ASK
Automotive Industries Group
zendar SIPE

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

AUTOMOTIVE SOLUTIONS

a JVCKENWOOD Company

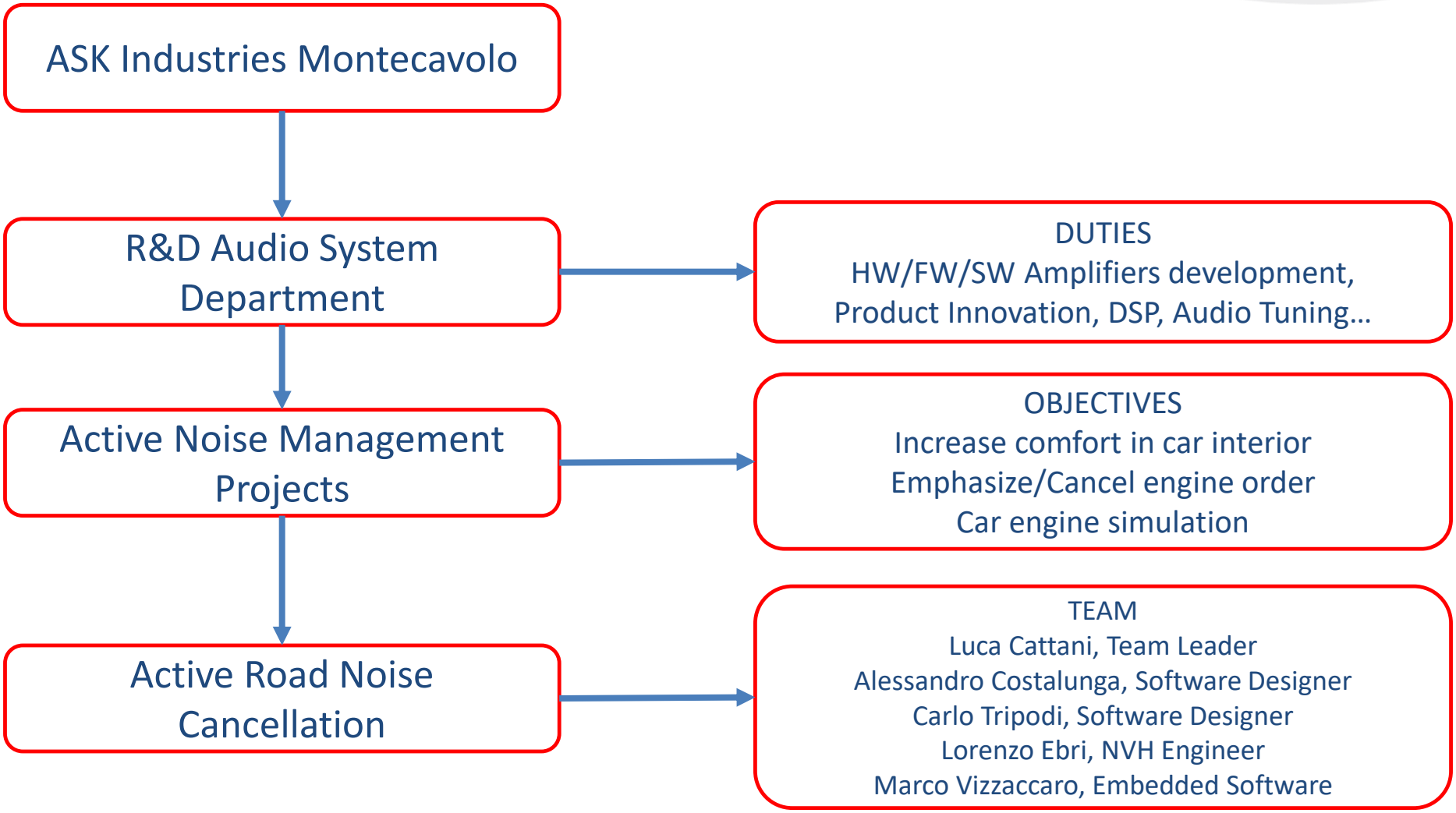
ASK Industries S.p.A.

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.

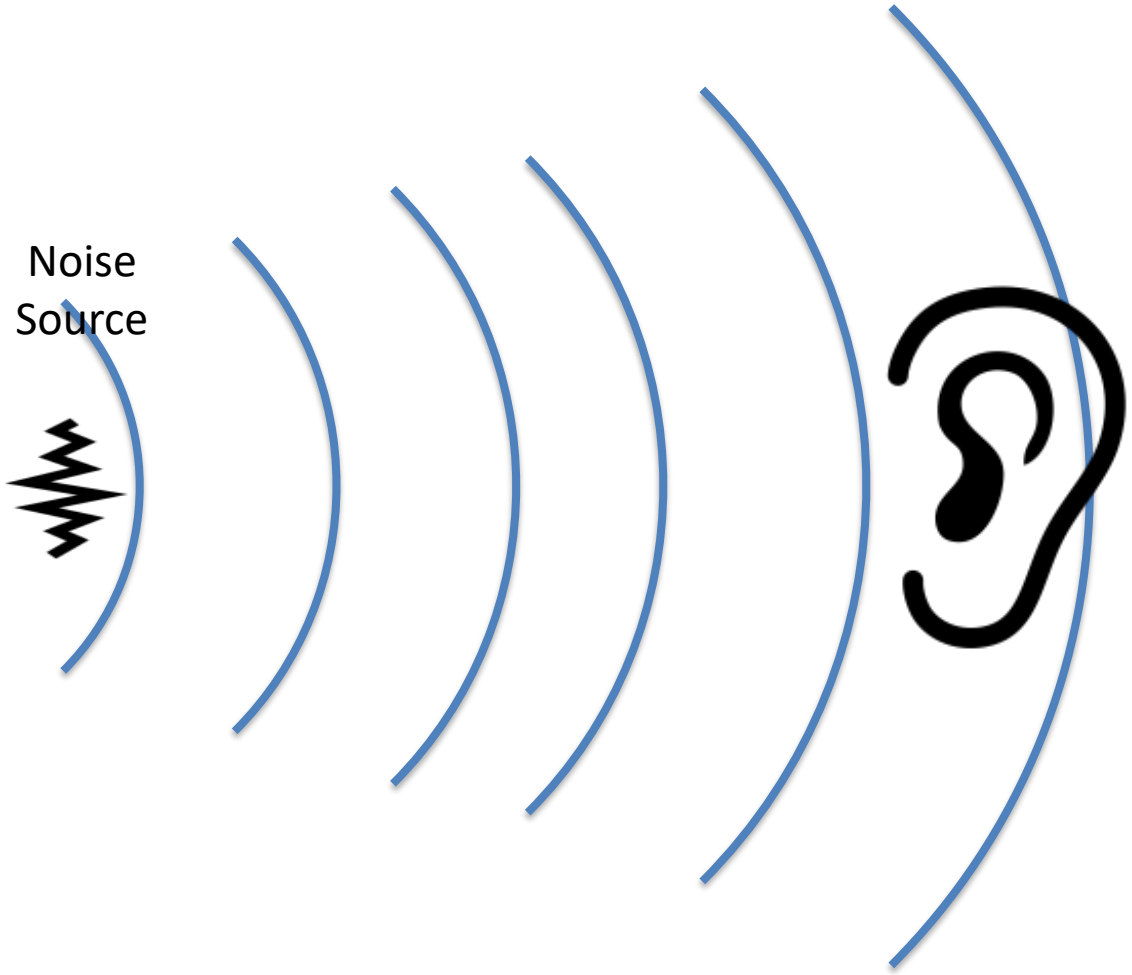
1965: Foundation

2015: enters in JVC KENWOOD Group

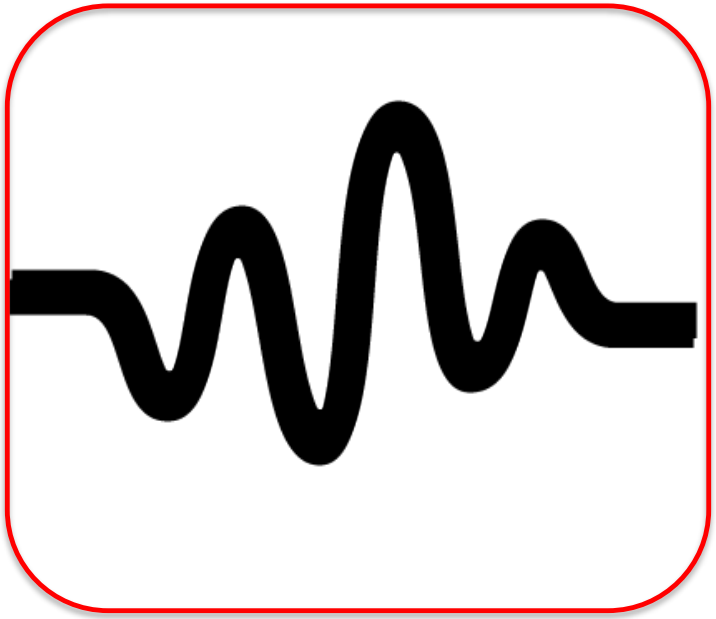
Team


ASK Industries Montecavolo
R&D Audio System Department
Active Noise Management Projects
Active Road Noise Cancellation
DUTIES
HW/FW/SW Amplifiers development,
Product Innovation, DSP, Audio Tuning…
OBJECTIVES
Increase comfort in car interior
Emphasize/Cancel engine order
Car engine simulation
TEAM
Luca Cattani, Team Leader
Alessandro Costalunga, Software Designer
Carlo Tripodi, Software Designer
Lorenzo Ebri, NVH Engineer
Marco Vizzaccaro, Embedded Software

