



MATLAB EXPO 2018

Progettazione di un sistema di cancellazione attiva del rumore stradale da rotolamento

Alessandro Costalunga

Software Designer

R&D Audio System

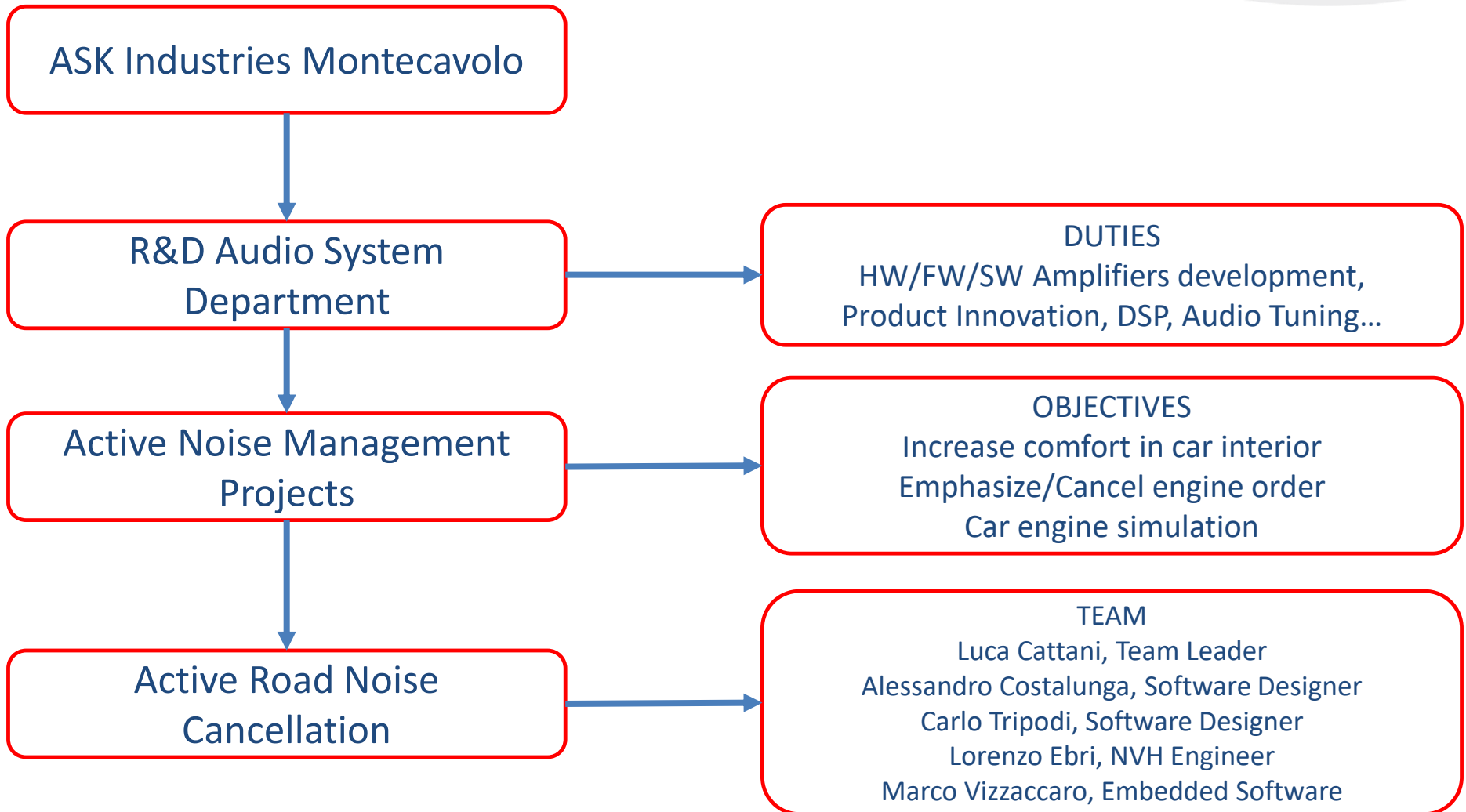
Ask Industries S.p.A

Global Supplier of Acoustic and Communication Technology for OEM customers in the Automotive Industry.
Main activities: Design, development and manufacturing of loudspeakers, amplifiers, antennas and cables for the automotive industry.

