



HEXAGON

NVH Solutions for the Shipbuilding industry

March 2021



A small city ?



**A luxury comfortable
private place ?**



**A transportation
platform?**



A working environment ?



A strategic asset ?

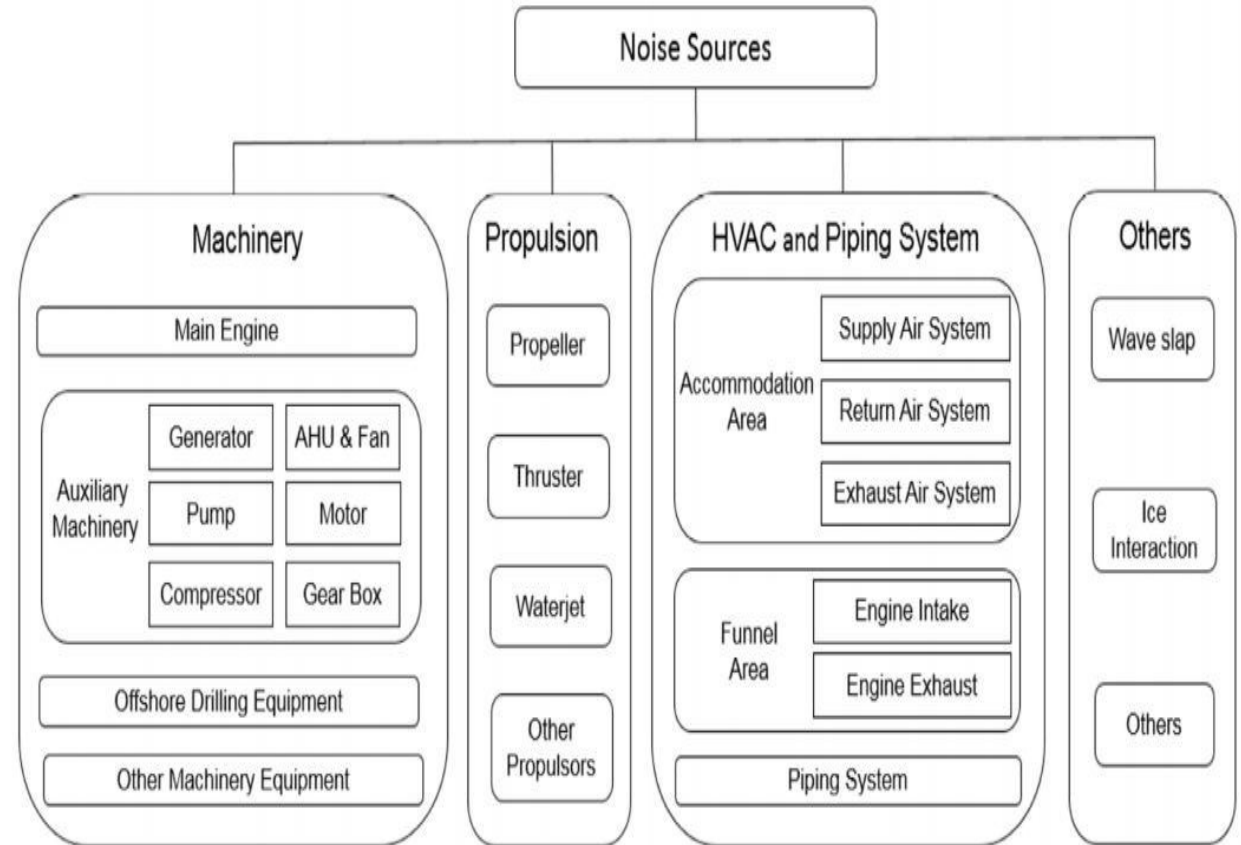


An unmanned vehicle ?

Interior noise

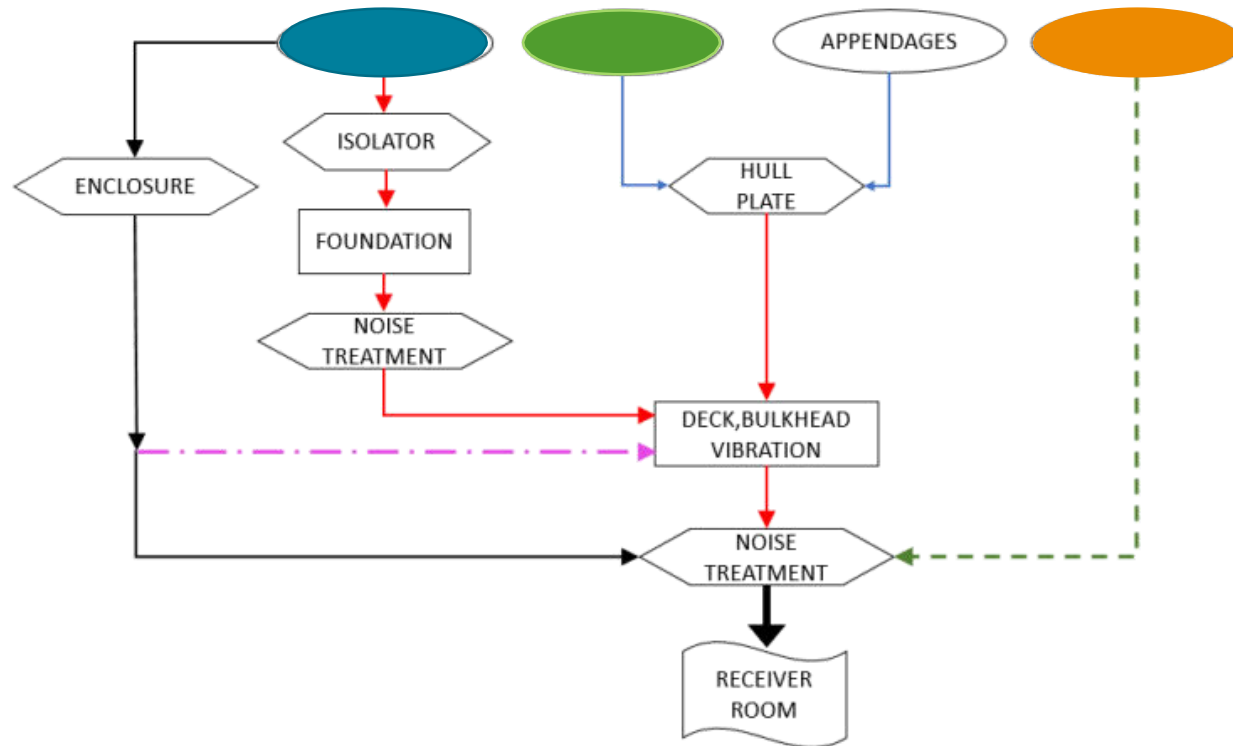
Know the **source**, understand the **path**, quantify the **contribution**

- Whatever the type of boats, noise control management aims at listing the different noise sources existing onboard
- Onboard noise sources can be divided into 4 main categories:
 - **Machinery**
 - **Propulsion**
 - **HVAC & Piping system**
 - **Others**
- For each categories, Multiphysics CAE can help
 - Understand & predict their **behavior**
 - Optimize their **performances**

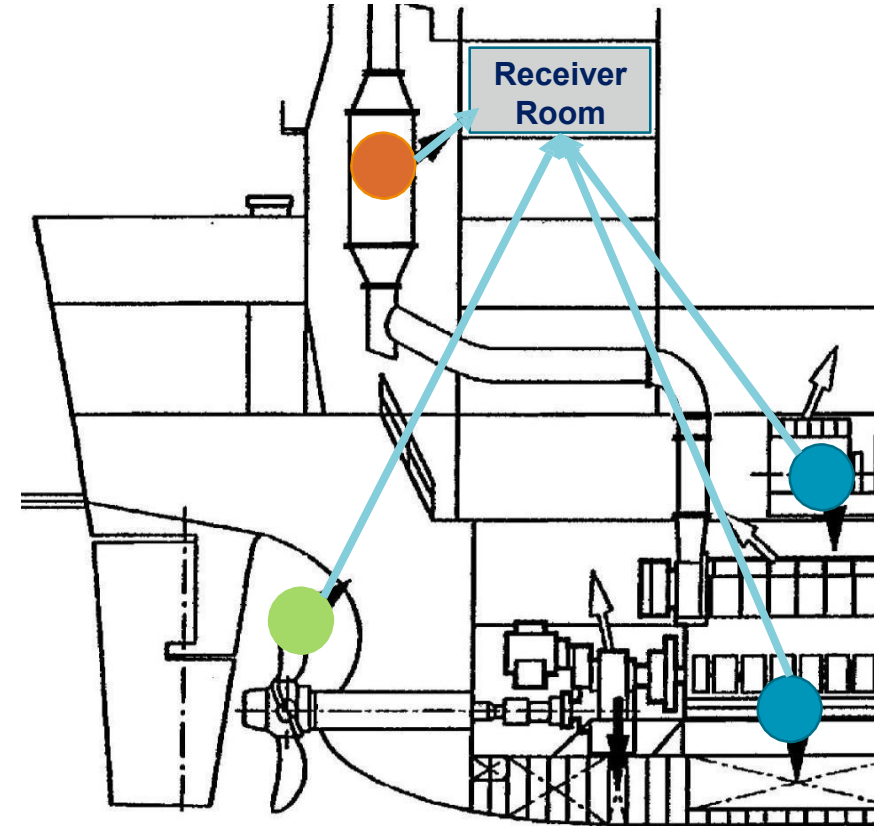


PROPAGATION MECHANISMS

Noise Transmission Flow Chart



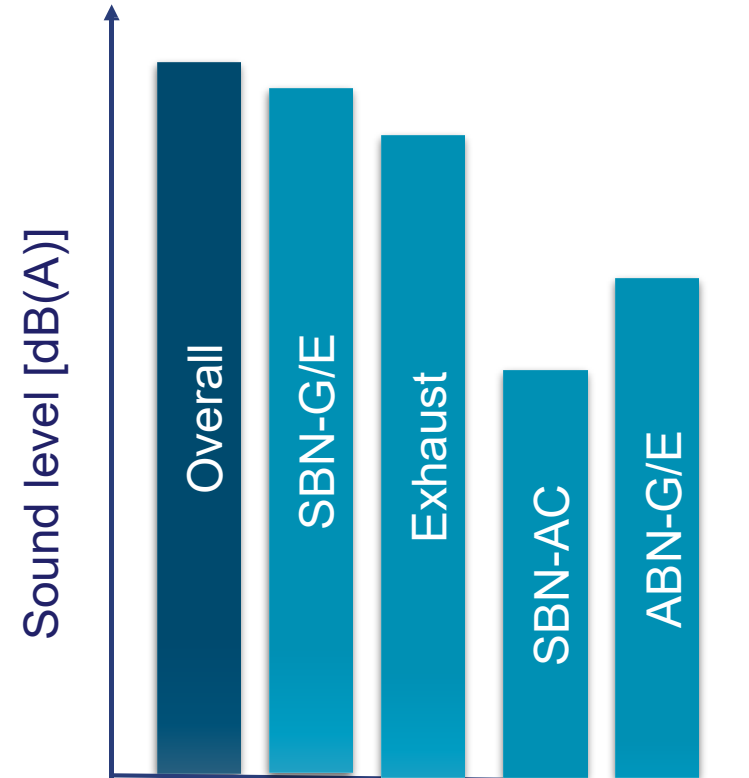
— Airborne Path — Structure-borne Path — Fluid-borne Path
 - - - Secondary Structure-borne Path - - - Duct-borne Path



GUIDANCE NOTES ON ONBOARD NOISE ANALYSIS, American Bureau of Shipping, April 2019

Interior noise source contribution

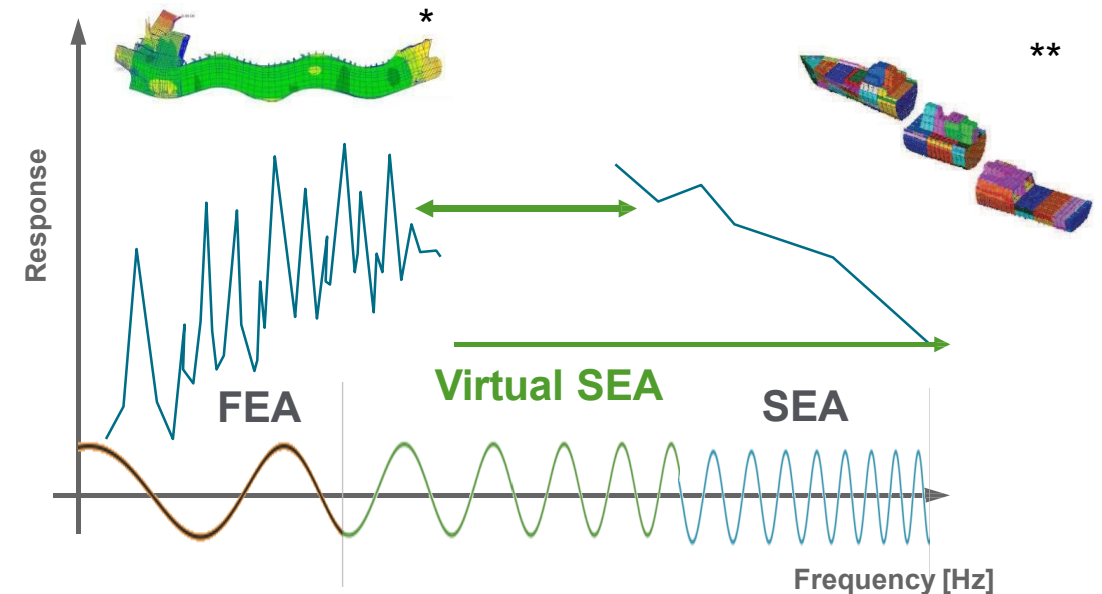
- Overall interior noise is the sum of the different noise sources
- Typical overall interior noise is mainly due to:
 - **Structure-borne noise (SBN)** contribution of **main engine and generators**
 - **Exhaust system**
 - **Structure-borne noise** contribution of **air conditioning system**
 - **Air-borne noise (ABN)** contribution of the **main engine and generators**