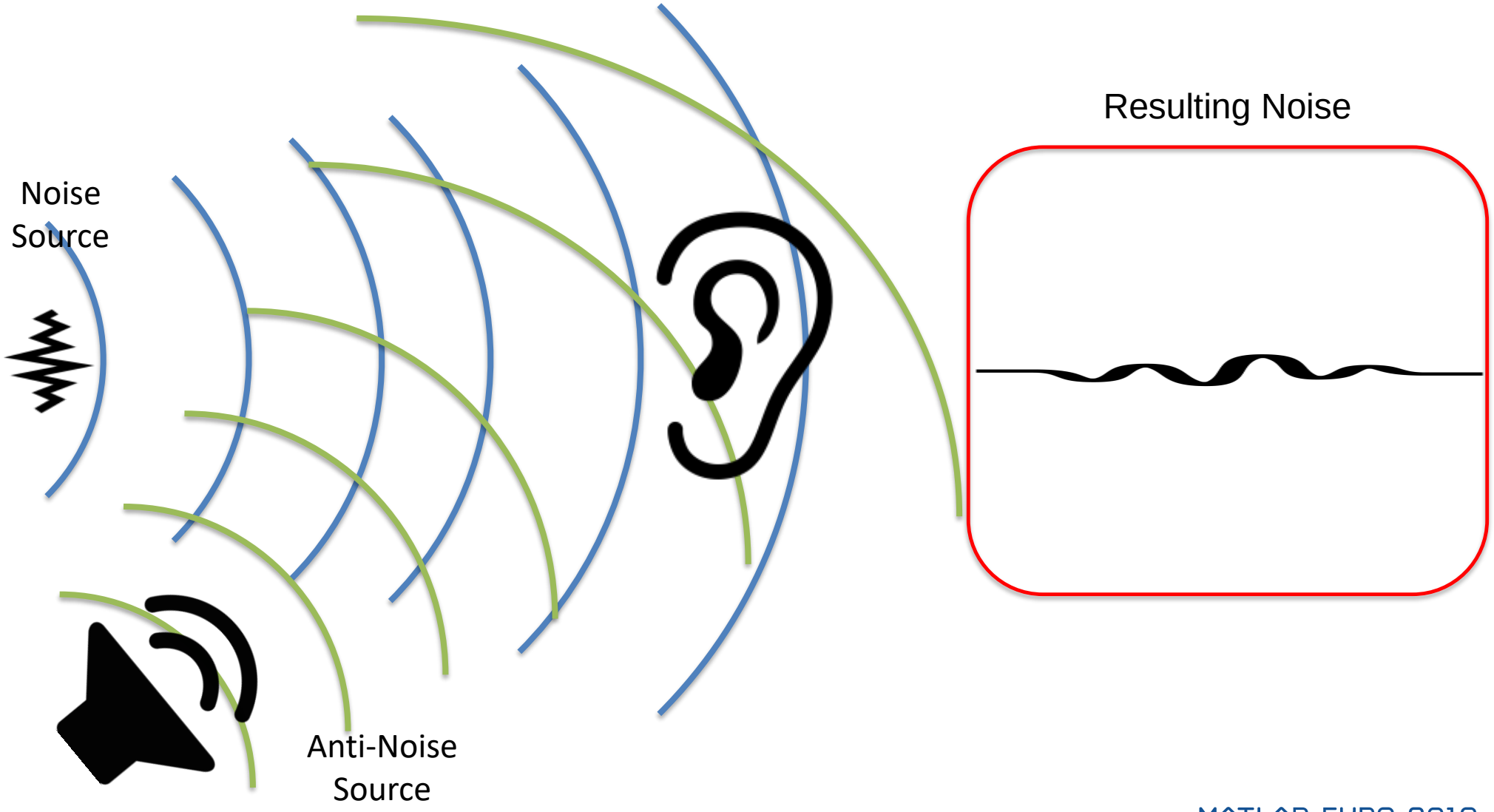
Active Noise Cancellation Systems



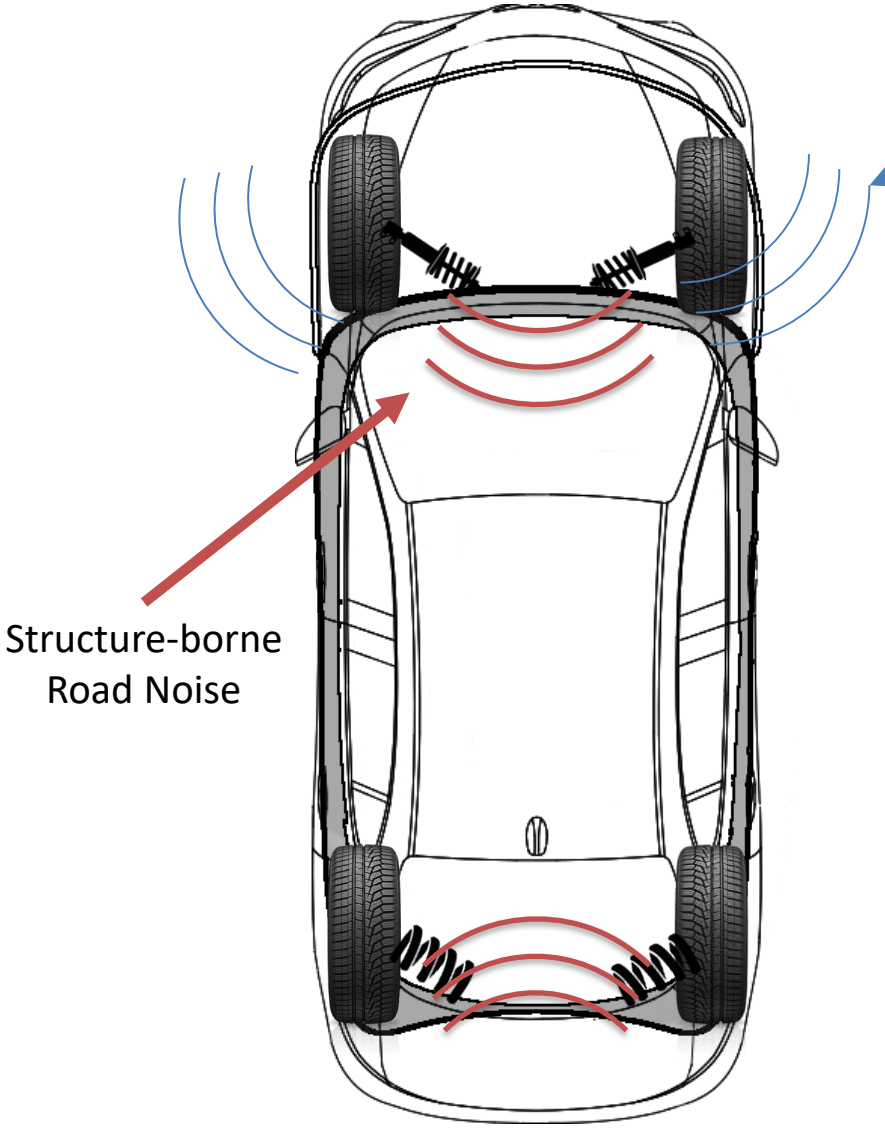
Resulting Noise

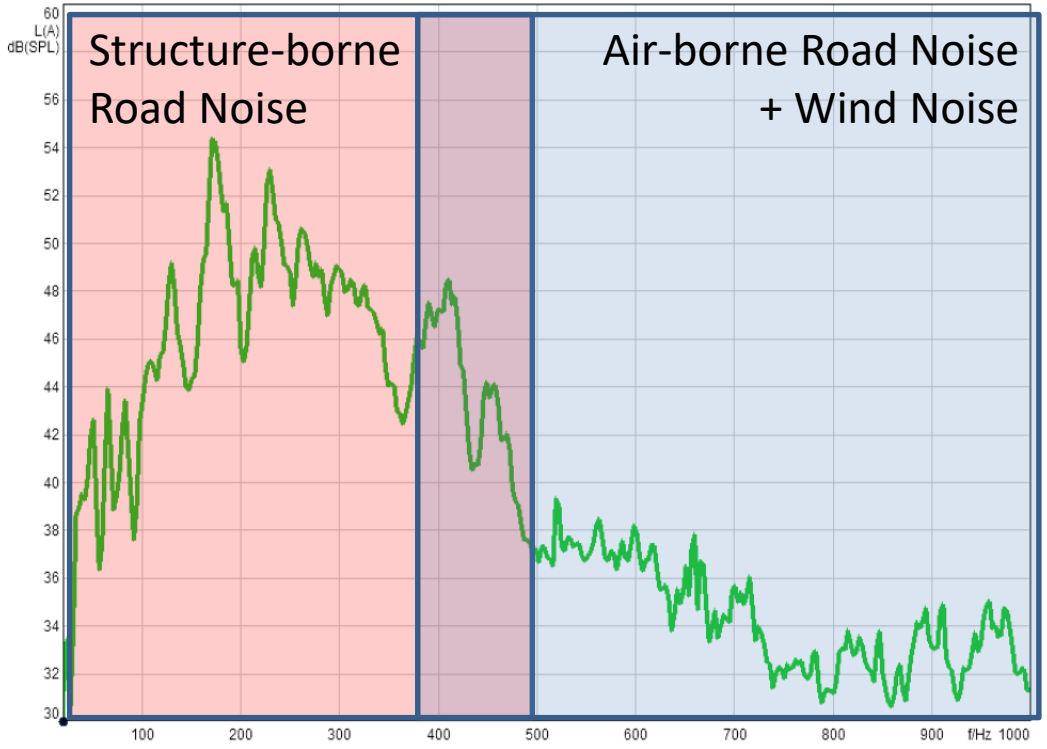


Active Noise Cancellation Systems

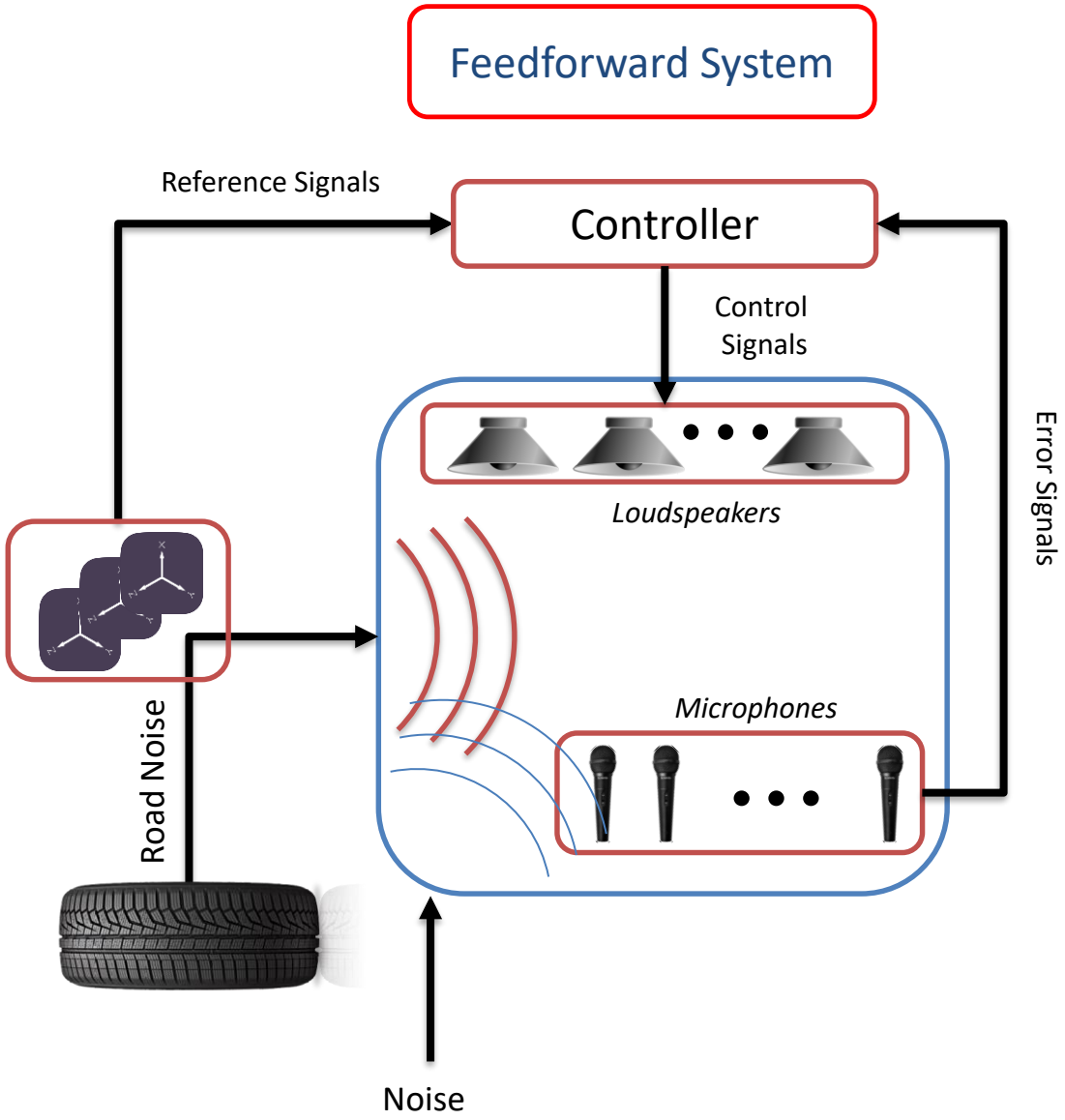


Problem: Road Noise

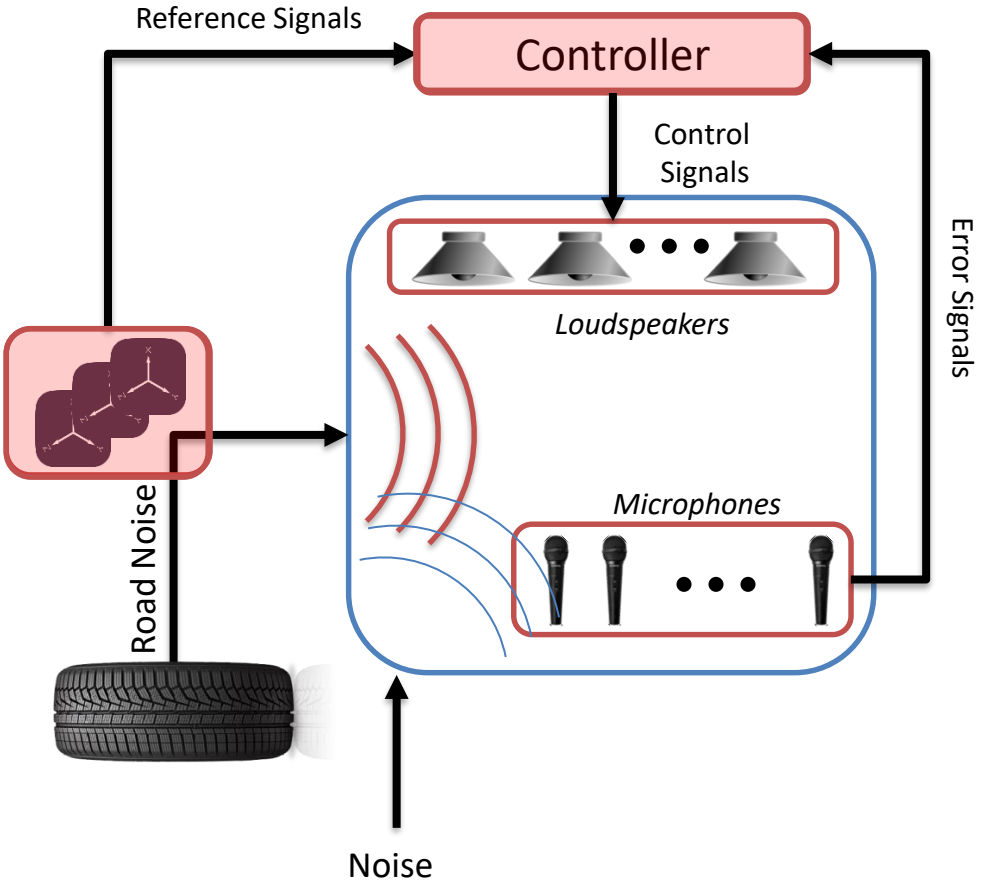




Active Control System Approach



Challenges

