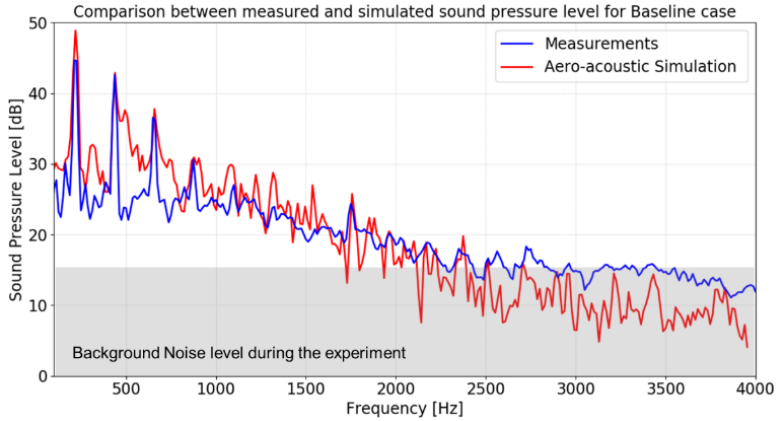
- Cradle CFD is used to compute the fan aerodynamic performance and the unsteady flow for a variety of designs.
- Actran is then using the CFD results from Cradle CFD to predict the generated noise using the Lighthill Analogy

Fan Geometry



Benefits

- The simulation process is able to predict fan noise consistently for different fan design changes
- Good correlation with measurements is achieved



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FACEBOOK

Cooling fan noise in IT Hardware

"Simulation-based design optimization helped reduce hard drive vibration due to the cooling fans by 50%."

- Kanwardeep Bhachu
Optimization Engineer
Meta

Challenge

- IT hardware manufacturers design fans to ensure thermal performance
- More and more intricate design require more powerful fans which tend to be louder
- Fan noise may be inconvenient for users but may also generate vibrations causing damage or hard drive reading / writing issues

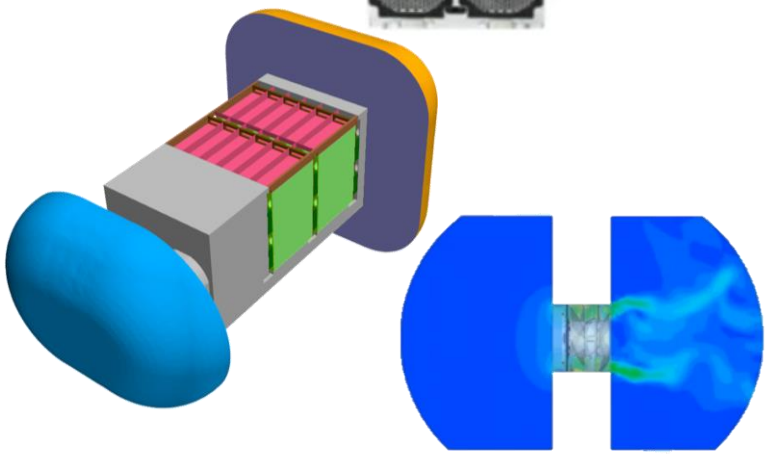
Solution

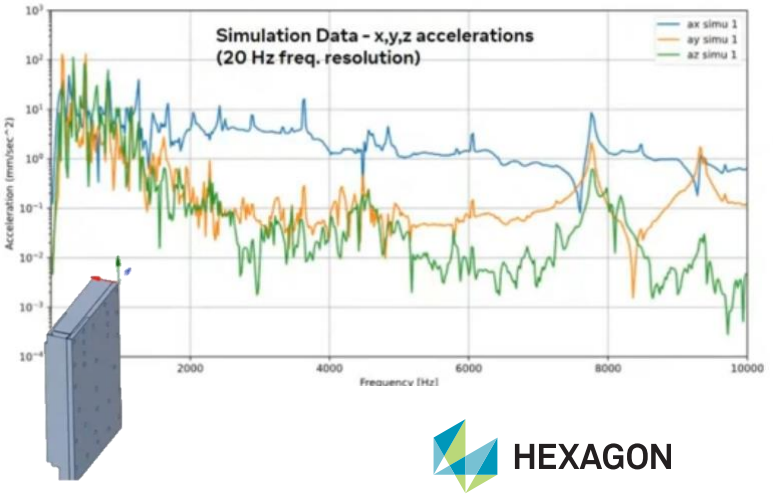
- Cradle CFD for CFD simulations for anticipating fluid flow and thermal performance
- Actran for aeroacoustic simulation for predicting fan noise impacting hard drives performances
- Modify fan design or propagation path to limit noise and ensure performances

Benefits

- Complete solution using MSC portfolio
- Cost efficient: Perform multiple iterations without the need for physical prototype
- More efficient use of tests for validation of simulation







HEXAGON

Meta

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Challenge

- IT hardware manufacturers design fans to ensure thermal performance
- More and more intricate design require more powerful fans which tend to be louder
- Fan noise may be inconvenient for users but may also generate vibrations causing damage or reducing hard drive performance

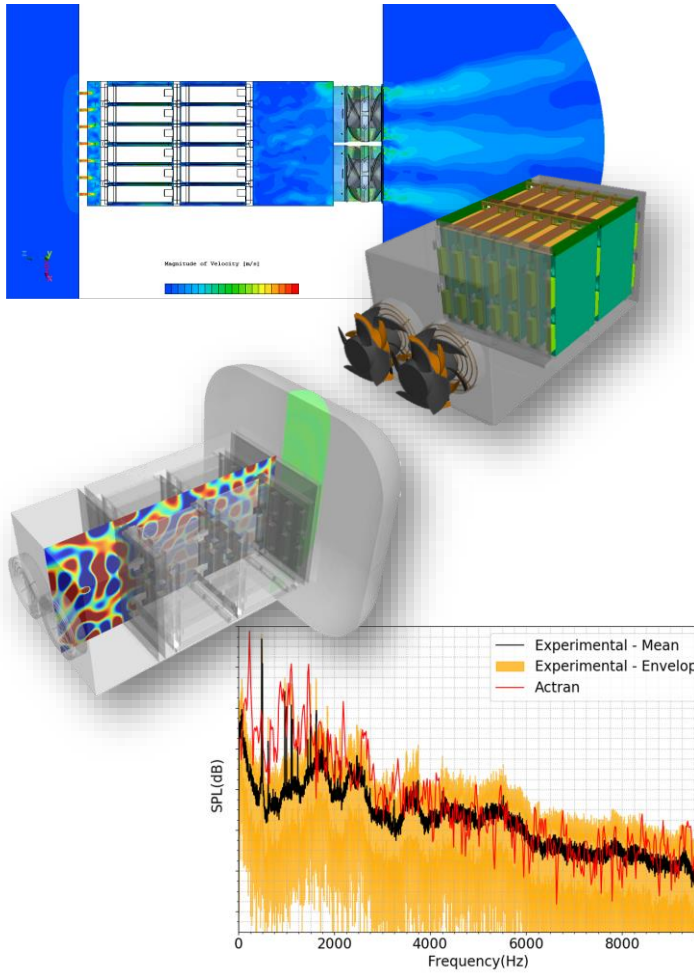
Solution

- Cradle CFD for CFD simulations for predicting fluid flow
- Actran for aeroacoustic simulation for predicting fan noise impacting hard drives performances
- Modifications of fan design or propagation path and introduction of acoustic treatments to limit noise and reduce vibration

Benefits

- Complete solution using MSC portfolio
- Cost efficient: Perform multiple iterations without the need for physical prototype
- More efficient use of tests for validation of simulation


Bryce Canyon Chassis
Courtesy of the Open Compute Project





Noise from a box fan

Internoise 2023, Numerical prediction of noise generated from a box fan, Y. Nakashima et al.

Challenge

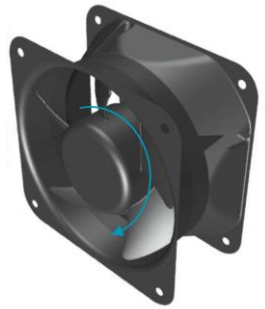
- Electronics fans have been steadily reducing in size and increasing in flow rate, resulting in greater noise
- Understanding and evaluating this noise requires accurate tools to model it early in the design phase
- At the same time, modeling such fans efficiently remains a challenge due to cost

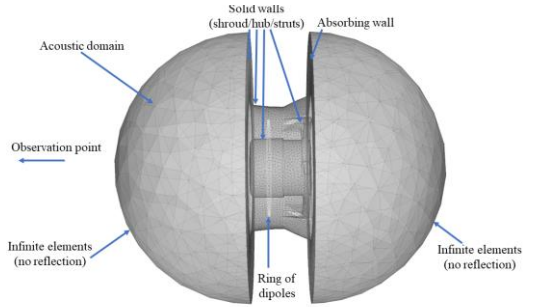
Solution

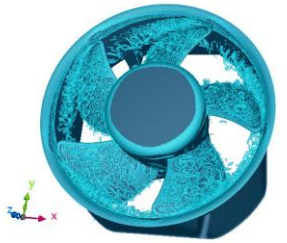
- A new method is created to evaluate fan noise based on a ring of dipoles approach
- Two methods are used in this study”
  - one that uses an FWH technique within scFLOW (baseline)
  - A hybrid one that uses scFLOW for CFD and Actran for sources and propagation

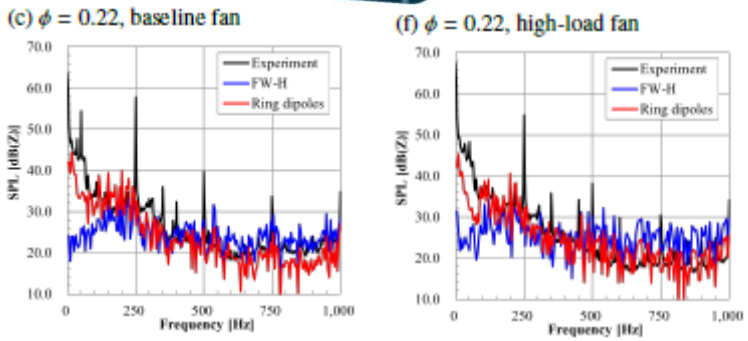
Benefits

- Both methodologies provide good matching with measurements across different fan loads and configurations
- Very good accuracy for the new methodology, especially in the low-frequency range









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Consumer Products

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Vacuum cleaner acoustics

FFT acoustic conference 2012, Aero-Acoustics Analysis in Vacuum Cleaner, J. Kim, K. Hyun, D. Kim

Challenge

- Vacuum cleaners are a large noise contributors in the home and multiple components need to be evaluate for noise reduction
- Noise level reduction from 60dB to 53dB without affecting the suction power performance by optimizing all the cleaner parts (Motor, Cyclone, Muffler and Nozzle)

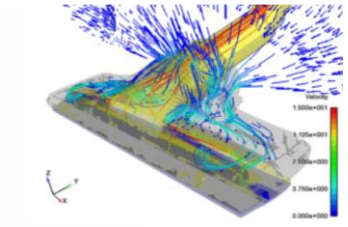
Solution

- Actran coupled with an unsteady CFD solution allows the aeroacoustic analysis of the motor.
- The optimization of the muffler is possible by means of perforate plates modeling and use porous materials

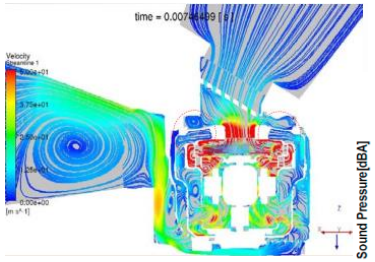
Benefits

- Ability to address multiple acoustic design issues in a vacuum cleaner
- Fine tuning of porous materials and perforation parameters for noise reduction
- Good correlation between simulation and experiments

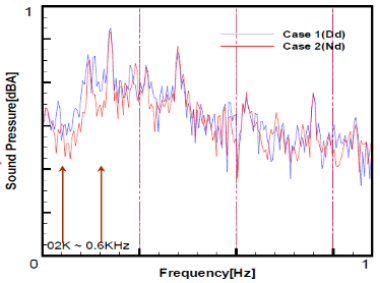




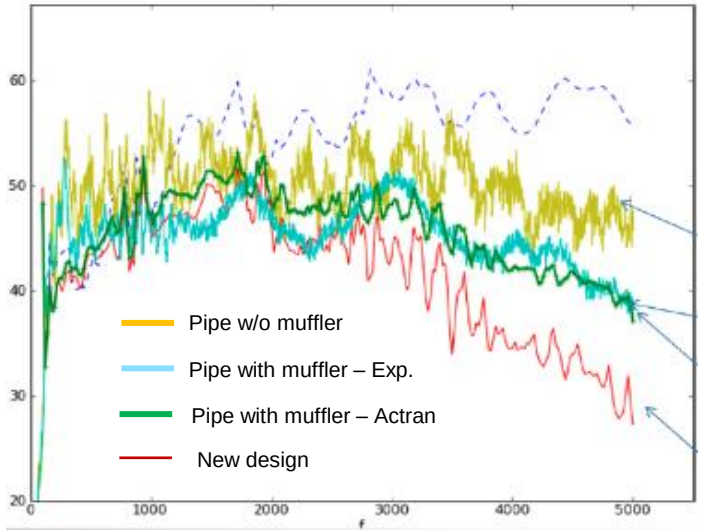
Nozzle acoustics



Nozzle acoustics



Fan aeroacoustics



Experimental comparison and design change assessment

Lawn mower noise

Fan Noise 2007, Validation of a Computational Aero-Acoustics formulation based on Lighthill's analogy for a cooling fan and mower blade noise, R. Sandboge et al.

Challenge

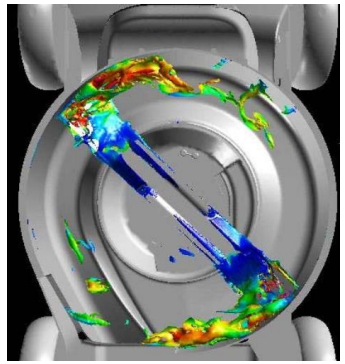
- In turf-care equipment, the cutting blades are the dominant noise source.
- In this case, the mower noise is produced by blades that rotate counter clock-wise at 3000 RPM.



https://www.deere.com/en/mowers/lawn-tractors/

Solution

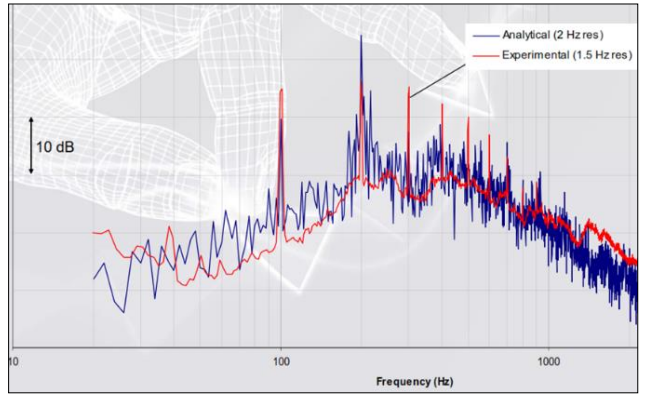
- Coupling of Actran with a commercial CFD tool allowed to predict the broadband and tonal noise sources.
- Propagation within a non-free field was studied.



Acoustic sources

Benefits

- The acoustic simulation well predicts both the tonal noise at BPF and the broadband noise.
- Possibility to integrate fan noise predictions into the development cycle, with a potential for many applications of flow-induced noise.



Characterization of HVAC unit acoustic radiation

Internoise 2019, Hybrid Experimental - Numerical Method to Predict Far Field Noise of HVAC Unit, B. Robinet, S. Lenaerts, M. Raskin, J. Jacqmot

Challenge

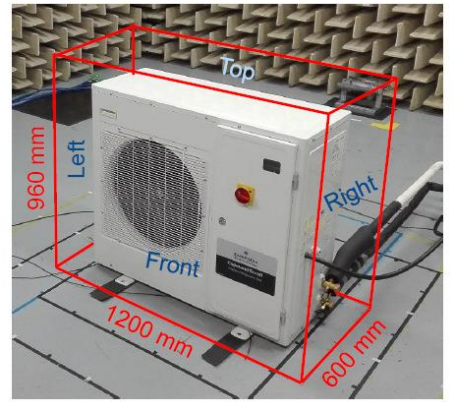
- Characterization of HVAC unit far field noise (amplitude, directivity,….) required to limit noise pollution by selecting optimal acoustic treatment locations based on numerical results
- Sound pressure in far field prediction is complex, need for an efficient approach

Solution

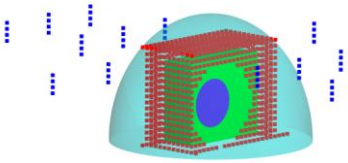
- A hybrid approach combining experimental results in near field and numerical acoustic pellicular modes is used to characterize complete system radiating characteristics

Benefits

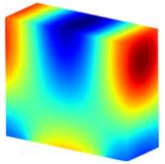
- Easy set-up and efficient characterization method
- Good match of near field acoustic transfer functions, directivity and far field sound pressure levels predicted



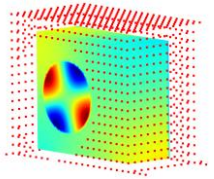
Actran model overview



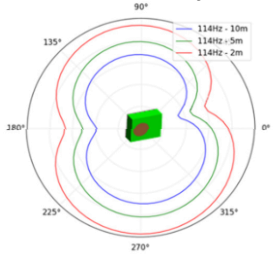
One pellicular mode of casing



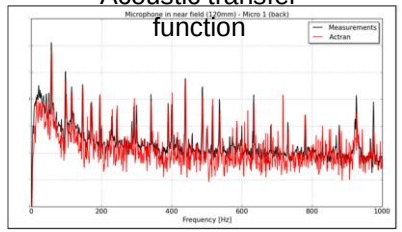
One pellicular mode of fan + measurements microphones



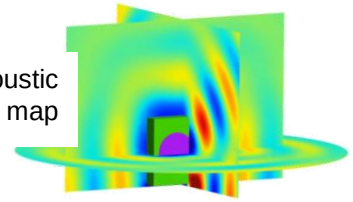
Frequency dependent directivity



Acoustic transfer function



Acoustic Radiation map



Acoustic analysis of washing machine low-frequency noise

J. Applied Acoustics 174, 2021, Numerical and experimental analysis on the vibration and radiated noise of the cylinder washing machine, J. Jiang, H. Yang, G. Chen, K. Wang

Challenge

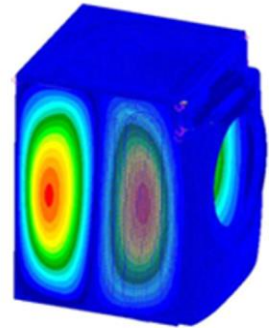
- Low-frequency vibration from washing machines is an important contributor to the overall noise level of a washing machine
- This noise has a high impact on acoustic discomfort within a household



Solution

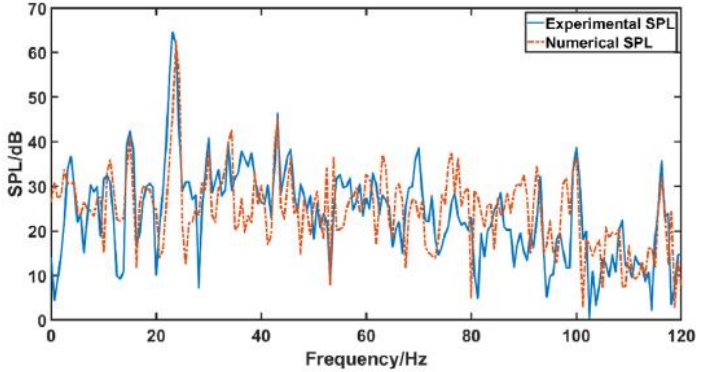
- Actran and Nastran are used for the acoustic radiation and dynamic analysis respectively.
- The analysis involves first the modal extraction of the washing machine structure and the prediction of the vibration response by Nastran
- Actran is then used for radiating the noise generated by the vibration





Benefits

- Excellent correlation for both the vibration analysis and the acoustic radiation analysis over a large number of rotation speeds
- The infinite element method provided in Actran can lead to high accuracy results at an affordable cost



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Aerodynamic noise and noise reduction of range hood

J. Applied Acoustics, 2020, Numerical simulation of aerodynamic noise and noise reduction of range hood, J. Huang, K. Zhang, H. Li, A. Wang, M. Yang

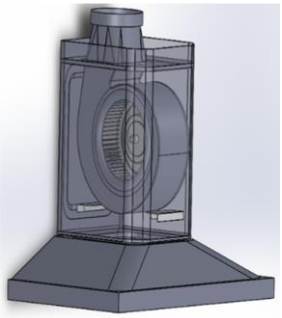
Challenge

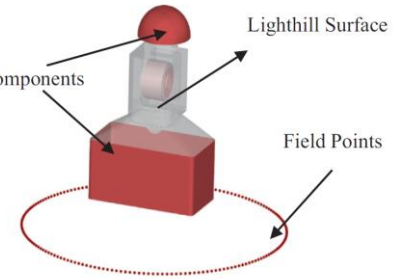
- With the increasing demand for low-noise fans, the issue of fan noise has received widespread attention
- The noise from the centrifugal fan of a range hood has a high impact on acoustic discomfort within a household



Solution

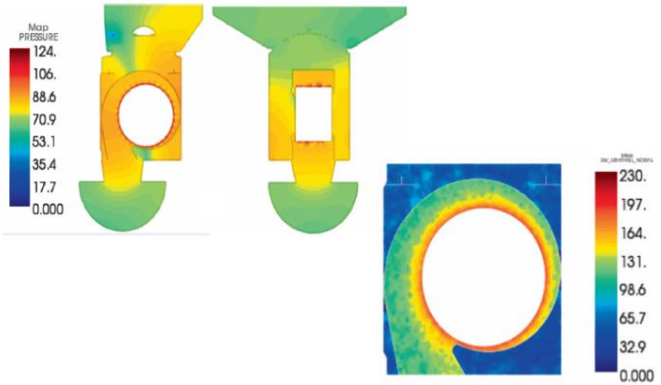
- Actran is used for performing an aeroacoustic analysis using CFD results as input
- The Lighthill surface technique is used to generate noise sources that are then propagated and radiated to the near and far field





Benefits

- The aeroacoustic analysis was able to provide valuable insight on the propagation path as well as the important frequencies for the system
- Using this insight, a noise reduction strategy was devised that allowed for a reduction of up to 2 dBA



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iSiD
IT Solution Innovator

Impact Sound of Golf Club

FFT Acoustic Simulation Conference 2014, Adams to Actran simulations – Noise and Sound Generated by Dynamic Mechanism, T. Nishigori

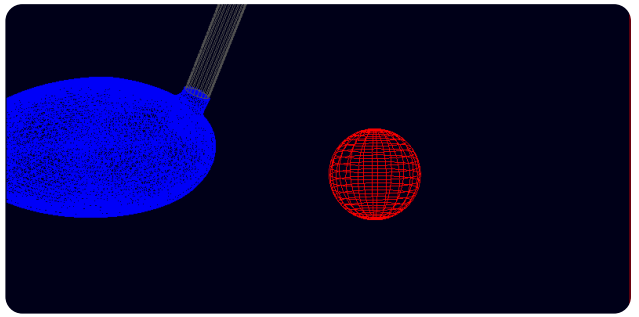
Challenge

- A golfer's choice of equipment is driven by the "feel" of a golf club.
- The impact sound between different clubs and balls strongly contributes to the feel of a shot



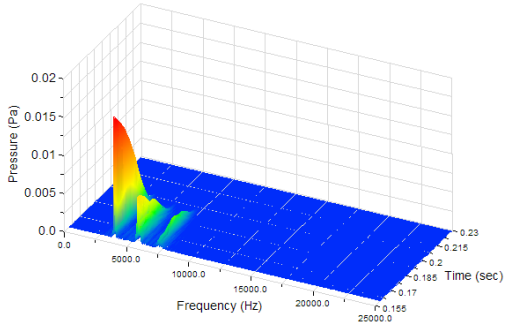
Solution

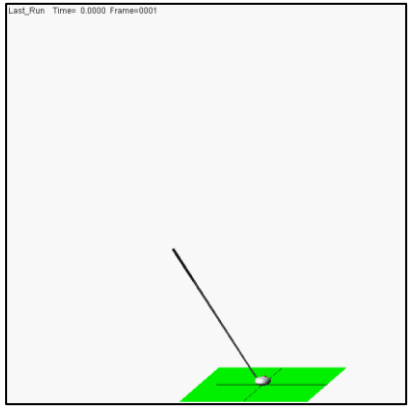
- The impact between ball and club is calculated by Adams
- The club structural response is input in Actran for computing the acoustic response.



Benefits

- Subjective evaluation: export time response result as a WAV file and evaluation by hearing
- Objective evaluation: by means of 3D spectra analysis in time and frequency. Sound pressure level visualization and numerical quantification of magnitude and reverberation for each frequency.