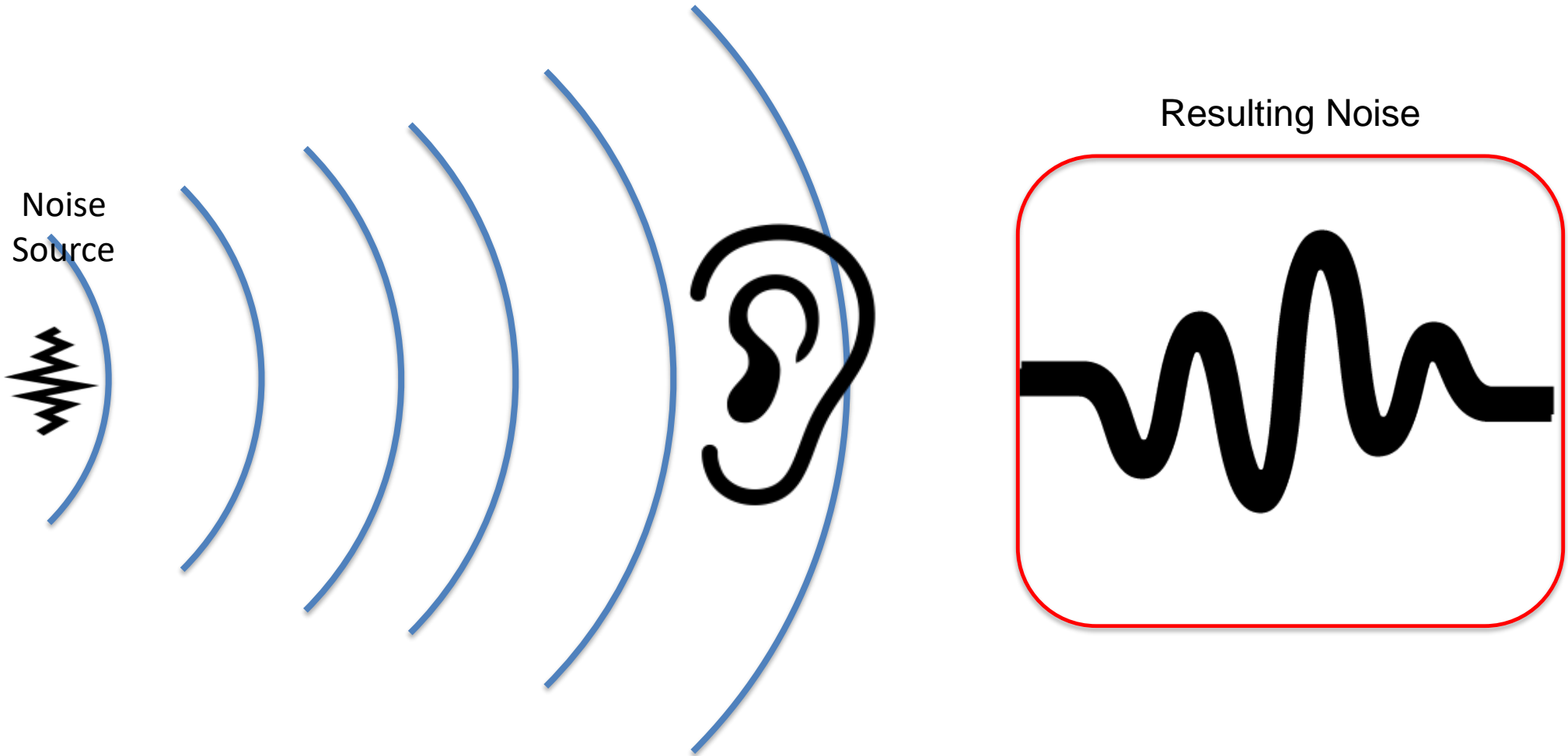


1965: Foundation

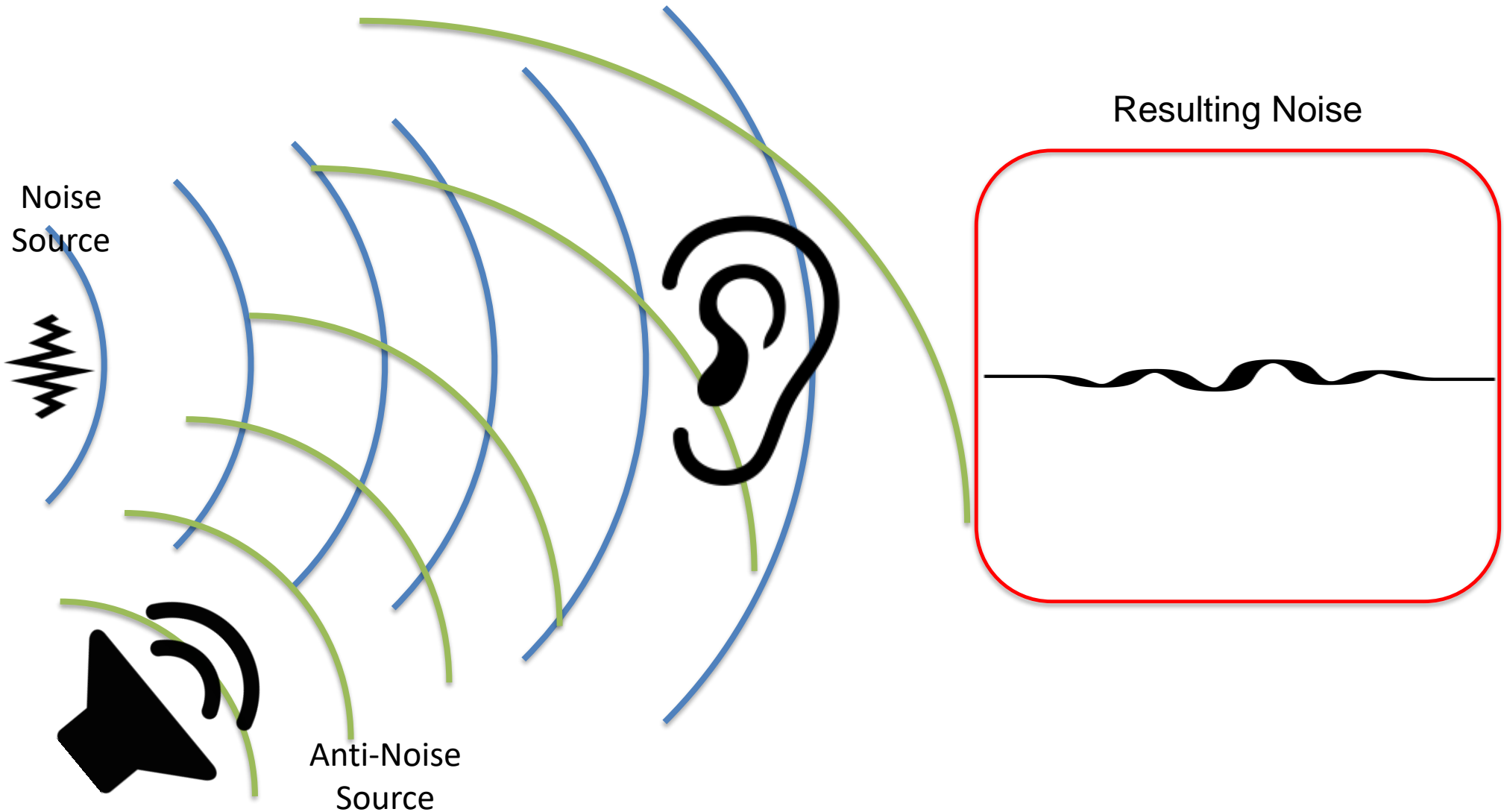
2015: enters in
JVC KENWOOD Group



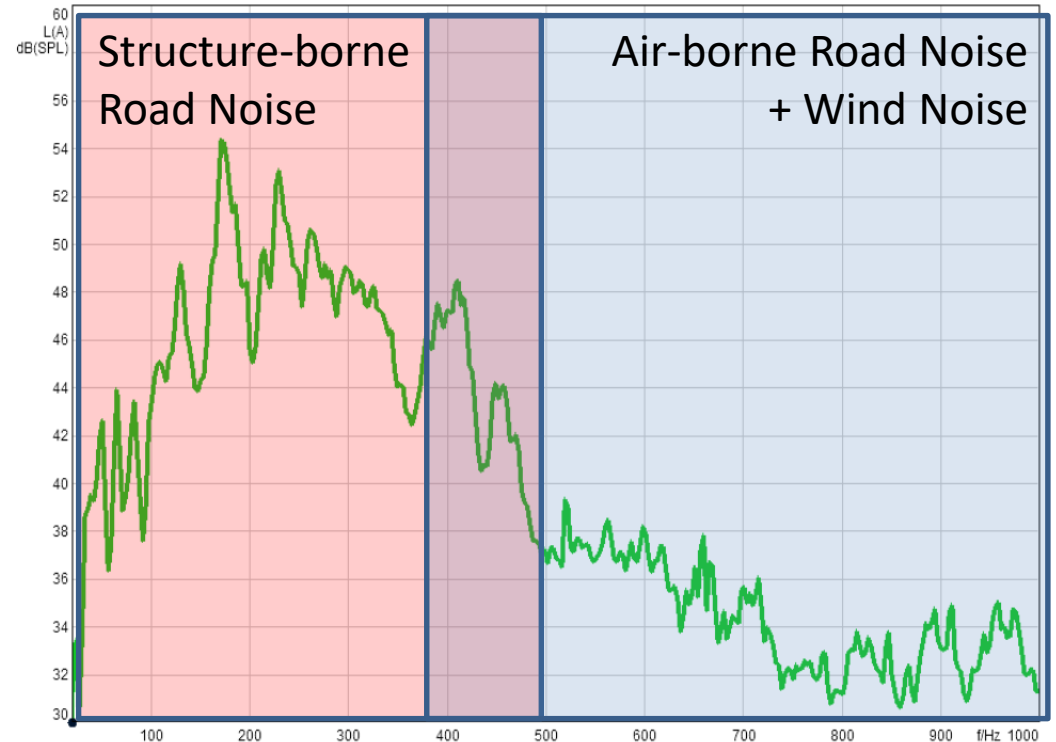
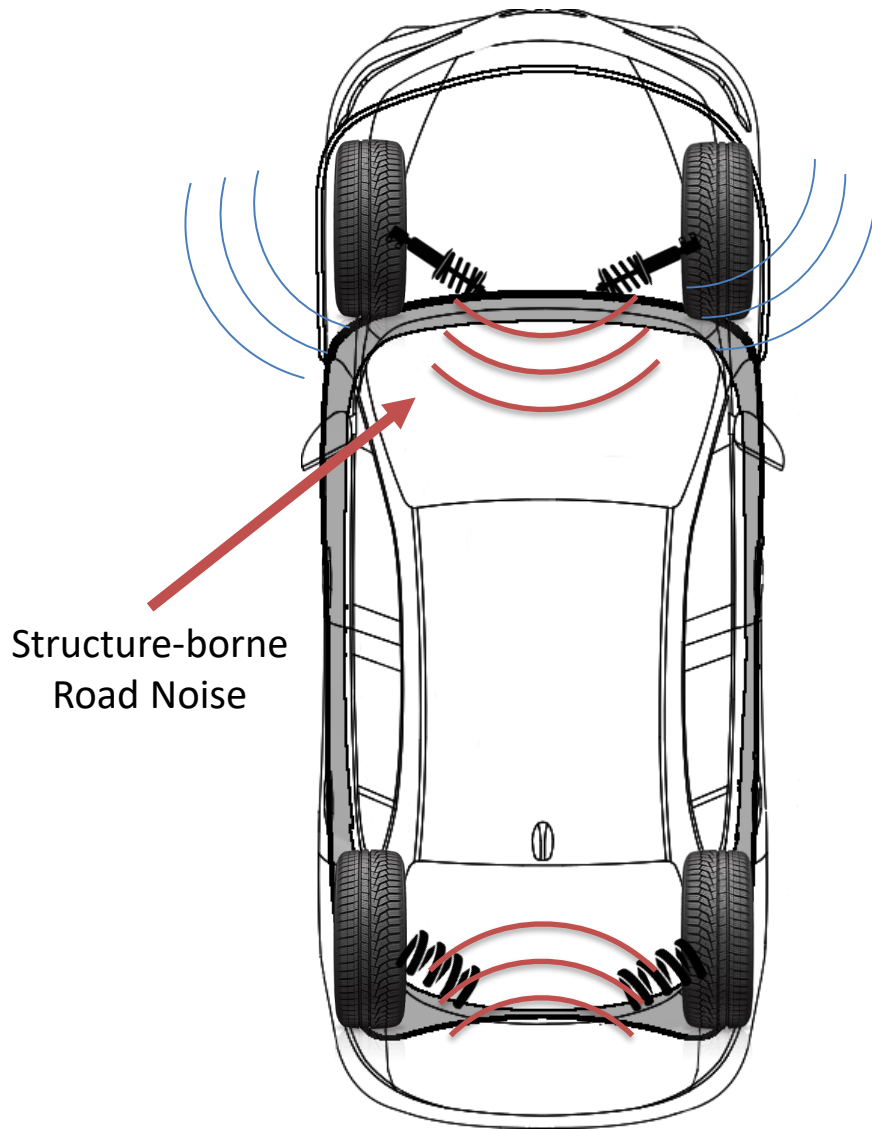
Active Noise Cancellation Systems