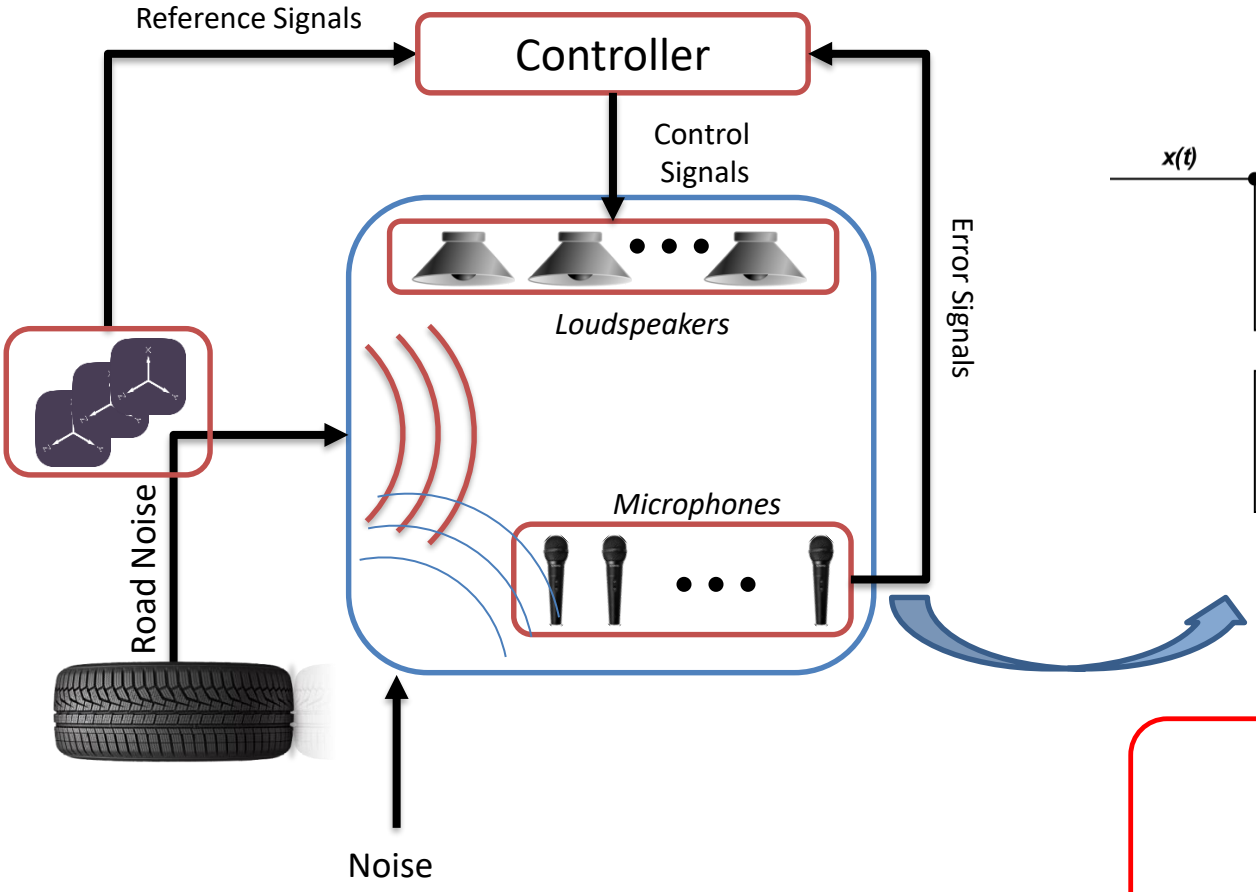


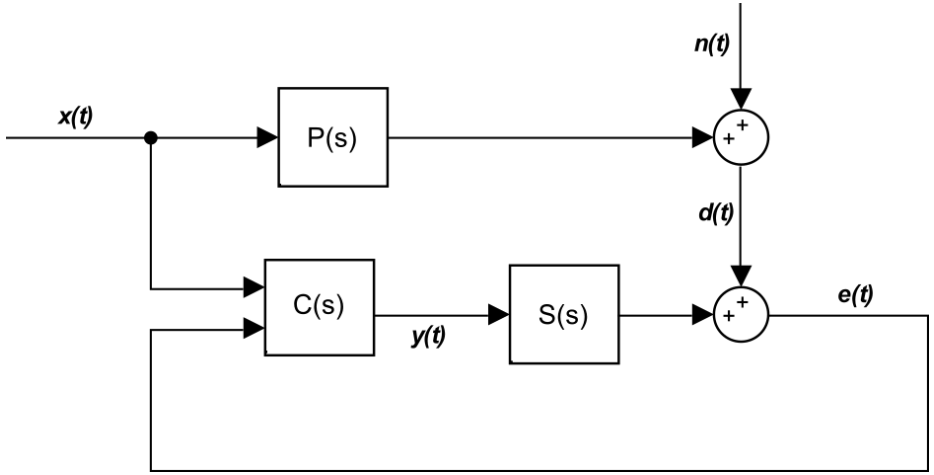
Control Algorithm

Reference Signals Selection

On-the-field Validation

Control Algorithm



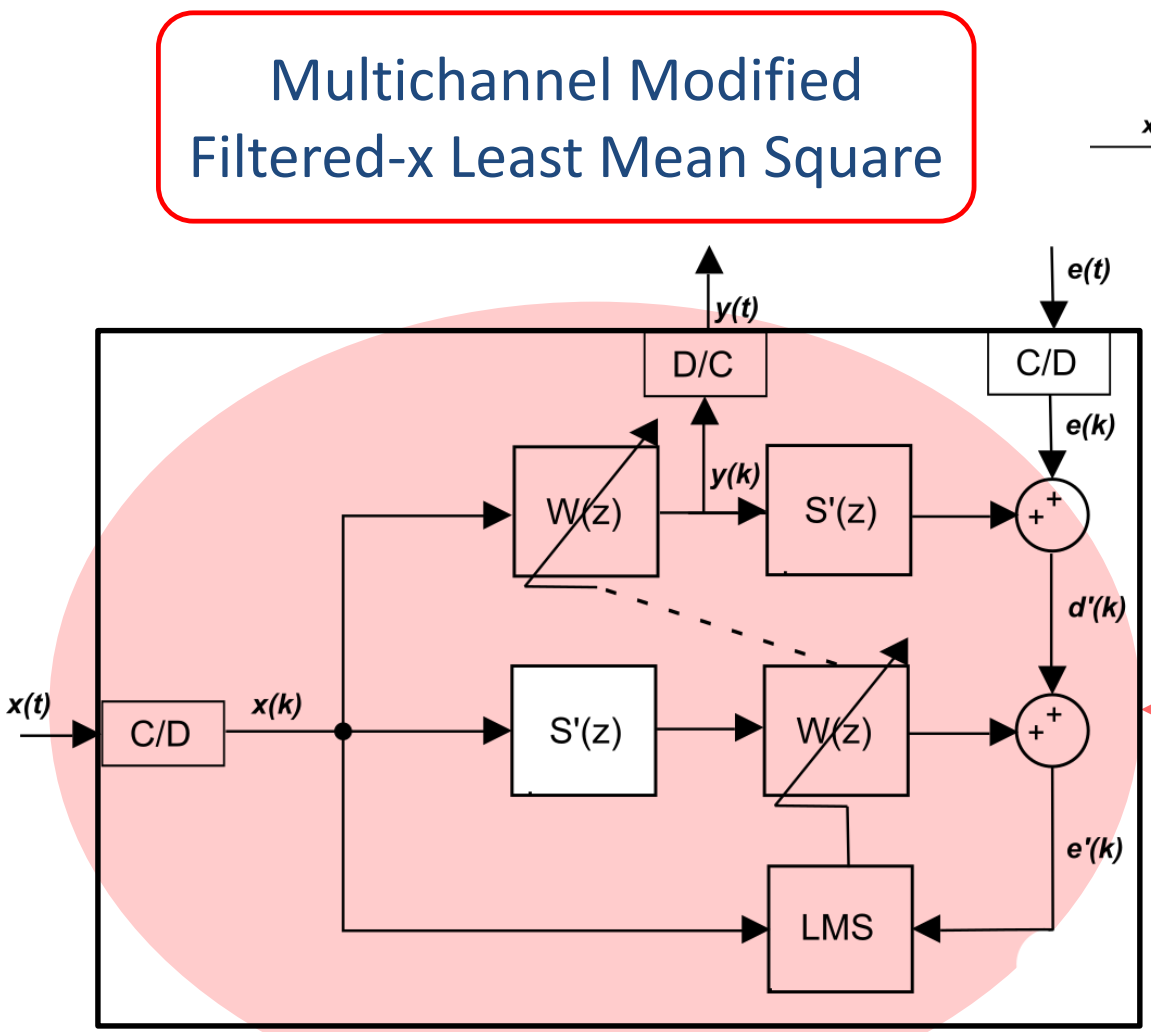


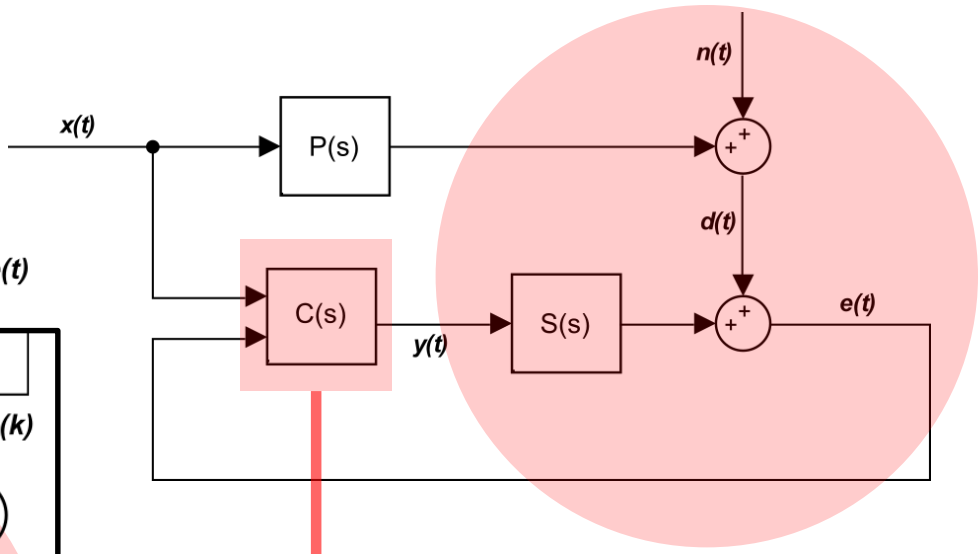
Goal:

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

Control Algorithm