Noise & Vibration analyses

Predicting **structure-** and **air-borne** noise

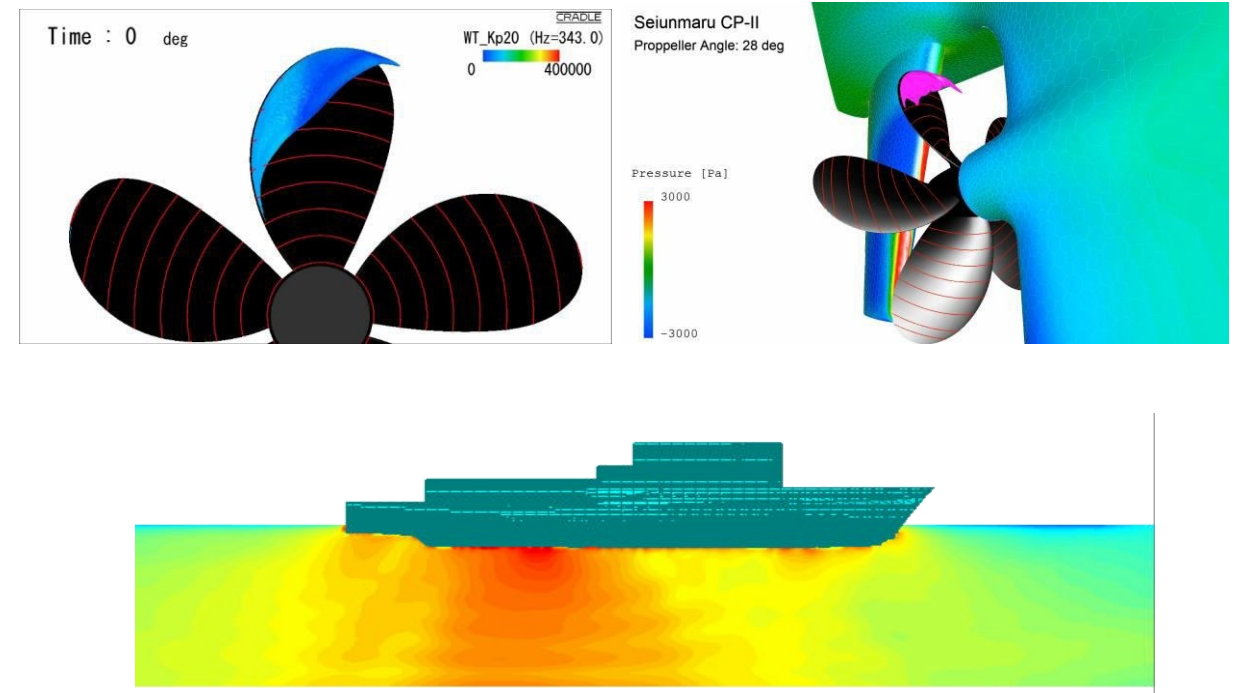
- **Recommended computational models by IMO:**
 1. **Finite Element Analysis (FEA)** [...] may contribute to estimate **low-frequency noise and vibration levels**
 2. **Statistical Energy Analysis (SEA)** for **high-frequency transmitted noise and vibration levels**
- Hexagon CAE solutions cover the entire frequency range allowing engineers to act at the source level or understand how to mitigate noise and vibrations propagation



Underwater noise*

Recommended computation models by IMO

1. **Computational Fluid Dynamics (CFD):** flow characteristics around the hull and appendages, generating the wake field in which the propeller operates;:
2. **Propeller** analysis with **CFD** can be used for predicting cavitation;.
3. **Statistical Energy Analysis (SEA)** for high-frequency transmitted noise and vibration levels from machinery
4. **Finite Element Analysis (FEA)** [...] may contribute to estimate low-frequency noise and vibration levels from the structure of the ship excited by the fluctuating pressure of propeller and machinery excitation



Numerical Acoustics capabilities

Overview

Acoustic radiation

Finite Elements Analysis

What:

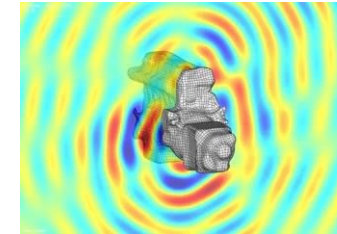
- Import vibrations from measurements or computed with other FEA solvers or define your own acoustic sources
- Consider all necessary acoustic mechanisms from convection, complex dissipations mechanisms, visco-thermal effects, ...

Outcome:

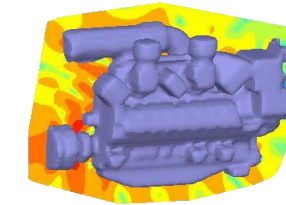
- Sound pressure, intensity, radiated power
- Contribution of different zones to the radiated power
- Mode contribution to far field results
- Narrow band, 3rd Octave, dB, dBA.

Applications:

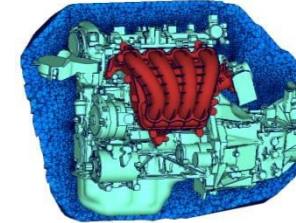
- Radiation of vibrating structures (Engine, gearbox, Manifold, oil pan, turbocharger, generator)
- Ducted acoustics (Air inlet, outlet, silencers, exhaust, ducts with perforated sheet)
- Interior acoustics (compressor, noise inside cabin)



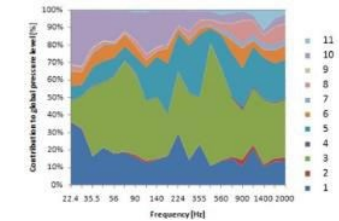
Heavy duty engine
acoustic radiation



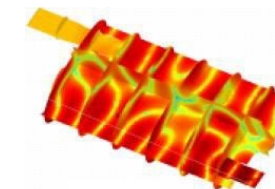
Ship engine
acoustic radiation



Model for sound radiation
of heavy duty engine



Contribution of different
areas to the radiated noise



Muffler modeling
in Actran

Vibro-Acoustic Simulation

Finite Element Analysis

What

- Translate existing FE models, use modal extractions (Nastran, ANSYS? ...) or build your model directly in Actran
- Define strong fluid/structure coupling
- Model accurately all acoustic treatments and acoustic dissipation mechanisms
- Define your excitations:
- Mechanical excitations: point load, distributed load, distributed pressure, moments, measurements
- Random excitations: diffuse sound field, turbulent boundary layer, rain-on-the-roof

Outcome

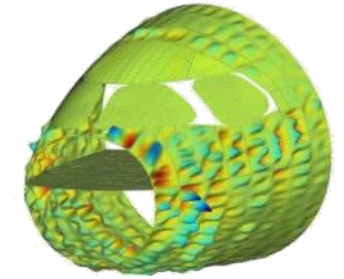
- Acoustic radiation and structural (displacement, acceleration, force, stress) results
- Energy balance statements
- Transfer path analysis (structure borne and airborne)
- Modal participation factors

Applications

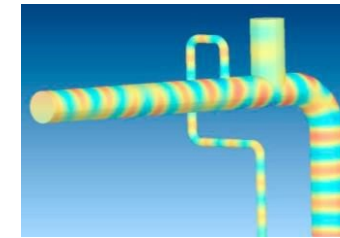
- Acoustic Induced Vibration Fatigue caused by interactions between acoustic and structure vibration modes
- Acoustic transparency of multi-layer structure (TL, stresses)
- Muffler with porous material, shell noise, entire exhaust line
- Car cabin noise with trim



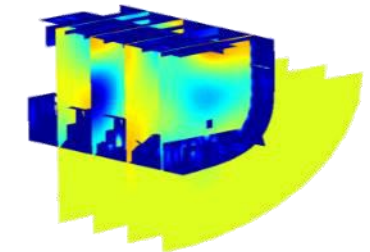
Extensive porous modeling capabilities



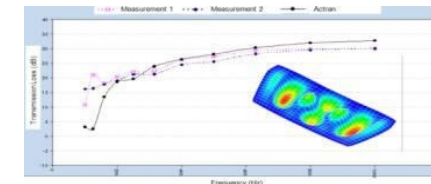
Vibrations computed by Actran on an aircraft cockpit



Acoustic Induced Vibrations



Ship hull vibration



Transmission loss of a windshield

Vibro-Acoustic Simulation

Virtual Statistical Energy Analysis – Virtual SEA

What:

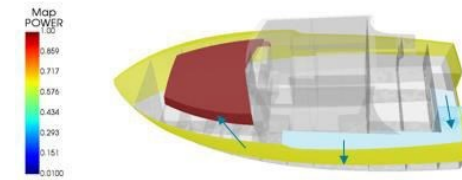
- **Extend existing vibro-acoustic FE model** to energetic models (SEA) for mid-and high frequency NVH analyses
- Inputs: Structural modes, K/M matrices & Finite element mesh for user-defined sub-structuring
- Excitations: Injected power, random excitation, distributed load, distributed pressure, point load and field point load (can be a constant, spatially or frequency dependent)

Outcome:

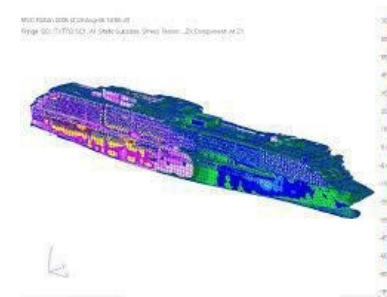
- Kinetic and potential Energy
- Accelerations, velocities, pressures
- Equivalent radiated power (ERP)
- Transfer path analysis
- CLFs, DLFs

Applications:

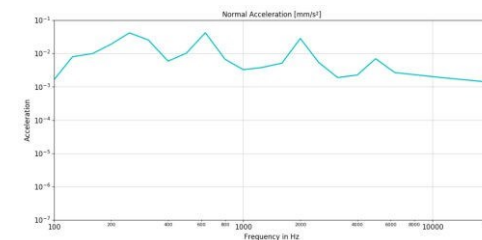
- Large automotive, aero-space & shipbuilding vibro-acoustic applications



On board noise



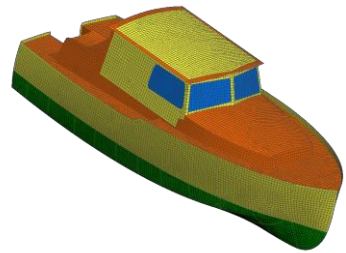
Full



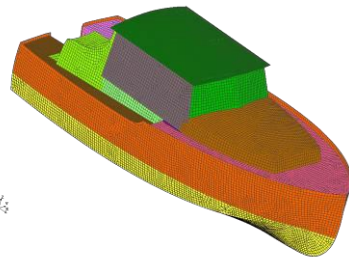
20Hz – 20kHz analysis

Virtual SEA

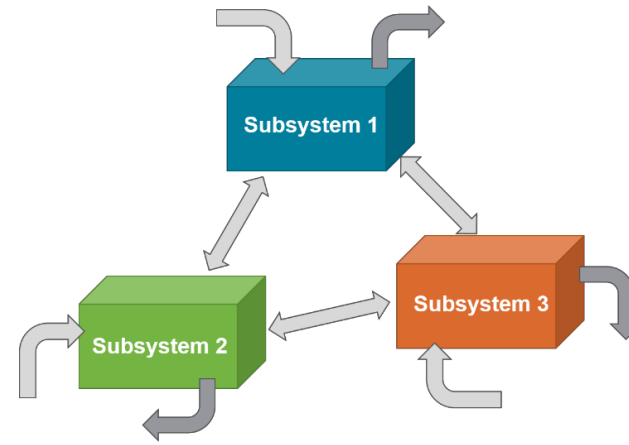
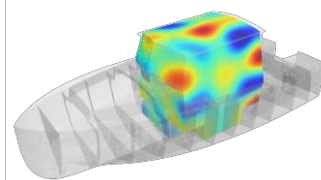
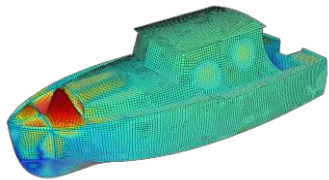
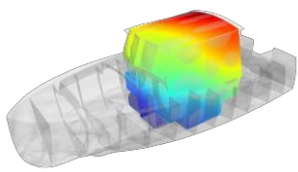
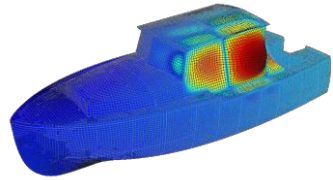
How does it work?