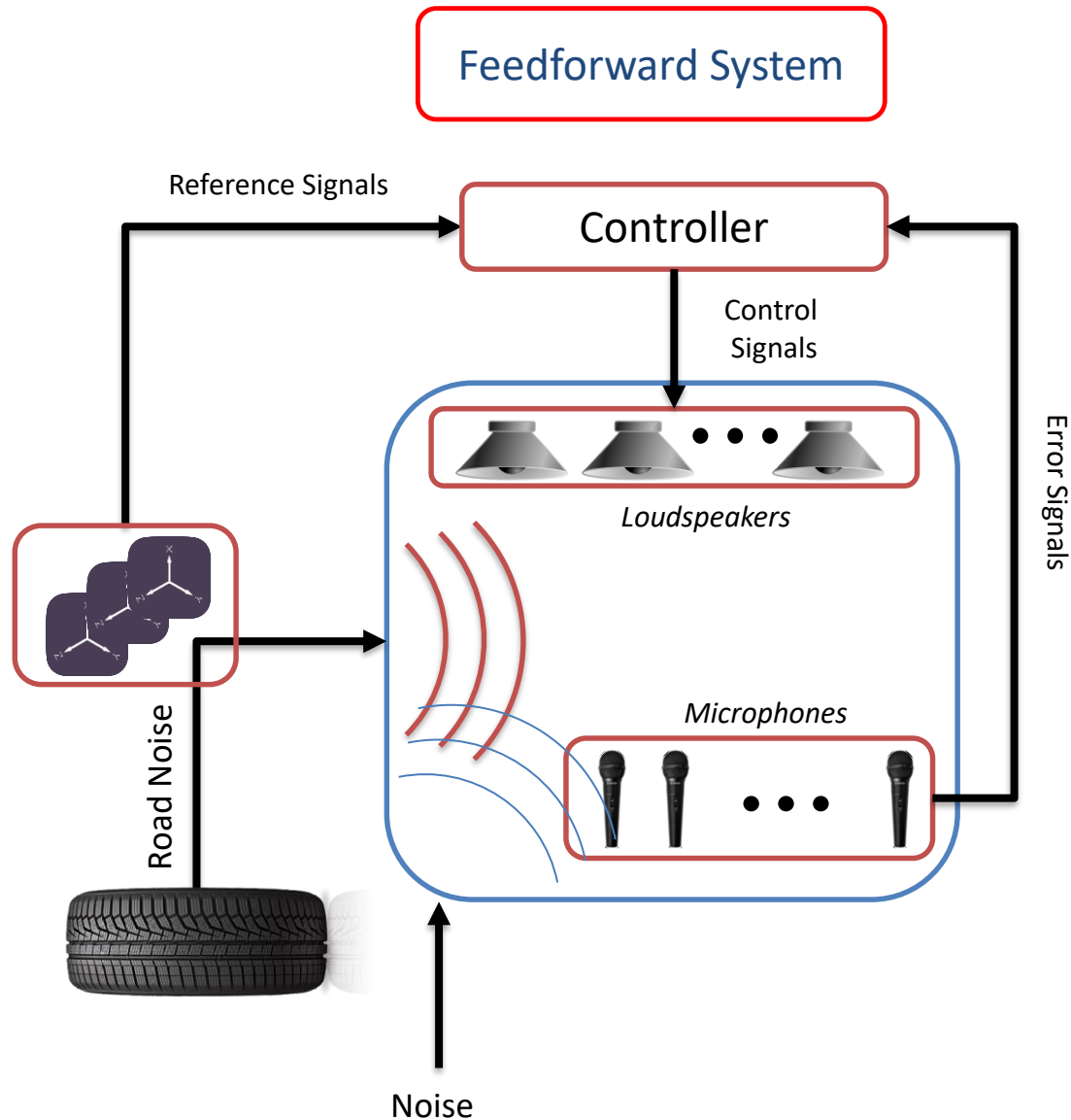
Active Noise Cancellation Systems

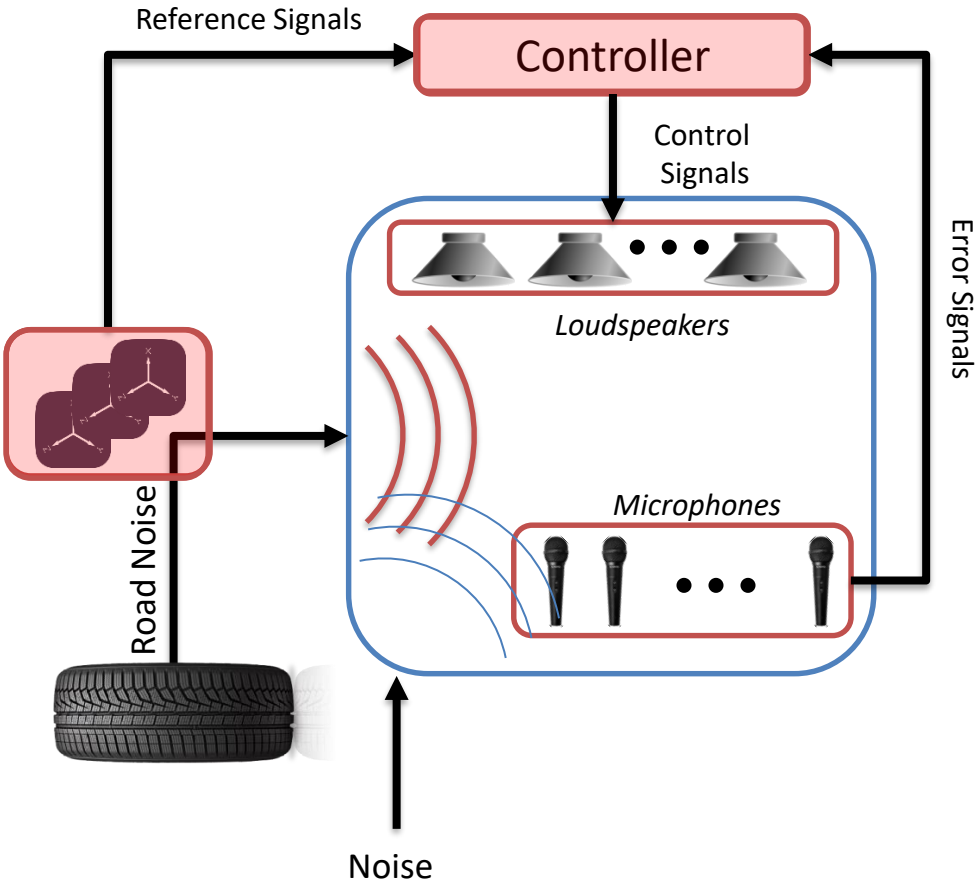


Problem: Road Noise



Active Control System Approach



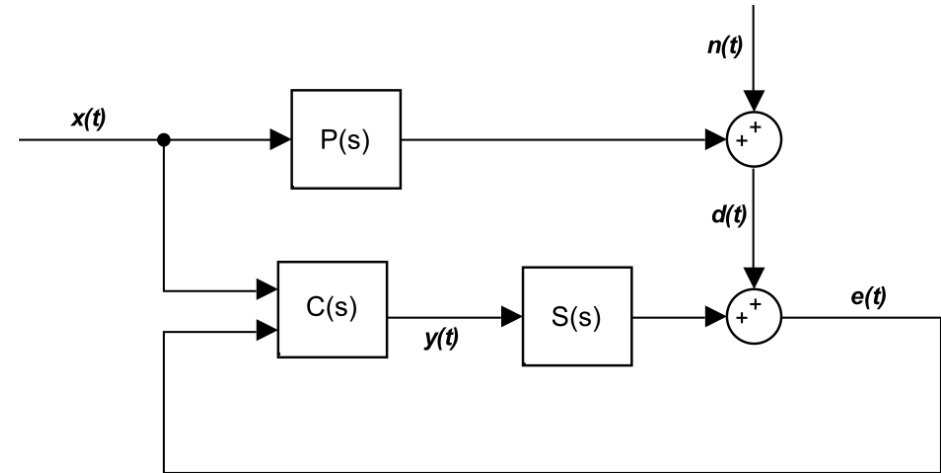
