



INTEGRATED
DESIGN
ANALYSIS
GmbH

InDesA

Approaches for Acoustics Simulation for Automotive Air Induction & Exhaust Systems

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Company Profile

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InDesA

Consulting, Engineering Services & Virtual Test Center

- Simulation and Analysis of complex fluid flow and heat transfer systems for engineering and industrial applications
- Virtual Performance Testing for automotive accessory units



3D CFD/CHT Analysis

GT-SUITE

1D System Analysis

Acoustics Simulation for Automotive Systems

Introduction

InDesa

INTEGRATED DESIGN ANALYSIS



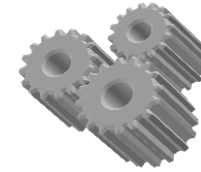
From engine



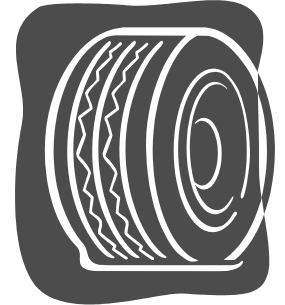
Driving noise



Body vibrations



Mechanic and wheel noise

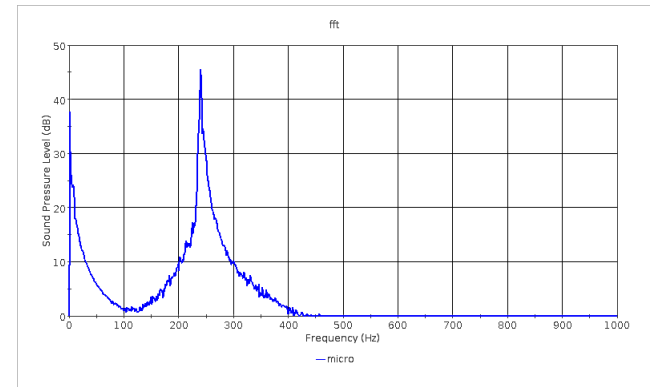
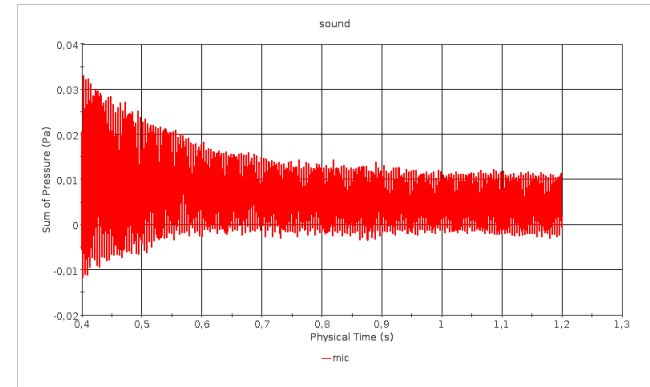
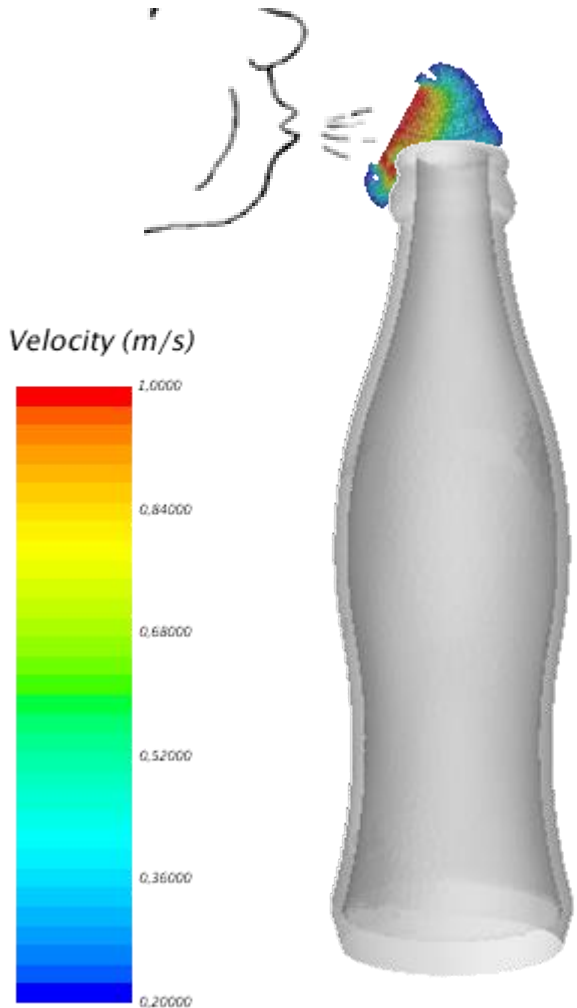


Aeroacoustics:

“...branch of acoustics that studies noise generation via fluid motion or aerodynamic forces interaction...” (source: Wikipedia)

Acoustics Simulation for Automotive Systems

Introduction



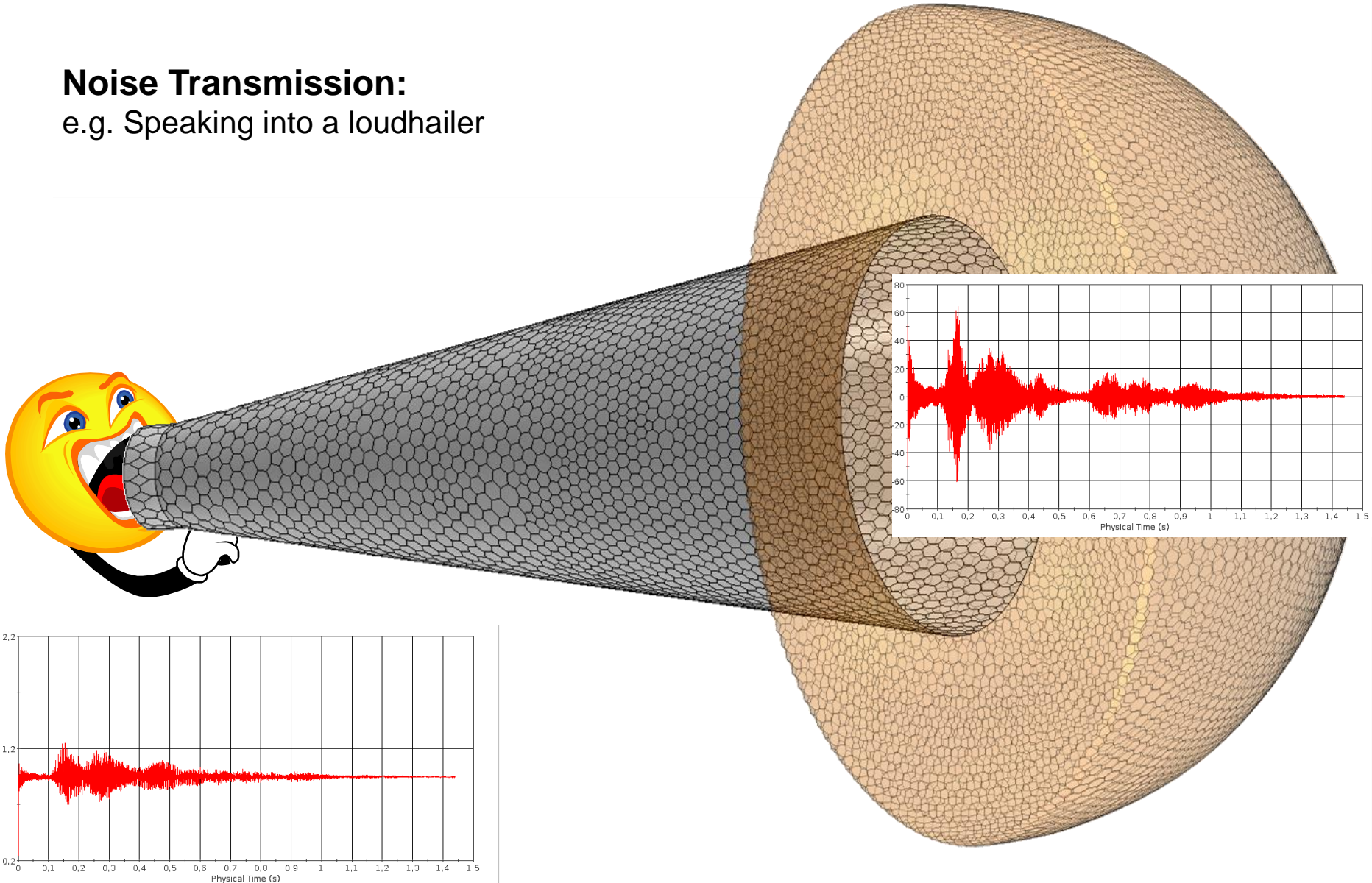
Noise generation via fluid motion:
e.g. Blowing in a bottle