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EMERSON

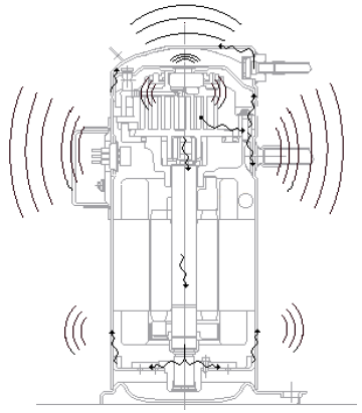
Acoustic simulation for scroll compressors

HxGN Live Design & Engineering 2021, Use of Acoustic Simulation in Design of Scroll Compressors and HVACR Units, S. Lenaerts

Challenge

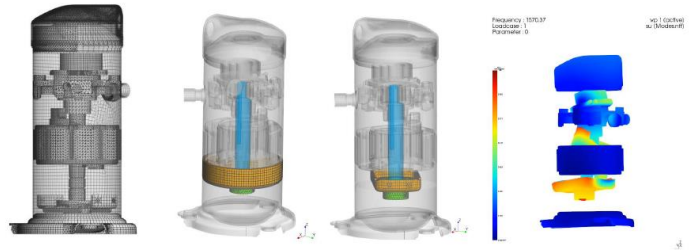
- Scroll compressors form part of the HVAC units used in residential and office buildings
- They are susceptible to be annoying for people living in the surroundings due to their noise emission
- Noise regulations are strict and challenging to meet





Solution

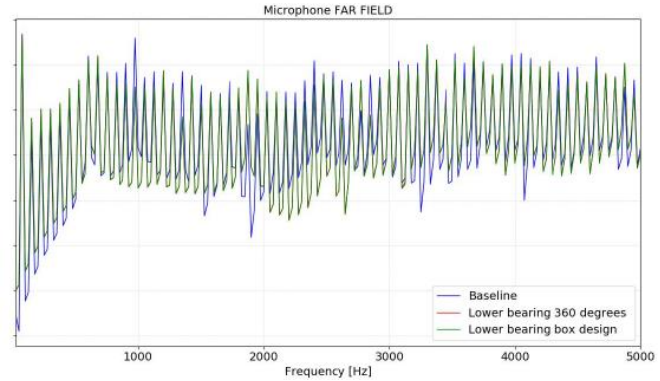
- Actran is used to perform vibroacoustic simulations at the component and system level
- For the complete unit, a hybrid approach combining experimental results in near field and numerical acoustic pellicular modes is used to characterize complete system radiating characteristics



Design of the lower bearing bracket

Benefits

- Ability to perform rapid design iterations and test component designs as part of the full system
- Good match of near field acoustic transfer functions, directivity and far field sound pressure levels predicted



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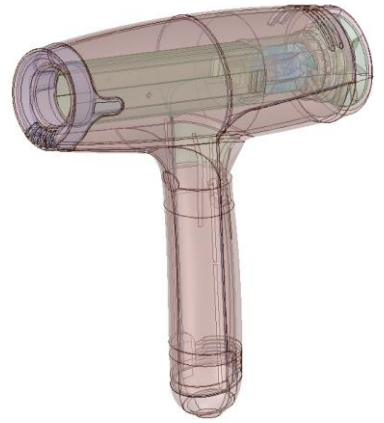
Hair dryer aero-acoustics and noise reduction solutions

Master's thesis, Hair dryer aero-acoustic study and passive solutions for noise reduction, L. Lahaye

Challenge

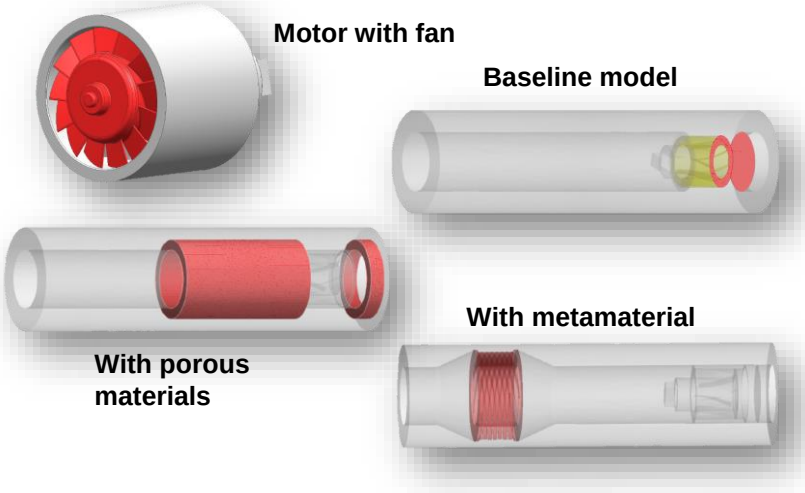
- Hair dryers make a lot of noise during usage, reaching up to 90 dB in high-power modes
- The noise comes mostly from the fan, but resonance could appear within the system as well
- Noise reduction techniques could be employed to reduce the overall noise





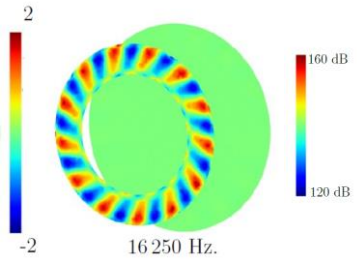
Solution

- Actran is used to create the aeroacoustic sources and calculate the propagation
- A number of different techniques like porous materials, perforations and acoustic metamaterials are used to reduce noise

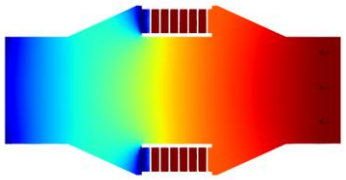


Benefits

- Aeroacoustic sources need to be calculated once and then only the propagation model needs to be run multiple times to evaluate the different noise reduction techniques
- Various different models for porous and perforation materials are available that reduce computational time with limited accuracy impact



Sources



SPL at 1250 Hz

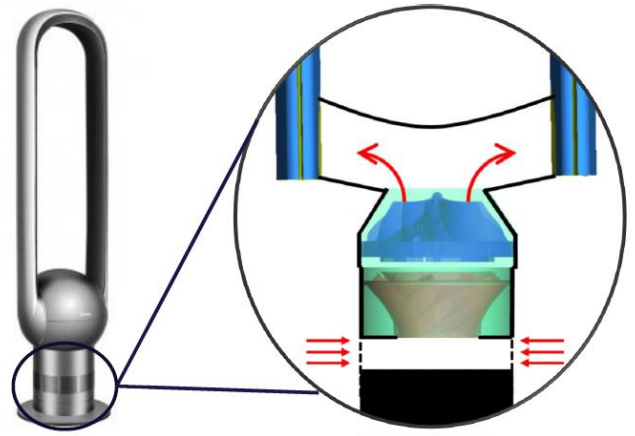
PURDUE UNIVERSITY

Noise control for ducted fan system

Noise-Con 2020, Noise Control Concept Verification for a Ducted Fan System, Weimin Thor et al.

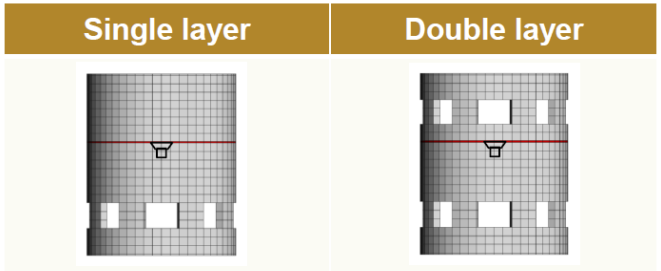
Challenge

- Bladeless fans are of interest to household product manufacturers due to their pleasing aesthetics and extra safety
- Since there is still a fan within the module, noise is emitted
- Noise control strategies need to be used to reduce the noise and meet customer expectations



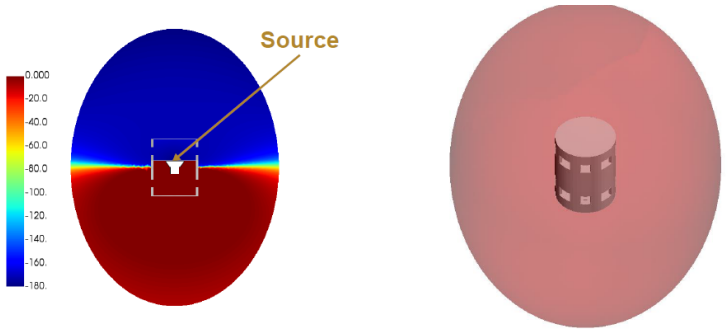
Solution

- Since a measurement showed most of the noise is coming from the intake perforations, an additional perforated intake is placed below to produce a cancellation effect
- The concept is simulated with Actran for the design verification
- The simulation shows similar trends to what is measured



Benefits

- Easy verification of design concept
- The cancellation effect is capable of reducing the noise up to 700 Hz



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Toilet bowl noise

VPE / PLM Symposium 2022, Simulation der Akustik im Sanitärbereich, Dario Liechti

Challenge

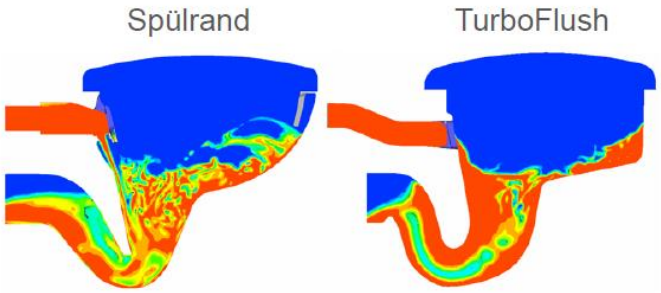
- Toilet noise can be coming from the toilet bowl or from the discharge tube system
- Reducing the noise would be evaluating different bowl designs that reduce turbulent flow





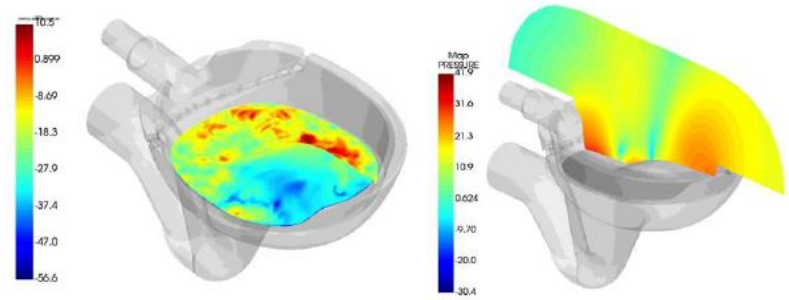
Solution

- A CFD simulation is combined with Actran to calculate the noise from the toilet bowl and the discharge tube
- Actran generates aeroacoustic sources and uses a Lighthill surface approach for propagation due to the multiphase flow



Benefits

- Identification of differences in noise sources and propagation between the designs
- Classification of designs based on noise signature

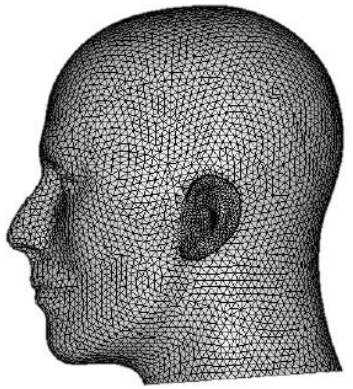


Head-related transfer function

Journal of Mechanics in Medicine and Biology, FINITE ELEMENT DETERMINATION of the HEAD-RELATED TRANSFER FUNCTION, F. Ma, J. H. Wu, M. Huang et al.

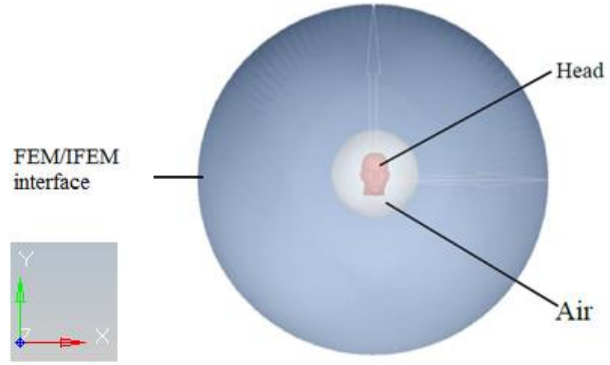
Challenge

- A better recognition of the acoustic characteristics of the auditory peripheral system, which is an important part of the overall auditory system, is key to guide the audio equipment design as well as the sound quality evaluation.



Solution

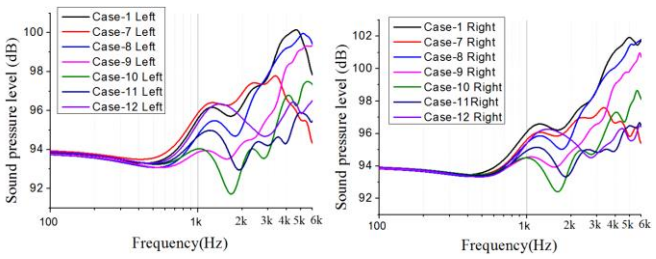
- Sound field distribution and HRTFs were determined in the horizontal, median and lateral planes by using 3D FEM/IFEM analysis in Actran.
- The HRTFs computed for the left and right ears at each source position were compared.



Schematic of the computational model used for determining the acoustic response

Benefits

- The proposed approach could clearly identify the reflection region in the source side and the diffraction region in the opposite side, together with the radiation tail and diffraction angle.
- The model is qualitatively validated by experimental data from the MIT database.
- Good correlation for SPL trends for frequencies below 1000 Hz.





Industrial Machinery

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Flow-induced vibrations in a water circuit

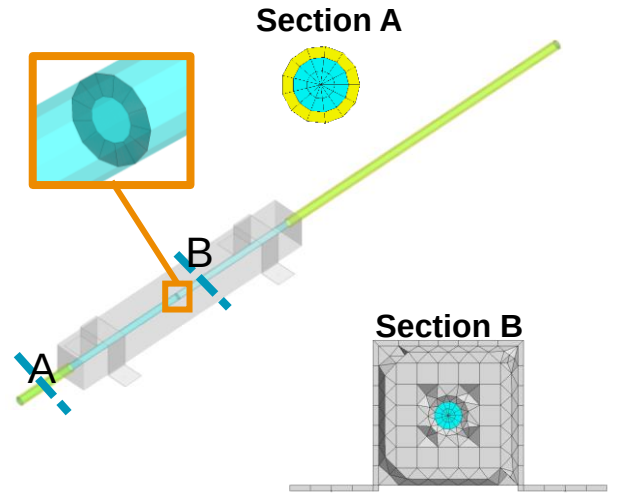
Challenge

- Flow-induced vibrations can be problematic for high precision devices.
- A restriction in a water circuit induces turbulences in the flow, which lead to the vibration of the complete device.



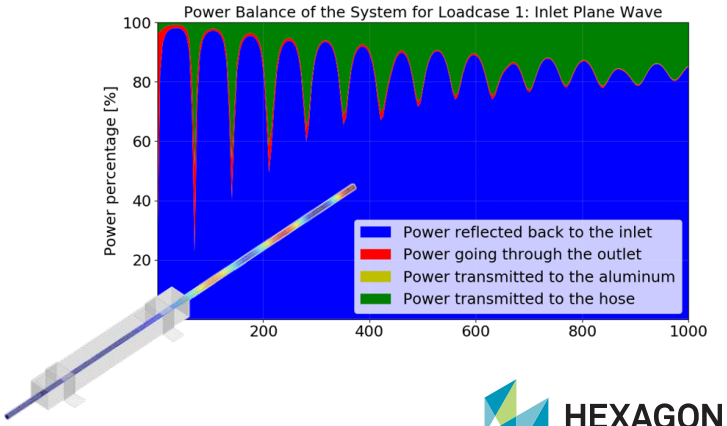
Solution

- Actran is used to solve complete vibro-acoustic model of the water circuit
- A variety of typical flow-induced acoustic sources are used to excite the circuit such as plane waves, monopole and dipole sources
- The evaluation of local/global vibrations and sound pressure levels as well as power balances for transfer path analysis



Benefits

- Prediction of device vibrations for different flow rates and restriction radius
- Better understanding of the physical phenomena
- Identification of the parts which contribute the most to the vibration
- Efficiently test new designs such as:
  - Better insulation by disconnecting specific parts
  - Material changes



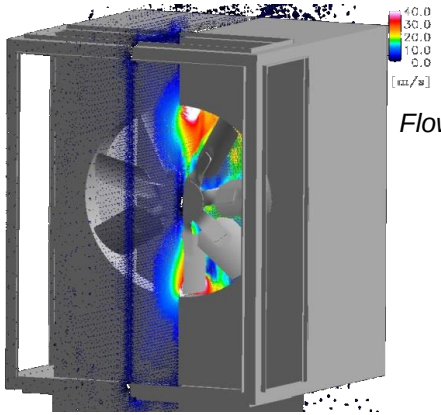
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Engine cooling fan noise

AIAA 2006, Validation of a CAA formulation based on Lighthill's Analogy using AcuSolve and Actran/LA on an Idealized Automotive HVAC Blower and on an axial Fan, R. Sandboge et al.

Challenge

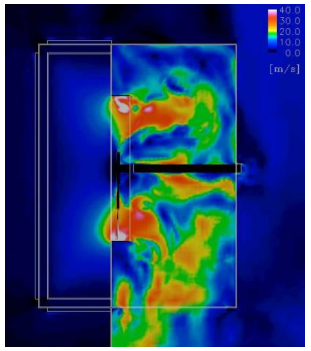
- In construction, forestry and agricultural applications, the engine cooling fan noise often dominates the total machine noise.
- The noise must be well managed to pass international noise regulations for machinery products.



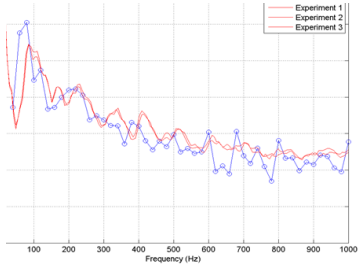
Flow velocity ($m.s^{-1}$)

Solution

- By coupling Actran with an unsteady CFD solver for computing the aeroacoustic noise source and its propagation in far field, we are able to accurately predict the noise from the fan.

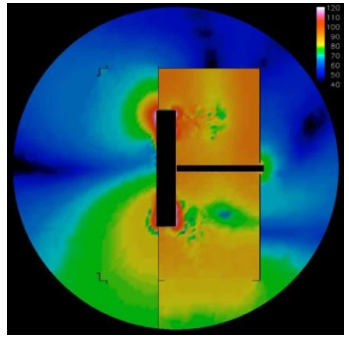


Sound pressure (dB) @1000rpm



Benefits

- Good correlation between simulation and experiment
- Reduction of the development cost by integrating aeroacoustic predictions in the design phase



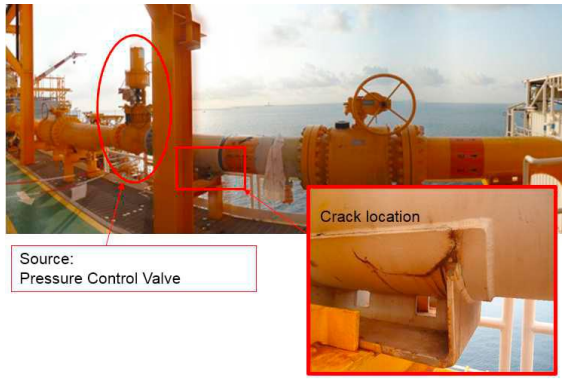
Sound pressure (dB) @600Hz, 2000rpm

Piping system acoustic fatigue

7th International Conference on Fatigue Design, Fatigue Design 2017, Innovative numerical fatigue methodology for piping systems: qualifying Acoustic Induced Vibration in the Oil&Gas industry, A. Coulon, R. Salanona, L. Ancian

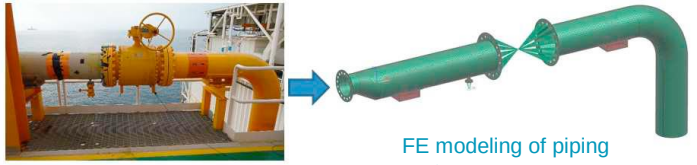
Challenge

- **Acoustic Induced Vibration** (AIV) can cause catastrophic piping failure
- New approach to identify AIV damage based on dynamic stress evaluation is developed considering **fluid/structure interactions** and identifying **Likelihood of Failure** (LOF)

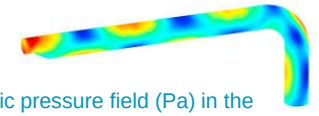


Solution

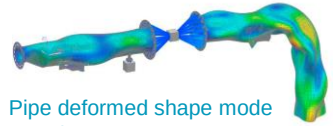
- Fluid-structure FE analysis considering a one-way coupling approach as gas (light fluid) is involved
- Sound power excitation based on pressure valve and flow parameters
- Improve LOF indicator by considering fluid impact on structure response



FE modeling of piping system



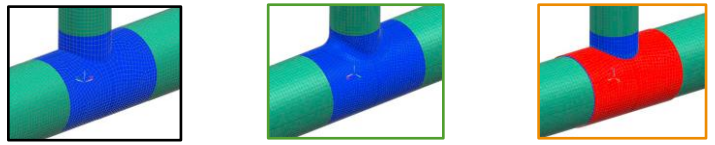
Acoustic pressure field (Pa) in the pipe at 980 Hz



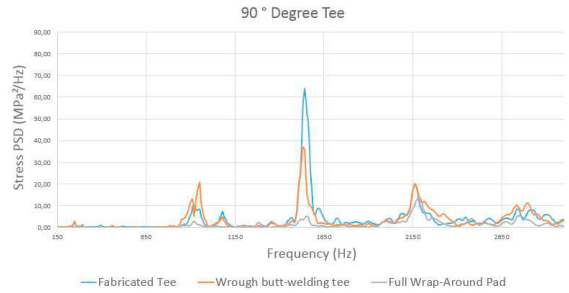
Pipe deformed shape mode at 770 Hz

Benefits

- Finite Element methodology has shown good agreement when compared to field measurements
- This method is a robust approach for performing comparative analyses
- Now possible to assess the direct impact of an AIV mitigation action



Valve Tailpipe 90° Tee connection – configurations analyzed



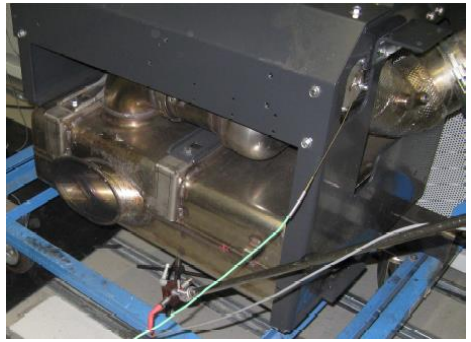
Truck muffler

“Actran helps further improve how we investigate and understand acoustic challenges in order to ensure that we continue to provide leading-edge acoustic solutions for exhaust systems.”

Jerome Voillequin,Senior acoustic engineer Emission Control Europe, Tenneco

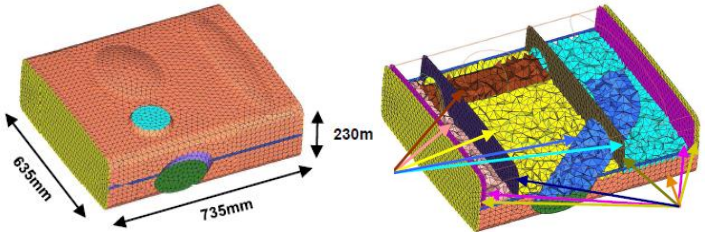
Challenge

- Methods used up to now for muffler noise are mainly 1D tools or FEM/BEM weak coupling, which are not accurate enough for complex geometries



Solution

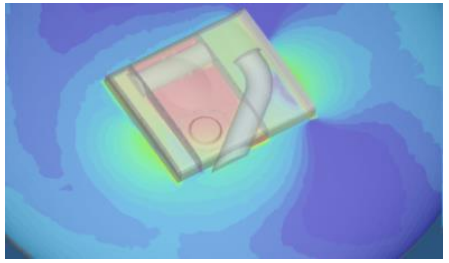
- Actran allows to predict the pipe and the shell noise of complex exhaust systems.
- Acoustic and structural components are all modeled in Actran for strongly coupled vibro-acoustic computations.



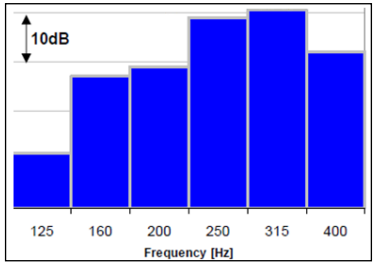
Vibro-acoustic model

Benefits

- Actran enables a better understanding of acoustic phenomena in order to continue providing leading-edge acoustic solutions for exhaust systems.



Pressure map



SPL (dB) with Actran

Industrial silencer

"Actran allows us to easily modify the model and re-run the analysis to determine the impact of a change .. when the original model did not shed light on the problem, we expanded the model to include the ductwork and quickly identified the root cause"

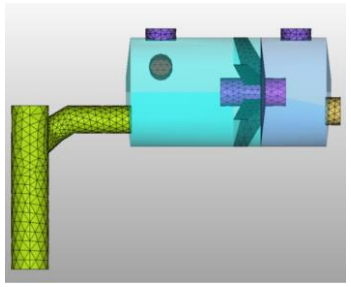
Erin Komi, Research Scientist for VTT Technical Research Centre

Challenge

- A nighttime noise complaint was issued from the residential area near one of Wärtsilä's factories and where ship engines are produced and subject to test runs.
- The main annoyance was due to a noise peak at 100 Hz 1/3 octave band.



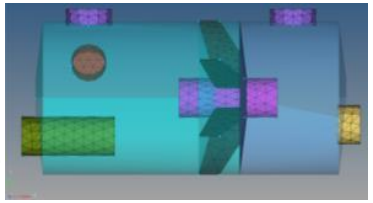
Industrial silencers



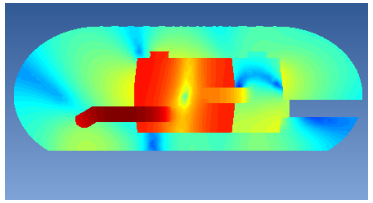
Actran model

Solution

- Actran was used to create a vibro-acoustic model of the silencer including both internal and external air volumes as well as far field sound radiation.



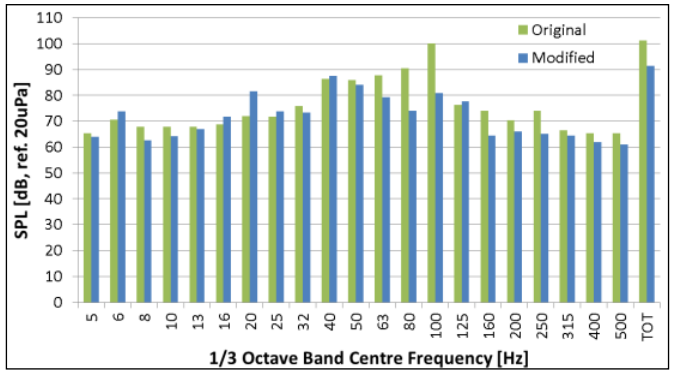
Modified design (tube inside the silencer)



Acoustic pressure map

Benefits

- The virtual prototype designed with Actran allowed to decrease by 20dB the 100Hz 1/3 octave band peak and solve the noise issue.



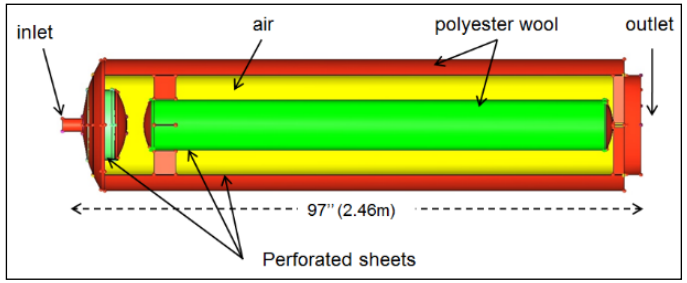
Sound level: original Vs new design

Read the Case Study

Vent silencer

Challenge

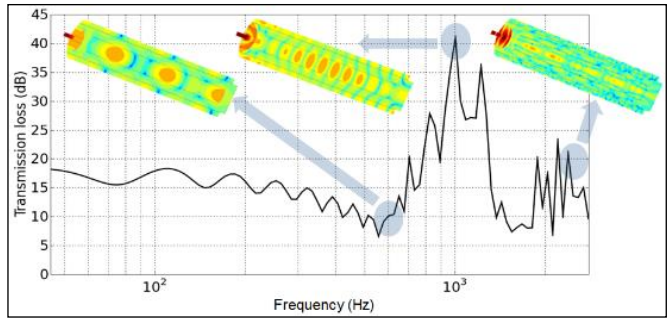
- Acoustic attenuation prediction of a vent silencer.



