Are tyres and road surfaces the best solution to noise?

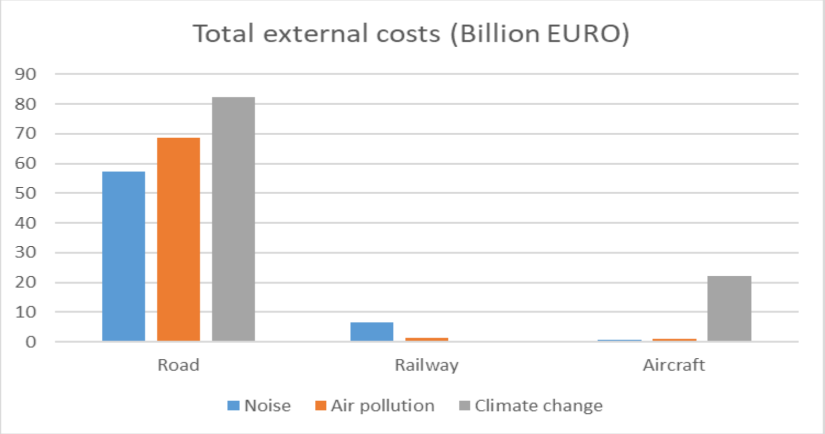
Marco Paviotti

07-10-2022

Context

- **Right political context:**
  Zero Pollution Action Plan
  Smart and Sustainable Mobility Strategy

- Noise one of the three **large** externalities linked to the transport sector;



- **Current legal framework**
  (Directive 2002/49/EC) + (a series of “source” legislation for tyres, cars, buildings, aircrafts, trains) + (national) + (local) = 357

- **10 infringements ongoing**

Green Deal

Sustainable and Smart Mobility Strategy (SSMS)

- Revision of airport charges Directive
- Revision of Urban Mobility Package
- ZPAP: reduction noise
- TAXONOMY
- Develop coherent rules for environmental, energy and safety performance of tyres
- Aviation label

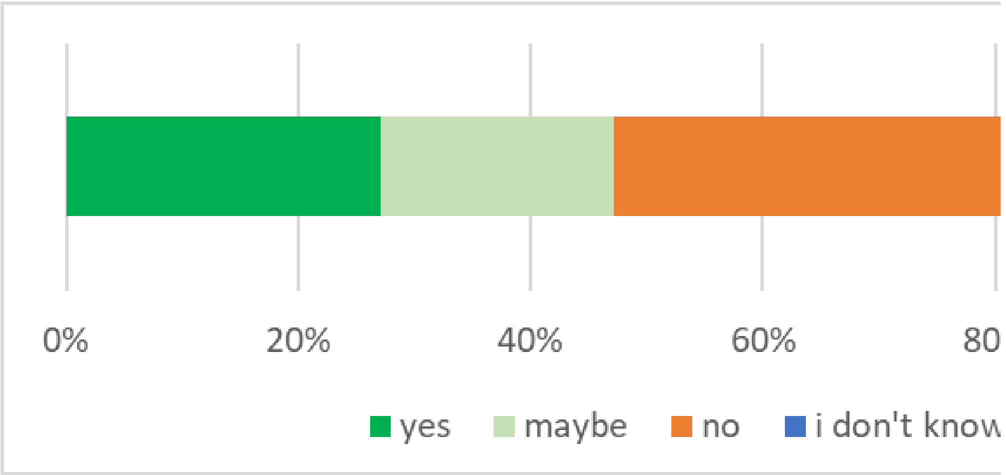
Zero Pollution Action Plan (ZPAP)

- By 2030, reduce by 30% those chronically disturbed by noise
- Improving the EU noise-related regulatory framework on tyres, road vehicles, railways, aircrafts, also at international level
- Set noise reduction targets at EU level in the Environmental Noise Directive

European Commission

Objective

- **By 2030 reduce by 30% the share of people chronically disturbed by transport noise;**



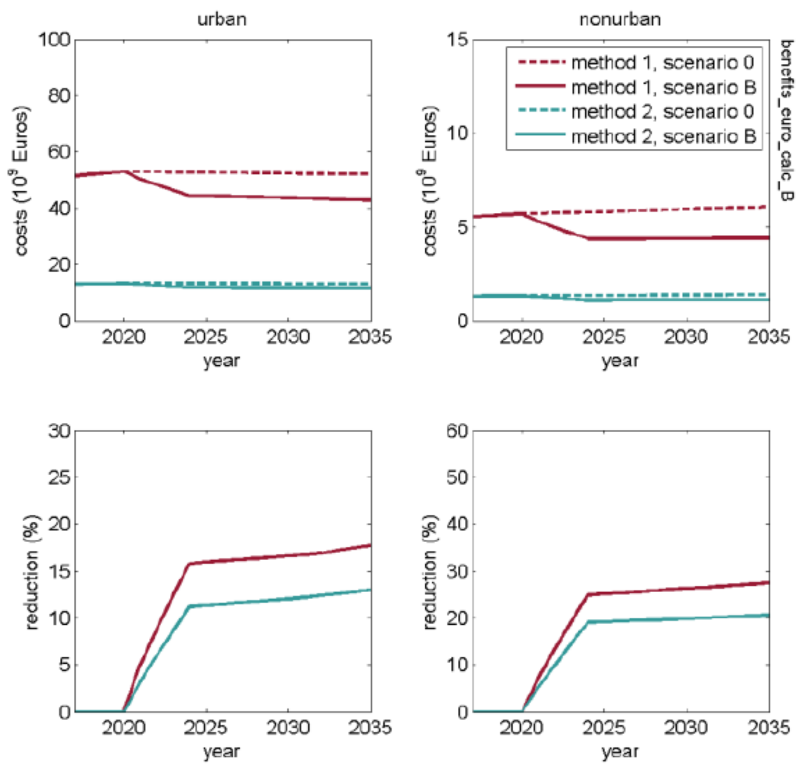
The Directive 2002/49/EC

- Mandatory process
- Mandatory reporting to the Commission
- No EU limits -> National ones

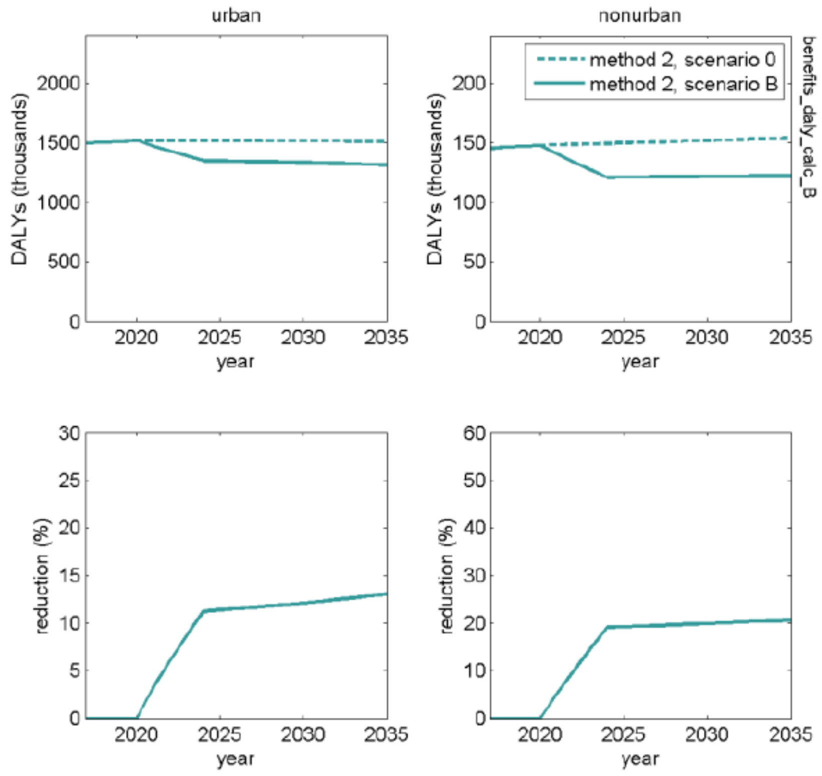
- Maps ‘wherever there is noise’ (even below national limits and reporting thresholds)
- Action plans ‘wherever there **POTENTIALLY** can be noise’

Looking forward

costs in Euros, 2017-2030

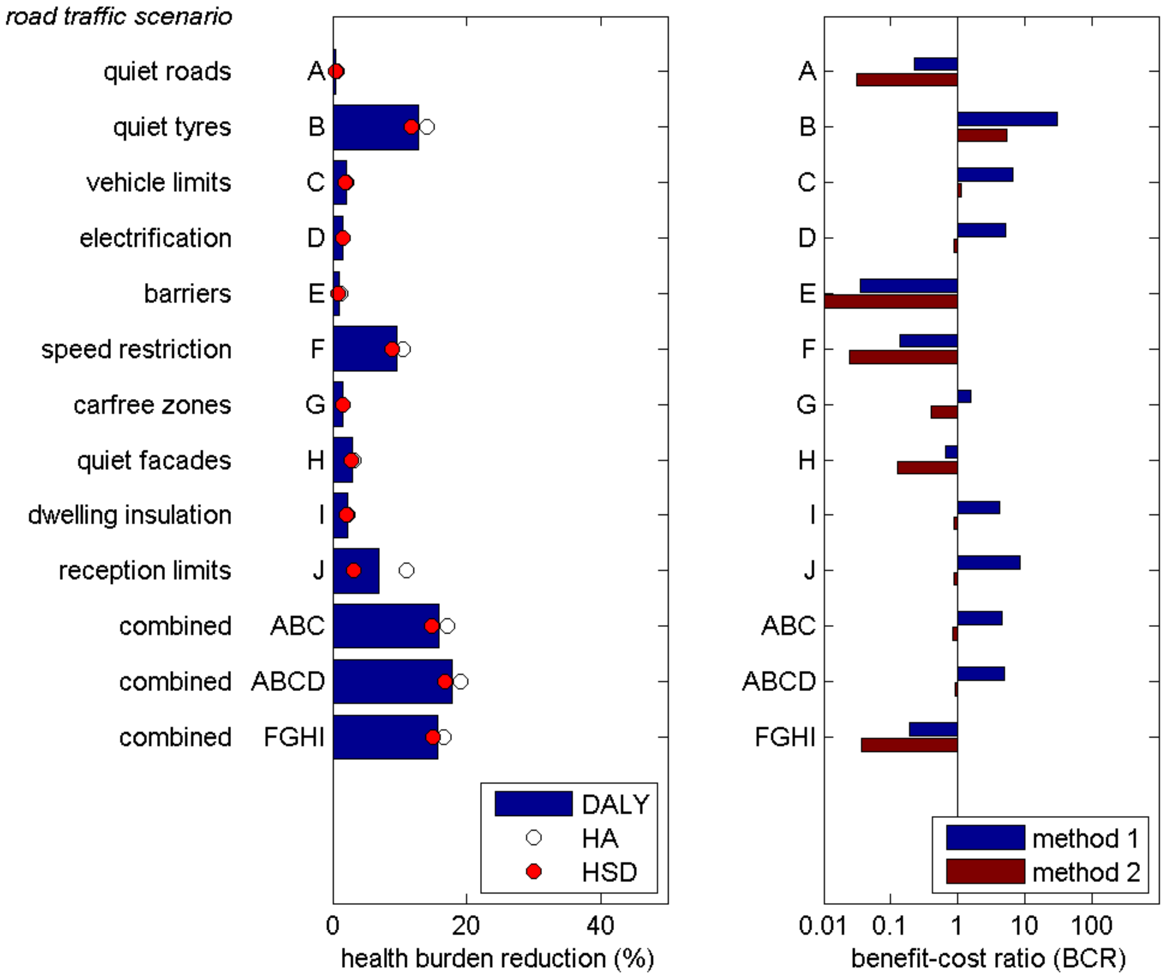


DALYs, 2017-2030
annoyance + sleep disturbance + myocardial infarction



Results

- For roads
  - Tyres
  - …and speed restrictions
  - …and vehicle limits
  - …and quiet roads



PRG	Projects	Engine noise		Mitigation at the source		Anti-propagation measures	Other measures	
		Quieter engines	Electric vehicles	Low-noise road surface	Low-noise tyres		Traffic management (including urban mobility)	Quieter modes of transport, quieter driving stiles, public awareness,
FP6	FIDEUS	√					√	
FP6	TURNOUTS							√
FP6	CORPTUS						√	
FP6	CALM II			√				
FP6	SILENCE			√	√		√	
FP6	QCITY					√	√	√
FP7	MID-MOD	√						
FP7	PERSUADE			√	√			
FP7	ENNAH						√	√
FP7	ECOQUEST	√						
FP7	CITYHUSH			√	√	√		√
FP7	QUIESST					√		√
FP7	CO2NTROL	√			√			
FP7	HOSANNA					√		
FP7	EVADER		√					
FP7	DELIVER	√	√					
FP7	CITI-SENSE							√
FP7	LORRY				√			
H20	NOVELOG						√	
H20	RESOLVE	√	√					
H20	Silver Stream		√					
H20	WEEVIL		√					
H20	MORE						√	
H20	GVI	√						√
Total		7	5	4	5	4	7	7

European Commission

Potential of tyres and road surfaces

- We expect tyres to provide around 3-4 dB reduction
(Meaning that using only the best tyres on the market, this is the possible gain)
  - Question: what happens to tyre abrasion, wet grip (much less on rolling resistance)

- We expect road surfaces to provide 1-4 dB reduction
  - What it the durability and the life cycle cost?

Conclusions

- Tyres have a potential and are the most cost-effective measures, delivering on all roads and at any speed above 30 km/h
- Tyres are the only solution for electric vehicles
- Road surfaces are extremely effective and should therefore be used where levels are too high and other solutions are not possible (e.g.: barriers, speed reduction)
- As these solutions are necessary to achieve the ZPAP target, we are reflecting on how to promote such solutions

Thank you

LIFE E-VIA

Electric Vehicle noIse control by Assessment and optimisation of tyre/ road interaction

www.life-evia.eu

LIFE E-VIA PROJECT
Final event 7th October 2022 – ExpoMove exhibition Firenze

Vie en.ro.se. Ingegneria
Introduction to project's activities

Raffaella Bellomini Vie en.ro.se. Ingegneria

COMUNE DI FIRENZE · Continental The Future in Motion · Université Gustave Eiffel · iPOOL · Università degli Studi Mediterranea di Reggio Calabria · Vie en.ro.se. Ingegneria

With the contribution of the LIFE programme of the European Union

LIFE18 ENV/IT/000201

LIFE18 ENV/IT/000201
LIFE E-VIA PROJECT
7 October 2022 - Vie en.ro.se Ingegneria

Partners:

Contintental Reifen Deutshland (Hannover, Germany)
Design, testing and development of new tyres

Université Gustave Eiffel (Lyon, Nantes, France)
Asphalt testing on test area

Comune di Firenze – (Florence, Italy)
Coord. Beneficiary - *Pilot case implementation*

Vie en.ro.se. Ingegneria srl (Florence, Italy)
Soundscape analysis and dissemination

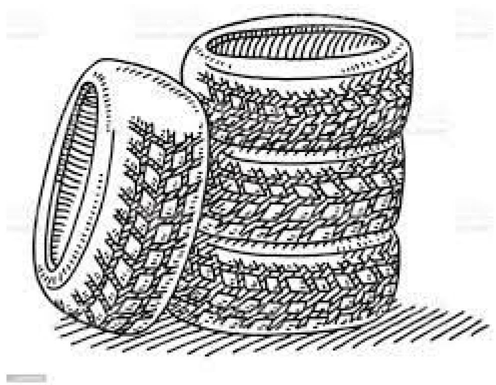
I-Pool srl (Pisa – Italy)
Acoustic measurements and pneumatic tests on field

Università degli Studi Mediterranea di Reggio Calabria (Reggio Calabria, Italy)
Design of the mixtures

General Framework

- Tackle noise pollution from road traffic noise focusing on a future perspective in which electric and hybrid vehicles will be a consistent portion of flow

- Combine knowledge of road optimization and tyre development in order to test an optimized solution for reducing noise in urban areas



LIFE E-VIA targets are in line with those of Europe…

In September 2020, Eurocities published a position paper on the future of road traffic noise reduction policies in European cities.
The position paper aimed to identify actions to achieve the target of a 3 dB reduction at source by 2032, through the introduction of quieter and less polluting vehicles, tyres and road surfaces, among others, by:

- Green Public Procurement criteria for road surfaces with noise and air pollution benefits
- A proposal for a regulation for labelling road surfaces with noise and air pollution benefits
- Systematic renewal of tyres and road surfaces to accelerate the benefits of noise reduction technologies

https://eurocities.eu/wp-content/uploads/2020/09/EUROCITIES_statement_noise_policy_in_Europe_2020.pdf

In March 2022, in their joint position paper, ‘EU legislation on road traffic noise’, the European Automobile Manufacturers’ Association (ACEA), the European Tyre and Rubber Manufacturers’ Association (ETRMA) and the European Tyre and Rim Technical Organisation (ETRTO) joined forces to make several key recommendations to policy makers, notably on noise abatement and environmental noise. They call, among other things, for:

- The systematic use of low-noise road surfaces, particularly in noise hotspots

https://www.acea.auto/publication/position-paper-eu-legislation-on-road-traffic-noise/

LIFE18 ENV/IT/000201

LIFE E-VIA PROJECT

7 October 2022 - Vie en.ro.se Ingegneria

LIFE E-VIA OBJECTIVES + EXPECTED IMPACTS AND PRESENTATION OF RESULTS

Design of optimized surfaces (volumetrics, materials, and surface texture) for mixed fleets with increasingly electric and hybrid vehicles proportion, in order to minimize noise from EV

Designing of a new low-emission asphalt
Filippo Giammaria Praticò

Development and building of EV tyres designed to give an optimal holistic relation between low exterior noise and other key performances

Holistic low noise tyres for electric vehicles
Carsten Hoever

Tyre-pavement coupling study and prototype implementation

Tyre-pavement coupling study and prototype implementation
Julien Cesbron

Pilot case implementation and replication

The LIFE E-VIA project in Florence and replication strategy
Arnaldo Melloni

Contribution to EU legislation effective implementation (EU Dir. 2002/49/EC - 2015/996/EC), providing rolling noise coefficients within the Common Noise Assessment Method (CNOSSOS-EU), specifically tuned for Evs. Reduction of CPX noise levels and of noise levels at receivers

Evaluation of pavement characteristics, EV noise emissions and Guidelines issuing ***Francesco Bianco***

Improvement of the soundscape and citizens' perception
Awareness-raising on project issues and results

Soundscape analysis
Chiara Bartalucci

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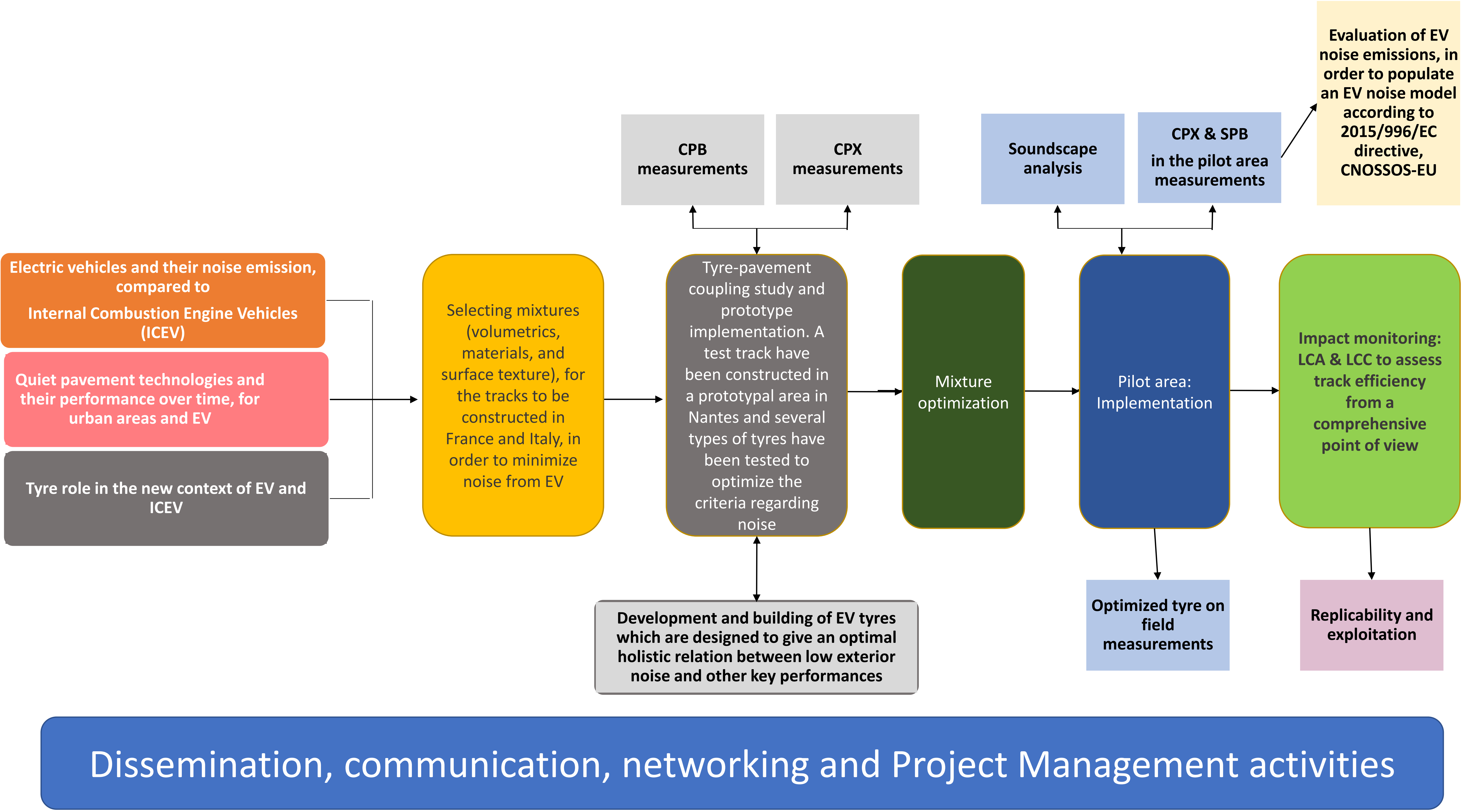
LIFE E-VIA PROJECT
7 October 2022 - Vie en.ro.se Ingegneria



LIFE E-VIA

Electric **V**ehicle no**I**se control by **A**ssessment and optimisation of tyre/ road interaction

www.life-evia.eu

Thank you for your kind attention!

With the contribution of the LIFE programme of the European Union

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www.life-evia.eu

Start : July 1st, 2019; End: January31st, 2023

7th October 2022 from 10.00 a.m. to 5.00 p.m.

Fortezza da Basso – Firenze in the frame of Expomove event and in digital mode on Zoom platform

Electric mobility and low-noise asphalts: the results of the LIFE E-VIA project and contributions from other projects

11.20-11.50

Design of a new low-emission asphalt

Filippo Giammaria Praticò

Università degli Studi 'MEDITERRANEA' di Reggio Calabria

With the contribution of the LIFE programme of the European Union

LIFE18 ENV/IT/000201

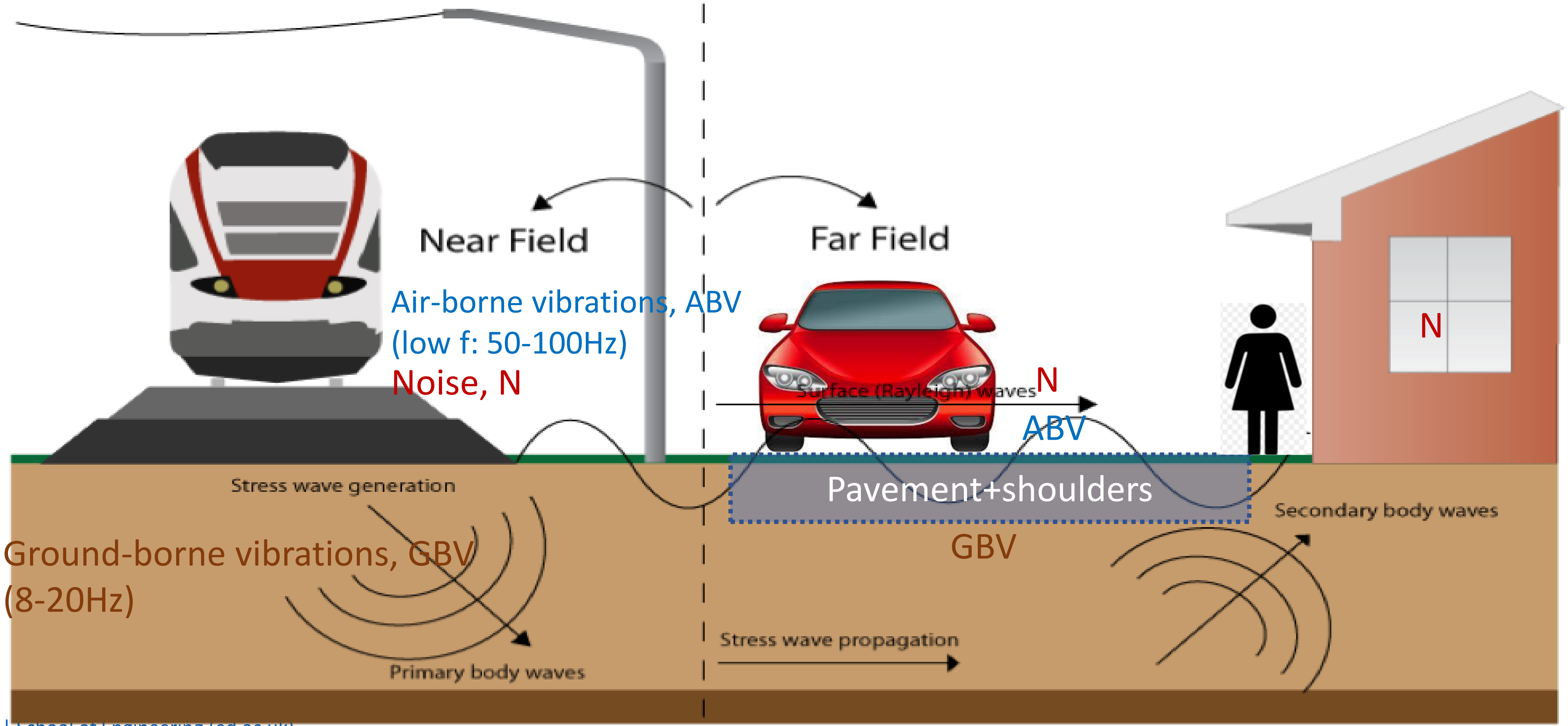
Come si progetta un asfalto per la mitigazione vibro-acustica? Designing to mitigate vibrations and noise

Scenari complessi-complex scenarios

Mitigazione vibrazionale-vibrations

Mitigazione Acustica-Noise

Scenari complessi – Complex scenarios



Adapted from [Railway Engineering | School of Engineering (ed.ac.uk)]

Mitigazione vibrazionale- mitigating vibrations

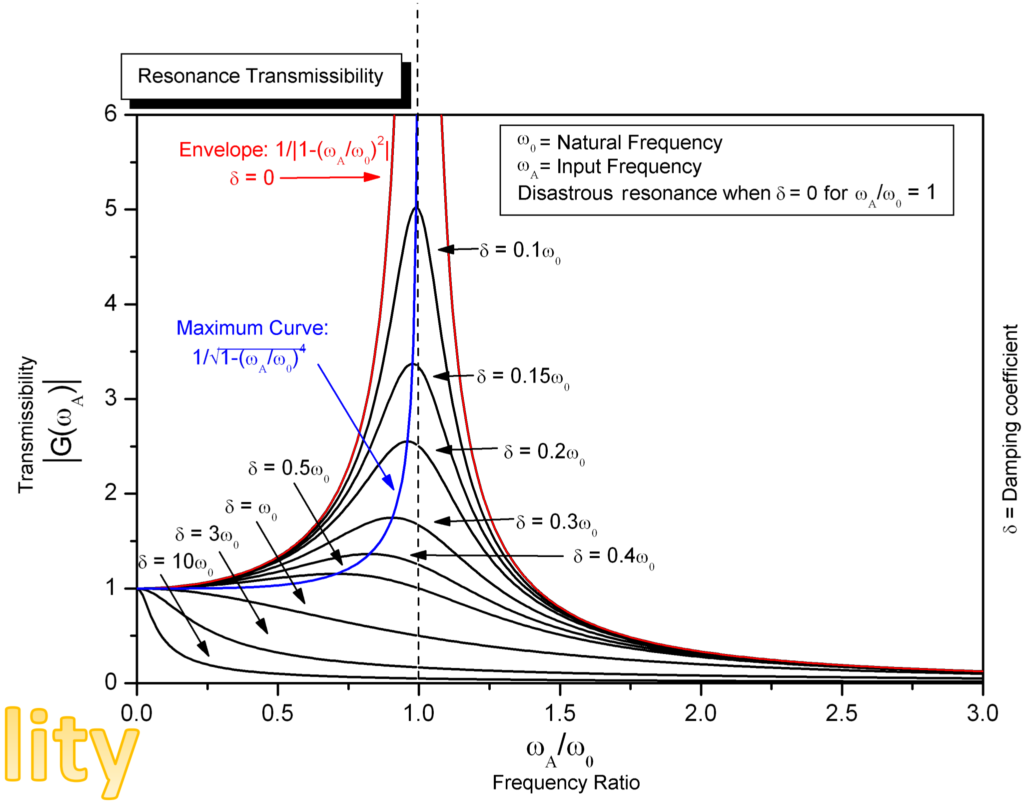
Una semplificazione del problema teorico

A simplified approach

Frequenze-frequencies

Smorzamento-damping

Trasmissione-transmissibility

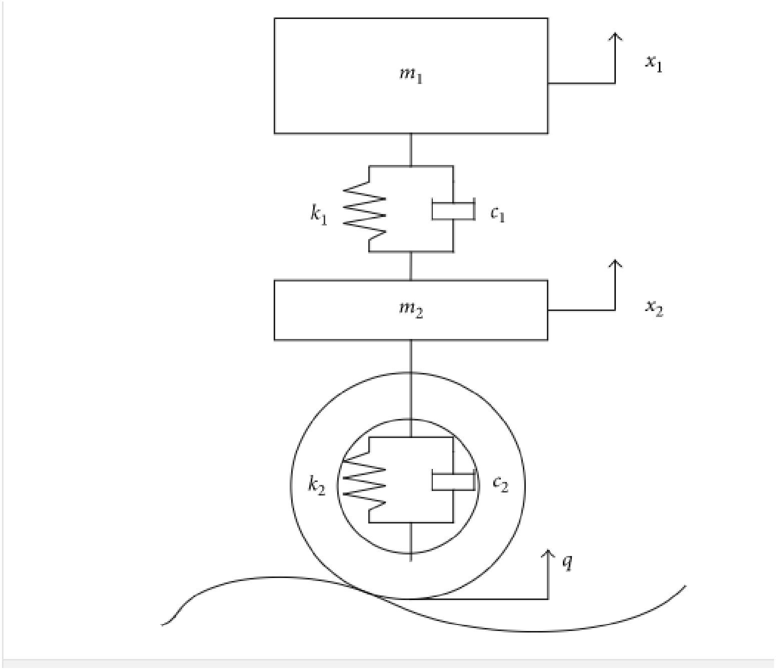


By "MasterHD" / MasterHD at English Wikipedia - "User:amueckl", Public Domain, https://commons.wikimedia.org/w/index.php?curid=4970356

Track excitation in relation to frequency (adapted from Esveld, 2001)

wavelength										
		0.3m		3m		10m			120m	
Hertzian spring	Welds		Wheels 20-100Hz		Bogie 5-20Hz		Sprung mass 0.7-5Hz			
			Rolling defects				Ballast and formation			

Pavement excitation



???

https://www.hindawi.com/journals/ace/2018/2714657/

Mitigazione vibrazionale-Mitigating vibrations

	Generation	Propagation	Receiver -Effects and generation
	Ground-borne (low f: 8-20Hz)	Pavement-geological strata	Building foundations and floors
	Air-borne	Air propagation	Building, front rooms, windows, doors
Mitigation class	Vehicle (tyre); rolling stock (bogie suspensions, brakes, wheels), Railtrack (rails), pavement (composition, geometry, damping layers), infrastructure overall design	Track (pads, slabs, rails), pavement (roughness), transmission path (trenches, embankment), Geometry, Tanks, trench barriers, wave barriers	Base isolation, walls, doors, windows

Come si progetta un asfalto più «silenzioso»?
Designing quiete asphalt concretes

1. **Soluzioni note (non-progetto) -adopting known solutions**

2. Soluzioni su misura od innovative (progetto)-Designing

2.1 Che cosa significa progettare una miscela? Overall design

2.2 Che cosa significa progetto acustico di una miscela? Noise design

1. Soluzioni note- Esempi-References for adopting known solutions

- Sandberg U., and Ejsmont J., Tyre/road noise. Reference book, INFORMEX.

- Praticò, F.G., Swanlund, M., George, L-A., Anfosso, F., Tremblay, G., Tellez, R., KAMIYA, K., Del Cerro, J., Van der Zwan, J., Dimitri, G.(2013). Quiet pavement technologies, Pages : 105, PIARC Ref. : 2013R10EN, ISBN : 978-2-84060-327-6.

- Lodico D., Donavan, P., CTHWANP-RT-18-365.01.1, Quieter Pavement: Acoustic Measurement and Performance, February 2018

1. Soluzioni note- bibliografia-References for adopting known solutions

Reference	Type of solutions	Thickness (mm)	Nominal Maximum Aggregate size or NMAS (mm)	Texture (mm) or/and air void content (%)	Acoustic indicator used	Noise reduction (dB)	Noise increase (dB/year)
(Donavan and Janello, 2018)	ARFC	25 mm	9.5 mm	20-21%	CPX/OBSI	/	0.5 dB/Year
(Anderson et al., 2013; Pierce et al., 2009)	OGFC-AR	19 mm	9.51 mm		OBSI	4.3 (vs. HMA)	2.1
	OGFC-SBS	19 mm	9.51 mm		OBSI	3.4 (vs. HMA)	1.45
	HMA	30 mm	12.5 mm		OBSI	/	1.03
(Bendtsen et al., 2010, 2009; Illingworth et Rodkin, 2002)	OGAC	25 mm	9.5 mm	/	/	/	0.11-0.19
(Bendtsen et al., 2010, 2009; Rochat et al., 2010)	DGAC	30 mm	12.5 mm	9%	SPB	/	0.24*-0.29**
	OGAC	30 mm	12.5 mm	15%	SPB	1.7 (vs. DGAC)	0.20*-0.12**
	OGAC	75 mm	12.5 mm	12%	SPB	3.3 (vs. DGAC)	0.10*-0.31**
	RAC-O	30 mm	12.5 mm	12%	SPB	2.3 (vs. DGAC)	0.40*-0.36**
	BWC	30 mm	12.5 mm	7%	SPB	0.9 (vs. DGAC)	/
(Bendtsen and Nielsen, 2008)	DGAC11	33 mm	11	2.8	SPB/CPX	/	0.72*-0.8**
	UTLAC	22 mm	8	14.4	SPB/CPX	2.2 (vs. DGAC11)	1.06*-0.35**
	OGAC	28 mm	8	15.3	SPB/CPX	2.9 (vs. DGAC11)	0.8*-0.09**
	SMA8	29 mm	8	12.4	SPB/CPX	0.4 (vs. DGAC11)	0.5*-0.21**
	SMA6+	26 mm	6+5/8	3.0	SPB/CPX	1.6 (vs. DGAC11)	0.93*-0.63**
	SMA8+	33 mm	8+8/11	5.7	SPB/CPX	2.5 (vs. DGAC11)	1.32*-0.67**

2. Tailored and/or innovative solutions: balancing…Soluzioni su misura od innovative: Contemperare..

<table>
<tr><th>Principali aspetti della progettazione di miscela-Domain of interest</th><th>Principali caratteristiche volumetrico-compositive, e superficiali affette-main volumetrics</th><th>Principali performance ed istanze affette-main impacts</th></tr>
<tr><td>Granulometria aggregati ed eventuali altri materiali di apporto</td><td rowspan="8">Gb, Gmb, Gmm,
Gsb, Gsa, Pb, Pba,
AV, Ω=neff,
VMA, VFA, DP

LTx
q^2, Rs, sρ, sκ, Λ, Λ', k_0'
Ottica e riflessione
….</td><td rowspan="8">Funzionali (Acustiche, di aderenza, di tessitura, ….).
Meccaniche (……) e di Durata (PD, TC, F; abrasione, PM).
«Globali»?(LCA, LCC, costi)
…..</td></tr>
<tr><td>Caratteristiche chimico-fisiche, di forma, di tessitura superficiale, natura mineralogica degli aggregati ed eventuali altri materiali di apporto</td></tr>
<tr><td>Qualità e quantità del legante bituminoso</td></tr>
<tr><td>Quantità e qualità materiali addizionali prevalentemente inerti o no</td></tr>
<tr><td>Tipologia di compattazione</td></tr>
<tr><td>Spessore</td></tr>
<tr><td>Temperature di trasporto, stesa, e compattazione</td></tr>
<tr><td>….</td></tr>
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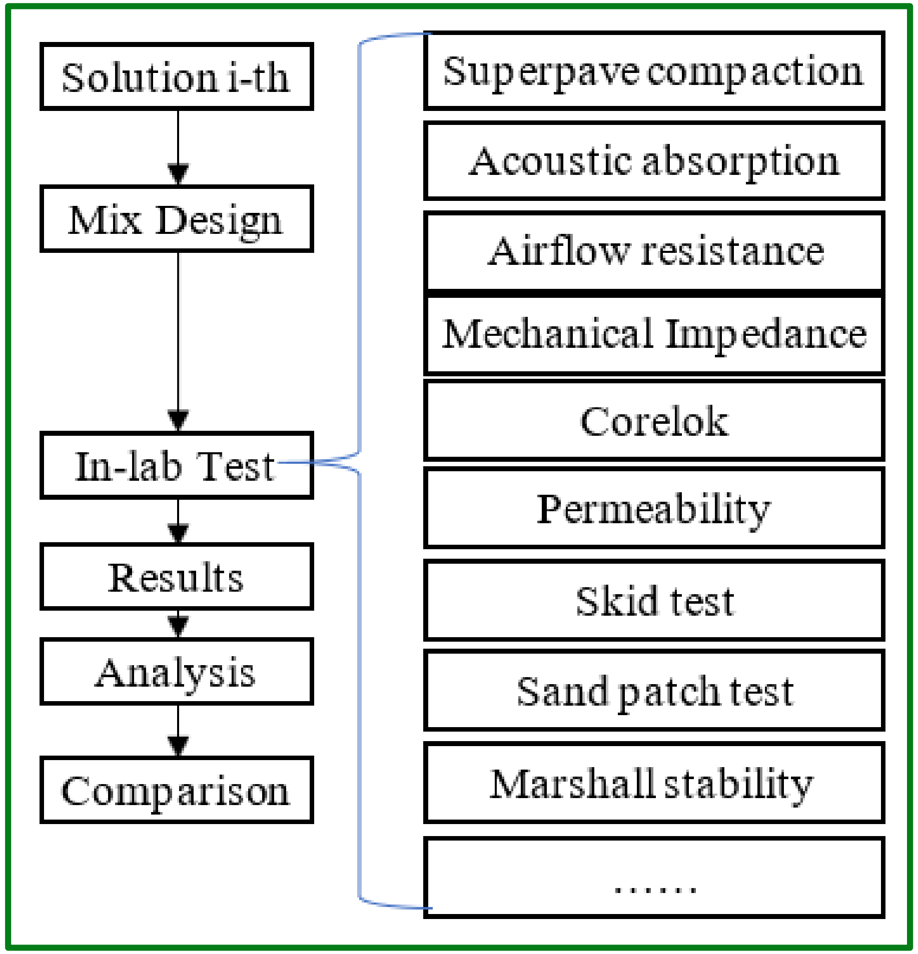
2.1 Che cosa significa progettare una miscela? The essence of design…

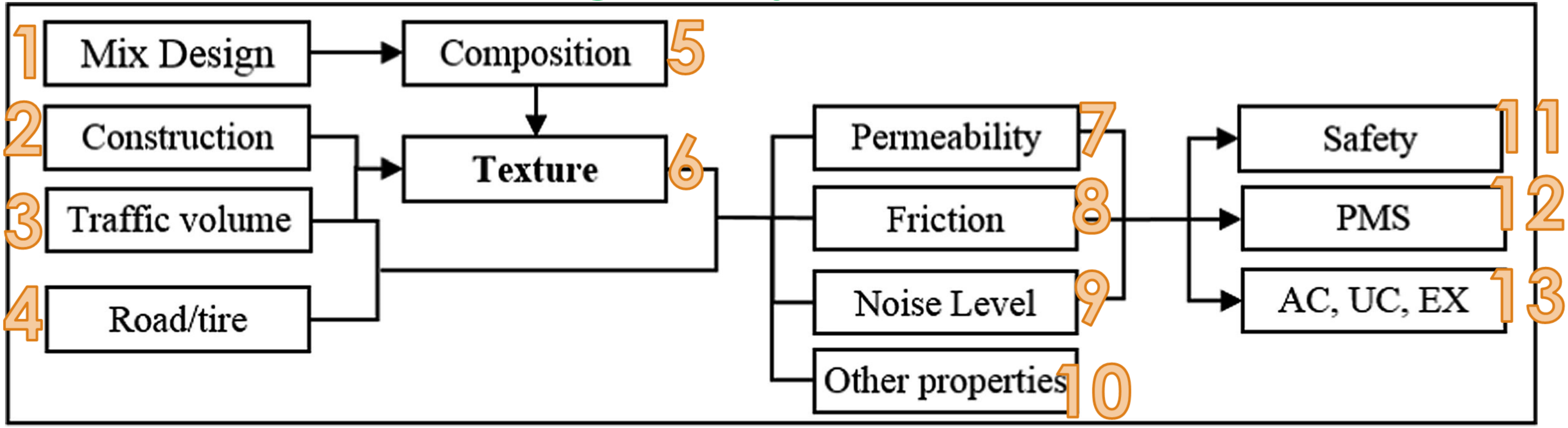
Soluzioni su misura od innovative: Contemperare..