Acoustics Simulation for Automotive Systems

Introduction

Noise Transmission:
e.g. Speaking into a loudhailer



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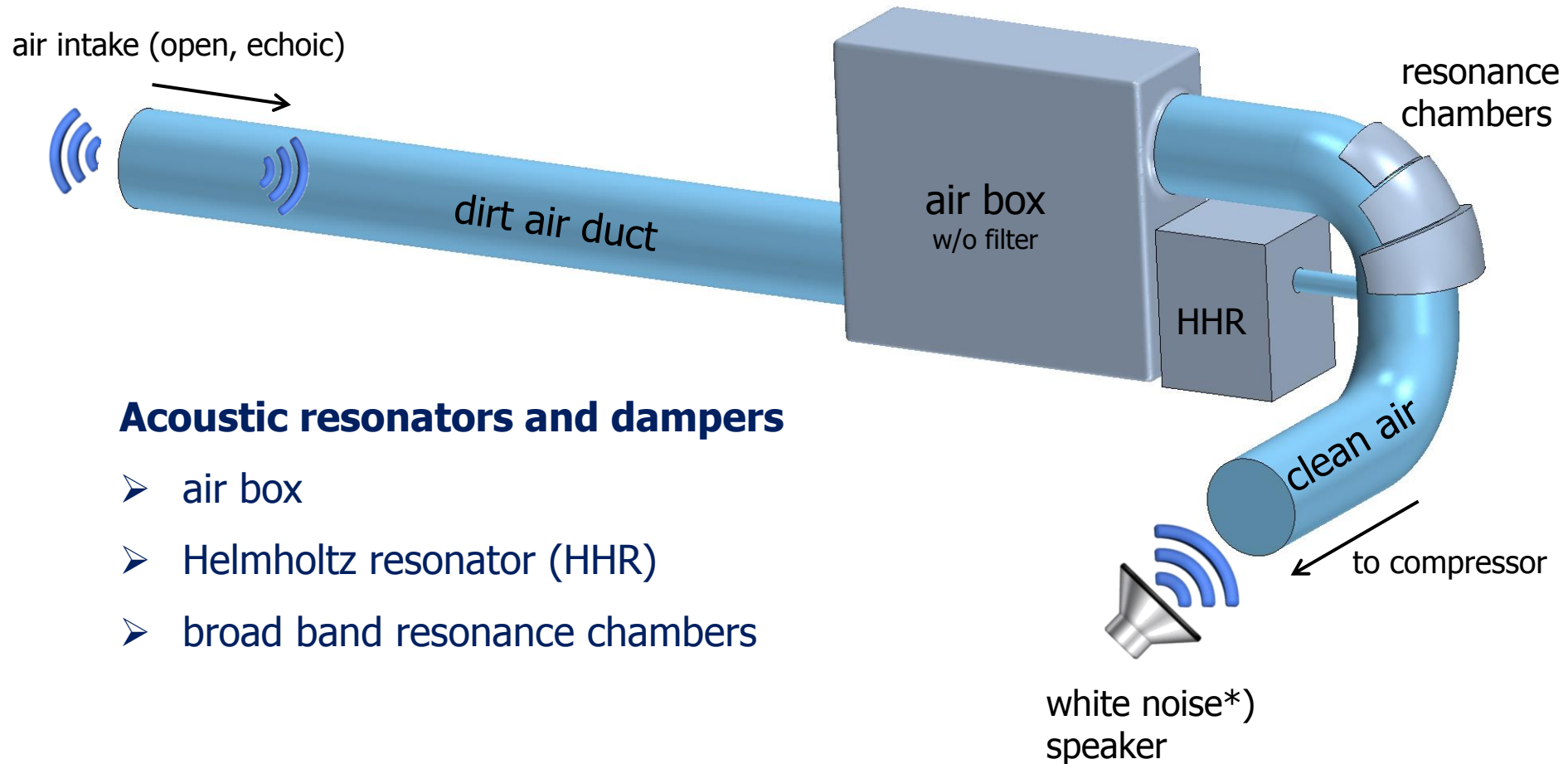
Overview

- 1. Design of a high frequency broad band resonator for an engine air induction system**
- 2. Simulation of exhaust sound pressure level for different tail pipe designs.**

Acoustics Simulation for Automotive Systems

Simplified Air Intake System

Virtual Transmission Loss Test Bench



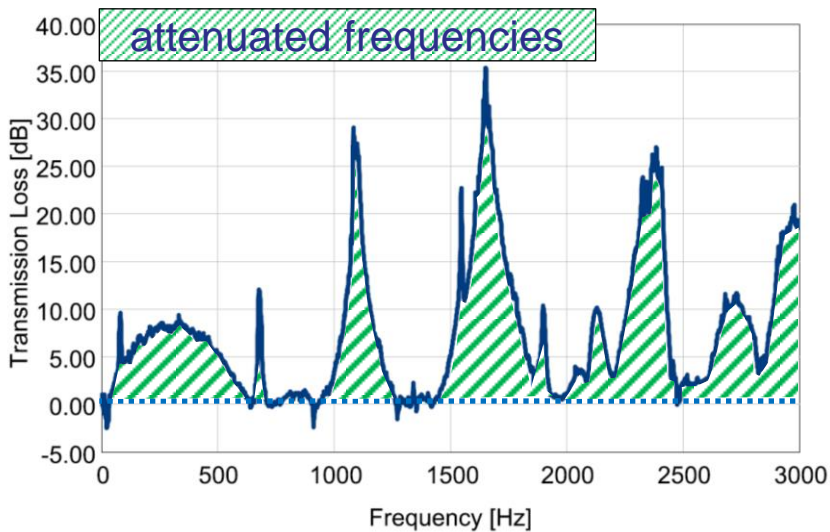
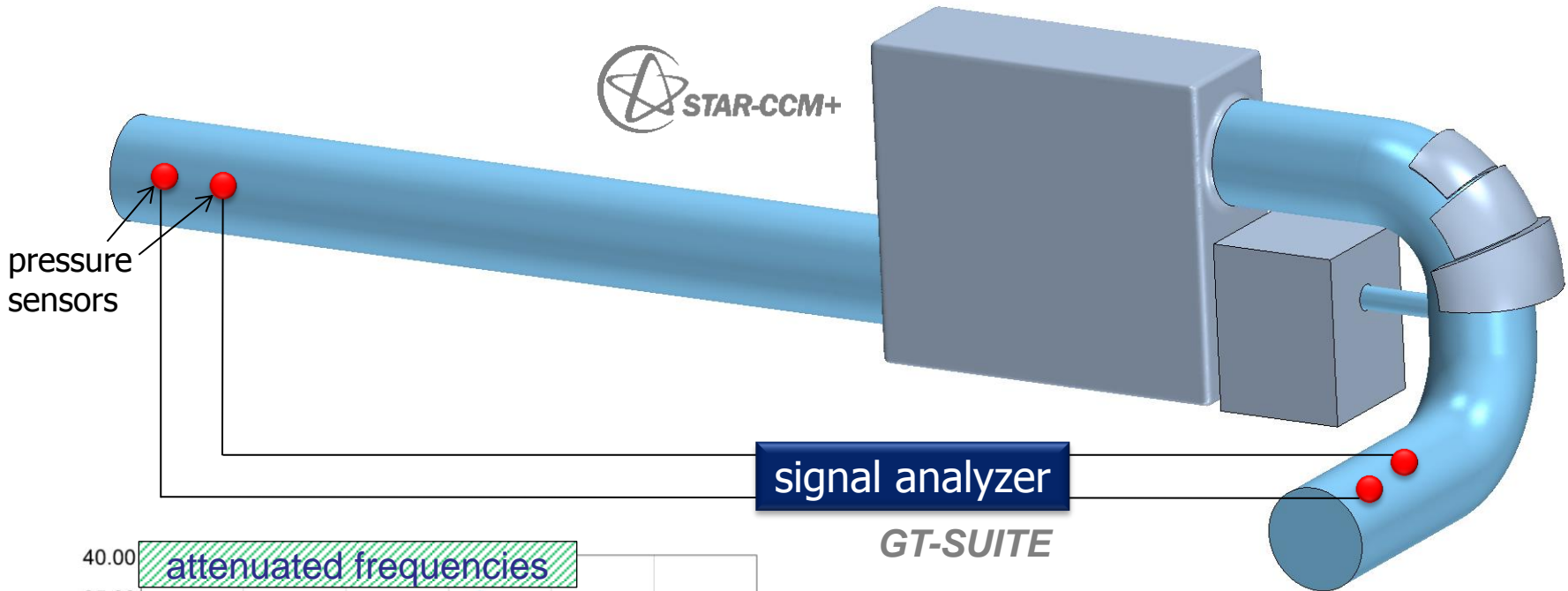
Acoustic resonators and dampers

- air box
- Helmholtz resonator (HHR)
- broad band resonance chambers

*) random signal with constant power spectral density (intensity)

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Signal Processing and Analysis



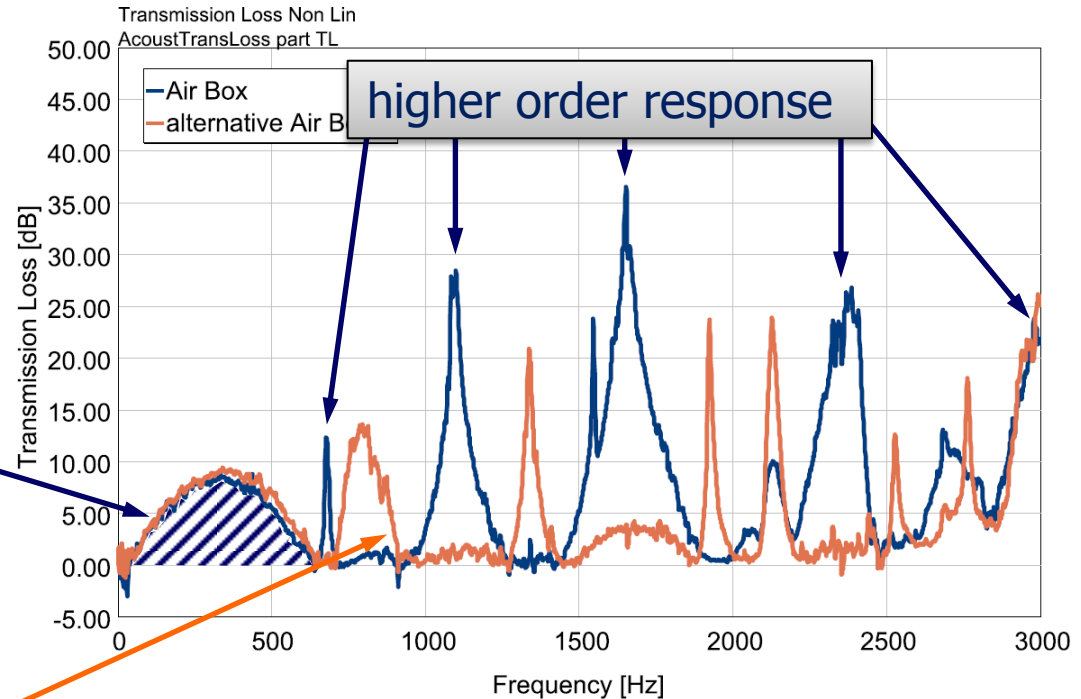
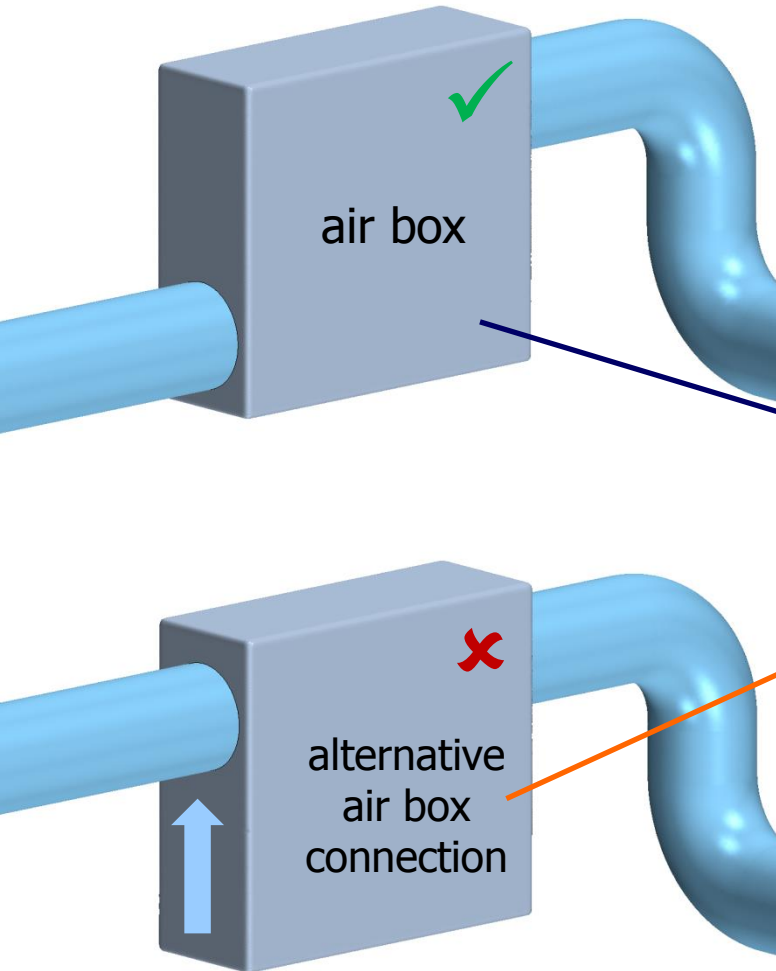
GT-SUITE