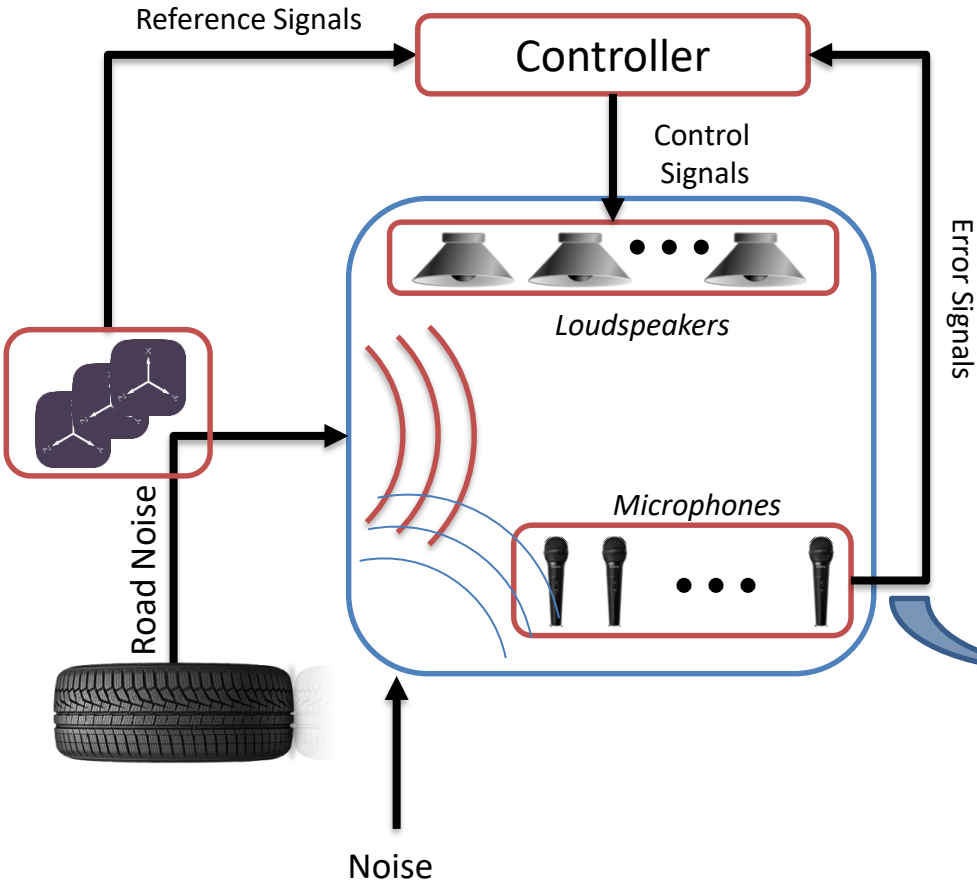


Control Algorithm

Reference Signals Selection

On-the-field Validation

Control Algorithm

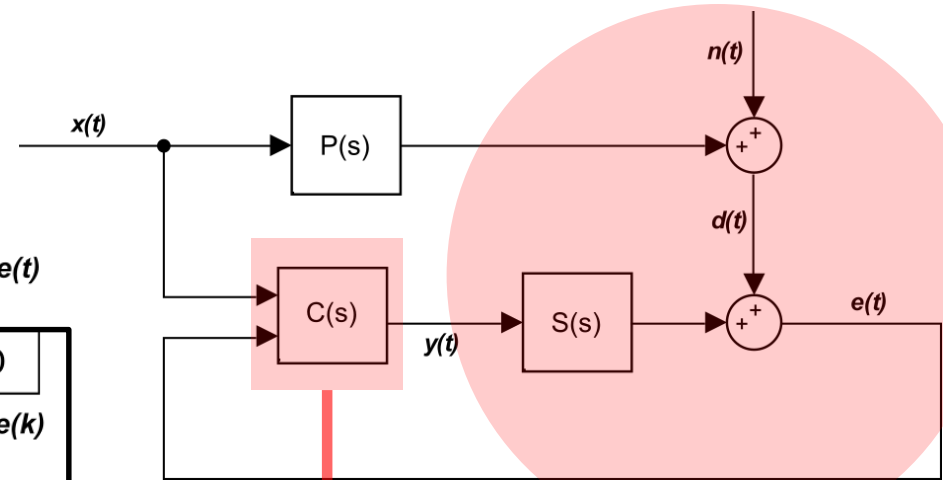
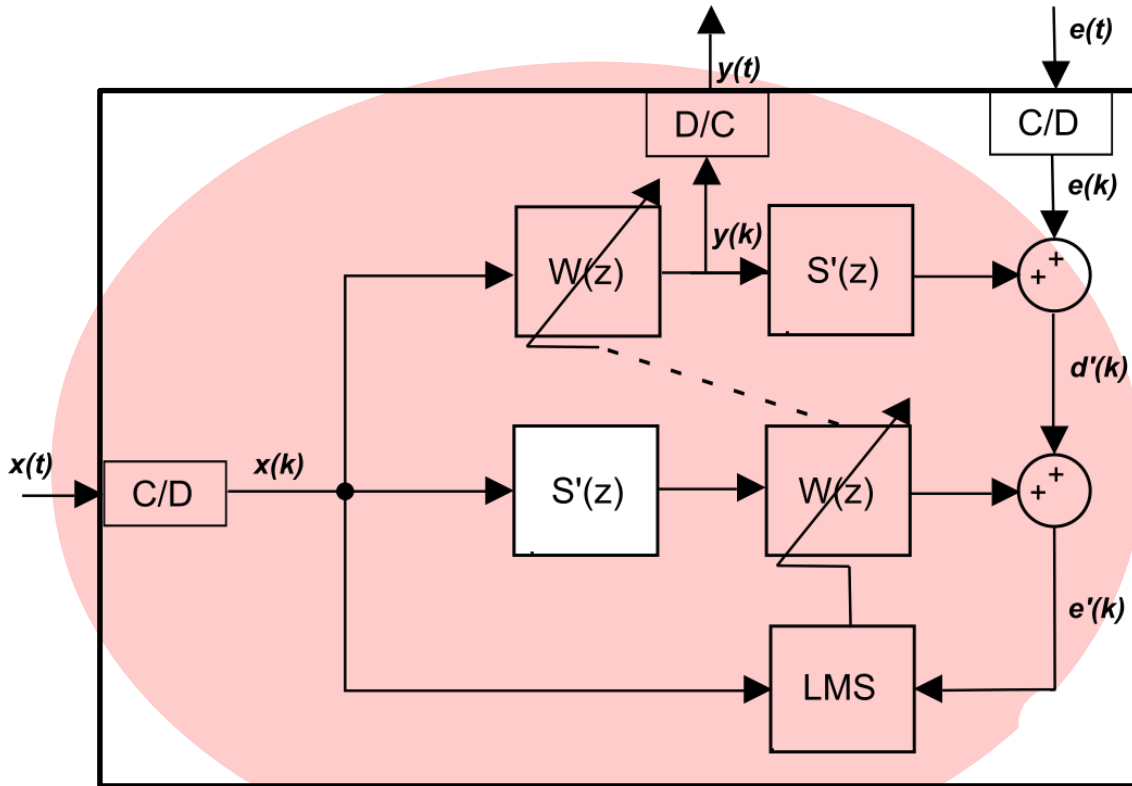