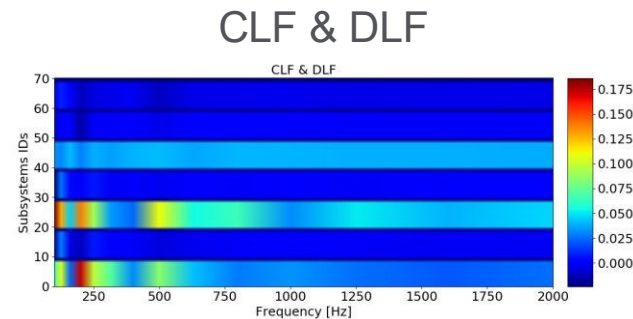
FE Model



SEA partitioning

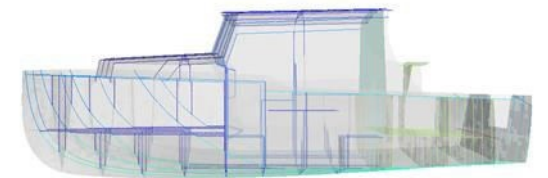
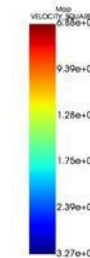
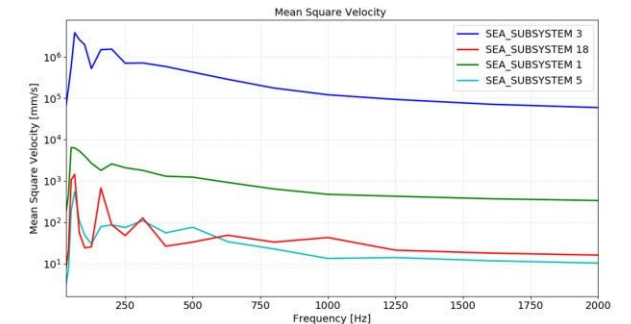


Virtual Power Injection Method



Built once: reusable

Loading Condition Definition



Model Preparation



SEA Model Building



Solution
Computation

Loading Condition Definition



Aero-Acoustic Simulation

Finite Element analysis

What:

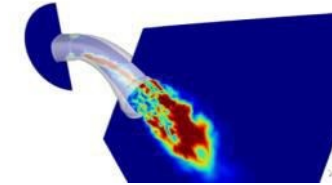
- Study the noise generated by turbulent flows
- Based on acoustic analogies
 - Noise sources are taking into account whatever they are: monopole, dipole, quadruple...
 - Lighthill for low speed flows
 - Möhring for mid to high speed flows

Outcome:

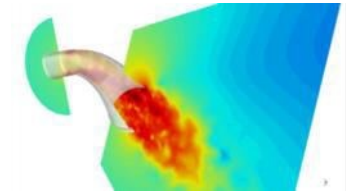
- Predict acoustic levels due to aero- or hydro- acoustic sources
- Efficiently compare blade profiles, duct geometry and working conditions on resulting noise level
- Couple aero- or hydro-acoustic noise sources with vibro- acoustic models

Applications:

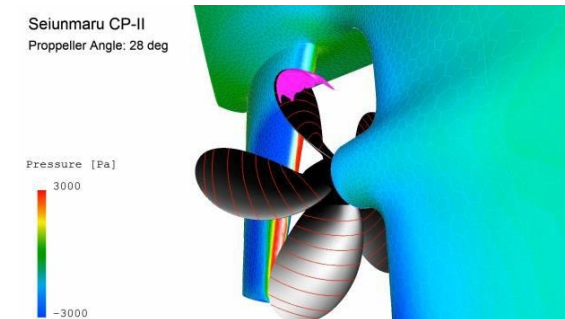
- HVAC noise, fan noise, wind noise, propeller noise



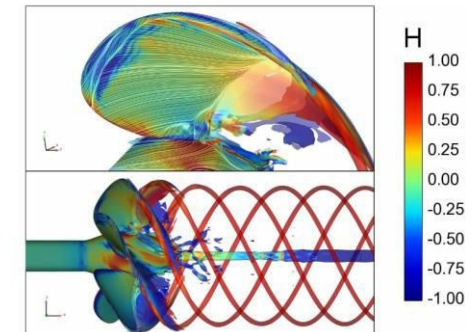
Unsteady flow in an HVAC duct



Noise produced by HVAC system



Cavitation modeling



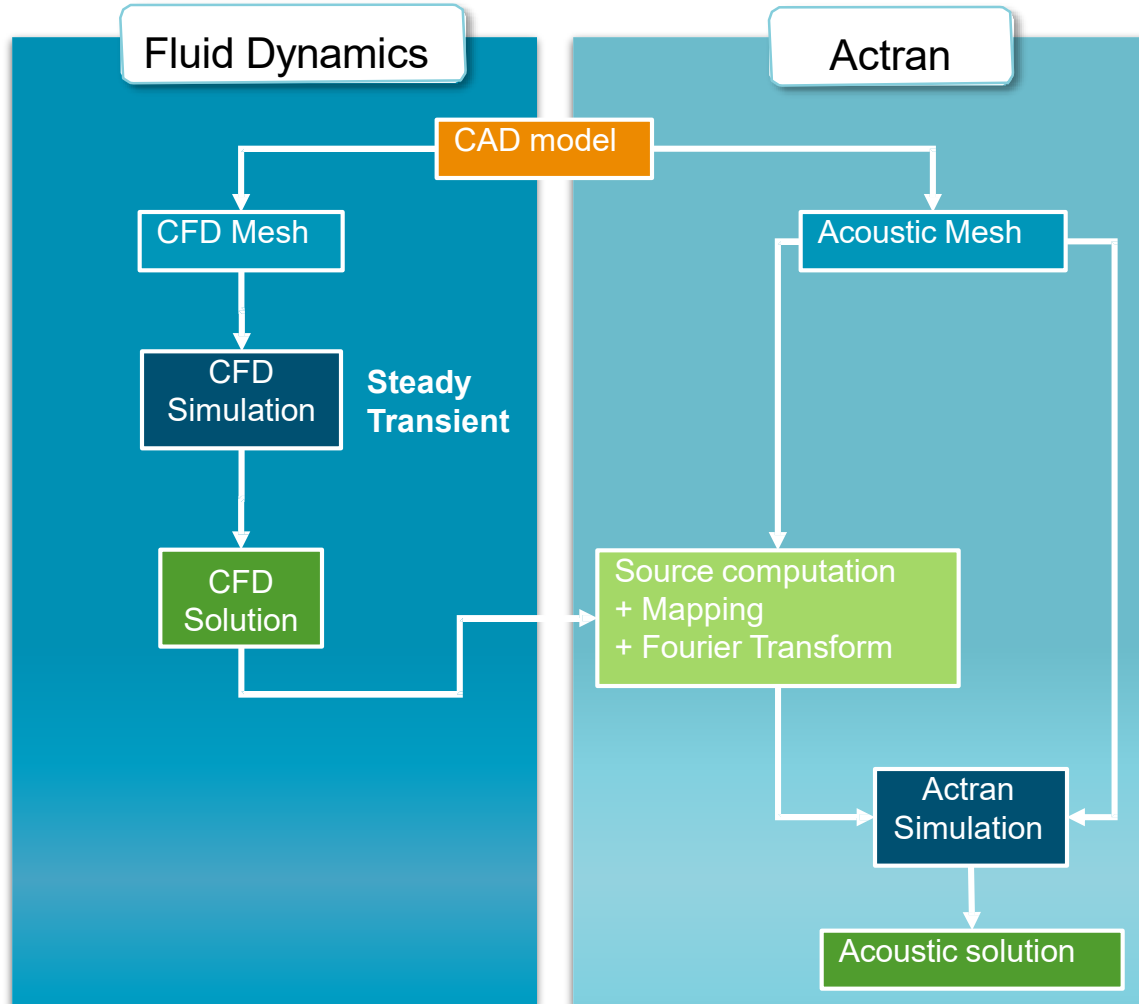
Hydro-acoustic analyses



Hydro-acoustic propagation

Hybrid aero-acoustic CAE analysis

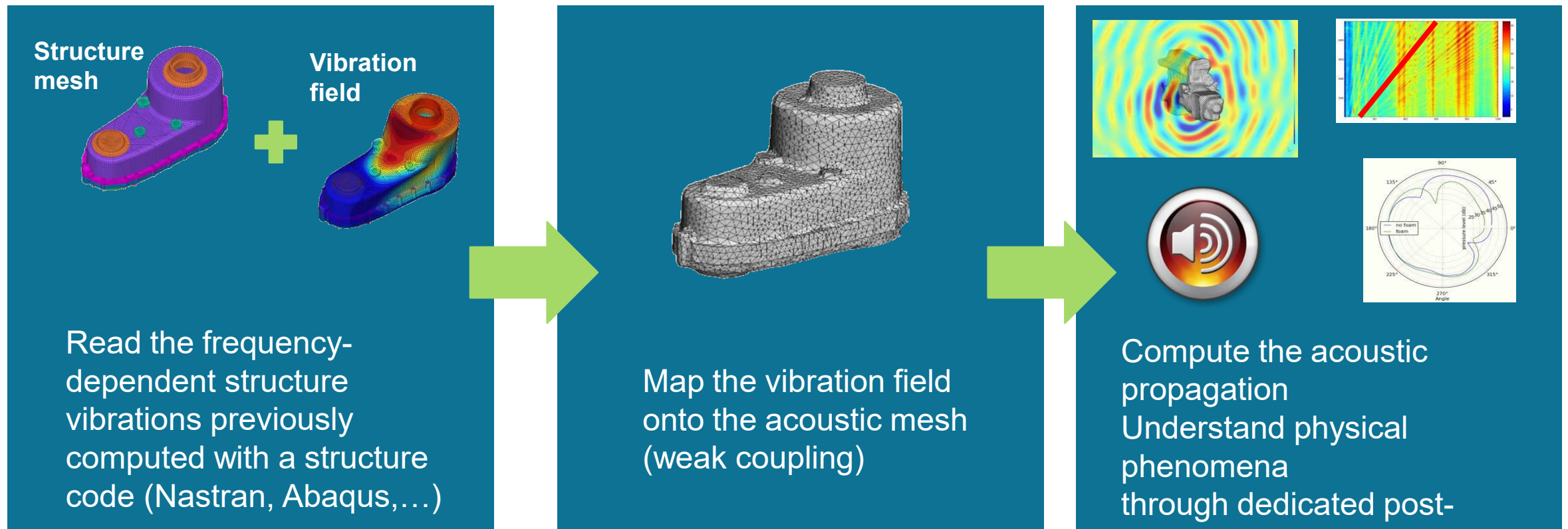
How does it work?



- **EASY** : CFD and acoustic computational chains are decoupled
- **EFFICIENT** mapping strategy (integration technique) → Acoustic meshing criterion is sufficient
- **ROBUST** : Actran directly reads native CFD files
 - MSC/Cradle
 - Fluent
 - StarCCM+
 - EnsightGold
 - Openfoam
 - Etc...

Applications review

Acoustic radiation of vibrating structure Workflow overview

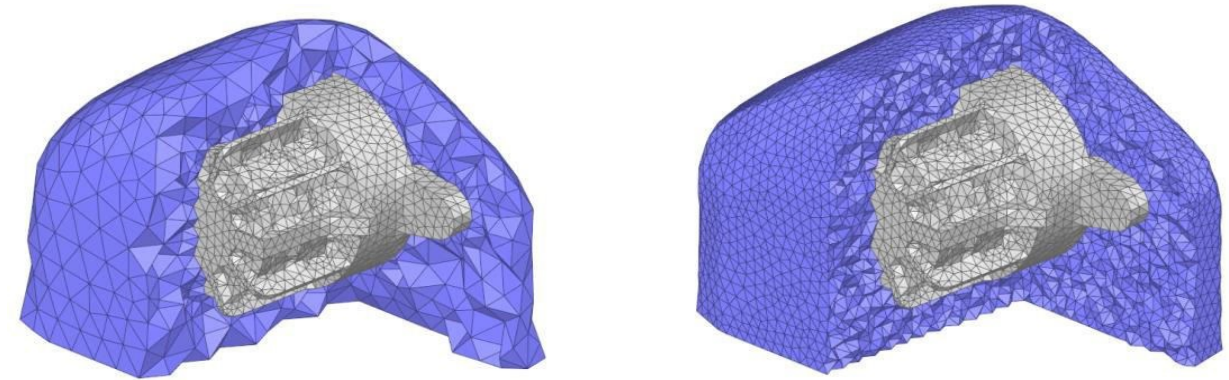
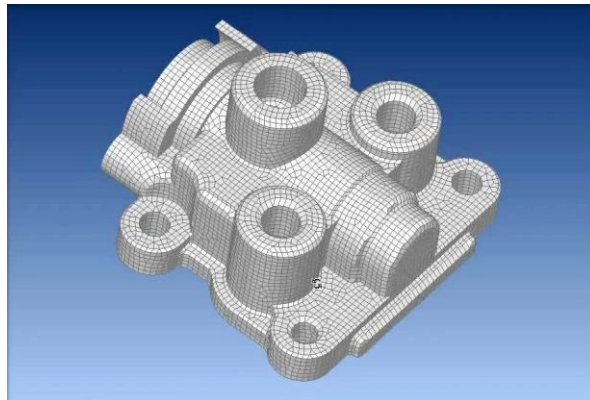


Acoustic radiation of vibrating structure

Hexagon unique offering

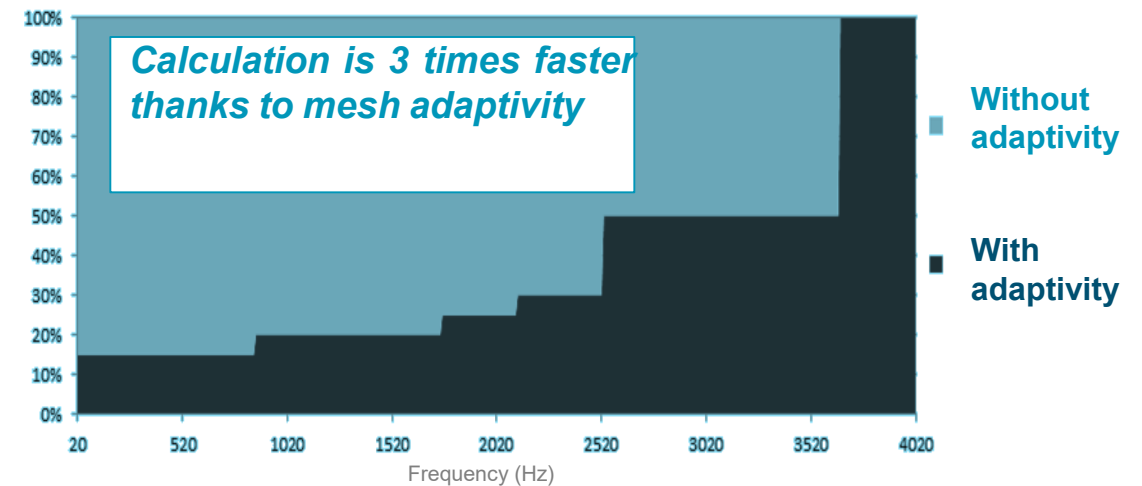
Automated Acoustic Radiation with Adaptive Meshing Technology

- Automated acoustic meshing technology for Radiation or Exterior Vibro-Acoustics problems
- Benefits:
 - No external meshing tool required anymore
 - No human effort needed to build the mesh
 - Optimized CPU time
 - Automatic Acoustic post-processing of existing FEA solution