- FFT
- noise reduction
- insertion loss
- transmission loss



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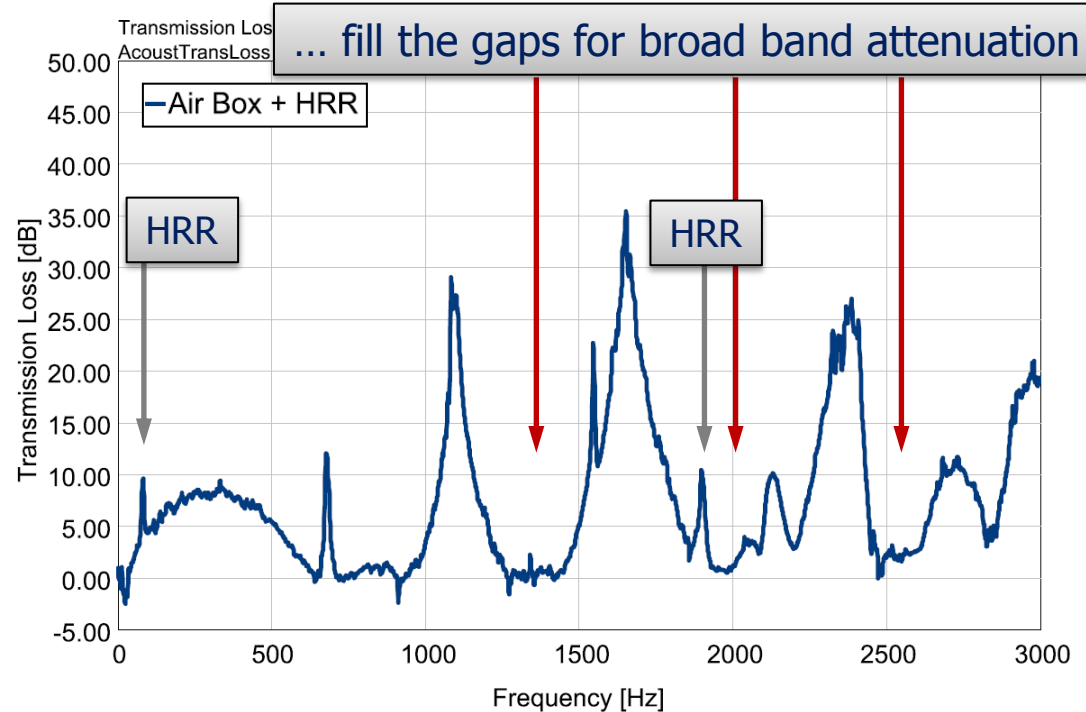
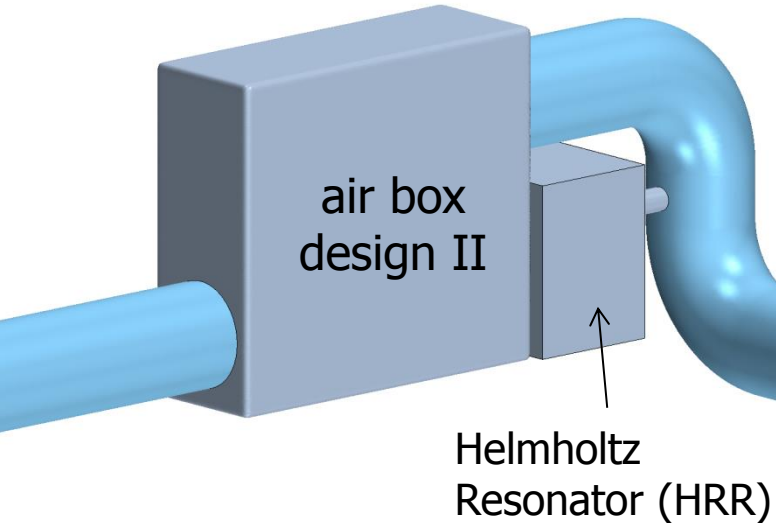
Transmission Loss Analysis for Air Box



- <700Hz, broad band attenuation due to expansion in air box
- > 1000 Hz narrow band attenuation due to reflections in airbox

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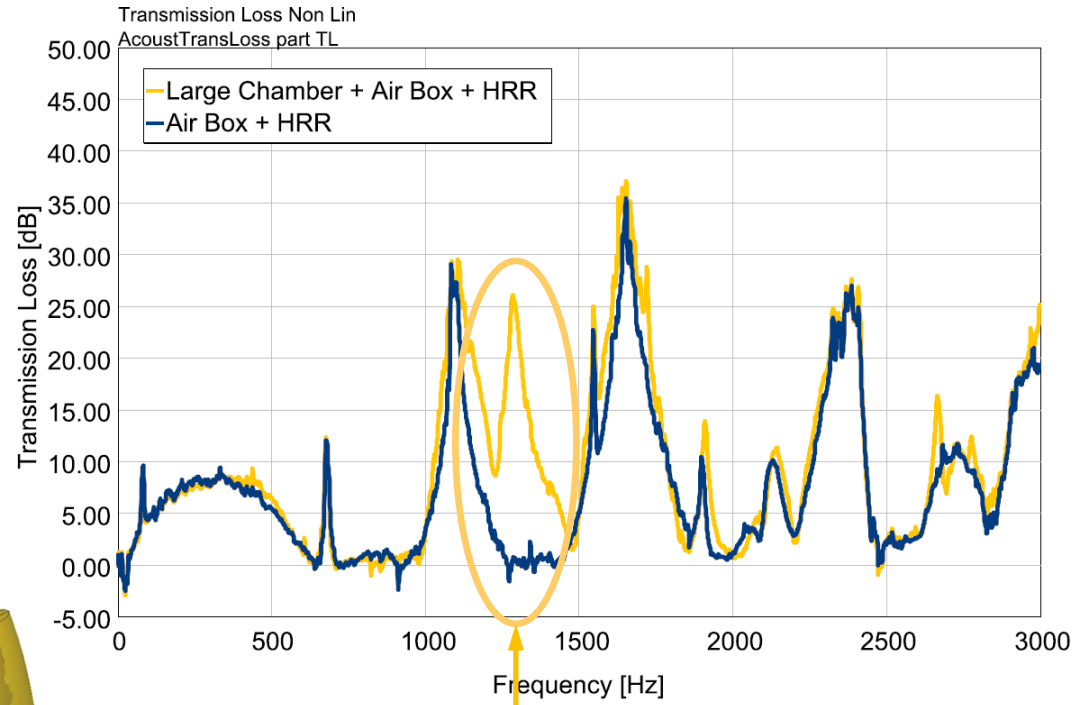
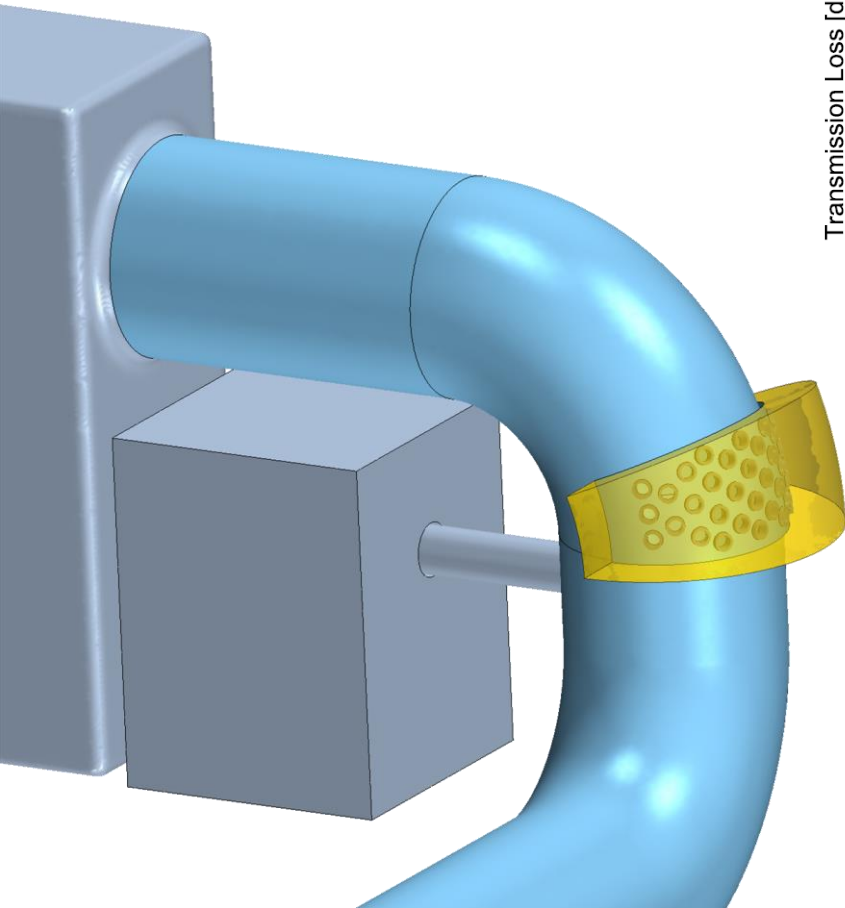
Transmission Loss for Air Box & HRR