Multichannel Modified Filtered-x Least Mean Square





1 Environment Simulator

2 Test several ANC algorithms from literature

Algorithm Development

Objectives

1 Environment Simulator

2 Test several ANC algorithms from literature

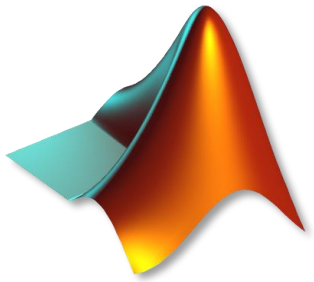
Constrains

Fast development

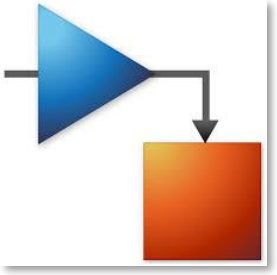
Accuracy

Solution

Development of a simulator in Simulink

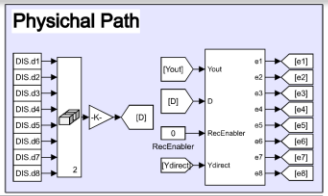


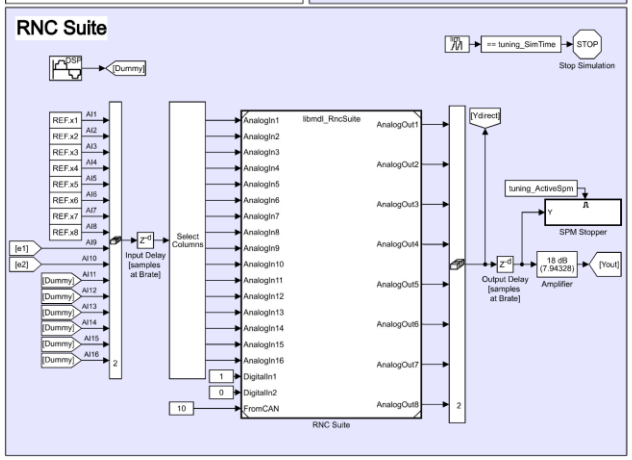
- Model Based Design
- Graphical Environment
- Rapid Debug
- Code generation

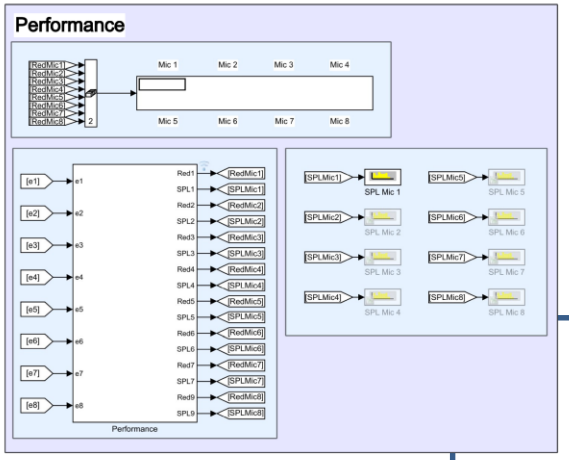


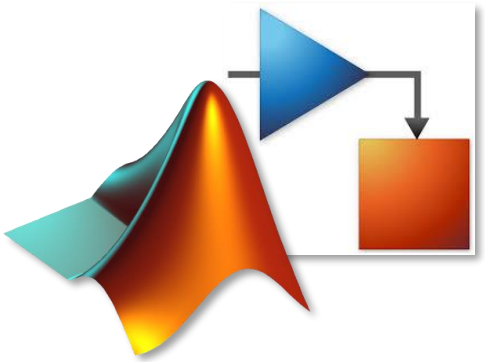
Simulator

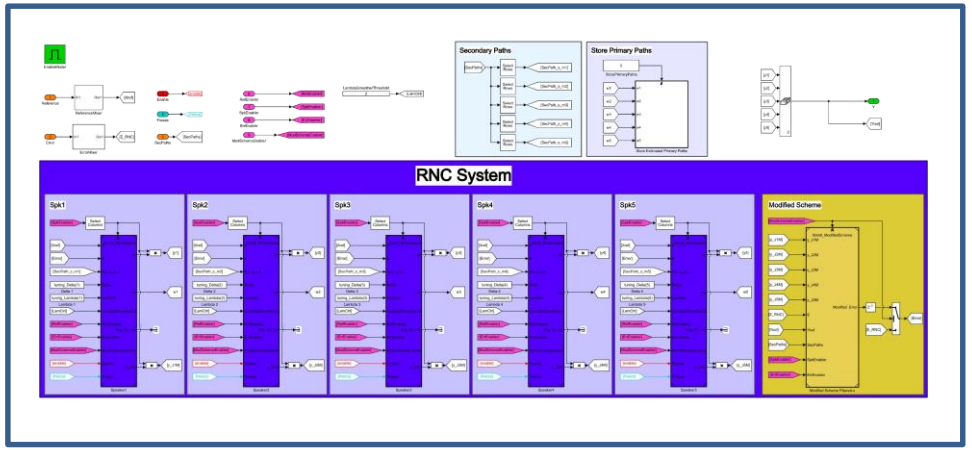
ASK
Automotive Industries Group
zendar
BIPE