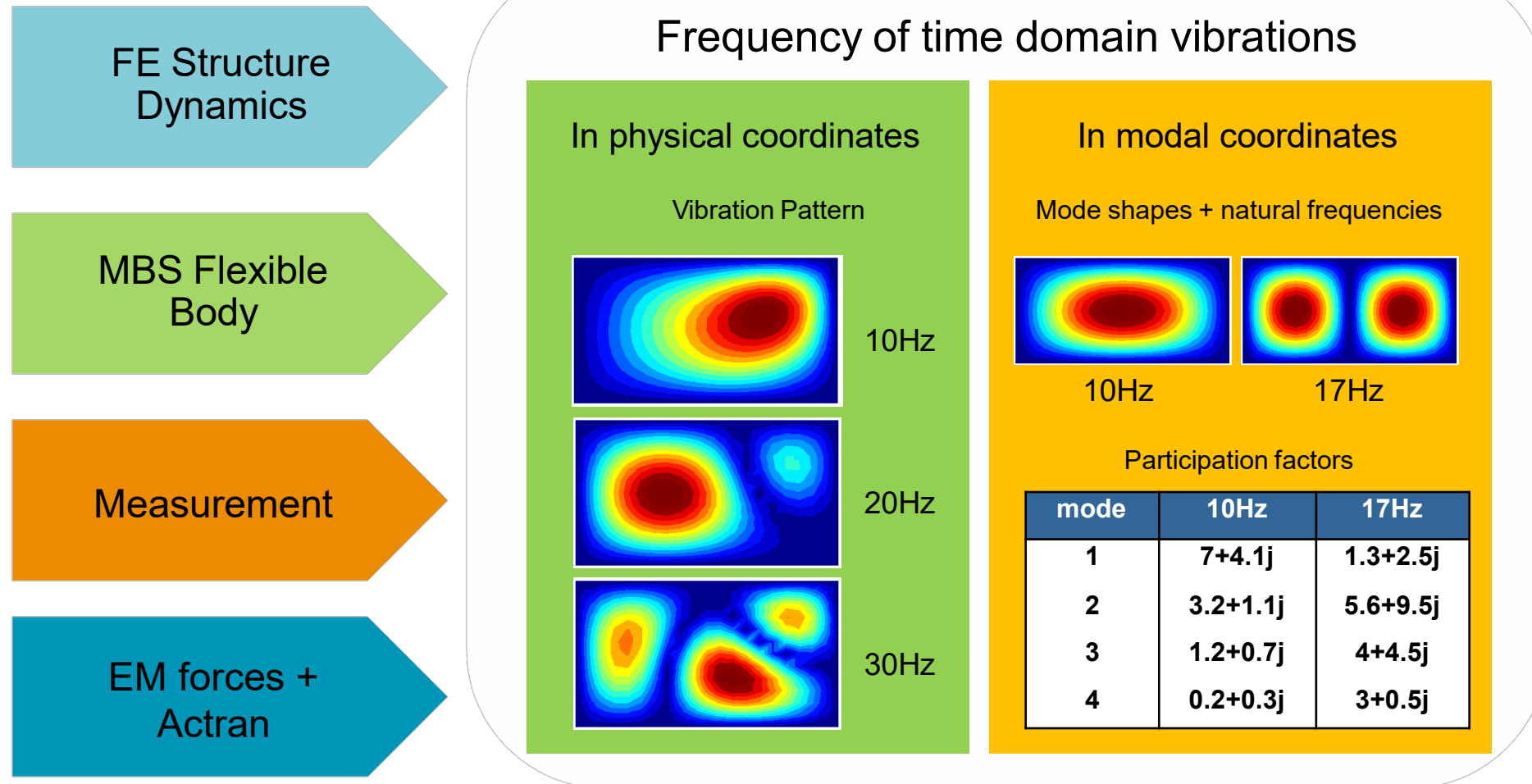
Low frequency mesh

High frequency mesh



Acoustic Radiation with Actran

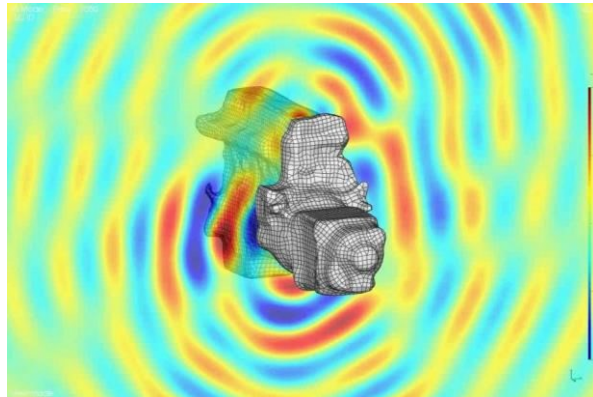
Noise Source



Acoustic Radiation with Actran

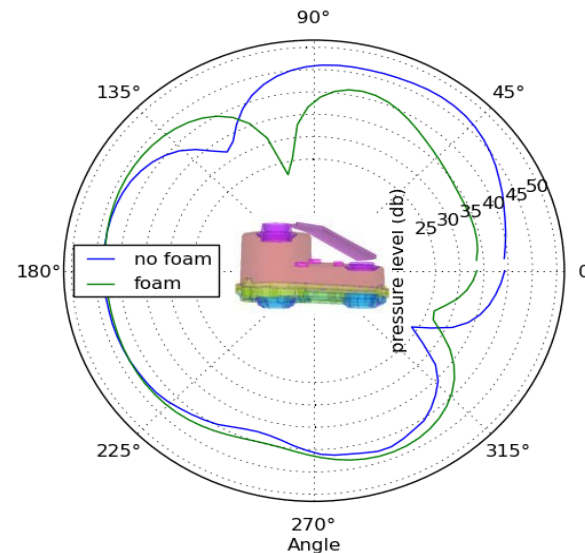
Evolution of Acoustic Radiation calculations

Free Field Radiation



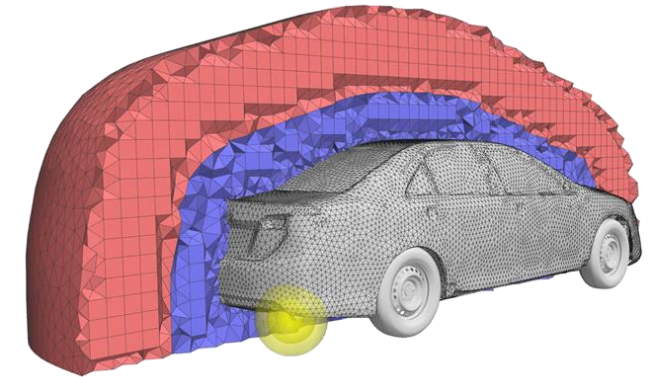
Sound Pressure Level
Radiated Power
Radiation efficiency
Transfer Path Analysis

Absorption mechanisms



Directivity change
Cover absorption
Coupling with structure

Complex propagation



Structure (rigid, porous)
Absorption on floor
Pass-by Noise



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.

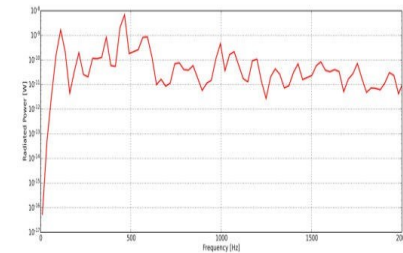
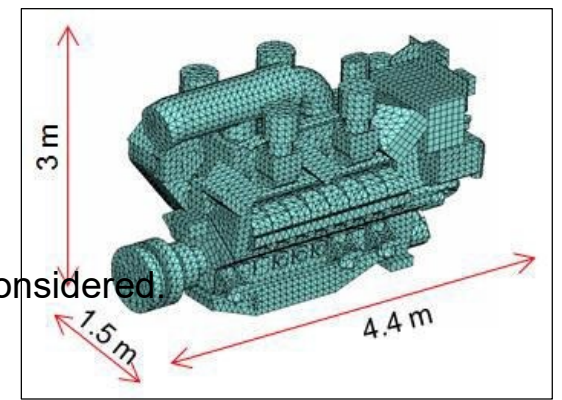
Noise at a given microphone position (as a function of frequency)

Solution

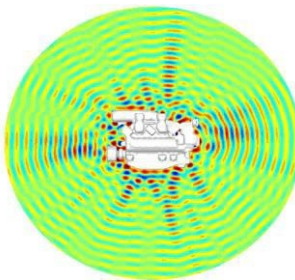
- Actran computes the radiated noise in the far field, from vibration levels computed by an FEA tool like Nastran.
- The acoustic model is designed to reach 1000Hz, namely the order 33 at RPM 1800.
- Acoustic covers can be modeled in Actran for the noise reduction.

Benefits

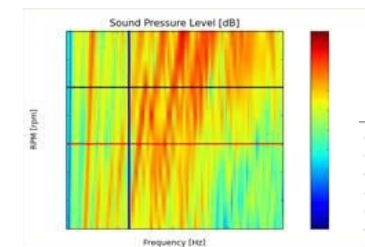
- Reduced development cost thanks to the fast simulation of the engine sound radiation.
- Engine order and structural modes can be identified on the Actran waterfall diagram.



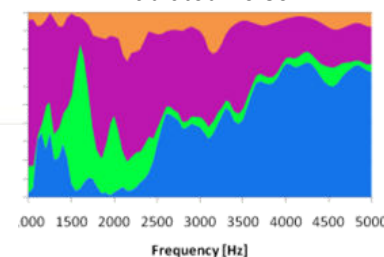
Map of the radiated noise



Waterfall diagram output by Actran

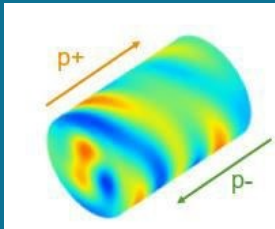


Contribution of different part of the engine to the radiated noise

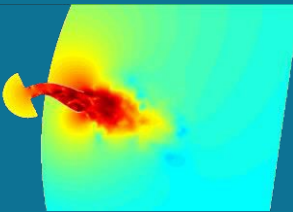


Key Modeling Capabilities

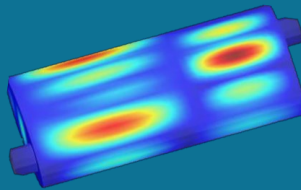
- Engine pulse
(duct mode
excitation)



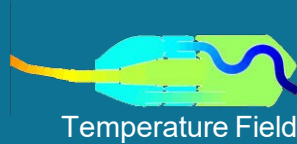
- Turbulent Flow
(based on steady or
unsteady CFD)



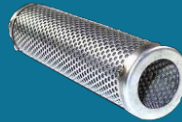
- Engine vibration
(shell modelling
& fluid coupling)



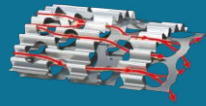
- Flow
heterogeneity



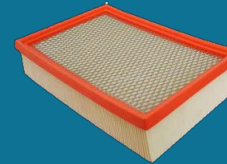
- Perforated
plate



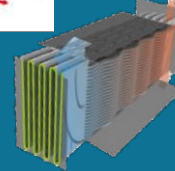
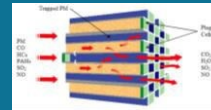
- Catalytic
converter



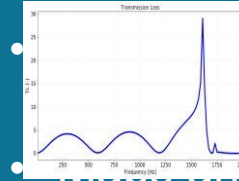
- (Anisotropic)
Porous
treatment



- GPF, Heat
exchanger



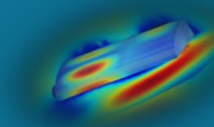
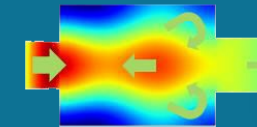
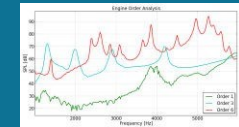
- Frequency response plots



- Modal analysis



- Maps and Animations





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



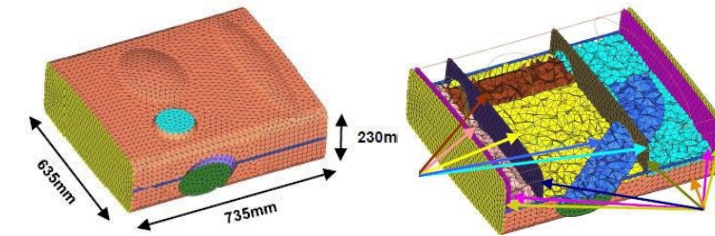
Truck muffler

“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

Solution

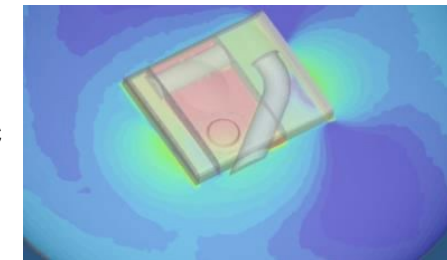
- Actran allows to predict the pipe and the shell noise of complex exhaust systems.
- Acoustic and structural components are all modeled in Actran for strongly coupled vibro-acoustic computations.



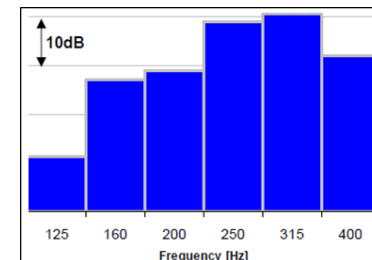
Vibro-acoustic model

Benefits

- Actran enables a better understanding acoustic of phenomena in order to continue leading-providing 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

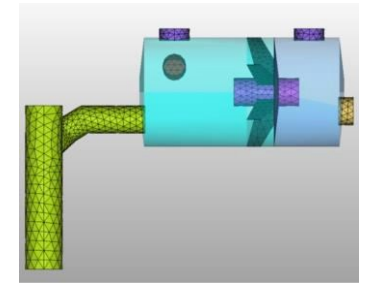
| hexagonmi.com/FFT Centre

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.



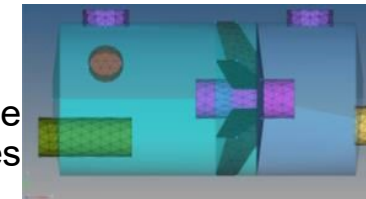
Industrial silencers



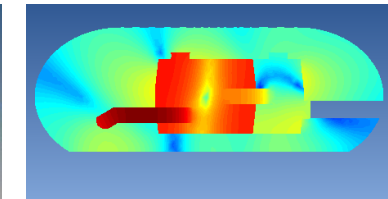
Actran model

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.