Plan of experiments

2.2 Che cosa significa progetto acustico di una miscela?

Noise-oriented design of a pavement mixture



F.G. Praticò, P.G. Briante, Prediction of surface texture for better performance of friction courses, Construction and Building Materials, Volume 230, 2020, 116991, ISSN 0950-0618, https://doi.org/10.1016/j.conbuildmat.2019.116991.

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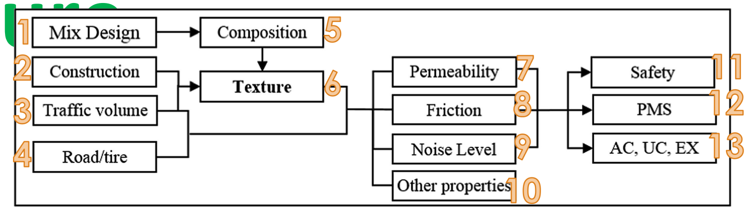
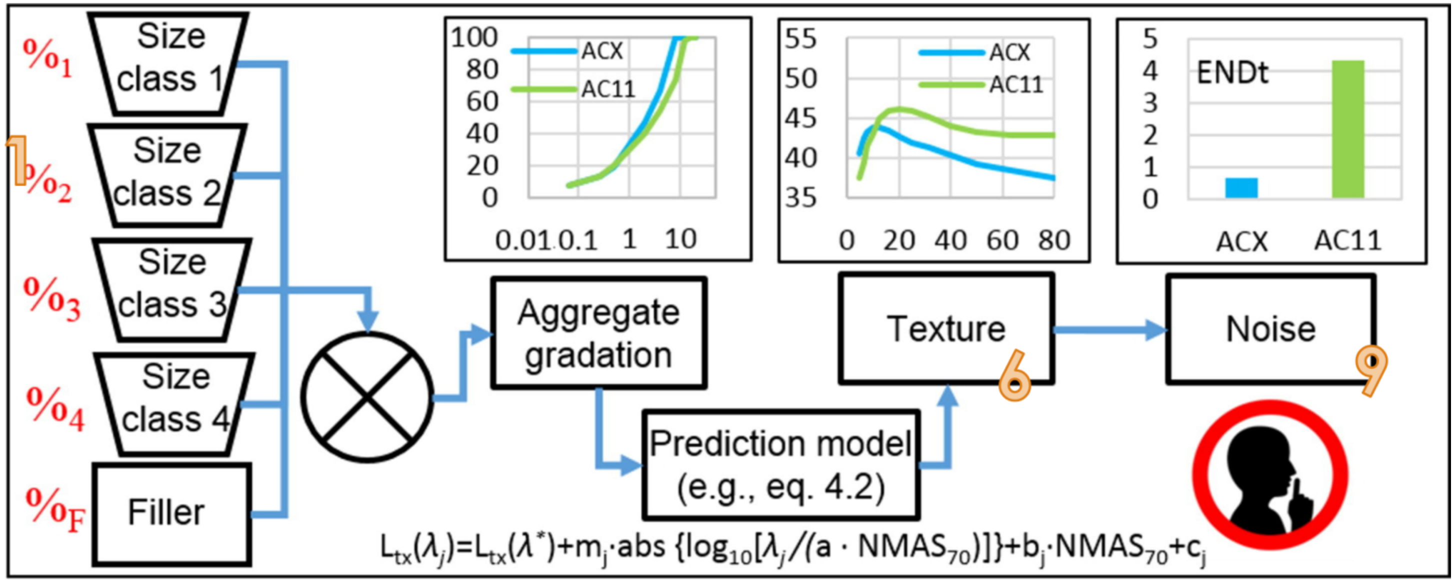


Soluzioni su misura od innovative

Dalla granulometria alla tessitura al rumore From gradation to noise



F.G. Praticò, P.G. Briante, Prediction of surface texture for better performance of friction courses, Construction and Building Materials, Volume 230, 2020, 116991, ISSN 0950-0618, https://doi.org/10.1016/j.conbuildmat.2019.116991.

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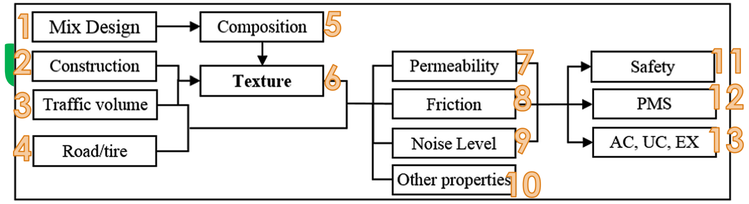
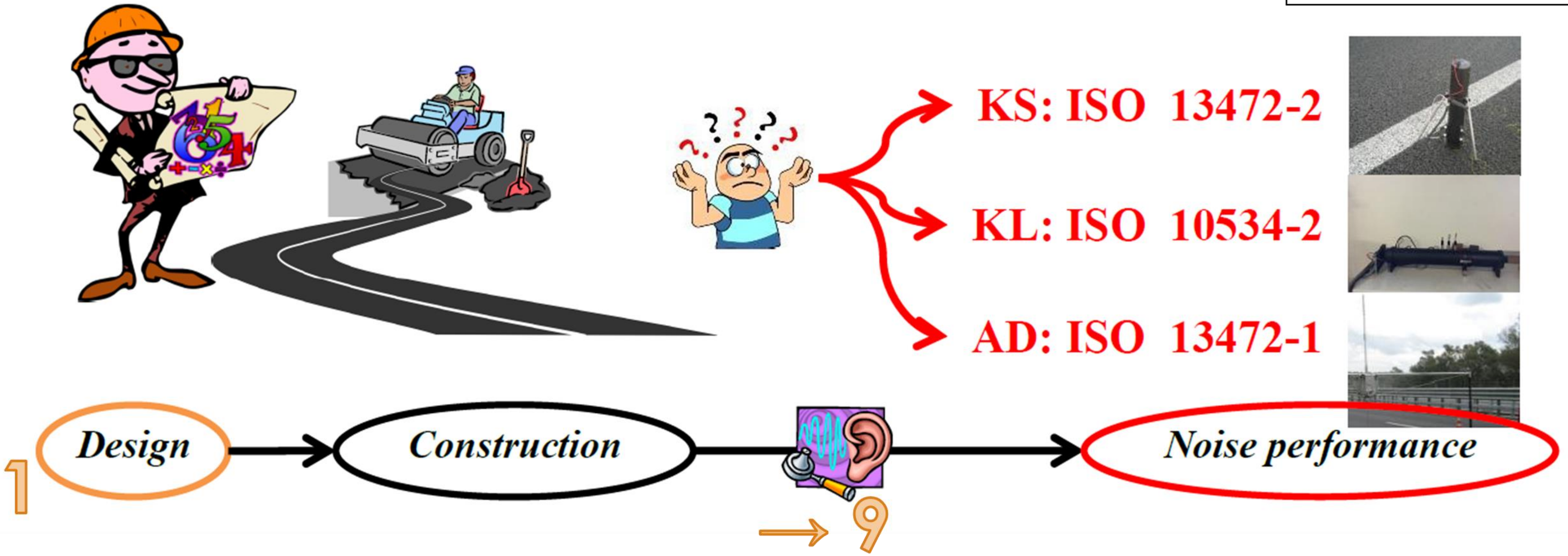


Soluzioni su misura od innovative dal progetto alla validazione (miscele porose)-Porous mixtures



Filippo G. Praticò, Rosario Fedele, Domenico Vizzari, Significance and reliability of absorption spectra of quiet pavements, Construction and Building Materials, Volume 140, 2017, Pages 274-281, ISSN 0950-0618, https://doi.org/10.1016/j.conbuildmat.2017.02.130.

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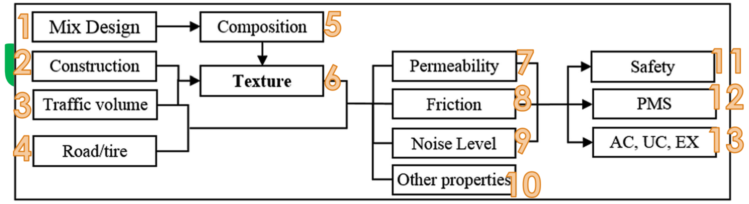
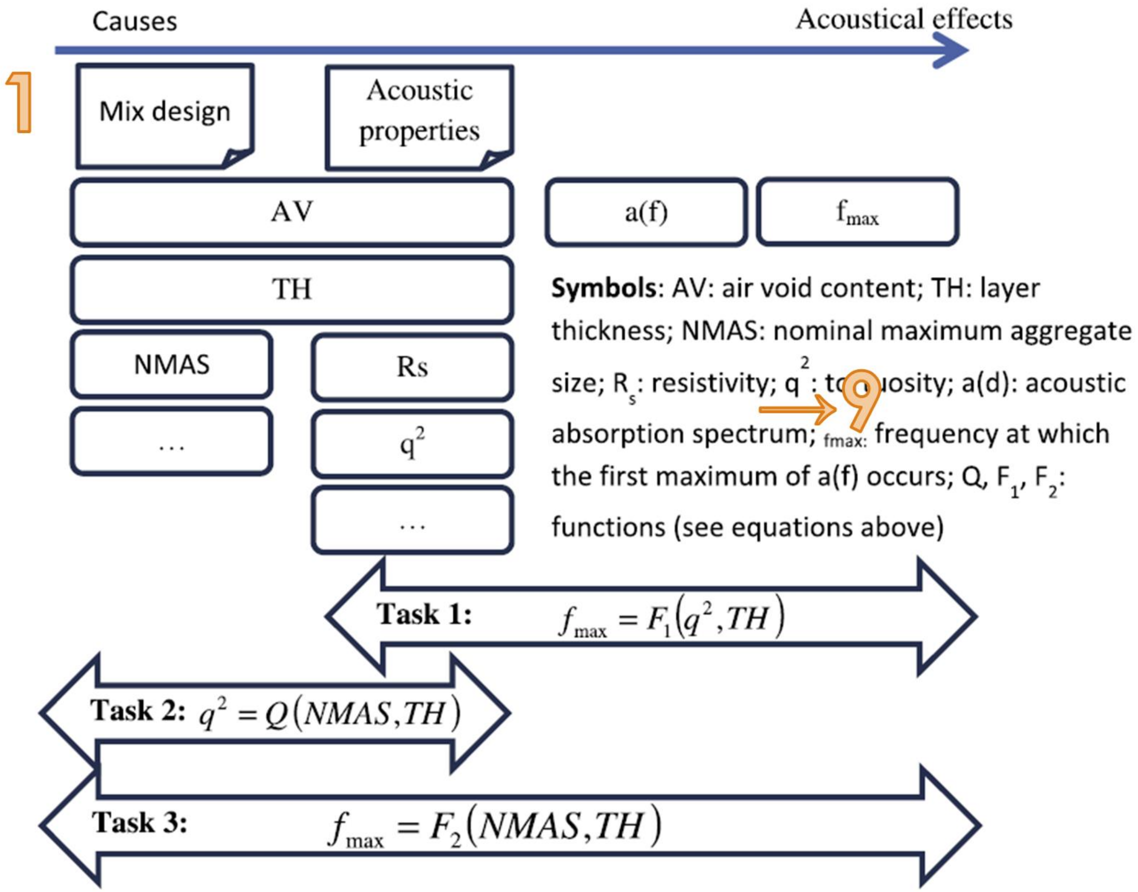


Variabili di progetto e variabili acustiche affette (miscele porose)-Porous mixtures



Filippo Giammaria Praticò, On the dependence of acoustic performance on pavement characteristics, Transportation Research Part D: Transport and Environment, Volume 29, 2014, Pages 79-87, ISSN 1361-9209, https://doi.org/10.1016/j.trd.2014.04.004.

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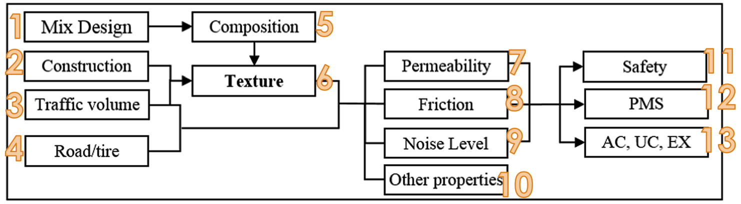
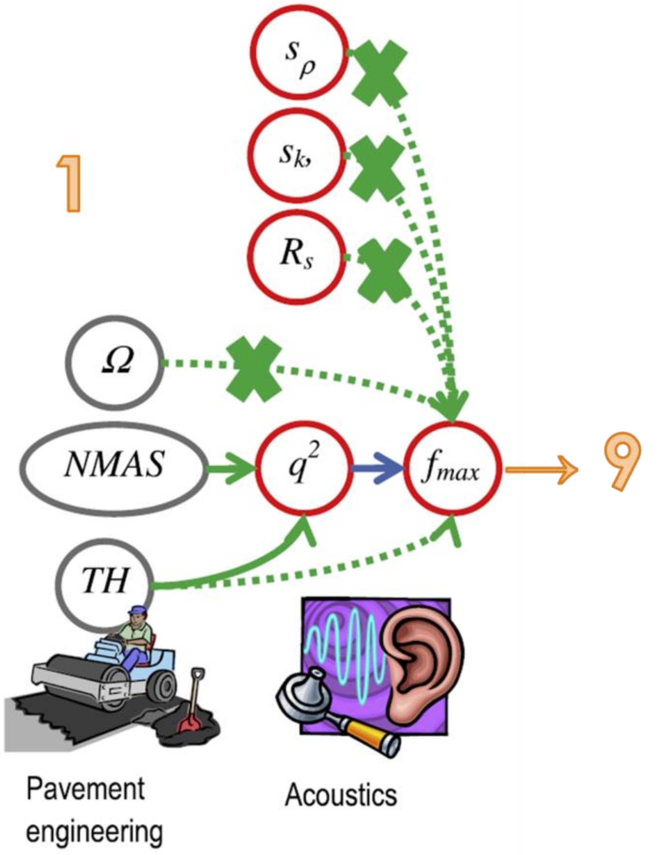


Variabili di progetto e variabili acustiche affette (miscele porose)-Porous mixtures



Strong correlation

Weak correlation

No correlation

s_ρ, s_k: viscous and thermal factors;

R_s: resistivity (Ns/m^4);

Ω: porosity;

q^2: tortuosity;

NMAS: nominal maximum aggregate size (mm);

TH: thickness (mm).

Filippo Giammaria Praticò, On the dependence of acoustic performance on pavement characteristics, Transportation Research Part D: Transport and Environment, Volume 29, 2014, Pages 79-87, ISSN 1361-9209, https://doi.org/10.1016/j.trd.2014.04.004.

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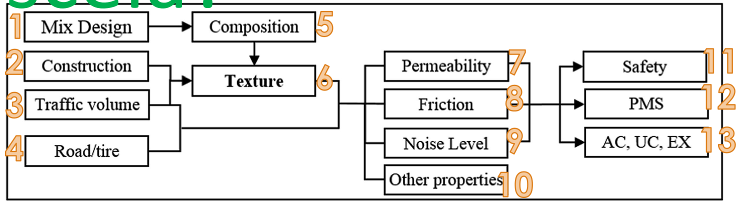

Variabili di progetto e variabili acustiche affette –Job mix formula and texture

$$\overset{9}{} \; L_{CPX} = C_1 + C_2 \frac{\overset{1}{D_{95}}}{D_f} + C_3 \frac{V_A}{\underset{2}{VMA}}$$

- Inputs:
  - 95th percentile passing sieve (D_{95})
  - fractal dimension D_f
  - the ratio of V_A and VMA
- *Output:* L_{CPX}

M. Losa, P. Leandri, G. Licitra, Mixture design optimization of low-noise pavements
Transp. Res. Rec., 2372 (1) (2013), pp. 25-33, 10.3141/2372-04

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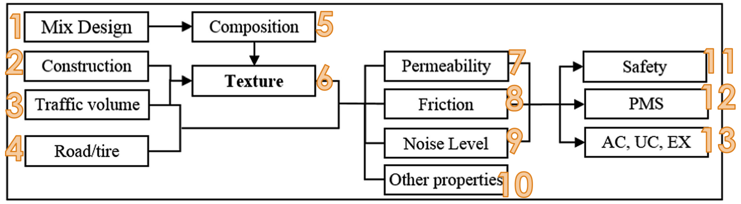
Noise-oriented design of a pavement mixture



2

$$L_{CPX}(Low) = \beta_1 + a_{l1}B\% + a_{l2}VMA + a_{l3}D_f + a_{l4}D_{95}$$

9

$$L_{CPX}(Mid) = \beta_m + a_{m1}D_f + a_{m2}D_{45} + a_{m3}VMA + a_{m4}B\%$$

$$L_{CPX}(High) = \beta_h + a_{h1}D_f + a_{h2}D_{45}$$

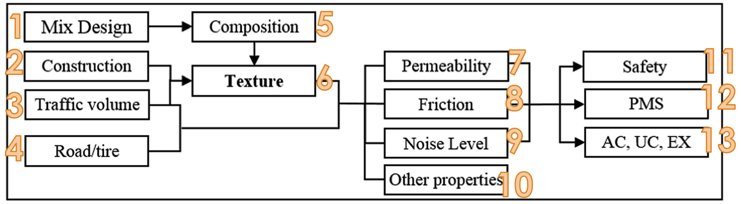
1

- Inputs:
  - 95th, 45th percentile passing sieve (D_{95})
  - fractal dimension D_f
  - V_A, *VMA*, *B%*
- *Output: LCPX* (Low (315–800 Hz; Mid (1000–1600 Hz); High(2000–5000 Hz))

M. Losa, P. Leandri, G. Licitra, Mixture design optimization of low-noise pavements
Transp. Res. Rec., 2372 (1) (2013), pp. 25-33, 10.3141/2372-04

2.2 Che cosa significa progetto acustico di una miscela?

Noise-oriented design of a pavement mixture



Variabili di progetto e variabili acustiche affette (miscele porose)-Porous mixtures

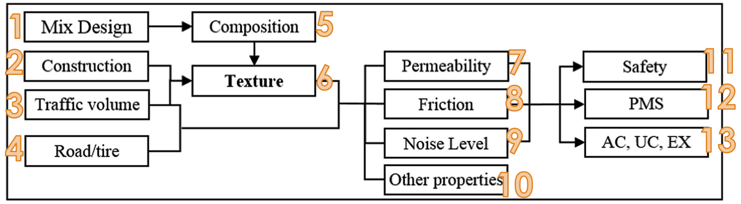
9 1 2

$$LN(S_i) = c_1 + c_2 \times L_{TX,0.5-8} + c_3 \times L_{TX,16-63} + c_4 \times (\alpha_{mean} - \alpha_0)$$

- Output: LN(Si): tire-pavement noise level at the measurement speed Si-A weighting;
- Inputs:
  - Si: the measured speed, km/h;
  - LTX,0.5–8: Surface texture (wavelengths from 0.4 mm to 10 mm)
  - LTX,16–63: Surface texture (wavelengths from 12.5 mm to 80 mm)
  - αmean: acoustic absorption coefficient of porous asphalt mixture
  - α0: acoustic absorption coefficient of dense graded asphalt mixture (? 0.034)
  - c1, c2, c3 and c4: model coefficients which need to be adapted to the vehicle speed.

De Chen, Cheng Ling, Tingting Wang, Qian Su, Anjun Ye, Prediction of tire-pavement noise of porous asphalt mixture based on mixture surface texture level and distributions, Construction and Building Materials, Volume 173, 2018, Pages 801-810, ISSN 0950-0618, https://doi.org/10.1016/j.conbuildmat.2018.04.062.

2.2 Che cosa significa progetto acustico di una miscela?
Noise-oriented design of a pavement mixture



Calculation of the Expected pass-by Noise level Difference from Texture level variation of road surface (*ENDT*)-ISO 10844:2011 **(no more in 2021)**

Output: ENDT
Inputs: Ltx, λ

$$\boxed{\Delta L_{\mathrm{tx},\lambda} = L_{\mathrm{tx},\lambda} - L_{\mathrm{tx,ref},\lambda}}$$

$$\boxed{C = 0{,}25\, \Delta L_{\mathrm{tx,5\,mm}}}$$

$$\boxed{B = \Sigma\, 10^{L_{\mathrm{m}i}/10} \quad \text{for} \quad i = 1 \ldots 13}$$

$$\boxed{A = \Sigma\, 10^{(L_{\mathrm{m}i} + b_i\, \Delta L_{\mathrm{tx},i})/10} \quad \text{for} \quad i = 1 \ldots 13}$$

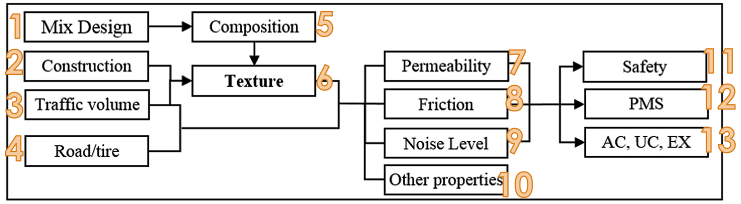
1

2

9 $$END_T = 10 \lg(A/B)\ \mathrm{dB} - C$$

2.2 Che cosa significa progetto acustico di una miscela?

Noise-oriented design of a pavement mixture

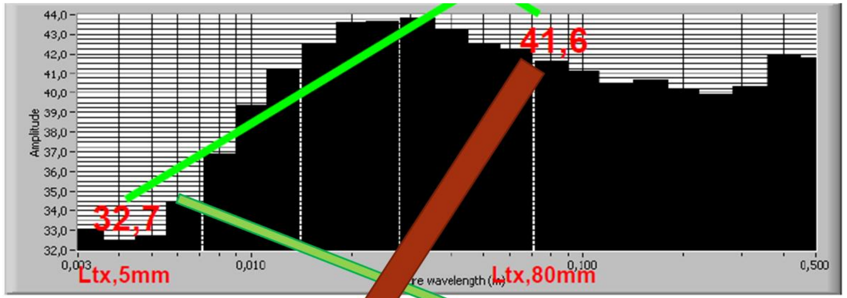


Variabili di progetto e variabili acustiche affette- main variables

- Output: Estimated road noiseness level (Descornet, 2000), and Controlled Pass-By method (Goubert, 2007)
- Input: Inputs: Ltx, λ

1

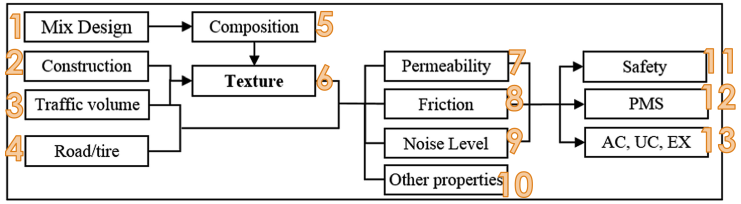
2



9 $$ERNL = 60 + 0{,}39\, L_{T80} - 0{,}13\, L_{T5}$$

2.2 Che cosa significa progetto acustico di una miscela?

Noise-oriented design of a pavement mixture



Traffico-Traffic

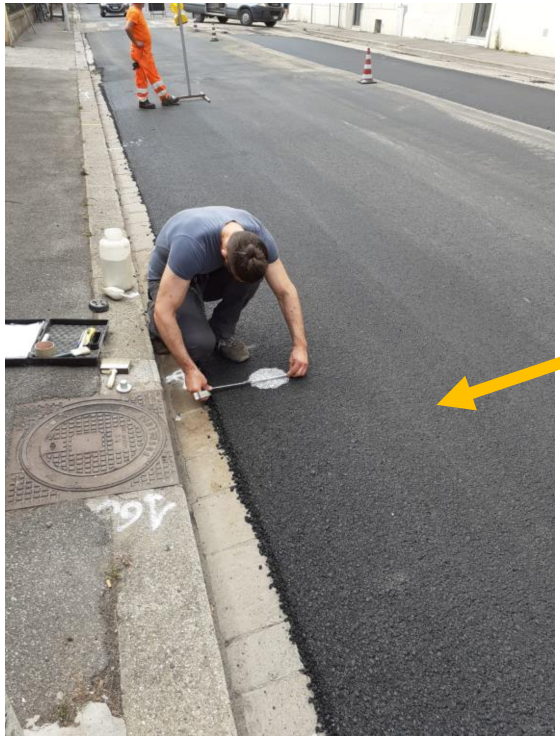
V: velocità. Q: flussi. Lp: SPL. LW: *LW,0,dir* is the directional sound power level of the specific noise (rolling, impact, squeal, braking, traction, aerodynamic, other effects) of a single vehicle in the directions ψ, ϕ, defined with respect to the vehicle's direction of movement (Stylianos Kephalopoulos, Marco Paviotti, Fabienne Anfosso-Lédée, 2012- CNOSSOS. Goubert, 2007)

$$L_{W',eq,line}(\psi,\varphi) = L_{W,0,dir}(\psi,\varphi) + 10 \times \lg\left(\frac{Q}{1000\,v}\right) \quad \text{(for } r \neq 4\text{)}$$

$$L_P \approx k \cdot 10 \log\left(\frac{v}{v_0}\right) \quad \text{(dB)}$$

9 3

2.2 Che cosa significa progetto acustico di una miscela?
Noise-oriented design of a pavement mixture



…… Via Paisiello Firenze!

Thank you for your attention!

Filippo G. Praticò, UNIRC

filippo.pratico@unirc.it

The Future in Motion

With the contribution of the LIFE programme of the European Union
LIFE18 ENV/IT/000201

www.life-evia.eu

Holistic low noise tyres for electric vehicles

LIFE E-VIA Final Meeting

7 October 2022, Florence

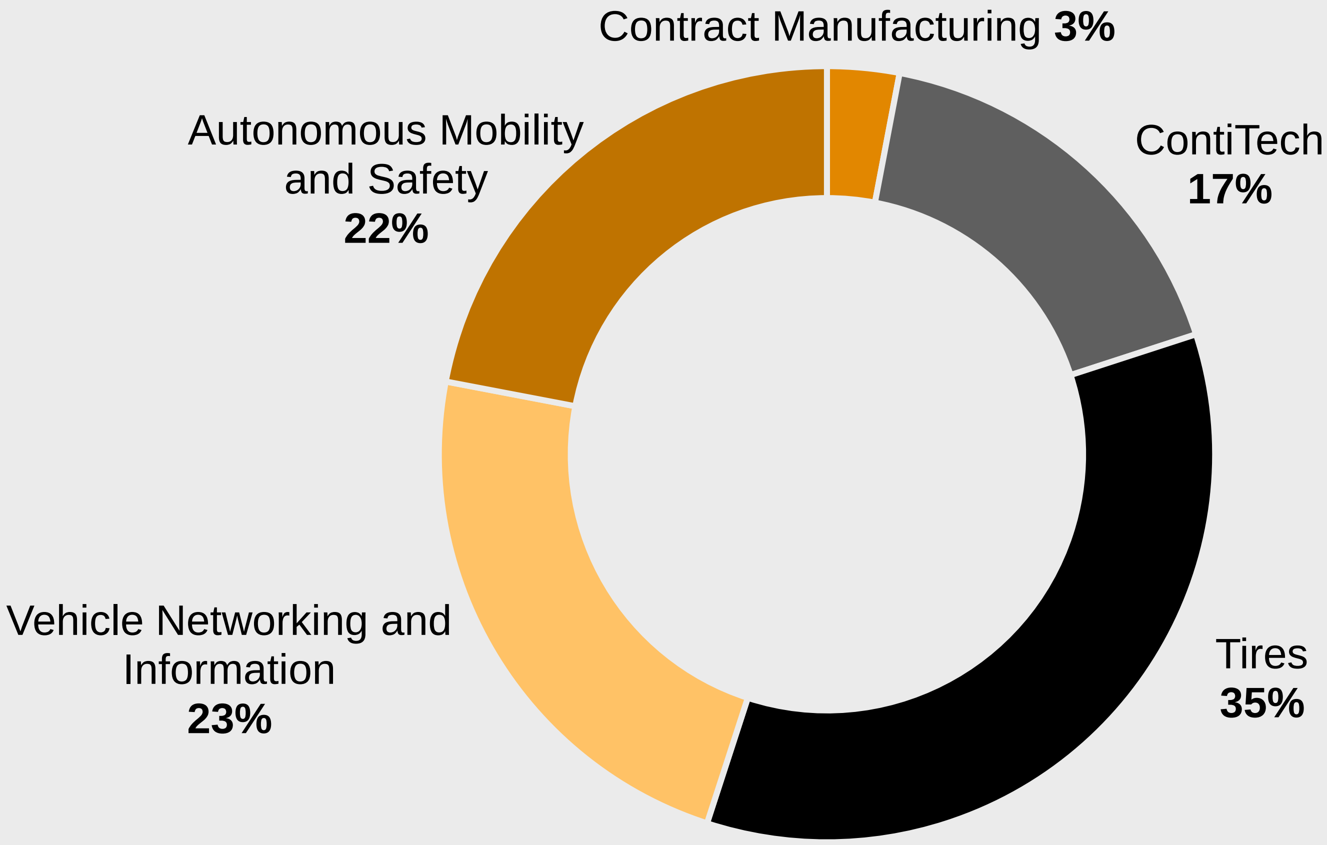
Continental Group
Overview 2021[1]

33.8 billion
in **Sales**

190,875
employees

527 sites
in 58 countries

Sales by Group Sector in %



[1] IFRS 5 has been adopted for Vitesco Technologies since 2021.

As at: Dec. 31, 2021

Tires Group Sector

- Continental is one of the world's leading tire manufacturers and offers a wide range of products for passenger cars, commercial and specialty vehicles as well as two-wheelers. This also includes services for the tire trade and fleet applications, as well as digital management systems for tires.
- Continuous investment in research and development makes a significant contribution toward safe, cost-effective and sustainable mobility.

€11.8 billion in **sales**

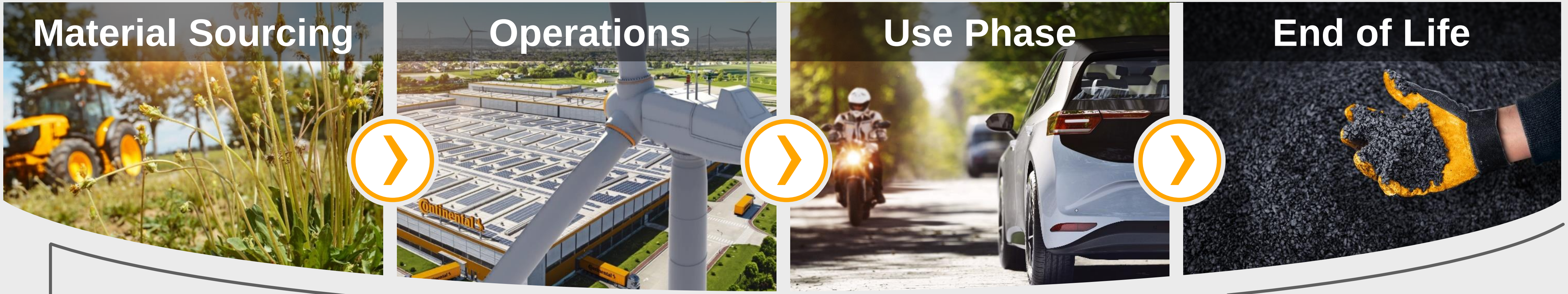
57,217 employees

As at: Dec. 31, 2021


Our Responsibility
We will be the most progressive tire company in terms of environmental and social responsibility.

Our Responsibility

Our eight strategic fields cover all four phases of the value chain



- Sustainable Materials
- Responsible Sourcing
- Green Operations
- Clean and Safe Mobility
- Renewing and Recycling
- Responsible Employer
- Responsible Citizen
- Circular Economy Solutions

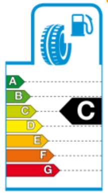
Agenda

Agenda

LIFE E-VIA's holistic low noise optimization approach

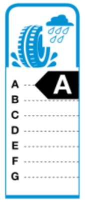
"Within action B7 [..] EV tyres [are developed and build] which are designed to give an optimal holistic relation between low exterior noise and other key performances."

Rolling resistance



- Affects the energy efficiency of a vehicle.
  - Contribution to CO_2 emission.
  - High achievable mileage is crucial for user acceptance of EVs.

Safety



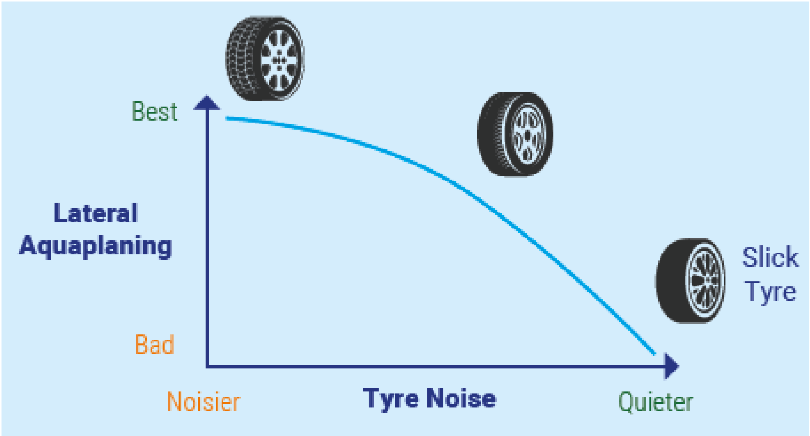
- Wet/dry braking
- Aquaplaning
- Safe driving is a paramount requirement a tyre has to fulfill.