Description of the silencer

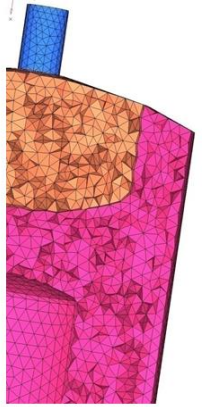
Solution

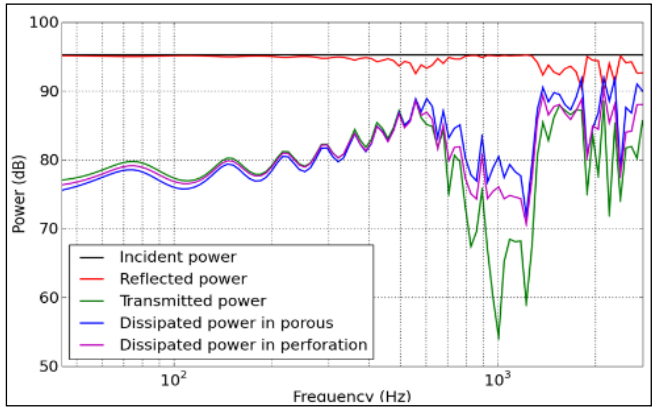
- Actran is used for modeling the complete silencer geometry including:
  - the acoustic insulation treatment (polyester wool)
  - the perforated sheets



Acoustic transmission loss

Actran model





Power balance

Benefits

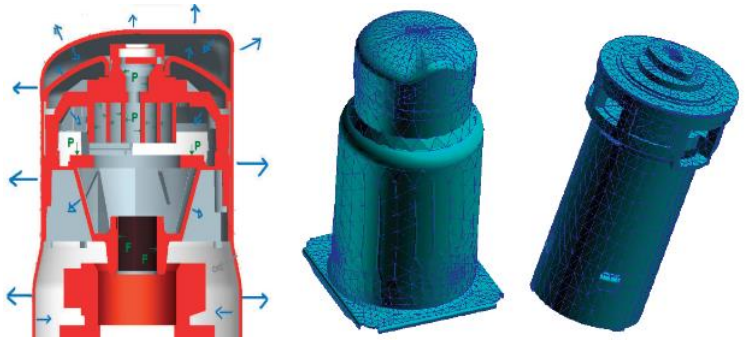
- Actran allows to assess:
  - geometry change effects
  - the modification of porous materials
  - Actran is thus a dedicated tool for improving silencers acoustic efficiency

Vibro-acoustics of a scroll compressor

International Compressor Engineering Conference 2008, Global Acoustic Finite-Element Simulation of Scroll Compressor Noise from Internal Sources, P. Dugast

Challenge

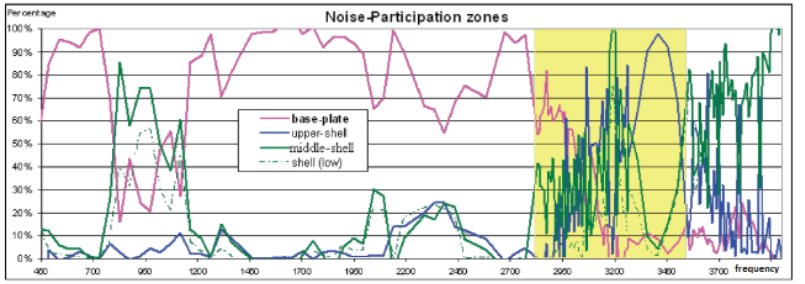
- Noise level becomes one of the most important criteria for a purchasing decision.
- Acoustic analysis at early design stages is required for identifying the internal noise sources.



Actran vibro-acoustic model

Solution

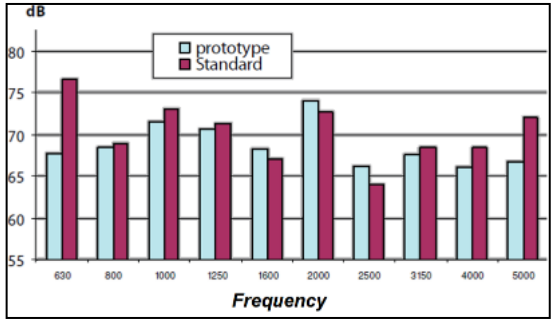
- Actran allowed modeling all physical parts involved, including oil, refrigerant, compressor structure and surrounding air.
- Actran allows also the identification of the main noise source and the evaluation of the main contributors to the noise radiated.



Contribution of different structural parts to the radiated noise

Benefits

- The primary source was identified as the pressure pulsation in the scroll and the noise is mainly radiating from the compressor base-plate at low frequencies.
- A design change allowed a reduction of 10dB in radiated sound power at around 630Hz and a global 2 dBA sound reduction



Acoustic Power measurement New prototype Vs baseline

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Hybrid measurement -calculation method for acoustic radiation

International Compressor Engineering Conference 2008, New portable hybrid method of compressor noise level calculation from vibrations measurements, P. Dugast

Challenge

- The growing interest in the mitigation of air conditioning and refrigeration systems noise implies silent compressor.
- Noise measurements lead to additional product development time, and cannot always be performed due to limitation of test equipment

Solution

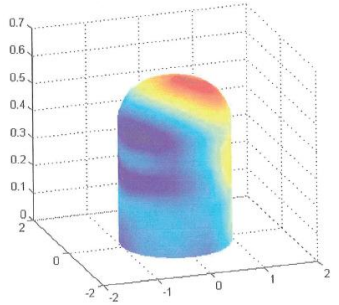
- Actran allowed to calculate the radiated noise using as input structure vibration measurements on the external compressor surface.

Benefits

- Time reduction for noise “measurement” in the development cycle.
- The compressor noise can be evaluated by identifying the contribution from each part of the compressor with much more accuracy than standard intesimetry.



Accelerometers on the compressor external shell

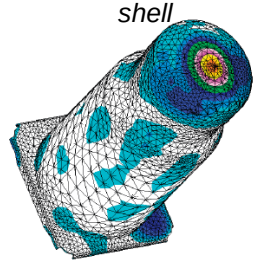


Acoustic intensity around the compressor shell

External compressor skin



Acoustic pressure on the compressor shell



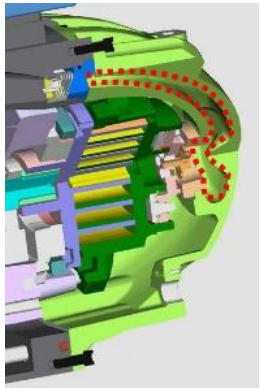
Dual-scroll compressor

Challenge

- Speed-up the design of a new technology based dual scroll compressor and meet the acoustic performance requirements.
- Initial discharge chamber design was too noisy, and a quick fix did not meet all the design constraints.



Dual scroll compressor



Discharge volume

Solution

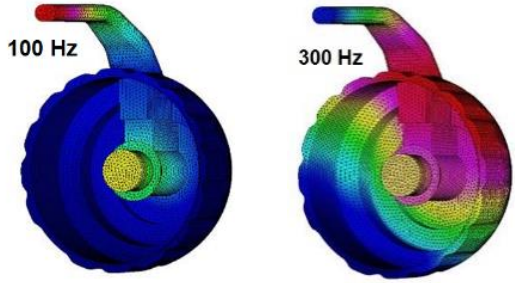
- Actran has been used to model the acoustic propagation on the discharge line and volume.
- Several discharge chamber designs were virtually tested.



Different designs of discharge chamber

Benefits

- By reducing the discharge volume, acoustical requirements as well as other design constraints have all been satisfied.
- Less noise was obtained at the exhaust and the development time was reduced.

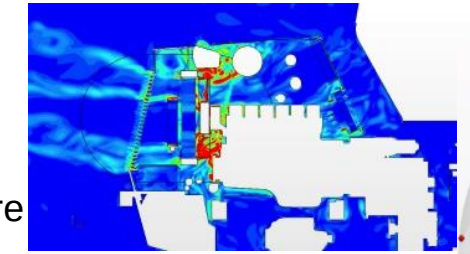


Acoustic pressure on the discharge chamber structure

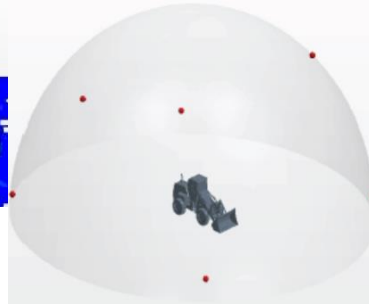
Wheel loader engine cooling fan

Challenge

- Noise regulations in a key Latin American country were revised to a lower level.
- The new standard required a noise reduction of about 6 dB(A) relative to the existing design with the fan being the main noise source.



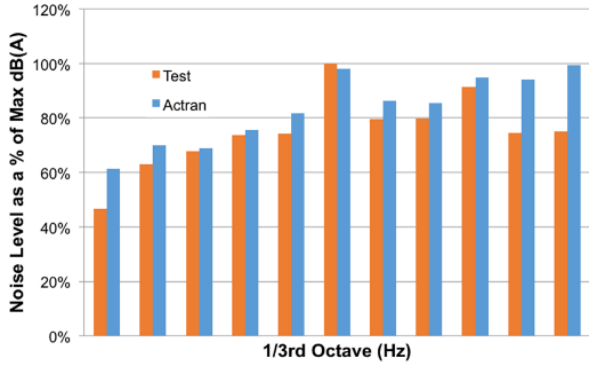
Unsteady CFD around the fan



Acoustic model

Solution

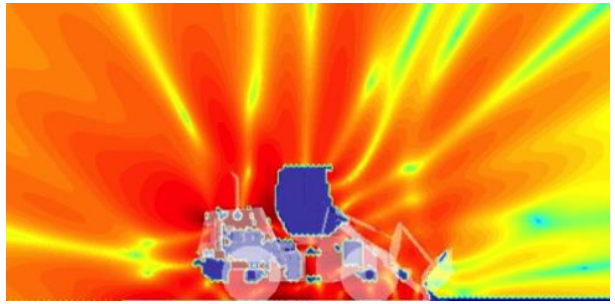
- An unsteady CFD solver is used for computing the unsteady flow, which is then read by Actran to calculate aeroacoustic sources and propagate the noise till the microphones located in far field (ISO 6393)



Simulation Vs tests

Benefits

- Actran helped CNH meet the standard in three months instead of 1 year.
- The muffler has also been optimized with Actran for delivering the needed noise reduction.



Exterior noise (dB) due to the cooling fan

Transformer noise

Challenge

- Transformers emit sound due to structural excitations caused by magnetostriction effect.

Solution

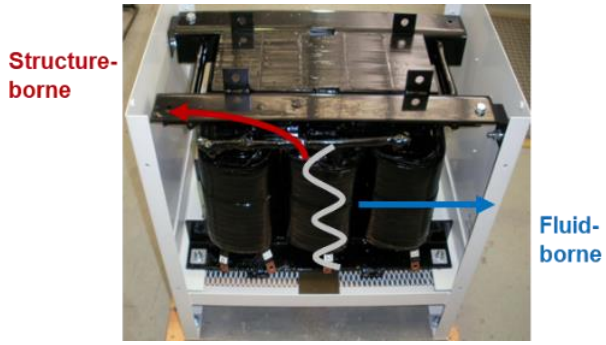
- Actran can input electromagnetic forces output by simulation software (Maxwell, JMAG…) to compute the vibro-acoustic response of the system (transformer core, oil, casing) up to the exterior.

Benefits

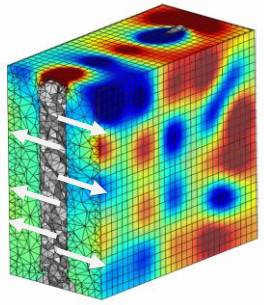
- The different noise transfer path are investigated and solution to reduce the emitted noise are proposed and tested.

Fully Coupled Vibro-Acoustic Model excited by EM forces (from Maxwell)

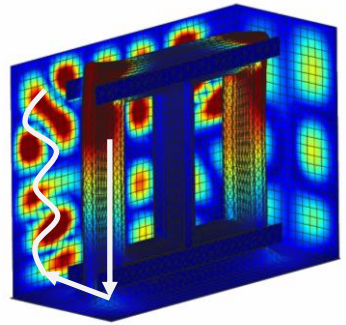




Fluid Pressure



Structural Vibrations



Centrifugal pump vibroacoustics

Optimization of vibro-noise in the pipeline system of centrifugal pump, Z.Cui, J. Wang, K. Ji

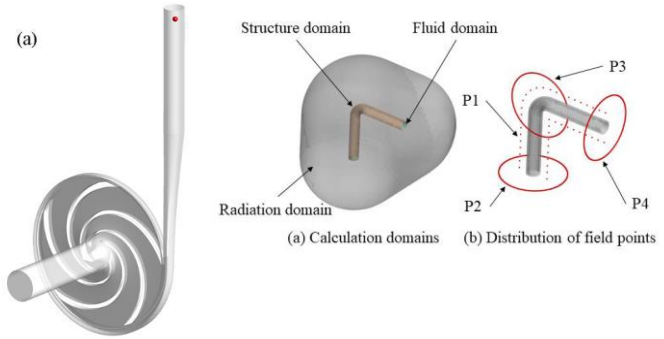
Challenge

- Pumps in pipeline systems can generate noise, from airborne and structure-born paths, due to the unsteady flow within the pump
- This noise is quite uncomfortable and can have negative impact within a working environment
- The pump discharge piping can be optimized for reduced noise



Solution

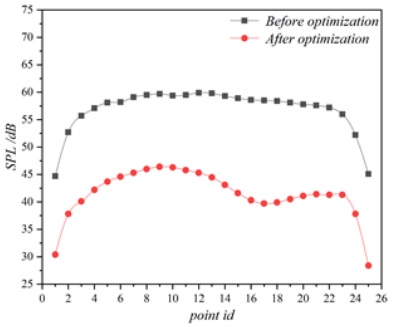
- Coupling Actran with an unsteady flow simulation for the calculation of the aeroacoustic sources and the acoustic propagation in the air and structure.
- Actran works well within an optimization workflow for optimizing a perforated plate at a pipe bend.
- Dedicated acoustic post-processing with polar plots

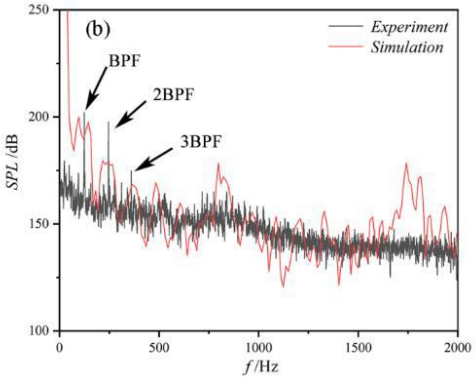


Benefits

- Accurate representation of pump noise, correlated with measurements
- Reliable predictions with perforated plates
- Better insight on the physical system with dedicated acousti post-processing







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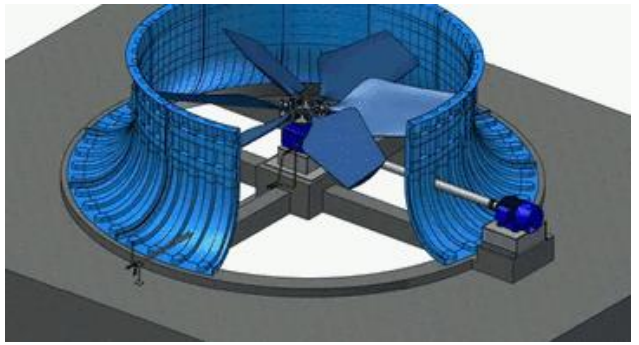
wentech®

Design of large industrial fan blades

It has been demonstrated that the CAA approach is sufficiently accurate to capture blade shape modifications during the engineering design search and optimisation

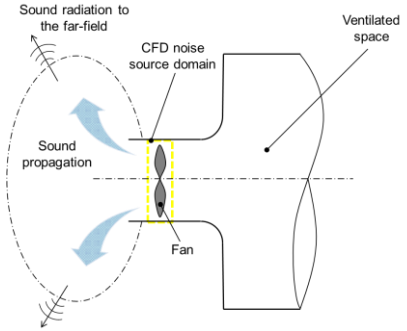
Challenge

- Creating fan components for both dry and wet fan coolers respecting the lowest noise level on the market
- Designing blades to fit to geometrical constraints, which are due to transportation of large blades (rotors approximately 10 metres diameter). This had to be achieved without worsening the acoustic and flow performances.



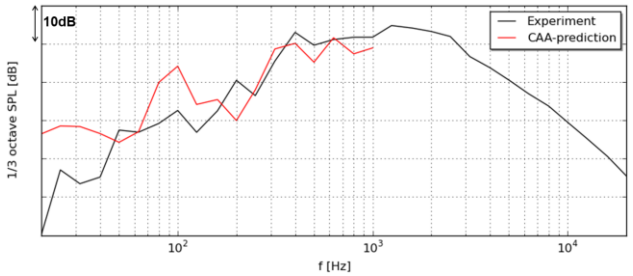
Solution

- Actran was used to calculate the acoustic propagation and radiation based on aeroacoustic sources as part of an optimization study which modified the blade geometry
- Actran DGM coupled with RANS-CFD sources can be efficiently used in practice for 3D low-speed fan noise predictions



Benefits

- The simulation allows to study the sensitivity of over 100 design parameters on flow and acoustic characteristics
- Efficient approach in terms of computational cost since it uses RANS-CFD to obtain acoustic sources



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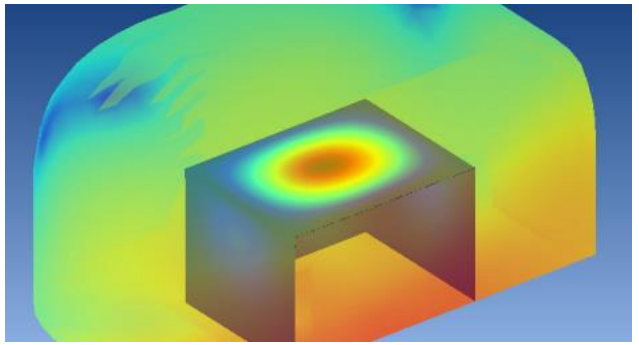
Acoustic design of enclosures to minimize noise

"On behalf of the Department of Chemical Engineering, I'm thankful to MSC to have launched a software like Actran that only comes with ease of use and provision of quick and reliable results, enabling the students to get the desired inferences in a timely manner"

Prof. Shabnam Siddiqui
Department of Chemical Engineering

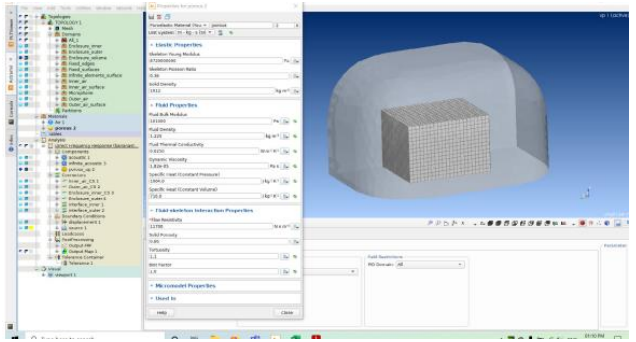
Challenge

- The chemical engineering laboratories in universities have several noisy machines and equipment.
- The noise levels force certain restrictions in terms of the time of day during which the machines can be used for experiments, so as to minimize disturbance to other students
- Enclosures can be used as a solution to reduce noise



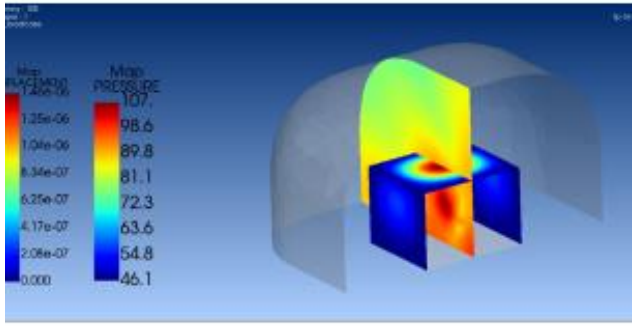
Solution

- Using Actran Student Edition, the student team conducted simulations with three different materials, and two different enclosure dimensions, to identify the best material as well as the optimum enclosure size to minimize noise
- Admittance conditions were used to model the absorption of each material

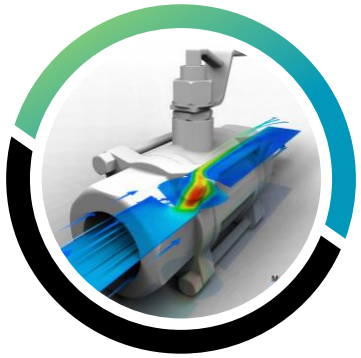


Benefits

- Actran enabled students to study and visualize noise patterns for different natural acoustic board materials and different dimensions, to find the optimum design for equipment enclosure
- The Actran Student Edition is a free tool that allows students to tackle real-problems while learning about acoustic simulation



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Ball valve aeroacoustic simulation

Challenge

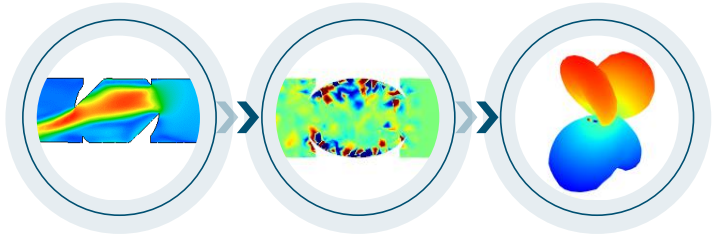
- Noise is both an occupational Health & Safety issue and potentially a manufacturing facility neighbourhood noise pollution problem
- Valve & pipework noise can be generated by structural vibration, turbulent flow, cavitation, flashing and
- Design to reduce damage to pipes and valves

Solution

- Cradle CFD and Actran can be used to model the complete workflow for noise in valves including fluid flow prediction, noise source estimation and noise propagation inside and outside of the valve
- Actran is embedded within Cradle CFD for seamless hybrid aeroacoustic simulations

Benefits

- Simulation can model the valve flow field and identify rapidly changing pressure and velocities
- Investigate which regions might generate noise and design effective noise treatments early in the design phase
- One environment for affordable, noise simulations

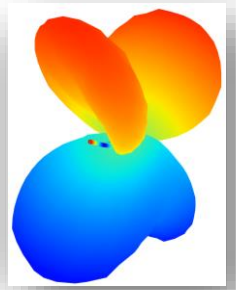


Steady CFD simulation (RANS) | **Aeroacoustic source generation (SNGR)** | **Acoustic radiation**

Interior propagation

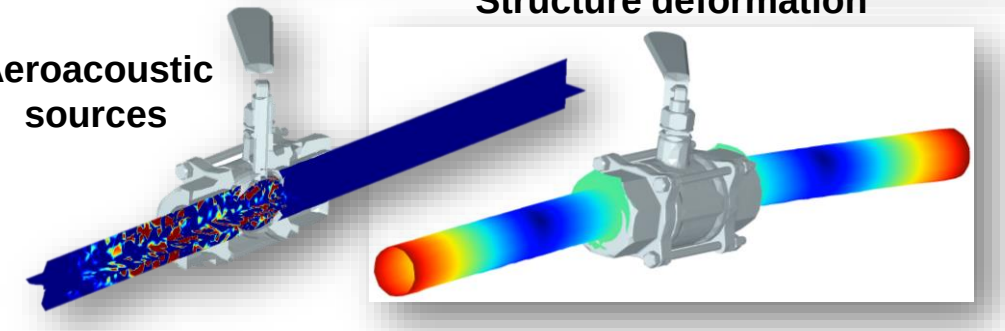


Noise directivity



Structure deformation

Aeroacoustic sources



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PURDUE UNIVERSITY

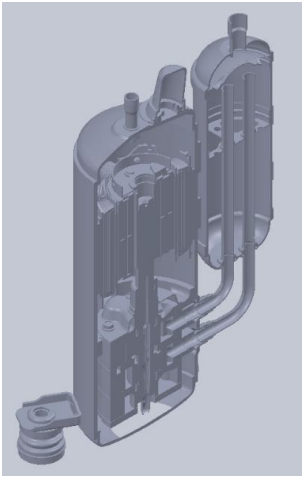
Vibro-acoustics of hermetic compressors

HxGN Live Design & Engineering 2021, Vibroacoustics Analysis of the Noise and Vibration Generated by Gas Pressure Pulsations in Hermetic Compressors, Dazhuang He

Challenge

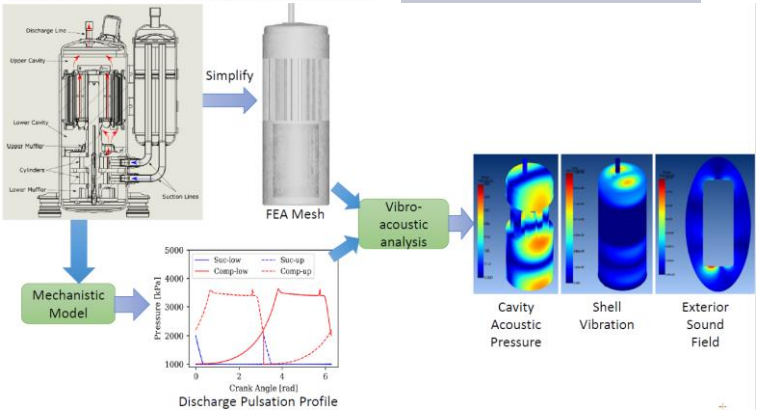
- Mitigation of noise and vibration effect of compressors is an important factor to ensure customer satisfaction and to meet noise standards.
- Understanding the interaction between thermomechanical operation of a compressor and the consequent noise and vibration is potentially helpful to improve NVH performance of compressors.