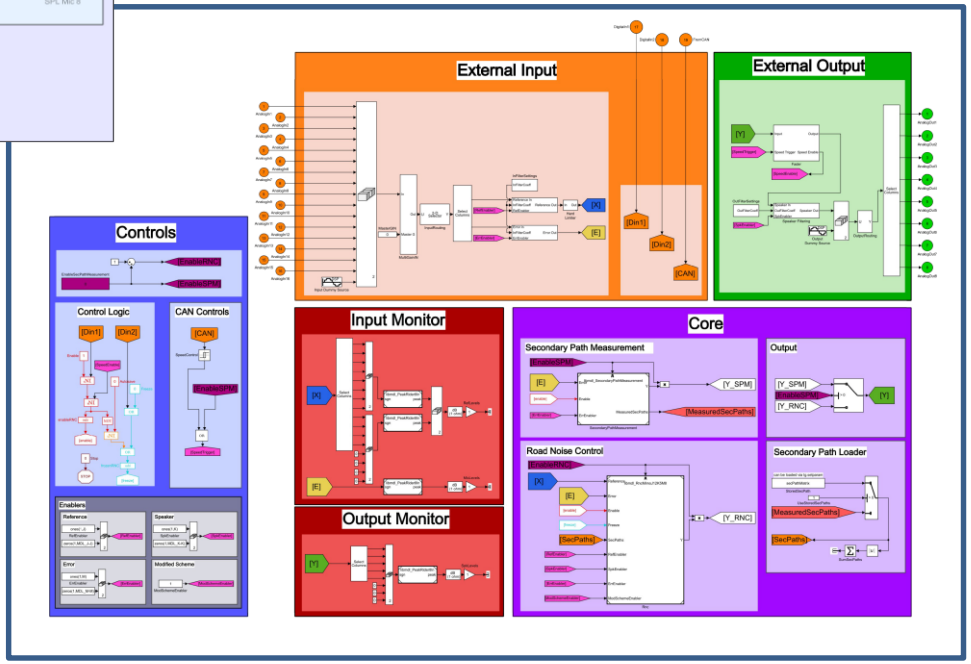

Physichal Path
DIS.d1
DIS.d2
DIS.d3
DIS.d4
DIS.d5
DIS.d6
DIS.d7
DIS.d8
[Yout]
[D]
RecEnabler
[Ydirect]
Yout
D
RecEnabler
Ydirect
[e1]
[e2]
[e3]
[e4]
[e5]
[e6]
[e7]
[e8]


RNC Suite
Dummy
== tuning_SimTime
STOP
Stop Simulation
libmdl_RncSuite
AnalogIn1
AnalogIn2
AnalogIn3
AnalogIn4
AnalogIn5
AnalogIn6
AnalogIn7
AnalogIn8
AnalogIn9
AnalogIn10
AnalogIn11
AnalogIn12
AnalogIn13
AnalogIn14
AnalogIn15
AnalogIn16
DigitalIn1
DigitalIn2
FromCAN
AnalogOut1
AnalogOut2
AnalogOut3
AnalogOut4
AnalogOut5
AnalogOut6
AnalogOut7
AnalogOut8
RNC Suite
[Ydirect]
tuning_ActiveSpm
SPM Stopper
Input Delay [samples at Brate]
Select Columns
Output Delay [samples at Brate]
18 dB (7.94328)
Amplifier
[Yout]


Performance
Mic 1
Mic 2
Mic 3
Mic 4
Mic 5
Mic 6
Mic 7
Mic 8
SPL Mic 1
SPL Mic 2
SPL Mic 3
SPL Mic 4
SPL Mic 5
SPL Mic 6
SPL Mic 7
SPL Mic 8
Performance




Secondary Paths
Store Primary Paths
RNC System
Spk1
Spk2
Spk3
Spk4
Spk5
Modified Scheme


External Input
External Output
Controls
Control Logic
CAN Controls
Input Monitor
Output Monitor
Core
Secondary Path Measurement
Output
Road Noise Control
Secondary Path Loader

Reference Signal Selection

Detecting the structural source of noise in car interior

Problem

Typology

Accelerometers

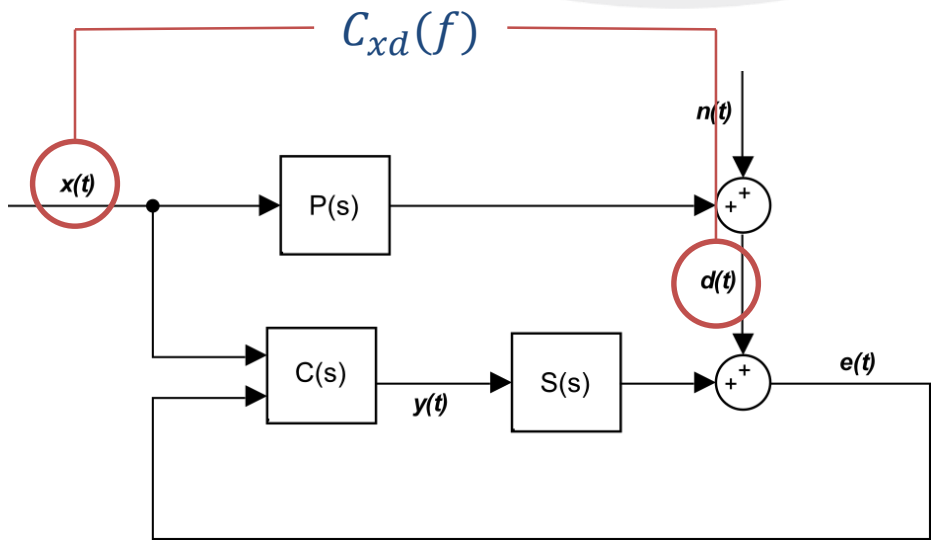
Sensor Placement

Adaptive Algorithm: Linear Filter Estimation of $\frac{P}{S}$

Coherence function

Reference Signal Selection: Coherence

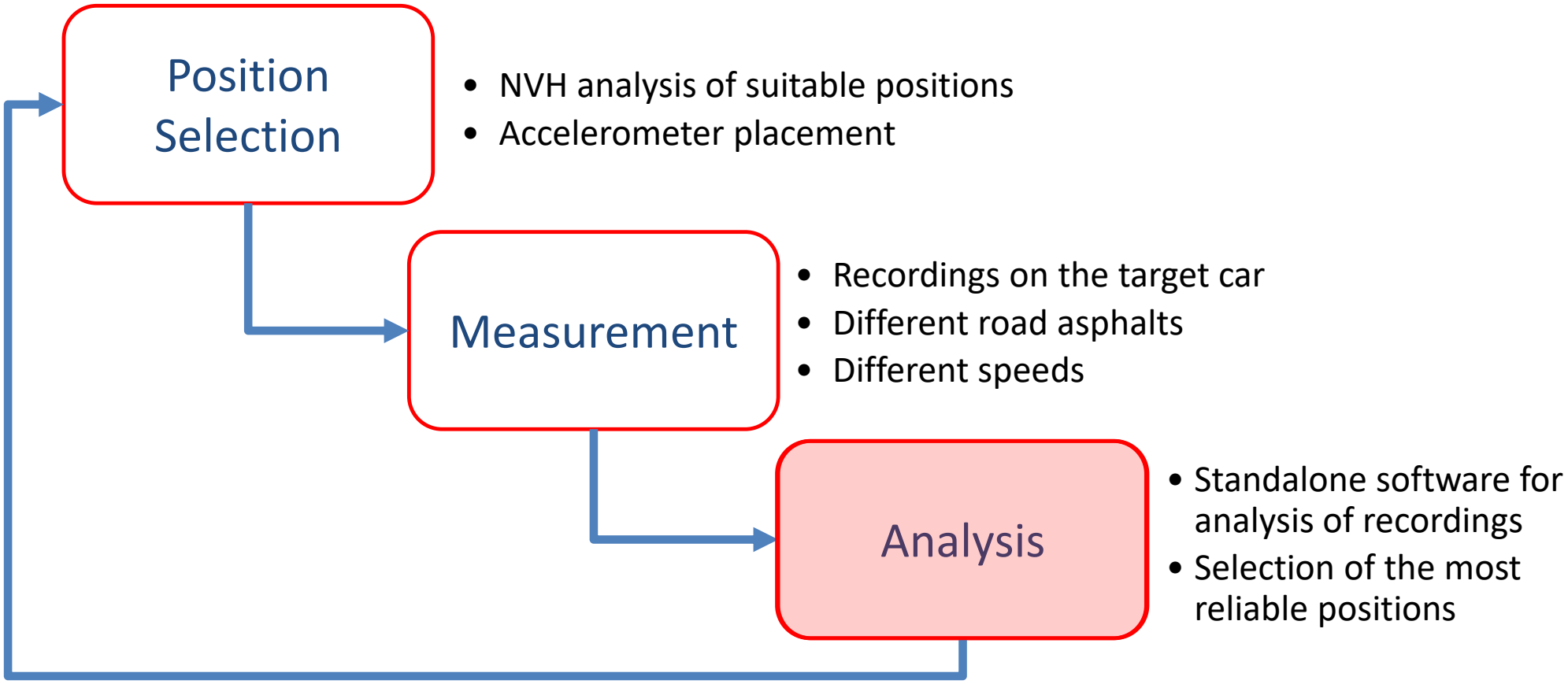
Coherence is a function of frequency with values between 0 and 1 which measures the relative linearity between two signals