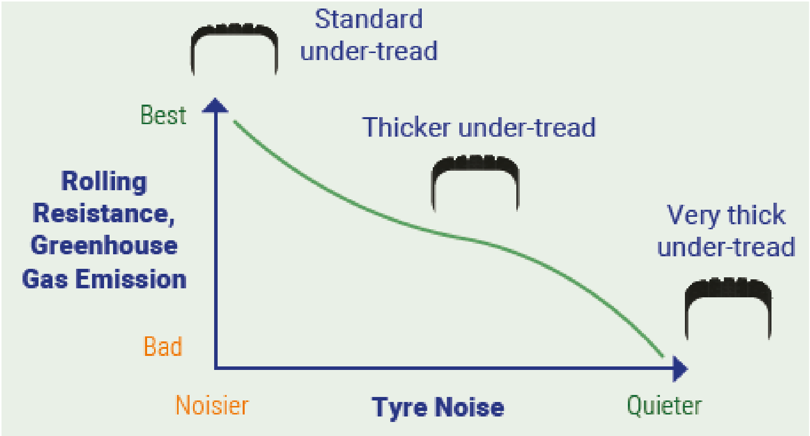
Wear

- High achievable mileage is crucial for user acceptance of a tyre.
- Long tyre lifespan reduces particle emission and waste.

The sustainability of a low noise tyre is only given when a holistic performance is assured.

Tyre performance target conflicts





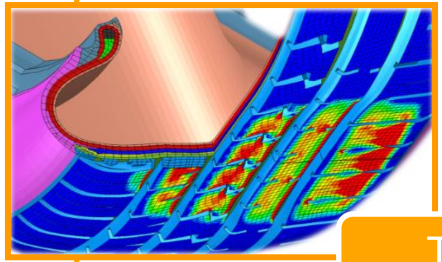
Source: *Tyre & Road Traffic Noise,* ETRMA, 2021

LIFE E-VIA requirement book for a holistic noise optimized EV tyre

Property	Value	Comment
Tyre dimensions	205/55 R16	
Load index	91 SL / 94 XL	Corresponding to 615 kg / 670 kg
Speed symbol	H (max. speed 210 km/h)	Minimum requirement
Tyre load	400 kg	Based on median EV weight in Compact segment
Inflation pressure	Based on LI and tyre load.	In accordance with the *ETRTO Standard Manual*.
Vehicle/road inclination	Representative angle (-1.5° to -2.5°)	
Rolling conditions	Free and under torque	
Noise performance	Excellent exterior noise performance on an EV operating under urban driving conditions up to 50 km/h.	Special focus on performance on noise optimized road surface property to be developed in B1/B2. Good performance up to 80 km/h.
Rolling resistance	R117 compliant, Label class A	
Wet grip	R117 compliant Label class B	Class A if achievable
Other performances	R30 and R177 compliant, market competitive	

Possible noise mitigation measures are determined by the physics of tyre/road noise generation

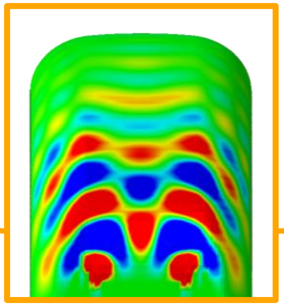
Excitation of the tyre in the footprint due to tread block impact and road roughness



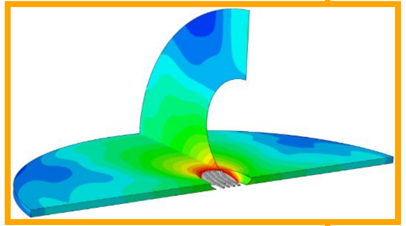
1. Tyre/road contact

2. Vibration propagation

Propagation of vibrations from the contact region to the tyre body



Tyre vibrations are radiated as sound waves into the air



3. Sound radiation

Possible noise mitigation measures

Minimize tyre excitation by
- **noise optimized tread profiles**
- **low noise roads**

Attenuate vibration propagation by **adding material mass** or **damping**.
→ **Target conflict** with **rolling resistance** and **resource usage**.

Only **passive measures** (absorption/attenuation) along the propagation path possible.

E-VIA approach of choice

Target conflict analysis summer tires

› Study 205/55 R16 European market summer tyres vs. slick summer tyre

- Slick tyre sets baseline for achievable noise reduction
- *Wet Grip* and *Aquaplaning* performance not acceptable

CERAM
UTAC CERAM

		TEST														
		Rolling Resistance	Wet Grip	Rolling Sound							Flat Trac		Dry Grip	Longitudinal Aquaplaning	Lateral Aquaplaning	
List	Tread type	RR (index)	WG (index)	R117 50 (-1dB with T° corr) (dB(A))	R117 80 (-1 dB with T° coor) (dB(A))	R51 ICE A (without T° corr) (dB(A))	R51 ICE C (without T° corr) (dB(A))	R51 ICE Lurban (without T° corr) (dB(A))	R51 EV A (with T° correction) (dB(A))	R51 EV C (with T° correction) (dB(A))	80% LI (N/°)	50% LI (N/°)	(index)	Mean LoA (kph)	LaA (Integer m/s)	Weight (kg)
B	Plain tread summer	6.663	0.93	61.6	68.2	68.3	64.1	66.9	63.6	63.4	1718	1613	1.07	43.83	18.97	7.54
D	Normal	7.985	1.38	64.3	72.6	70.1	67.1	69.1	66.7	65.8	1576	1304	0.94	84.32	78.62	8.77
E	Normal	8.011	1.39	63.1	69.9	70.2	66.9	69.1	66.3	65.2	1297	1089	0.99	96.22	90.42	8.03
F	Normal	9.171	1.20	62.8	69.8	68.8	65.6	67.8	65.5	64.9	1647	1346	0.86	81.88	67.66	9.62
G	Normal	8.439	1.25	61.9	68.2	69.7	65.8	68.5	66.1	64.0	1427	1134	0.94	74.92	49.33	9.34
H	Normal	7.914	1.43	62.0	68.7	69.0	65.7	67.9	64.7	64.2	1519	1238	1.04	77.36	58.27	9.41
J	Normal	7.047	1.59	63.9	70.7	69.4	65.7	68.2	66.3	65.2	1335	1144	0.95	80.64	70.40	8.10

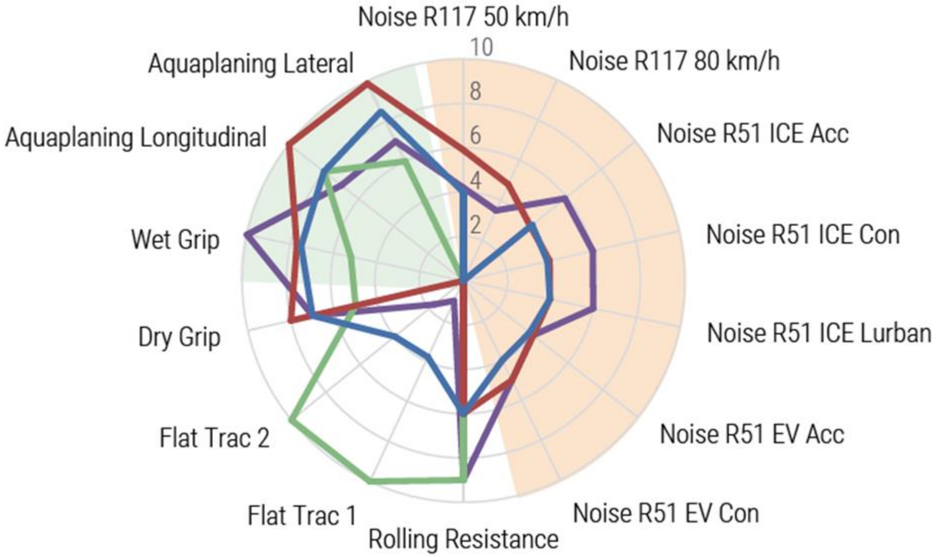
- Difference between regular summer patterns and slick defines range of highest possible noise reduction from pattern optimisation.
- Does not yet account for requirements from target conflicts.

Average all *Normal*			63.0	70.0	69.5	66.1	68.4	65.9	64.9
Average delta to *slick*			+1.4	+1.8	+1.2	+2.0	+1.5	+2.3	+1.5
Worst case delta to *slick*			+2.7	+4.4	+1.9	+2.8	+2.2	+3.1	+2.4

Adapted from: ETRTO Tyre Performance Study, GRBP-73-11, January 2021

Further limitation from target conflict to *wet safety*

- Comparison of the four best tyres for *wet safety*
- Rating:
  - 0 → worst performance among all tyres
  - 10 → best performance among all tyres
- **Best for *wet safety* → bad for *rolling noise***



- Circumferential groove essential for *wet safety* for summer tires
- Continental study on impact of circumferential grooves on R117 80 km/h noise performance

Slick tire:

71.2 dB(A)*

+1.3dB(A)

With circumferential grooves:

72.5 dB(A)*

Necessity to include circumferential reduces the noise reduction potential for the tyre pattern by approximately 1.0 dB(A) to 1.5 dB(A).

*: levels not directly comparable to ETRTO Study on previous slide due to different test track

Source: *Tyre & Road Traffic Noise,* ETRMA, 2021

LIFE E-VIA: Noise reduction potential and development strategy

- Development starting point was a ***Continental EcoContact 6*** tyre which is a typical **premium European Summer tyre** (Fuel Efficiency and Wet Label class A).

- Strategy was to use **existing, validated technologies** in a **smart and novel way**.

- Focus was mainly on the tread design as this maximizes the **control of target conflicts**. Tread design has a high impact on noise generation, especially **in combination** with **noise-optimized road surfaces**, but only limited impact on target conflicts like rolling resistance or wear.

- Accounting for the necessity to **include circumferential grooves** in the optimized tread pattern **to account for *wet safety*** requirements, the noise reduction potential was expected to be in the **range of 0.5 dB(A) to 1.5 dB(A)**.

Agenda

Importance of torque for electric vehicles (EV)

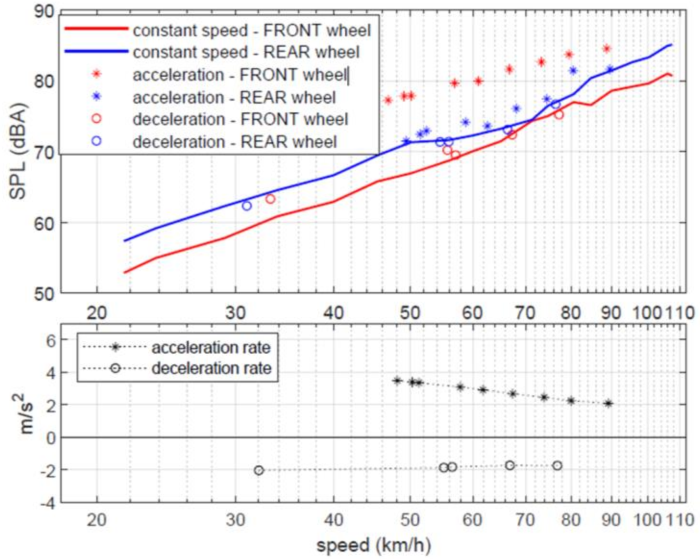
Université Gustave Eiffel

Compared to internal combustion engine vehicles (ICE), EVs are typically characterized by…

- …considerably wider RPM ranges at which maximum torque is (instantaneously) available, and
- …a higher-power-to-mass ratio.

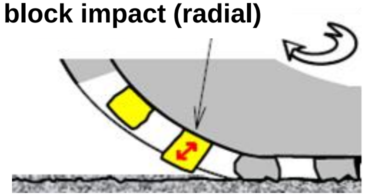
Higher tire torque (acceleration) is known to increase rolling noise.

This is believed to be caused by the increased importance of tangential tread block vibrations (*stick-slip* und *snap-out*).



Without torque

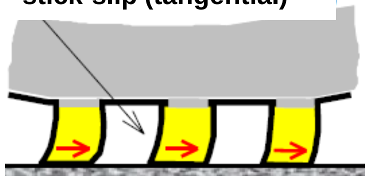
block impact (radial)



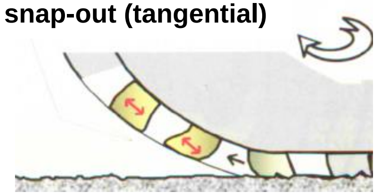
+

With torque additionally

stick-slip (tangential)



snap-out (tangential)



Source: U. Sandberg, J. Ejsmont; Tyre/road noise reference book, Informex, 2002.

Torque influences the ranking between different tires

- *E-Via* reference tires and serial tires from UGE test vehicles.
- Indoor drum test without/with torque.

- Ranking and relative differences change significantly under torque.
- This needs to be considered in the rolling noise optimization within the *E-Via* project.

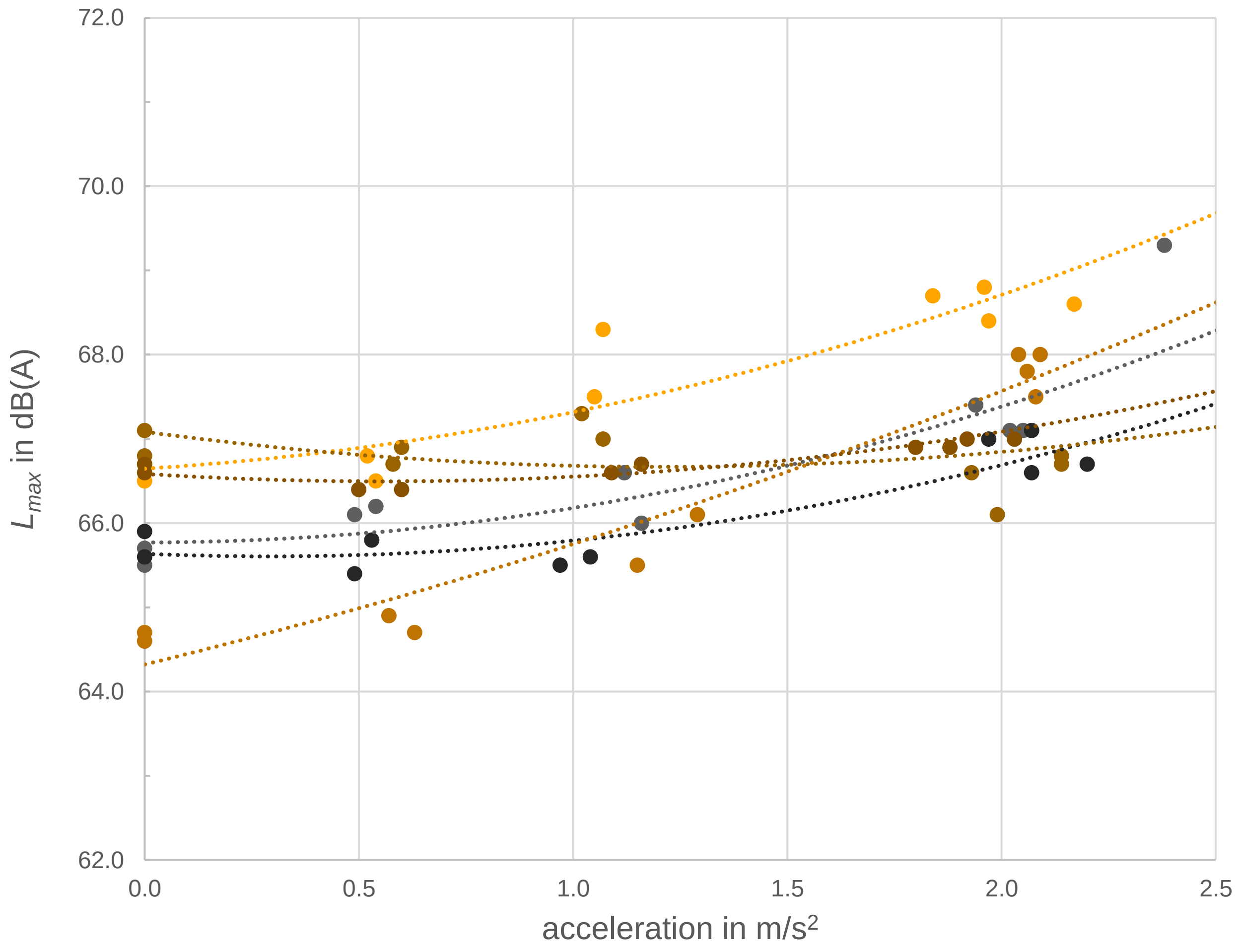
Tire	Size	∆ to ref. in dB(A)		
		constant 50 km/h	constant 80 km/h	SPL increase 0 Nm → 500 Nm @50 km/h
E-Via Ref.	205/55 R16	0,0	0,0	0,0
Test vehicle 1	195/65 R15	1,8	1,6	-1,7
E-Via Ref.	195/65 R15	1,7	0,2	-0,1
Test vehicle 2	185/65 R15	2,7	1,4	0,9
E-Via Ref	185/65 R15	0,1	-0,9	0,7

Noise increase under torque depends on tyre

› Six different summer tires.

› Tested on the same test track with the same vehicle.

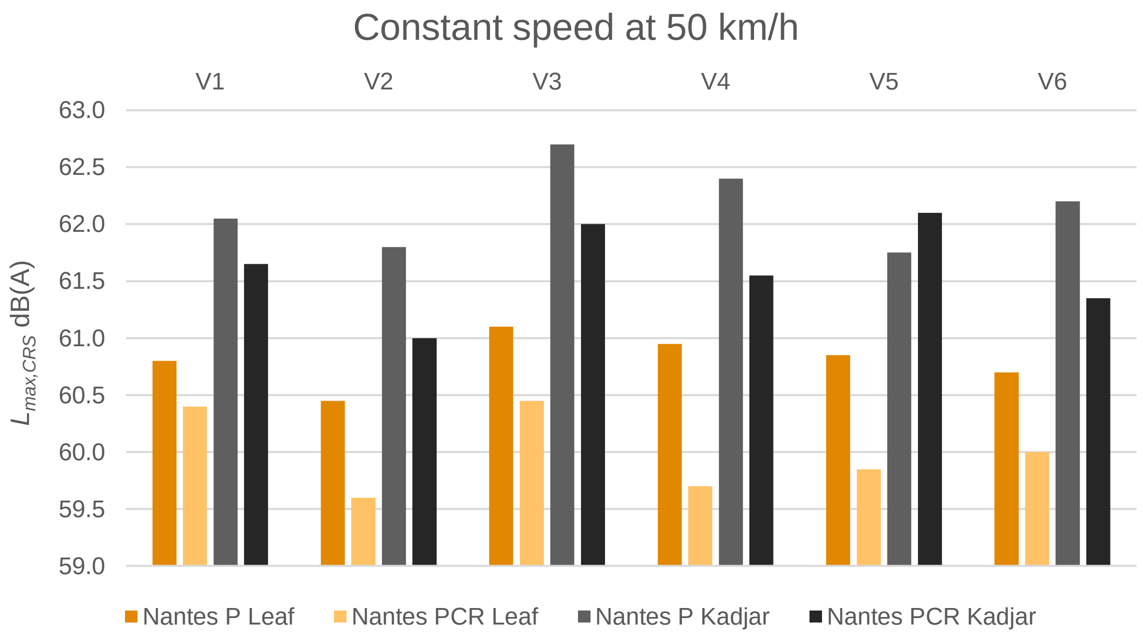
› <u>No</u> obvious systematic relation $L_{max}(a\text{=0 m/s}^2) \leftrightarrow L_{max}(a\text{>0 m/s}^2)$ under acceleration.

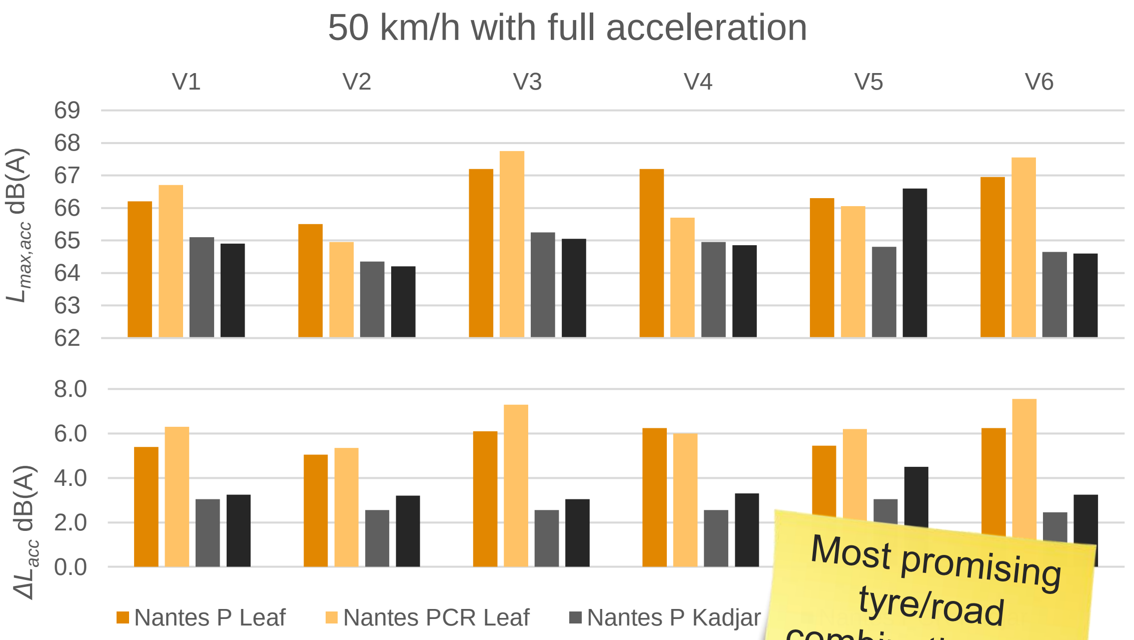


Road surface influences sound pressure level change under acceleration

- Six *E-Via* prototype tyres 1st development loop (V1-V6).
- E-Via VTAC prototype road surfaces without/with crumb rubber (P/PCR) at the UGE test track in Nantes.
- Two different test vehicles.

- Constant speed: PCR for all tyre/vehicle combinations except one quieter than for P.
- Acceleration: in 33% of cases PCR louder than P.
- Acceleration: ΔL_{acc} for all tyre/vehicle combinations except one higher for PCR than for P.





Most promising tyre/road combinations still on PCR.

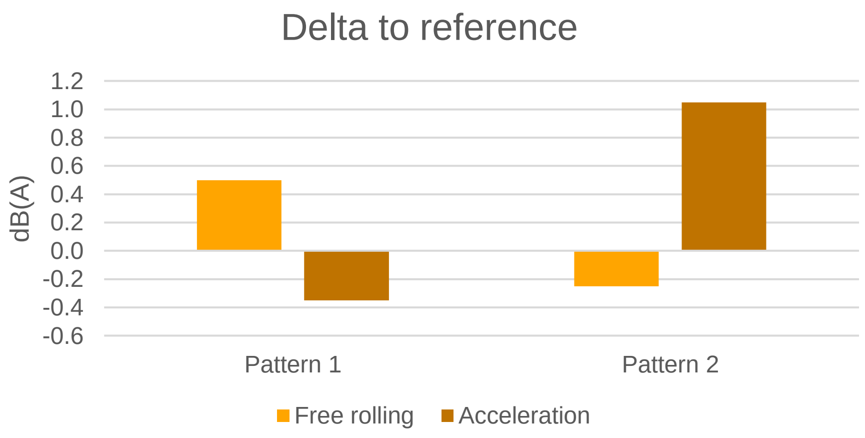
Tyre pattern influence on sound pressure level change under acceleration

- *E-Via* prototype tyres 2nd development loop compared to EC6 reference tire.
- *E-Via* prototype road surfaces without/with crumb rubber (P/PCR) at the UGE test track in Nantes.
- Two different test vehicles.

Reference: serial production tire

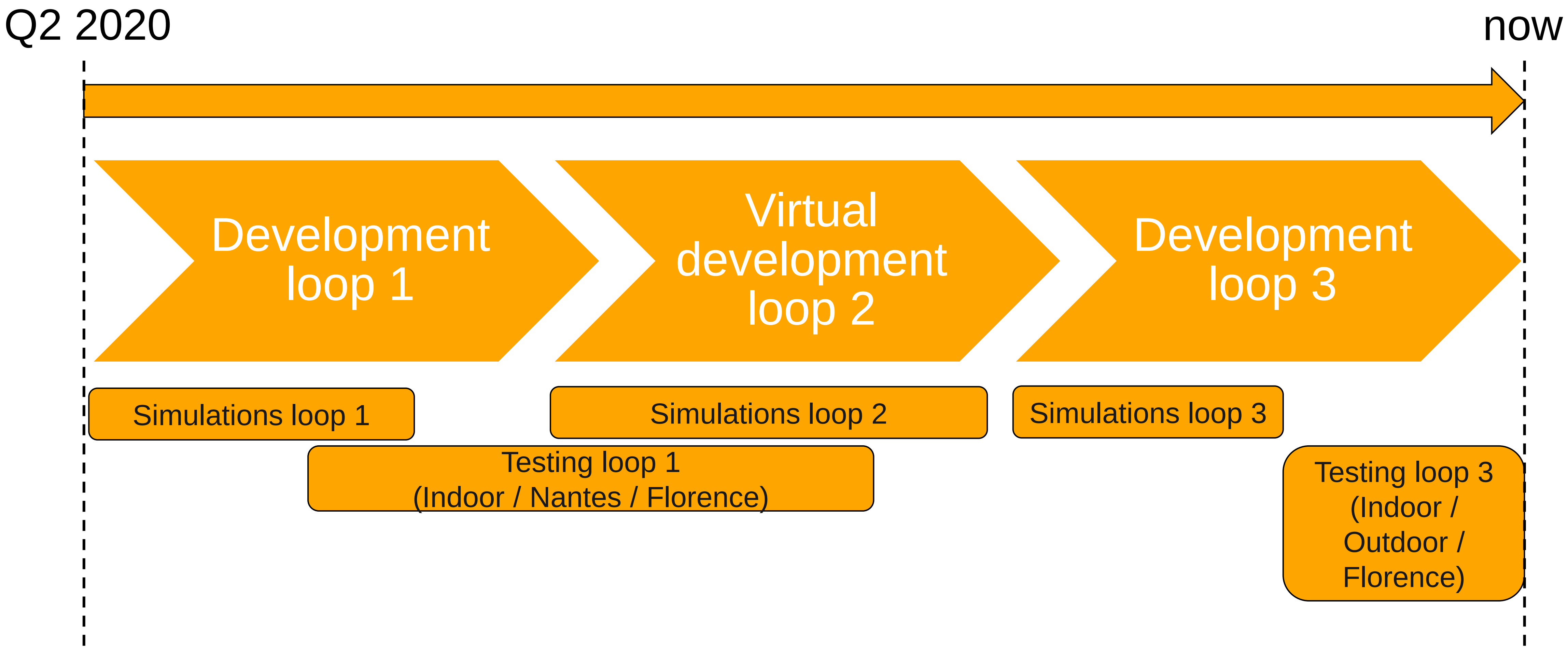
	ratio shear stiffness/ radial stiffness
Pattern 1	> Reference
Pattern 2	< Reference

- Lower ratio shear/radial stiffness …
  - lowers pass-by level for constant speed, and
  - increases pass-by level under acceleration.
- Opposite effect for increased ratio shear/radial stiffness.



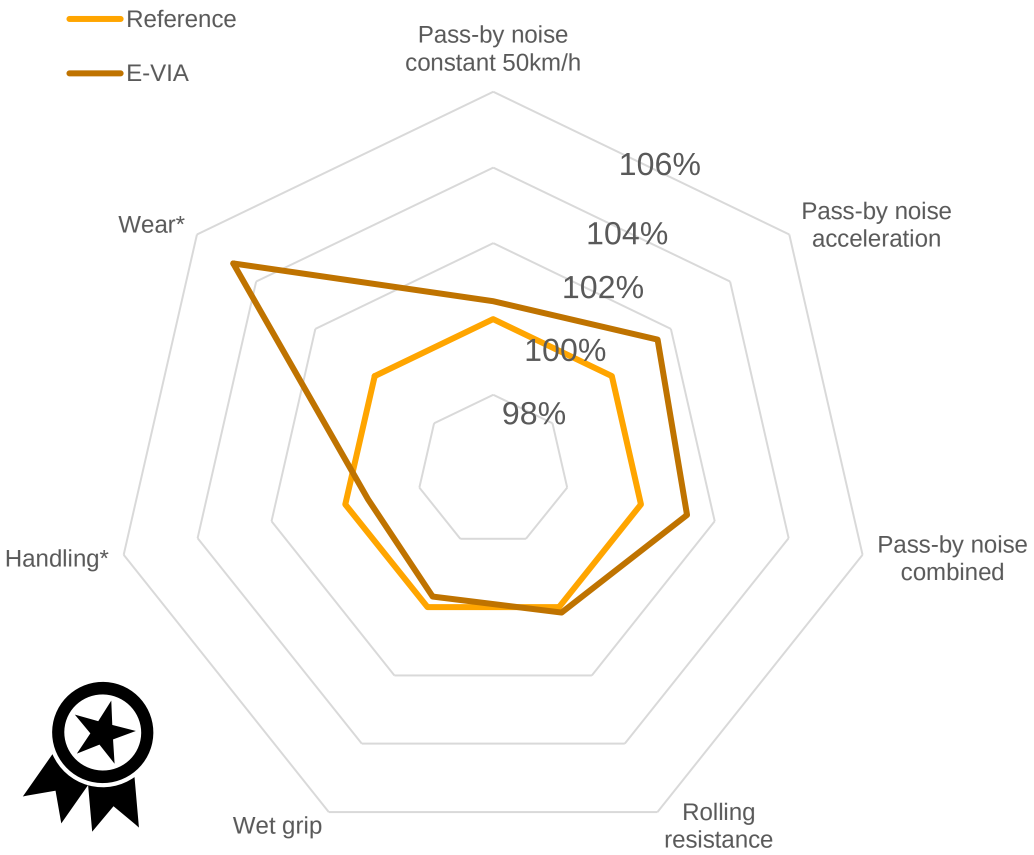
Agenda

LIFE E-VIA tyre development



The LIFE E-VIA holistic noise optimized EV tyre

Target conflict analysis



Pass-by noise performance

Difference in pass-by noise level compared to reference

50 km/h constant	acceleration	combined
-0.3 dB(A)	-1.0 dB(A)	-0.8 dB(A)

Have a look at the LIFE E-VIA Expomove booth!

Agenda

Summary

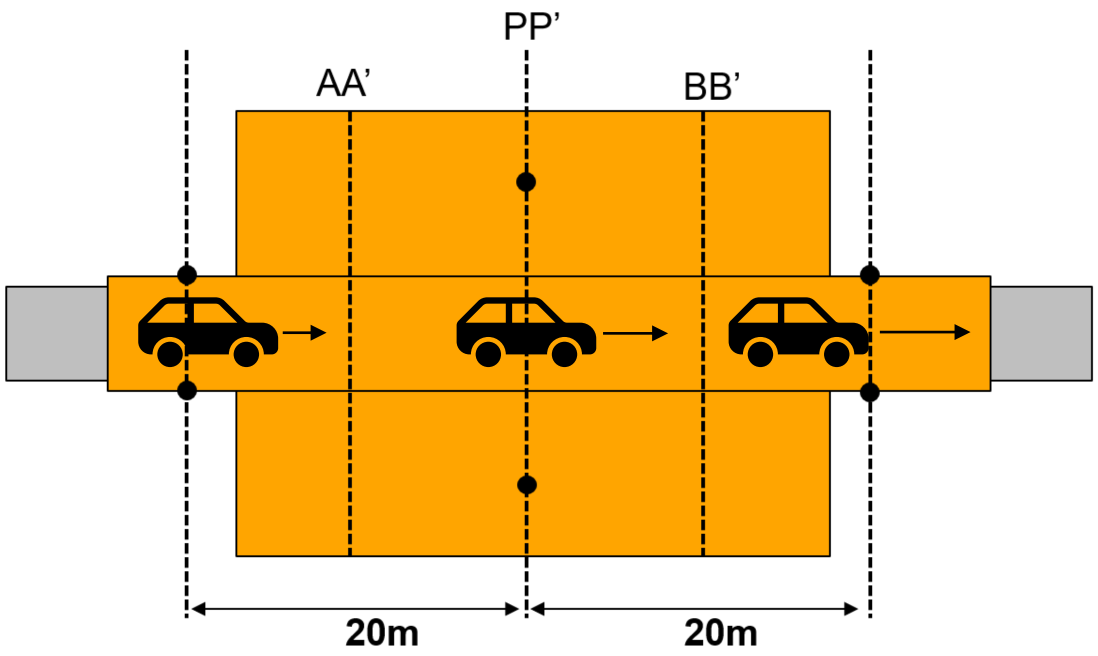
- Within LIFE E-VIA existing, validated technologies were combined in a smart and novel way to develop a **holistic noise optimized EV tyre**.
- Compared to the reference tyre a **reduction in pass-by noise** of up to **1.0 dB(A)** was observed.
- The **performance level** of the reference tyre could **be maintained** for important areas of **target conflicts**.
- In addition, the project created **valuable insight** into the **interaction of vehicle, road surface and tyre design**, especially under **torque conditions**.