- Helmholtz Resonator is used to attenuate specific frequencies (here: 80Hz)
- to build broad band high frequency resonator reflections of airbox are used. Resonator chambers must be added to fill the gaps.

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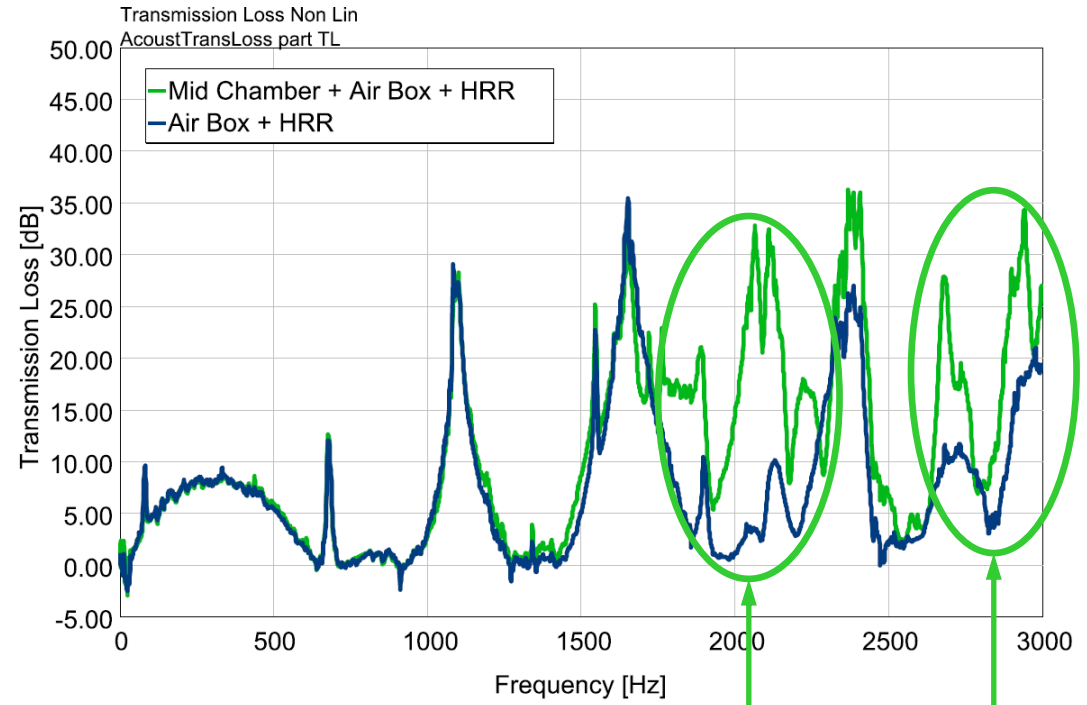
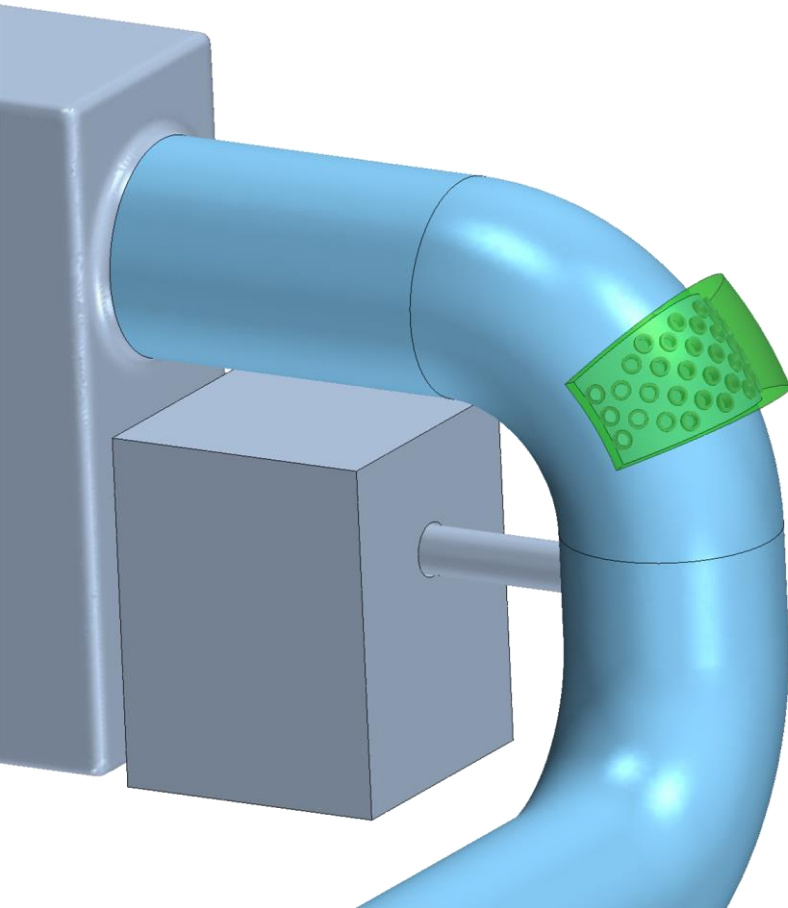
Transmission Loss for 1st Chamber



chamber response
frequency: 1320 Hz

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Transmission Loss for 2nd Chamber

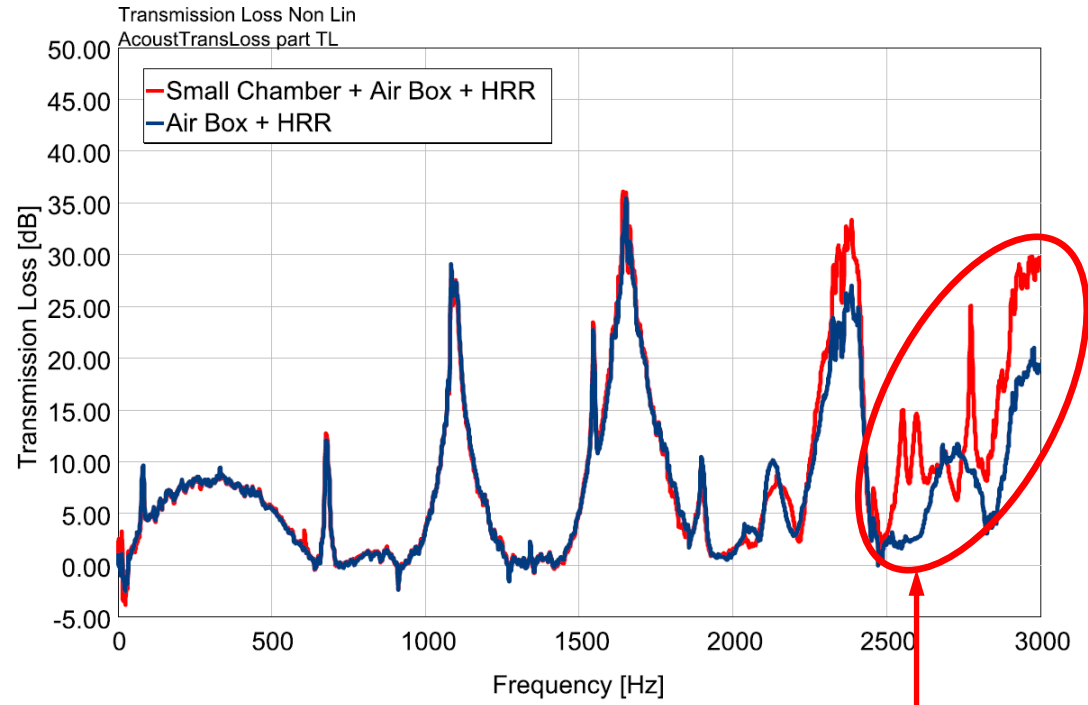
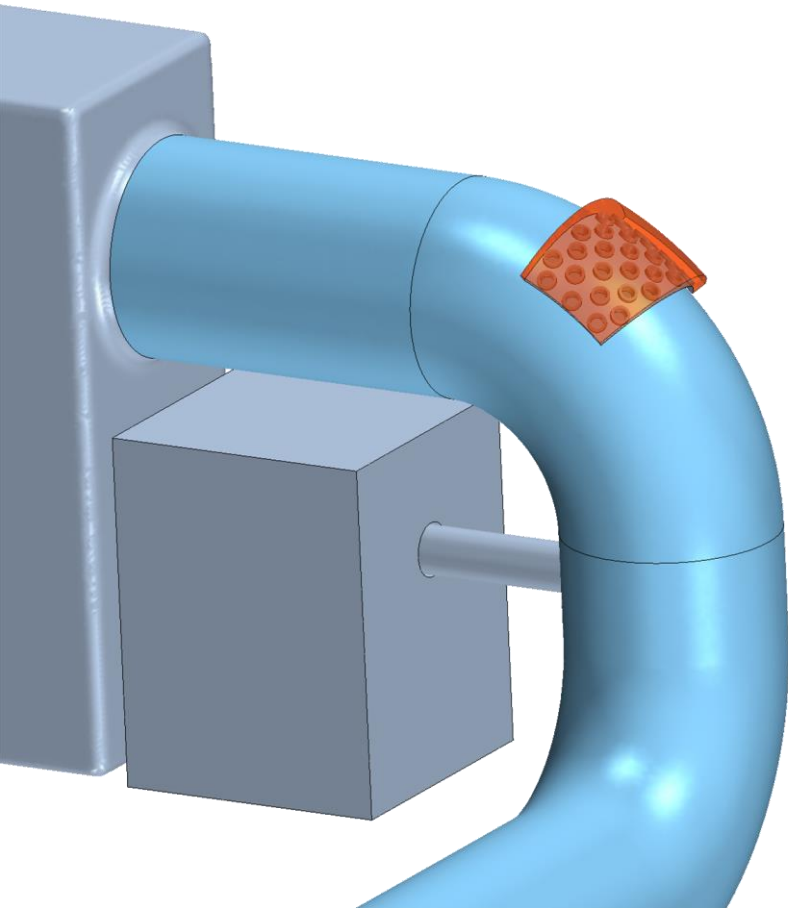