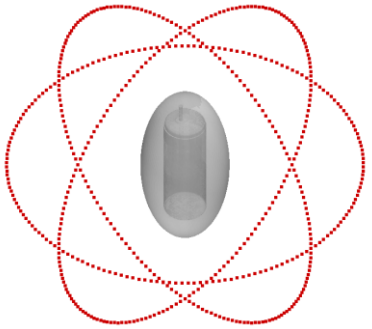
Solution

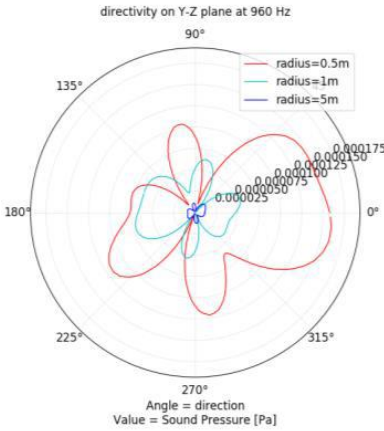
- Actran is used to model the vibroacoustic behaviour of the compressor, calculating the cavity pressure, the shell vibration and the exterior sound field
- An introspective window technique is used to perform a vibro acoustics finite element analysis with dynamic input/output in Actran for modeling a discharge valve



Benefits

- Component and system simulation of complex mechanical compressors
- Advanced techniques can be used for modeling dynamic input/output in a vibroacoustics simulation





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Reverberation Room Simulation

HxGN Live Design & Engineering 2021, Effective Use of Simulation in an Applied Research Laboratory, David Herrin

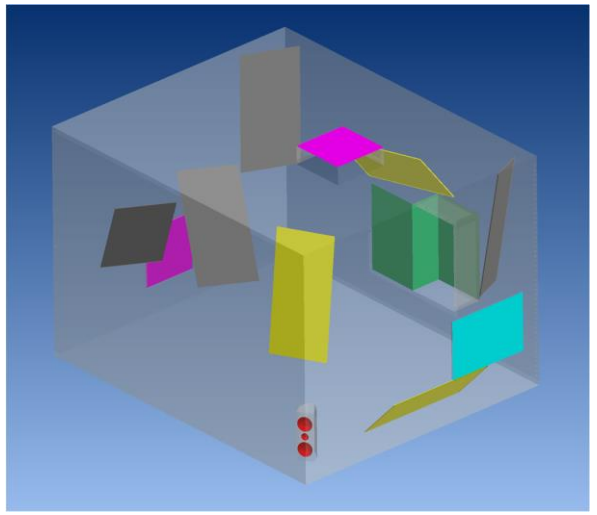
Challenge

- Reverberation rooms are very common in characterizing the acoustic performance of porous materials, such as the absorption coefficient
- Reverberation rooms need to follow international standards in order to be accepted
- The acoustic field in these rooms is assumed to be diffuse, something that is difficult to achieve in low frequencies



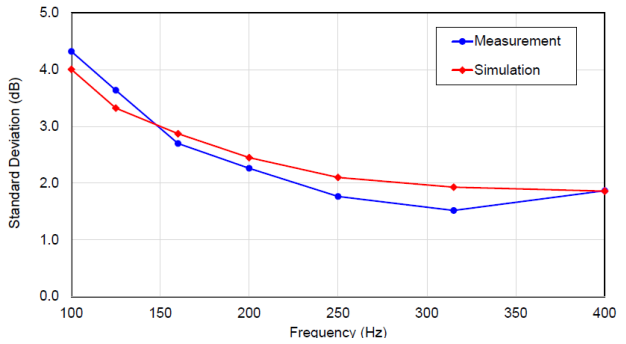
Solution

- Actran is used to model the acoustic behaviour of the room as well as the different panels inside it
- Material involve gypsum, metals, glass, plywood and concrete



Benefits

- A simulation model was developed that can be used to drive reverberation room design changes
- Good correlation between measurements and simulation
- Students can be trained trained to effectively use software and compared results with data from a real room



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University of Kentucky

Development of an Anechoic Termination

HxGN Live Design & Engineering 2021, Effective Use of Simulation in an Applied Research Laboratory, David Herrin

Challenge

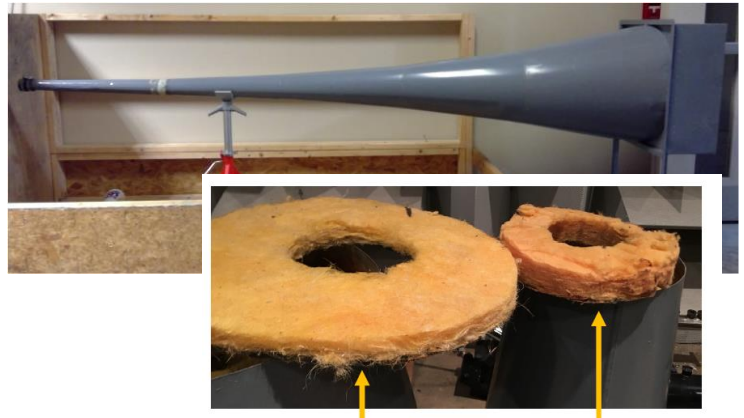
- Anechoic terminations are very commonly used in muffler measurements
- For example, they are used when measuring the sound power of flow noise produced in the muffler or the transmission loss (TL)
- A good anechoic termination is required for accurate measurements

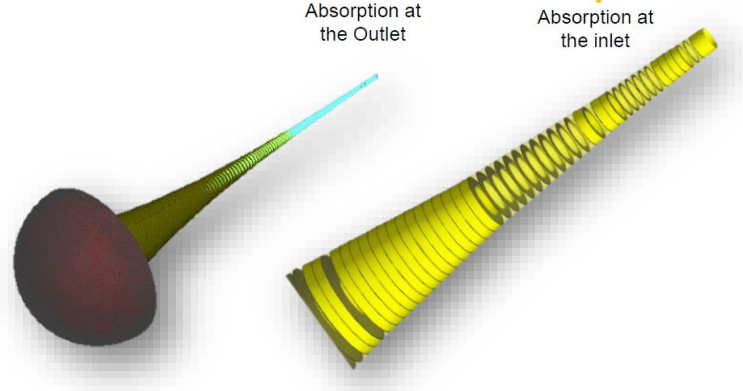
Solution

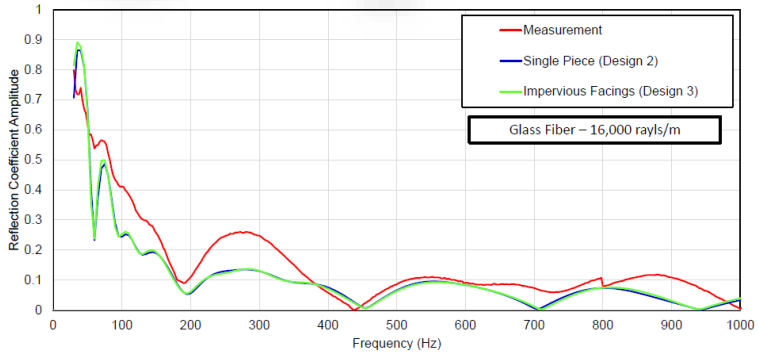
- Actran is used to model the anechoic termination reflection coefficient
- The material used for creating the termination is glass fiber and it was modeled as porous
- Heavy canvas was placed in front of each section and it was modeled as porous, viscothermal or impervious

Benefits

- Successfully correlated simulation model with measurement.
- Simulation model provides insight into how the anechoic termination might be improved.







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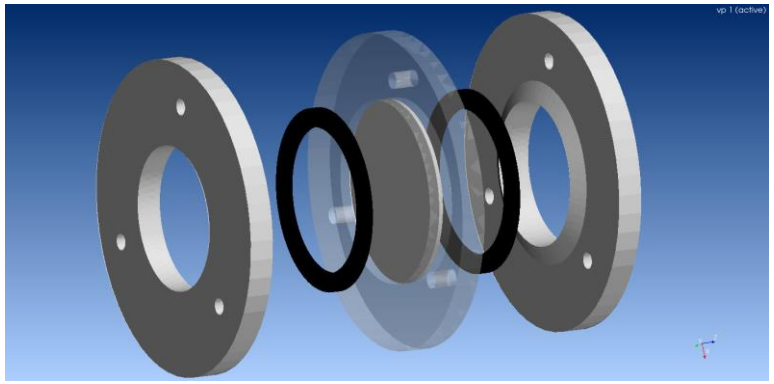
University of Kentucky

Panel Transmission Loss Measurement

HxGN Live Design & Engineering 2021, Effective Use of Simulation in an Applied Research Laboratory, David Herrin

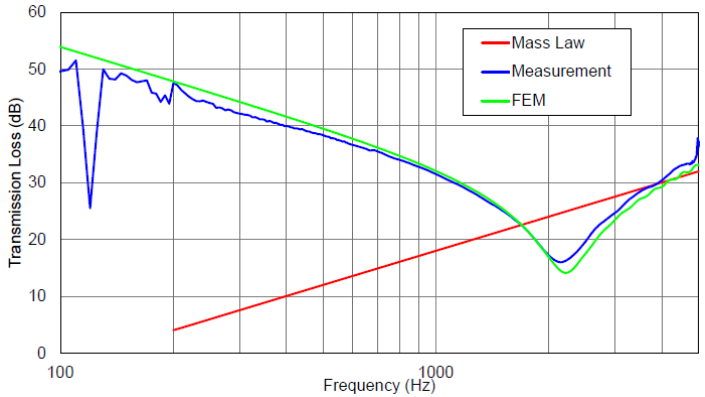
Challenge

- Mounting points for samples when performing panel transmission loss can have an impact on the measurements
- Understanding how they work and how they can be improved is crucial



Solution

- Actran is used to model the mounting method, which is a custom flange with an elastomer surrounding the sample



Benefits

- Successfully correlated simulation model with measurement.
- Validated simulation model is being used to drive improvements to the measurement procedure

HEXAGON

Industrial engine cooling fan noise aeroacoustics

25th International Conference on Sound and Vibration 2018, Engine cooling fan noise prediction based on hybrid method and aero-acoustic analogy, David Herrin

Challenge

- For large engines used in agricultural or construction vehicles, the engine cooling fan plays an essential role and must be carefully designed for optimal performances
- The noise generated by these fans dominates among other noise sources and mainly affects the operators while the noise restrictions may reduce the usage of the vehicles.

Solution

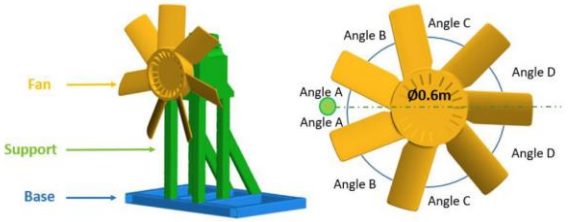
- A hybrid approach, combining an incompressible LES simulation from scFLOW with an acoustic FEM simulation from Actran, is used to model an industrial engine cooling fan
- The fan has unevenly spaced blades and the model includes the support and base of the measurement setup

Benefits

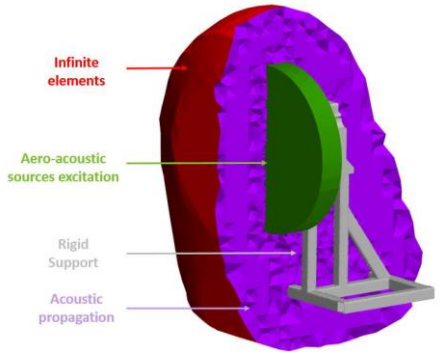
- Good correlation is observed between the measurements and the simulation



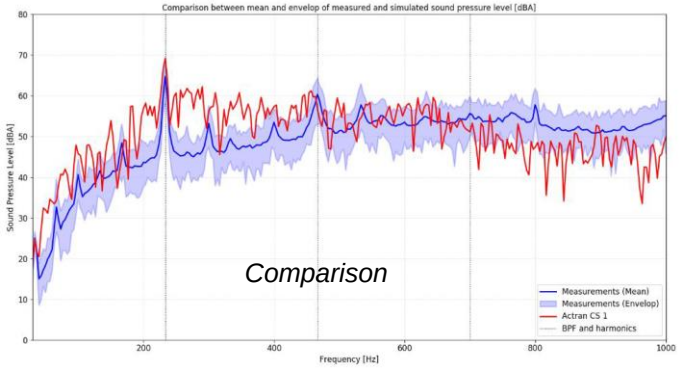
Measurement setup



Fan and blade repartition



Actran model



Comparison



Wind Turbine Gear Box

Challenge

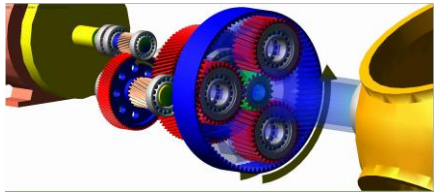
- In such an applications several tools are usually chained because it involve 3 physics: dynamic, vibrations and acoustics. The aim is to reduce the number of tools to use with the Adams / Actran co-simulation.

Solution

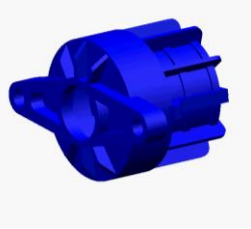
- Adams is used for MBD simulations and for computing vibrations. Actran read Adams vibrations, compute the radiated noise and is used for getting waterfall diagrams. Simulations are performed in time domain, for steady state and for ramp-up conditions.

Benefits

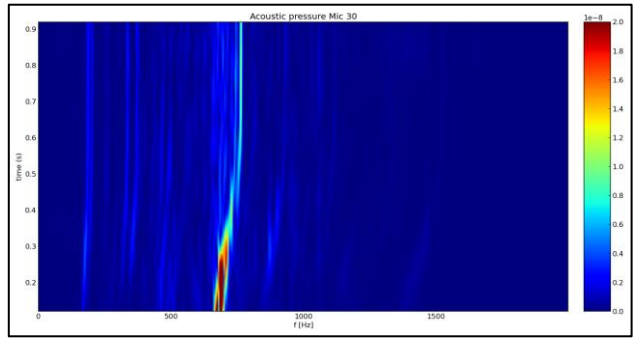
- Acoustic study could be done earlier in the product development if integrated with other processes.



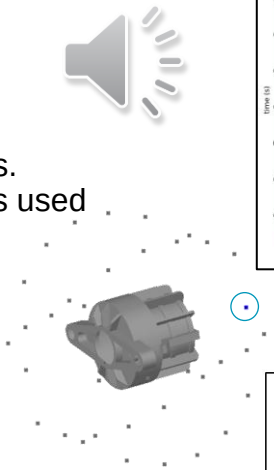
Multi-Body Dynamics in Adams



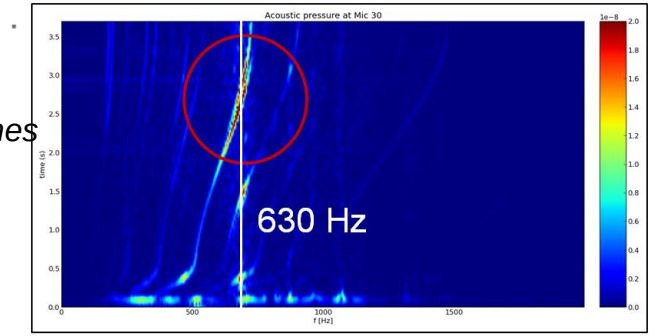
Vibrations in Adams



Waterfall Diagram – steady state



Virtual microphones



Waterfall Diagram – ramp-up

Acoustic radiation with Actran

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Gear Noise – Ramp up

Challenge

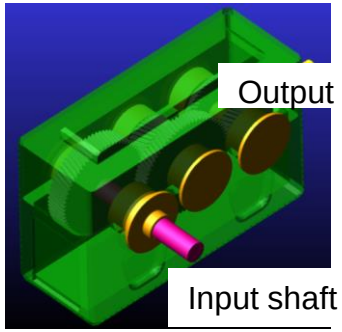
Predicting the noise emitted by gears contacts or by casing vibrations imply coupling MBD and FEA during ramp-up.

Solution

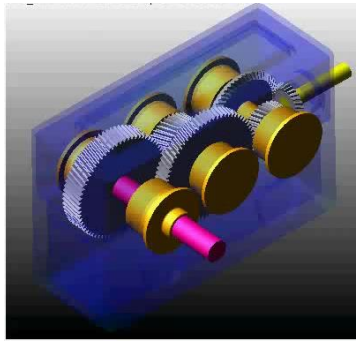
Actran can read data from MBD in time for predicting gear noise. Actran is embedded in Adams for an easier coupling.

Benefits

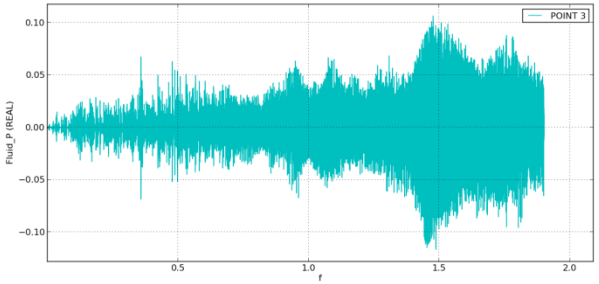
Adams and Actran are highly coupled solutions. In the Adams interface, microphone time histories and wav files are directly available enabling MBD engineers to perform preliminary acoustic results.



MBD model using Adams/Machinery

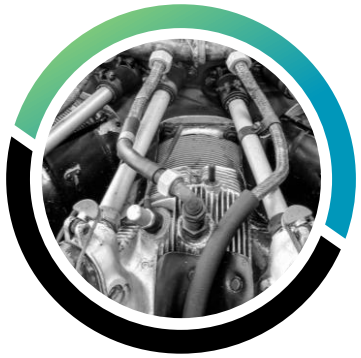


Multi-Body Dynamics modeling



Sound Pressure at one microphone

HEXAGON



Gear Noise – Ramp up

Challenge

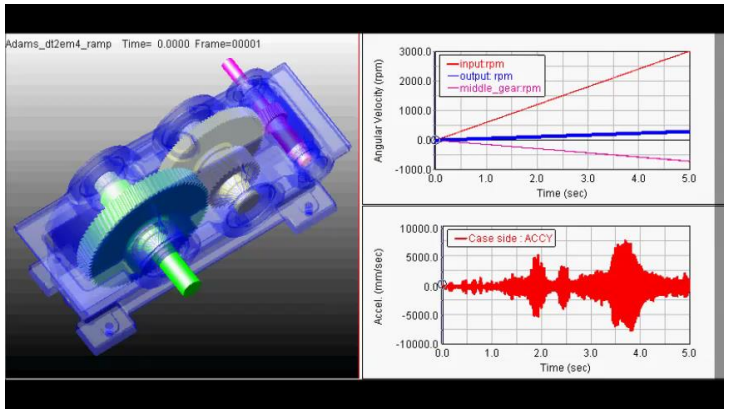
- Predicting the noise emitted by a gearbox implies coupling MBD and FEA during ramp-up.

Solution

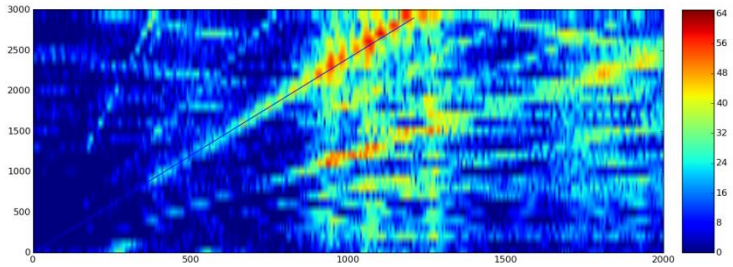
- Actran can read data from MBD in time for predicting gear noise. Actran is embedded in Adams for an easier coupling.

Benefits

- Adams and Actran are highly coupled solutions. In the Adams interface, microphone time histories and wav files are directly available enabling MBD engineers to perform preliminary acoustic results.
- Advanced post-processing is available in Actran. This allows to have the same indicator than those provided during experiments (waterfall diagram).



Multi-Body Dynamics simulation & Acoustic results



Rpm Vs frequency diagram (waterfall)

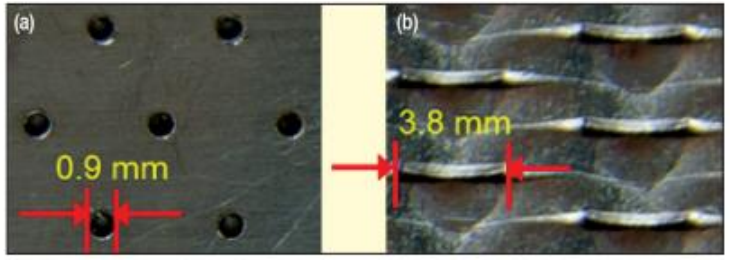
University of Kentucky

Microperforated sound panel absorbers

NOISE-CON 2022, Simulation of perforations using a distance-based linearized Navier-Stokes-Fourier model, Xin Yan, David Herrin

Challenge

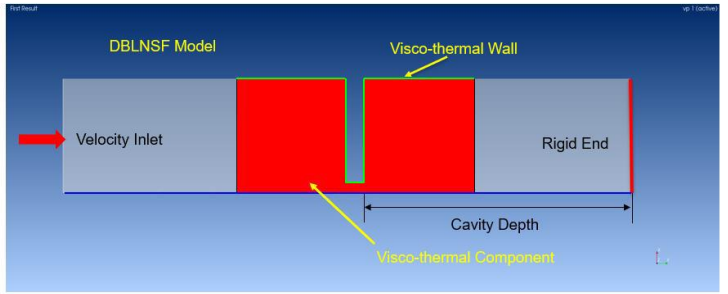
- Microperforated panel (MPP) sound absorbers are increasingly being used as noise control treatments in building and industrial applications.
- Existing analytical equations can sometimes be difficult to apply to microperforated panel sound absorbers which, in order to significantly reduce the manufacturing cost, have irregular perforations.



Schematic showing a MPP with (a) circular and (b) micro-slit perforations

Solution

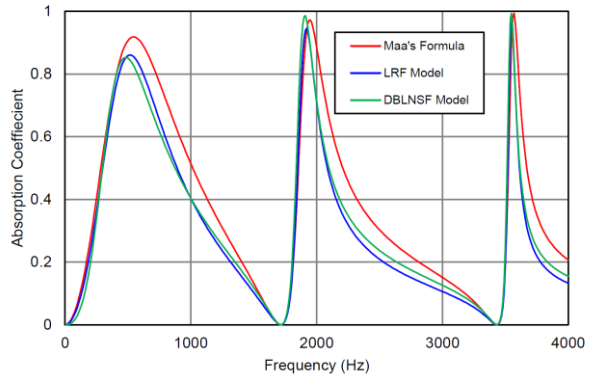
- Two-dimensional, finite element models for various microperforation types are created to predict the performance of the panel absorbers.
- For evaluating the microperforations, the distance-based linearized Navier-Stokes-Fourier model implemented in Actran is used.



Schematic of 2D axisymmetric model using DBLNSF approach

Benefits

- The results of the finite element model are in good correlation with classic analytical equations
- This approach allows is suitable for simulating irregular perforation geometries when fast answers are needed.



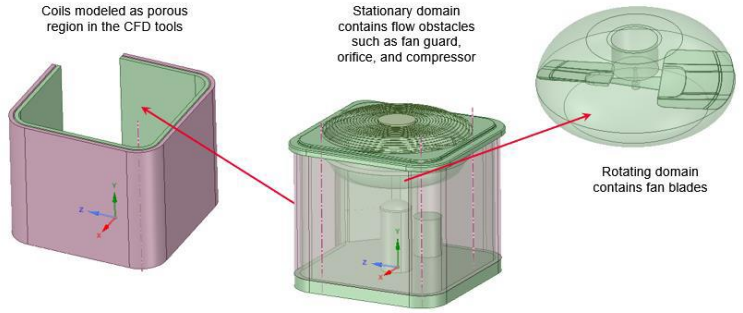
HEXAGON

Outdoor unit split fan noise

Noise-Con 2022 Lexington KY, Outdoor Unit Split Fan Noise Prediction Using A Hybrid Lighthill Analogy Method, Ali Nikparto

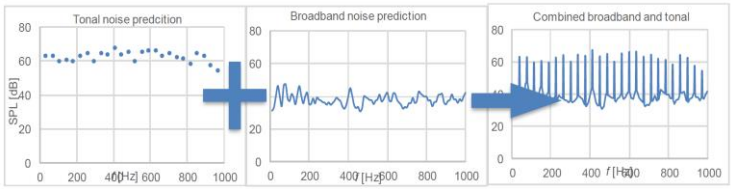
Challenge

- The demand of outdoor units and split HVAC systems has been increasing with system performance over the years.
- Fans being the main source of noise of the system, finding effective ways of designing them is essential.
- Existing hybrid methods could produce more accurate results with a better Fourier transform methodology.



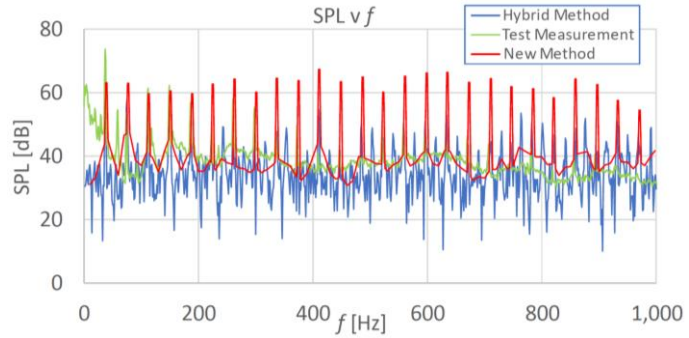
Solution

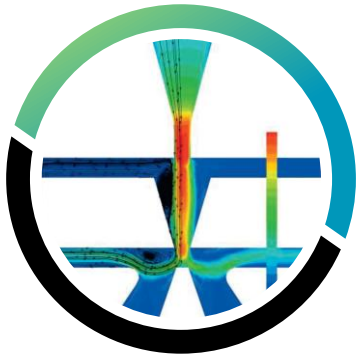
- Actran is using results from a hybrid LES-RANS CFD simulation to generate aeroacoustic sources for the tonal and broadband noise.
- Actran then combines the propagation results to get the final fan noise.
- Two complimentary Discrete Fourier Transform setups are used to accurately compute tonal and broadband noise in Actran.



Benefits

- Better correlation between simulations and measurements for broadband noise under 188 Hz.
- The signal has been flattened and a more reasonable output is produced.





Flow-Induced Noise of Deflector Jet Servo Valve

Hindawi Shock and Vibration 2022, Numerical Study on Flow-Induced Noise of Deflector Jet Servo Valve Based on LES/Lighthill Hybrid Method, Yukai Ren et al.

Challenge

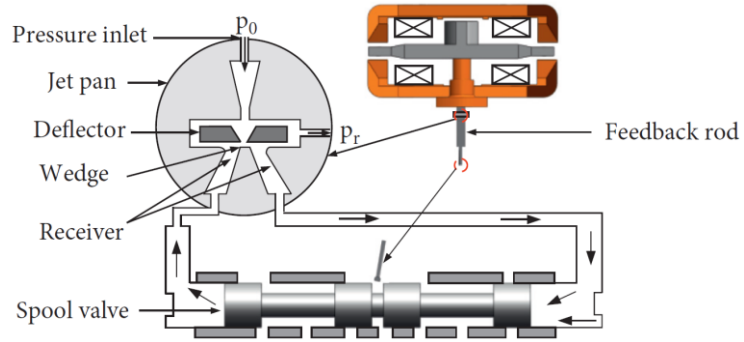
- Flow-induced noise in the prestage of a Deflector Jet servo Valve (DJV) significantly affects its performance
- Different types of sources for this noise including cavitation, shear layer instability, pressure oscillation, vortex, and Helmholtz resonance – difficult to investigate

Solution

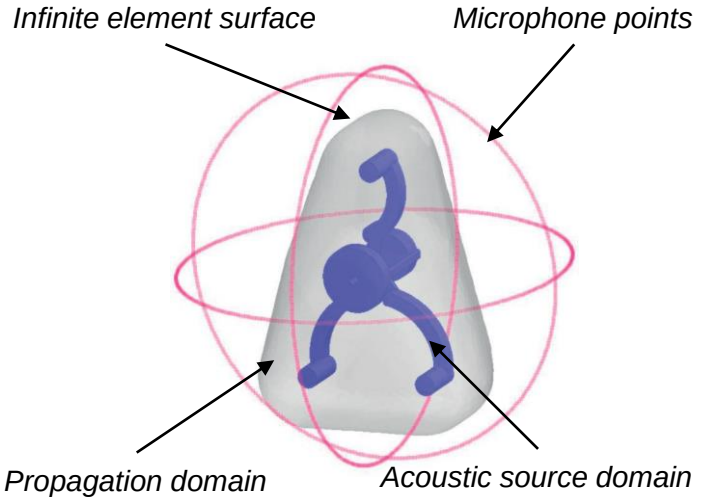
- Two-phase flow simulation of DJV was performed using LES model in a CFD simulation
- Using the LES model results, Actran computed the flow-induced noise inside the DJV
- Noise was propagated into far field and captured at microphone locations

Benefits

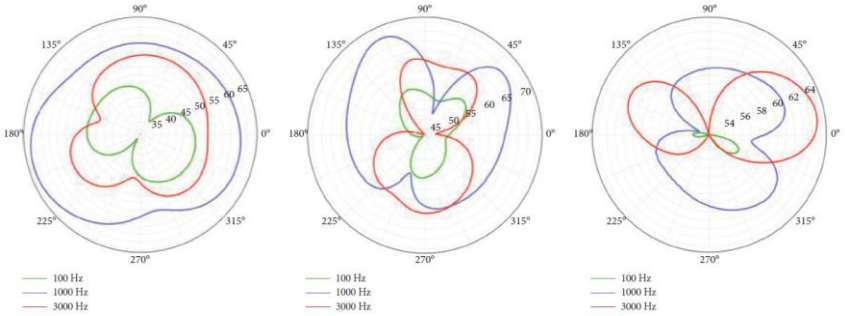
- Actran was able to process a complex two-phase flow with cavitation
- Main mechanisms and locations of flow noise in the DJV were identified from Actran simulation results
- Acoustic simulation trends matched closely with that of test measurements



Working principle of DJV



Actran model



Directivity plots for the different axes

Aero-acoustic noise of steam pipeline valve junction

19th Asia Pacific Vibration Conference 2022, Based Hybrid Simulation Method Study of Pipe Resonance Cavity Noise, Bai et al.