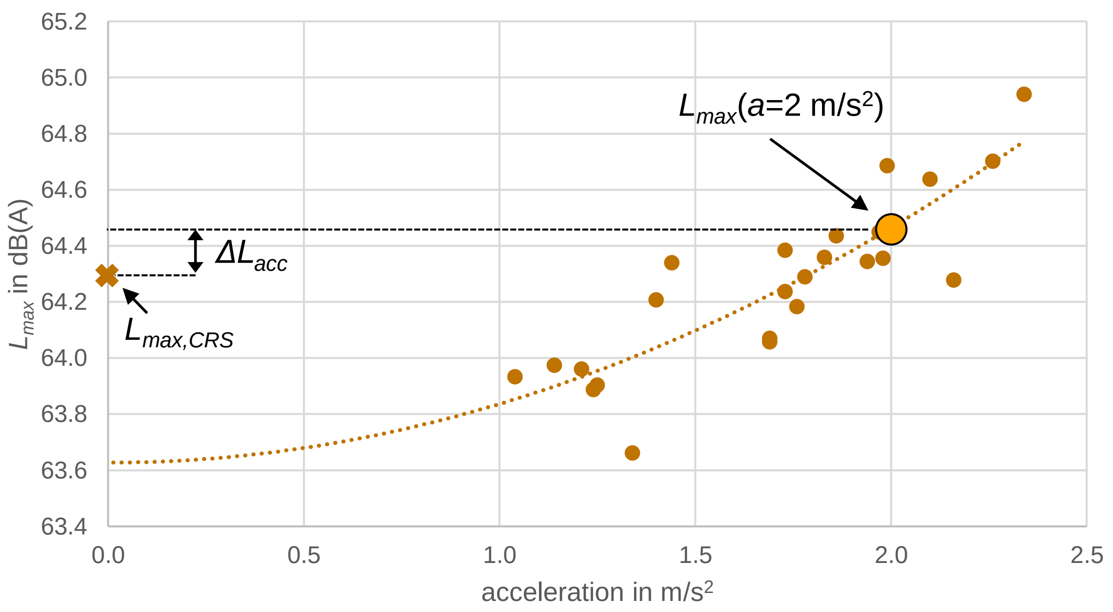
Thank you for your attention

BACKUP

Accelerated pass-by noise measurements

- Evaluated is the maximum sound pressure level L_{max} measured between AA' and BB' for accelerated pass-bys which pass PP' with 50±1 km/h.
- Additional constant speeds pass-bys are measured following the same procedure.
- L_{max} for a reference acceleration of 2 m/s² is interpolated.
- It is still under discussion if the pass-by level for *constant rolling*, $L_{max,CRS}$, needs to be considered in this interpolation or not.
- On all slides which follow the sound pressure level change under acceleration is given as: $\Delta L_{\text{acc}} = L_{max}\left(a = 2\ \text{m/s}^2\right) - L_{max,CRS}$





LIFE18 ENV/IT/000201

LIFE E-VIA final event
EXPOMOVE 2022
Florence – 7th October 2022

Tyre-pavement coupling study and prototype implementation

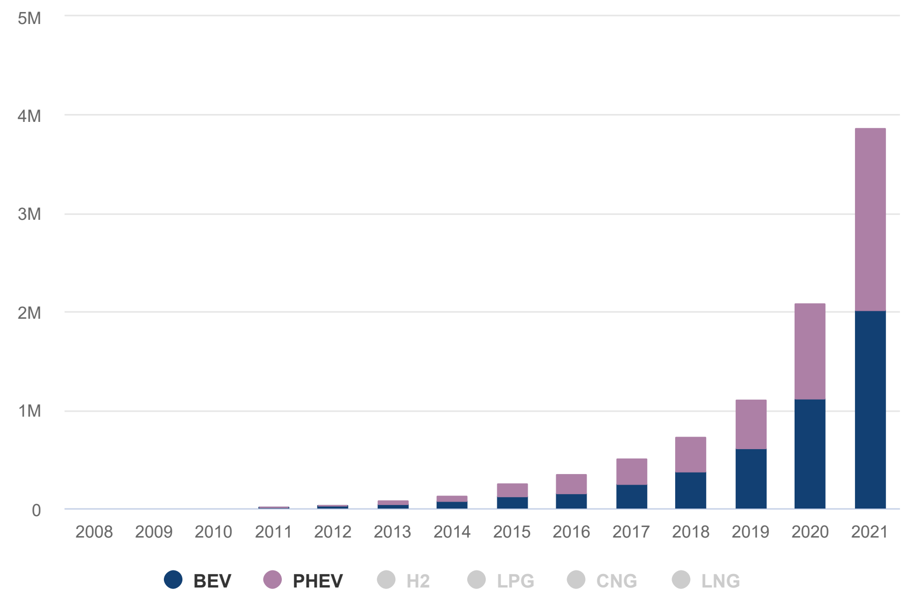
Julien CESBRON and Marie-Agnès PALLAS

Université Gustave Eiffel (UNI EIFFEL)
Joint Research Unit in Environmental Acoustics (UMRAE)

Context

- Exponential increase of electric vehicles (EVs) in European Union (3.9M of EVs and 18% of new registrations in 2021)
- Projection scenario: 15 to 30% of EVs market share in 2030
- Electric motors quieter than internal combustion engine (ICE): tyre/road interaction becomes the prominent source of noise emission for EVs in urban area from about 20 km/h
- Future market of EV tyres will stay within standard tyre dimensions
- EVs have some specificities in comparison with ICE vehicles such as vehicle range optimization, higher torque and curb weight

Evolution of the total number of electric vehicles in EU27 (light passenger cars)



Source : https://alternative-fuels-observatory.ec.europa.eu/

Action B2 – Tyre-pavement coupling study

- Implementation action of the LIFE E-VIA project
- Tyre-pavement coupling study divided in 4 sub-actions:
  - B21: Acoustical characterization of EVs on existing tracks
  - B22: Construction of a B1-based test track prototype
  - B23: Characterization of the B1-based prototypal test section
  - B24: Selection of optimized EV tyres
- Contributing partners: UNI EIFFEL, UNIRC, IPOOL, CRD
- Final deliverable published on 13/05/2022, available on the website: https://life-evia.eu

LIFE E-VIA

"Electric Vehicle noise control by Assessment and optimisation of tyre/road interaction"

LIFE18 ENV/IT/000201

Deliverable	Report on action B2
Content	Prototype implementation and tyre/road noise performances
Action/Sub-action	B2: Tyre-pavement coupling study and prototype implementation
Status - date	Final version - 13-05-2022
Authors	Julien CESBRON, Marie-Agnès PALLAS, Simon BIANCHETTI, Philippe KLEIN and Véronique CEREZO (UNI EIFFEL) Antonino MORO and Francesco BIANCO (IPOOL)
Beneficiaries	UNI EIFFEL CRD IPOOL UNIRC
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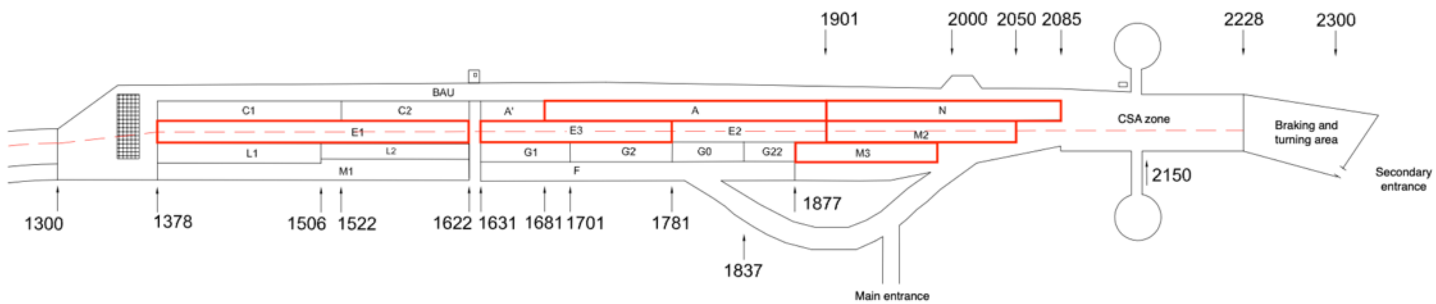
Project Website	https://life-evia.eu/

Action B21 - Acoustical characterization of EVs

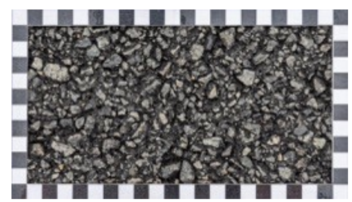
- Measurement campaign performed on UNI EIFFEL reference test track



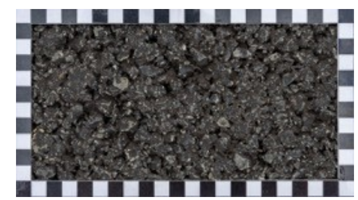
3 impervious road surfaces

N - ISO 10844

E1 - DAC 0/10



E3 - SMA 0/10

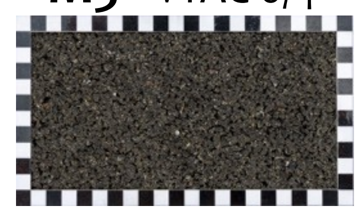


3 absorbing road surfaces

A - PA 0/6

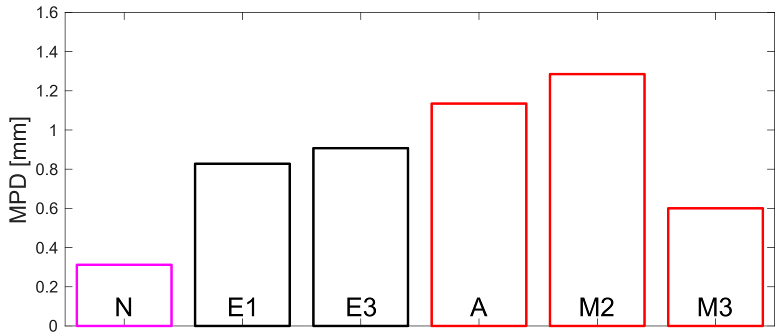
M2 - VTAC 0/6

M3 - VTAC 0/4

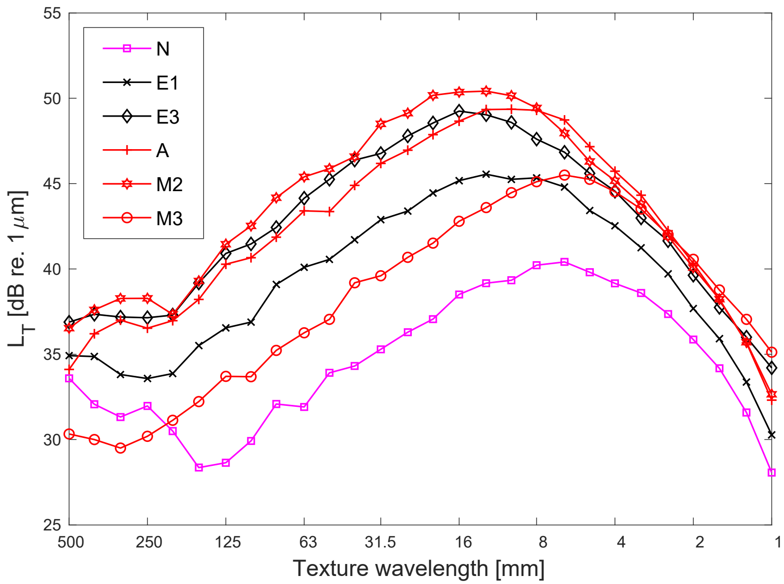


Action B21 - Acoustical characterization of EVs

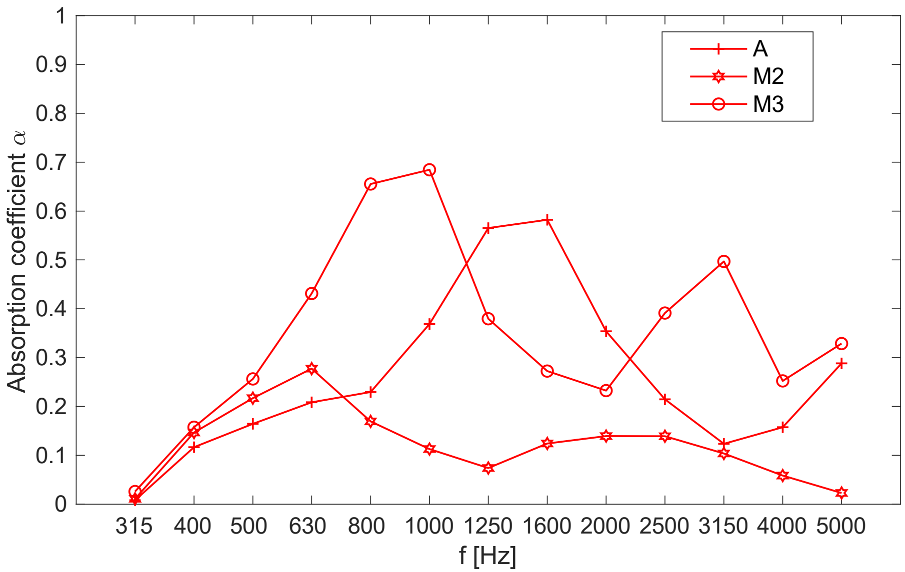
Mean Profile Depth (MPD) - ISO 13473-1



Texture spectra - ISO 13473-4



Sound absorption - ISO 13472-1



Action B21 - Acoustical characterization of EVs

- Types of pass-by measurements
  - Standard Controlled Pass-By (CPB) on all road surfaces (E1, E3, N, A, M2, M3)
  - Microphone array pass-by measurements (only on N road surface - ISO 10844)
- Pass-by conditions :
  - Constant speed : from 20 to 110 km/h in 5 km/h steps
  - Full acceleration for start speeds from 0 to 50/90 km/h initial speed
  - Regenerative deceleration from 40 to 90 km/h initial speed

Controlled pass-by tests

Microphone array pass-by tests

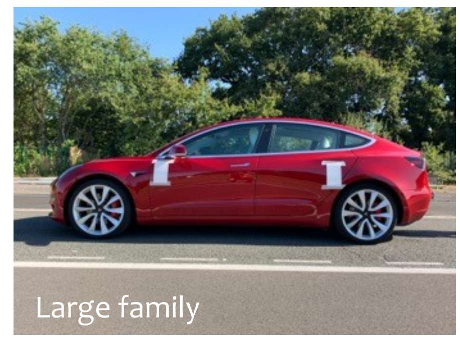
Action B21 - Acoustical characterization of EVs

- 6 recent EVs (5 passenger cars and 1 light commercial vehicle)
- EV segments: 2 supermini, 2 small family, 1 large family and 1 light commercial

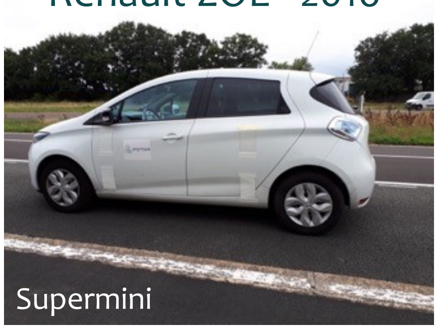
Peugeot e-208 - 2020

BMW i3 - 2018

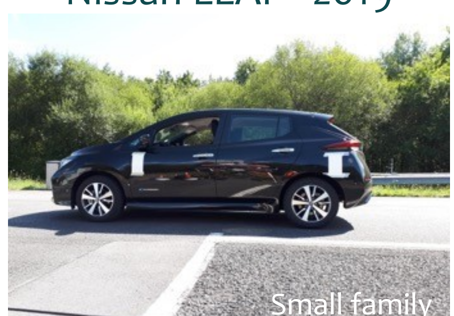
Tesla Model 3 - 2019



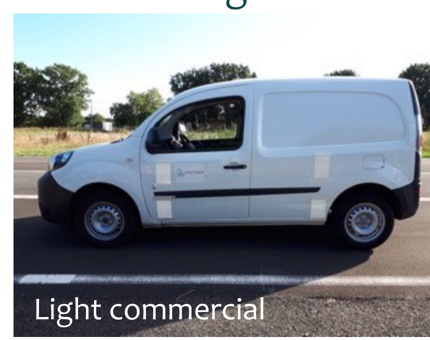
Renault ZOE - 2016



Nissan LEAF - 2019



Renault Kangoo ZE - 2013



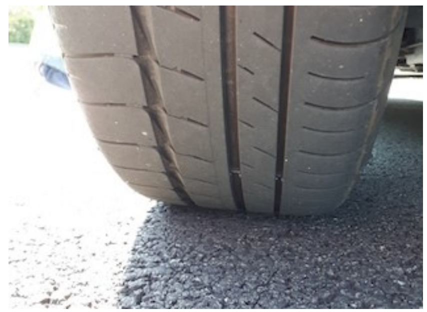
Action B21 - Acoustical characterization of EVs

- Passenger cars fitted with their original equipment tyres
- Renault Kangoo ZE fitted new tyres for comparison with a Kangoo Diesel (ICEV)

Peugeot e-208

Michelin Primacy 4
195/55 R16

BMW i3

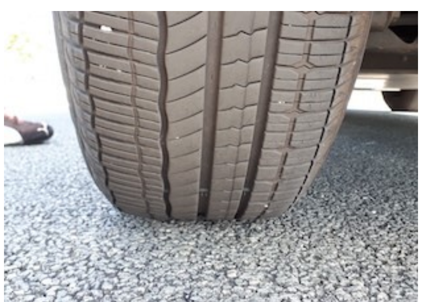


Bridgestone Ecopia EP500
175/55 R20 (front) - 195/50 R20 (rear)

Tesla Model 3

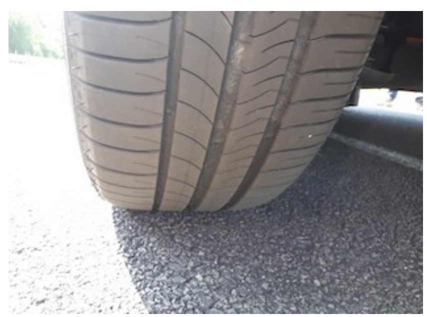
Michelin Pilot Sport 4S
235/35 ZR20

Renault ZOE



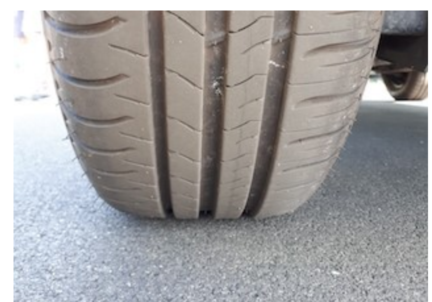
Michelin Energy E-V
185/65 R15

Nissan LEAF



Michelin Energy Saver
205/55 R16

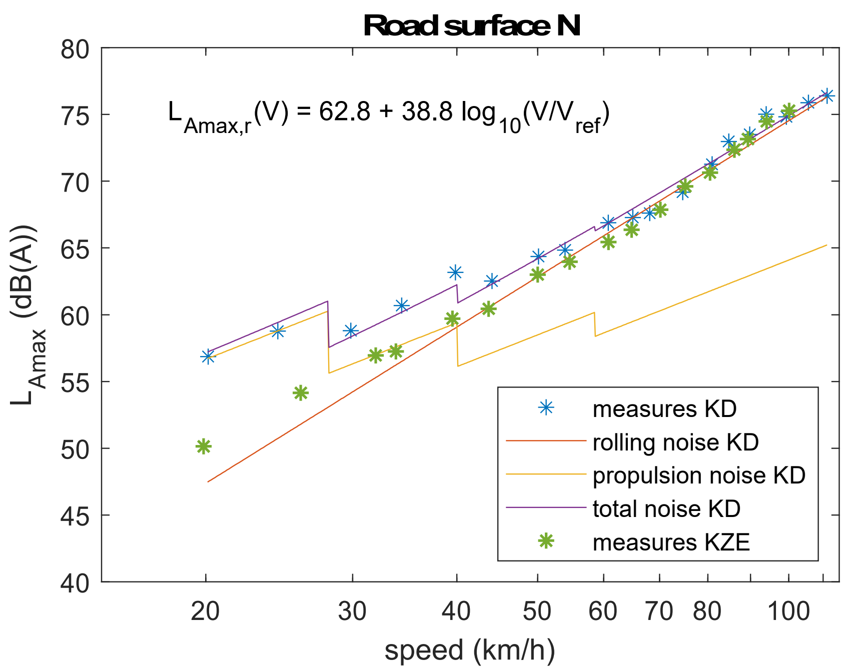
Renault Kangoo ZE



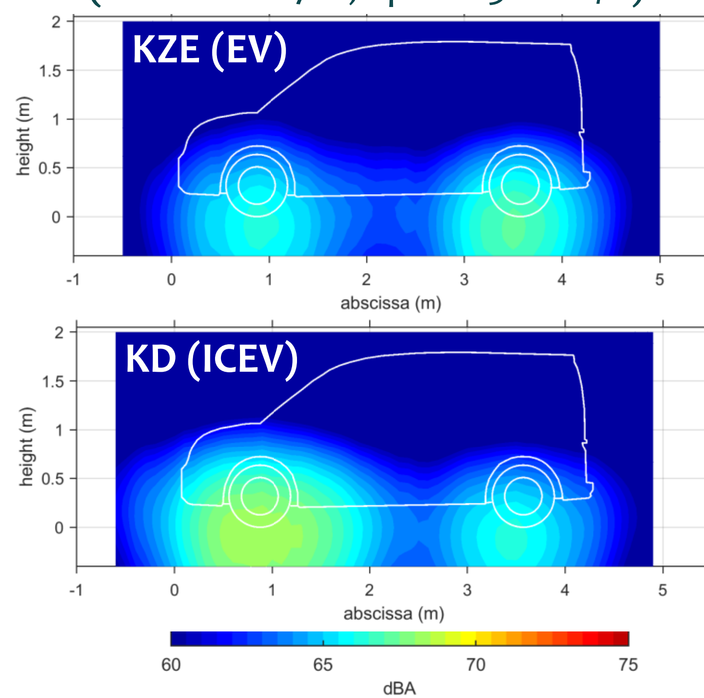
Michelin Energy Saver
195/65 R15

- Comparison of Renault Kangoo ZE (KZE) and diesel (KD) at **constant speed:**
  - Separation of engine and rolling noise components for the ICEV KD
  - Cross-over speed of the two components around 40 km/h for test section N
  - Rolling noise component of KD very close to the overall noise of KZE: **tyre/road noise dominates the noise emission of the electric vehicle at constant speed**

CPB noise level – L_{Amax} (distance 7.5m)

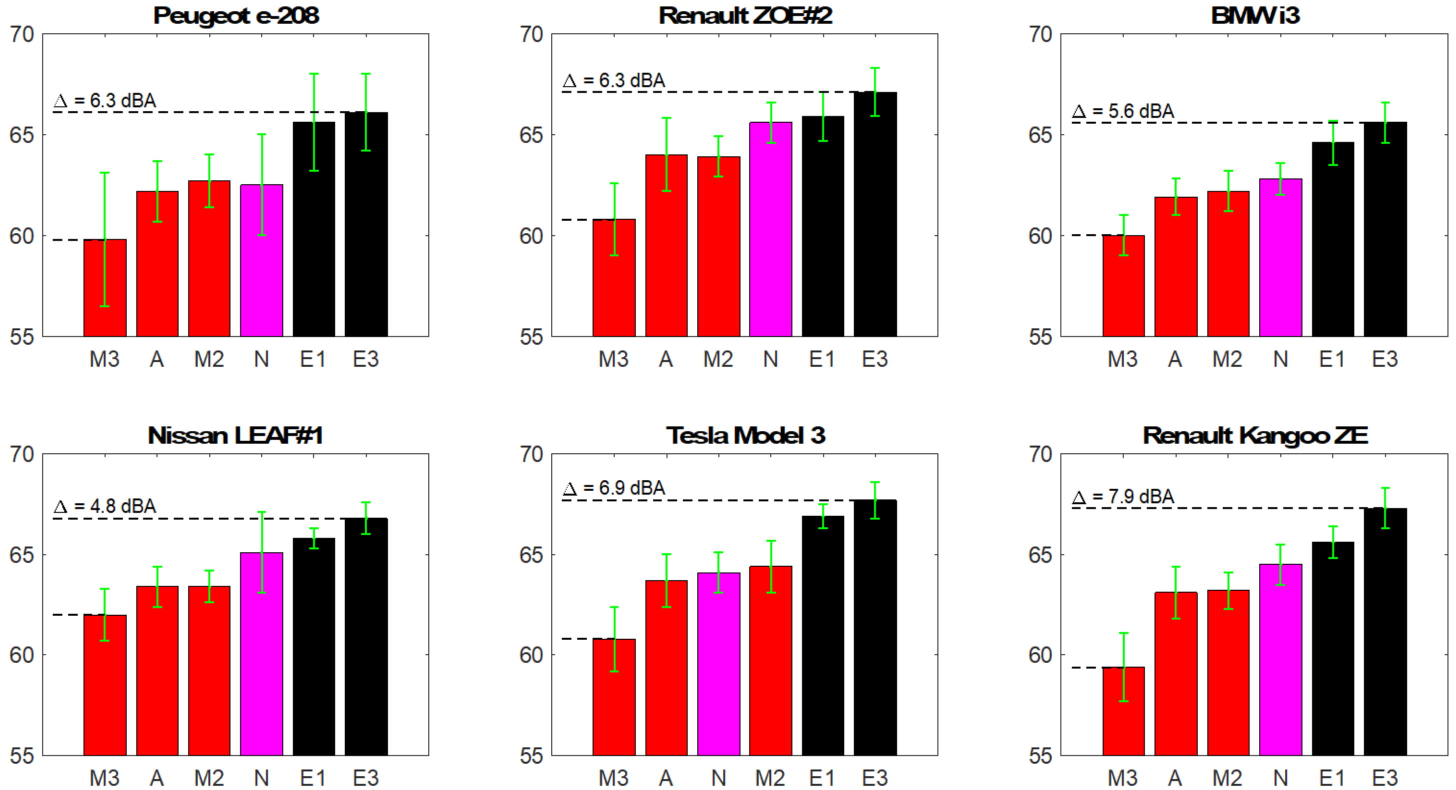


Microphone array noise levels (distance 2.7m, speed 50 km/h)



Action B21 - Acoustical characterization of EVs

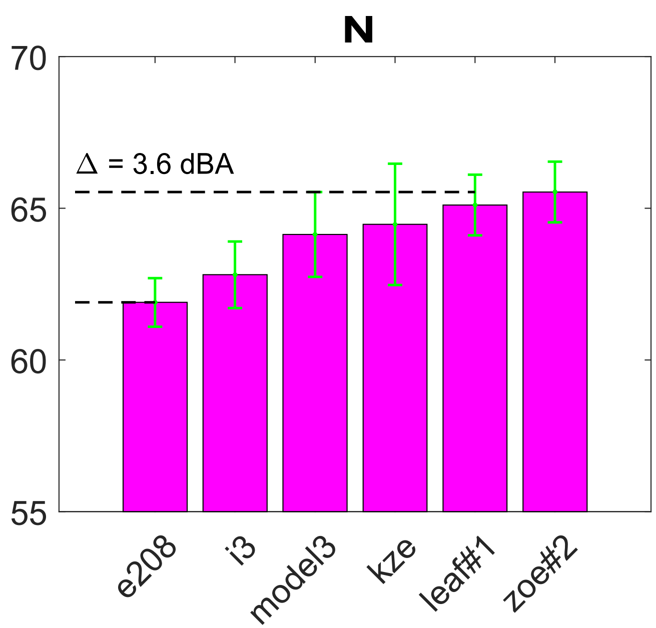
- CPB noise levels at **constant speed 50 km/h** (regressed, corrected at 20°C):
  - Similar classification of road surfaces for different EV models
  - Road surfaces with low macro-texture (M3, N) and/or absorption (A, M2, M3) are the quietest
  - Noise level difference between **4.8 dBA and 7.9 dBA**, depending on EV model

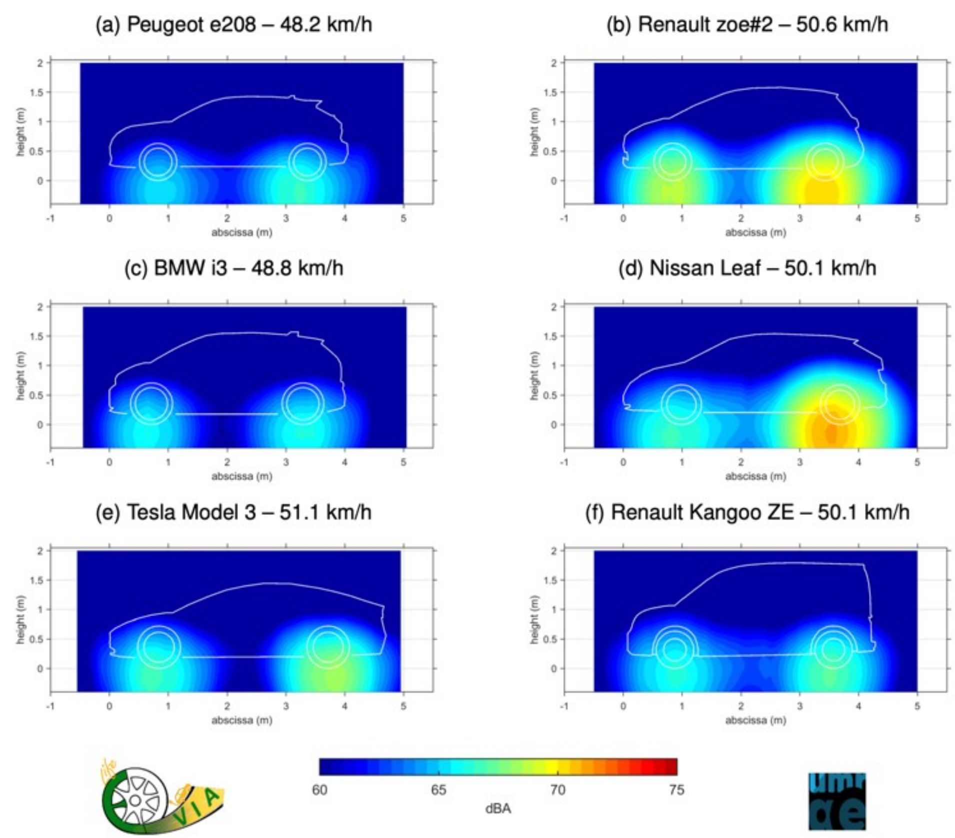


Action B21 - Acoustical characterization of EVs

- CPB and microphone array noise levels at **constant speed 50 km/h** for test section N:
  - Difference of 3.6 dBA between the quietest and the loudest EV
  - No clear relationship between vehicle segment and noise levels
  - Rear wheel louder than front wheel for the loudest EVs (Renault ZOE and Nissan LEAF)

CPB noise level at constant speed 50 km/h
(regressed, corrected at 20°C)

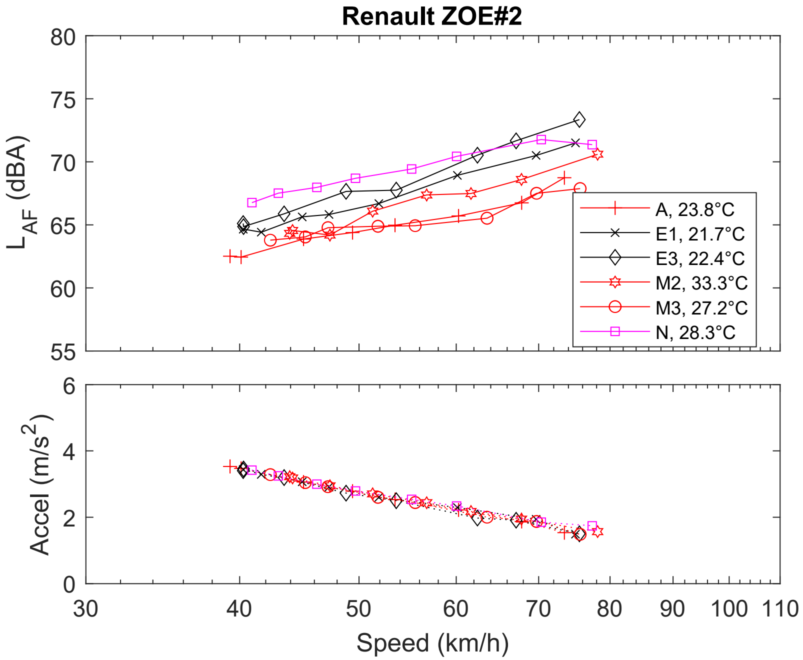




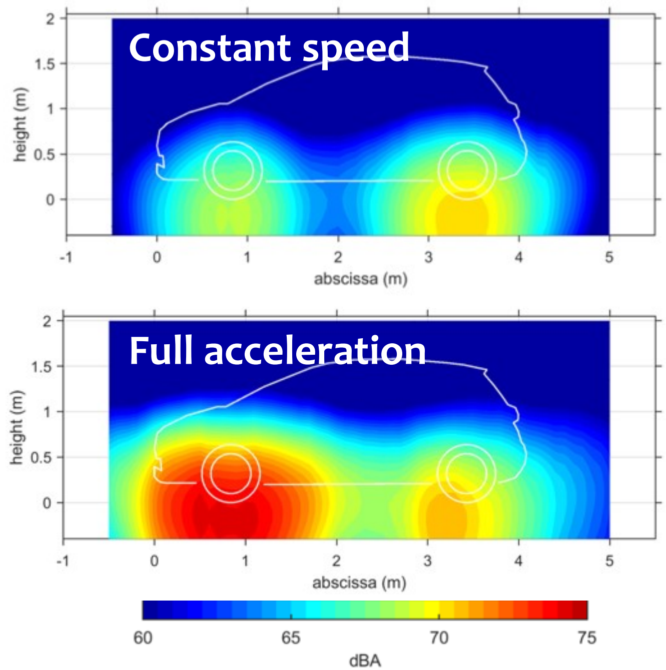
Action B21 - Acoustical characterization of EVs

- CPB and microphone array noise levels in **full acceleration** conditions:
  - Classification of test section similar to passages at constant speed except for N (impervious surface with low macro-texture) becoming among the noisiest, especially at low speeds
  - Noise increase for N in the order 5 dBA in acceleration compared to constant speed
  - Combination of electric motor noise and torque effect increasing rolling noise

CPB noise level
L_{AF} in front of the microphone



Microphone array noise levels at 50 km/h
(Renault ZOE, front wheel driven)



Action B22 – Prototype construction

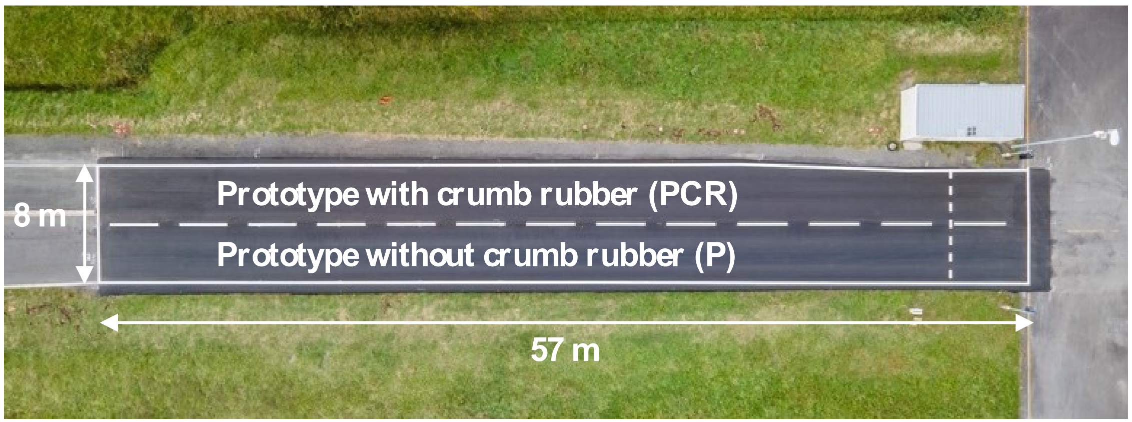
- Design of a low-noise asphalt concrete mix for electric vehicles by UNIRC within action B1, following a holistic optimization
- Two different mixes of very thin asphalt concrete (VTAC) 0/6 have been proposed (with or without crumb rubber)

Fraction (mm)	Mix without crumb rubber	Mix with crumb rubber
4/6.3	7.0%	7.0%
2/4	33.0%	33.0%
0/2	52.0%	51.0%
0/1 (RARX-CR)	-	1.9%
Fines	1.6%	1.0%
Filler bitumen	-	6.1%
Total bitumen	6.4%	6.4%

- Thickness of the compacted mixture: 0.025m
- Underlayer: Dense-Graded Asphalt Concrete 0/10 + as dug gravel

Action B22 – Prototype construction

- Prototype construction in September 2020
- Test site: Université Gustave Eiffel reference test track in Nantes (France)



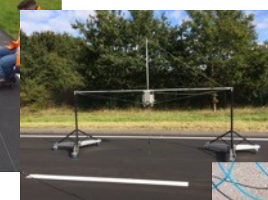
PCR

P

E1 (ref DAC 0/10)

Action B23 – Prototype characterization

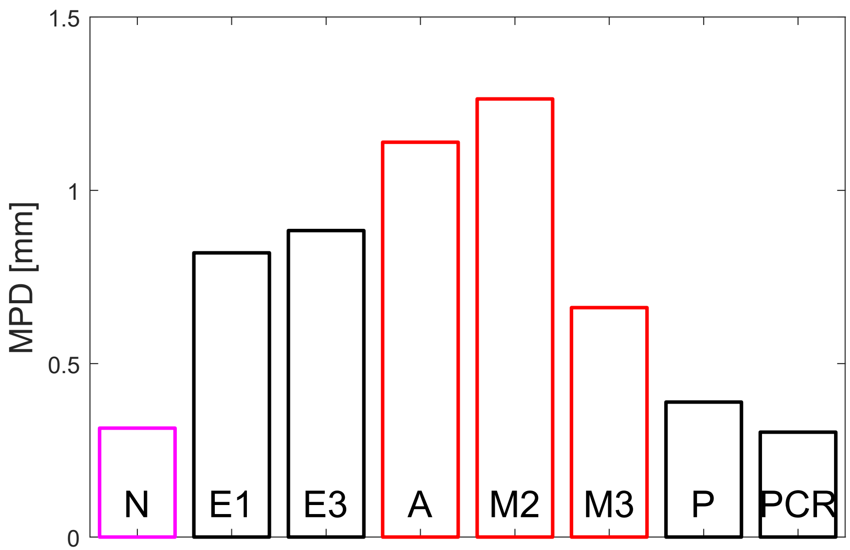
- Measurement campaigns in Sep/Nov 2020 and spring 2021
- CPB and microphone array measurements for a selection of EVs
- Measurement of road surface properties influencing tyre/road noise
  - 3D surface texture
  - Sound absorption - extended surface method
  - Dynamic stiffness
- Other road surface properties related to friction
  - SRT pendula friction tests
  - MPD measurements
  - Dynamical wet friction test
  - Wehner and Schulze tests
- Close-ProXimity (CPX) measurements
- Simultaneous CPB/CPX measurements

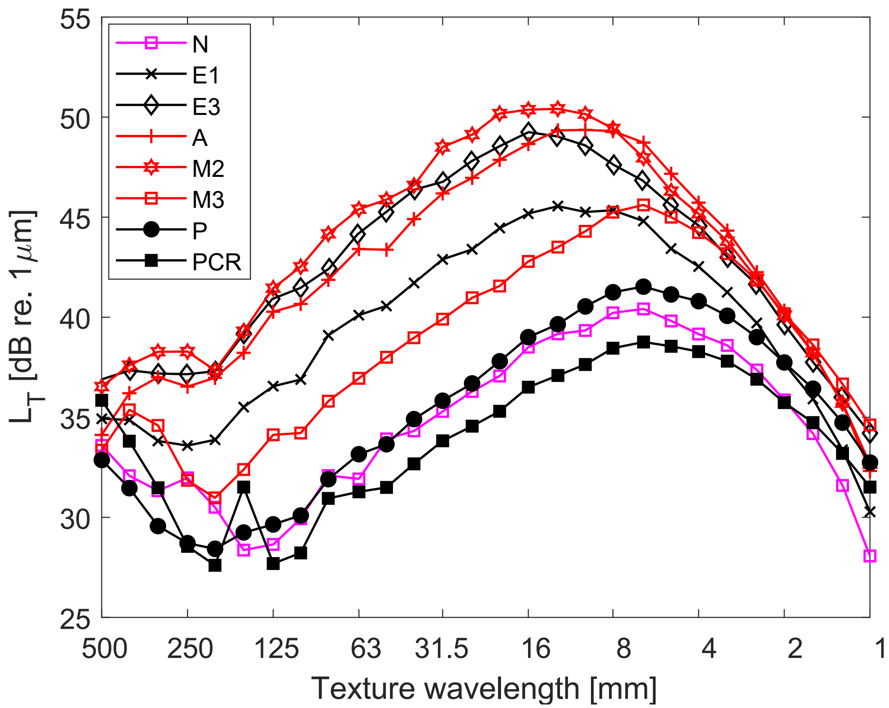

Action B23 – Prototype characterization

- Characterization of road surface texture according to ISO 13473-1 and ISO 13473-4

Mean Profile Depth (MPD)