Goal:

$$C(s) = -\frac{P(s)}{S(s)}$$

Control Algorithm

Multichannel Modified Filtered-x Least Mean Square



1 Environment Simulator

2 Test several ANC algorithms from literature

Objectives

1 Environment Simulator

2 Test several ANC algorithms from literature

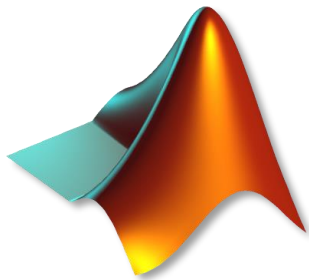
Constrains

Fast development

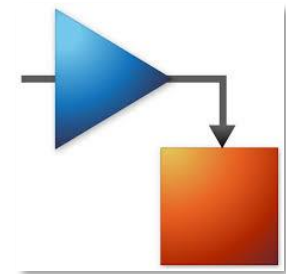
Accuracy

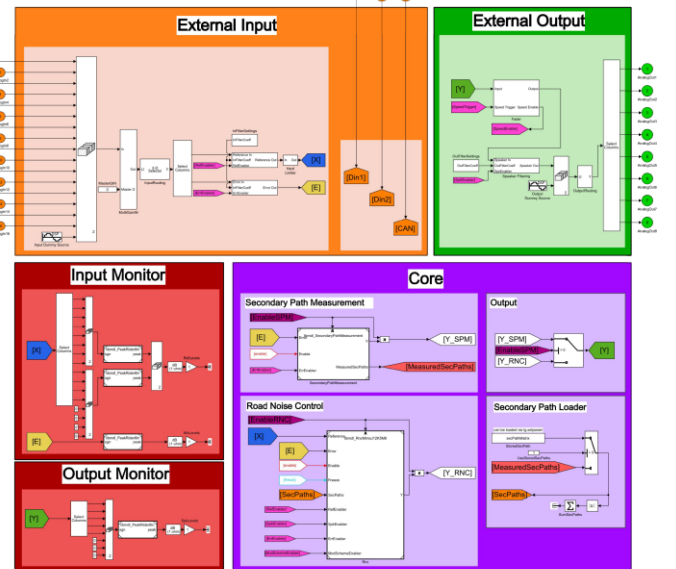
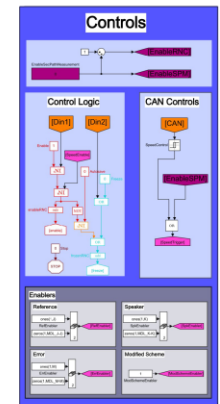
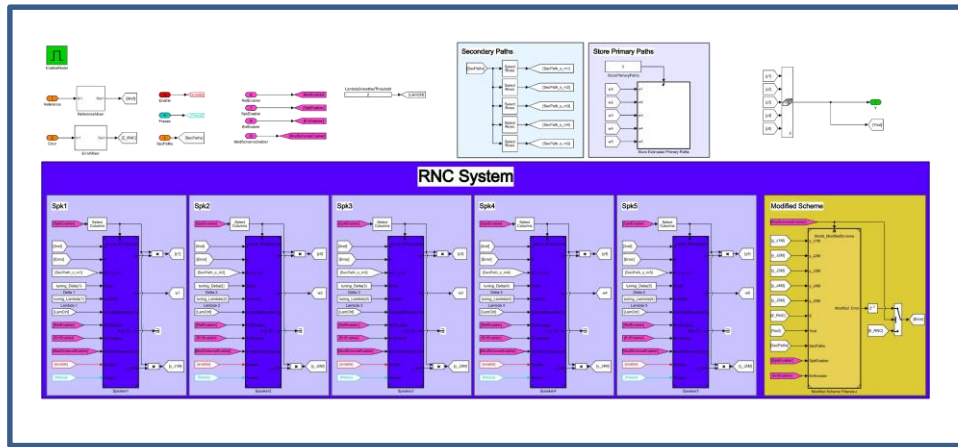
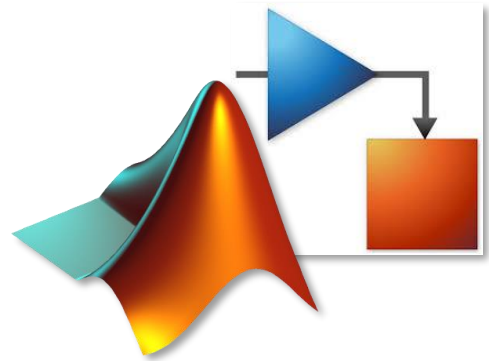
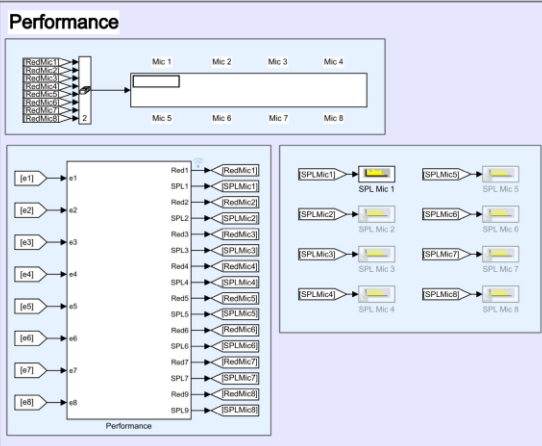
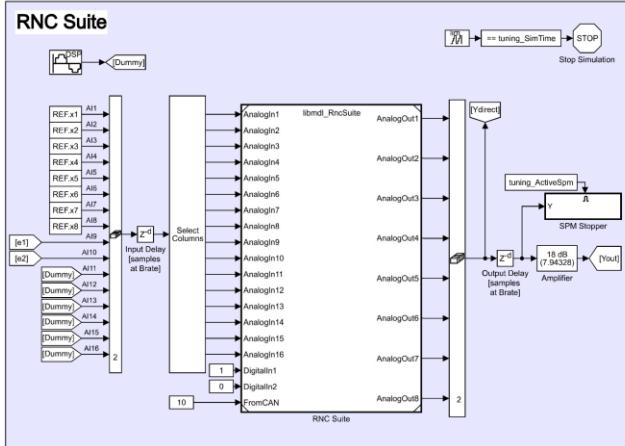
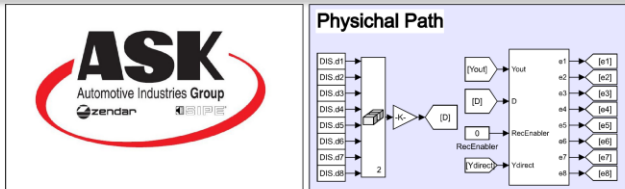
Solution