Challenge

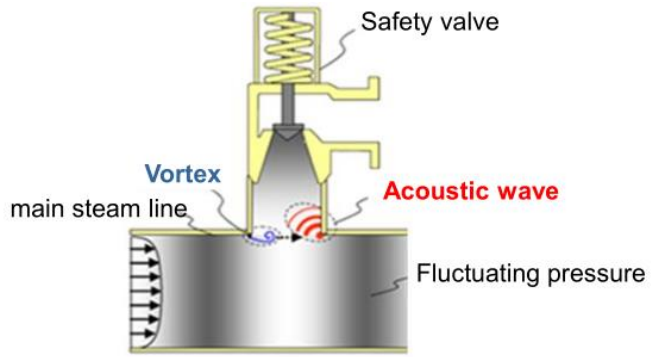
- Fluctuating fluid flow at the valve junction of a steam pipe can lead to the generation of acoustic waves, that resonate within the junction cavity
- These acoustic waves can damage the downstream components of the steam pipeline, for example the dryer

Solution

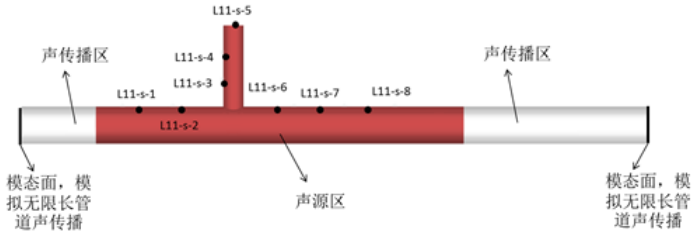
- A CFD simulation was performed for the valve junction using both RANS and LES turbulence models
- LES model element size limits the frequency up to which Actran can compute aero-acoustic noise due to turbulence (cut-off frequency)
- Above the cut-off frequency, noise was computed using Actran SNGR approach, which used the steady RANS results

Benefits

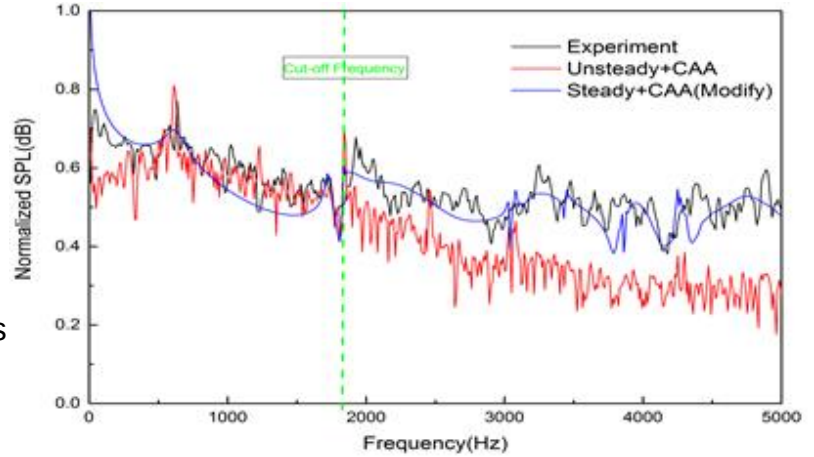
- Cut-off frequency limitation was overcome by combining two methods of Actran to compute aero-acoustic noise
- Good correlation of simulation results with experimental measurements



Acoustic wave generation mechanism



Actran model with microphone locations



Comparison of Actran results with experimental measurements

Aero-acoustic noise of centrifugal pump

Vacuum volume 172, February 2020, Influence of blade number on flow-induced noise of centrifugal pump based on CFD/CAA, Wang, Y., Ding, Ze.

Challenge

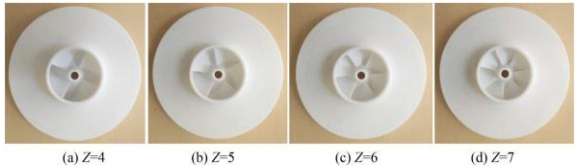
- Previous studies have shown that the flow-induced noise of a centrifugal pump is influenced by the number of blades
- The mechanism of flow-induced noise is very complex, and is caused by the unsteady flow of the fluid
- Flow noise generated inside passes through the volute casing – aero-vibro-acoustics

Solution

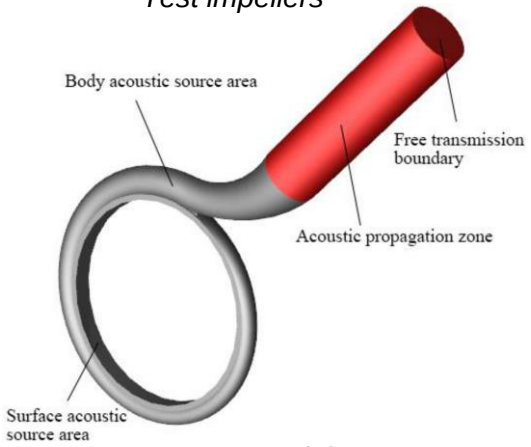
- A CFD simulation was performed for the internal fluid flow
- Flow-induced noise due to impeller (surface source) and due to turbulence in the volute casing (volume source) was computed using Actran

Benefits

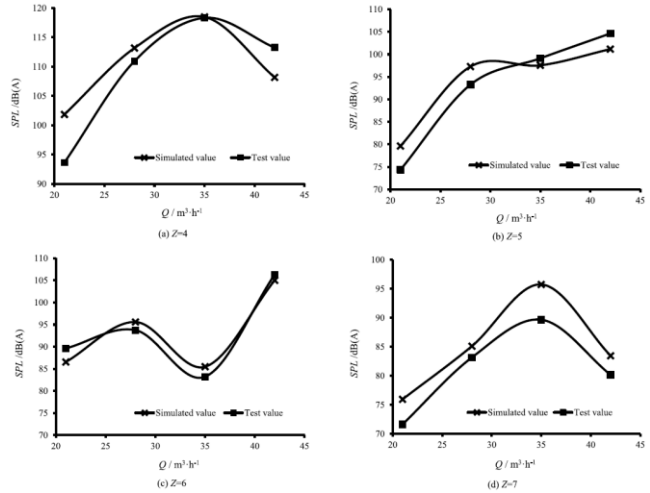
- Identification of the optimal number of blades for the pump (6 blades)
- It was determined that the flow turbulence at the baffle tongue was the major source of noise in the system



Test impellers



Actran model



Comparison of Actran results with experimental measurements

HEXAGON

Flow-induced noise in oblique flow pump

Processes 2022, 10, 2221., Investigation of Flow-Induced Noise Characteristics in the Oblique Flow Pump., Xu, Z.; Zhao, F.; Liu, J.; Zhang, F.; Zhang, J.; Song, M.

Challenge

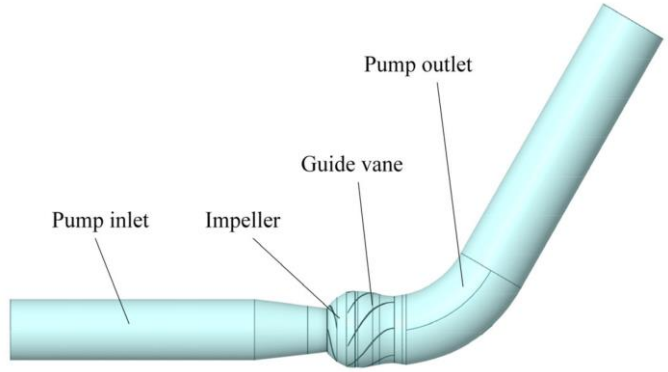
- Unstable flow factors in an oblique flow pump can easily lead to pump vibration and noise
- Noise from oblique flow pump has both aero-acoustic and vibro-acoustic components

Solution

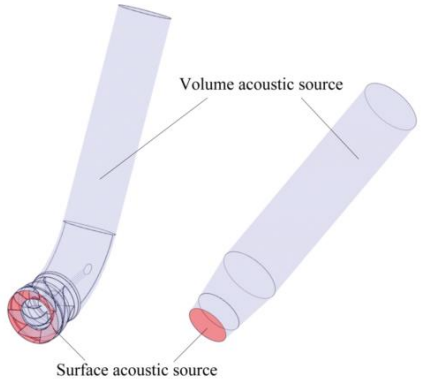
- CFD simulation was performed on the oblique flow pump for various flow rates
- Actran was used to compute the aero-acoustic noise due to flow inside the oblique flow pump, using CFD results
- Vibration due to flow impacting on pump walls, and subsequent noise radiation was also calculated using Actran

Benefits

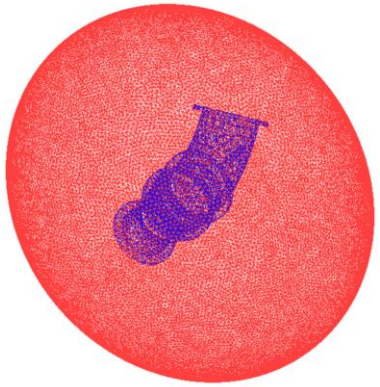
- The flow noise was found to be dependent on the flow rate, and is minimum for the optimal flow rate
- Lower and higher flow rates led to vortices in the fluid which was the major source of noise
- Sound pressure level frequency domain distribution was evaluated at monitor points in the pump
- Directivity of noise radiation was computed



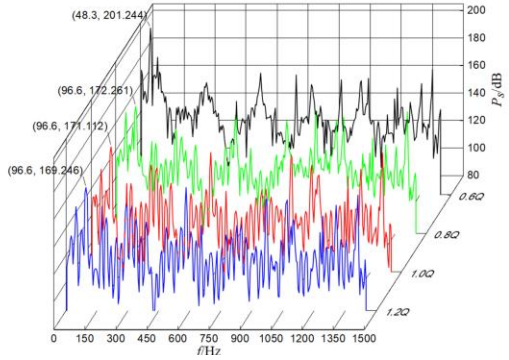
Oblique flow pump CFD domain



Actran aero-acoustic sources



Radiation noise domain



Sound pressure levels in dB under different flow rates



Railway

HEXAGON

CHINA RAILWAY DESIGN CORPORATION

Achieve sound attenuation prediction of railway sound barrier

"In the past, we had a half-analytical formula with which we could only roughly calculate the vertical non-absorbent barrier. Now, we can accurately simulate the complex shape and sound absorption boundary of the sound barrier to determine its effective height and structure and improve its efficiency in reducing noise."

***Dr. Wenlin Hu**,*
R&D Engineer
China Railway Design Corporation.

Challenge

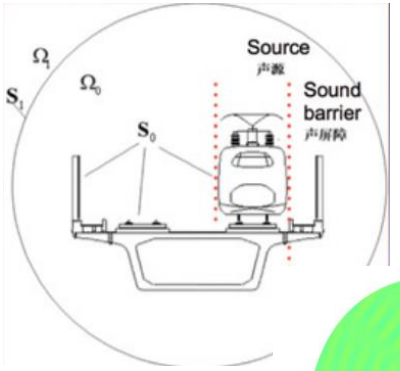
- To deploy a sound barrier that was a widely used method to mitigate pass-by-noise created by high-speed railways
- The traditional semi-analytical formulas predicted the insertion loss of sound barriers with large deviations. Such methodology could not be applied to complex geometries and acoustic properties

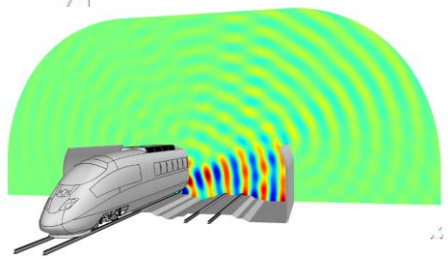
Solution

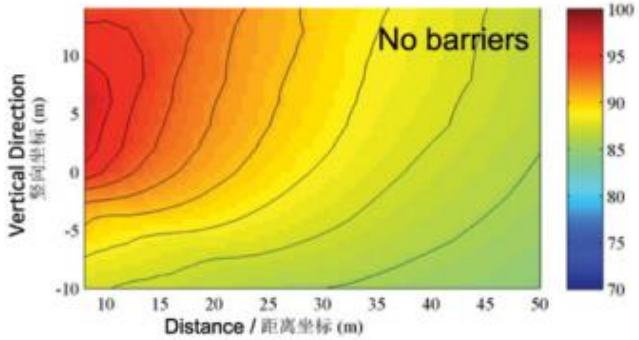
- Actran could create a large-scale model around a vehicle and performed a wide-frequency range analysis for both near and far field acoustic propagation under complex geometrical configurations and material property effects

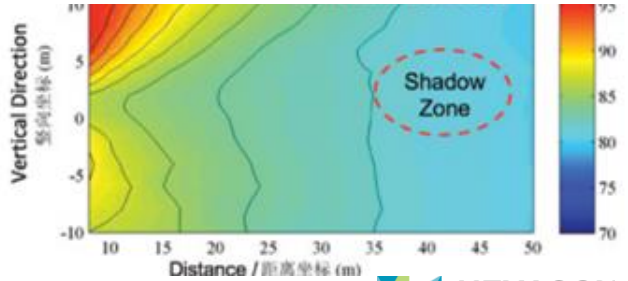
Benefits

- By using Actran, user could perform more accurate simulations under complex geometric forms and sound-absorbing boundary conditions
- Actran's efficient and easy modeling method provided a great solution for developing higher acoustic reduction yet cost-effective sound barriers









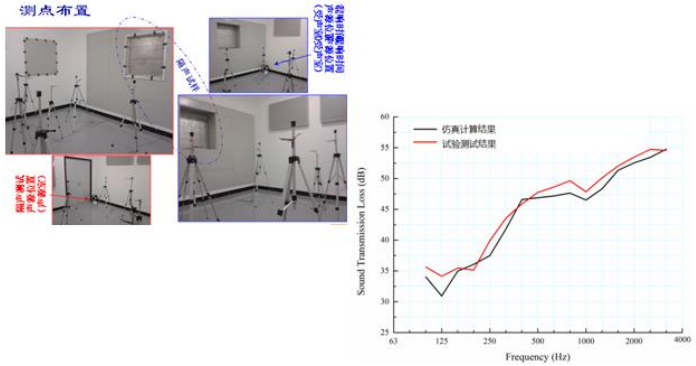
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中国北车股份有限公司
China CNR Corporation Limited

Rolling stock applications

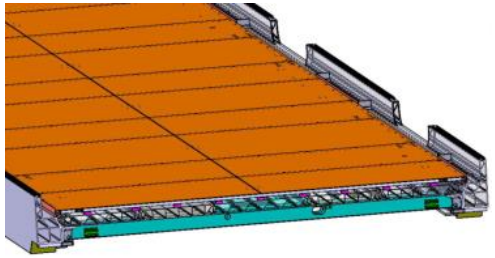
Challenge

- Strict requirement by customers on noise levels of railway and subway trains



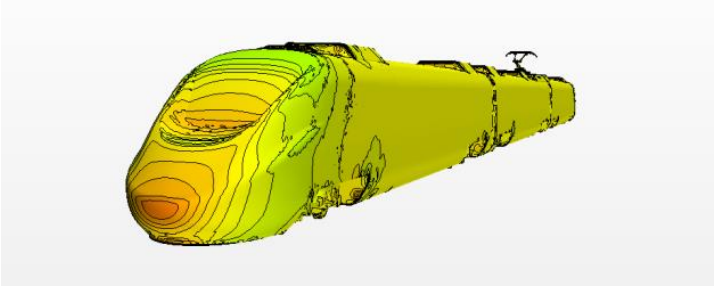
Solution

- Actran has been extensively deployed to study various acoustic issues: panel insulation, exterior aero-acoustics (pantograph), interior aero-acoustics (HVAC ducts)



Benefits

- Design improvements can be proposed based on Actran simulation of vibro-acoustic and aero-acoustic problems



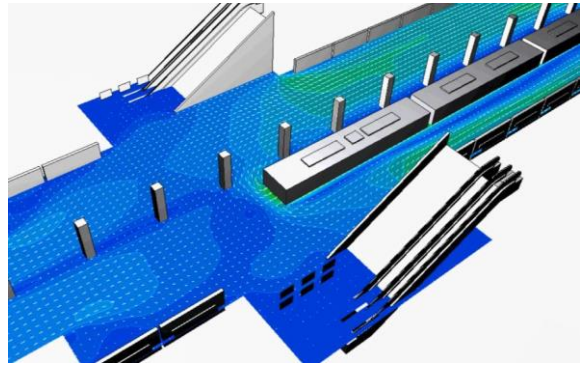
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Aerodynamic noise

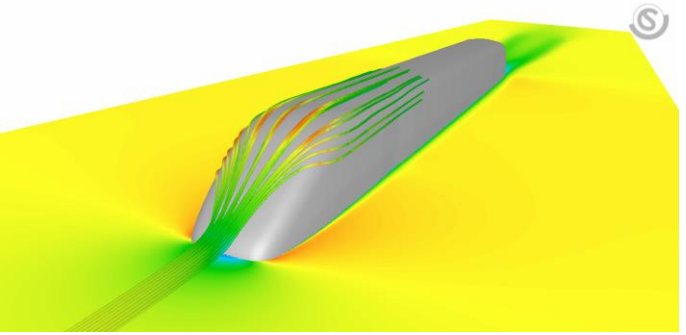
Challenge

- The main source of noise for high-speed trains is the flow around the pantograph, wagon intersection, wheels,…
- This requires to solve both the CFD and acoustic for large volumes and high frequency range



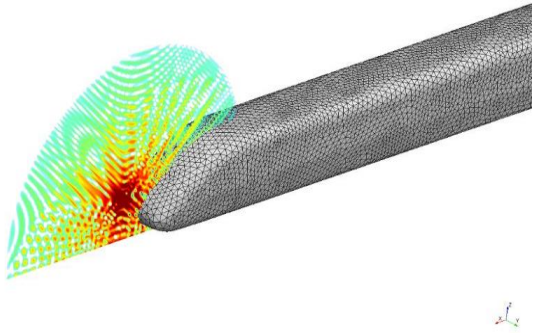
Solution

- The MSC software portfolio features both the Cradle CFD solver and the Actran aero-acoustic solution.
- Such integrated solution allows efficient calculation of the flow, the sources and their radiation around the train



Benefits

- A unique SNGR technology can use RANS steady CFD solution much cheaper than the standard transient solver. Delta between configurations can be efficiently assessed
- The flow noise can be propagated inside the train compartment using vibro-acoustic capabilities



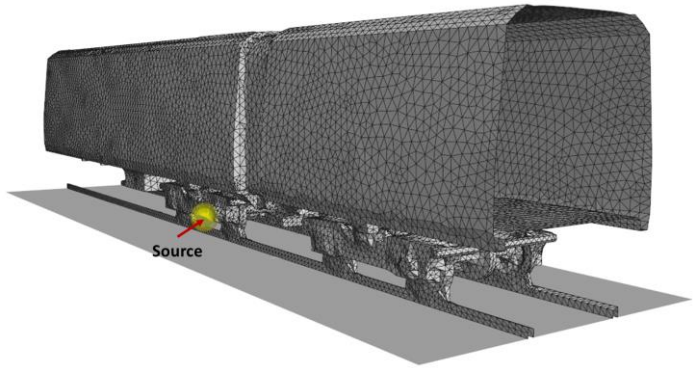
HEXAGON



Metro wagon noise

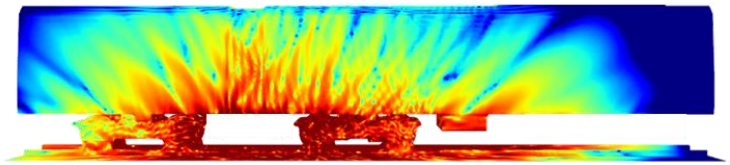
Challenge

- Prediction of acoustic pressure on metro exterior walls due to rolling stock noise
- Real size metro (~20m)

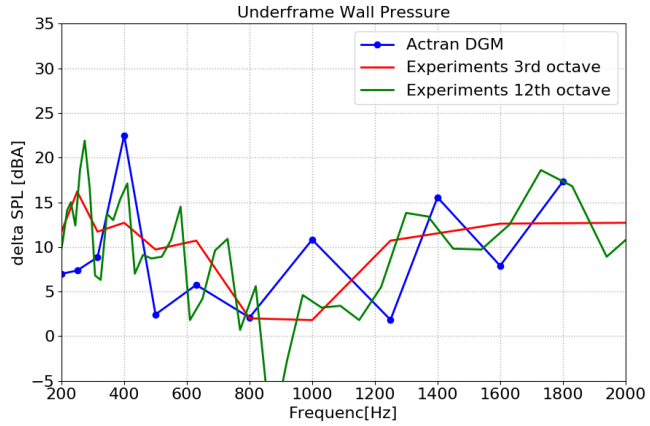


Solution

- Actran DGM is a unique tool able to efficiently model large acoustic domains
- GPU accelerated to reach affordable computational times
- Simplified noise sources used to assess sound directivity



Pressure map in dB



Benefits

- Large frequency range : L/l>50
- Ease-of-use with the mesh creation and post-processing done into Actran
- Modelling of the environment (e.g. ballast and tunnel)
- Multi-frequency excitations in one model (one simulation with multi-load cases)
- Performance thanks to GPU acceleration

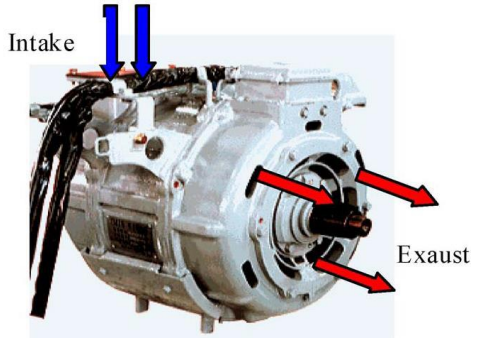
HEXAGON

BOMBARDIER

Acceleration of design of noise mitigation parts for e-motor cooling fans

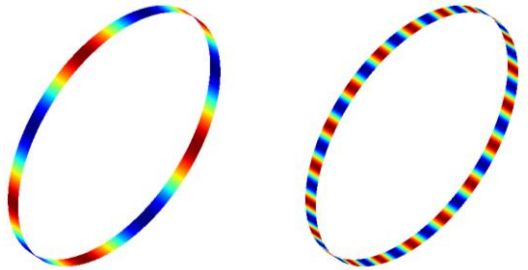
Challenge

- Railway e-motors have high cooling requirements and as a result can produce a high amount of noise
- Noise from embedded cooling fans, that rotate together with the motor in order to cool it, needs to be mitigated via downstream devices



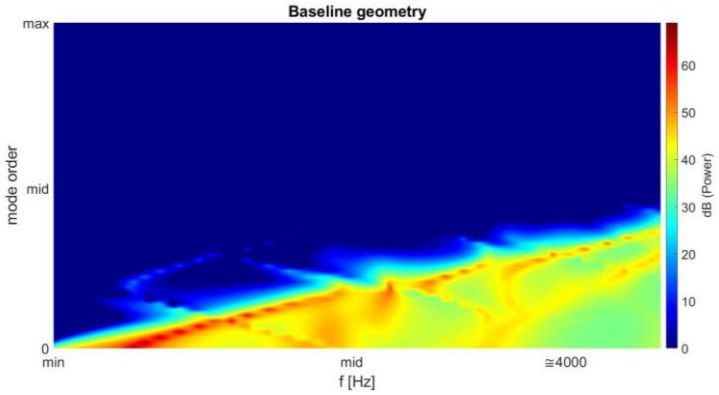
Solution

- With the use of Actran, validation was performed against measurements and then a reduced method was proposed in order to speed up the analysis of the downstream devices
- Instead of an excitation coming from a CFD analysis, a number of acoustic modes were injected so as to evaluate the acoustic performance, reducing the turnaround time from geometry to results



Benefits

- This fast methodology allowed Bombardier to evaluate a large number of configurations at a highly reduced cost, since no expensive CFD analyses were required



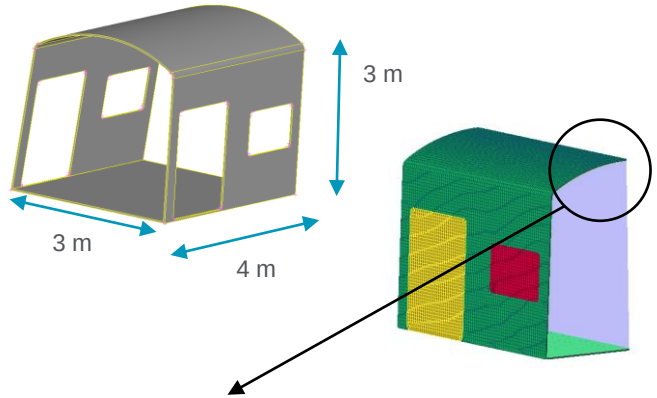
HEXAGON

南车株洲电力机车有限公司
CSR ZHUZHOU ELECTRIC LOCOMOTIVE CO., LTD.

Interior & exterior wagon noise

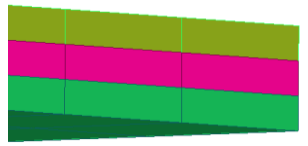
Challenge

- Simplified geometry with realistic dimensions
- Structural excitations to model suspensions
- Coupled vibro-acoustic simulation to study both interior and exterior noise



Solution

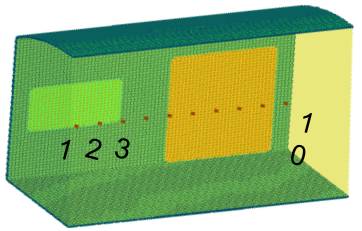
- Actran vibro-acoustic model including virtual interior and exterior microphones
- Interior acoustic treatment is modeled using 3D multi-layered model



aluminum, 10 mm

porous material, 10 mm

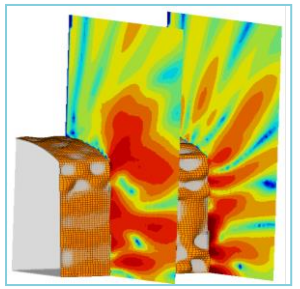
plastic material, 10 mm



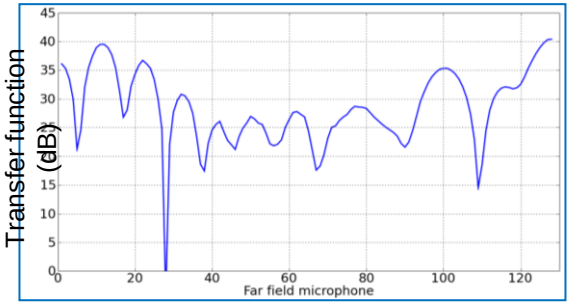
Benefits

- Access to both interior and exterior frequency results including frequency response function and maps
- Assessment of exterior sound directivity
- Input used to design sound barriers

500 Hz, SPL (dB)



500 Hz, outer arc directivity (dB)



HEXAGON

Noise mitigation in railway platforms

Hexagon Live Design & Engineering 2021, Dr. Wenlin Hu

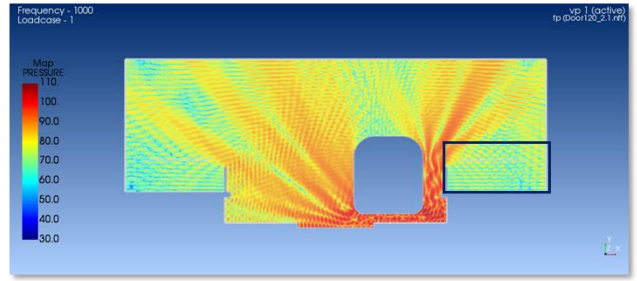
Challenge

- Instantaneous noise in the waiting area of a rail platform can reach 85-95 dB(A) due to trains passing through the station at 120km/h, causing discomfort to passengers
- Different solutions in terms of noise mitigation are available such as platform screen doors, sound-absorbing barriers and sound-absorbing plates on the tracks

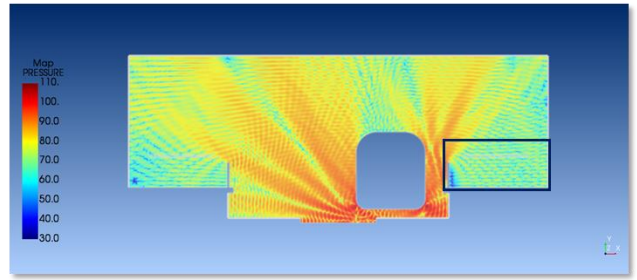


Solution

- Actran can create a large-scale model around a vehicle and performed a wide-frequency range analysis for both near and far-field acoustic propagation under complex geometrical configurations and material property effects
- Using Actran, it can be established that by using different mitigation techniques noise can be reduced by 5.3-8.5dB(A)



1000Hz – screen door only



1000Hz - screen door +
sound absorption platform wall +
sound absorption board on track plate

Benefits

- By using Actran, the user can perform more accurate simulations under complex geometric forms and sound-absorbing boundary conditions for treating all different mitigation techniques
- Actran's efficient and easy modelling method provided a great solution for developing higher acoustic reduction yet cost-effective sound barriers

ALSTOM

Transmission loss simulation for railway HVAC

ISMA 2012, Transmission loss simulation of treated HVAC ducts for railway applications, J. Jacqmot, F. Guerville, D.R. Burd

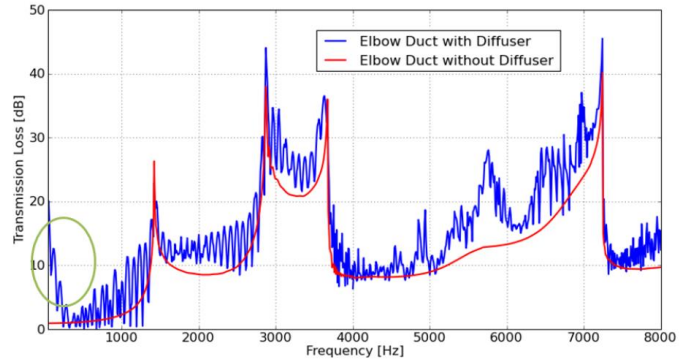
Challenge

- Noise generated by climate control systems is one of the primary noise sources affecting the acoustic comfort of passengers in railway cars.
- As the noise from the exterior are reduced, it becomes more prominent.
- Providing noise reduction as part of a retrofit can prove a cost-effective solution.