chamber response
frequency: ~2050 Hz

higher order
response

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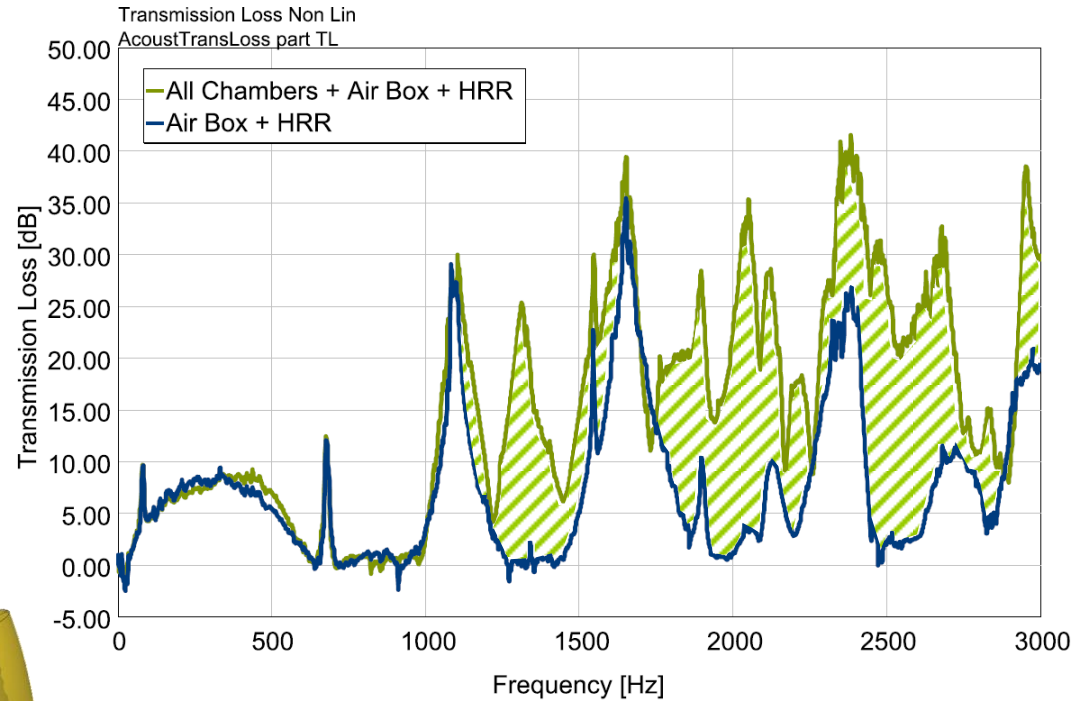
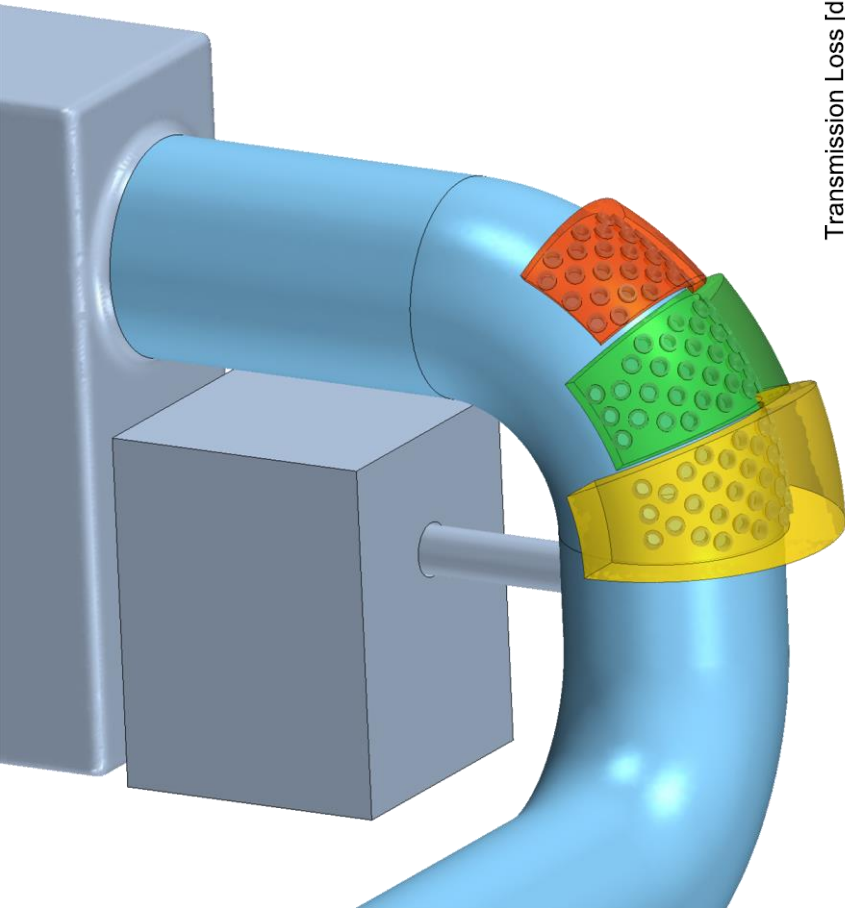
Transmission Loss for 3rd Chamber



chamber response
frequency: ~2600 Hz

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Transmission Loss of Broad Band Resonator

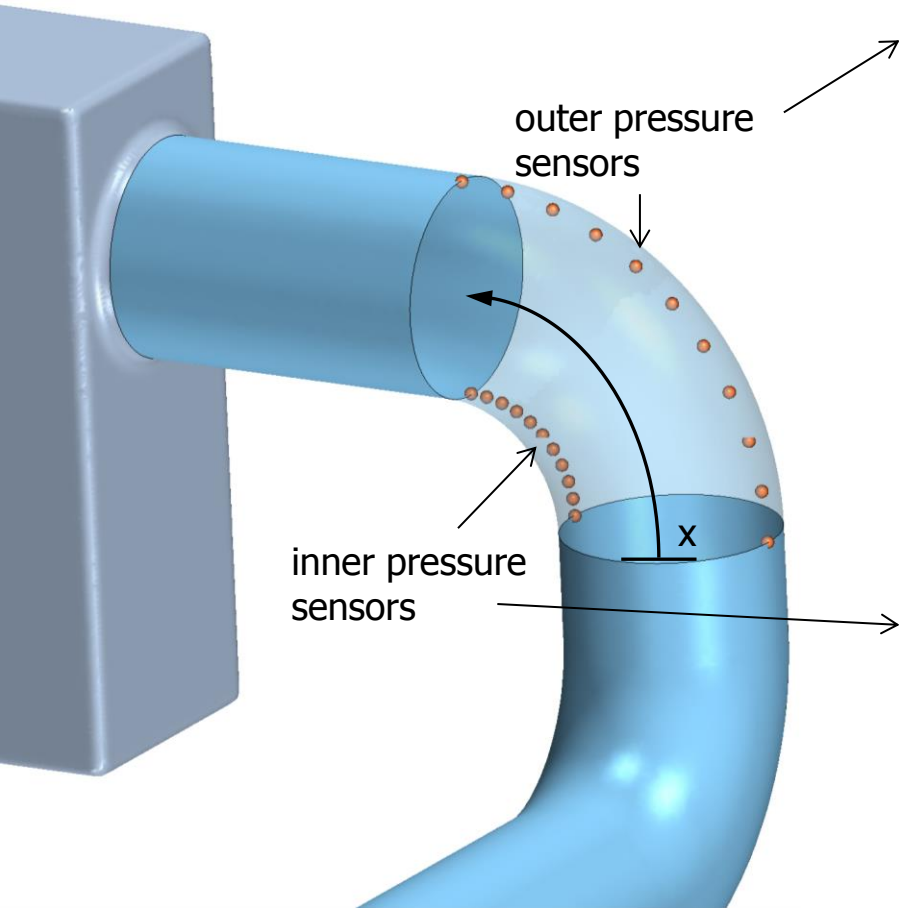


- 3 chamber broad band resonator in combination with airbox reflections

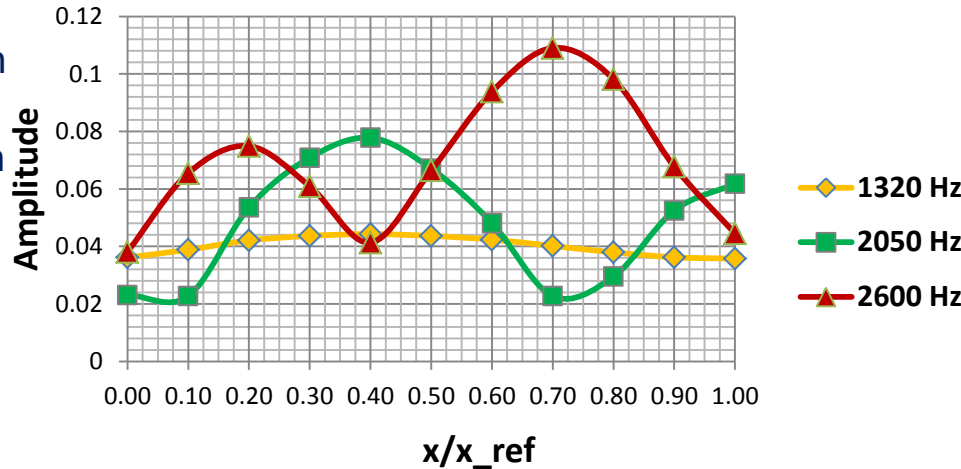
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Wave Analysis for 90° Bent