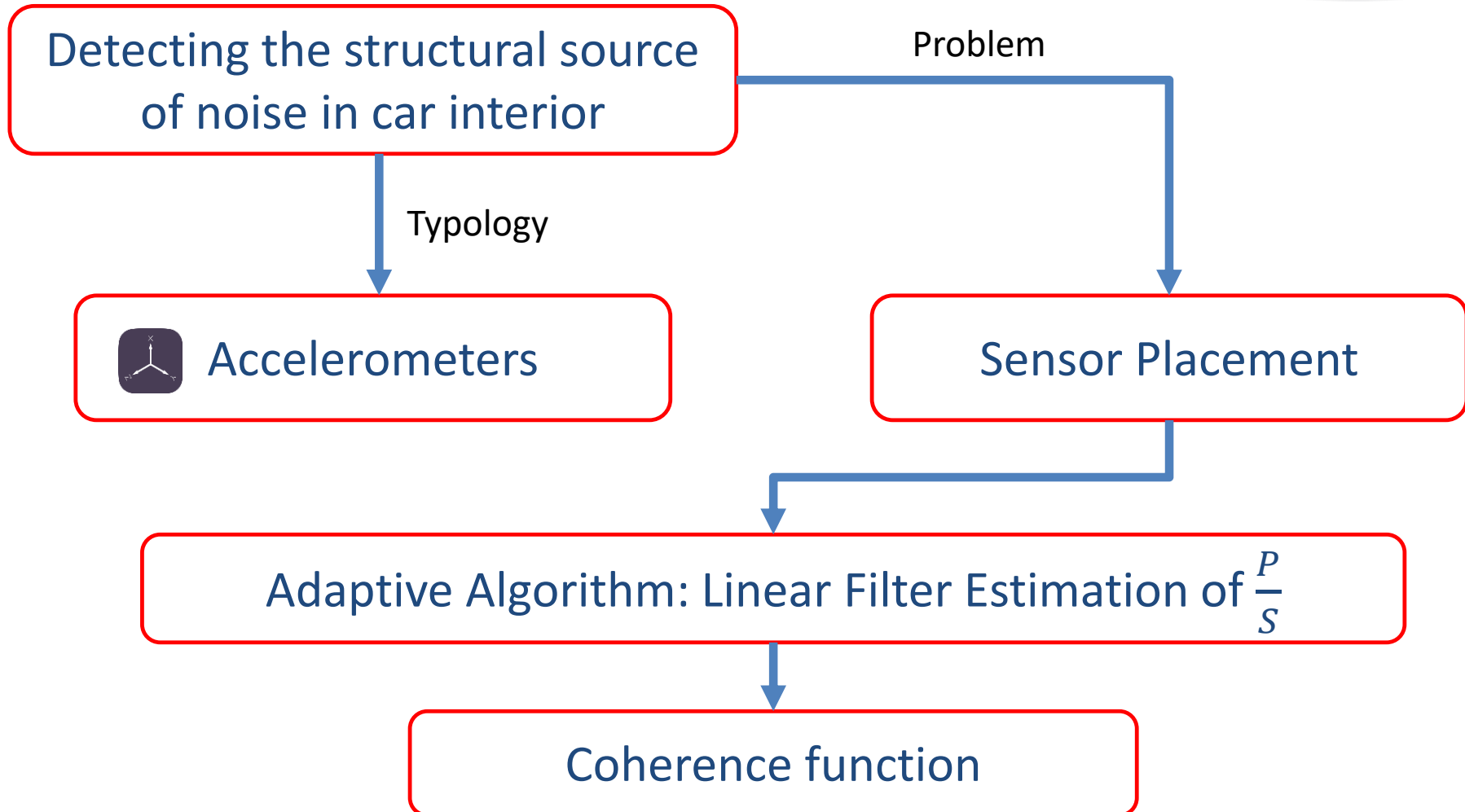
Development of a simulator in Simulink



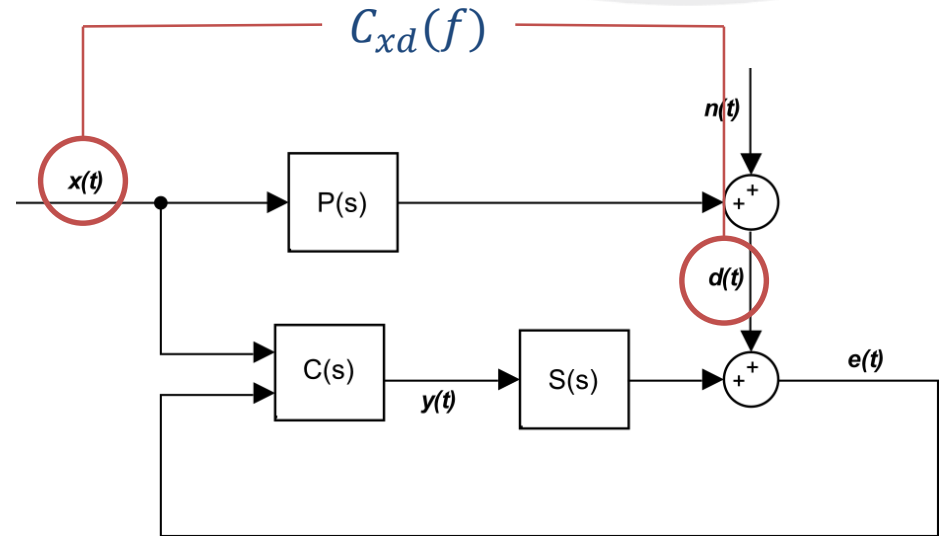
- Model Based Design
- Graphical Environment
- Rapid Debug
- Code generation



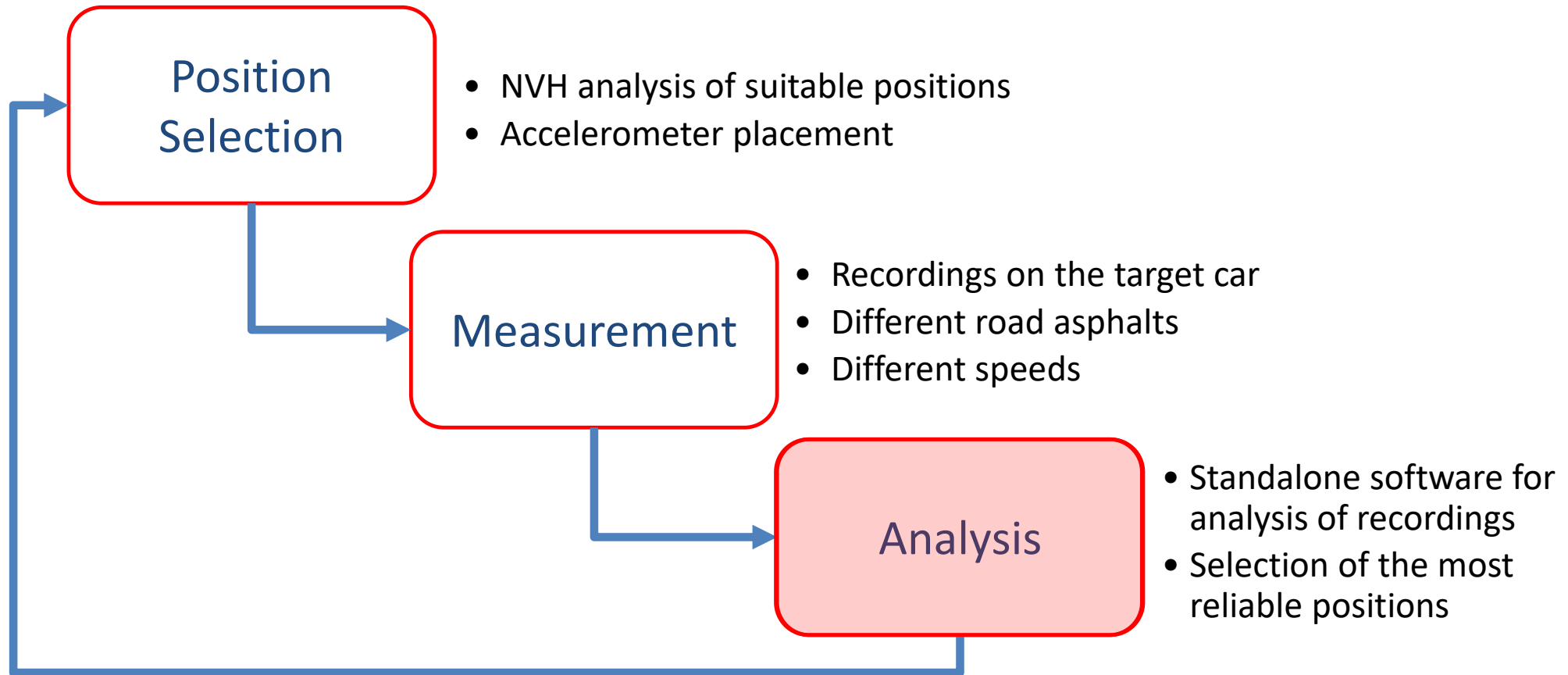




Coherence is a function of frequency with values between 0 and 1 which measures the relative linearity between two signals