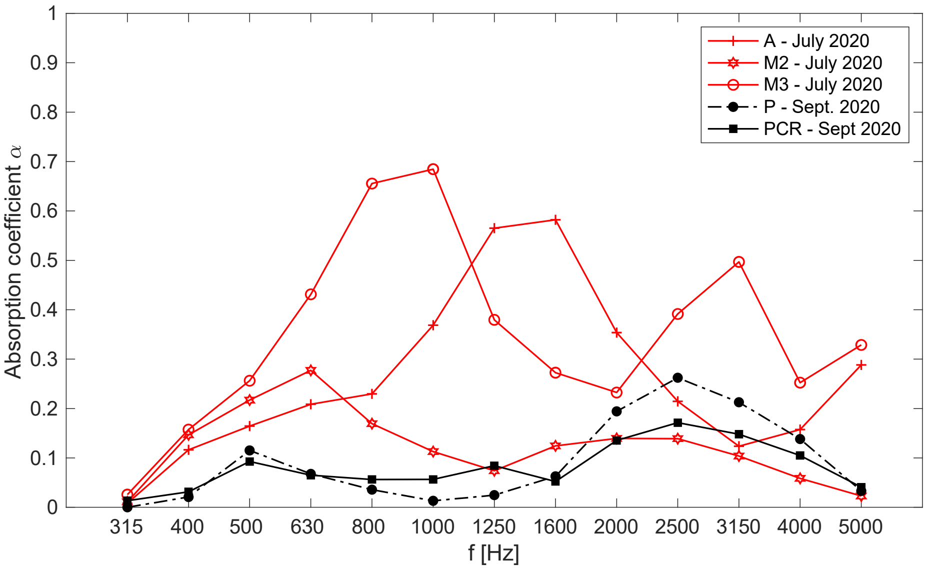
Texture spectra



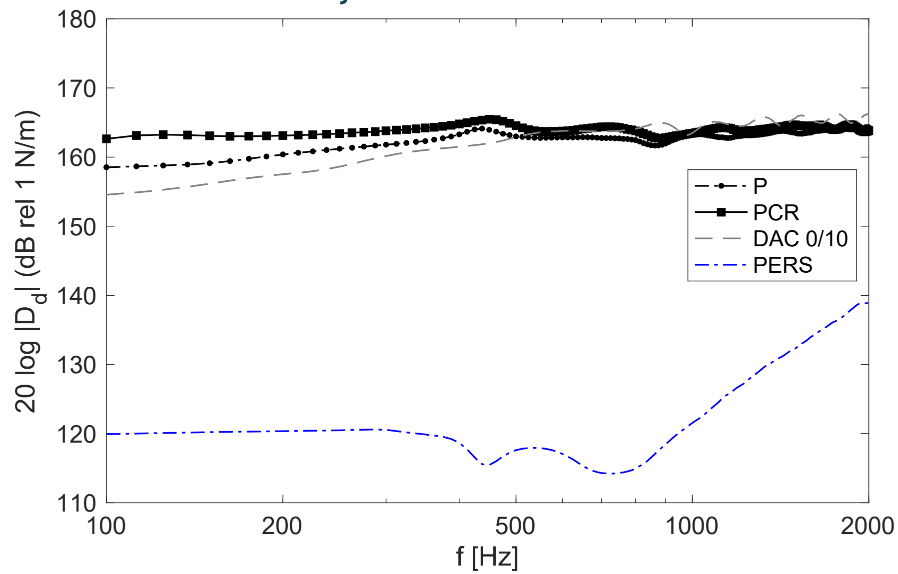
Action B23 – Prototype characterization

- Sound absorption measurement according to ISO 13472-1 – Extended surface method
- Characterization of direct dynamic stiffness with an impedance head and impact hammer

Sound absorption coefficient



Dynamic stiffness

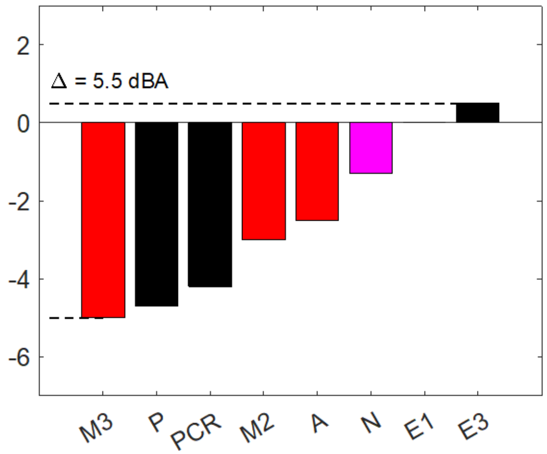


Test section	P	PCR
α_{max}	0.26@2500Hz	0.17@2500Hz

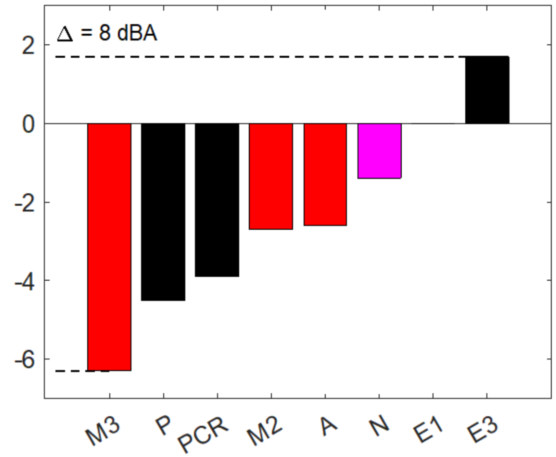
Action B23 – Prototype characterization

- Controlled Pass-By (CPB) noise measurements of EVs at constant speed

Renault ZOE
(Michelin Energy EV 185/65 R15)



Renault KANGOO Z.E.
(Michelin Energy Saver 195/65 R15)



CPB overall noise levels in dBA at constant speed 50 km/h (corrected at 20°C)

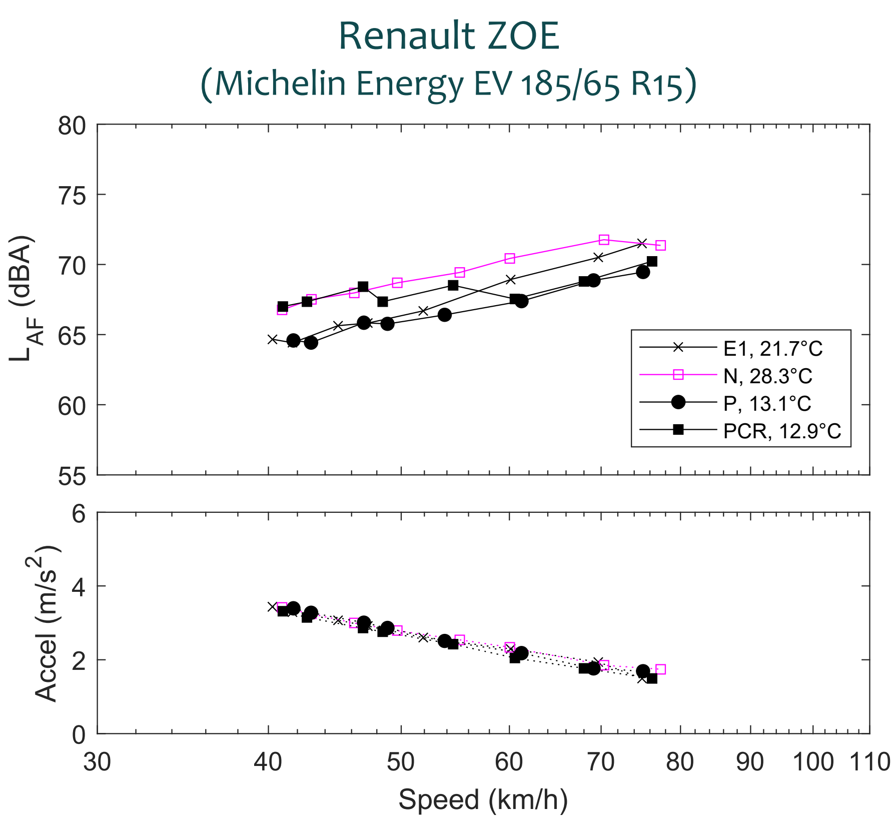
Test section	E1	P	PCR
ZOE	67.3	62.6	63.1
KZE	65.7	61.2	61.8

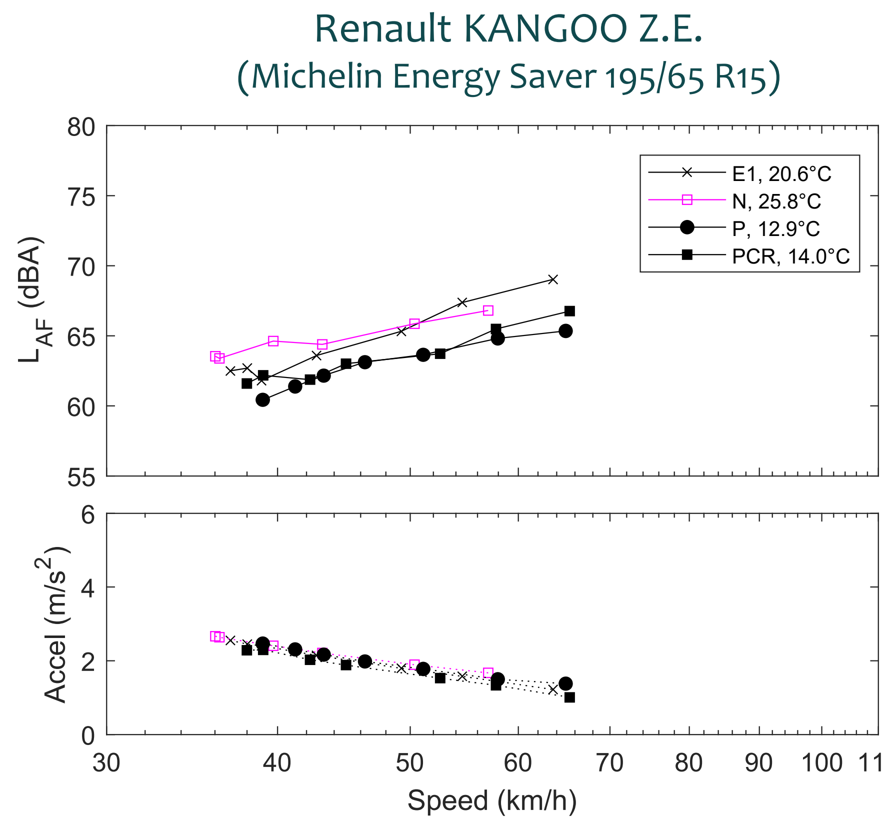
≈ -4.5 dB(A)
≈ -4 dB(A)

Prototype test sections P and PCR are 3.9 dBA to 4.7 dBA quieter than the reference DAC 0/10 E1

Action B23 – Prototype characterization

- CPB noise levels on the prototype in full acceleration conditions

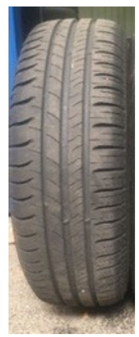




Action B23 – Prototype characterization

- Close-ProXimity (CPX) noise measurements according to ISO 11819-2

Renault Scénic – UNI EIFFEL
(Michelin Energy Saver 195/60 R15)



Mercedes Vito – I-POOL
(SRTT P225/60 R16 - ISO 11819-3)

CPX overall noise levels at 50 km/h (corrected at 20°C)

Test section	E1	P	PCR
Michelin Energy Saver 195/60 R15	86.7 dBA	83.6 dBA	84.0 dBA
SRTT P225/60 R16	90.2 dBA	88.5 dBA	87.8 dBA

P and PCR meet the Core criterion of GPP for a low-noise pavement (L_{CPX} < 90 dBA with SRTT tyres)
PCR close to the more stringent Comprehensive criterion of GPP (L_{CPX} < 87 dBA with SRTT tyres)

Action B24 – Selection of optimized EV tyres

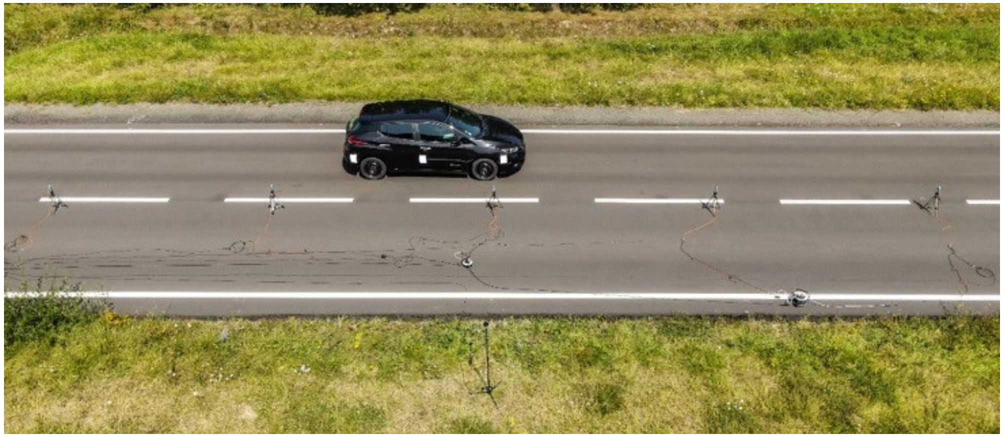
- Technical demonstrators of tyres delivered by CRD to UNI EIFFEL for testing on the prototype test sections P and PCR:
  - 1 set of reference tyres + other tyre sets (variations of tread pattern, construction and compound similar to the reference tyre)
  - Aim: optimizing the balance of exterior noise performance and other tyre performance (e.g. rolling resistance, grip) for EV vehicles

- **Constant speed and accelerated pass-by noise measurements,** according to UNECE R51.03, **on the tyre versions** provided by CRD
  - Pass-by measurements with 1 EV and 1 ICE vehicle fitted with the test tyres

- **CPX measurements with the tyre versions** on the prototypal test sections and further standard road surfaces

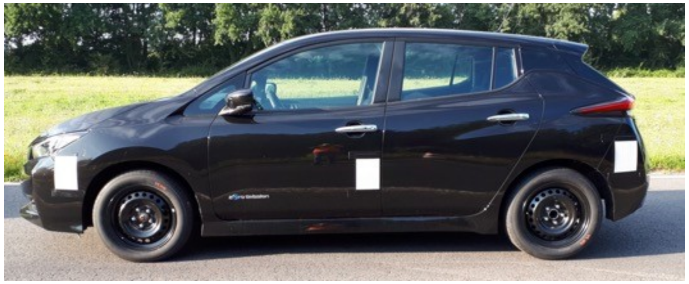
Action B24 – Selection of optimized EV tyres

- 2 pass-by conditions according to UNECE R51.03 procedure:
  - Constant speed 50 km/h
  - Full acceleration with 50 km/h when facing the microphone

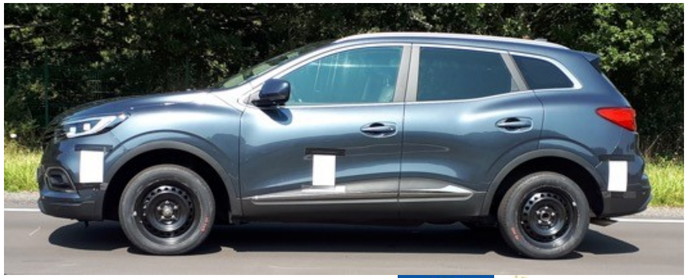


- **6 tyre versions** (205/55 R16) designed by CRD tested on 2 vehicles

Nissan LEAF (EV)

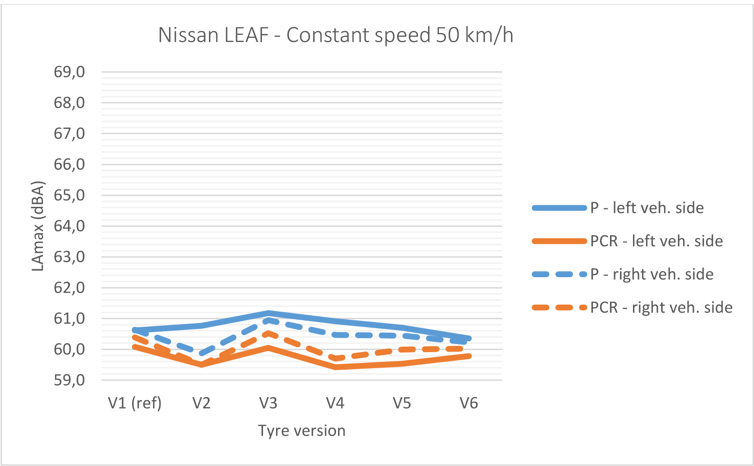


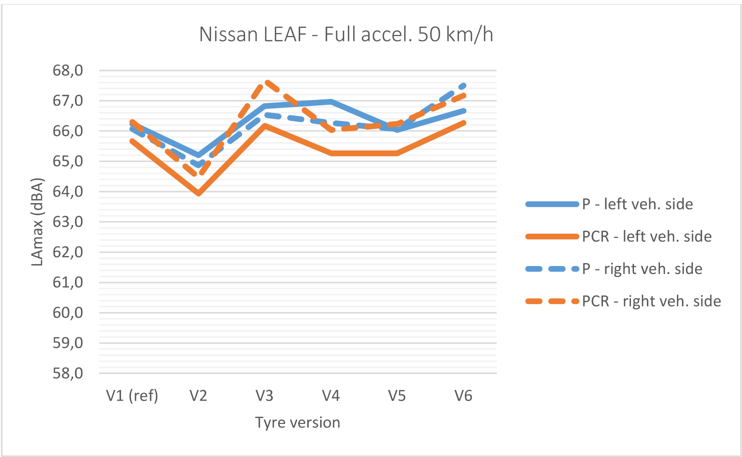
Renault KADJAR (ICEV)

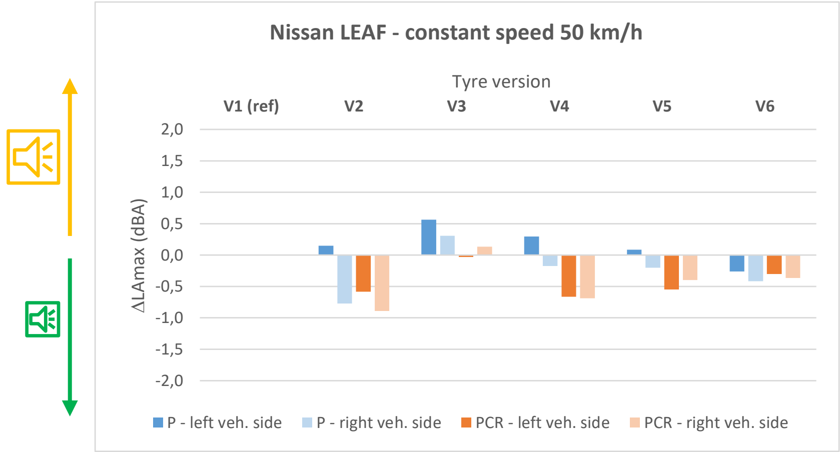


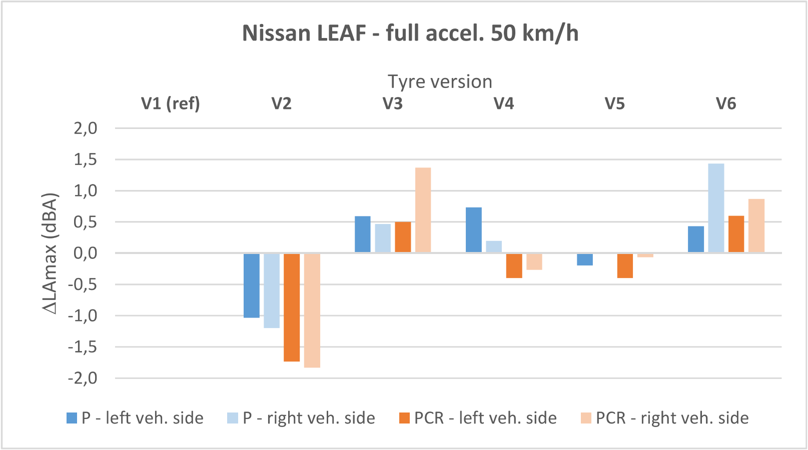
Action B24 – Selection of optimized EV tyres

○ Results for the Nissan LEAF – overall noise levels at 50 km/h









Action B24 – Selection of optimized EV tyres

- Overall CPX noise levels measured at constant speed 50 km/h
  - P and PCR among the quietest road surfaces : noise reduction between 4.2 and 5.8 dBA
  - PCR up to 1.1 dBA quieter than P (depending on tyre version)
  - Noise reduction relative to tyre V1: up to -0.6 dBA on PCR for V2 and -1 dBA on P for V4

V1

Surface	V	L_{rAeq}	ΔL_{rAeq}
M3	50.3±0.5	80.1±0.3	-7.7
PCR	50.0±0.8	82.4±0.4	-5.4
P	50.7±0.8	83.1±0.4	-4.7
A	50.5±0.5	84.5±0.9	-3.3
N	50.3±0.5	85.7±0.6	-2.1
M2	50.6±0.4	86.2±0.9	-1.6
E1	50.6±0.6	87.8±0.7	NA
E3	50.4±0.7	88.3±0.5	+0.5

V2

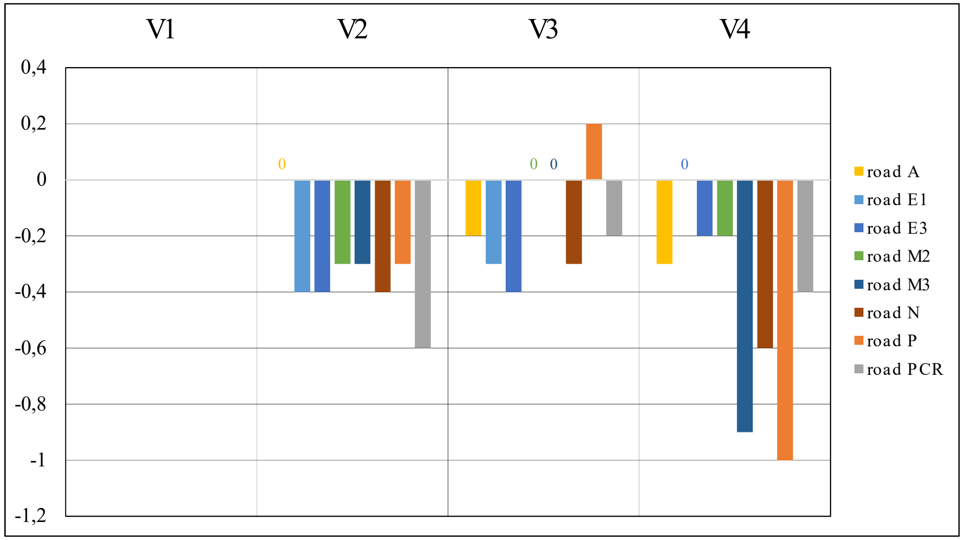
Surface	V	L_{rAeq}	ΔL_{rAeq}
M3	50.4±0.5	79.8±0.5	-7.7
PCR	50.2±0.3	81.8±0.8	-5.6
P	50.7±0.3	82.8±0.5	-4.6
A	50.4±0.8	84.5±1.0	-2.9
N	50.7±0.6	85.3±0.6	-2.1
M2	50.0±0.5	85.9±0.7	-1.5
E1	50.1±0.5	87.4±0.7	NA
E3	50.1±0.4	87.9±0.4	+0.5

V3

Surface	V	L_{rAeq}	ΔL_{rAeq}
M3	50.3±0.4	80.1±0.5	-7.4
PCR	50.3±0.3	82.2±0.5	-5.3
P	51.3±0.7	83.3±0.4	-4.2
A	50.3±0.8	84.3±1.0	-3.2
N	50.5±0.7	85.4±0.6	-2.1
M2	50.6±0.6	86.2±0.8	-1.3
E1	50.0±0.6	87.5±0.7	NA
E3	49.7±0.5	87.9±0.5	+0.4

V4

Surface	V	L_{rAeq}	ΔL_{rAeq}
M3	50.0±0.7	79.2±0.4	-8.6
PCR	50.3±0.8	82.0±0.9	-5.8
P	50.2±1.3	82.1±0.6	-5.7
A	50.4±0.4	84.2±1.0	-3.6
N	50.1±0.5	85.1±0.6	-2.7
M2	50.8±0.7	86.0±0.9	-1.8
E1	50.7±0.6	87.8±0.7	NA
E3	50.2±0.9	88.1±0.6	+0.3



Conclusions of action B2

- **Road surface influence** on CPB noise levels ranges between **4.8 dBA and 7.9 dBA** at constant speed 50 km/h, depending on EV model
- **Tyre/road noise dominates** EV noise emission at constant speed: road surfaces with low macro-texture and/or absorption are the quietest
- In **full acceleration**, increase of electric motor noise and rolling noise (torque effect) leads to an increase of CPB noise levels (e.g. +5 dBA on test section N)
- Implementation of **two VTAC 0/6 prototype test sections** P and PCR: same formulation but PCR contains 1.9% of crumb rubber
- **Surface properties** of P and PCR: low MPD and texture levels, very low acoustical absorption, dynamic stiffness close to conventional asphalts
- CPB noise levels at constant speed 50 km/h: test sections **P and PCR** are **3.9 dBA to 4.7 dBA quieter** than the reference DAC 0/10 test section E1
- **P and PCR** test sections **meet the Core criterion of GPP** for a low-noise pavement (L_{CPX} < 90 dBA with SRTT tyres at 50 km/h)
- **EV tyre optimization**: further noise reduction vs. reference tyre at best in the order of 1 dBA at constant speed and 1.5 dBA in full acceleration

Thank you for your attention

- Contact:
  - julien.cesbron@univ-eiffel.fr
  - marie-agnes.pallas@univ-eiffel.fr

- Link:
  - http://www.umrae.fr/

LIFE18 ENV/IT/000201

LIFE E-VIA

Electric **V**ehicle no**I**se control by **A**ssessment and optimisation of tyre/ road interaction

www.life-evia.eu

LIFE E-VIA PROJECT

Final event 7TH October 2022 – ExpoMove exhibition Firenze

Comune di Firenze

The LIFE E-VIA project in Florence and replication strategy

Arnaldo Melloni – project manager

Gessica Pecchioni, Iacopo Bianchi

Comune di Firenze · Continental The Future in Motion · Université Gustave Eiffel · iPOOL · Università degli Studi Mediterranea di Reggio Calabria · Vie en.ro.se. Ingegneria

With the contribution of the LIFE programme of the European Union

LIFE18 ENV/IT/000201

PILOT AREA IMPLEMENTATION: Paisiello street

1)Two-way road without significative curves

2)High density population in the area

3)Busy road due to traffic toward the city center

4)Close to public offices
(Regional Agency for Environment Protection)

5) Close to the most relevant park in Florence
(Cascine)

6) Close to one of the most important intervention of urban requalification (ex Manifattura Tabacchi) with new dwellings, primary school, fashion school (Polimoda University)

Construction related procedures:

- Technical documents: prepared in September 2020
- New mixture (technical minimum requirements actions B1 e B2). December 2020
- Tender conduction March 2021
- Definitive awarding June 2021
- Implementation July 2021

Work in progress….

Post operam

LIFE18 ENV/IT/000201
LIFE E-VIA PROJECT
7 October 2022 – COMUNE DI FIRENZE

LIFE E-VIA PROJECT:

PILOT CASE IMPLEMENTATION IN THE CITY OF FLORENCE

REPLICATION 1/2

According to the satisfactory results of the post operam test and measures, **three more areas in Florence** have been identified for the replication:

- Laying of the Life E-VIA asphalt along the entire Paisiello Street. **Citizens asked municipality to extend the repaving, since they directly perceived acoustic benefits**.

- Via Bolognese

- Via Senese

A total amount of € 500,000 have been budgeted for these interventions

REPLICATION 2/2

Moreover, the Life E-VIA asphalt was proposed:

1. as remediation action for critical areas identified in the **Noise action plan of the Comune of Inzago (MI); new pavements** and has already been laid and tested with more than satisfactory results in two different road sections.

Tabella 2 – Tratti stradali oggetto del Piano d'Azione

Section 1

Strada Provinciale EX S.S. 11 "Padana Superiore"		
Tratto	Lunghezza [Km]	Tipologia di strada (Codice della Strada, D.L. n. 285 del 1992)
Dal km 168+350 al km 170+850	2,5	F – Strada Locale Cb – extraurbana secondaria

Codifica Scenario di Misura	Periodo di riferimento	L'_{Aeq} [dB(A)]	Attenuazione [dB(A)]
SC01	TR notturno	39,8	5,5
SC02	TR notturno	34,3	
SC03	TR notturno	40,9	4,5
SC04	TR notturno	36,4	

Section 2

Codifica Scenario di Misura	Periodo di riferimento	L'_{Aeq} [dB(A)]	Attenuazione [dB(A)]
SC01 (2021)	TR notturno	34.4	5.3
SC01 (2020)	TR notturno	39.8	

2. as remediation action for critical areas identified in the In the **Noise action plan of Livorno Province main roads (not yet realized)**

LIFE E-VIA

Electric **V**ehicle no**I**se control by **A**ssessment and optimisation of tyre/ road interaction

www.life-evia.eu

Thank you!

Comune di Firenze

Arnaldo Melloni – project manager

Gessica Pecchioni – Iacopo Bianchi

Comune di Firenze | Continental The Future in Motion | Université Gustave Eiffel | iPOOL | Università degli Studi Mediterranea di Reggio Calabria | Vie en.ro.se. Ingegneria

With the contribution of the LIFE programme of the European Union

LIFE18 ENV/IT/000201

E-VIA LIFE 18 ENV/IT/000201

EXPOMOVE

07 OTTOBRE 2022

Valutazione delle emissioni acustiche dei veicoli elettrici e predisposizione di una linea guida

Francesco Bianco - iPOOL S.r.l. (Enteca n. 8360)
francesco.bianco@i-pool.it

E-VIA LIFE 18 ENV/IT/000201

EXPOMOVE

07 OTTOBRE 2022

Evaluation of acoustic emissions of electric vehicles and guideline preparation

Francesco Bianco - iPOOL S.r.l. (Enteca n. 8360)
francesco.bianco@i-pool.it

CONTENT INDEX

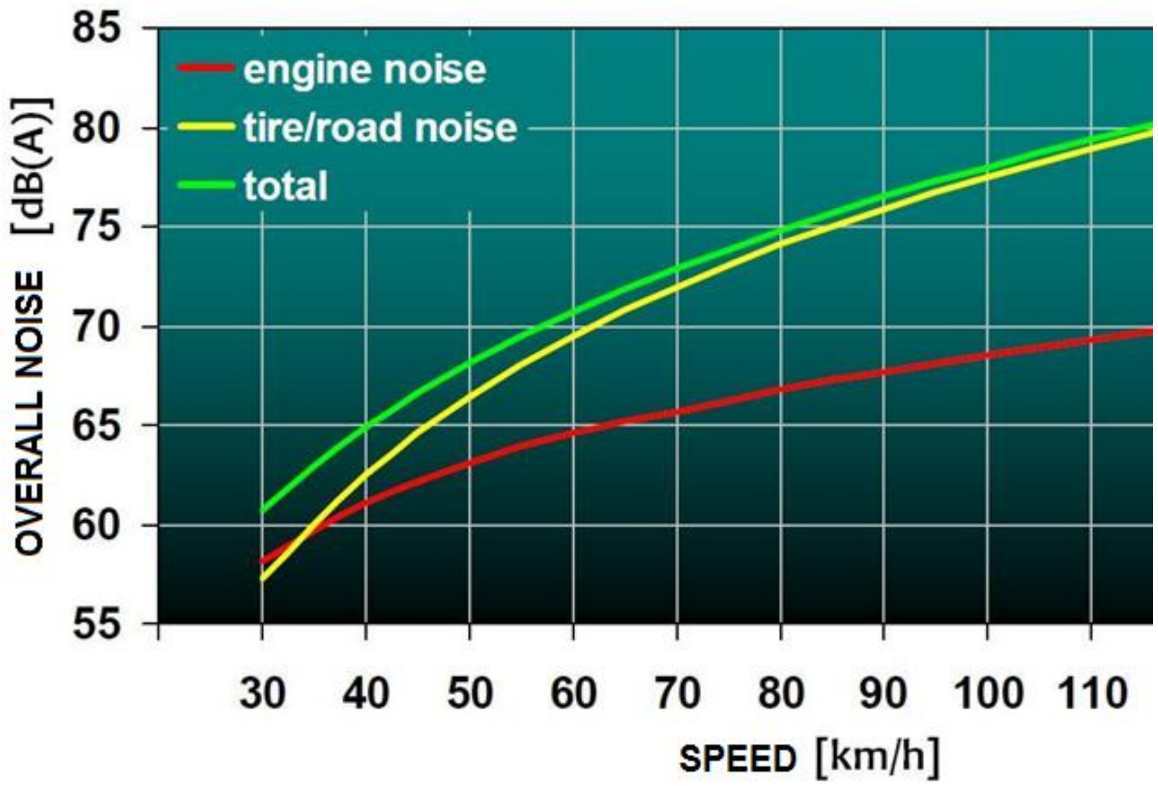
- INTRO – WHEEL/PAVEMENT INTERACTION NOISE
- MEASUREMENTS METHODS
- TEST SITE
- GUIDELINE PREPARATION

INTRODUCTION

INTRO – WHEEL/PAVEMENT INTERACTION NOISE

Noise sources

- power unit and mechanical parts
- tyres rolling
- aerodynamics



INTRODUCTION

INTRO – WHEEL/PAVEMENT INTERACTION NOISE

Tyre vibrations

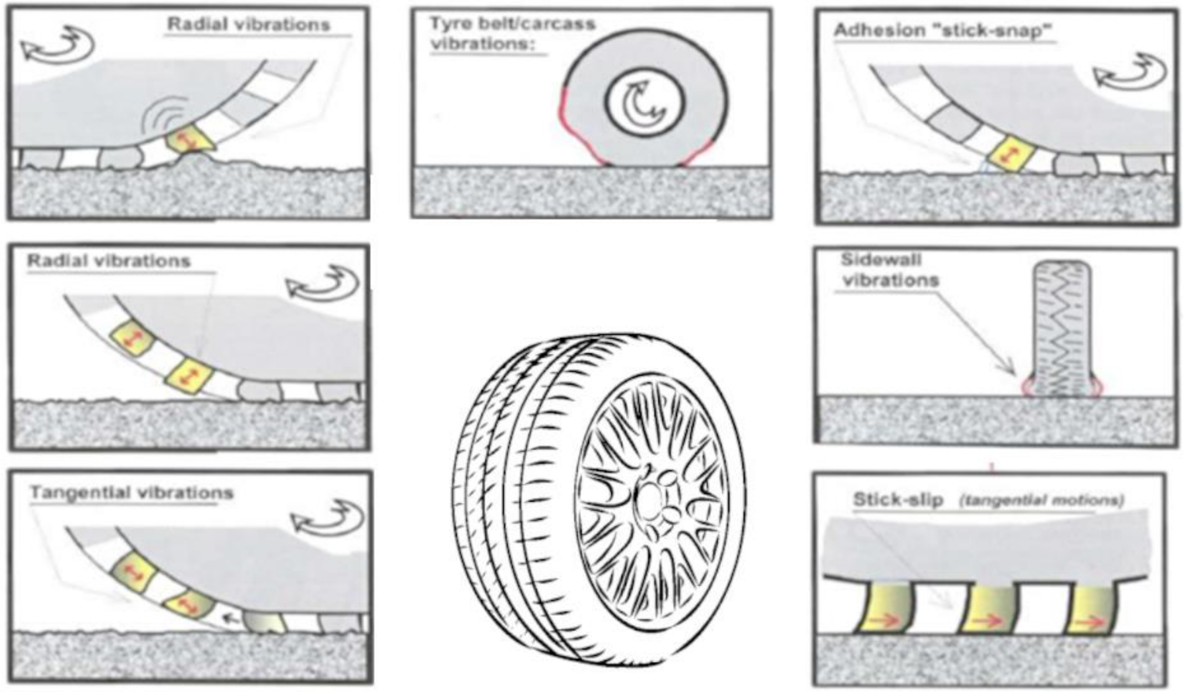
Vibratory phenomena caused by the impact of the tyre against the road surface during its motion.
These affect mainly frequencies **below 1 kHz**

Aerodynamics

Mechanisms around the tyre and near the road surface.
These are source of noise at **medium and high frequencies**.