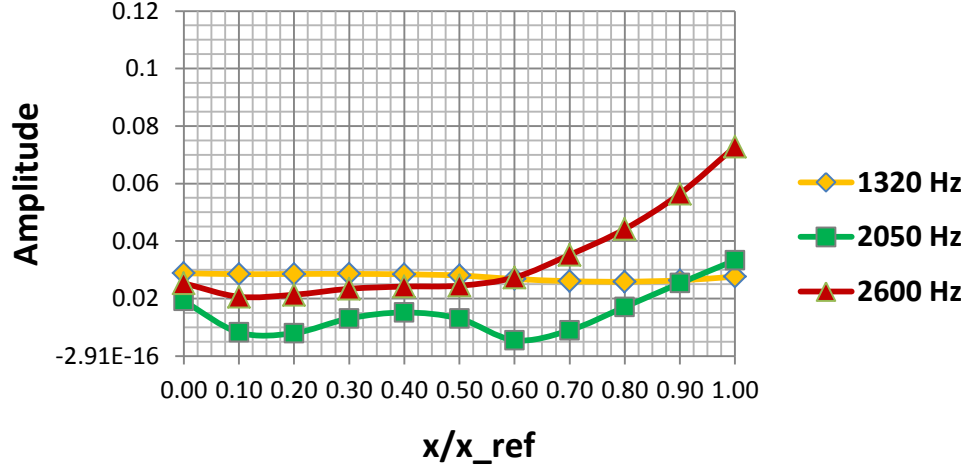
- higher amplitudes occur at outer radius, thus more effective for chamber connection.
- high frequency resonators can be shifted to position where amplitudes are highest.
- inner radius is less effective for chamber connection



FFT outer pressure sensors

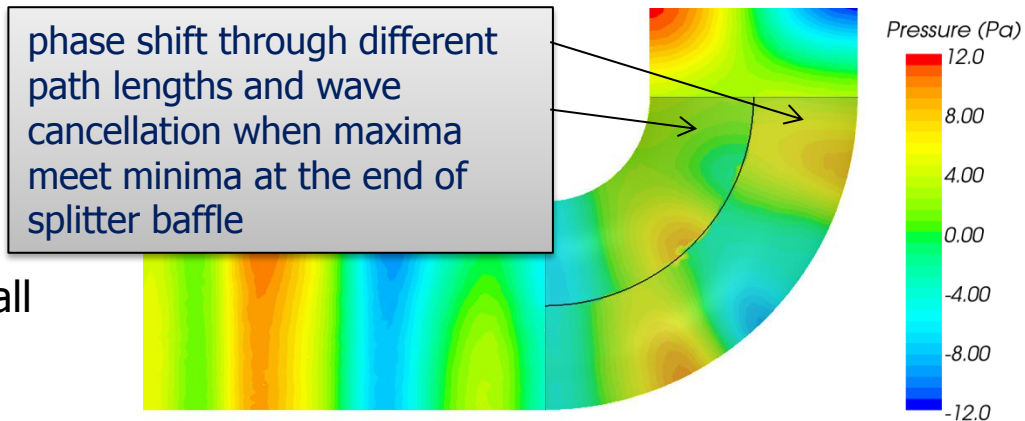
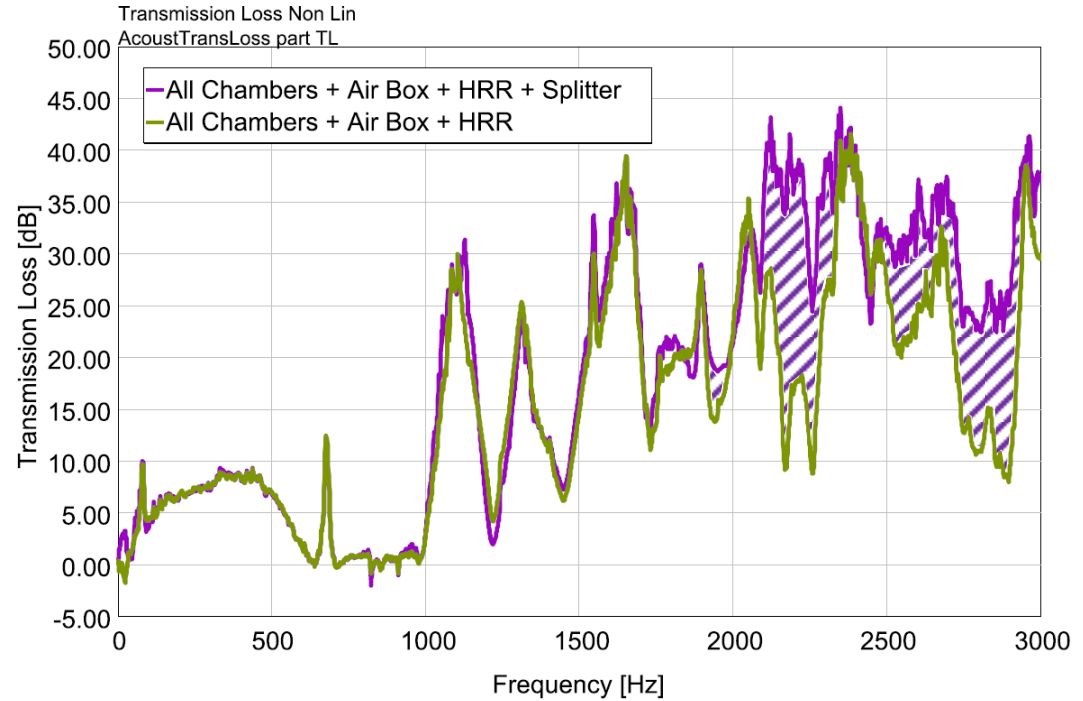
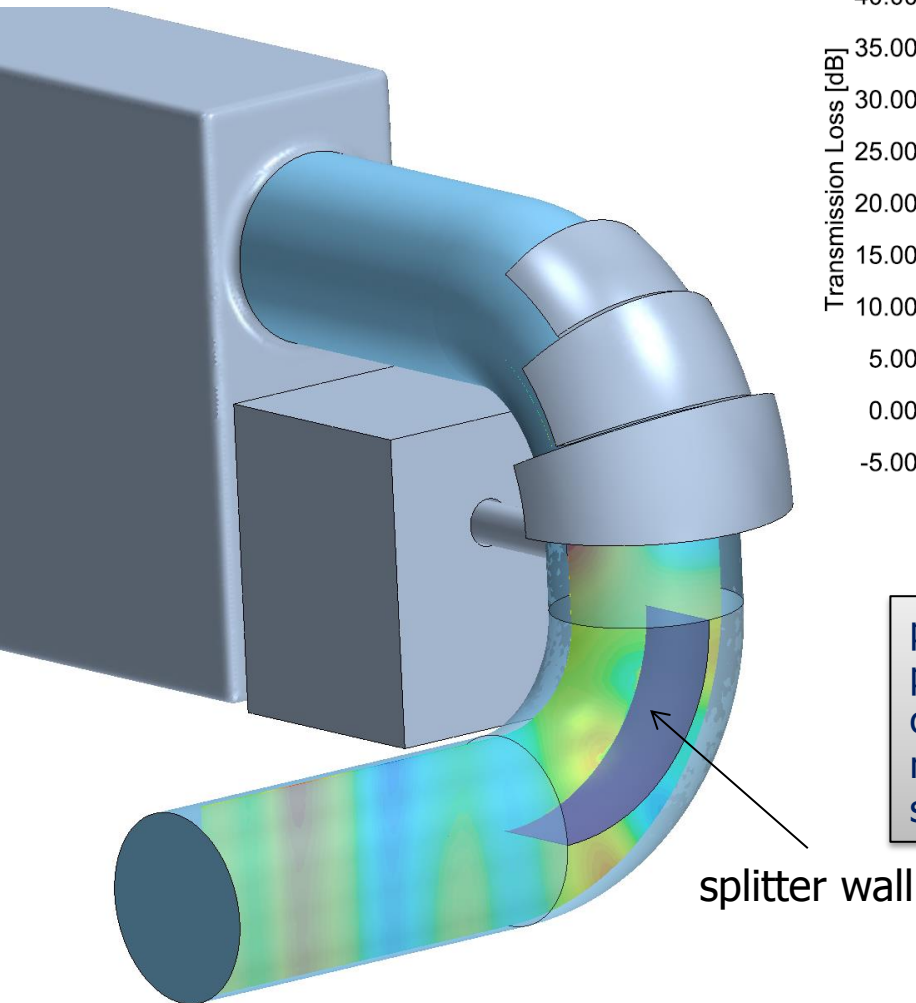


FFT inner pressure sensors



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Splitter Baffle in 90° Bent as Resonator