Maximum theoretical noise reduction:
$$-10 \log_{10}[1 - C_{xd}(f)]$$



Development of a standalone application in
MATLAB



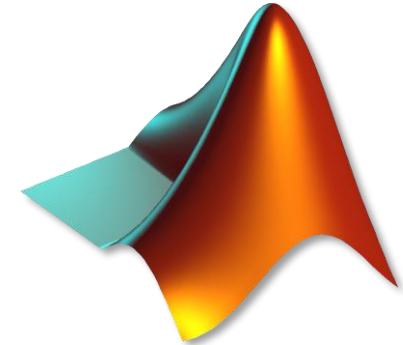
Collect and explore large signal dataset

Signal Processing

Easy to use: Graphical User Interface

Fast implementation

- Smart data types
- Wide set of build-in functions
- App Designer API
- Quick debug
- Complete documentation



Reference Signal Selection: Analysis



Coherence Analyzer Tool

ASK Ready Global Parameters sampling_rate = 12800 time_max = 7 sw = Matlab Opening Signal Analysis Coherence Analysis

Open Session Signal Visualization Coherence Calculation Coherence Analysis Evaluation

Coherence Analysis

Graph waterfall

Coherence Cancellation

Frequency Limit

Minimum Frequency 0 Maximum Frequency 1000

Select

References Error Mics Experiments

References

- 31.pls202_V-X
- 32.pls202_V-Y
- 33.pls202_V-Z
- 34.pls351_double_V-X
- 35.pls351_double_V-Y
- 36.pls351_double_V-Z
- 37.spring_V_3-X
- 38.spring_V_3-Y
- 39.spring_V_3-Z
- 40.spring_V_4-X
- 41.spring_V_4-Y
- 42.spring_V_4-Z

Error Microphones

- 4.MicP1-S
- 5.MicP2-S
- 6.MicP3-S
- 7.MicP4-S
- 8.MicP5-S
- 9.MicP6-S
- 10.MicP7-S
- 11.MicP8-S
- 12.eFL-S
- 13.eFR-S
- 14.eRL-S
- 15.eRR-S

Experiments

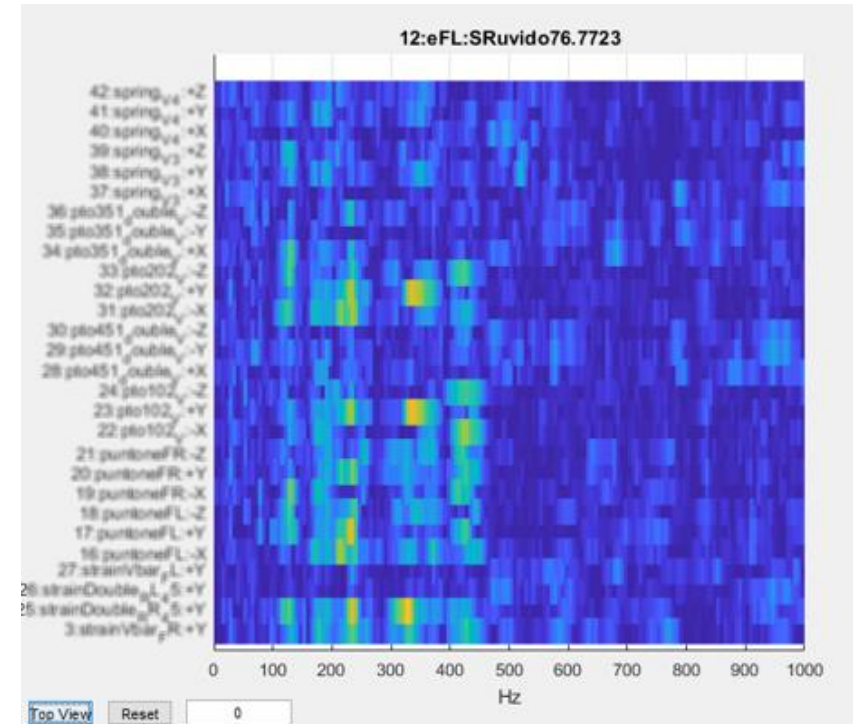
- Ruvido51.7453
- Ruvido76.7723
- Ruvido100.4661
- Liscio52.6389
- Liscio77.1515
- Liscio102.024

Signals Visualization H1 Filtering MatLab Multiple MSC Evaluation

Off On Time Frequency

Same Figure Signals Domain Show Signals

New Window Close All High View

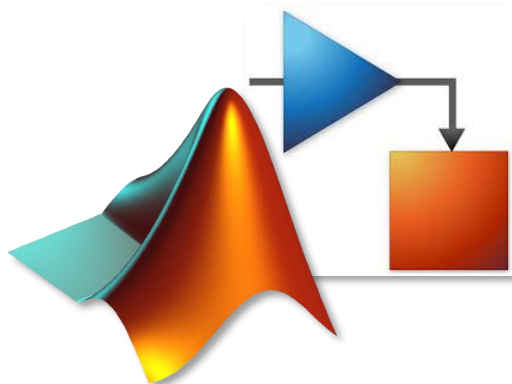


Performance Analysis

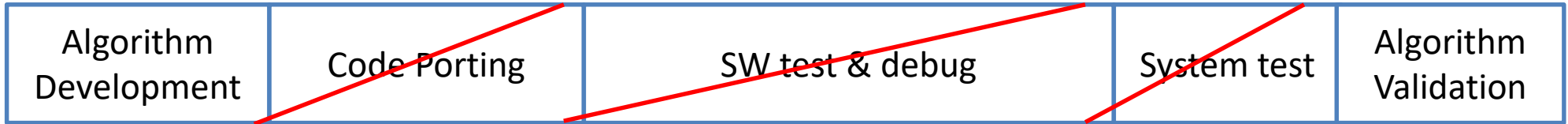
Tight Deadlines

Constant Algorithm
improvements

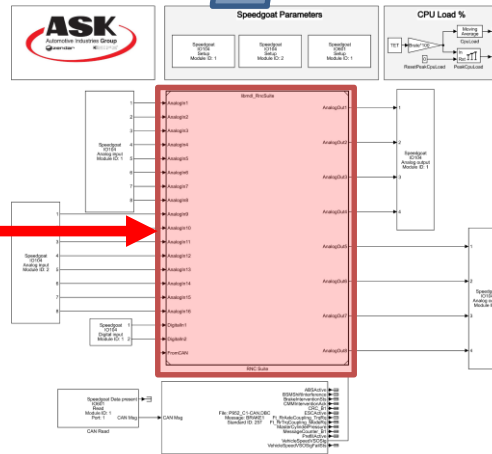
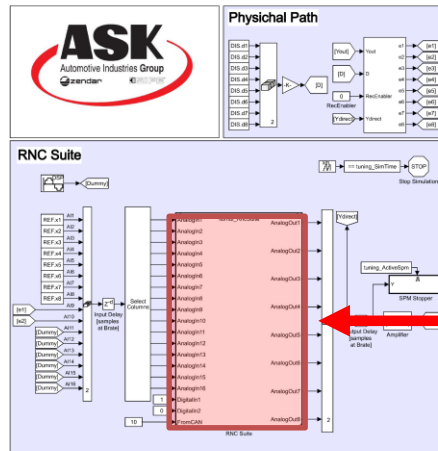
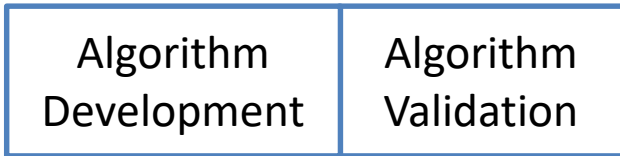
Rapid Prototyping
Approach