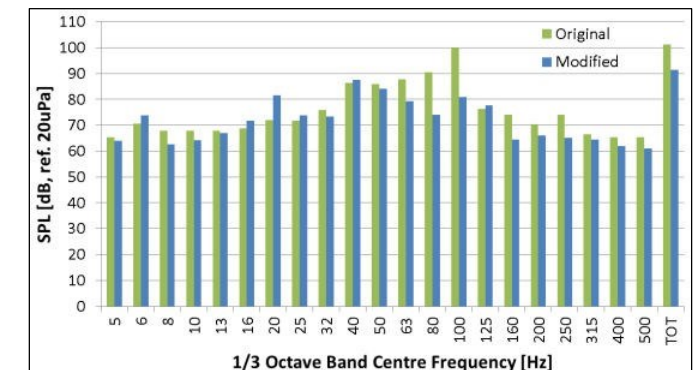
Modified design
(tube inside the silencer)



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

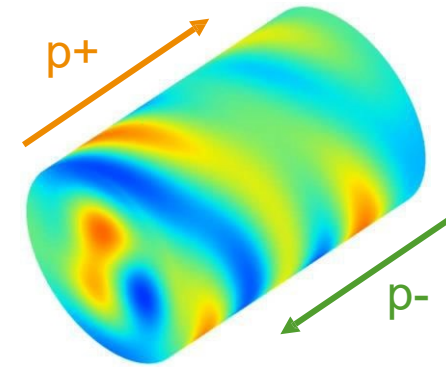
Exhaust and HVAC systems

Modeling Capabilities Details

Engine pulse

Acoustic duct modes

- Engine generate acoustic **harmonic pulse** propagating through the exhaust duct
- **Inside a duct**: any acoustic wave that propagate:
 - can be decomposed into an **incident wave** and a **reflected wave**
 - can be represented as a **superposition of duct modes**
- At low frequencies and/or small sections, only plane wave propagate → 0 order mode
- Note:
 - Higher order modes can be also be injected (higher frequencies and larger sections)
 - “Free” modes can be applied to model the duct (infinite) continuity



modal amplitude

$$p(f) = p^+ + p^- = \sum_{i=1,N} \alpha_i \bar{\varphi}_i + \sum_{j=1,N} \alpha_j \bar{\varphi}_j^-$$

mode shape

anar mode

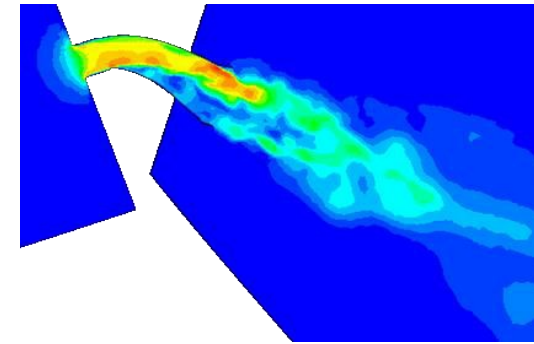
PI

The diagram illustrates the decomposition of an acoustic pulse into its constituent duct modes. At the top, a 3D visualization of a pulse is shown with incident (p+) and reflected (p-) waves. Below this, a light blue box contains the equation: $p(f) = p^+ + p^- = \sum_{i=1,N} \alpha_i \bar{\varphi}_i + \sum_{j=1,N} \alpha_j \bar{\varphi}_j^-$. An orange arrow labeled 'modal amplitude' points to the coefficients α_i and α_j . A green arrow labeled 'mode shape' points to the mode shapes $\bar{\varphi}_i$ and $\bar{\varphi}_j^-$. Below the equation, three 3D visualizations of duct modes are shown, each with a different color gradient (red, blue, and green). The first two are labeled 'anar mode' and the third is labeled 'PI'.

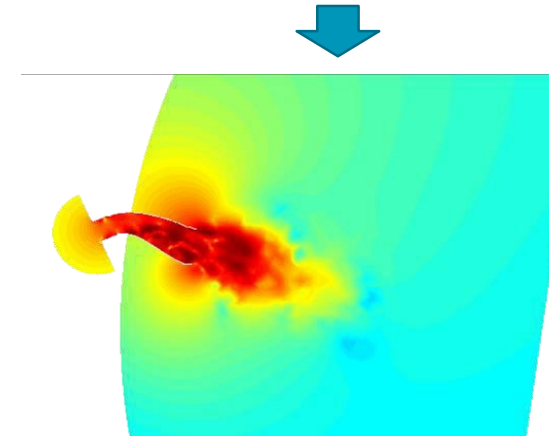
Turbulent Flow (1)

Aero-acoustic sources from **unsteady** CFD

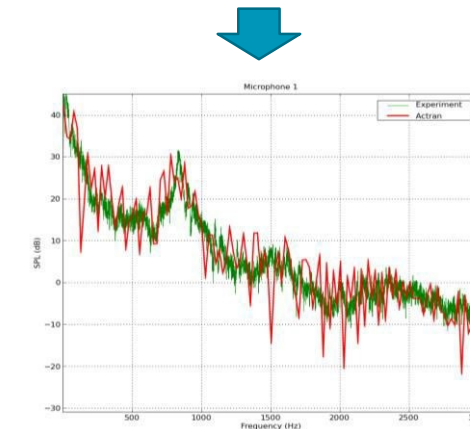
- **Flow noise**: sound generated noise from flow instabilities and fluctuations
- One-way interaction between the flow field and acoustic field → the computation of **the flow and the acoustic** can then be **decoupled**:
 1. The flow is computed using an unsteady CFD solver
 2. Using the Lighthill analogy, Actran extracts the acoustic sources from the CFD results and computes the acoustic propagation
- The Lighthill analogy approach used in Actran is preferred over pure CFD approach:
- Faster than (compressible) CFD for Acoustic
- Accurate results (small acoustic perturbations)
- Possibility to definition of damping, structure and acoustic boundary conditions



Unsteady CFD
velocity results



Source computation
and acoustic
propagation (Actran)

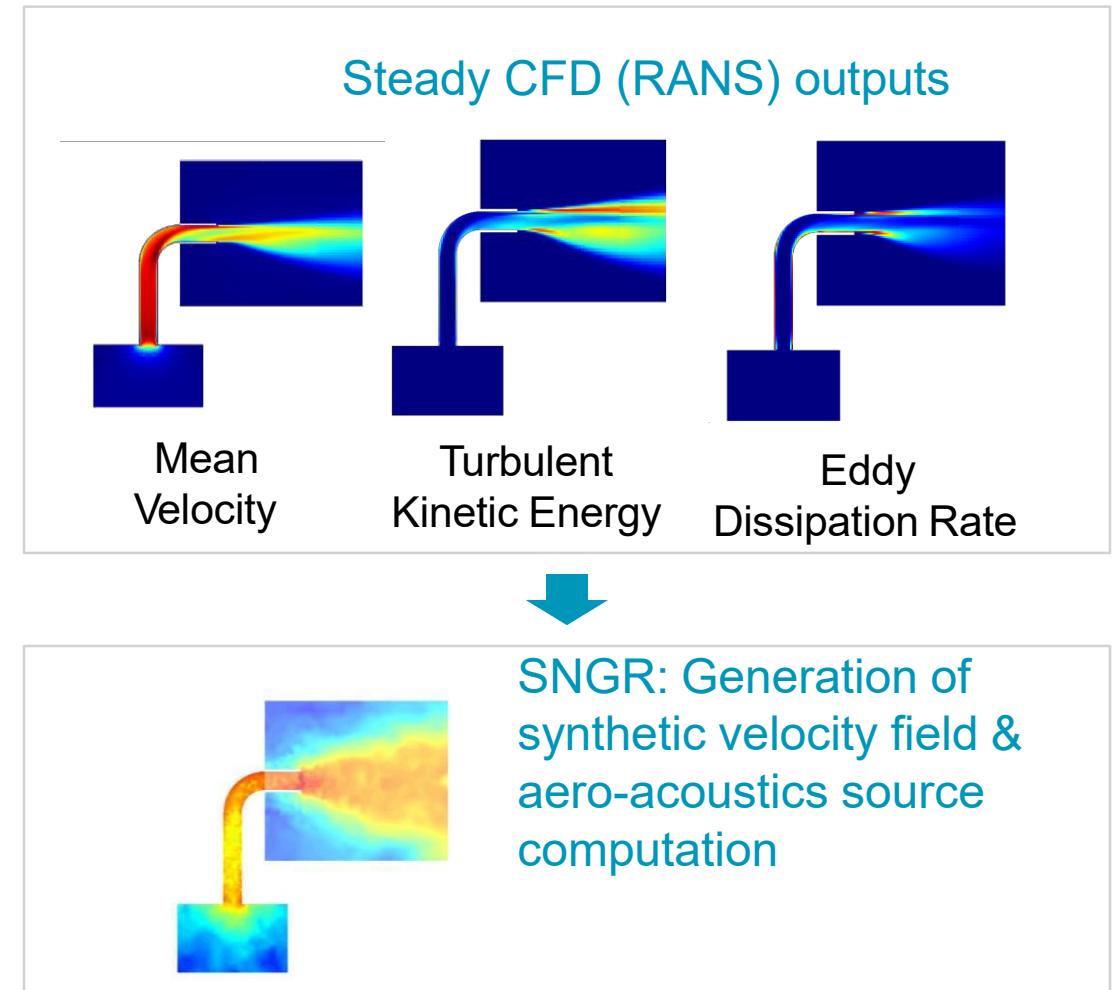


Far field results

Turbulent Flow (2)

Aero-acoustic sources from **steady** CFD

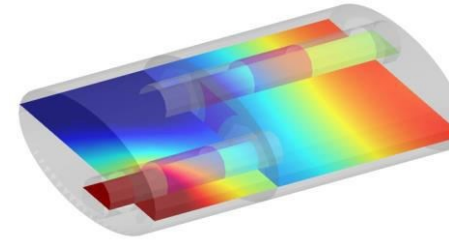
- The **SNGR** is a **source computation** strategy that can be used in Actran for Aero-acoustic analysis
- Based on **steady CFD** outputs Actran creates a synthetic unsteady velocity field
- This unsteady velocity field can then be used to compute Lighthill sources and perform the Acoustic propagation
- This method allows a much **faster overall computation process** and can be used **relative noise level** prediction



Engine vibration

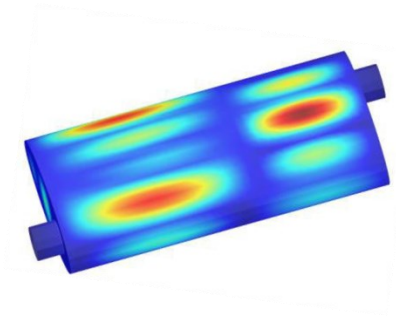
Shell modelling and coupling to fluid

- Shell vibration due to **structure-borne noise** from engine vibration
- Acoustic sources (engine pulse, turbulent flow) from the inner volume (**air-borne noise**) also contribute to the shell vibration
- Vibrating structure:
 - Can be coupled to the inner acoustic domain (e.g. muffler)
 - The outer radiation can be computed



Physical modeling of inner fluid

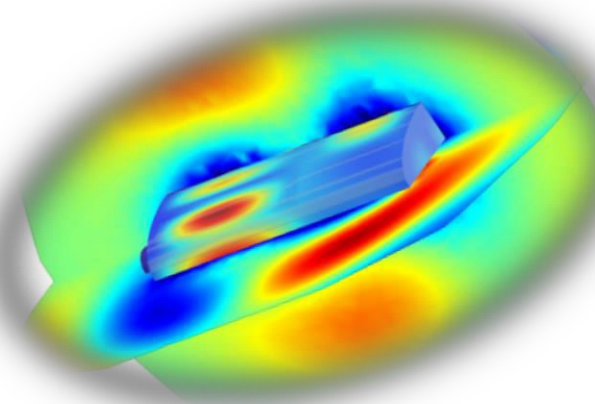
+



Finite element model for structure (physical or modal)

Modes computed using

other Nastran (or MSC Nastran) Ac Actran



Physical modeling of outer fluid

Key feature: medium Heterogeneities

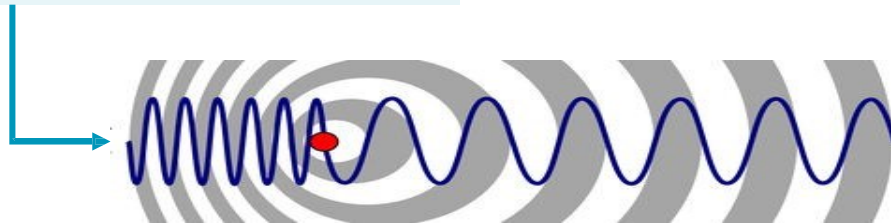
Flow and Temperature Effect

- A muffler in working conditions typically involves:
 - Temperature gradient, whose heterogeneity impacts the local sound speed:

$$c(x) = \sqrt{\gamma R T(x)}$$

- A mean flow, which modifies the acoustic waves propagation (i.e. Doppler Effect)

$$\lambda(x) = \frac{c(x) \pm v_0(x)}{f}$$

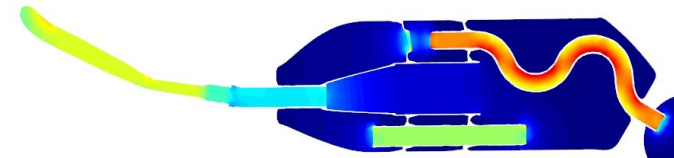


- Mean flow and temperature field can be input in the Actran analysis which will account for local sound speed and flow effect
- Those fields were generated using Actran, but CFD data can also be imported:

Temperature Field

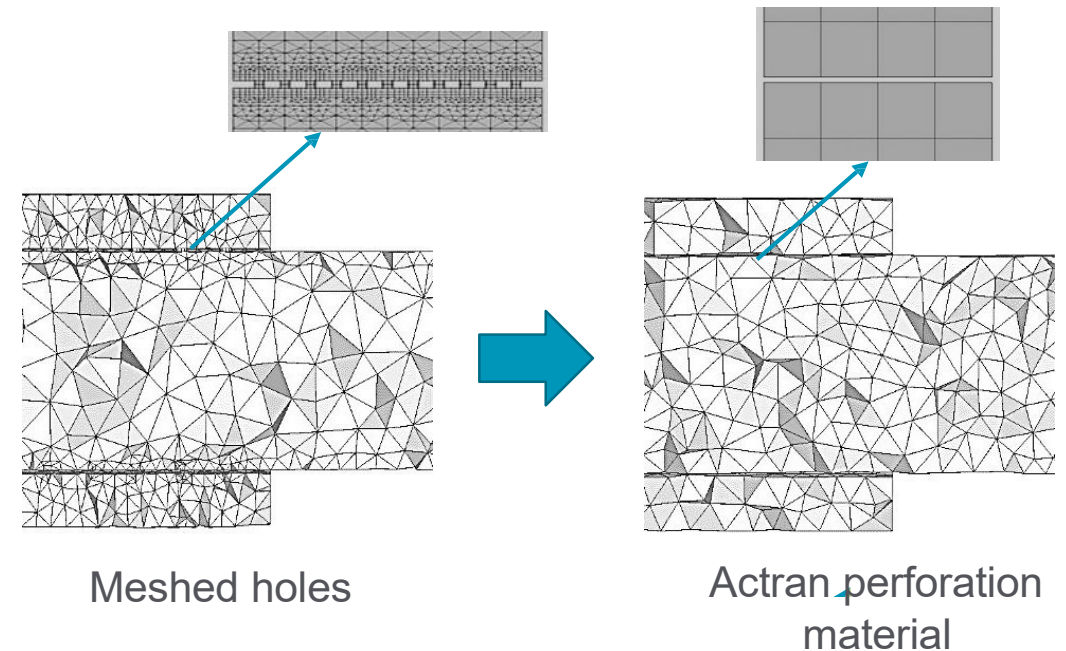
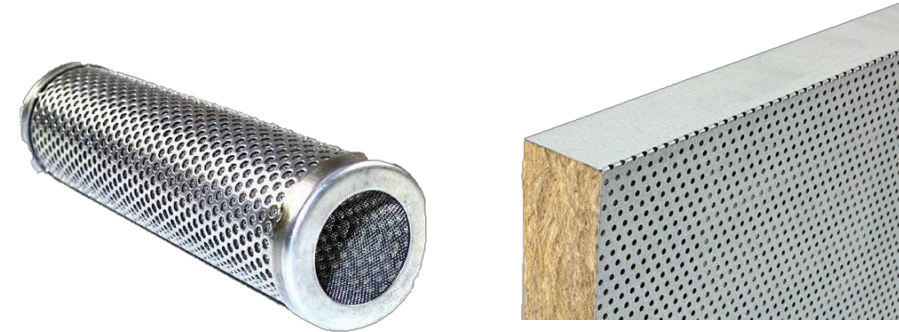
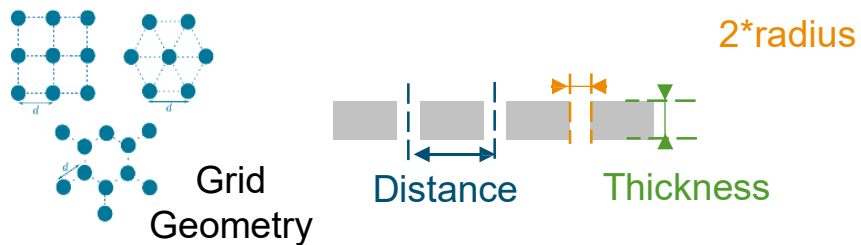


Mean Velocity Field



Perforated plates

- **Perforated plates** are quite common in many acoustic systems such as acoustic baffle, exhaust line, in-line silencer...
 - **Specific dissipation** occurs when acoustic wave is exposed to the holes
 - **Meshing** such holes is **cumbersome** and lead to CPU-greedy models
- **Actran Solution:** perforation modelling with specific formulation based on Maa's theory → only requires perforation main geometrical parameters



Acoustic Absorption - Porous Materials

- Modeling **foam, rock wool, fibers,...**
- Porous elements based on **Biot model**
- Frequency dependent material properties:
 - Foam skeleton
 - Fluid properties
 - Foam properties
- Different models can be used depending on the number of available material properties
- Extension to **anisotropic porous materials**

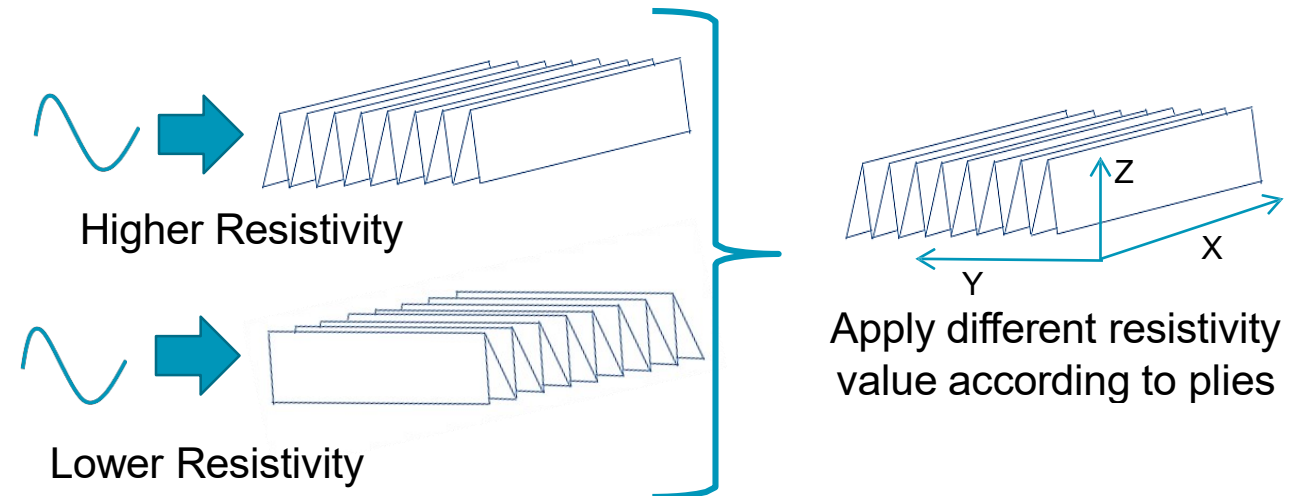
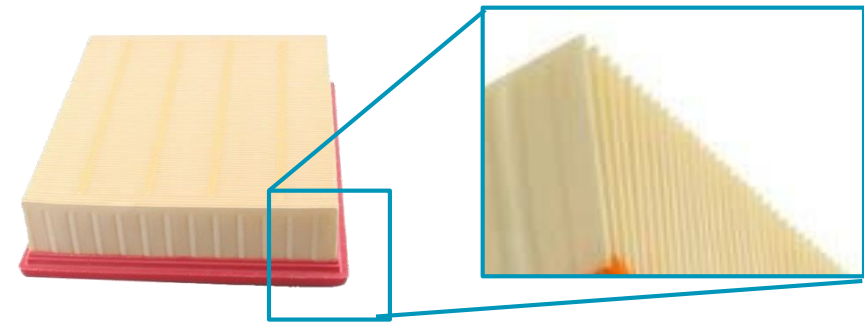
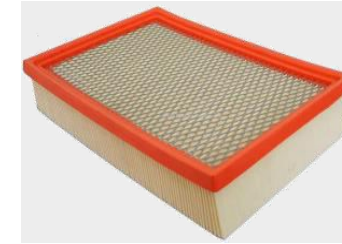


Anisotropic porous

Example for Air Filter modeling

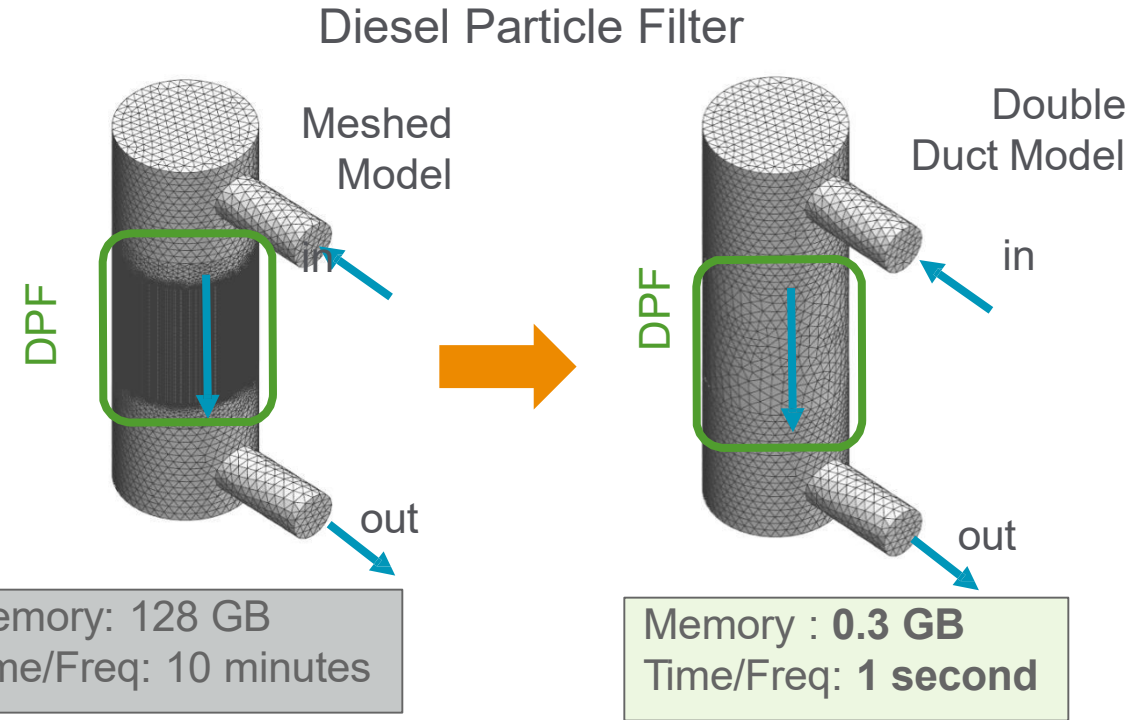
- How Biot model can help modeling filters?
- Orientation of plies has preferred directions
- Resistivity is depending on plies orientation
- Setting resistivity value according to plies orientation allows an accurate modelling of the filter

Air Filter

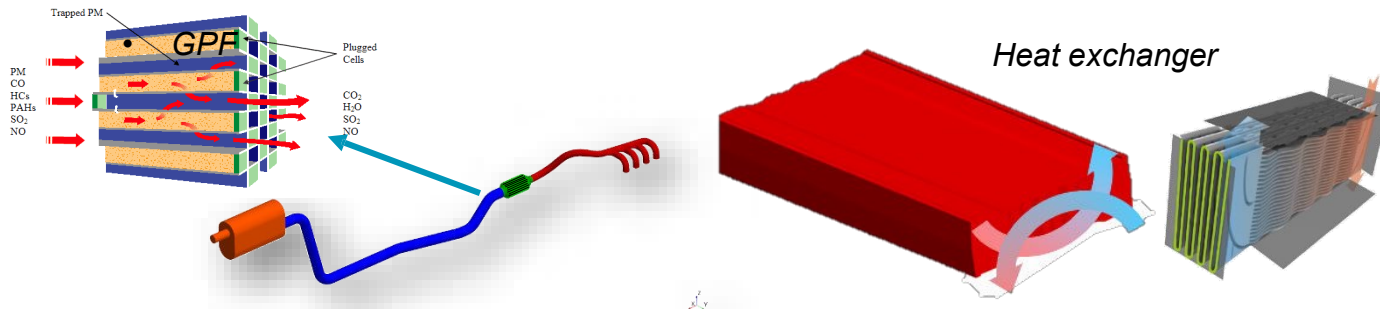
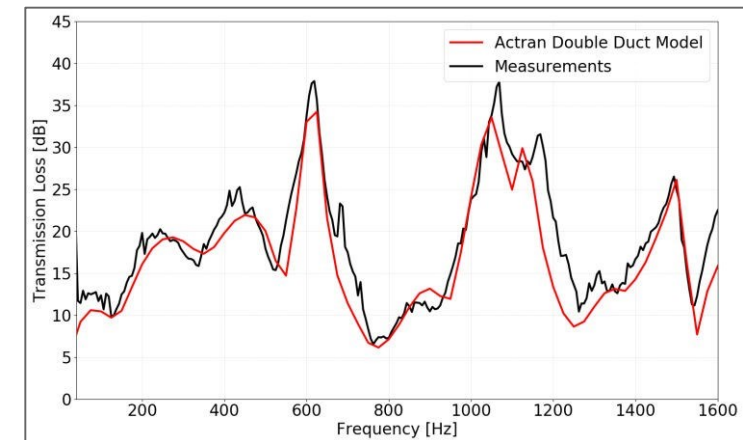


Transfer Model for Double Ducted Arrays Systems

- **What:** DOUBLE_VISCOTHERMAL component modeling two visco-thermal phases coupled through resistive layer.
- **Key benefits:**
 - Accurate acoustic effects prediction of double flow devices (diesel particulate filters, heat exchangers,...)
 - Simplified meshing definition of complex multi thin ducts systems
 - CPU and memory footprint reduction
- **Targets:**
 - Acoustic propagation inside exhaust line component (DPF, GPF), heat exchangers, radiators

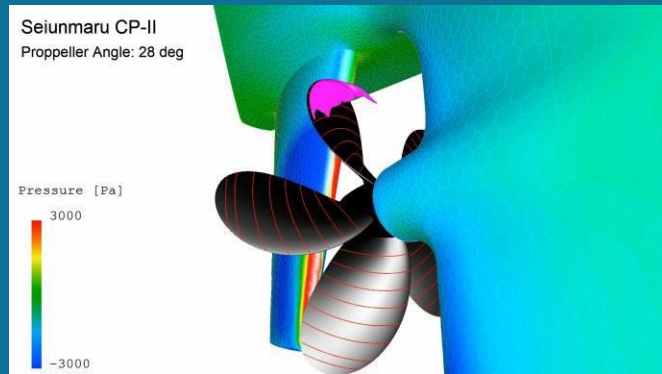


Acoustic Modeling of a Diesel Particulate Filter using a Double Equivalent Fluid Homogenization Approach , G. Lielens, M. Brandstetter, A. Talbot , DAGA 2018