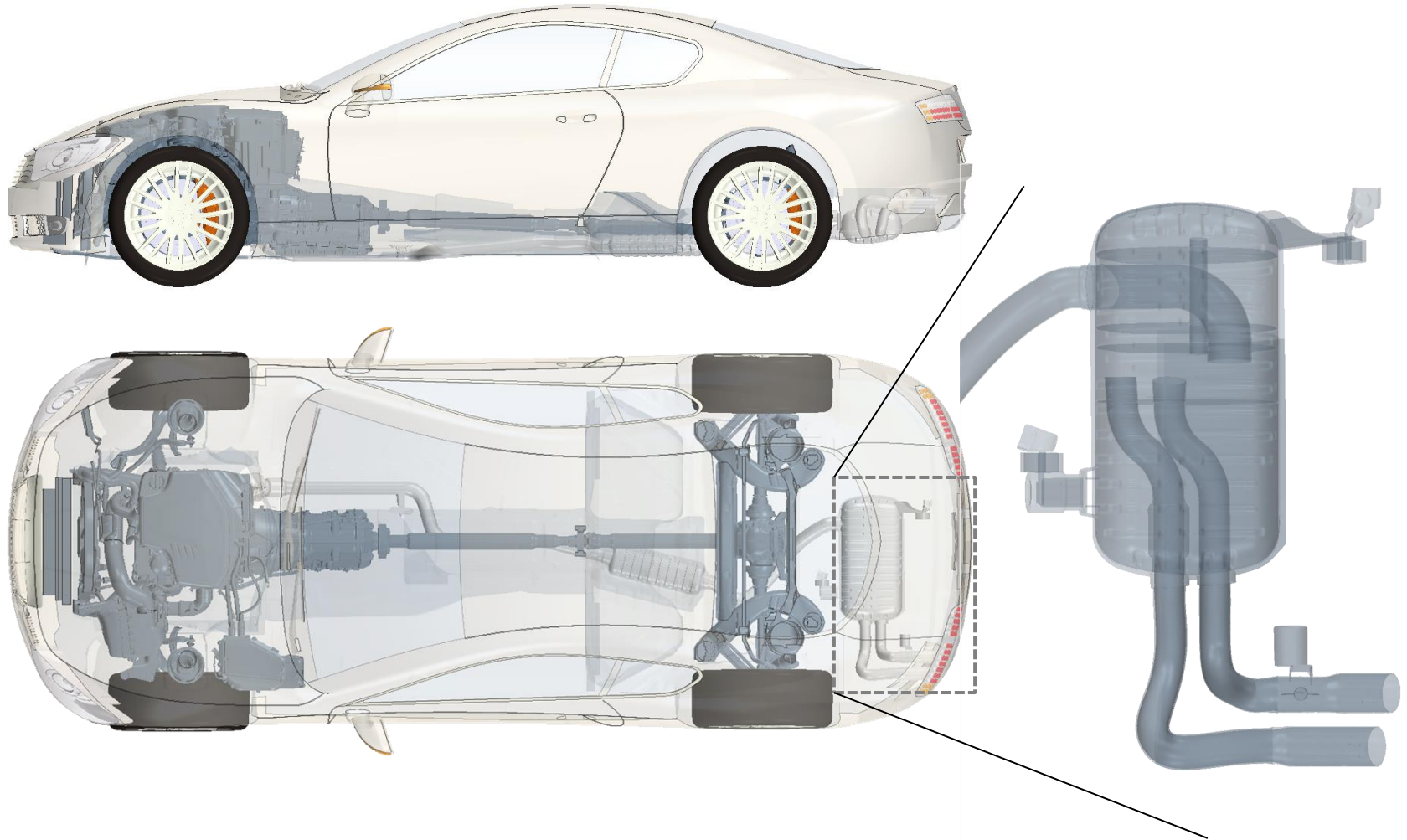
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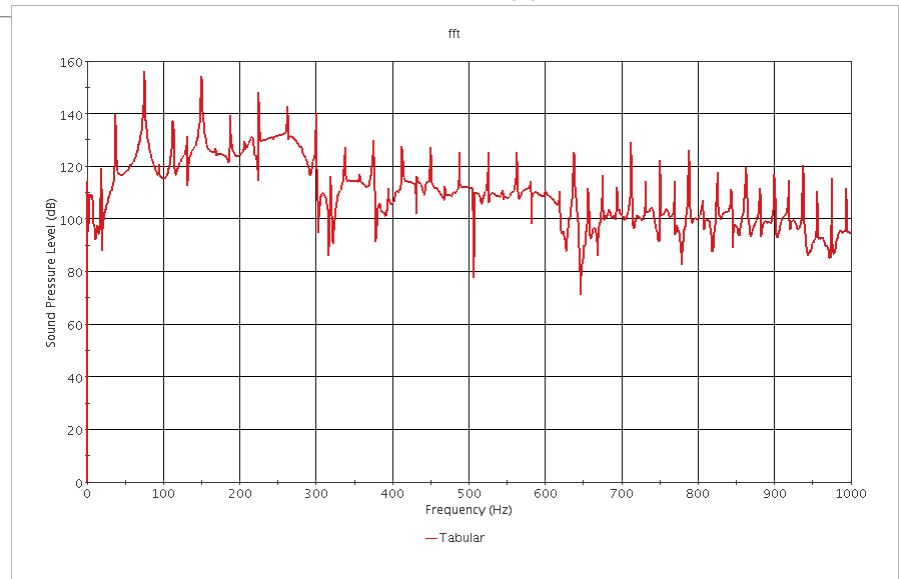
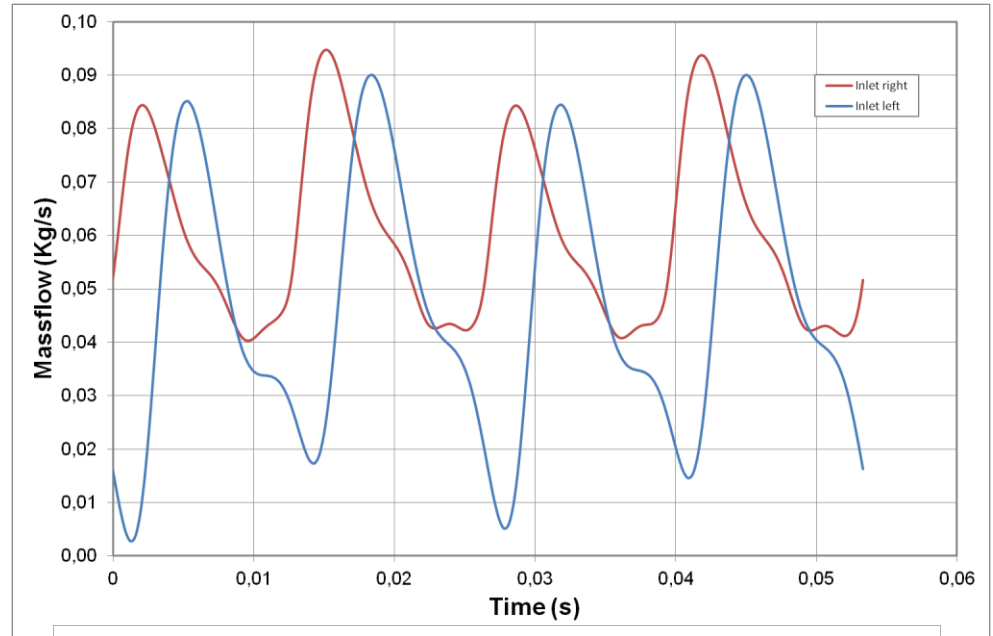
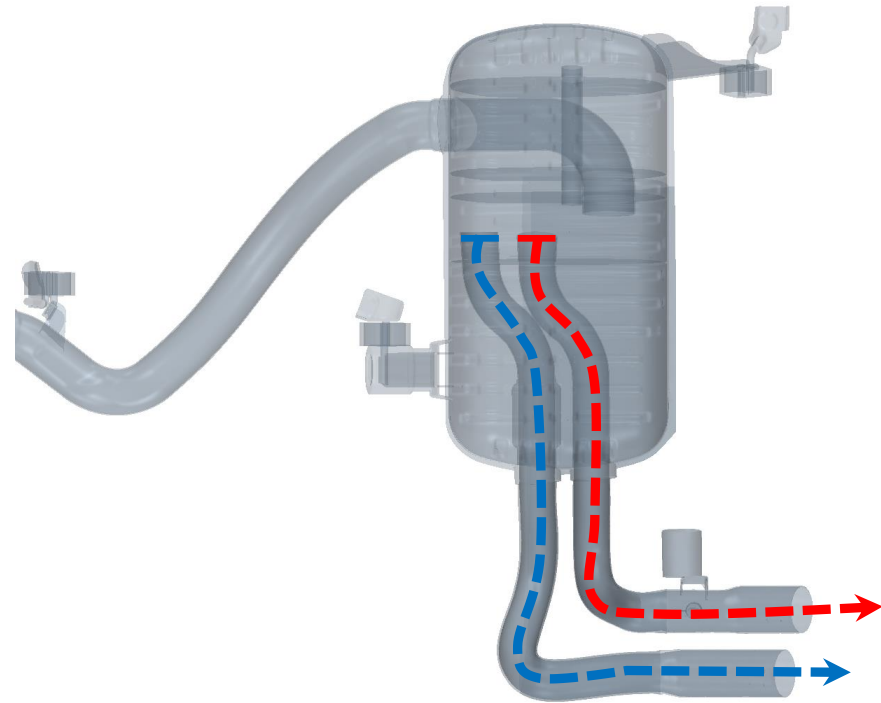
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Different tail pipe design