Rapid Prototyping Approach



Expensive in term of time and resources

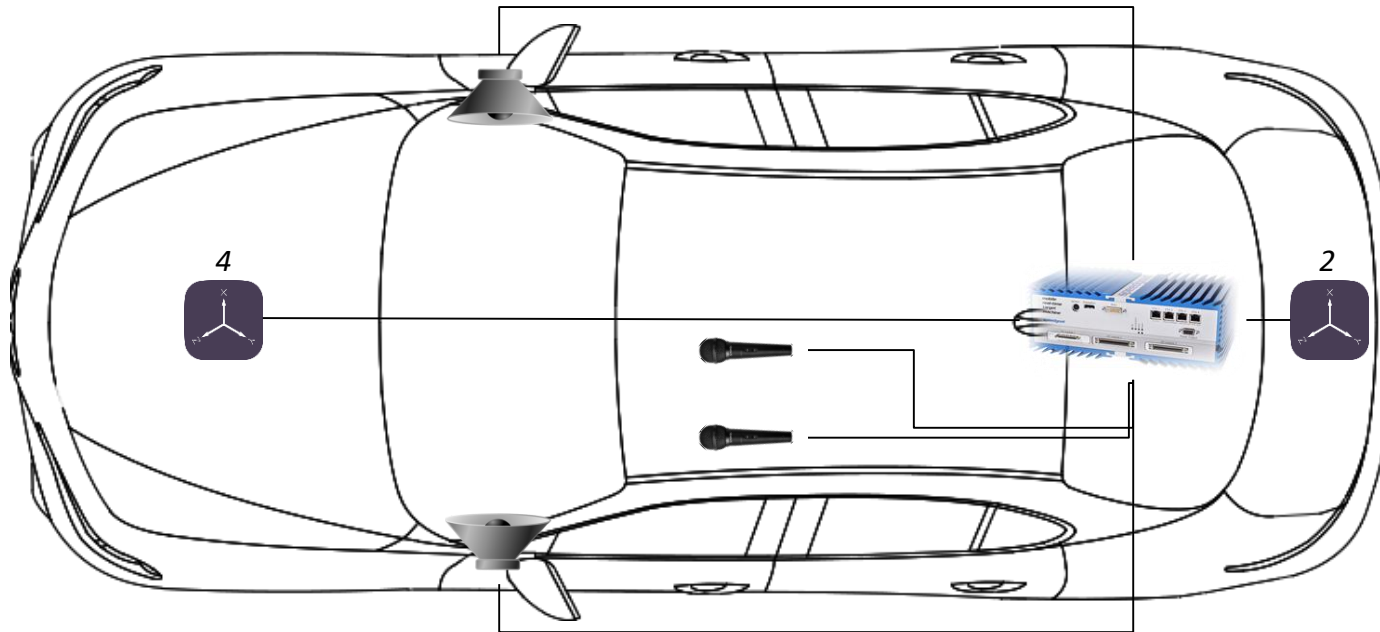


Alfa Romeo Giulia

2.0 L4 TurboGasoline 200Hp RWD AT8

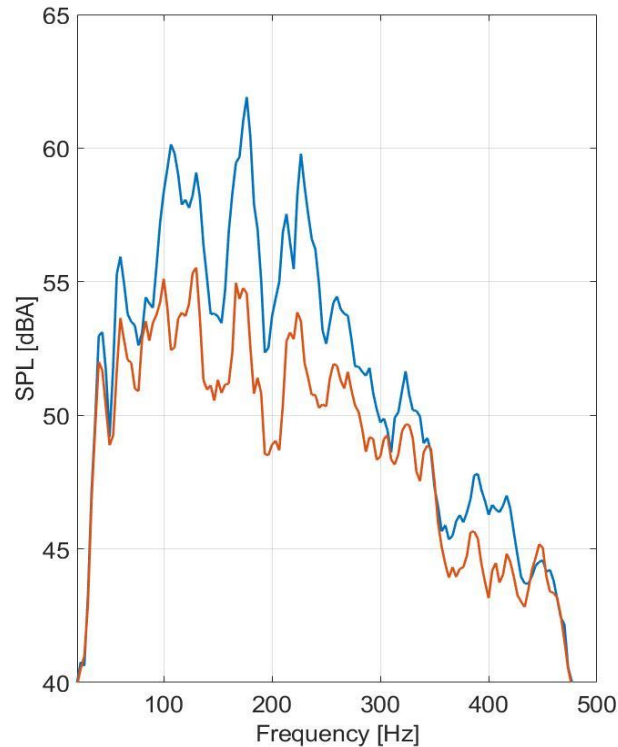


Cancellation performed on Driver Seat

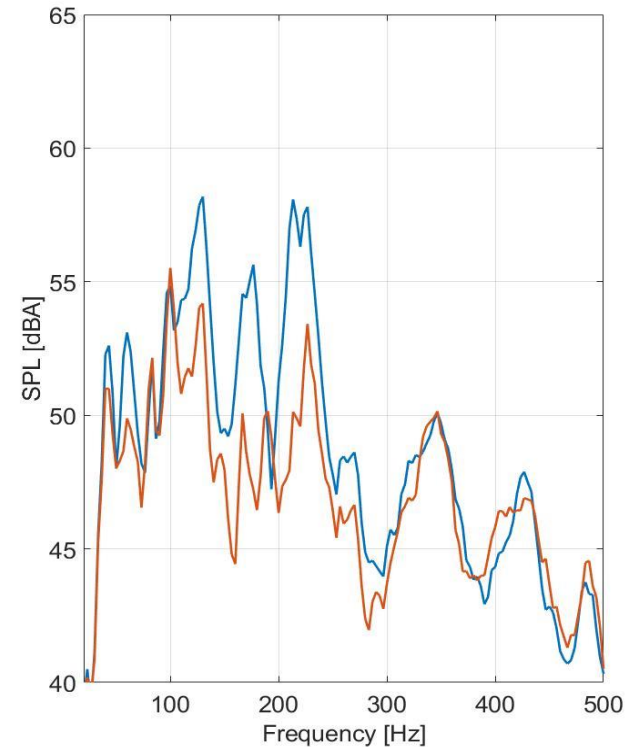


6 Accelerometers; 2 Loudspeakers; 2 Microphones

Rough asphalt, 50 km/h



Cancellation on left ear
Average: 3db
Peak: 8db @ 180Hz

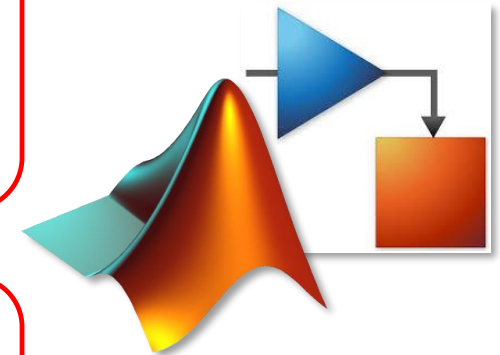


Cancellation on right ear
Average: 2.5db
Peak: 9db @ 210Hz

RNC system for automotive applications is feasible and effective

MATLAB and Simulink are the best options for the development of innovative systems

Rapid prototyping with MATLAB and Simulink is cost and time effective





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