Maximum theoretical noise reduction:

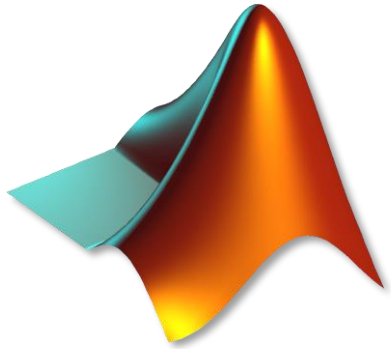
$$-10\log_{10}[1 - C_{xd}(f)]$$

Reference Signal Selection: Process



Reference Signal Selection: Analysis

Development of a standalone application in MATLAB



Collect and explore large signal dataset

- Smart data types

Signal Processing

- Wide set of build-in functions

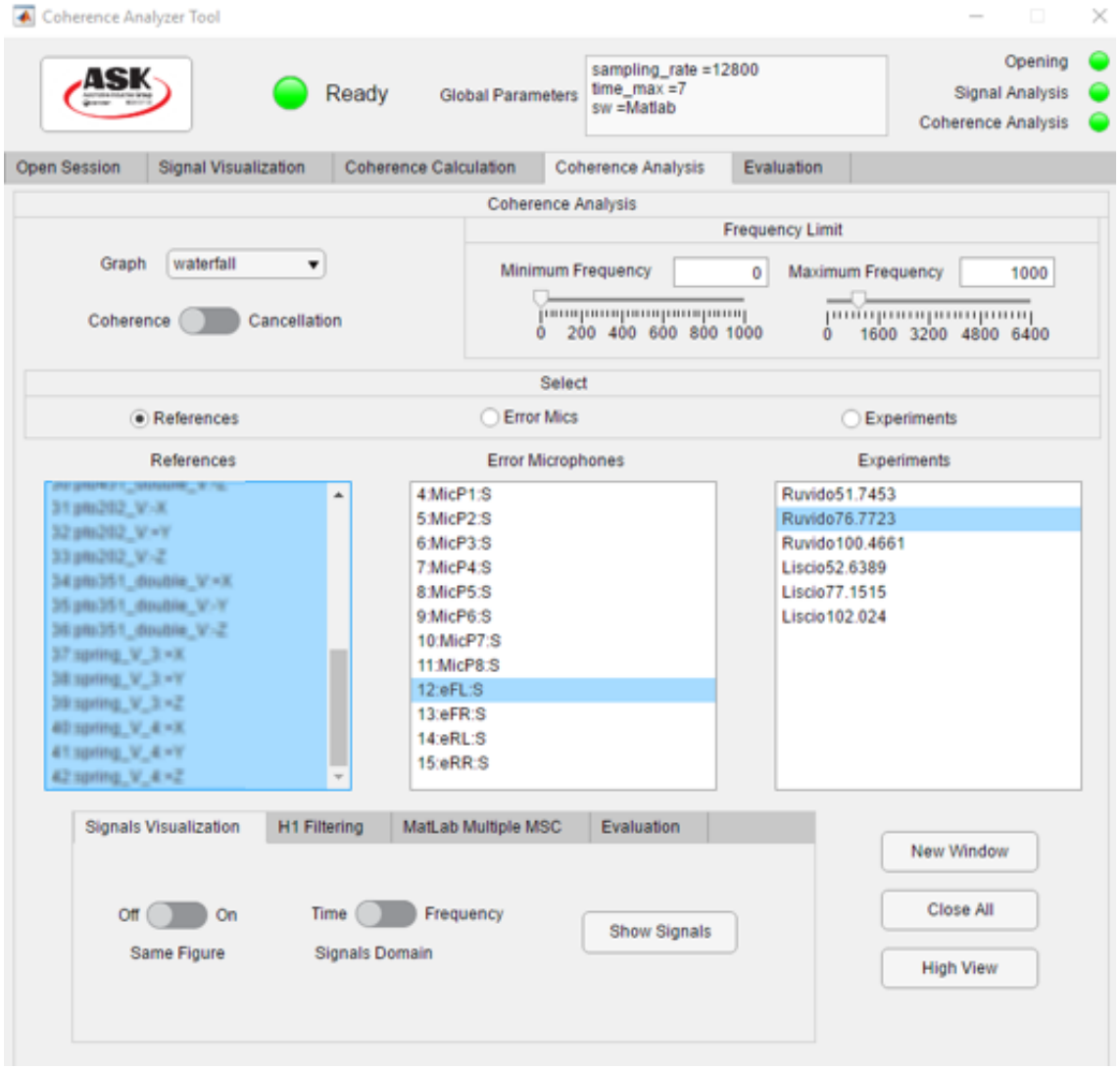
Easy to use: Graphical User Interface

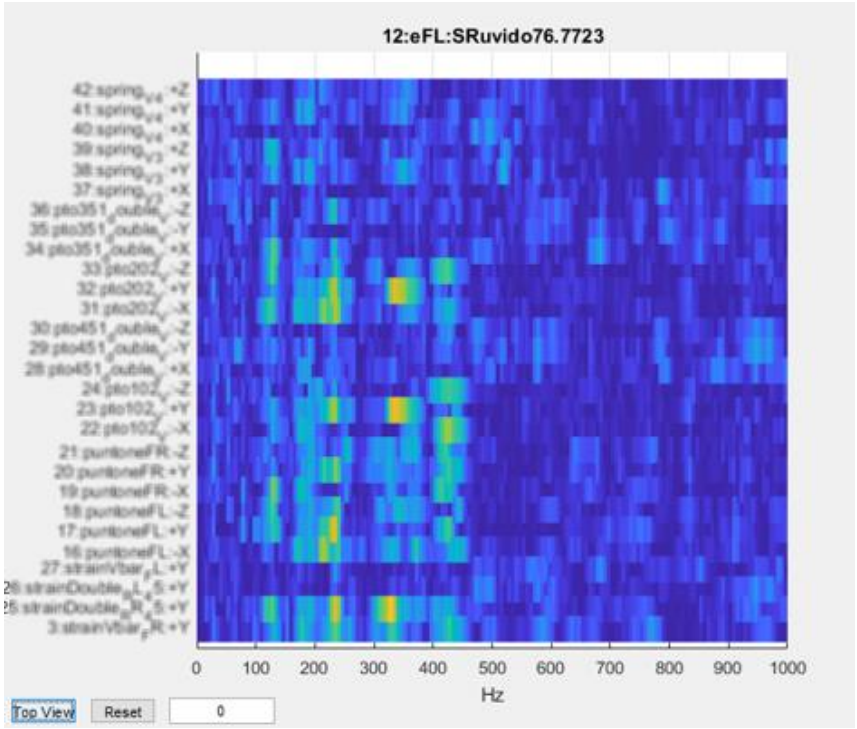
- App Designer API

Fast implementation

- Quick debug
- Complete documentation

Reference Signal Selection: Analysis





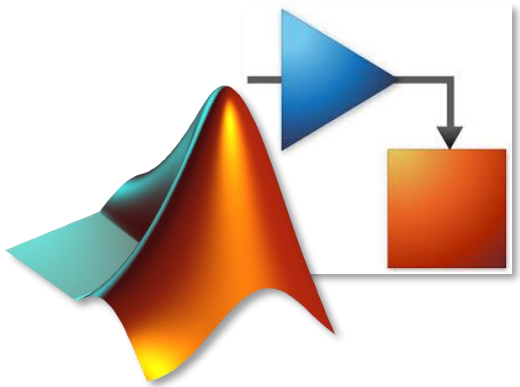
On-the-field Validation

Performance Analysis

Tight Deadlines

Constant Algorithm improvements

Rapid Prototyping Approach

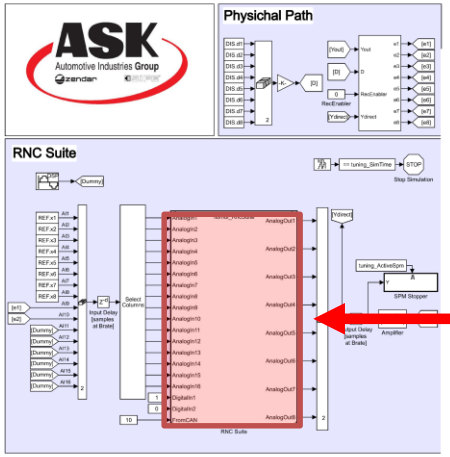


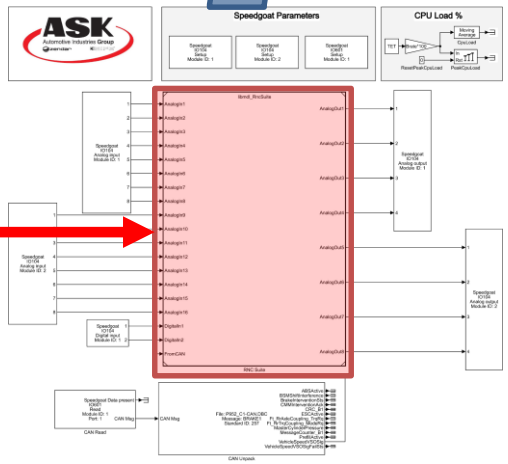