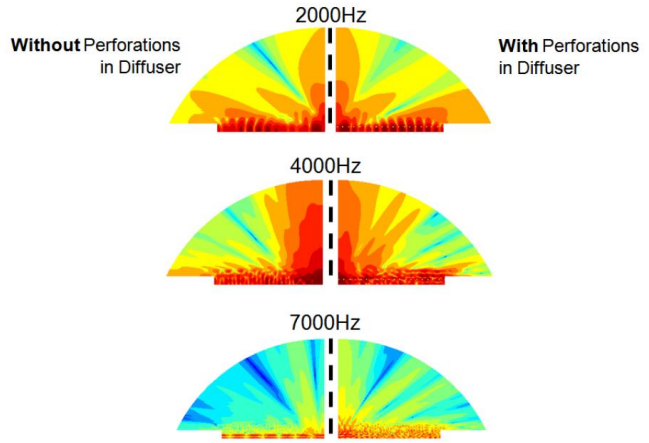
Solution

- Actran is used to calculate the transmission loss through two different HVAC duct geometries, by using analytical duct modes
- Different treatments such as perforations, diffusers and acoustic materials were simulated for the two geometries



Benefits

- Multiple configurations with different treatments (perforations, diffusers, acoustic materials) can be efficiently and accurately simulated
- Valuable insight can be derived using acoustic simulation on which treatments work and on what frequency range



Medium-frequency noise radiated from bridges and rails

Journal of Sound and Vibration, 2016, A combined power flow and infinite element approach to the simulation of medium-frequency noise radiated from bridges and rails, Q. Li, W.Q. Li, D.J. Wu, X.D. Song

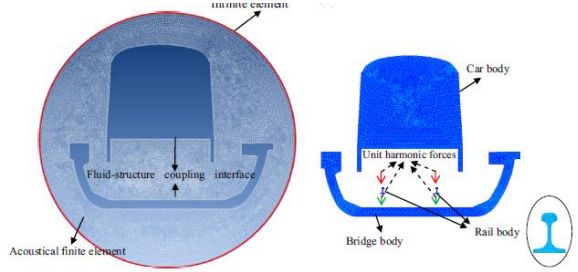
Challenge

- In elevated urban rail transit systems, it can be difficult to distinguish between rail and bridge noise in the medium-frequency range (200Hz–1 kHz).
- Different methods are used for each but there is always a trade-off between efficiency and accuracy



Solution

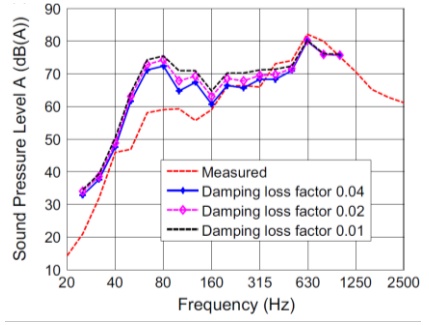
- An analytical model of the infinite Timoshenko beam to model the rail is combined with a finite element model of the bridge structure in Actran
- A two-dimensional acoustical model, which is a combination of the infinite and finite elements, is adopted to calculate the noise field generated by the boundary effect of the bridge, rails and car bodies with constant sections.



The 2D infinite element model with unit harmonic forces on the rails and bridge

Benefits

- Efficient in the modelling and computing procedures compared to BEM methods.
- Good correlation with other reliable vibration and noise simulation methods.



Simulated sound pressure spectra with different damping loss factors

Sound field at an underground subway station

Building Acoustics, 2013, Volume 20 Number 3, Sound Field Simulation and Optimization at an Underground Subway Station, C.H. Tang, Y.S. Wang , H. Guo

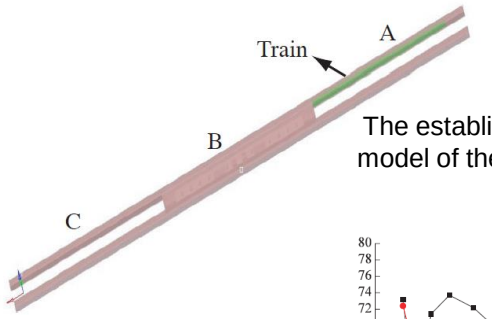
Challenge

- When a subway train is approaching or leaving the station, the noise created by the collision and friction of wheels and rails, as well as the noise from braking and operating, increase the noise levels in the waiting and working areas, which affects both the physical and mental health of people involved.
- Applying optimized noise mitigating solutions can be more easily done with simulation.



Solution

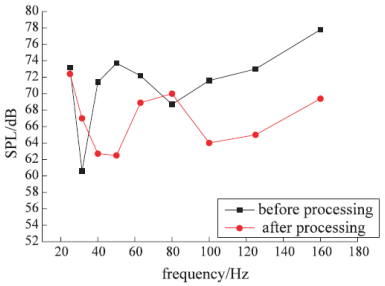
- Actran is used for analyzing the sound field at the underground subway station at the two common working conditions: coming and going.
- The analysis is run between 20 and 200 Hz and the station measures 137 by 9 meters.



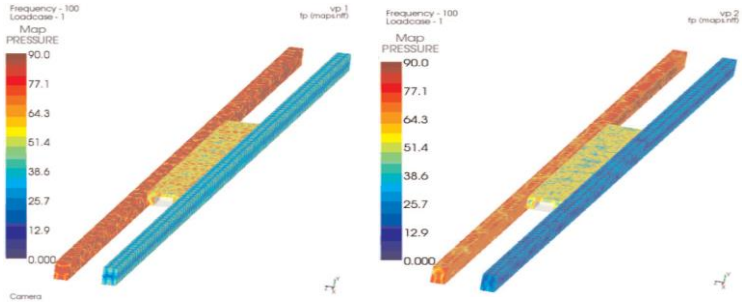
The established finite element model of the Xingzhong station

Benefits

- Good correlation with measurements.
- The validated model is used as part of an optimization process to position acoustic treatments for noise reduction.
- A noise reduction of 5dB was achieved for the subway stations.



Noise spectrum, with and without acoustic treatments



Comparison of the sound energy distributions (a) before and (b) after acoustic treatments in the Xingzhong station

Interior acoustic comfort for railway

Actran allows a fine simulation of the design as well as the physical mechanisms involved, including absorption and insulation, allowing to imagine different scenarios and quantify the effects in terms of noise.

Claire Chaufour,Project Manager, SNCF

Challenge

- Comfort from noise and vibration in trains is an essential feature for passengers so manufacturers and operators must guarantee low noise levels
- The development of a simulation methodology for modeling interior noise propagation could help reduce costs of retrofitting acoustic treatments
- Main challenge: the characteristic size of a train body is very large for reaching medium to high frequencies

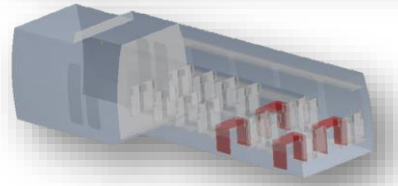
Solution

- A methodology is developed based on Actran for interior noise comfort with rolling noise as the excitation
- A train car cavity with different treatment is used for design exploration and performing what-if analyses for reducing cabin noise
- The geometry cleaning is performed with MSC Apex

Benefits

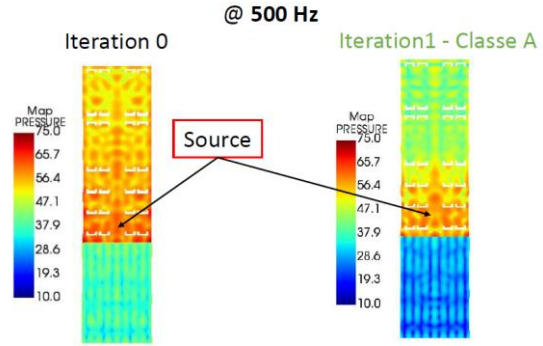
- A methodology has been developed for evaluating railway interior comfort up to 1000 Hz
- Fast what-if analyses can be performed easily changing the position and properties of noise-reducing materials
- User-friendly preprocessing with MSC Apex
- Taking advantage of simulation to gain insight on the interior comfort and make better engineering decisions

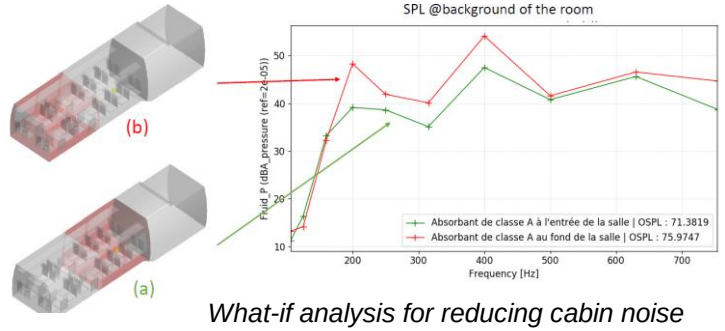




Absorption patches in various places

Design exploration





What-if analysis for reducing cabin noise

Sonic crystal noise barrier design

Forum Acusticum,2020, Sonic crystal noise barrier design to reduce railway noise emissions, Claire Chaufour

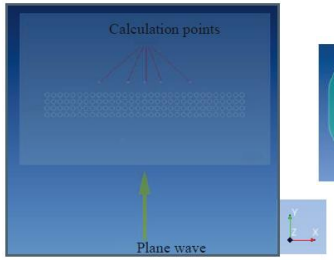
Challenge

- Noise emissions are a major concern for people living near railway infrastructures.
- Noise barriers which are a solution to reduce noise pollution are often not well accepted by the population for aesthetic reasons.

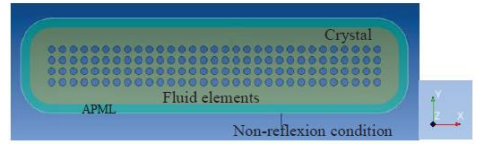


Solution

- Actran uses a two-dimensional finite element method to investigate the potential application of sonic crystals as acoustic barrier.
- Multiple crystal geometries and arrangements are simulated to find the one that provides the best insertion loss.



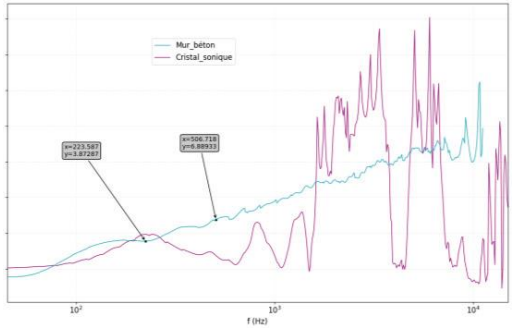
FEM generic model



FEM generic model of crystal

Benefits

- Using simulation, evaluation of different possibilities can be done quickly, providing valuable insight.
- The use of sonic crystals to reduce the acoustic impact of rail traffic is very attractive, particularly in terms of design and cost (lighter foundations).
- Different crystal designs are possible in order to optimize performance for acoustic sources with different frequency ranges.



Insertion loss results for both technical solutions

Railway rolling noise prediction

24th International Congress on Sound and Vibration, 2017, A innovative numerical approach for railway rolling noise forecast, M. Viscardi, P. Napolitano, M. Arena

Challenge

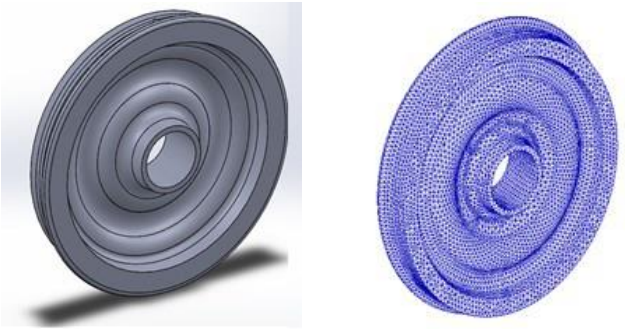
- Rail transport has been developing worldwide in recent years because it is an easy way to move goods or passengers over long distances in a short period of time.
- Travelling fast is the main goal so long as it is comfortable and safe.
- Regulations concerning acoustic comfort and environmental impact become more and more strict over the years.

Solution

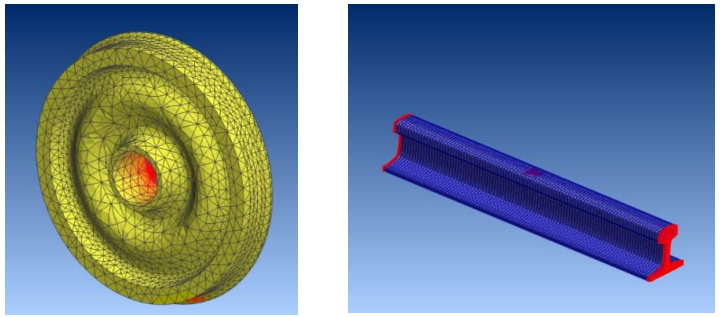
- Starting from 3D CAD models of the wheel and the rail, their mode shapes and frequency responses have been determined, up to the noise emitted characterization within Actran.
- The acoustic analysis performed by Actran is based upon the finite element models developed for vibration characterization.

Benefits

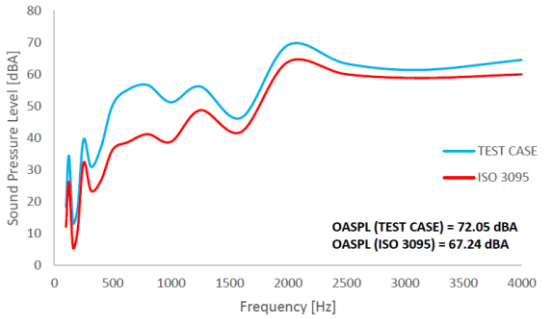
- Good correlation between experimental data, the numerical model and the ISO 3095.



3D CAD reference model (left), 3D FEM model (right)



Wheel mesh (left), rail mesh (right) – Actran Models



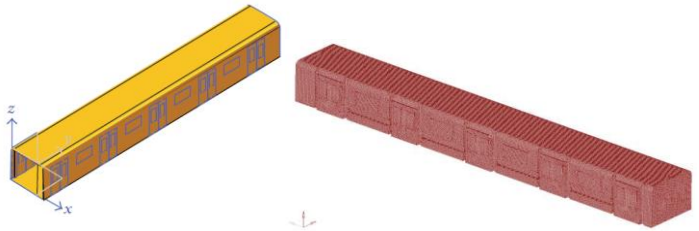
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Interior noise of rail vehicle

Advances in Mechanical Engineering, 2014, Sound quality evaluation and optimization for interior noise of rail vehicle, K. Hu, Y. Wang, et al.

Challenge

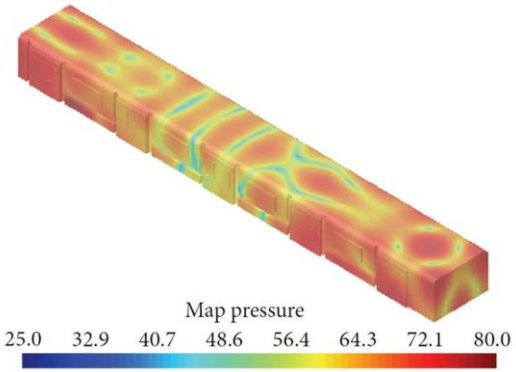
- Interior noise in the subways can seriously affect the ride comfort and the physical and mental health of the passengers.
- The noise can be reduced by applying acoustic treatments.
- The performance needs to be evaluated with psychoacoustic criteria before applying them.



3D CAD model Finite element model

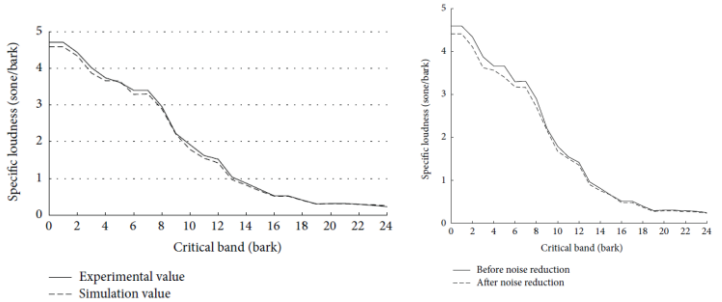
Solution

- An Actran model of a rail car is built for evaluating interior noise from wheel-rail noise.
- By using orthogonal experimental design in Actran, an optimization scheme for interior noise reduction is provided.



Benefits

- Good correlation between the simulation and the experimental data.
- A 4.81 dB decrease in sound pressure level and a 1.07 sone reduction in loudness were achieved thanks to the optimization scheme.
- With the help of acoustic maps, researchers were able to get insight on which position would work well for treatment placement.

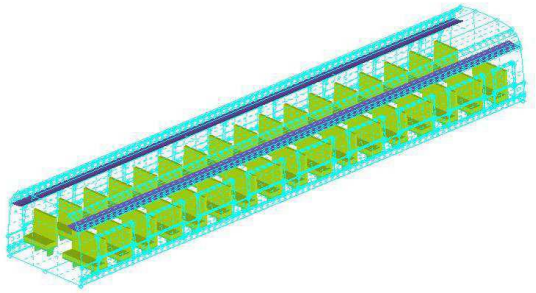


High speed train interior noise

Advanced Materials Research, 2015, Optimisation of Sound Source Model for the Simulation of High Speed Train Interior Noise Using Finite Element Method, Wu Di, Ge Jianmin

Challenge

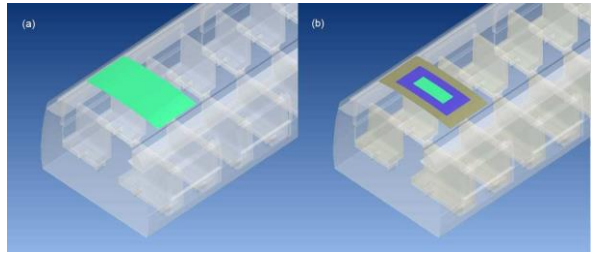
- Placing an appropriate area source in acoustic simulation can be challenging due to the source being uniform across the area.
- A source with varying amplitude and phase across the area could be more accurate.



Geometrical model of the train compartment

Solution

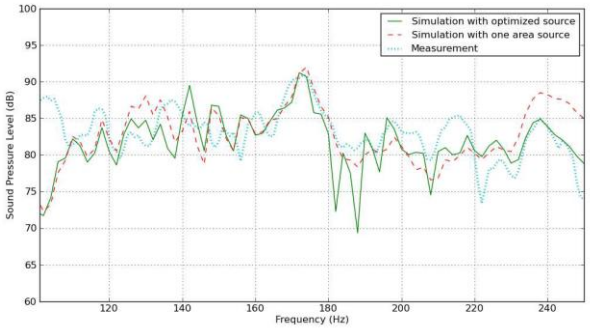
- Actran uses a finite element method with an optimized area source to simulate interior sound fields.
- The originally single area source is divided in multiple sub-area sources and each of them is given a certain amplitude and phase based on their distance to the sound-source.



Simulation of sound source : original area source (left), optimized area source (right)

Benefits

- Good correlation between simulations and experiments for low-frequency sound field in high-speed train.



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Shipbuilding

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DNV GL – Ship hull sound radiation

ISMA 2010, Simulation of the vibro-acoustic coupling between structures and heavy fluids, B. Van Antwerpen, et al.

Challenge

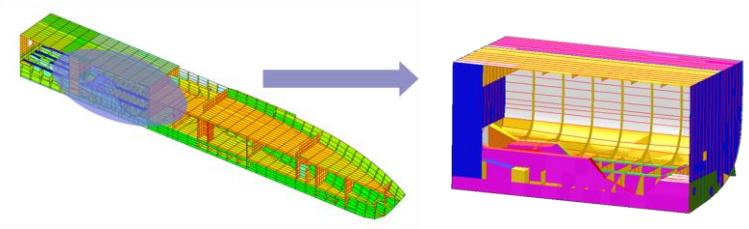
- Sea animal protection codes impose maximum noise emission levels for vessels.
- The engine room noise emission, an important portion of the total noise, must be studied.

Solution

- Engine room structure and hull are modeled using Patran and Nastran.
- The structure was translated to an Actran model in which the sea water was added.
- Sound radiation into sea was computed taking into account the added mass effect by sea water.

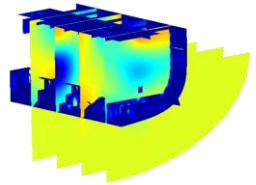
Benefits

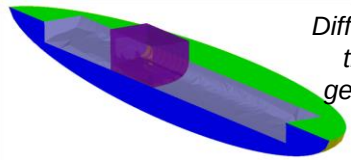
- Sound power radiation into sea water could be predicted in order to evaluate the ship's noise impact to the underwater environment.



Nastran engine room model translated into Actran model

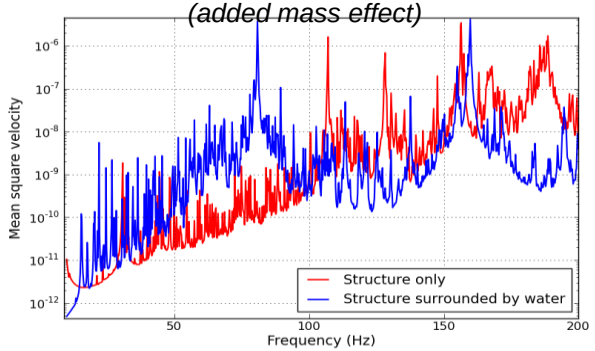
Pressure map inside and outside the hull





Diffraction accounted through full ship geometry (hardwall condition)

Impact of the water around the hull (added mass effect)



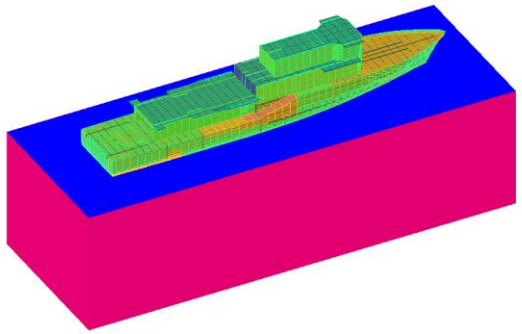
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Underwater noise radiation in shallow water

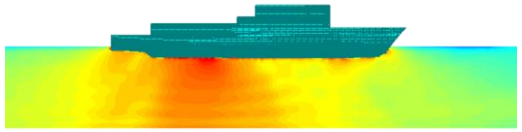
Challenge

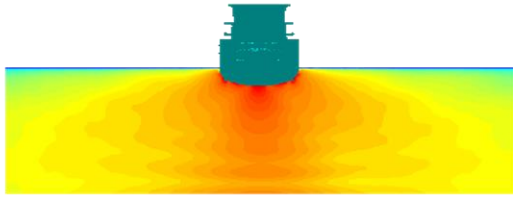
- Predict the underwater noise directivity considering shallow water environment and seabed absorption impact



Solution

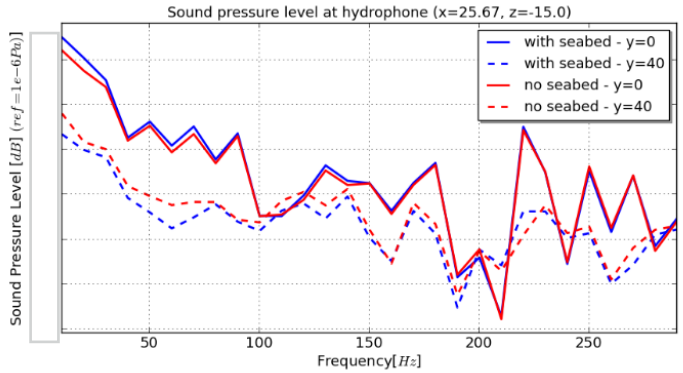
- FE model-based approach of complete ship structure and underwater environment
- Acoustic absorption modeling of the seabed thanks to dedicated conditions
- Use of measured vibrations at engine mountings as FE model excitations





Benefits

- Assessment of seabed impact on underwater noise directivity



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Engine sound radiation

Challenge

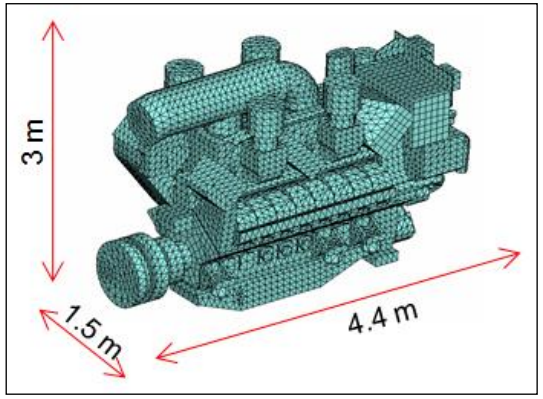
- Large ship engines are very powerful and are thus very noisy.
- In this example a 320KW (5900CV) engine, with 16V cylinders is considered.