INTRODUCTION

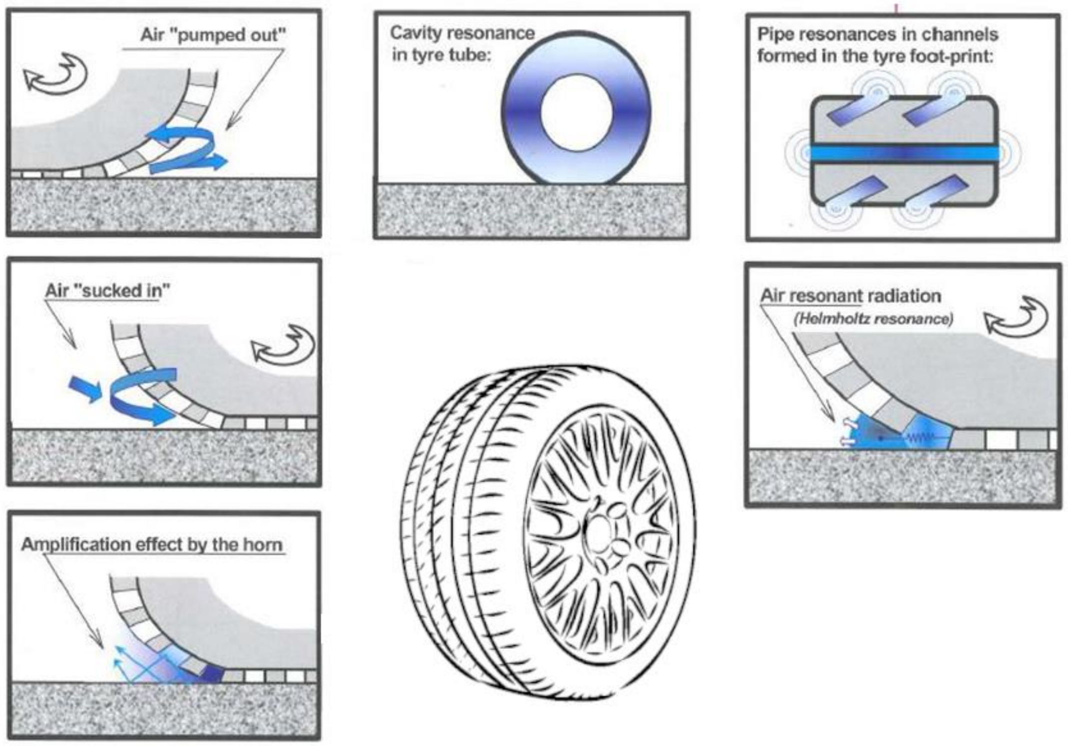
Tyre Vibrations



- Sidewall deformation
- Tread block impact and deformation
- Stick/slip
- Stick/snap

INTRODUCTION

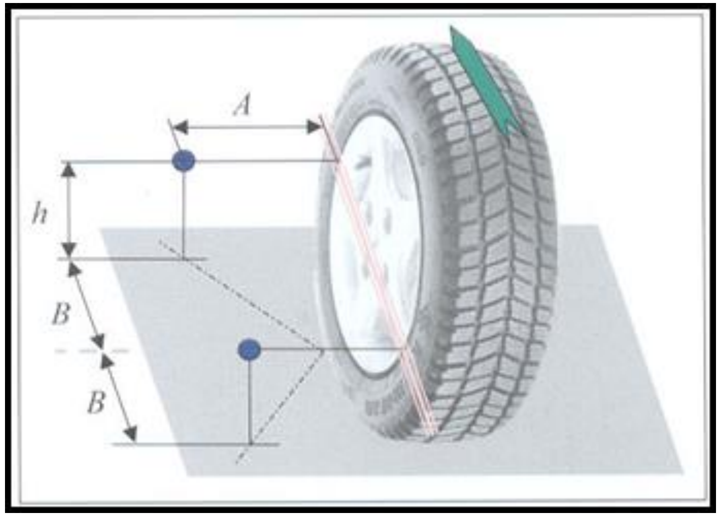
Aerodynamics



- Turbulence
- Air resonant radiation
- Air pumping
- Cavity resonance inside the tyre tube
- Cavity resonance inside the tread pattern

MEASUREMENTS METHODS

CPX - UNI EN ISO 11819-2:2017



Two microphones located close to a reference tyre (SRTT, size 225/60 R16)

Continuous acquisition of sound pressure and position / speed

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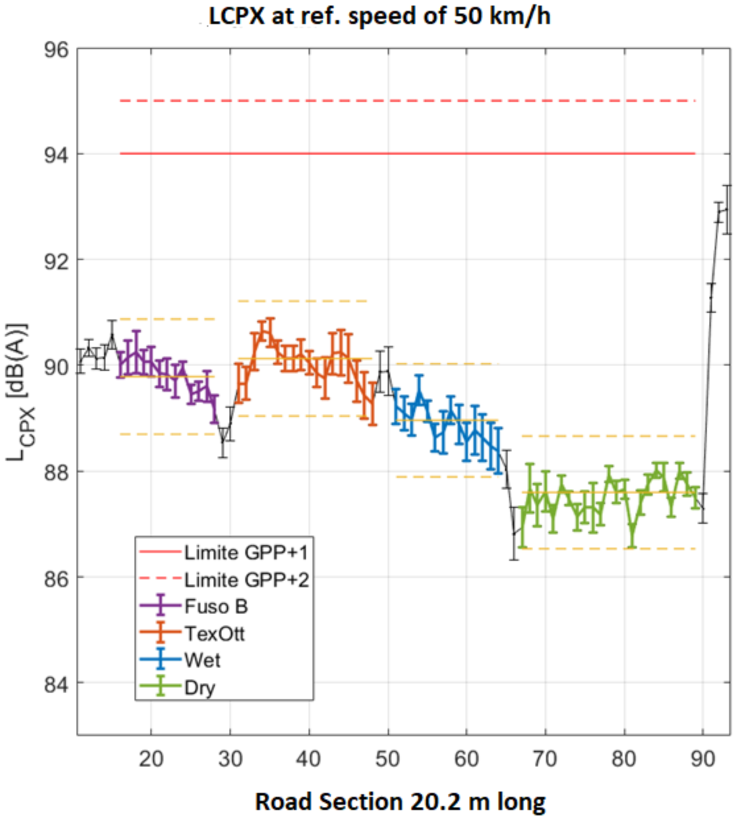
MEASUREMENTS METHODS

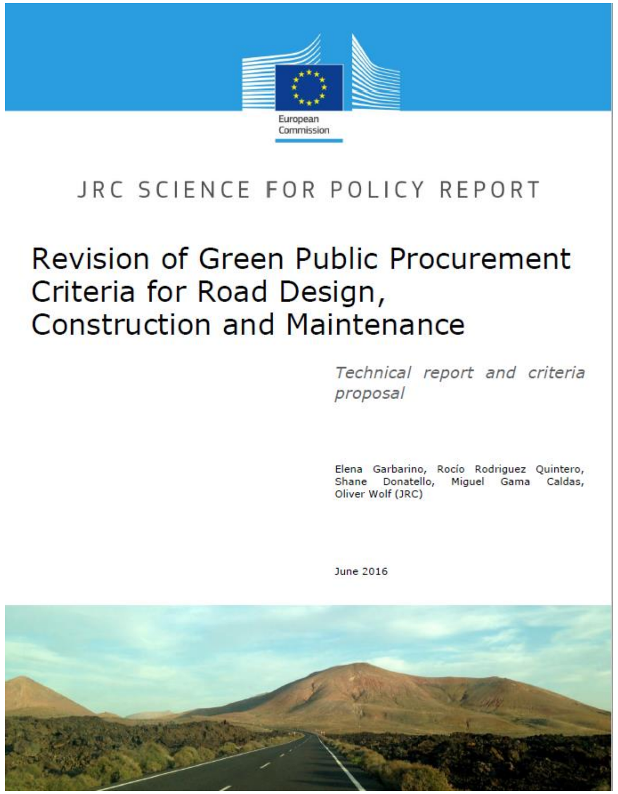
CPX



- ✓ Spatial basis (section) equal to 20 m;
- ✓ "Continuous" evaluation of vehicle / road interaction;
- ✓ Third-octave bands spectrum for each section;
- ✓ Lcpx A-weighted levels from the third-octave bands spectrum for each section;
- ✓ Overall pavement values as spatial average;
- ✓ The Lcpx level is corrected for air temperature and tyre hardness.

MEASUREMENTS METHODS

GPP LIMITS


European Commission
JRC SCIENCE FOR POLICY REPORT
Revision of Green Public Procurement Criteria for Road Design, Construction and Maintenance
Technical report and criteria proposal
Elena Garbarino, Rocío Rodriguez Quintero, Shane Donatello, Miguel Gama Caldas, Oliver Wolf (JRC)
June 2016

EUR 28013
EN June 2016

Conformity (within 4-12 weeks)

- 90 dB(A) @ 50 km/h,
- 95 dB(A) @ 70 km/h,
- 98 dB(A) @ 90 km/h.

Durability (within 5 years)

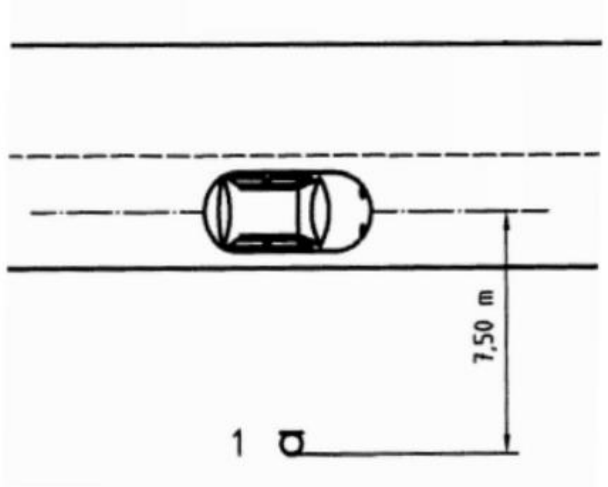
- 93 dB(A) @ 50 km/h
- 98 dB(A) @ 70 km/h
- 101 dB(A) @ 90 km/h.

MEASUREMENTS METHODS

CPB - NF S 31-119-2

Several Pass-by events were recorded in the two CPB points, at several speeds.

SLM were placed according to the figure below



MEASUREMENTS METHODS

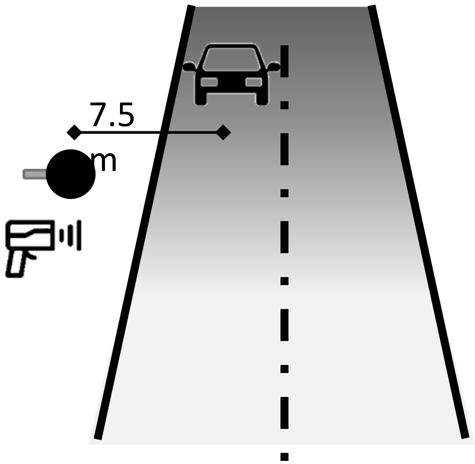
Acquisition
- Calibration file .wav
- Sample files .wav
- Speed
- Temperature

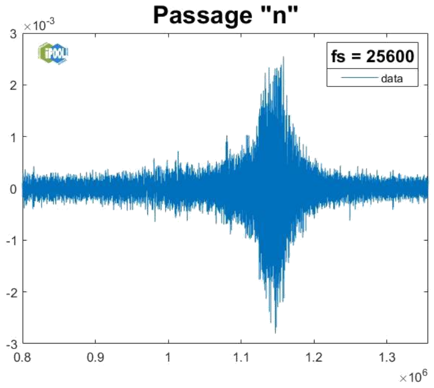
→

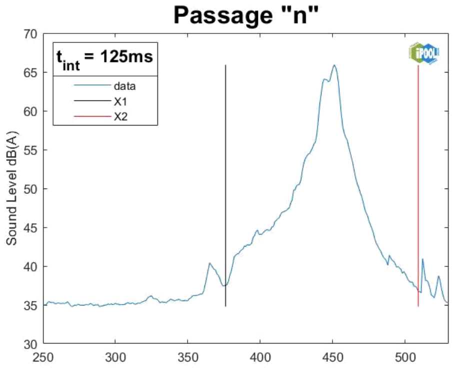
dB(A) Values
- Calibration
- A Filtering
- Fast time integration 125(ms)

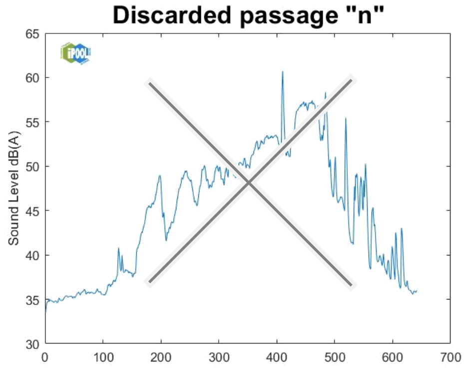
→

Samples inspection
- Listen to every sample
- Trimming signals
- 1/3 Octave banks









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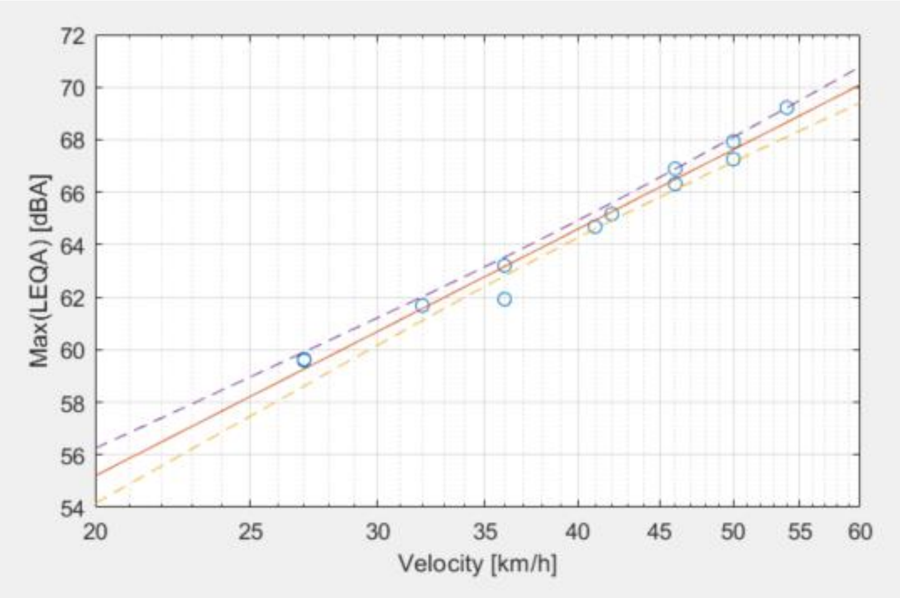
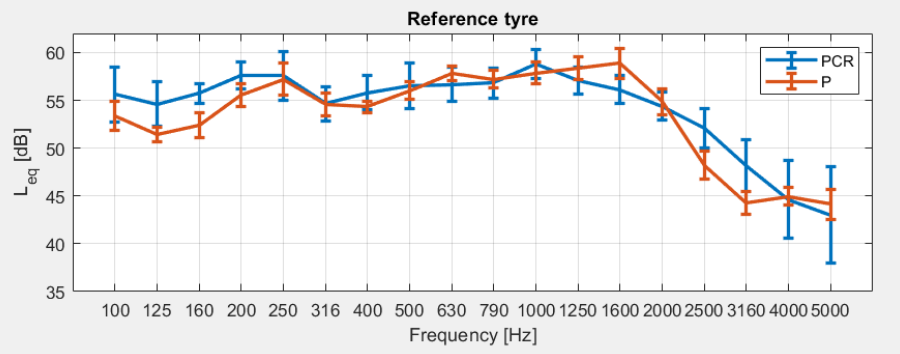
MEASUREMENTS METHODS



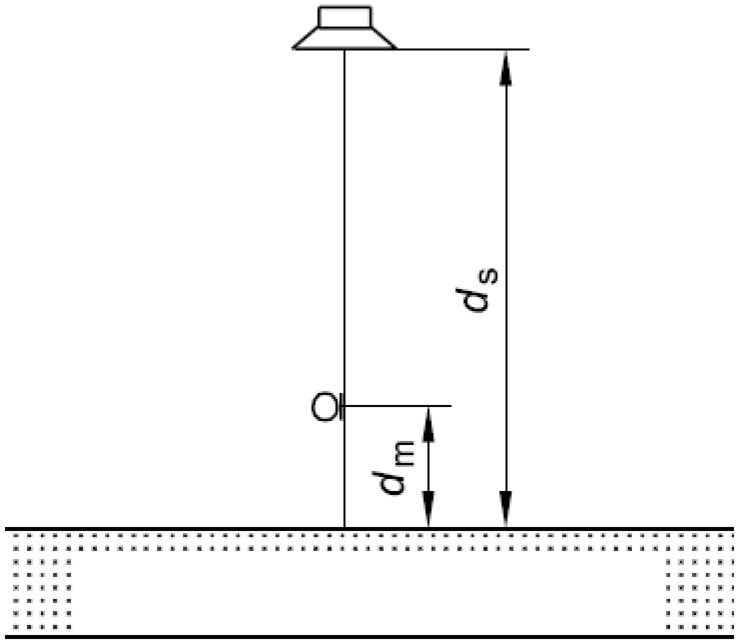


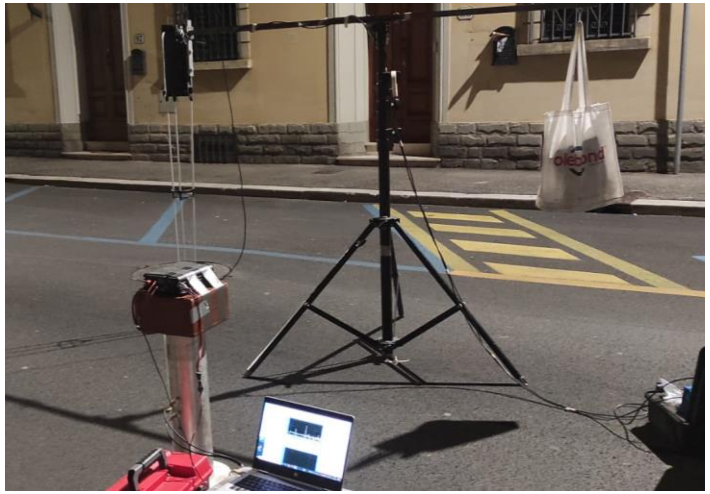
- ✓ "Point" evaluation of vehicle / road interaction;
- ✓ Dependence on local surface condition;
- ✓ Third-octave bands spectrum between 100 Hz and 5 kHz;

MEASUREMENTS METHODS

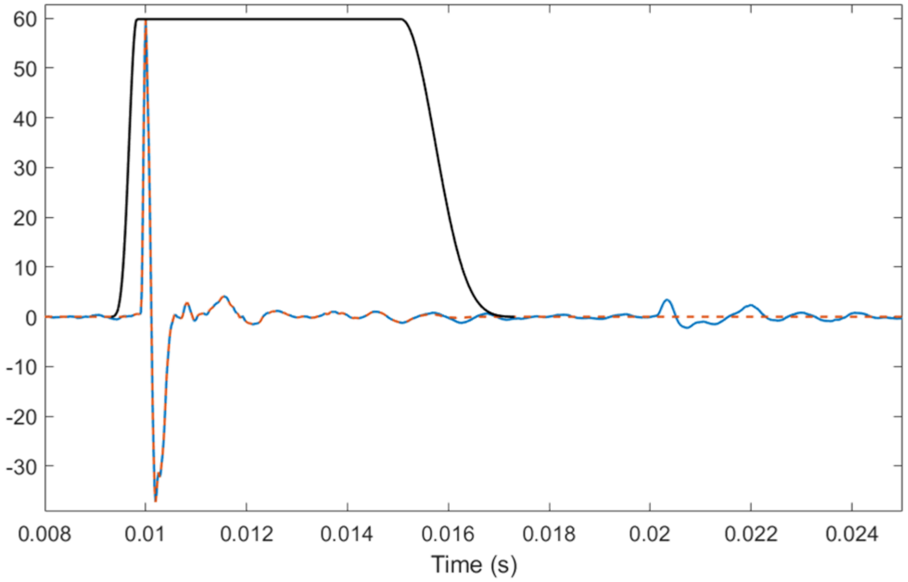
EXTENDED SURFACE - ISO 13472-1 (2022)

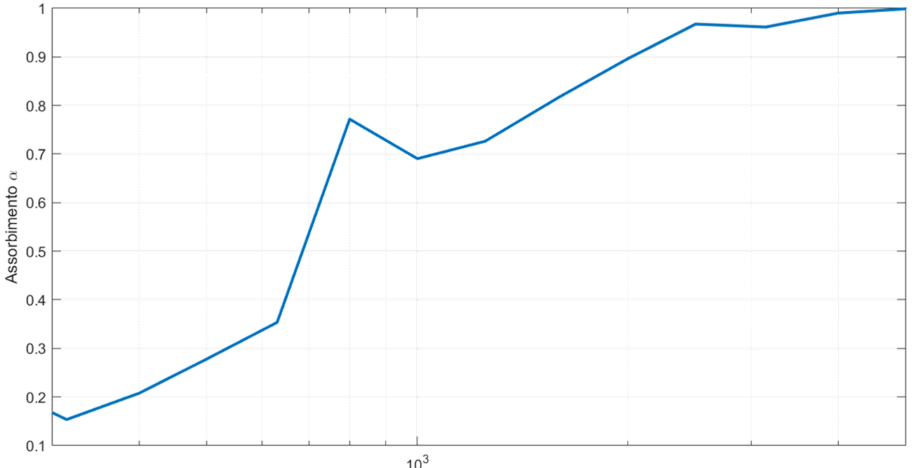
Single microphone, time subtraction technique (no calibration needed).





MEASUREMENTS METHODS

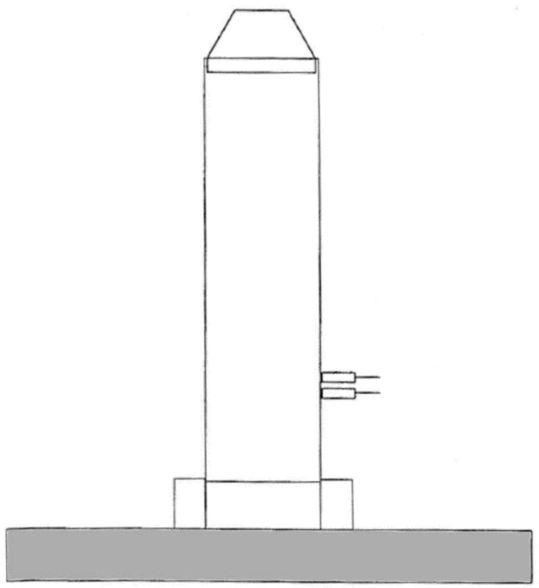


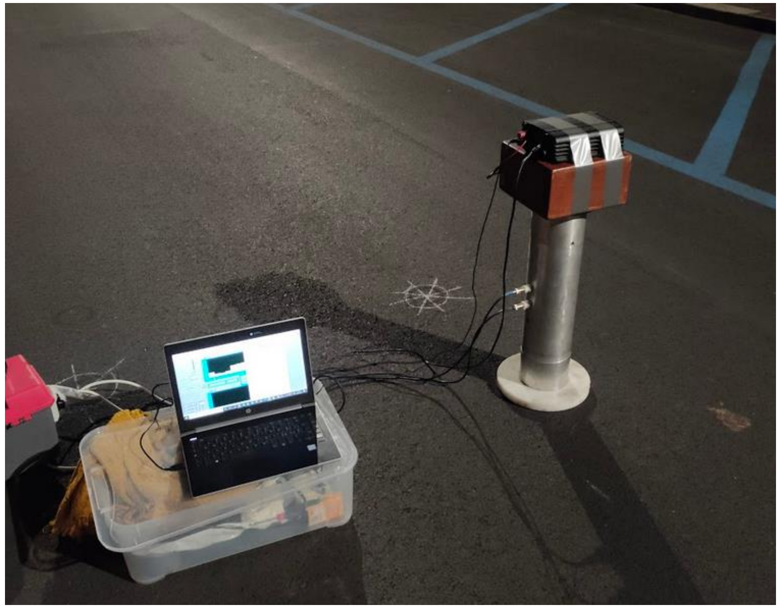


- ✓ High snr for MLS and sine sweep signals;
- ✓ Surface evaluation: sampled area 1.34m;
- ✓ Third-octave bands spectrum between 250 Hz and 4 kHz;
- ✓ Imperfect subtraction leads to small errors;
- ✓ Technique uncertainty 0.05: low "snr" for highly reflective pavements;
- ✓ Specific for absorptive pavements.

MEASUREMENTS METHODS

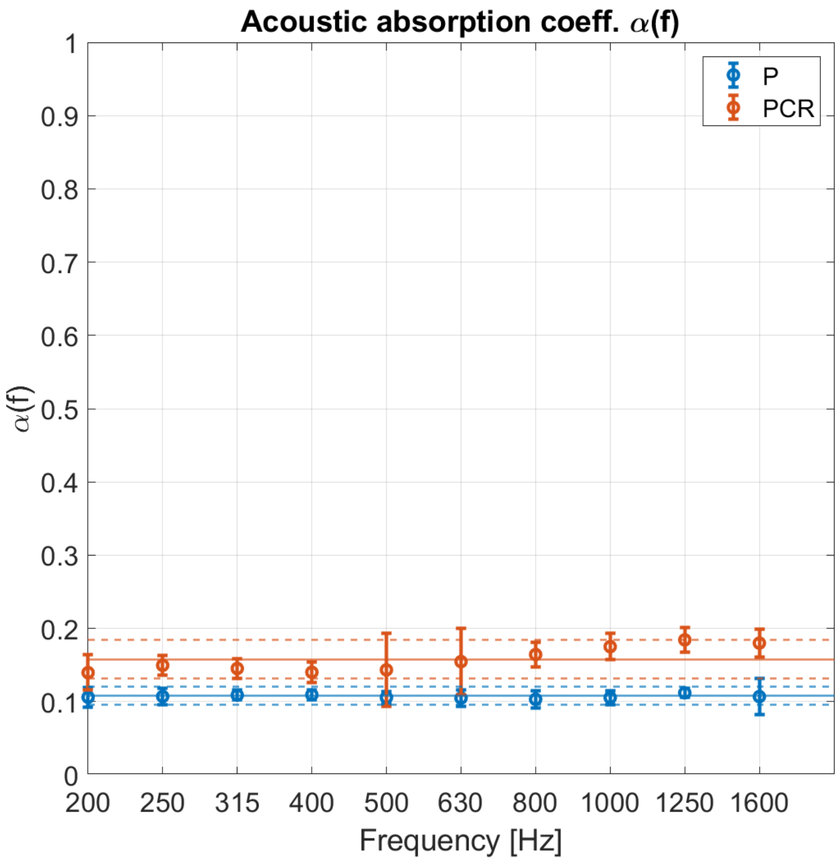
IMPEDANCE / KUNDT TUBE ON SITE - ISO 13472-2 (2010)





Double microphone, FRF calculation technique (no calibration needed).

MEASUREMENTS METHODS



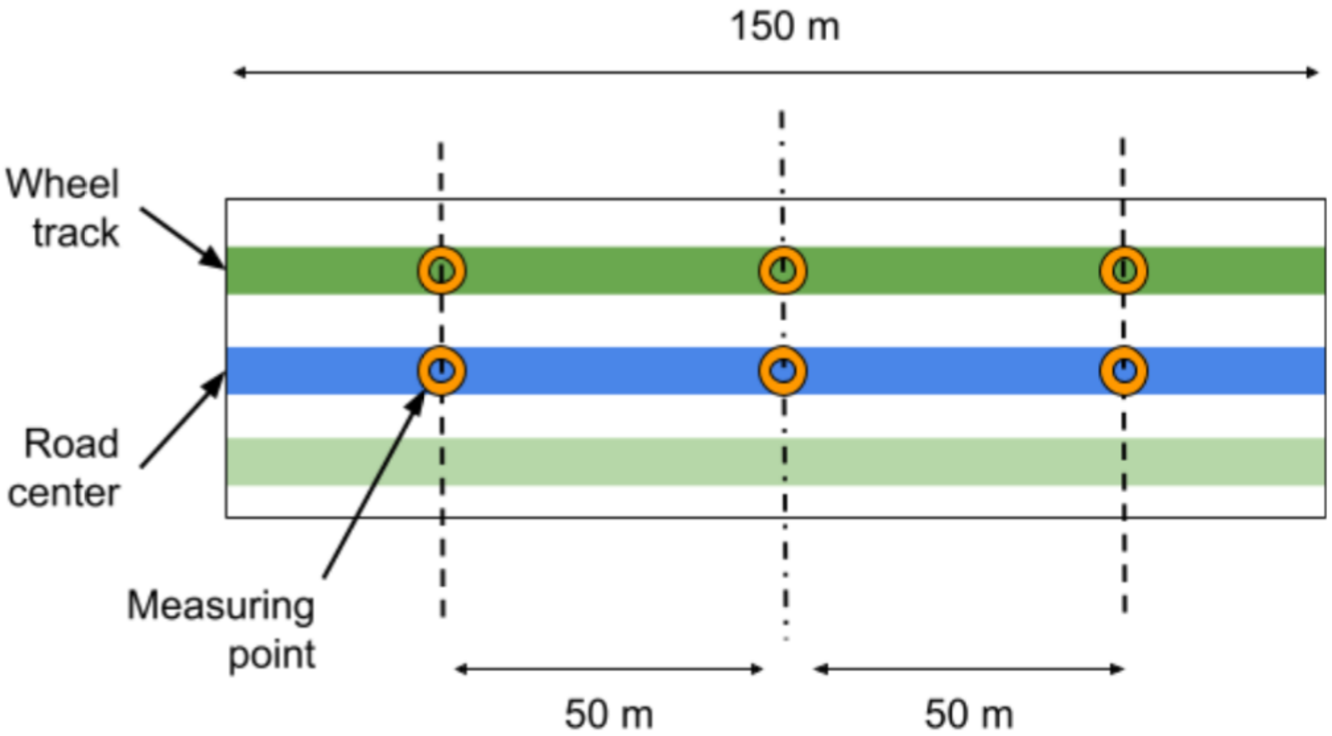
- ✓ "Point" evaluation;
- ✓ Third-octave bands spectrum between 250 Hz and 1.6 kHz;
- ✓ Low frequency overestimation in presence of leaks;
- ✓ Unreliable for absorptions over 0.15: lateral energy losses;
- ✓ Specific for reflective pavements.

TEST SITE

TEST SITE – VIA PAISIELLO (FI)

TEST SITE

MEASUREMENT PLAN *(Via Paisiello, Florence)*



Extended Surface(ISO 13472-1)
Impedance Tube (ISO 13472-2)

TEST SITE

- 3D texture and dynamic stiffness static measurements
- Performed in October 2021 (during the night)

TEST SITE

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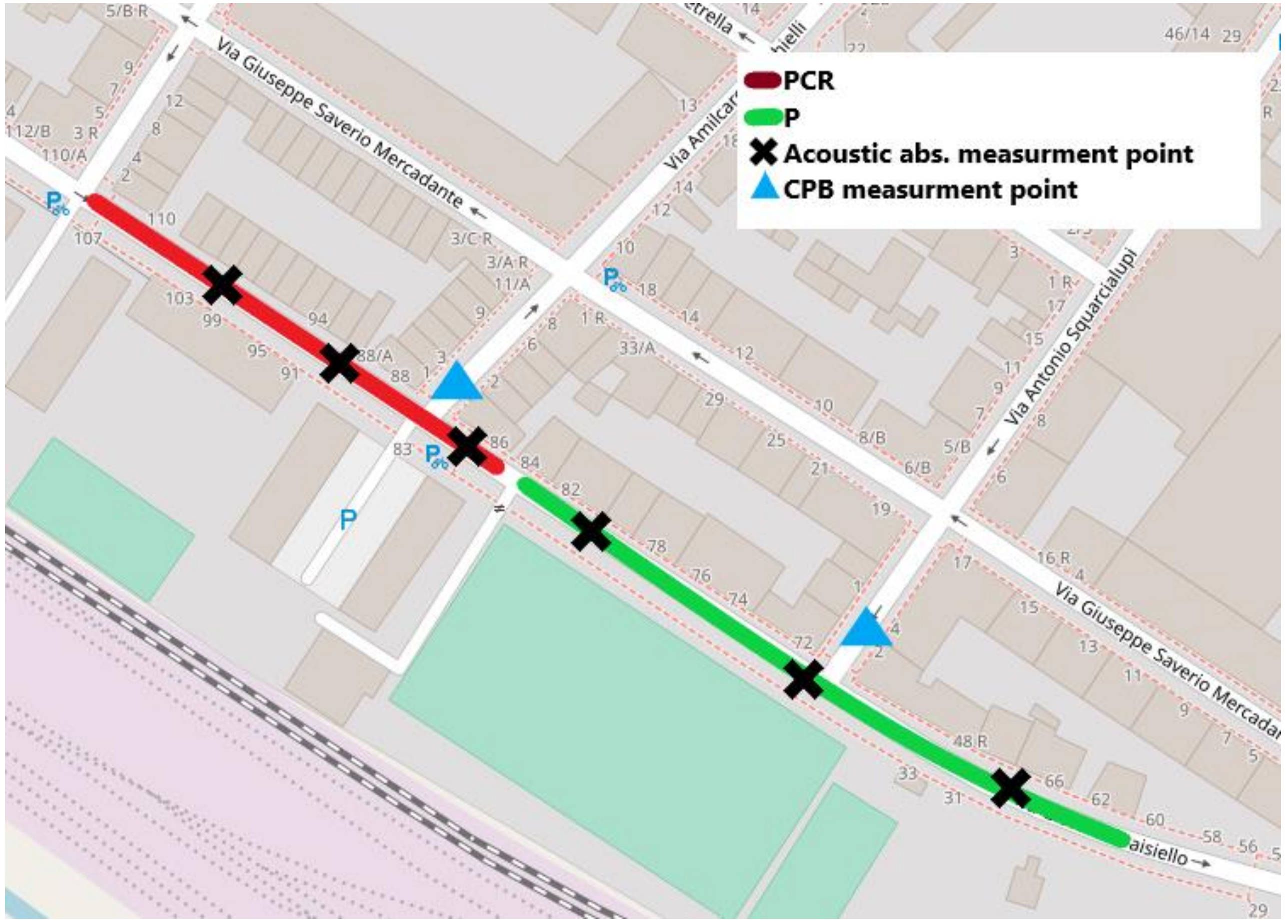
MEASUREMENT PLAN *(Via Paisiello, Florence)*



For each acoustic absorption measurement point both the wheel track and center lane are evaluated.

CPB is measured in two position, 7.5 m (1.2 m height) and 15 m (2.4 m height) from the center lane.

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RESULTS

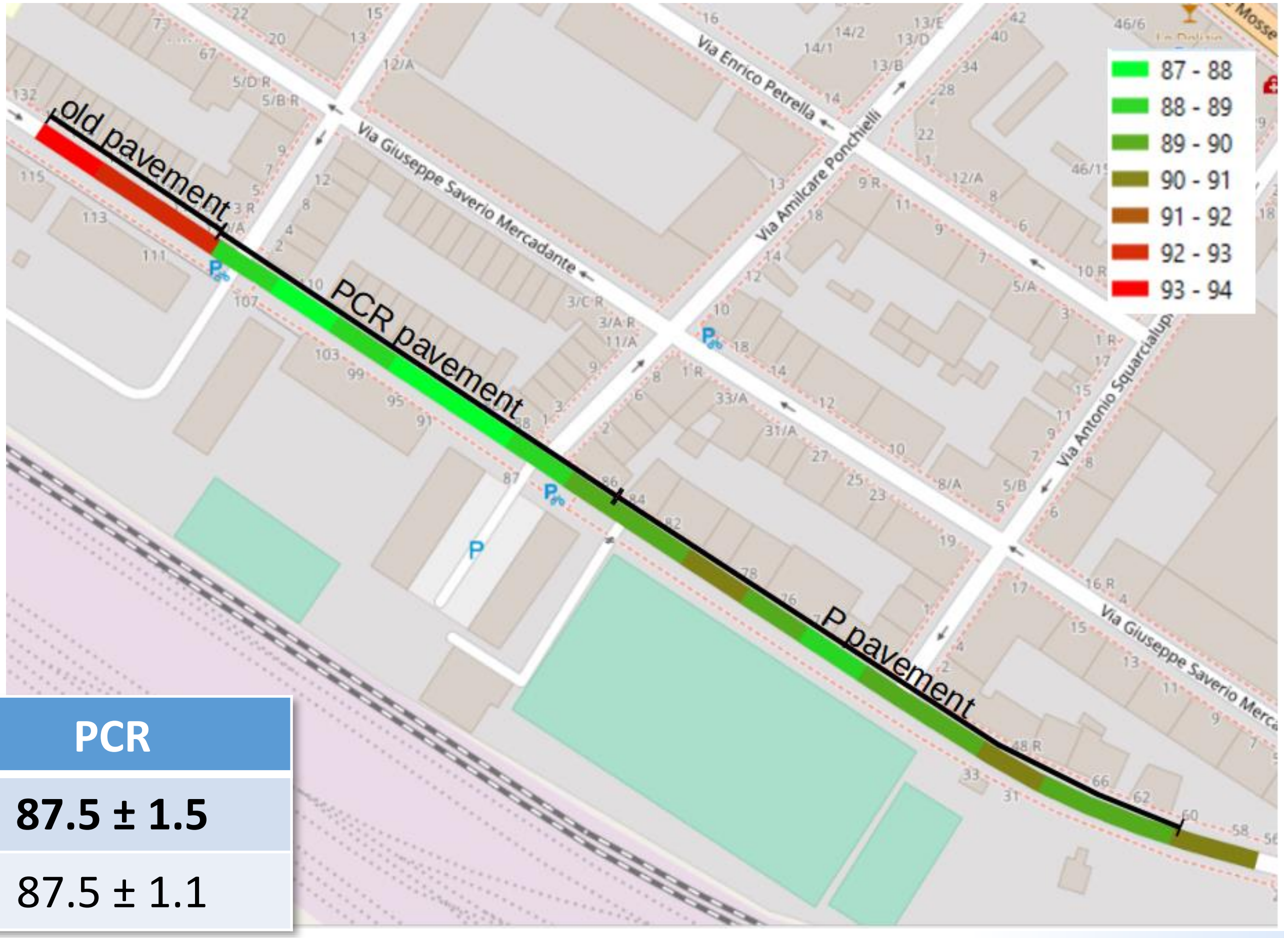
4 measurement sessions:

- October 2021
- February 2022
- July 2022
- October 2022 (yesterday…)

TEST SITE

CPX

First measurement session (October 2021) and confrontation with Nantes prototype pavements