Rapid Prototyping Approach

Algorithm Development	Code Porting	SW test & debug	System test	Algorithm Validation

Expensive in term of time and resources

Algorithm Development	Algorithm Validation





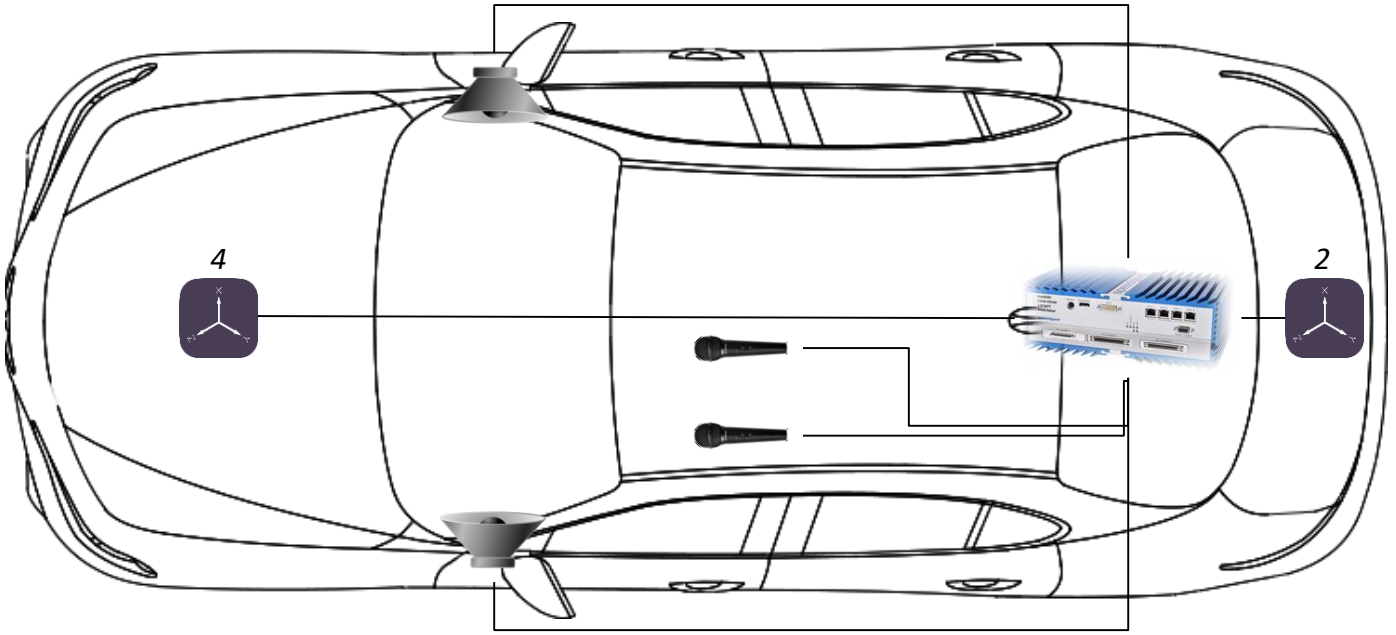
Prototype Car

Alfa Romeo Giulia

2.0 L4 TurboGasoline 200Hp RWD AT8

Prototype Configuration

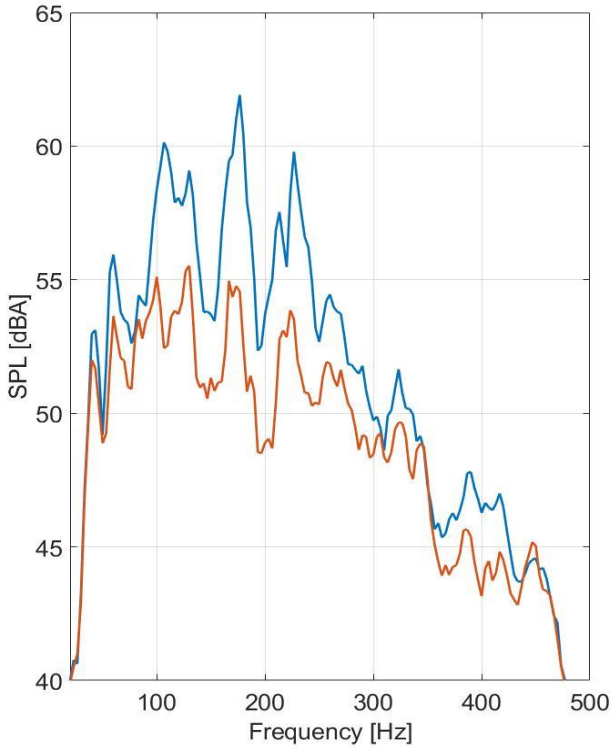
Cancellation performend on Driver Seat

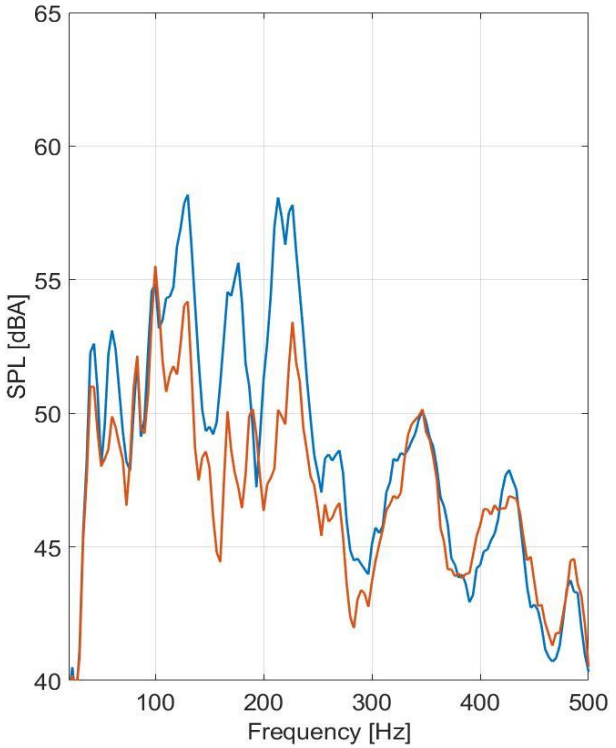


6 Accelerometers; 2 Loudspeakers; 2 Microphones

Experimental Results

Rough asphalt, 50 km/h





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

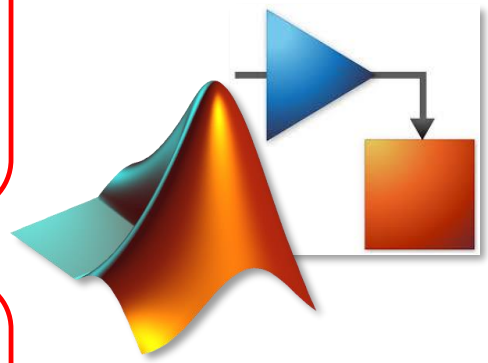
Cancellation on right ear
Average: 2.5db
Peak: 9db @ 210Hz

Conclusion

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



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