Solution

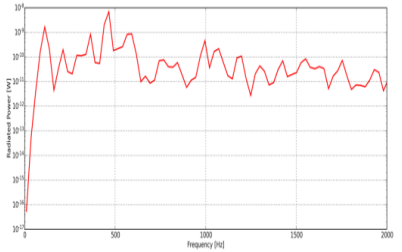
- Actran computes the radiated noise in the far field, from vibration levels computed by an FEA tool like Nastran.
- The acoustic model is designed to reach 1000Hz, namely the order 33 at RPM 1800.
- Acoustic covers can be modeled in Actran for the noise reduction.

Benefits

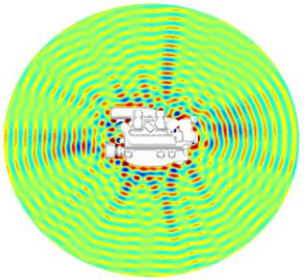
- Reduced development cost thanks to the fast simulation of the engine sound radiation.
- Engine order and structural modes can be identified on the Actran waterfall diagram.



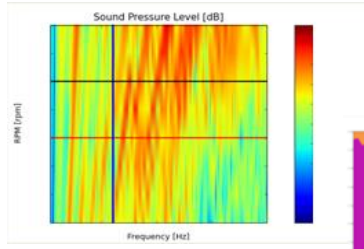
Noise at a given microphone position (as a function of frequency)



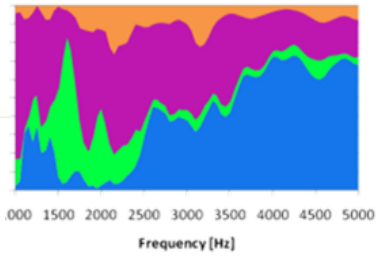
Map of the radiated noise



Waterfall diagram output by Actran



Contribution of different part of the engine to the radiated noise



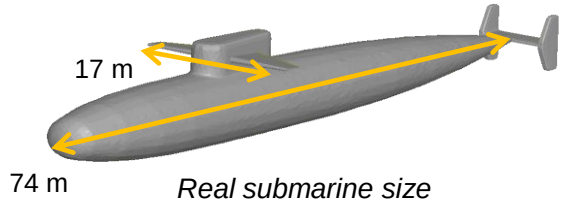
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Submarine hull vibration

Challenge

- The noise emitted by a submarine below 1kHz is mainly due to the engine, the electric generator and the hull vibration.

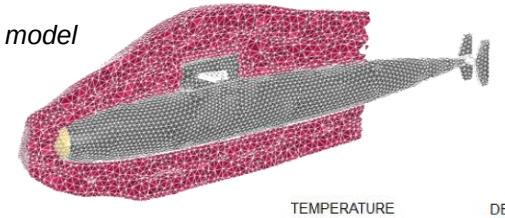


Real submarine size

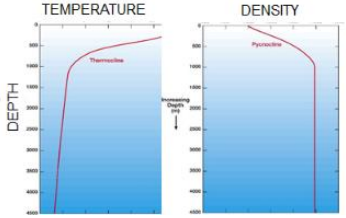
Solution

- Actran is used to model the submarine hull structure, to compute its vibration and the noise radiation in far field.
- The pressurization effect is taken into account
- the water outside is also modeled for taking into account added mass effect.
- Water temperature and density are also considered.

Actran model

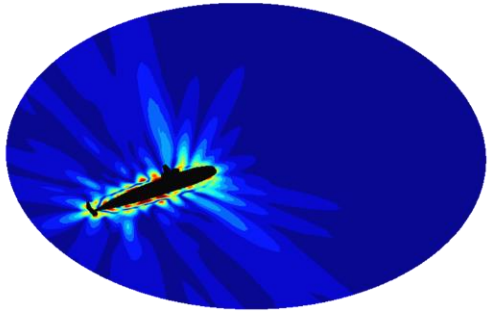


Take account of water properties



Benefits

- Sound power radiation into sea water could be predicted in order to evaluate the ship's noise impact to the underwater environment.



Sound radiation of a submarine hull

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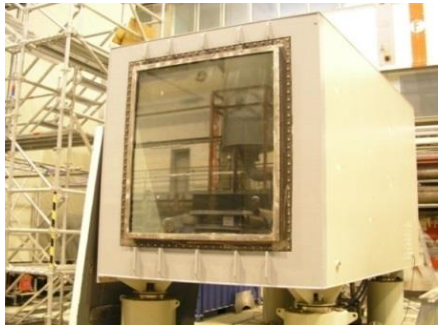
Windows Insulation

DAGA 2009, Radiation of Ship Windows Induced by Structure-borne Sound, S. Semrau, Ch. Weienborn.

Challenge

- Regulations concerning ship interior noise are becoming more restrictive.
- The window insulation need to be studied and improved

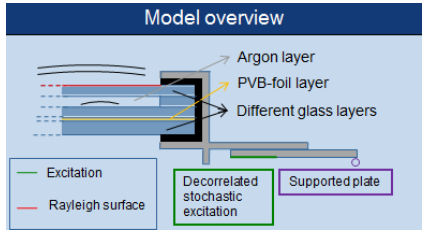
Board room

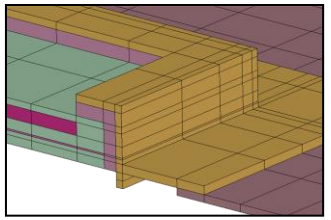


Solution

- A multi-layer window was modeled using Actran.
- The acoustic radiation of ship windows for structure-borne and airborne excitations has ben evaluated.

Actran vibro-acoustic model

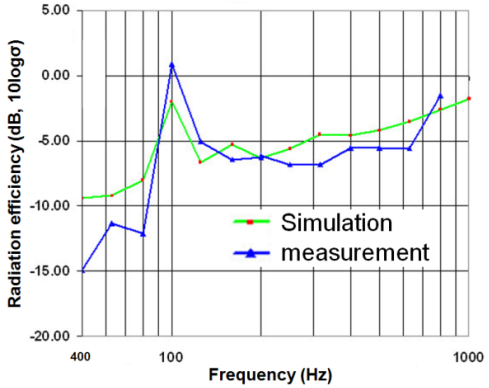




Modeling of the window frame

Benefits

- **Good correlation** with measurement was obtained.
- **Optimization** of **window** and **frame** design based on numerical prediction becomes feasible.



Radiation efficiency

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Open Ship Propeller

Challenge

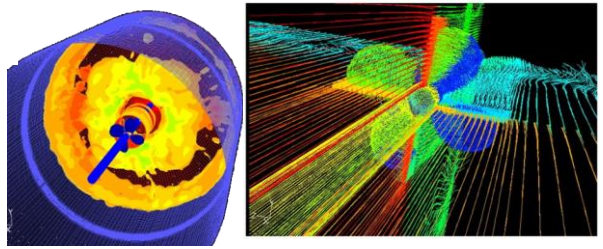
- Propeller noise is an important contributor to marine noise and has a large impact on the marine ecosystem
- Predicting the underwater propeller noise could lead to mitigation techniques that will reduce the noise

Solution

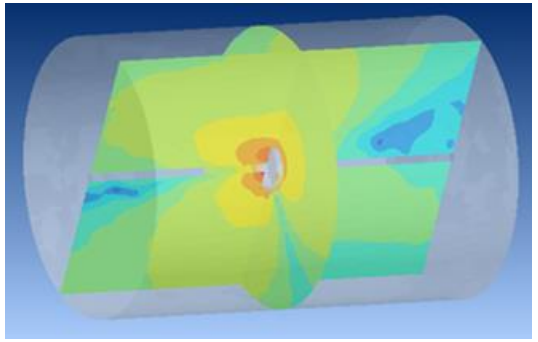
- Actran is coupled with CFD LES results, for computing and propagating aeroacoustic sources in the far field.

Benefits

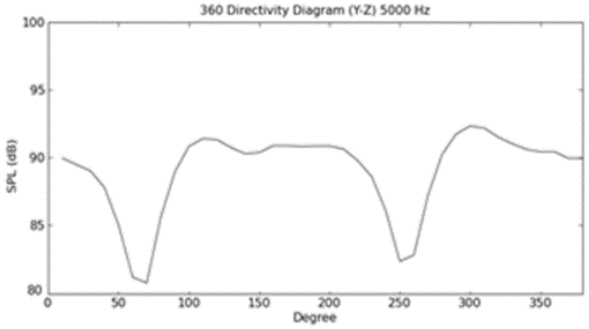
- Reduction of the cost of the flow computation, as it only needs to be acoustically accurate close to the propeller.
- Acoustic obstacles like ship hull can be modeled during the acoustic propagation



Noise map



Acoustic directivity around the propeller @5kHz



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Ship propeller in its real environment

Challenge

- A ship propeller can be located inside a duct and its sound radiation is influenced by the hull of the ship.

Solution

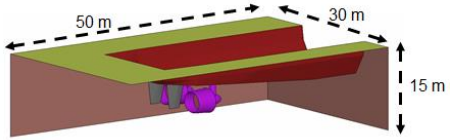
- Actran is used for modeling the acoustic source represented by the propeller by injecting duct modes.
- Porous materials are positioned on the rudder for attenuating the sound.

Benefits

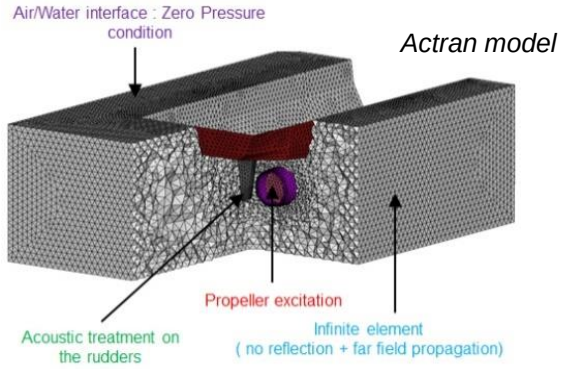
- Actran is capable to simulate the noise emitted by a propeller in its real environment.
- In addition, modeling the source with duct modes is much faster than using an unsteady CFD: 2min per frequency and 3.5GB of RAM memory only!

Lafayette Class Frigate



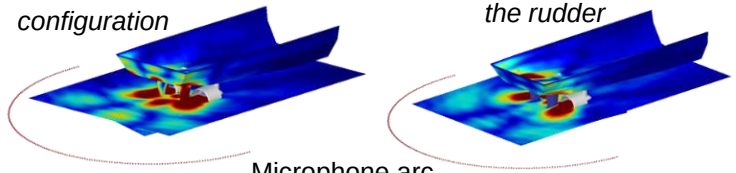


Modeling of the propeller vicinity



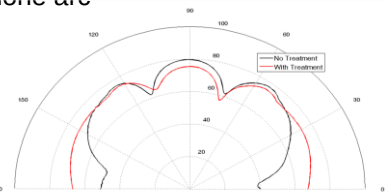
Noise in hard wall configuration

Noise with treatment on the rudder



Microphone arc

Acoustic directivity: with and without treatments (on the microphone arc)



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Towed Array Sonar

Challenge

- A towed array sonar receives acoustic waves in the sea water for detecting underwater objects like submarines.
- Its reception of acoustic waves needs to be understood.

Solution

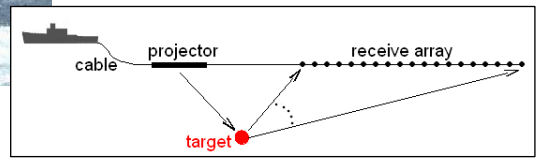
- A tube of passive transducer, about 100 meters below the warship or behind the submarine, can be modeled in Actran.
- Actran simulates acoustic waves traveling through the tube, then captured by the hydrophones.
- Plane waves can be directly injected for the source modeling.

Benefits

- Actran simulates the acoustic waves reception for passive sonar.
- Virtual prototyping provides guidelines to physical design

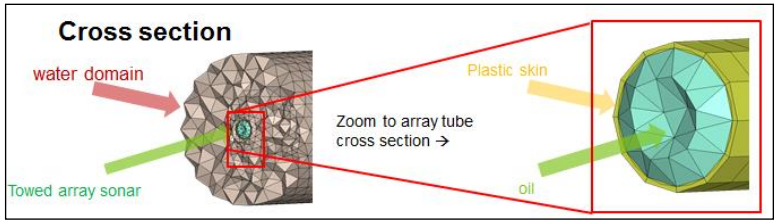
Boat towing a sonar array



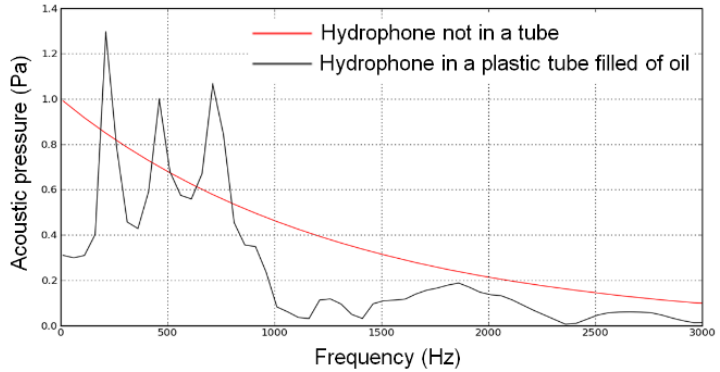


The passive array can be used with a projector

Actran vibro-acoustic model



Noise at one microphone



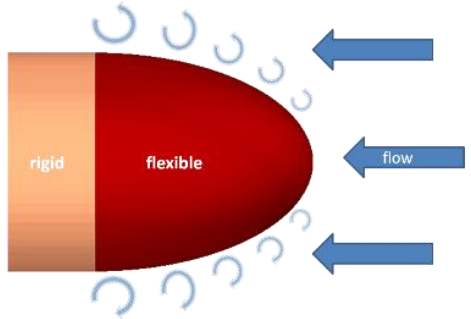
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Turbulent boundary layer noise

Challenge

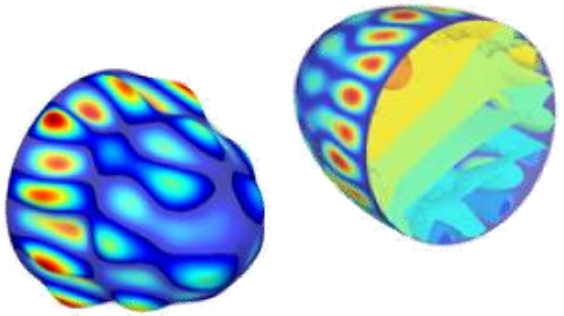
- The dome at the front of a submarine is filled with water and contains the sonar.
- The dome is submitted to a turbulent boundary layer (TBL) excitation, which influences the sound perceived by the sonar and could lead to measurement errors



Turbulent boundary layer around the dome

Solution

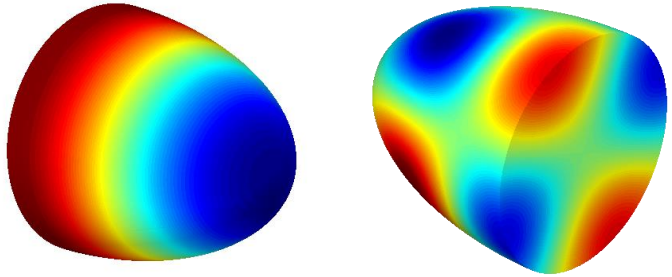
- Actran is used to model the TBL excitation with semi-empirical model (Corcos or Chase).
- This excitation is applied on the dome structure model and acoustic pressure is calculated inside the dome



Turbulent boundary layer excitation in Actran

Benefits

- Prediction of turbulence induced noise inside the dome. This information is useful for improving the sonar accuracy.
- Multiple outputs that can provide engineering insight can be exported:
  - The mean square pressure inside the dome
  - The mean square velocity of the dome structure
  - The power dissipated by the dome structure



1st and higher order cavity mode

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Tonpilz Transducer

Challenge

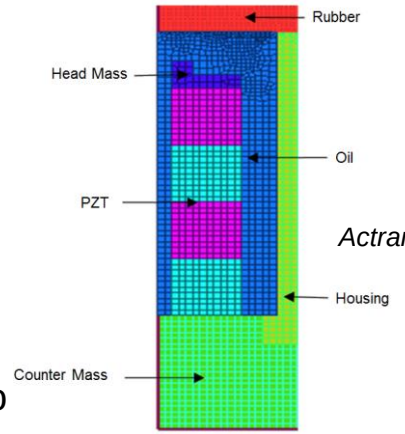
- The Tonpilz transducer is one of the most popular transducer: low cost, simplicity and good performance.
- How to optimize the design for a large bandwidth?



Tonpiltz transducer

Solution

- Actran is used to model the Tonpilz transducer, including piezoelectric ceramic.
- Ability to compute results in the near and the far field.
- Direct input of piezoelectric matrices into the software (no scripting required).

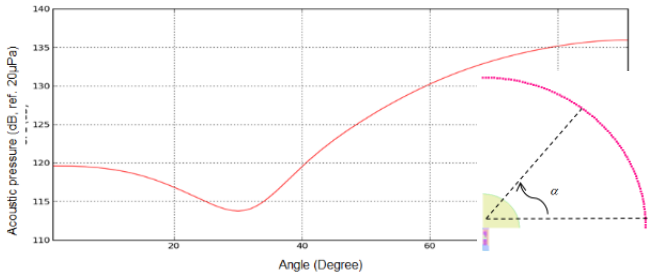


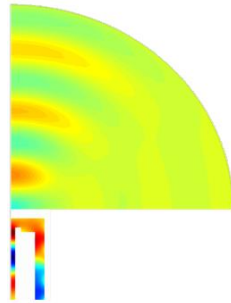
Actran model

Benefits

- Increase the accuracy of projector transducer and hydrophones.

Directivity of the transducer @45kHz





Pressure real Part @45kHz

HEXAGON



Transducer array sonar

Challenge

- A transducer has a very narrow directivity. How can we scan a larger region?

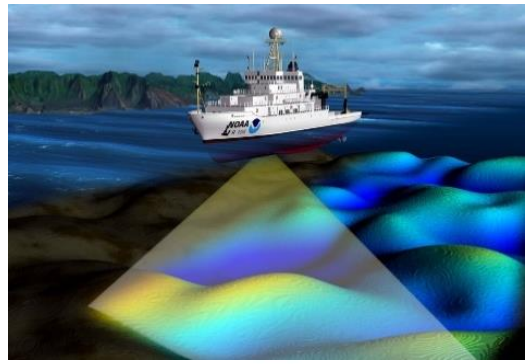
Solution

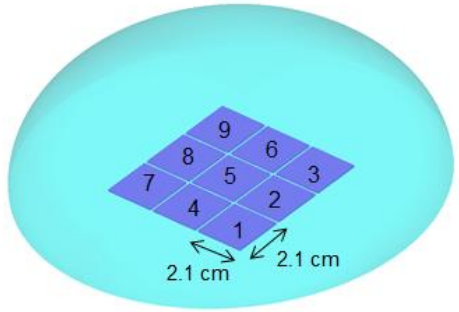
- Use of Actran for modeling an array of piezoelectric ceramics.
- Interactions between the ceramics can be predicted through self and mutual radiation impedance.

Benefits

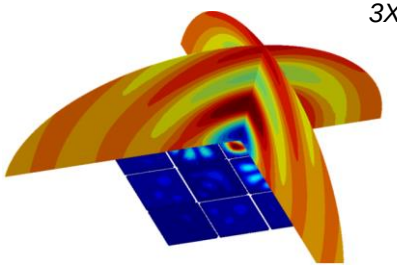
- Maximize the efficiency of transducers and control its directivity by predicting easily the behavior of a transducer array in a unique tool.

Directivity increased with the use of several transducer



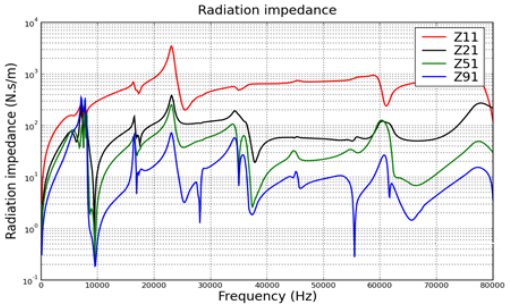


3X3 sonar array



Vibration and noise due to the excitation of one ceramic

Interactions between ceramics: self and mutual radiation impedance



Impact of cavitation on propeller noise

Fifth International Symposium on Marine Propulsors, 2017, CFD and CHA simulation of underwater noise induced by a marine propeller in two-phase flows, Ville M. Viitanen, Antti Hynninen, Lars L¨ubke, Rhena Klose, Jukka Tanttari, Tuomas Sipil¨a, Timo Siikonen

Challenge

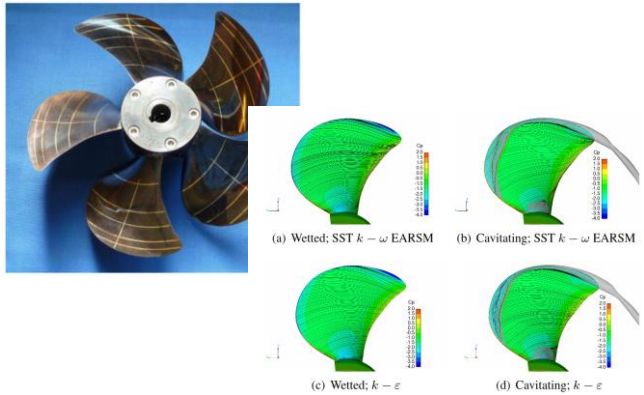
- Numerical prediction of cavitation is a very difficult problem from both a fluid and an acoustic point of view
- Due to the nature of cavitation, very high noise is generated by the propeller and must be predicted in order to be reduced
- For this, it is important to also understand the noise mechanisms

Solution

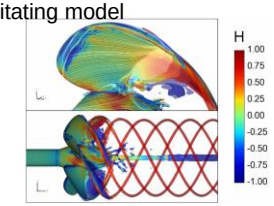
- To predict the propeller noise, a CFD solver is coupled with Actran for a hybrid aeroacoustic approach
- The cavitation is predicted by the CFD solver and Actran is used to create sources and propagate them

Benefits

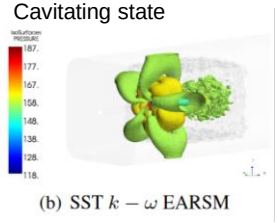
- The propeller wake acts as an acoustic source on a wide frequency range, while the cavitating tip vortex enhances the tonal signature considerably.
- Cavitation contributes significantly to the acoustic emission due to the source term related to the density variations



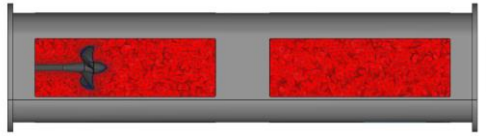
CFD results – Cavitating model



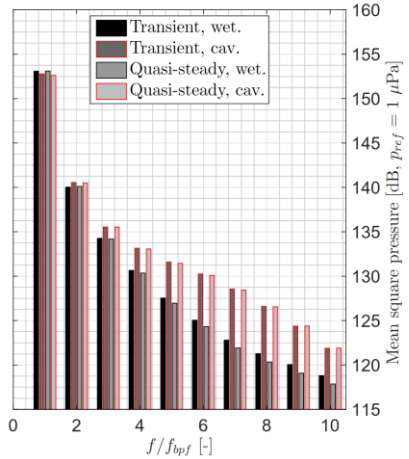
Iso-surface noise – Cavitating state



Cavitation tunnel - FE Acoustic model and mesh



Impact of cavitation on sound radiation



Prediction of sound from cavitating propeller

Fifth International Symposium on Marine Propulsors, 2017, On predicting the sound from a cavitating marine propeller in a tunnel, Antti Hynninen, Jukka Tanttari, Ville M. Viitanen, Tuomas Sipil¨a

Challenge

- The marine propeller represents one of the most important sources of underwater radiated noise
- The recommended test procedures might not represent all real loading conditions
- Assessment and validation of numerical procedure

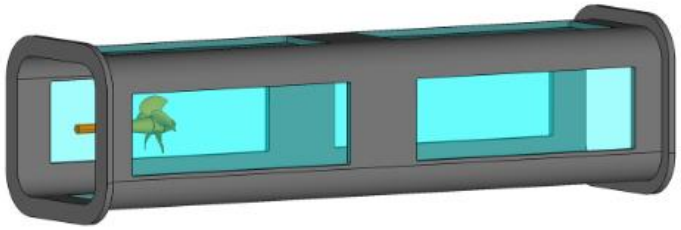
Solution

- CFD results coupled to Actran using hybrid approach
- *With this procedure the moving boundaries are naturally taken into account and there are no limitations on the elasticity or geometry of the surrounding boundaries […] Therefore this procedure is suitable also for full scale underwater hydro-vibro-acoustic simulations of cavitating marine propellers."*

Benefits

- The propeller wake acts as an acoustic source on a wide frequency range, while the cavitating tip vortex enhances the tonal signature considerably.
- Cavitation contributes significantly to the acoustic emission due to the source term related to the density variations

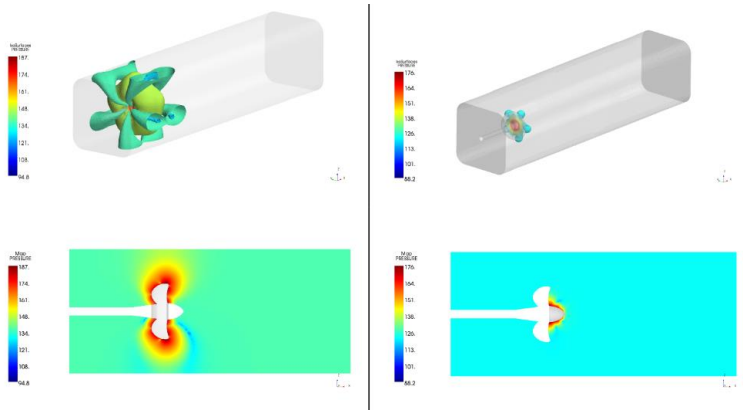
CAD model of the PPTC propeller in the cavitation tunnel.



Acoustic source contribution at 100 Hz

Propeller blade

Propeller hub





Onboard noise comfort prediction

Challenge

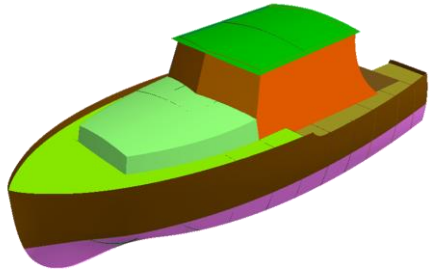
- Excessive onboard noise levels can impact crew performance, human error potential, health and comfort.
- The most commonly adopted approach to tackle with numerous noise sources involved is the source-path-receiver modeling technique.
  - Noise source characterization
  - Transmission path analysis
  - Receiver acoustic characteristics

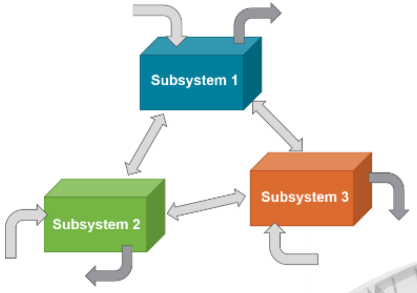
Solution

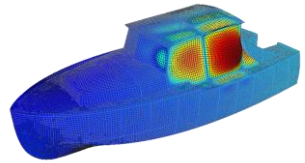
- Actran Virtual SEA approach allows to tackle large structures with existing large FE model and easily extend the frequency range of analysis.
- Mid and high-frequency vibrations propagation path can be analyzed.

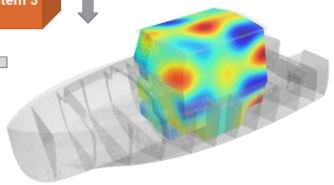
Benefits

- There is a need for designers and builders to perform noise analyses at an early design stage.
- Virtual SEA numerical approach is an efficient an elegant approach to address these needs by relying on existing FE models and offering relevant indicators at mid- and high frequencies.