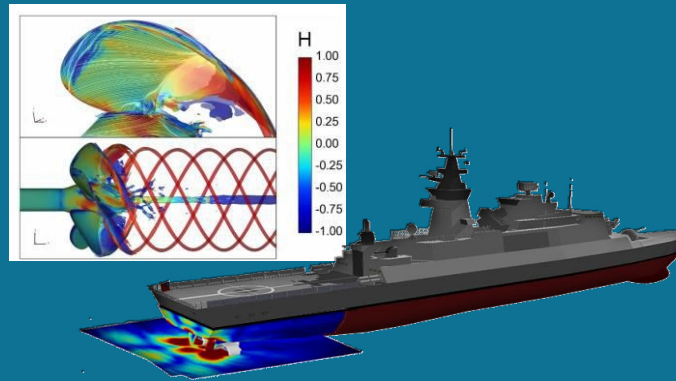


Solutions for noise prediction

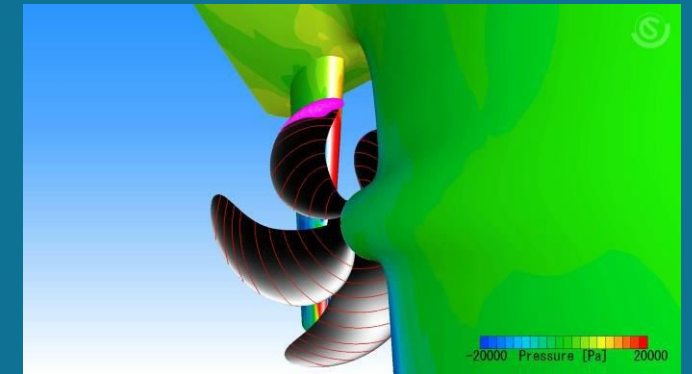
- Assess propeller design and cavitation apportion based on unique CFD model



- Get acoustic radiation of propeller
- Assess the contribution of turbulent flow noise and cavitation noise



- Understand pressure impact on structure and assess resulting vibrations and induced interior noise





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 Sipilä, Timo Siikonen

Challenge

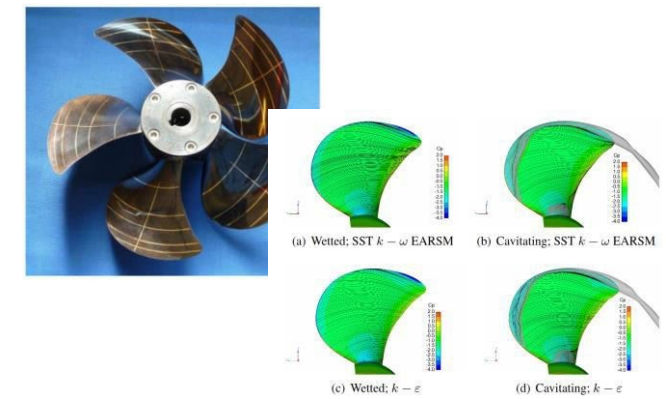
- Numerical prediction of cavitation is a very difficult problem from both a fluid and an acoustic point of view
- Due to the nature of cavitation, very high noise is generated by the propeller and must be predicted in order to be reduced
- For this, it is important to also understand the noise mechanism

Solution

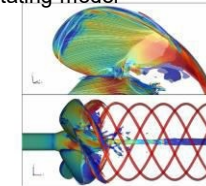
- To predict the propeller noise, a CFD solver is coupled with Actran for a hybrid aeroacoustic approach
- The cavitation is predicted by the CFD solver and Actran is used to create sources and propagate them

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



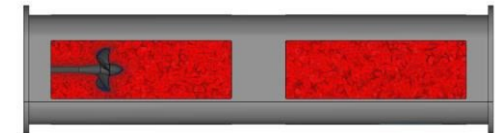
CFD results –
Cavitating model



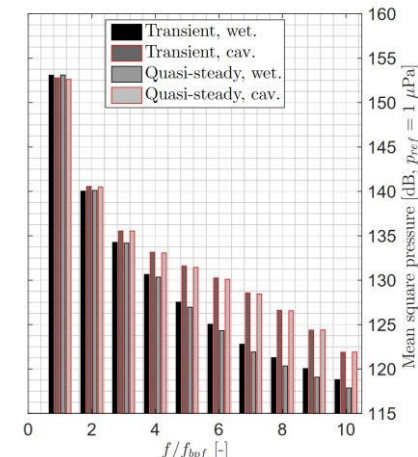
Iso-surface noise –
Cavitating state



Cavitation tunnel - FE Acoustic model and mesh



Impact of cavitation on sound radiation

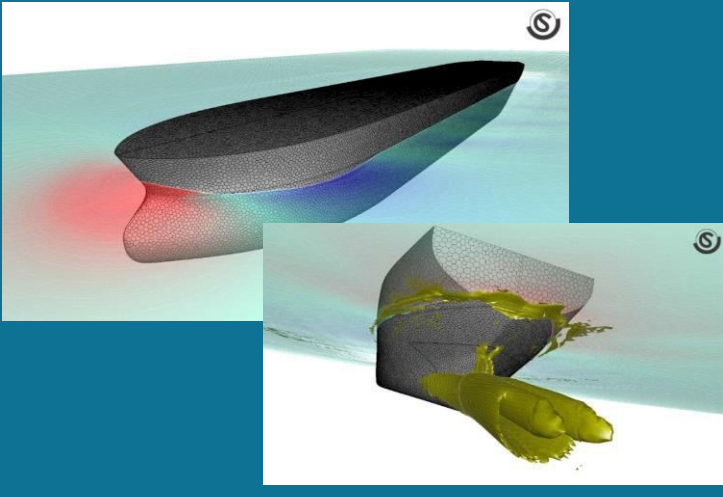


Hull design and efficiency

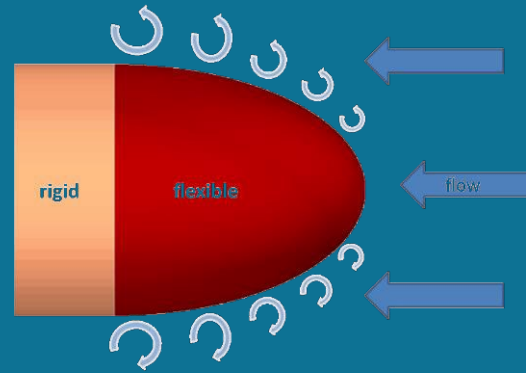
Flow induced noise

Predicting the vibrations and noise induced by flow

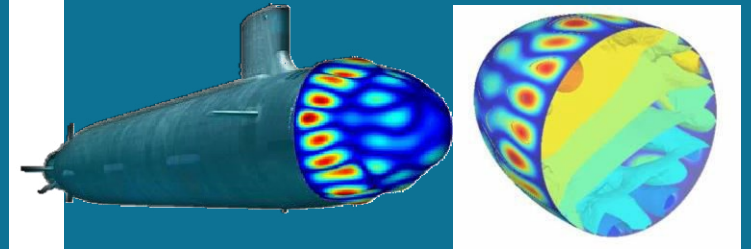
- Resistance analysis
- Wake distribution
- Wave profile



- Use steady CFD data to feed turbulent boundary layers models
- Get extra flow scenarios thanks to machine learning

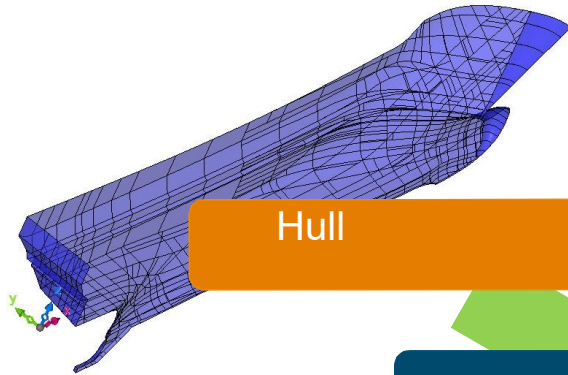


- Assess vibrations and noise due to turbulent flows
- Understand noise pollution on sonar and radars for different flow conditions
- Predict extra scenarios thanks to machine learning



Handling of hull model data

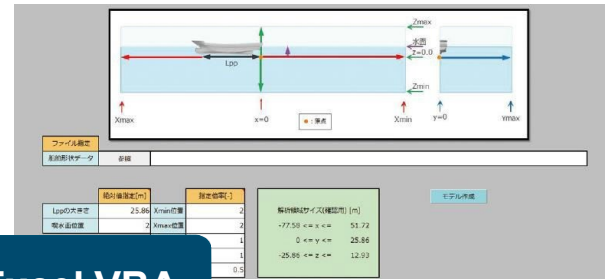
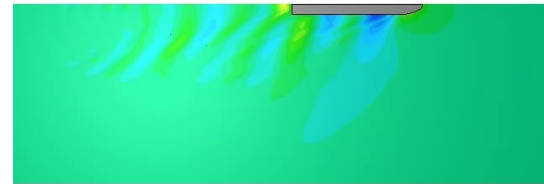
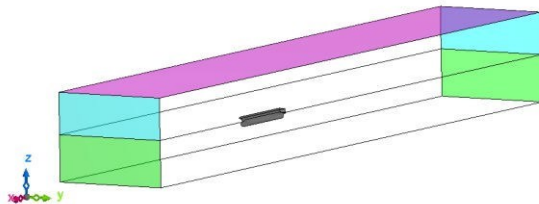
Automatic preparation for analysis from hull model data



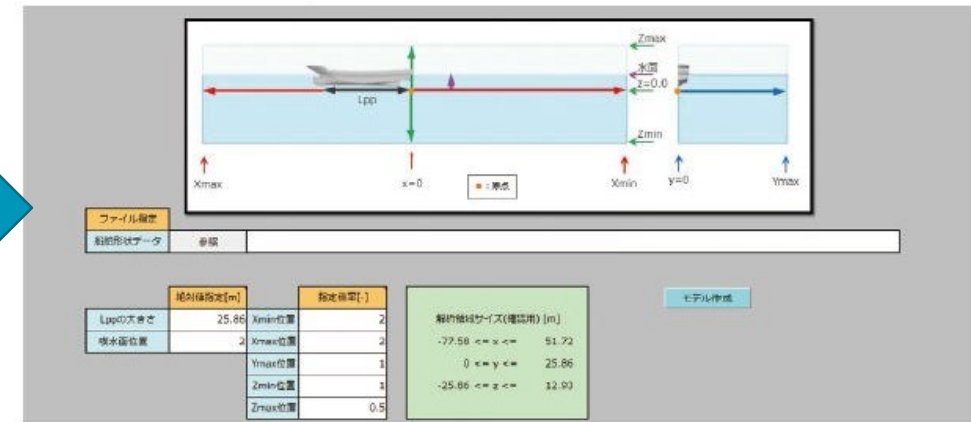
Hull

mation by Excel VBA

tion a



Input of Excel VBA

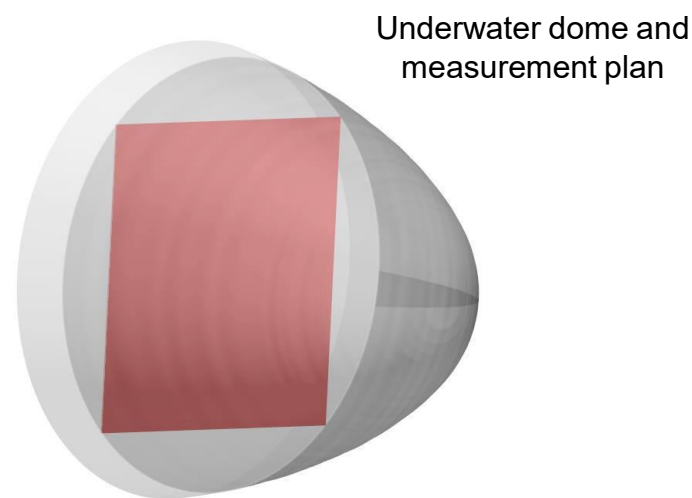


Input:

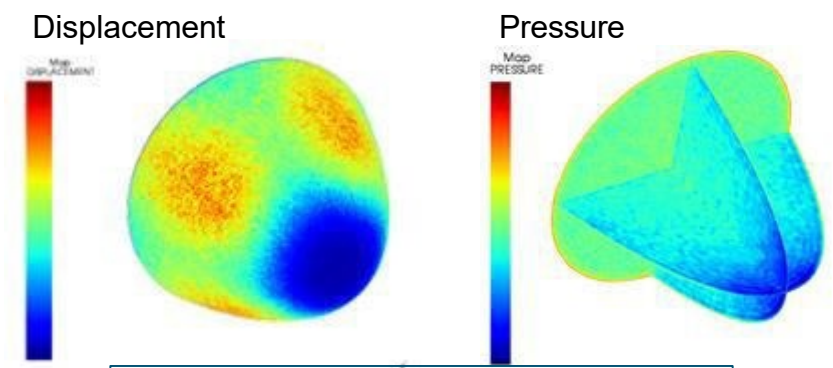
- Lpp size
- Computational domain size by the ratio of Lpp
- Waterline height

Computation of the hydro-acoustics noise inside an underwater dome

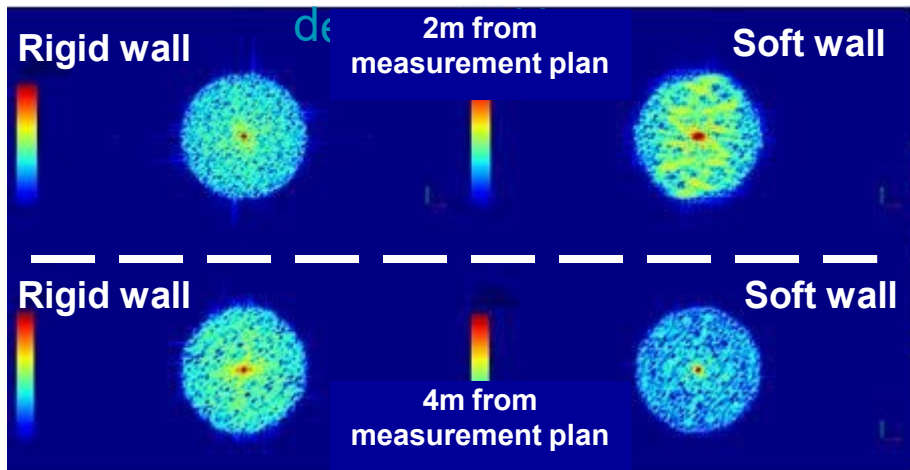
- Dome length 6m / radius 4m
- Excitation : TBL fed with CFD data