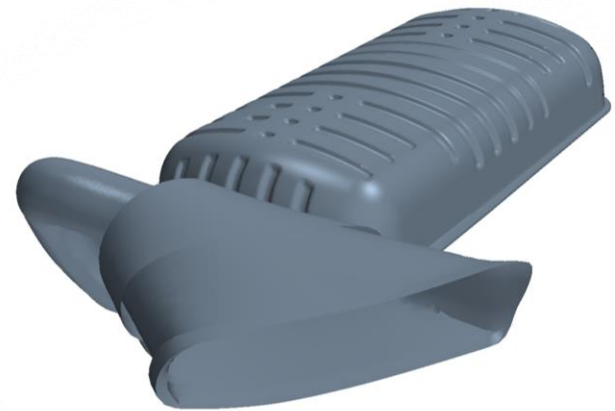
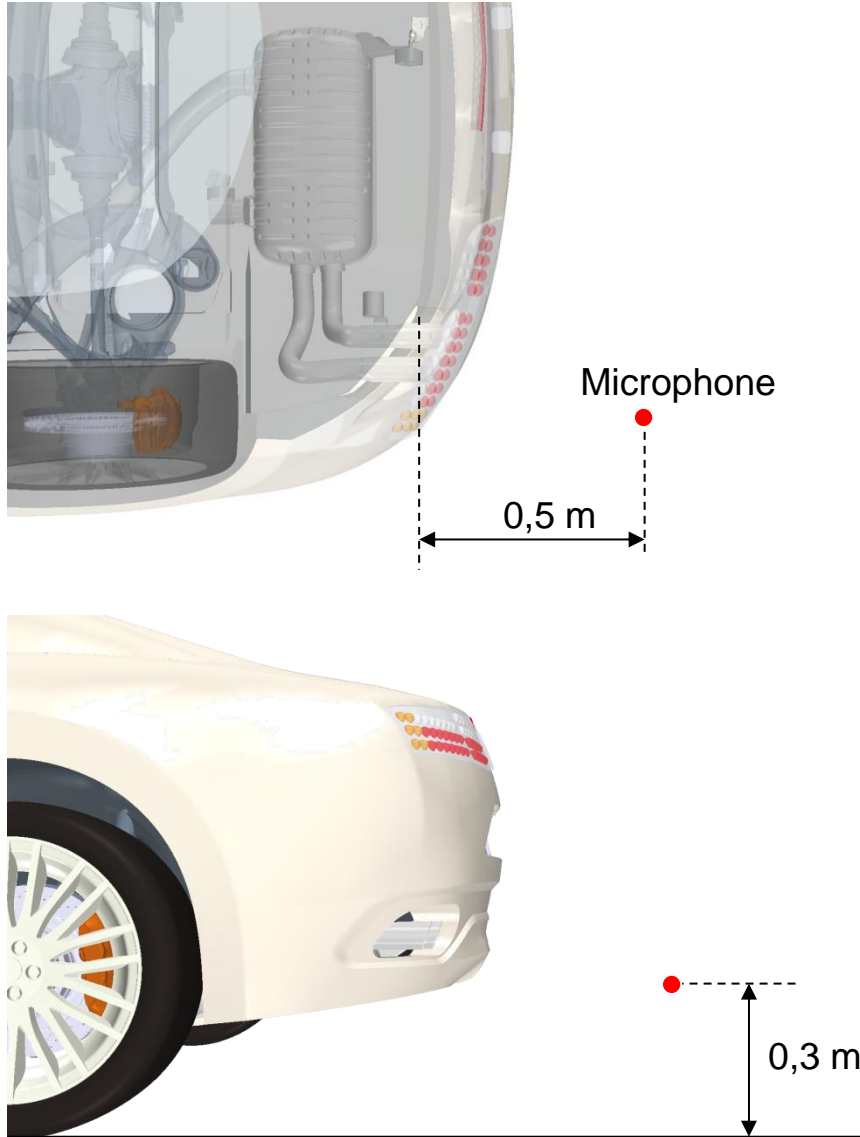
Acoustics Simulation for Automotive Systems

Different tail pipe design



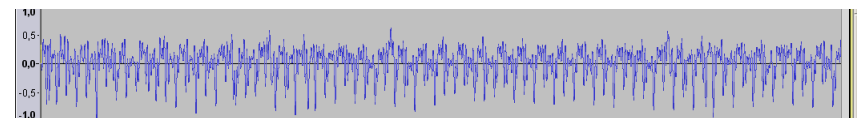
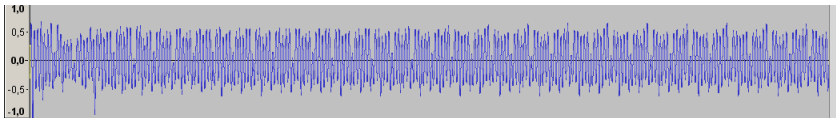
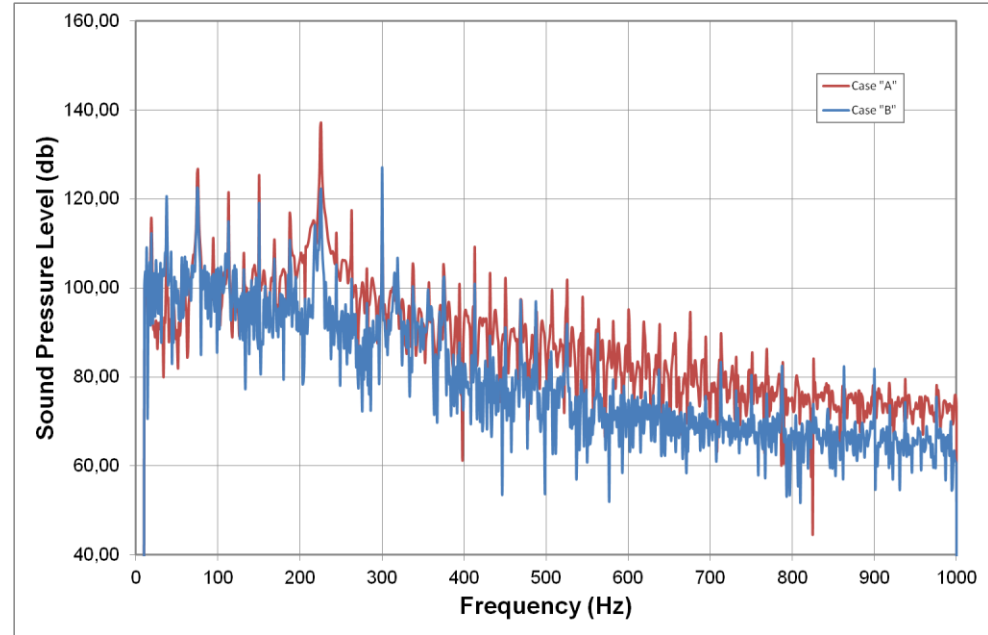
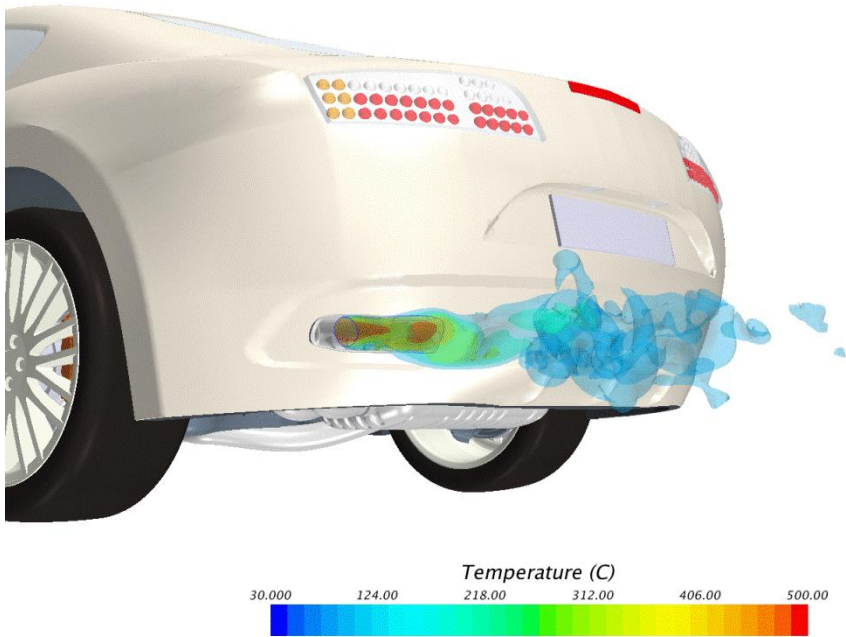
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Different tail pipe design



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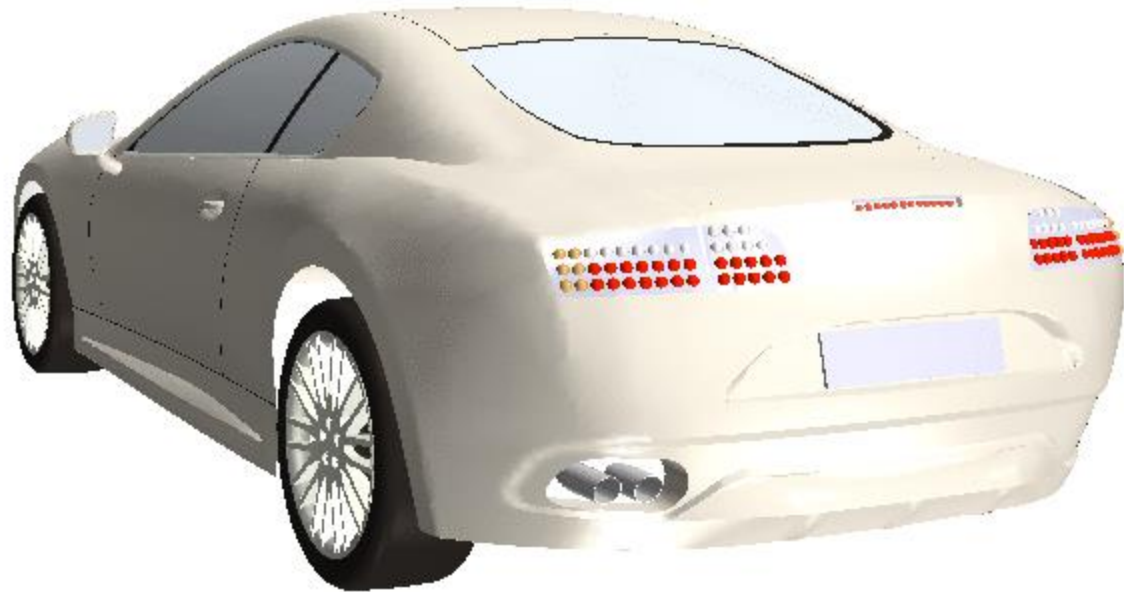
Different tail pipe design



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Outlook

Pass-By Simulation (coming soon)



...thank you for Your attention!