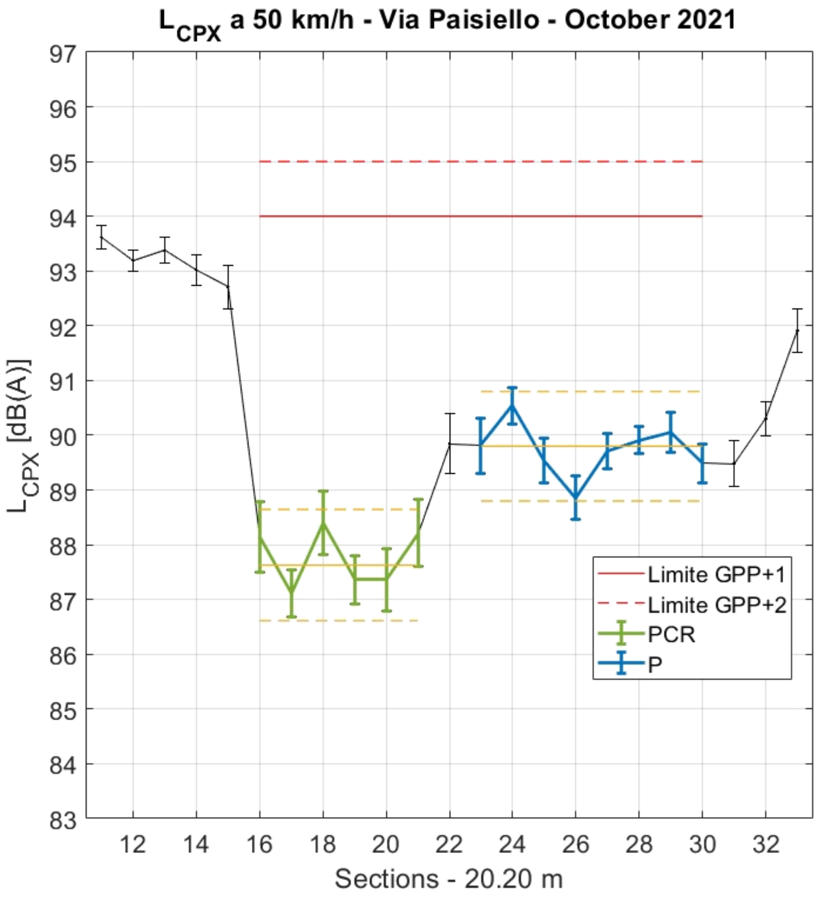


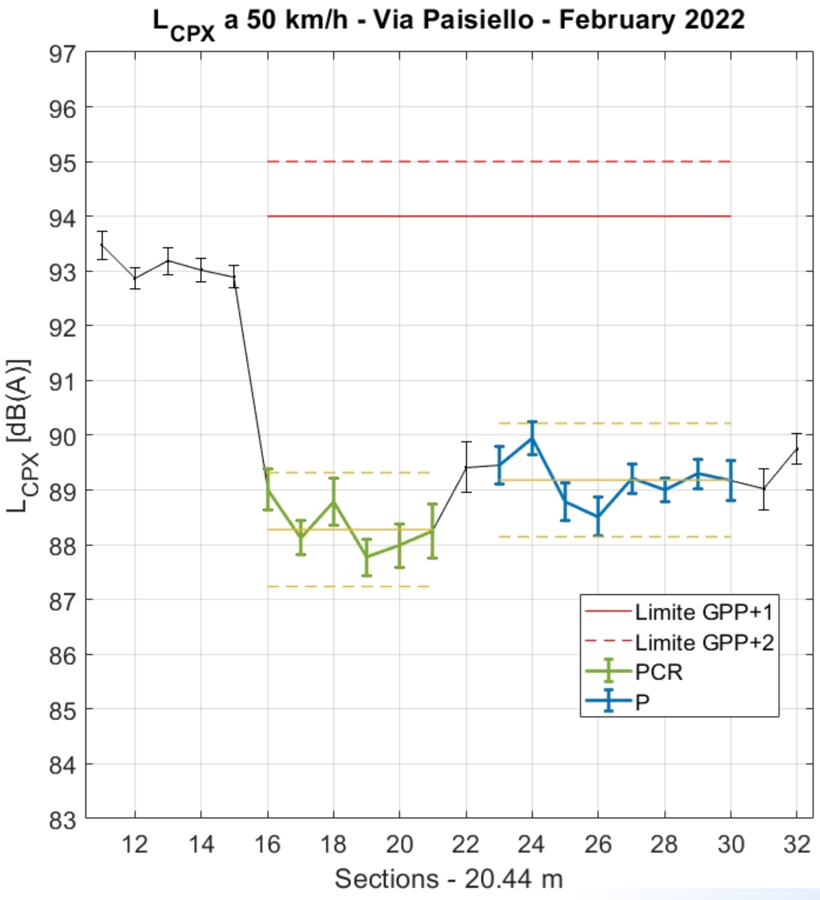
Lcpx @ 50km/h [dBA]

	P	PCR
Firenze	**89.6 ± 1.1**	**87.5 ± 1.5**
Nantes	88.1 ± 0.9	87.5 ± 1.1

TEST SITE

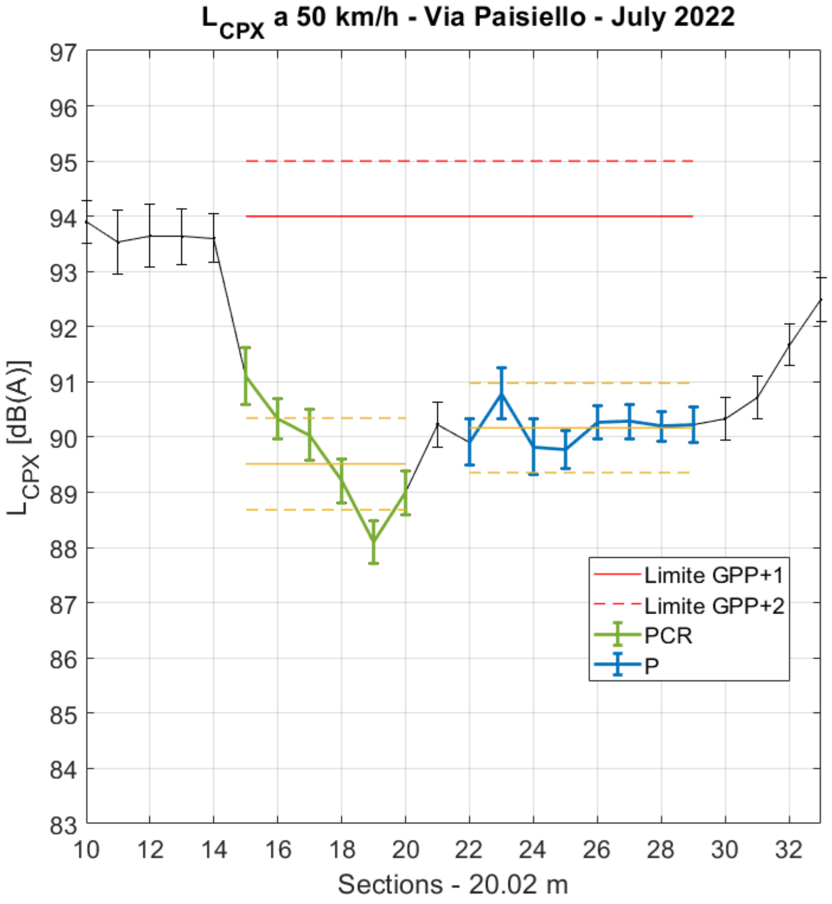
CPX

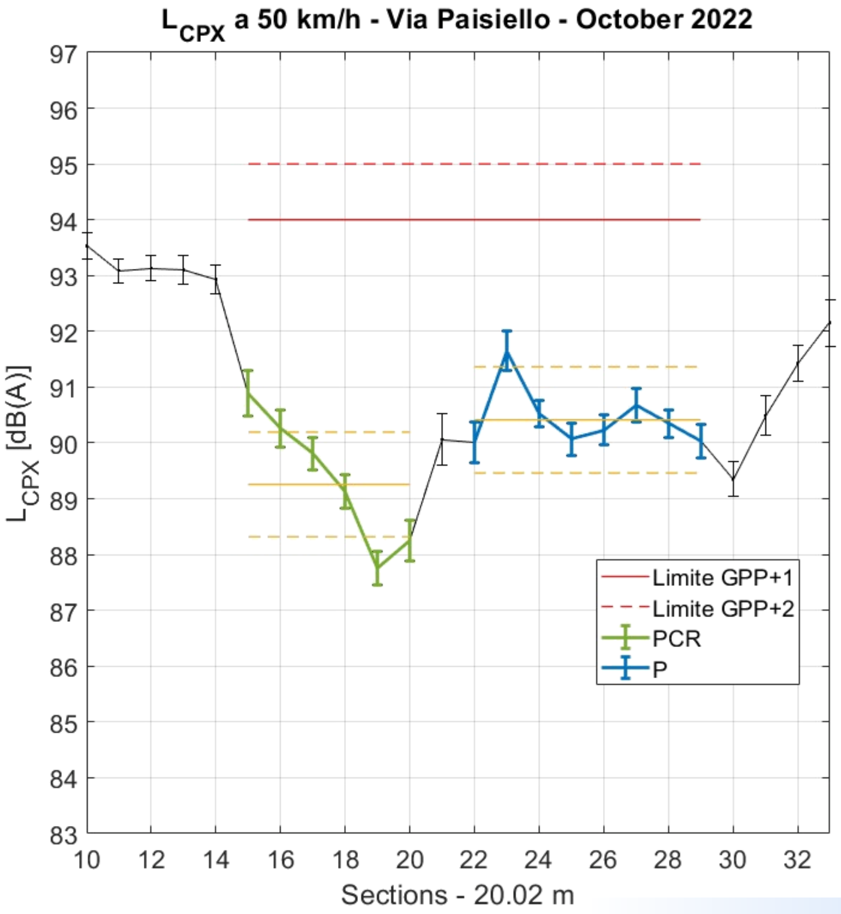




TEST SITE

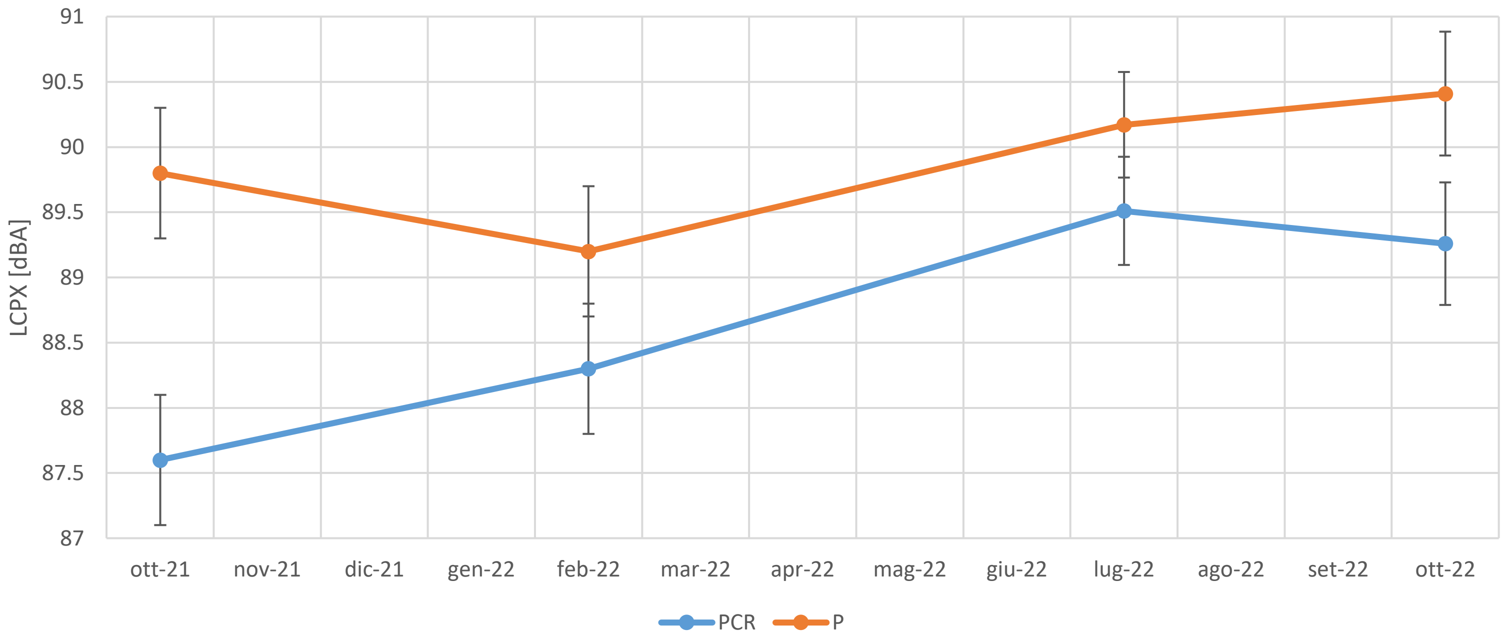
CPX





TEST SITE

CPX



	Oct 21	Feb 22	Jul 22	Oct 22
PCR	87.6 ± 1.0	88.3 ± 1.0	89.5 ± 0.8	89.3 ± 0.9
P	89.8 ± 1.0	89.2 ± 1.0	90.2 ± 0.8	90.4 ± 1.0

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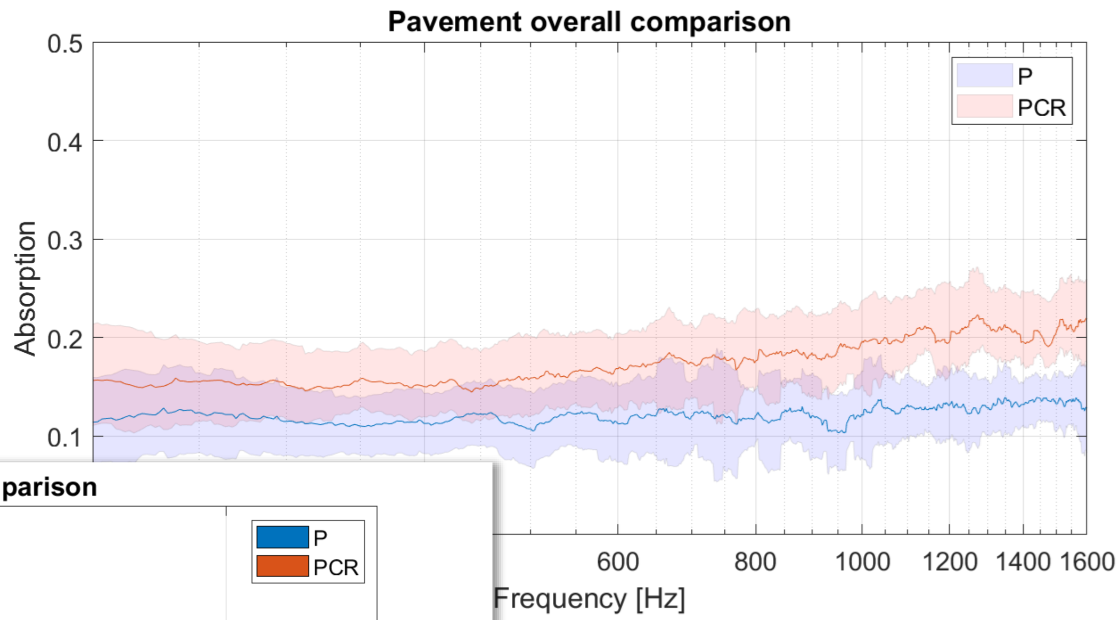
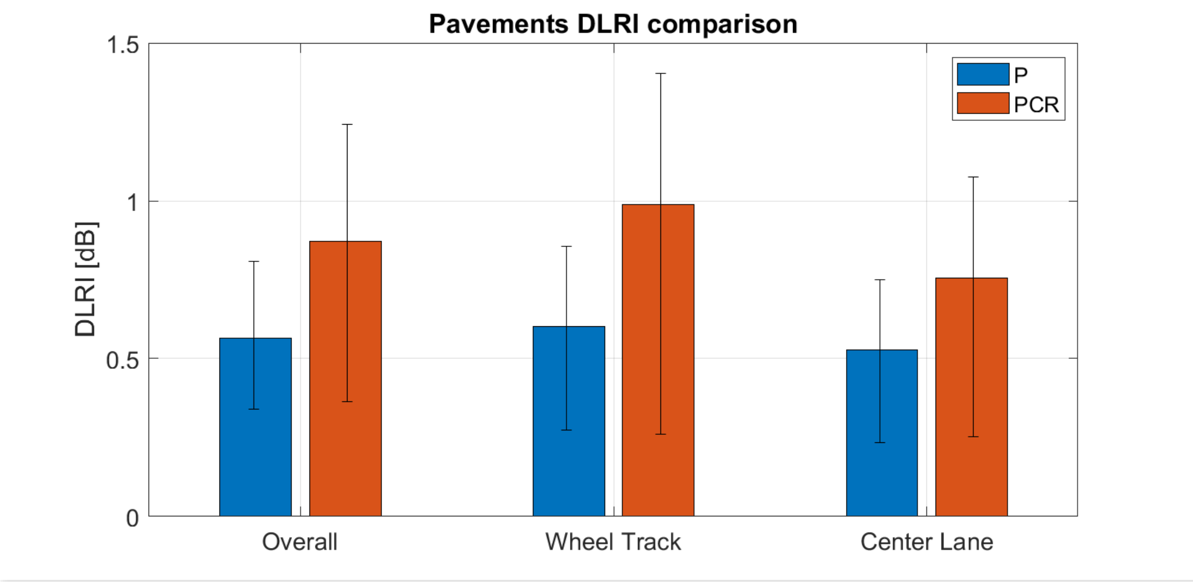
KUNDT TUBE

Evaluations for center lane, wheel track and average on the pavement. Calculation of DLRI (overall absorption).





TEST SITE

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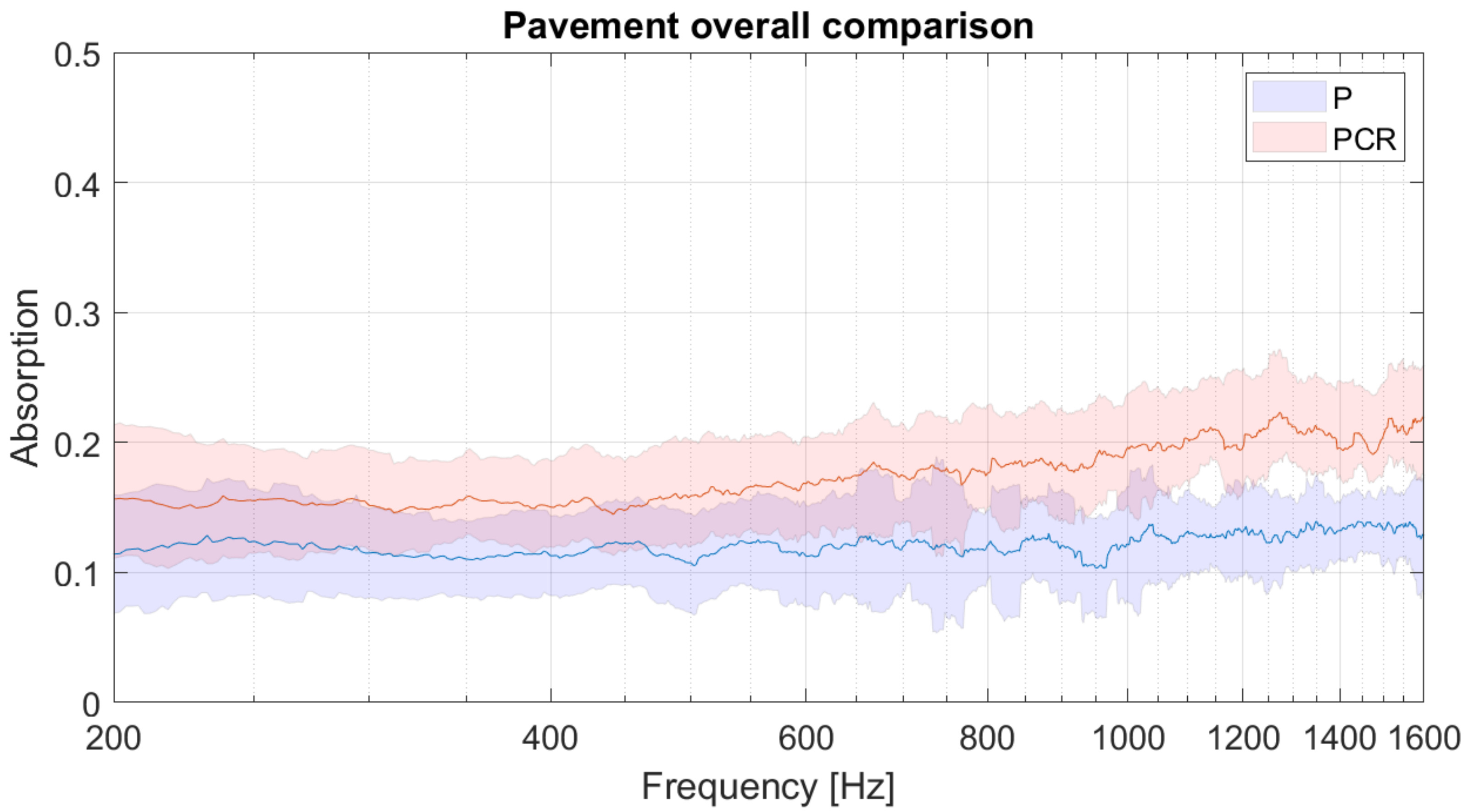
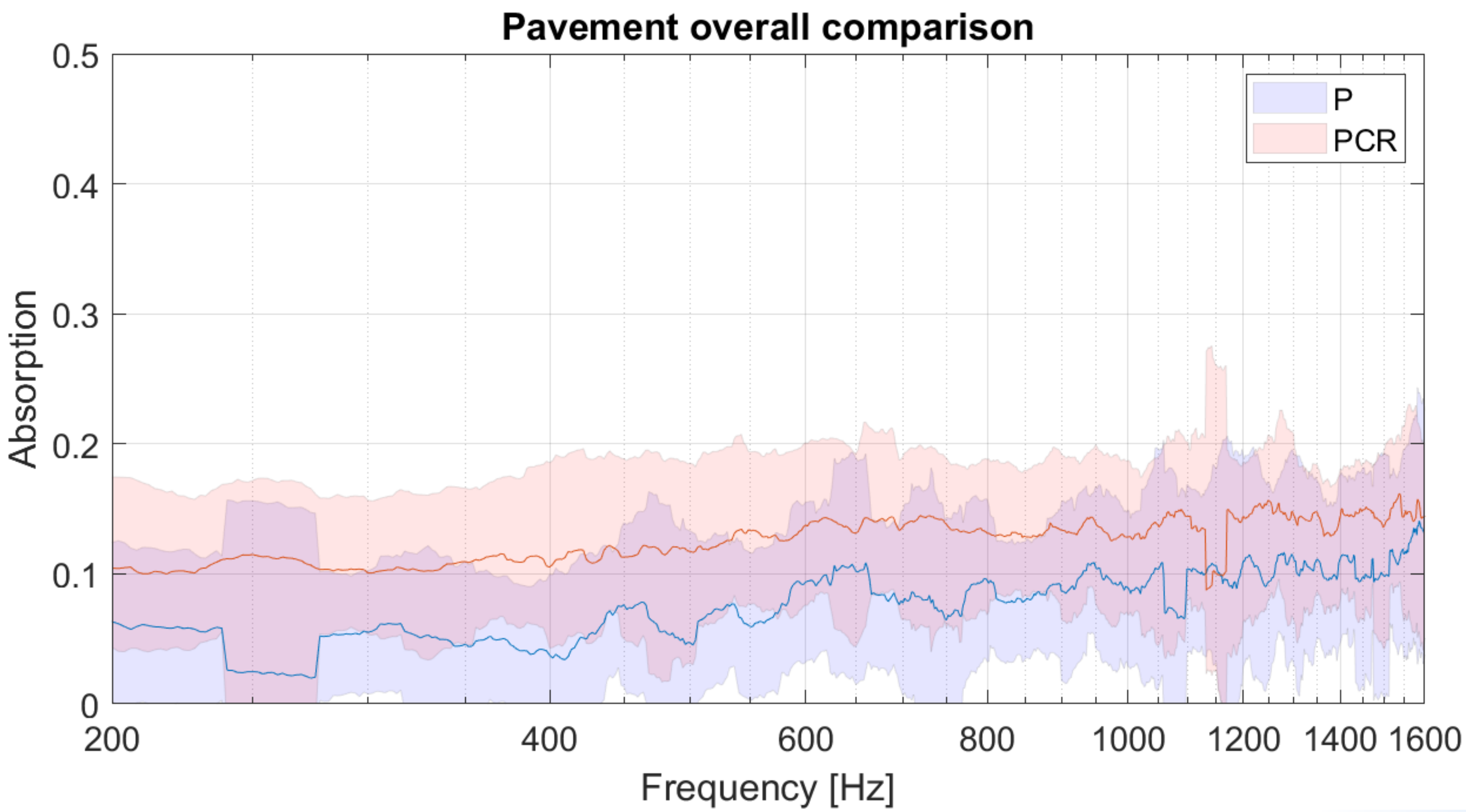
October 2021



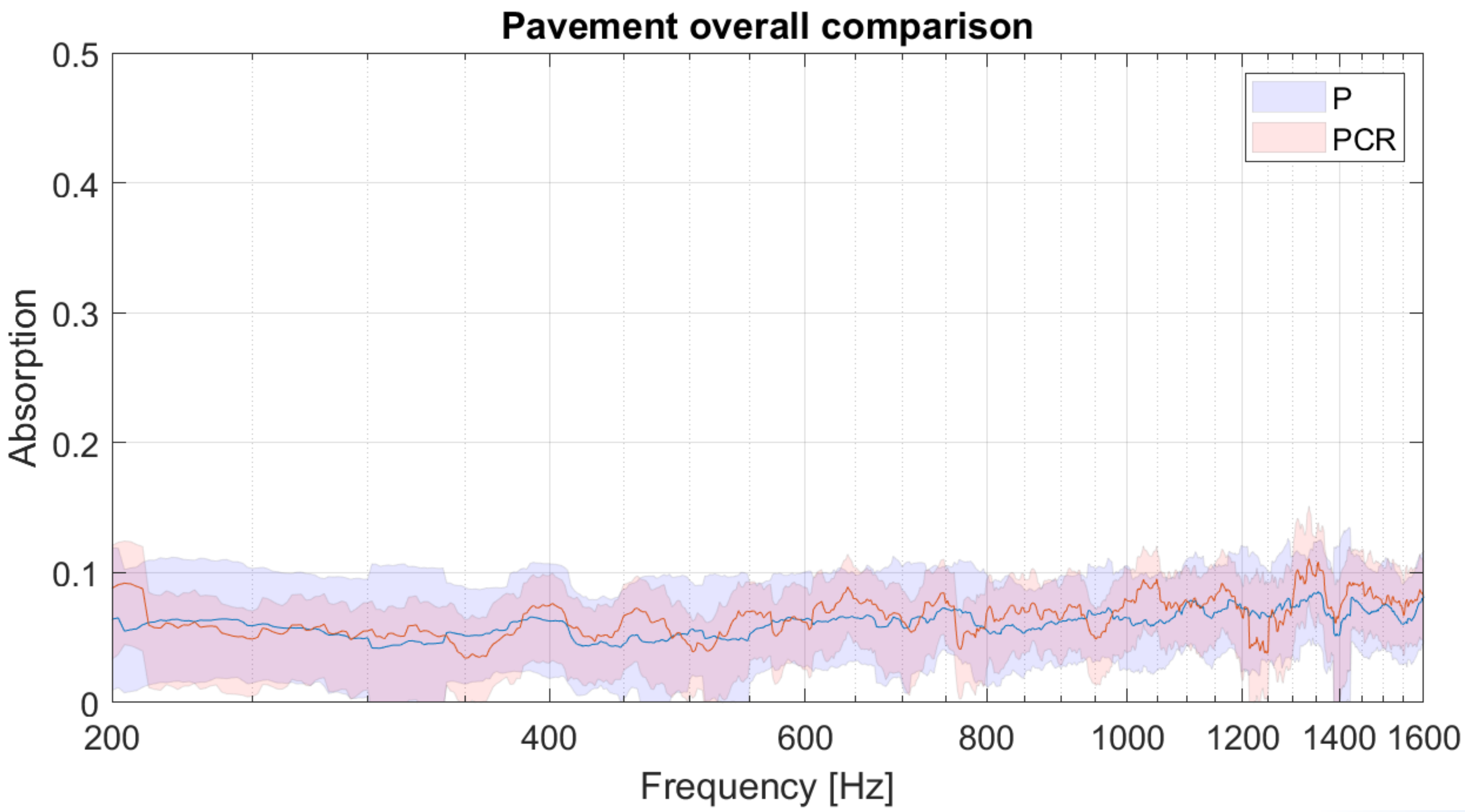
TEST SITE

February 2022

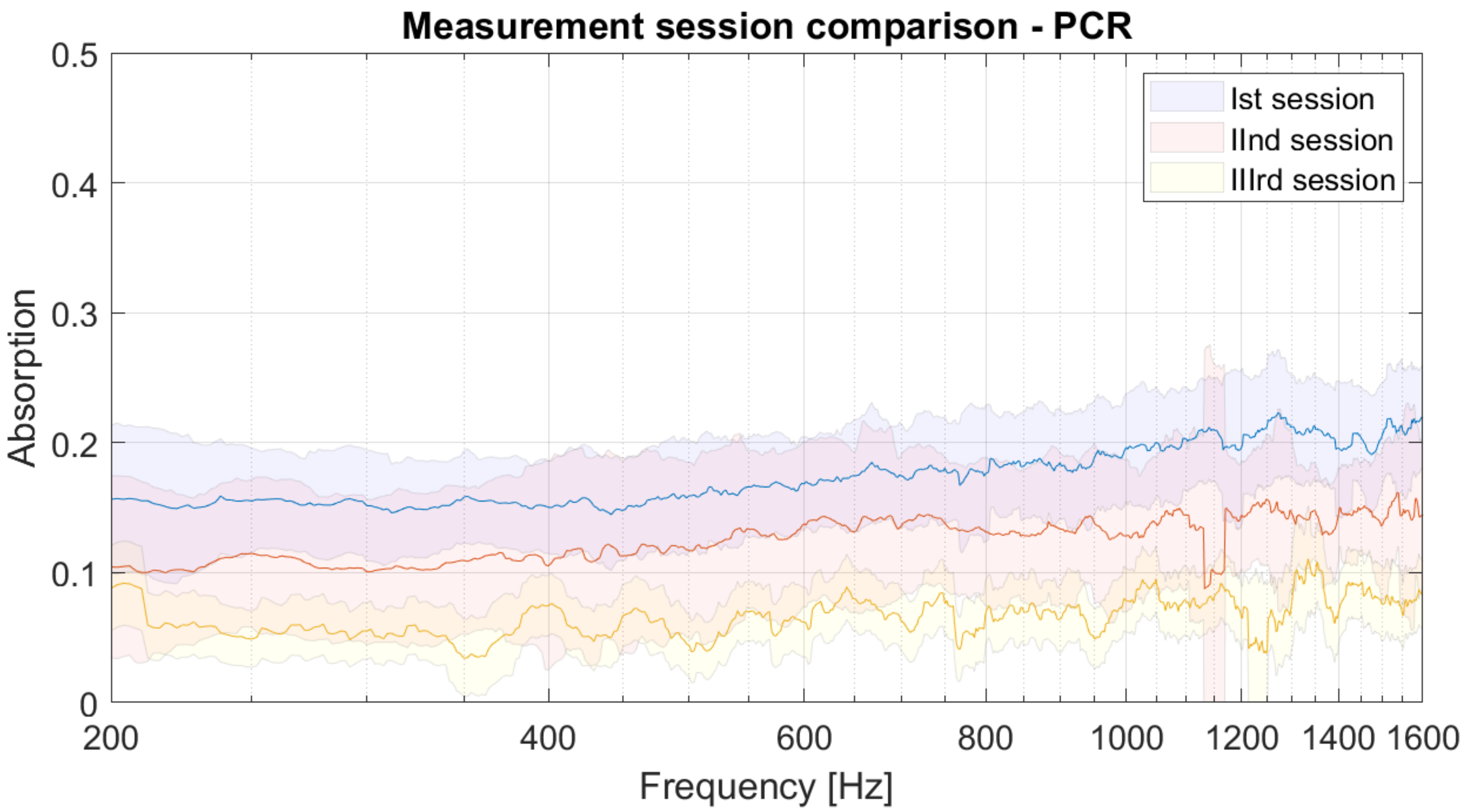


TEST SITE

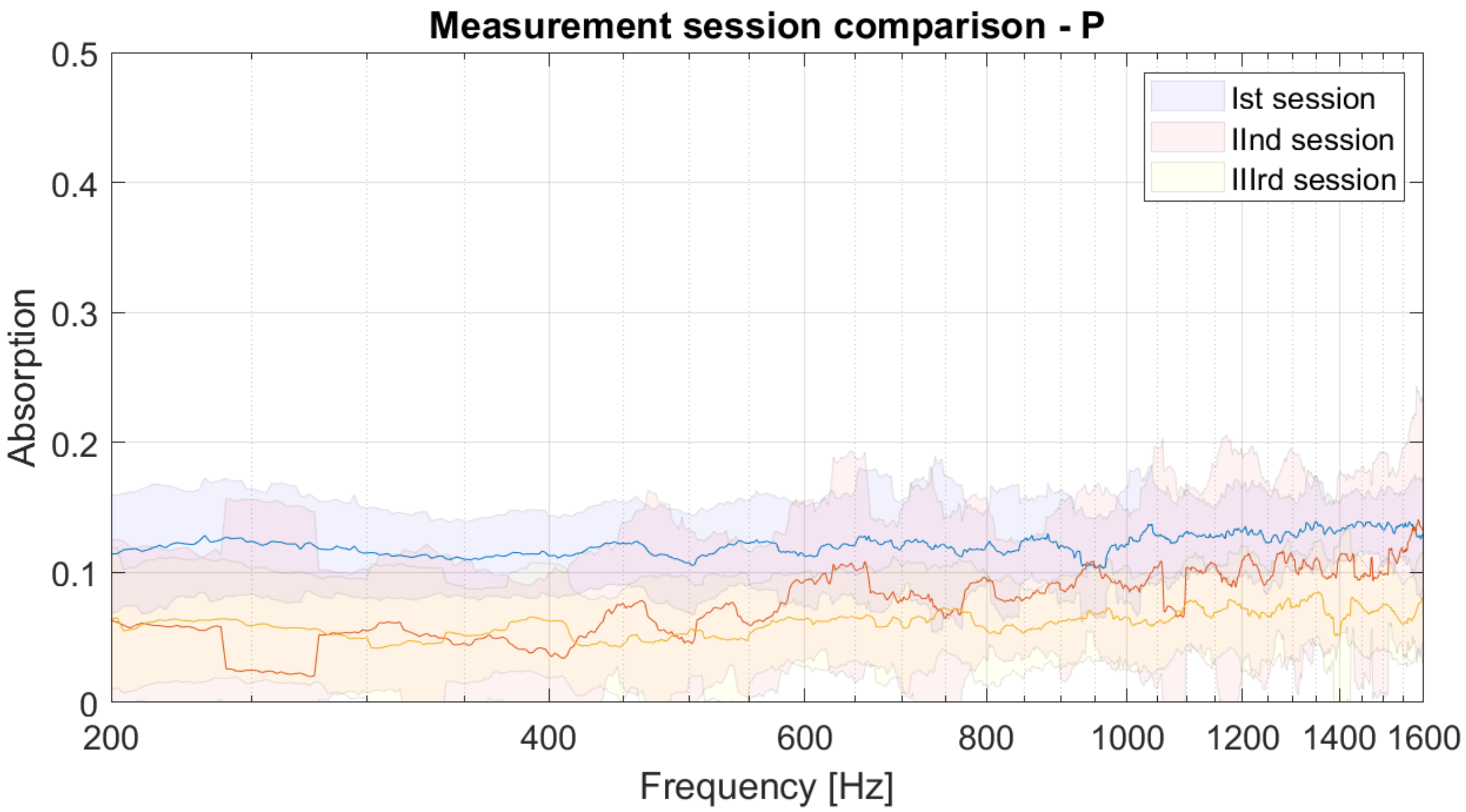
July 2022



TEST SITE

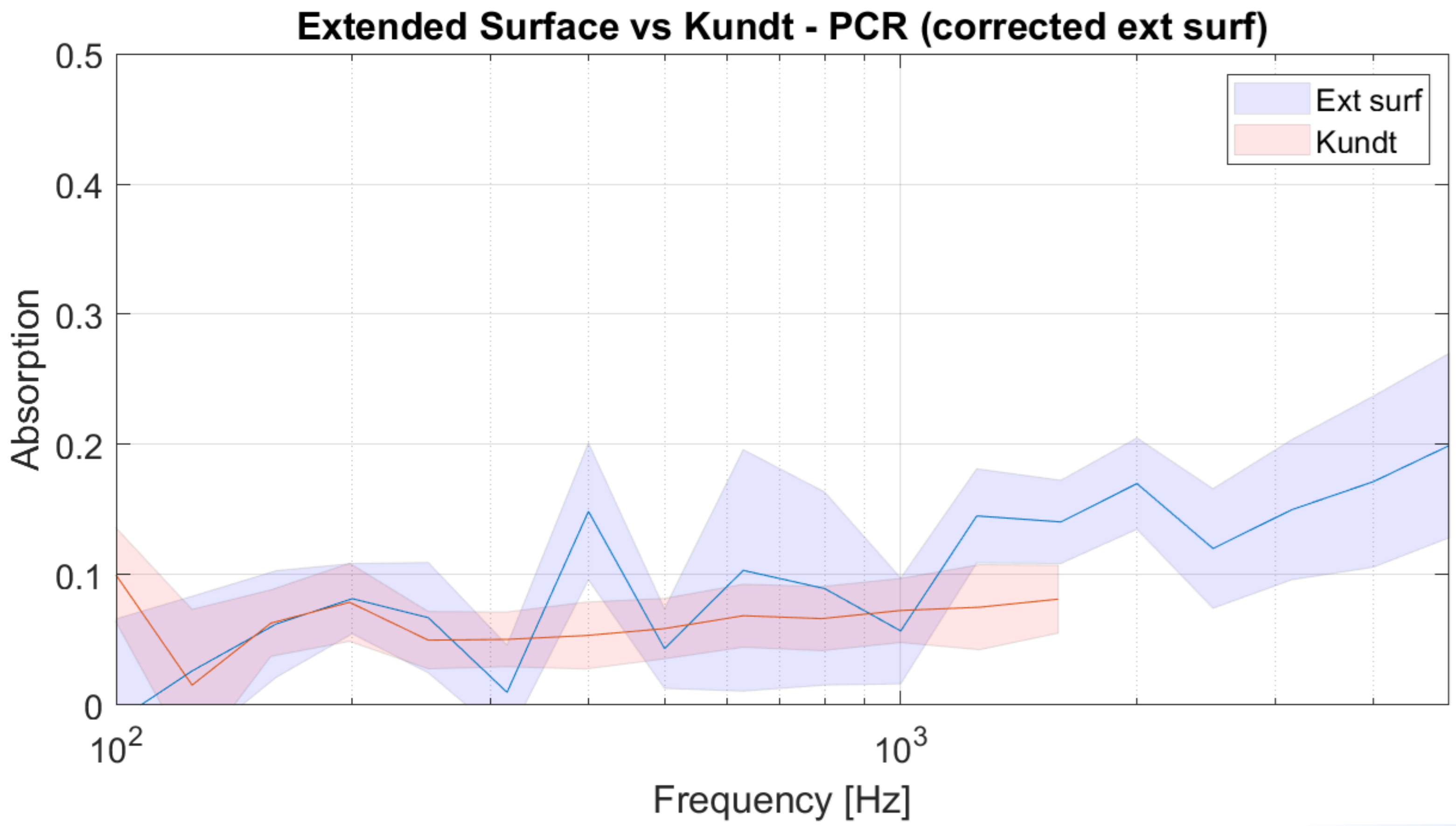

Measurement session comparison - PCR
Ist session
IInd session
IIIrd session
Absorption
0.5
0.4
0.3
0.2
0.1
0
200
400
600
800
1000
1200
1400
1600
Frequency [Hz]