Examples of map



Wave number

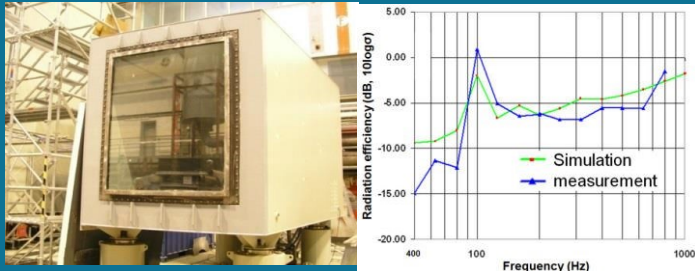


Case	Frequency	Number of Frequencies	Degree of Freedom	Computation Time	Memory Consumption
Rigid Wall	500Hz-6000Hz	12	4 600 000-8 300 000	17h21m11s	301 029 Mb
Soft Wall			4 900 000-8 600 000	18h56m59s	324 350 Mb

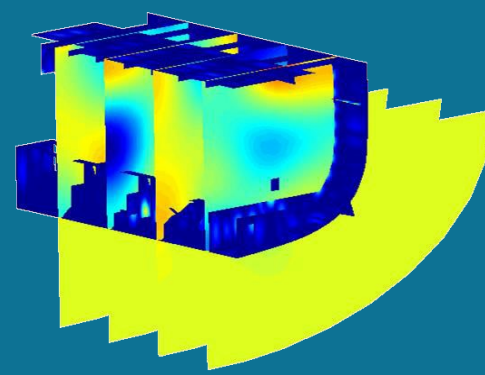
Structure vibrations and insulations

Predicting the vibrations propagation and insulation

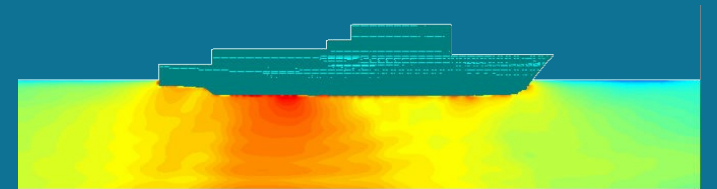
- Transmission Loss analysis
- Acoustic treatments & enclosure optimization
- Windows, multi-layered & floating floors materials analysis



- Subsystems NVH performances
- Transfer path analysis
- Cabin noise levels
- Comfort class assessment



- Underwater hull radiation
- Shallow water effects consideration





Underwater noise radiation in shallow water

Challenge

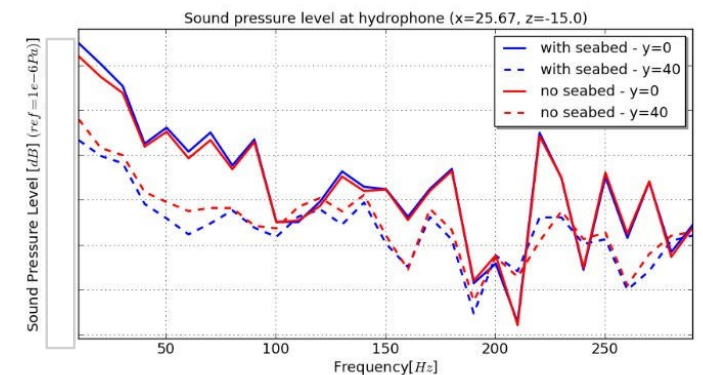
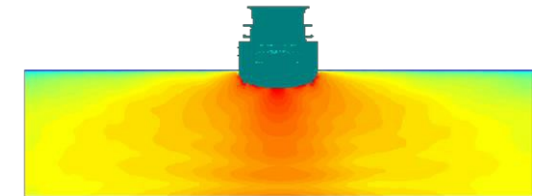
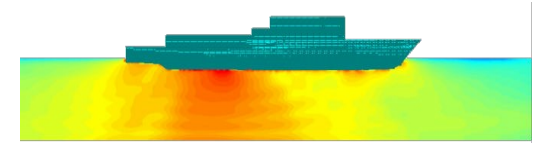
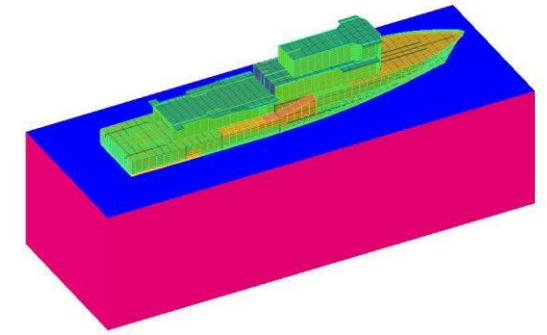
- Predict the underwater noise directivity considering shallow water environment and seabed absorption impact

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



Case Study Germanischer Lloyd (DNV GL)



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

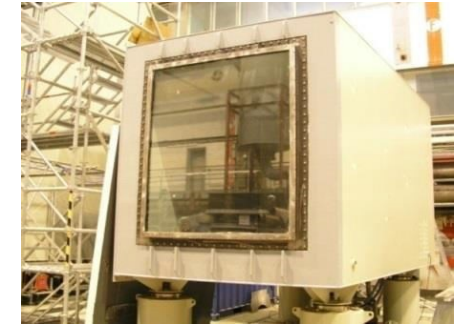
Solution

- A multi-layer window was modeled using Actran.
- The acoustic radiation of ship windows for structure-borne and airborne excitations has been evaluated.

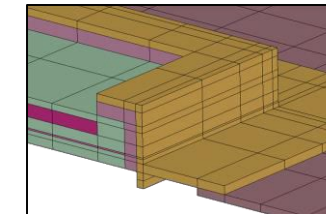
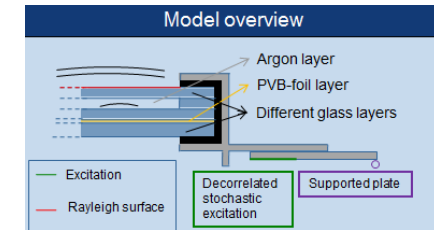
Benefits

- **Good correlation** with measurement was obtained.
- **Optimization** of **window** and **frame** design based on numerical prediction becomes feasible.

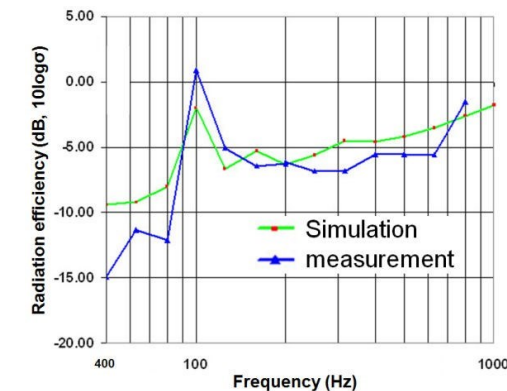
Board room



Actran vibro-acoustic model



Modeling of the window frame



Radiation efficiency



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

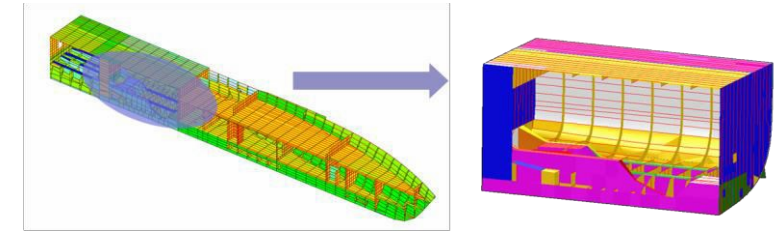
- Sea animal protection codes impose maximum noise emission levels for vessels.
- The engine room noise emission, an important portion of the total noise, must be studied.

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.

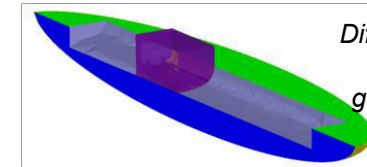
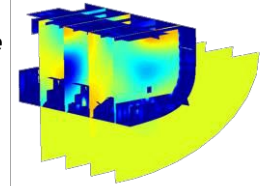
Benefits

- Sound power radiation into sea water could be predicted in order to evaluate the ship's noise impact to the underwater environment.



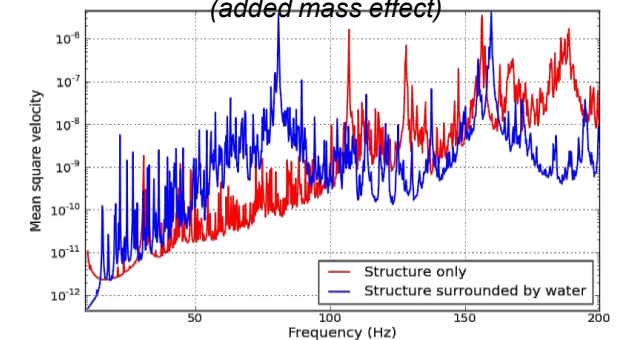
Nastran engine room model translated into Actran model

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)



Application Case



Onboard noise comfort prediction

Challenge

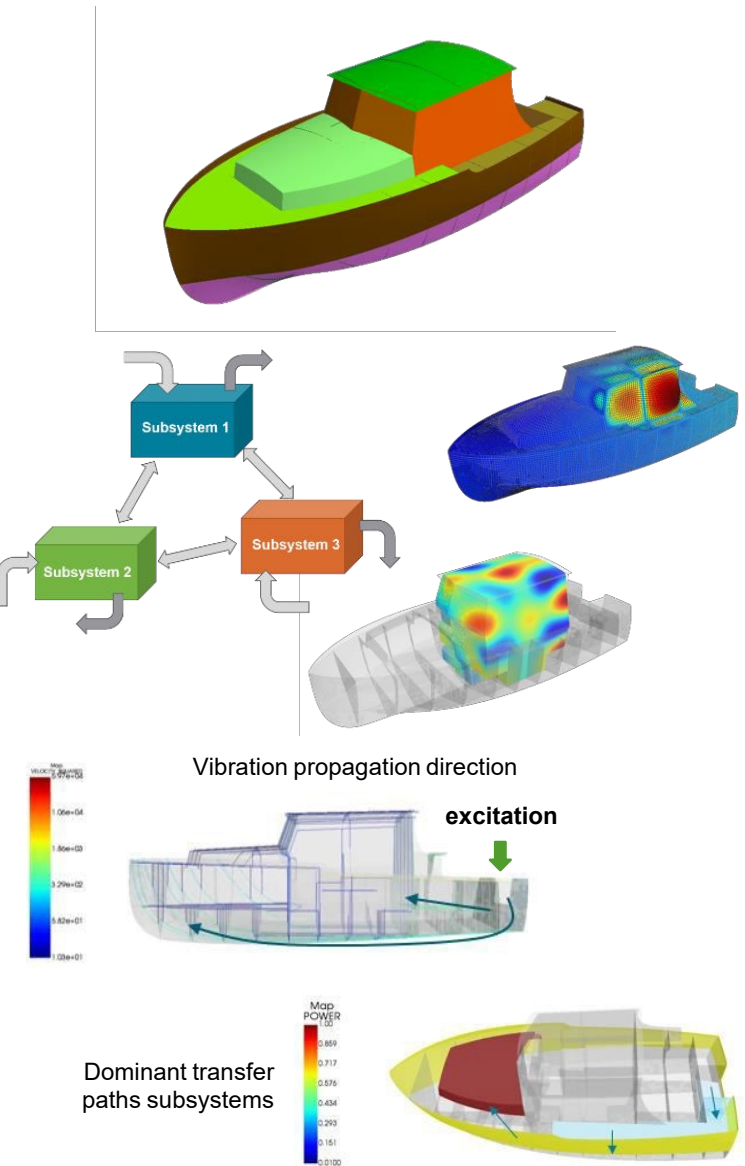
- Excessive onboard noise levels can impact crew performance, human error potential, health and comfort.
- The most commonly adopted approach to tackle with numerous noise sources involved is the source-path-receiver modeling technique.
 - Noise source characterization
 - Transmission path analysis
 - 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 and elegant approach to address these needs by relying on existing FE models and offering relevant indicators at mid- and high frequencies.





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



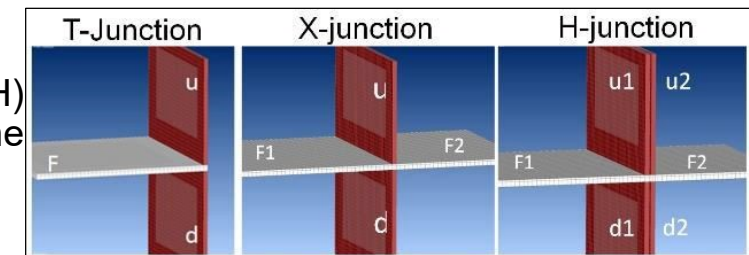
Challenge

- 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.



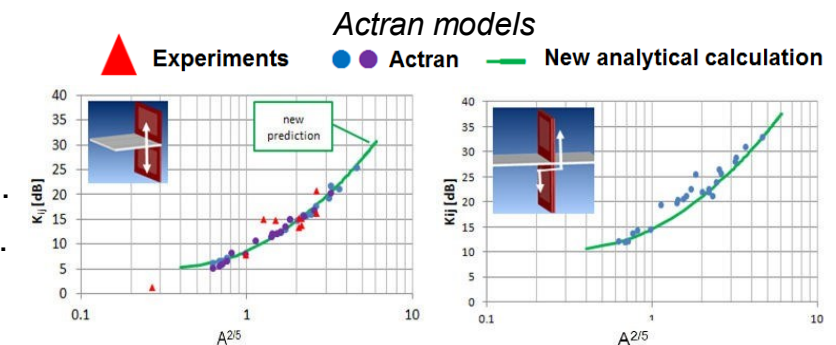
Solution

- 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