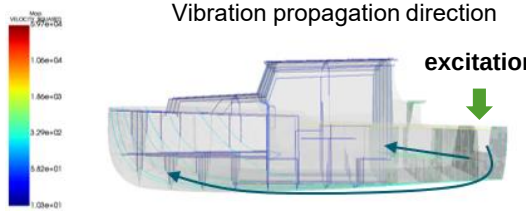




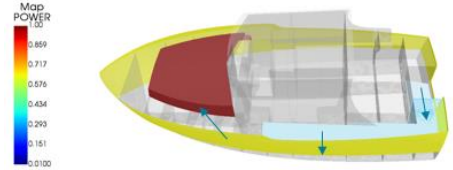




Vibration propagation direction



Dominant transfer paths subsystems



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Underwater objects coated with viscoelastic damping layer

IOP Conf. Series: Earth and Environmental Science, 2021, Analysis of the acoustic scattering properties of underwater objects coated with viscoelastic damping LAYER, T. Zhiyin, Z. Jijian, et al.

Challenge

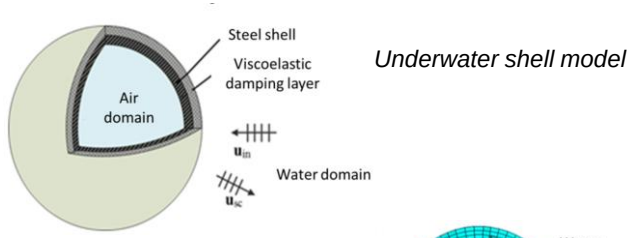
- In recent years, the acoustic scattering fields of underwater targets treating with various technologies to enhance the invisibility ability is gathering interest.
- Analytical methods are difficult to solve the scattering sound field when the structure shape is irregular and complex.

Solution

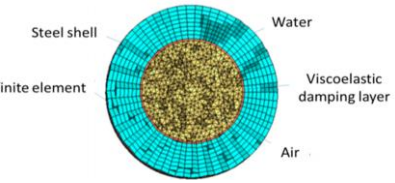
- Actran uses the finite element model to solve the scattering characteristics of simple shape objects.
- The scattering sound field of rigid spherical shell, elastic spherical shell and the viscoelastic shell with damping layer is calculated in Actran.

Benefits

- Good correlation between simulation and analytic result for the elastic smooth shell.
- By applying the viscoelastic damping layer to the spherical shell, the target intensity can be decreased in most range of the analysis frequency.

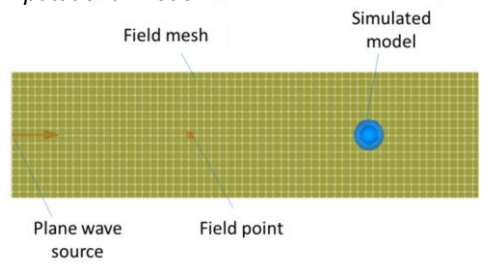


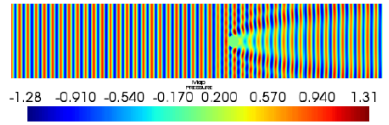
Underwater shell model



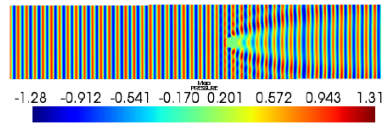
Acoustic model

Computational model

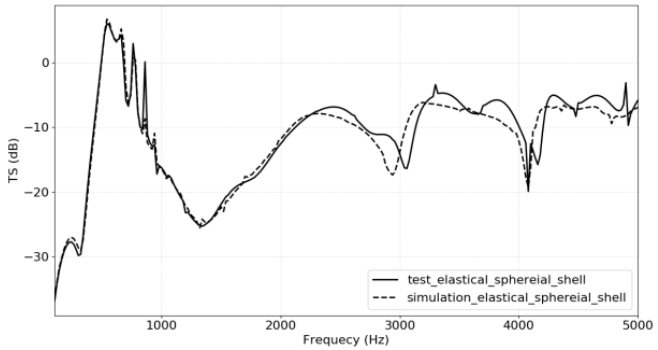




(a) Elastic smooth shell



(b) Elastic shell with 50mm damping layer



Comparison between simulation and measurements



Buildings

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Schindler

Driving elevator design through simulation

"We drive design forward through simulation, pragmatically trying out new design ideas.

We can share the simulation models with internal development departments to drive innovation further and hit quality targets faster."

– Thomas Halama, Lead Engineer Digital Transformation, Modelling & Simulation Schindler Lifts

Challenge

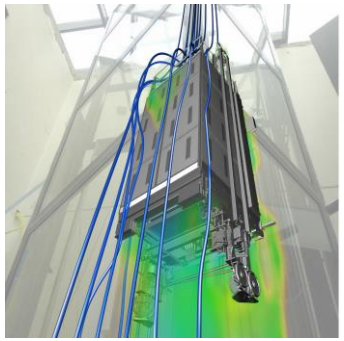
- "You should be able to stand a coin up on its edge on any handrail of a Schindler Elevator in motion without the coin falling over!"
- Hard to test new ideas and designs due to system size.

Solution

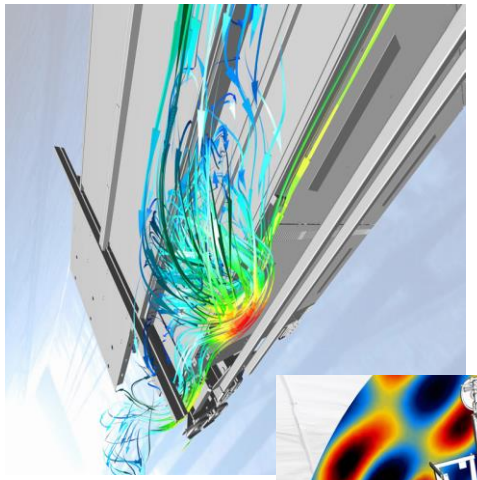
- Use of digital twin technology to try new ideas, test new materials, and understand identified NVH issues.
- Cradle CFD and Actran solutions coupled to develop aero-vibro-acoustic digital model

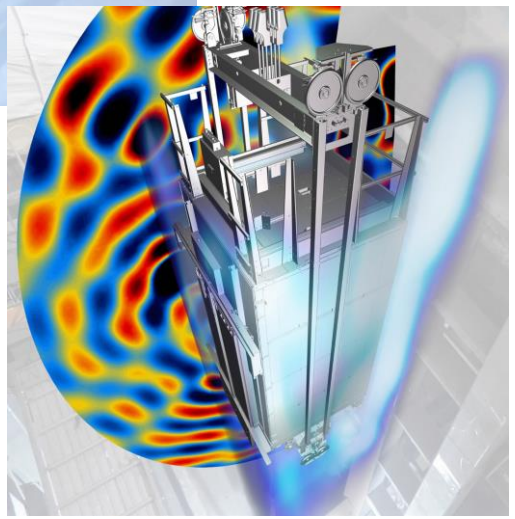
Benefits

- Understanding of noise relate issue, design improvements virtual testing.
- Detailed modeling of airflow around cabin and evaluation of components interactions to reduce noise emission and improve comfort.









[Read the article]

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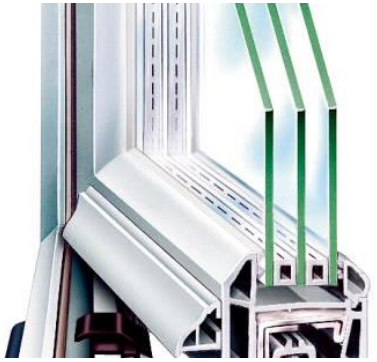
SAINT-GOBAIN

Sound transmission loss

FFT Acoustic Simulation Conference 2014, Acoustic insulation of steel & thermoset panel, Gérald Mercier, (Saint-Gobain), Kévin Ching (INSA de Lyon)

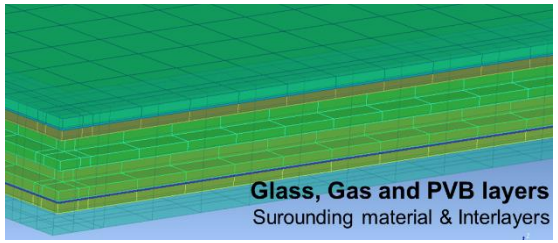
Challenge

- Integration of a vibro-acoustic simulation tool in the product development cycle of new glass designs



Solution

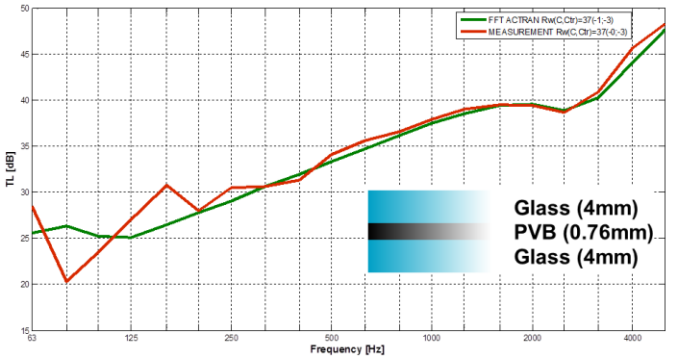
- Actran is a comprehensive vibro-acoustic tool allowing the complete simulation of multilayered materials.
- The Actran API capabilities allow for an easy integration in any HPC environment.



Process automation and Mesh creation with Actran

Benefits

- Virtual prototyping of a huge number of design variations allows avoiding very costly physical testing;
- Drastic reduction of time-to-market for many Saint-Gobain products.



Acoustic transmission losses (TL): Actran Vs Experiments

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bbri.be
Researches • Develops • Informs

Room to room vibration transmission

"We used Actran because of its proven ability to provide accurate results over a broad application range and because it is so easy to use."

***Charlotte Crispin**, Head of Laboratory, BBRI*

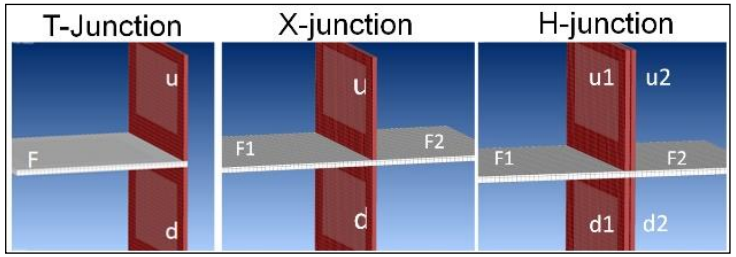
Challenge

- Acoustic requirements in civil engineering become more restrictive.
- Sound insulation is affected by solid-borne vibration transmission through junctions, which usually requires expensive experiments. These phenomena cannot be captured by current empirical formulas.



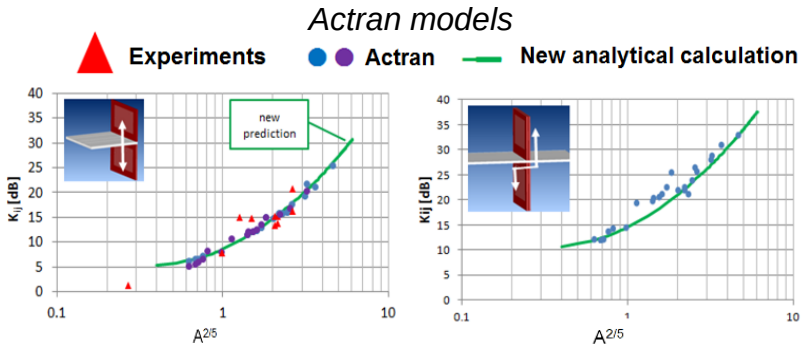
Solution

- Actran simulates wall and floor junctions (T, X and H) and outputs mean square velocities for predicting the vibration reduction index.
- This process can be automated using the Actran API



Benefits

- Successful cross validation between tests and simulation.
- New empirical prediction formula proposed and validated.



Vibration reduction for several wall configurations

[Read the Case Study]

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Heat exchanger modeling

Internoise 2019, Numerical modelling and characterization of a heat exchanger, G. Vatin, B. Ganty, Y. Detandt, S. Lesoinne, J.-J. Embrechts

Challenge

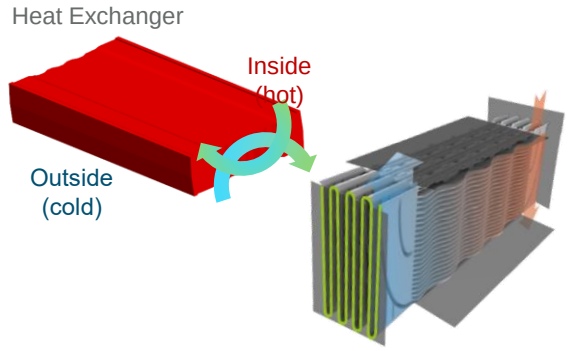
- Numerical modeling of a decentralized unit heat exchanger.
- Account for double flux design on acoustic propagation
- Modeling of visco-thermal dissipations

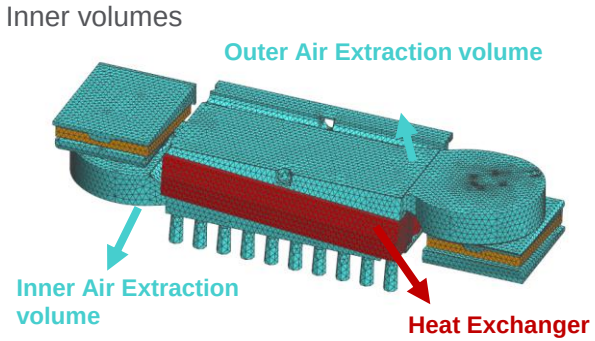
Solution

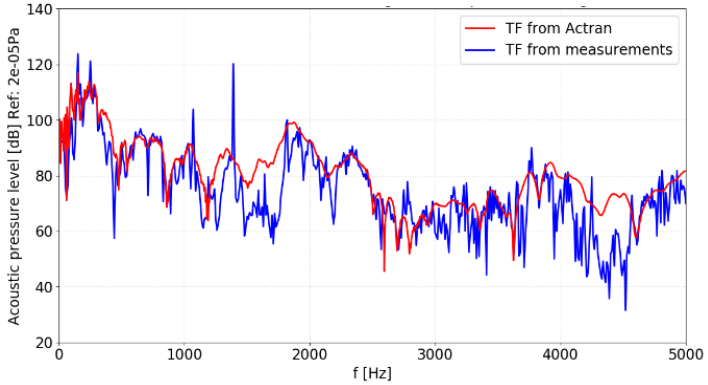
- Anisotropic and visco-thermal dissipations included in homogenized double duct array systems transfer model avoiding complex representation of channels

Benefits

- Model parameters retrieved from measurements.
- Good match in-between experimental and numerical acoustic transfer functions
- Numerical model used for design and optimization







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Acoustic Behaviour of Louvers

Software like Actran it provides a unique experience for fresh learners by exposure to a plethora of scientific methods and yet keeping it distinctly user friendly.

***Dr Avinash Govindaraju**,*
Assistant Professor,
BMS Institute of Technology.

Challenge

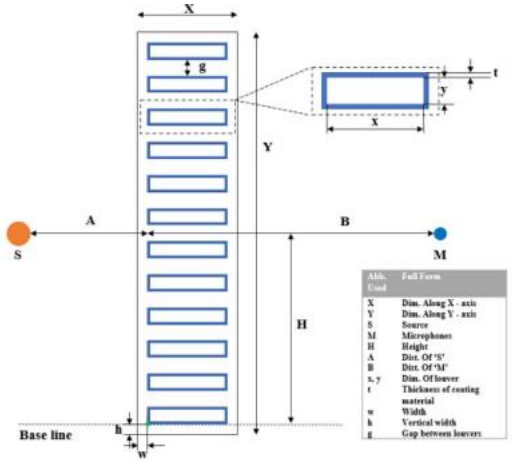
- A louver or louvre is a type of window blind with angled horizontal slats and it is designed to admit light and air but keep out rain and direct sunshine.
- By adjusting the angle of louver panels, one can control the direction of airflow as well as distribution of daylight in the building
- What is the impact of louvers on noise transmission?

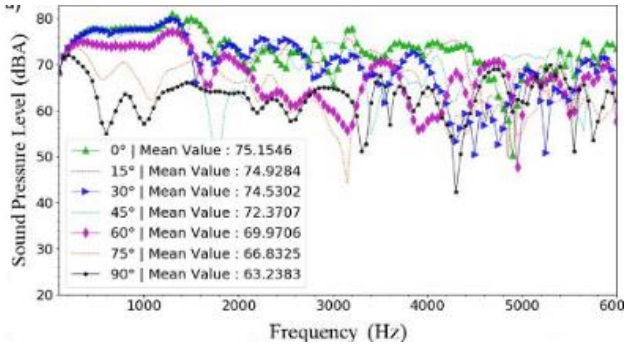
Solution

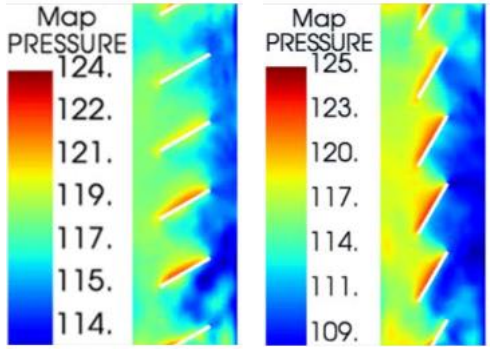
- Actran is used to evaluate the attenuation provided by different louver configurations and shapes as well as identifying the best sound absorbing coating material to cover the surface.
- An insertion loss metric was used to evaluate performance

Benefits

- With Actran, it has been possible to model several variations in a number of parameters such as number of louvers, angle of the louvers, as well as coating materials in a short period of time.







[Read the Case Study]

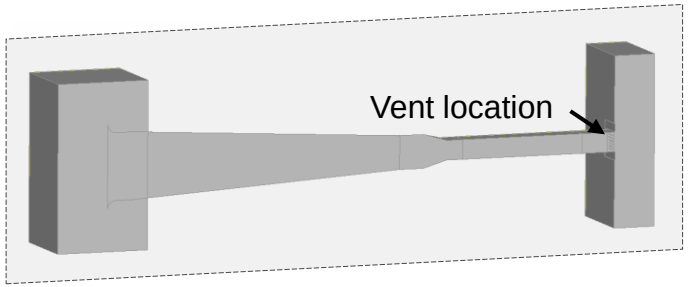
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Air-conditioning vent noise

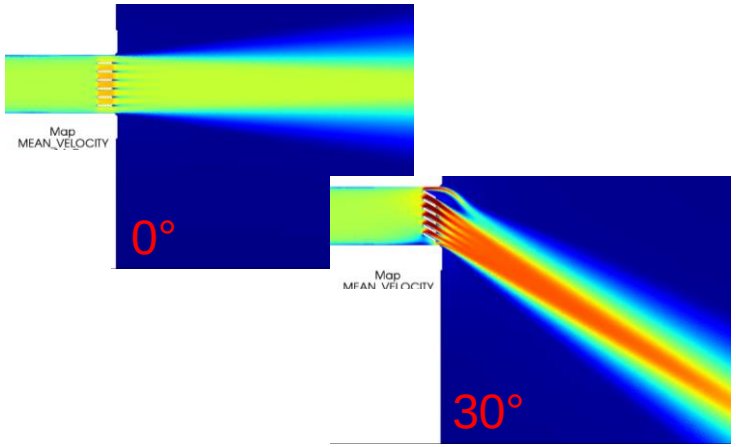
Challenge

- Ventilation noise in buildings come in two forms: fan noise from the fan pushing air around and noise from the vents in the rooms
- Manufacturers need to design vents that have low flow noise emissions since noise can be very annoying



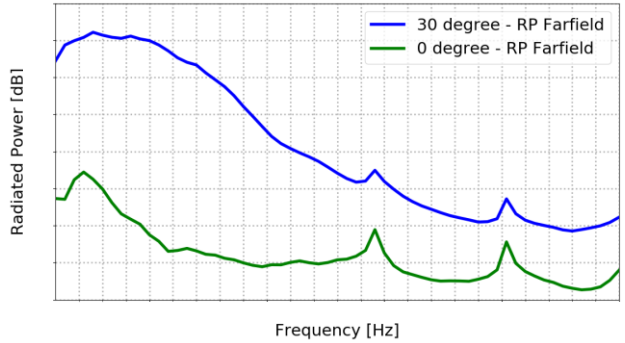
Solution

- A hybrid aeroacoustic approach is used to calculate the flow field, generate the noise sources and propagate the noise to the microphones
- Cradle CFD and Actran are used to compute the different parts of the process in a seamless way



Benefits

- Having access to acoustic indicators based on CAD of the vent, noise assessment can be early performed and drive the choice of low sound air vent design



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Assessment of acoustic panel configuration for working environment

Challenge

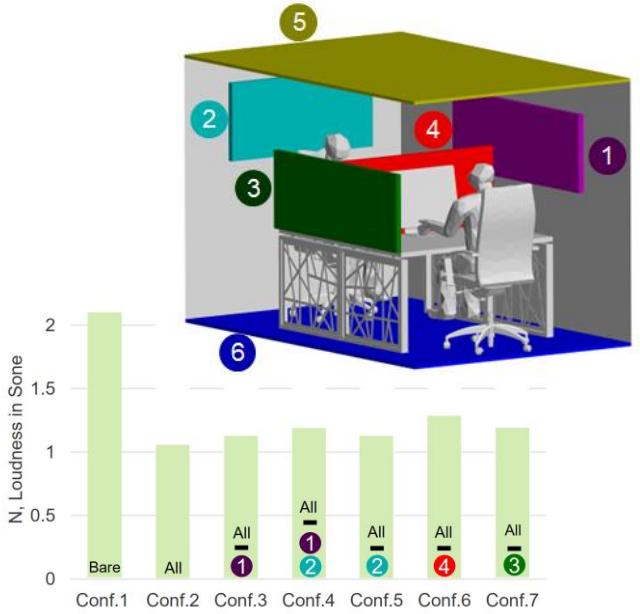
- In an open office environment, employees frequently experience high noise during conversations and phone calls
- It is essential to improve acoustic comfort by using absorbing acoustic panels
- Acoustic panel can be introduced to reduce noise, but optimal positioning remains a challenge

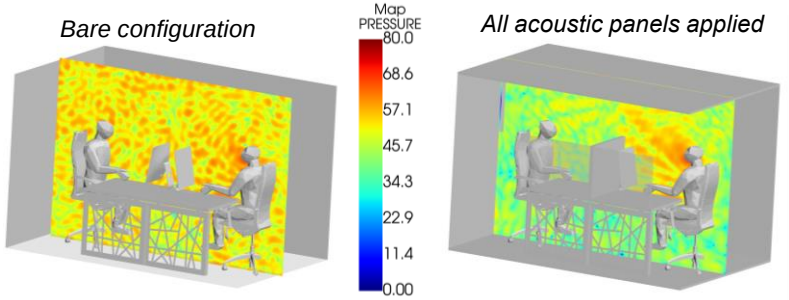
Solution

- Actran is used toe valuate panel performance based on absorption data provided by manufacturers
- A corner of the room is modelled, and the global loudness is considered to assess the different acoustic panel configurations when a person is speaking

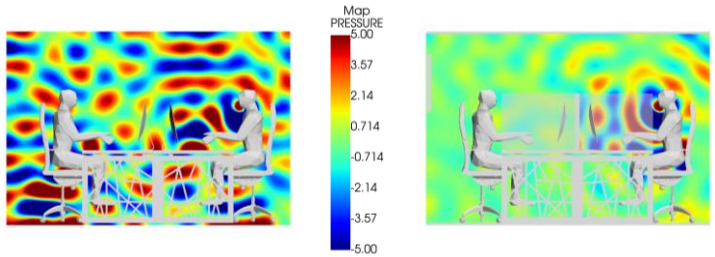
Benefits

- Different panel materials and positions can be easily evaluated with acoustic simulation
- Dedicated indicators, such as loudness and the speech intelligibility index (SII) can be accessed readily





Sound Pressure Level [dB] at 2kHz



Real sound pressure [Pa], radiation maps at 1kHz

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Sound reduction index of double window system

Acoustic Science & Technology, 2022, Pilot Study on Numerical Prediction of Sound Reduction Index of Double Window System : Comparison of Finite Element Method with Measurements, M. Mimura, T. Okuzono, K. Sakagami

Challenge

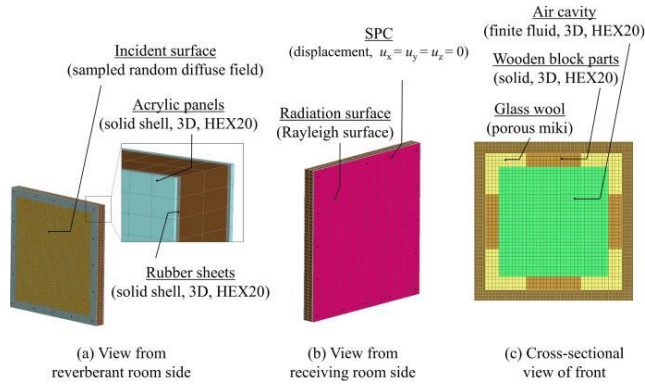
- Sound insulation is essential for preventing the infiltration of outdoor noise such as traffic noise and for protecting privacy.
- Simulation is an effective way to reduce sound insulation testing and development costs.

Solution

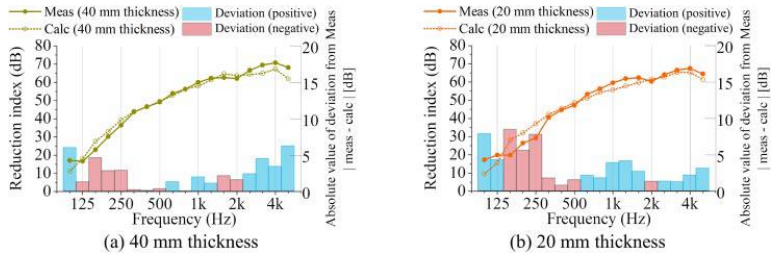
- A double window panel and frame model is solved with Actran, comprising of the glass panel, rubber sheets, acrylic panels, an air cavity, wooden block parts and glass wool.
- Various types of finite element components are used to evaluate the transmission loss, including solids, solid shells and porous materials.
- Only some elements are discretized with finite elements to keep the calculation cost reasonable at high frequencies.

Benefits

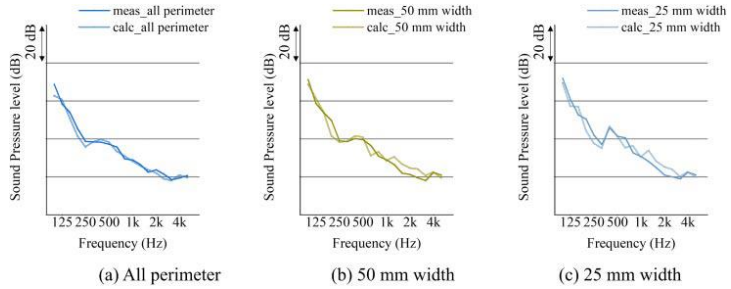
- Good correlation between the sound pressure level inside the air cavity and the measurement for all frequencies.
- Good correlation between the finite element results and the measurements in the entire frequency range for the sound reduction index.



Finite element model



Simulations and measurements of the sound reduction indices of improved model



Simulation and measurements of SPL

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Template



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Solution

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Benefits

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