TEST SITE

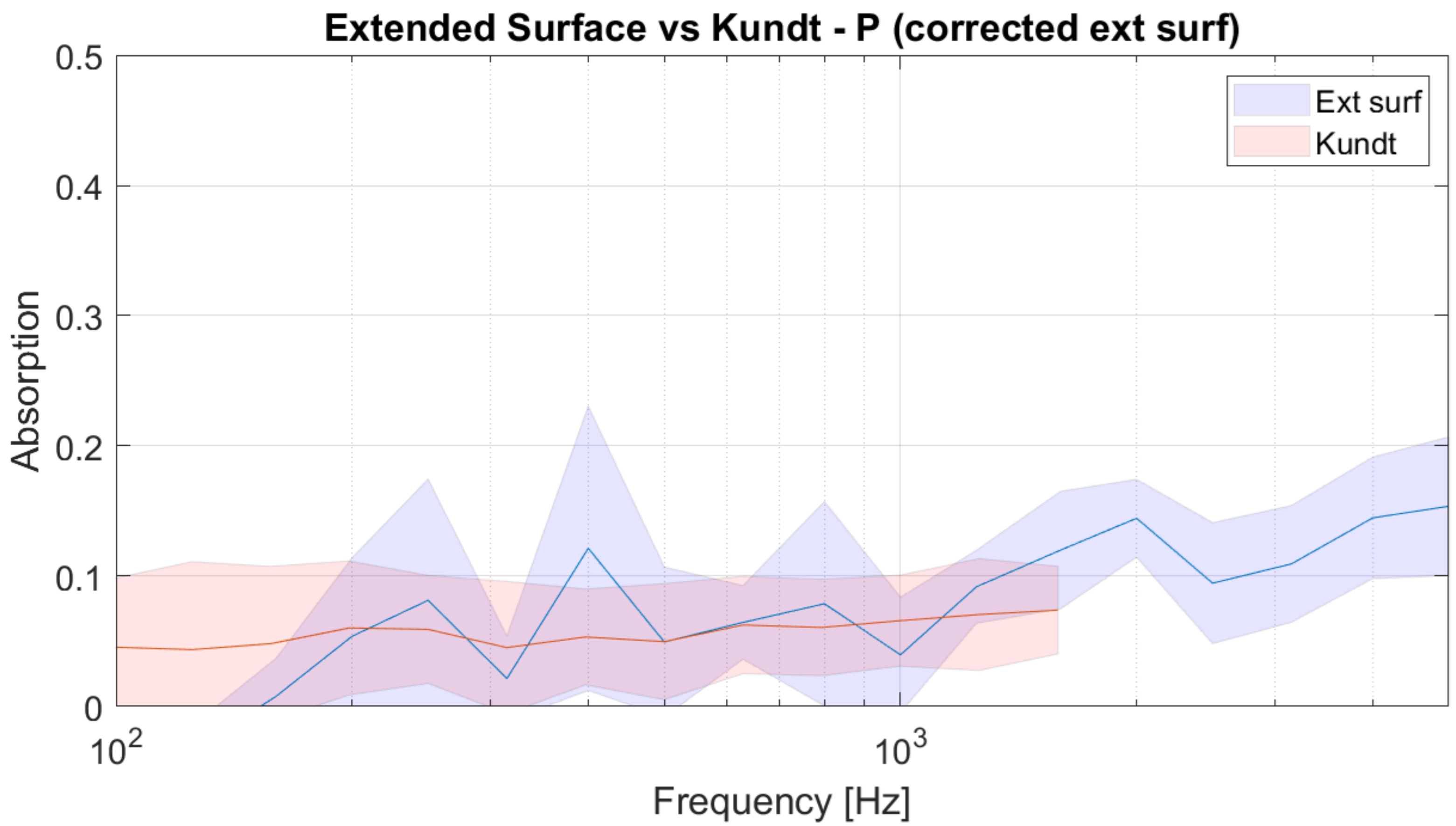

Measurement session comparison - P
Absorption
Frequency [Hz]
0.5
0.4
0.3
0.2
0.1
0
200
400
600
800
1000
1200
1400
1600
Ist session
IInd session
IIIrd session

TEST SITE

EXTEDED SURFACE VS KUNDT TUBE (IIIrd Session)



TEST SITE


Extended Surface vs Kundt - P (corrected ext surf)
Ext surf
Kundt
Absorption
0.5
0.4
0.3
0.2
0.1
0
10^2
10^3
Frequency [Hz]

TEST SITE

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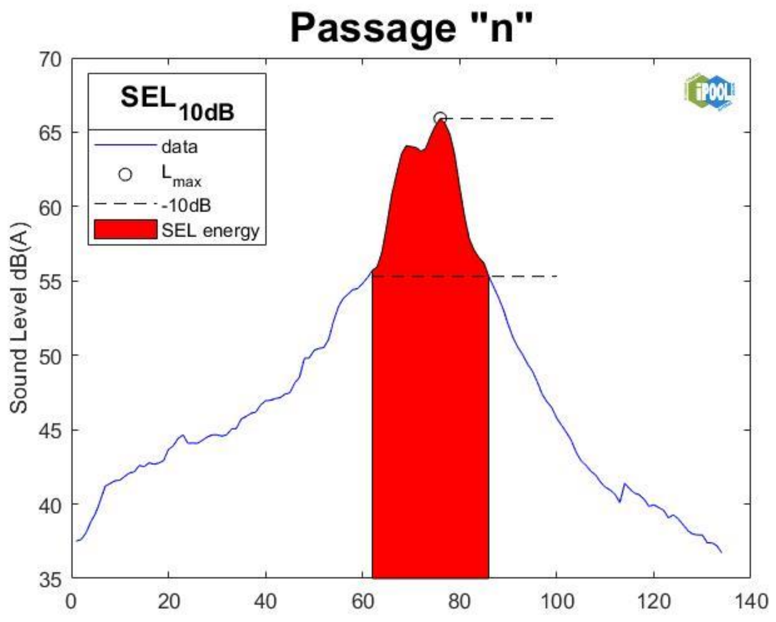
CPB – SEL CALCULATION FOR MODELING

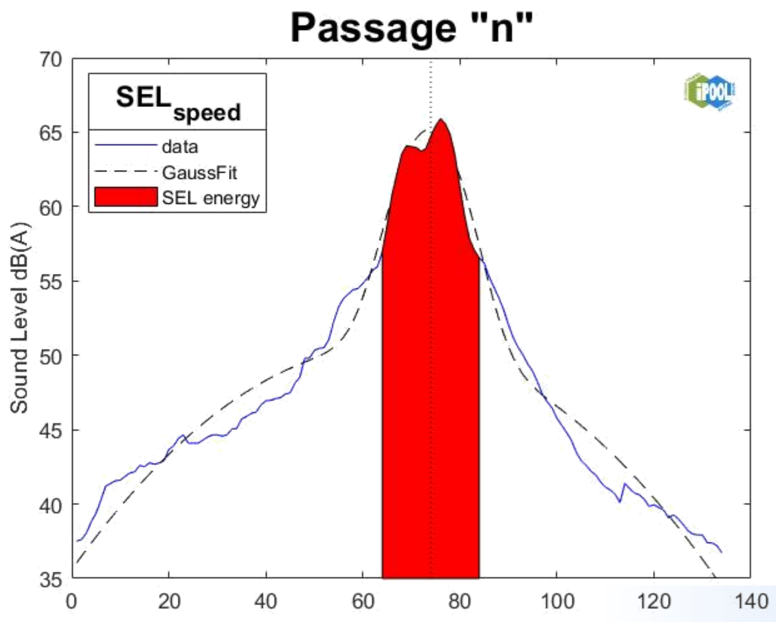
$$SEL = 10\log\left(\frac{1}{T_o}\int_{-\infty}^{+\infty}\frac{p^2(t)}{P_o^2}\,dt\right)$$

$$T_o = reference\ duration\ of\ 1s$$
$$p(t) = sound\ pressure$$
$$P_o = Reference\ sound\ pressure\ of\ 20\mu Pa$$

SEL Threshold -10dB

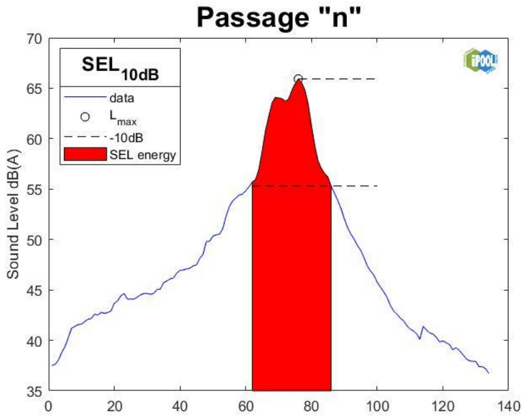


SEL speed



TEST SITE

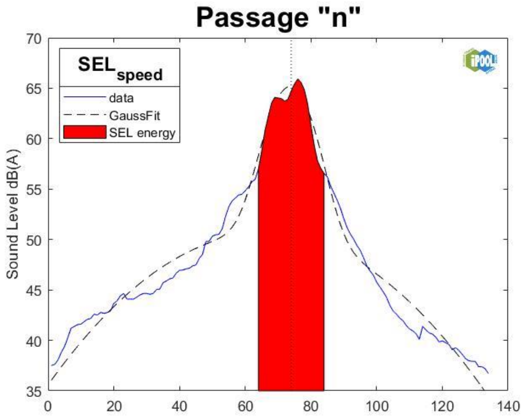
SEL Threshold -10dB



$$L_{AE} = 66.3287\ dB(A)$$

- Find peak value of the passage and -10dB threshold.
- Longer tail of integrated energy
- Longer segment at low-speed runs

SEL speed



$$L_{AE} = 66.1595\ dB(A)$$

- 7.5m before and after to reach the microphone position

Speed [km/h]	Integration time [ms]	Samples [n]
15	3,781	32
30	1,905	16
60	0,968	8

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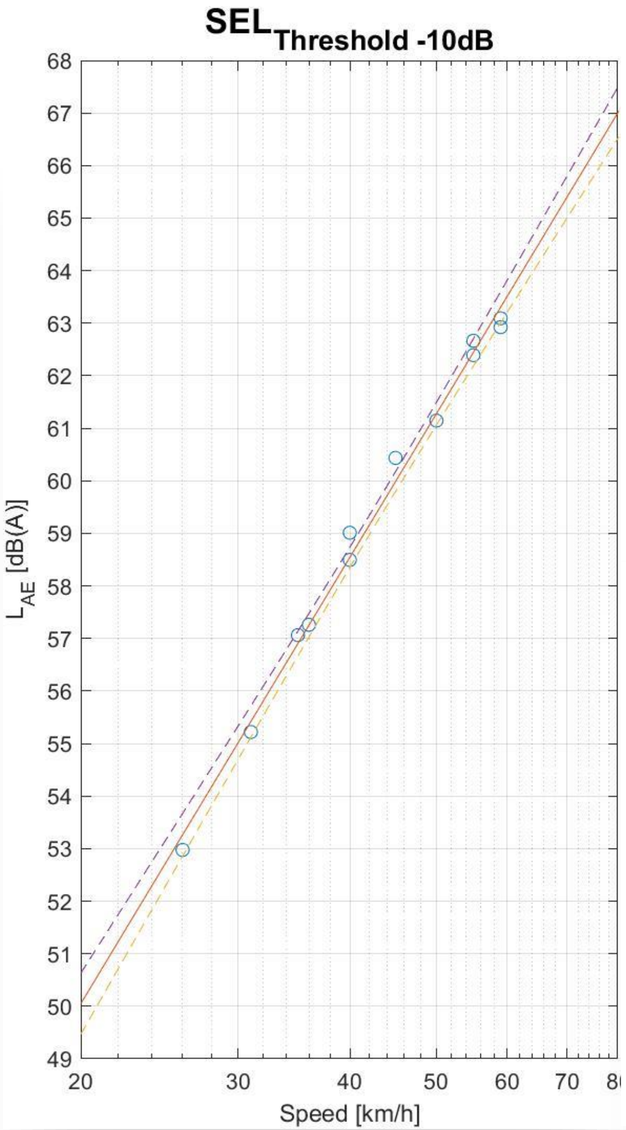
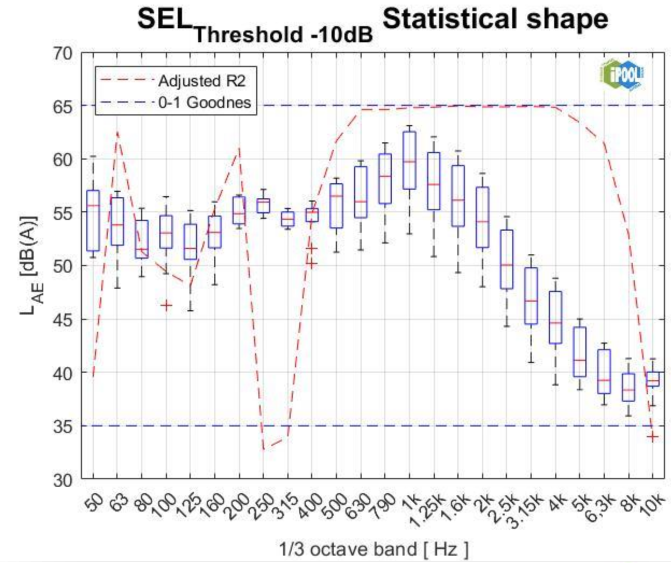
TEST SITE

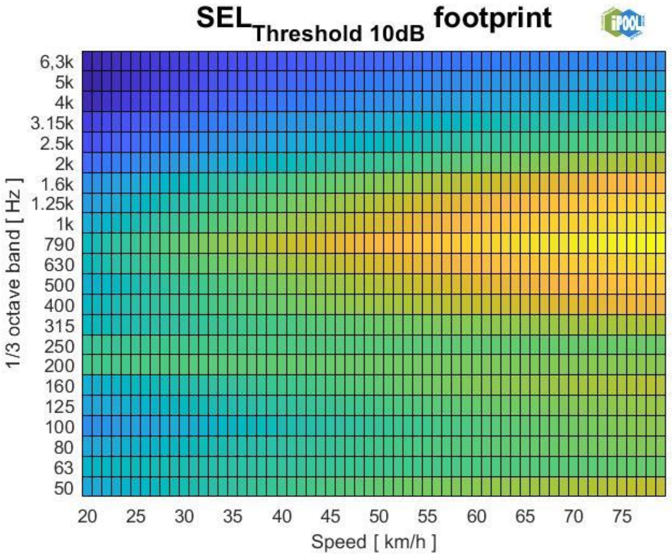
Data analysis

- Linear regression
- Adjusted R squared
- Footprint of the prediction

Hyundai Ioniq on Reference Pavement – Via Paisiello







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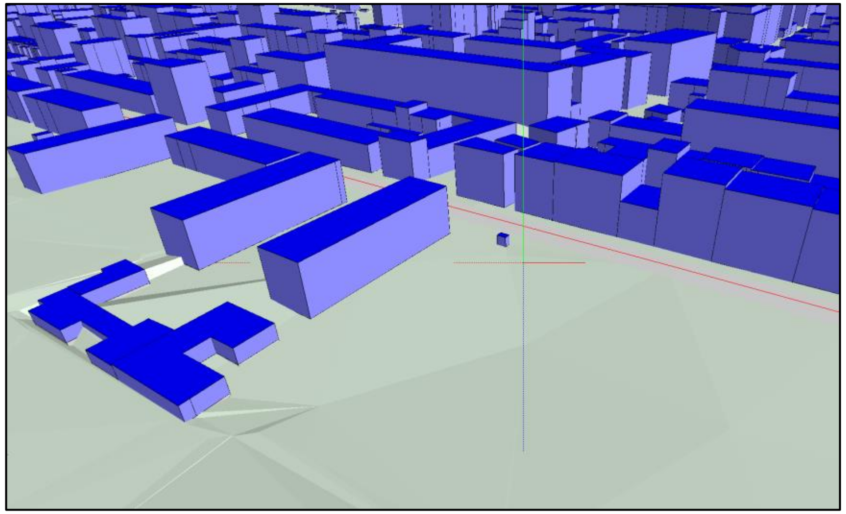
CNOSSOS Parameters - EV

The cars whose noise was measured by CPB methodology are electric vehicles, with different tires, measured both in the section made with traditional asphalt (hereafter "reference asphalt" or "REF"), and in the section made with asphalt with rubber powder (hereafter "Crumb Rubber" or "CR").

The objective of the study is to obtain values related to electric cars, to be included in the calculation model described in Directive 996/2015 and Directive 1226/2022 CNOSSOS, on specific calculation software (SoundPlan 8.2).



GUIDELINE PREPARATION

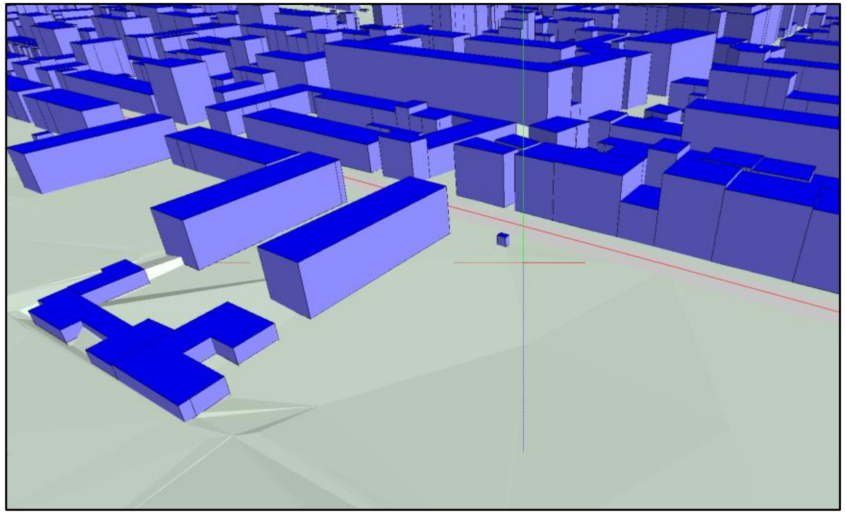
CNOSSOS Parameters - EV

It was preliminarily assumed that for electric vehicles the noise emitted by the propulsion can be considered negligible. The formula on the basis of which the coefficients are to be obtained is 2.2.4 of Directive 996/2015:

$$L_{WR,i,m} = A_{R,i,m} + B_{R,i,m} \times \lg\left(\frac{v_m}{v_{ref}}\right) + \Delta L_{WR,i,m}$$

Which describes the contribution of rolling noise emitted by vehicles and it has a dependance both on vehicle type in the parameters A and B, and directly on the speed Vm.

To do this, we first look for correlations between SEL and measured vehicle speeds.



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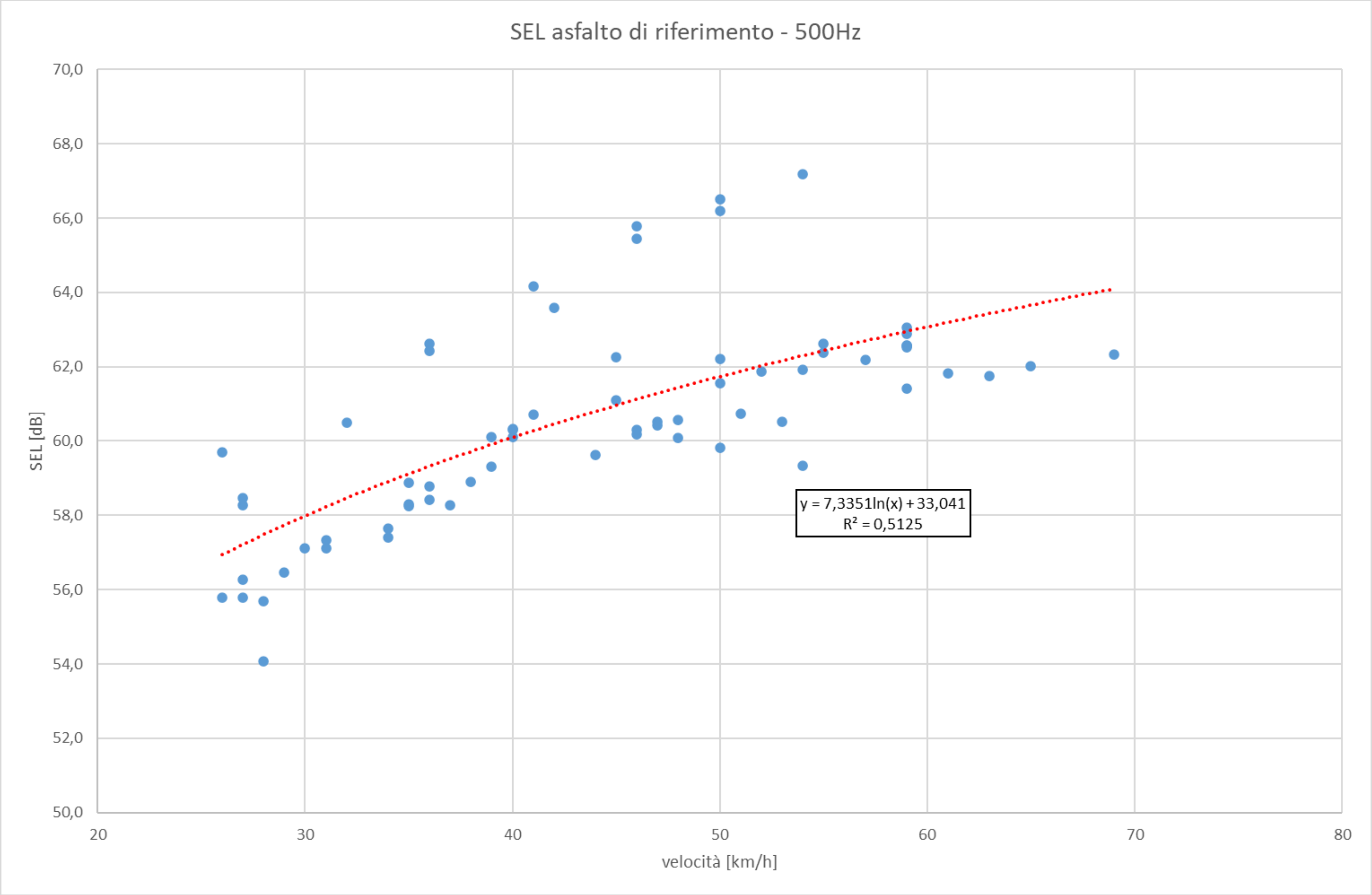

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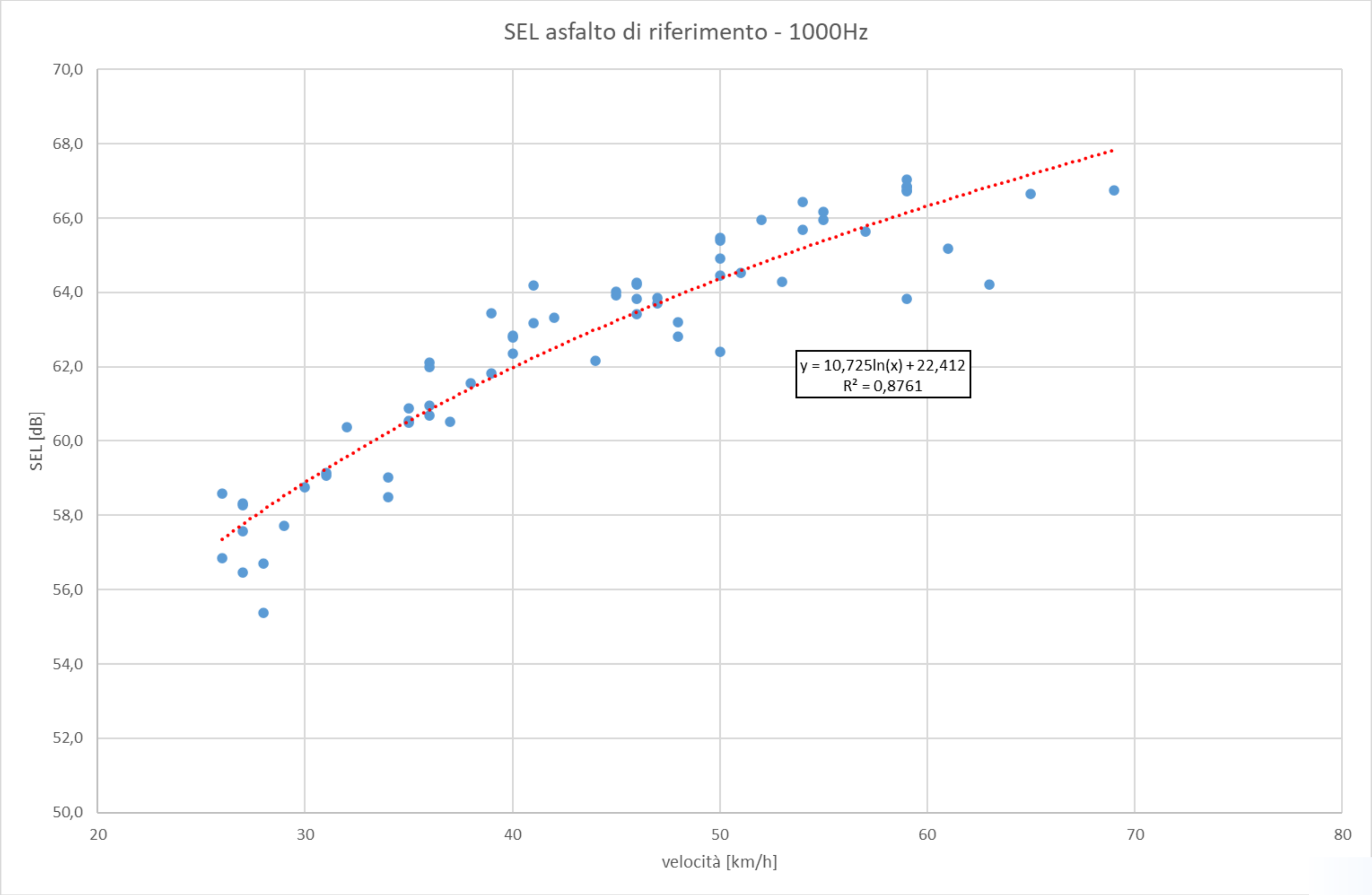

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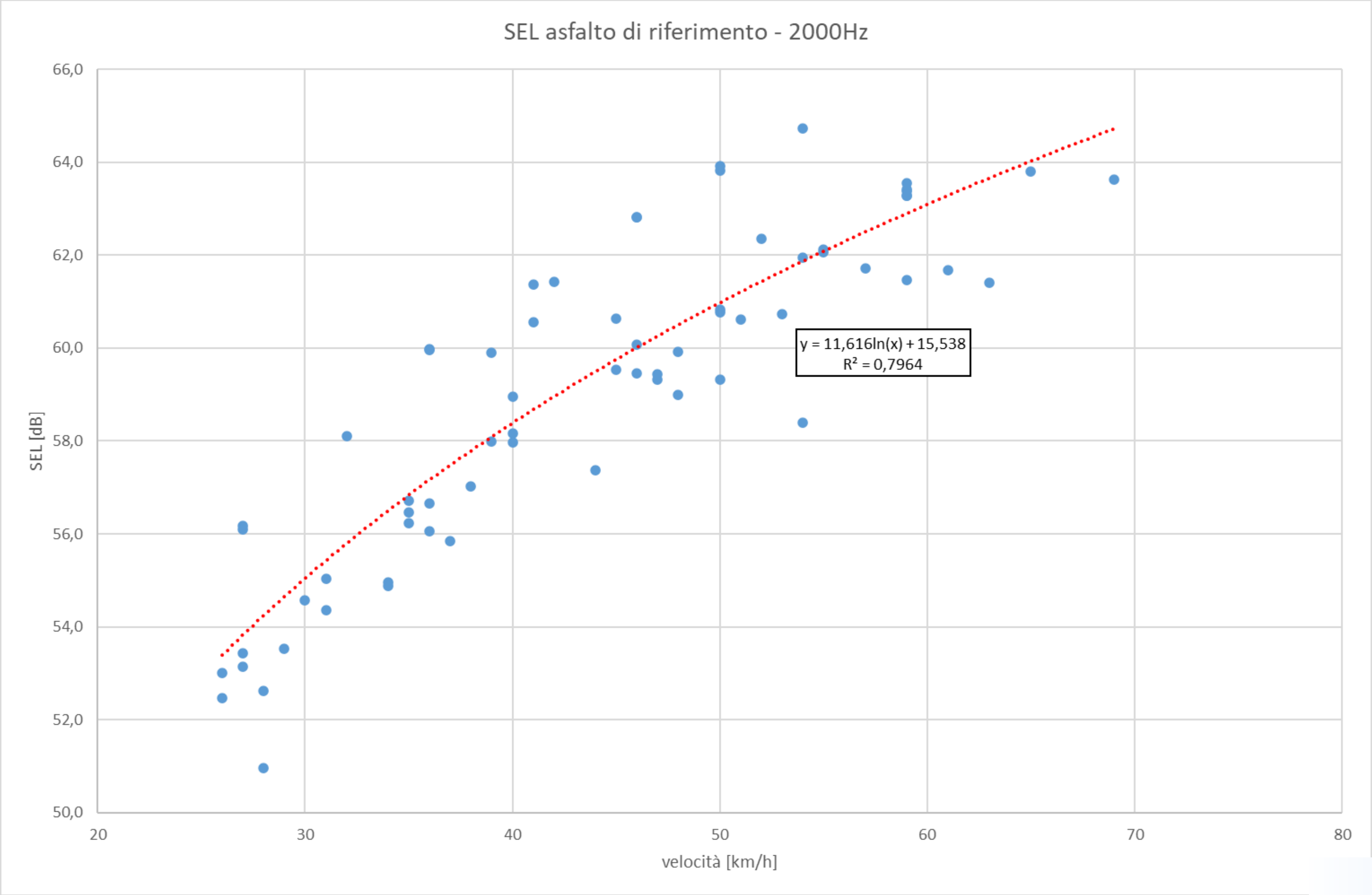
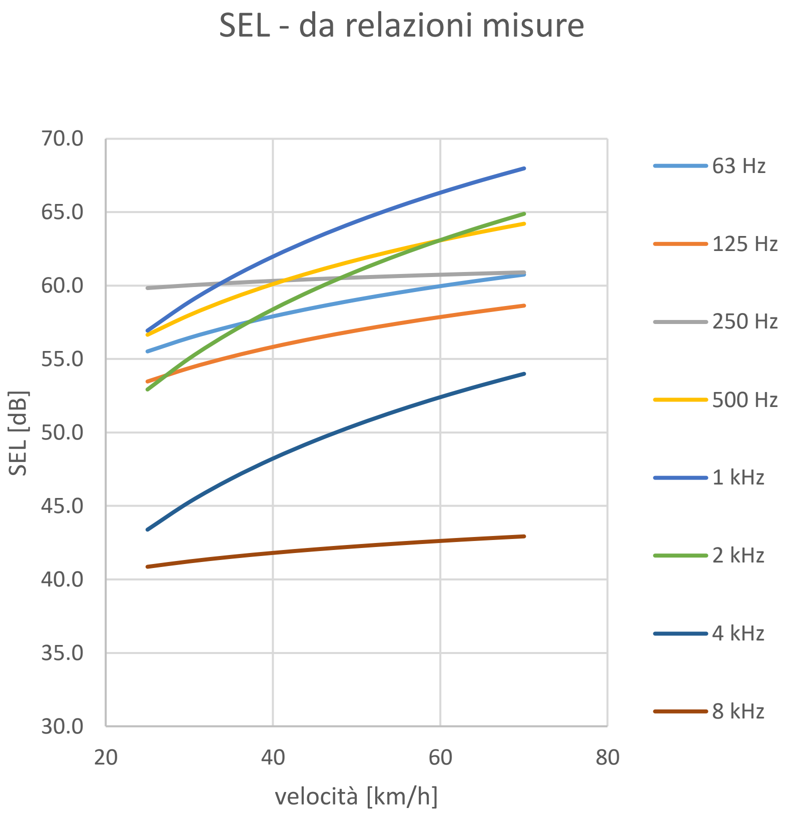


GUIDELINE PREPARATION

CNOSSOS Parameters - EV

Referring to Equation 2.2.4, and considering that the contribution of propulsion noise for electric vehicles is neglected, first of all, the trend of the predicted SELs, at the measurement point, was obtained by means of a logarithmic fit made for all measured vehicles passing on the reference asphalt (considered appropriately identical to the reference asphalt referred to in Directive 996/2015).



A graph is shown with the inferred values of the SEL value as a function of vehicle speed and frequencies.

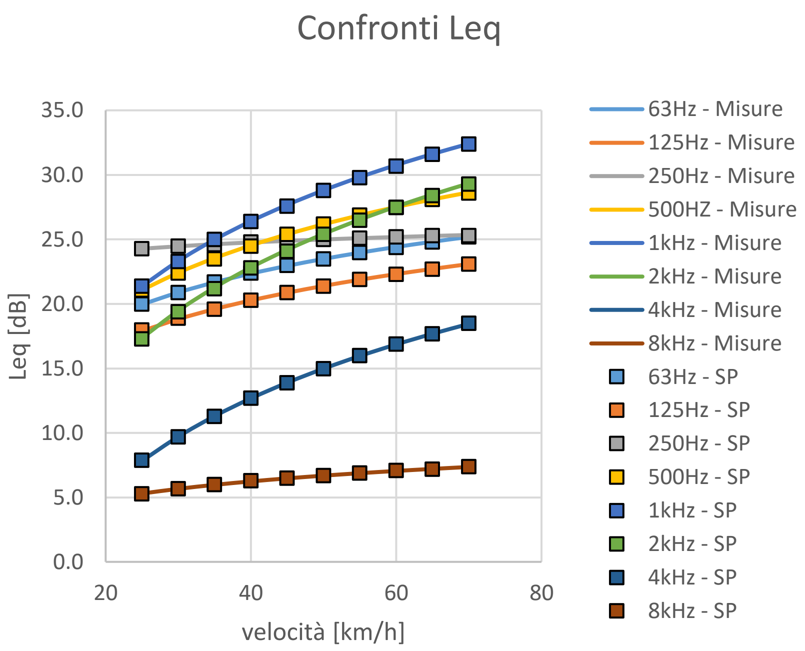
GUIDELINE PREPARATION

CNOSSOS Parameters - EV

By means of iterative solver, the values of the coefficients Ar and Br were therefore derived that would allow the model obtained by CNOSSOS calculation method to be matched with the results deduced from the evaluation of the logarithmic fit obtained.

It should be noted that the comparison was made not on a SEL (single event level, relating to the contribution of the passage of a single vehicle) but of the value that such a vehicle would produce, as an equivalent Leq level, in one hour of time: CNOSSOS's output is a Leq.

A graph showing comparisons between logarithmic fits inferred from measurements and calculated levels is shown.

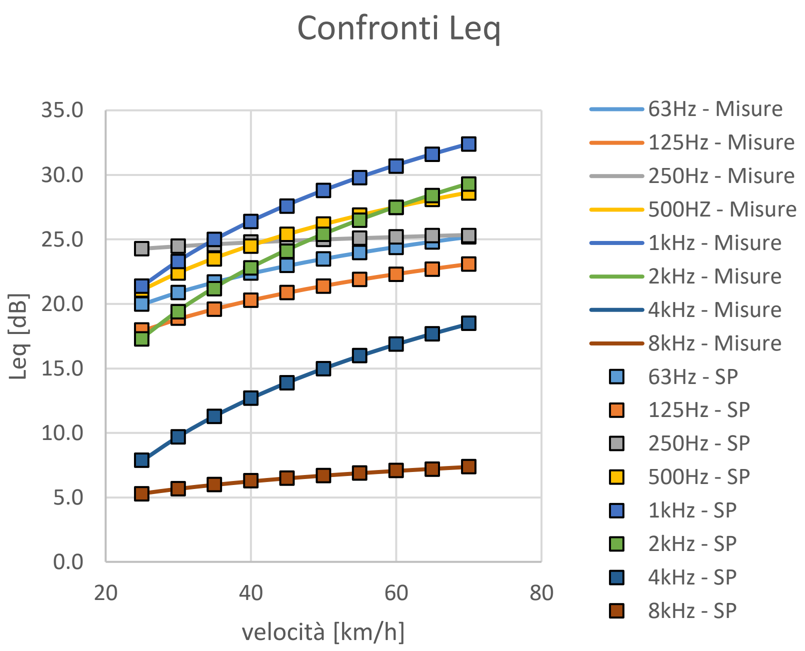


GUIDELINE PREPARATION

CNOSSOS Parameters - EV

The process adopted made it possible, against the initial measurement data, to obtain coefficients expendable on computational models for road traffic evaluation, considering among the component categories of the vehicle fleet an additional category that could represent electric vehicles.

The coefficients obtained through evaluation described above are shown in tabular form.



	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
Ar	85,3	83,3	85,5	88,8	92,8	90,0	79,3	69,2
Br	21,6	21,5	12,4	26,9	34,6	36,7	33,7	14,6

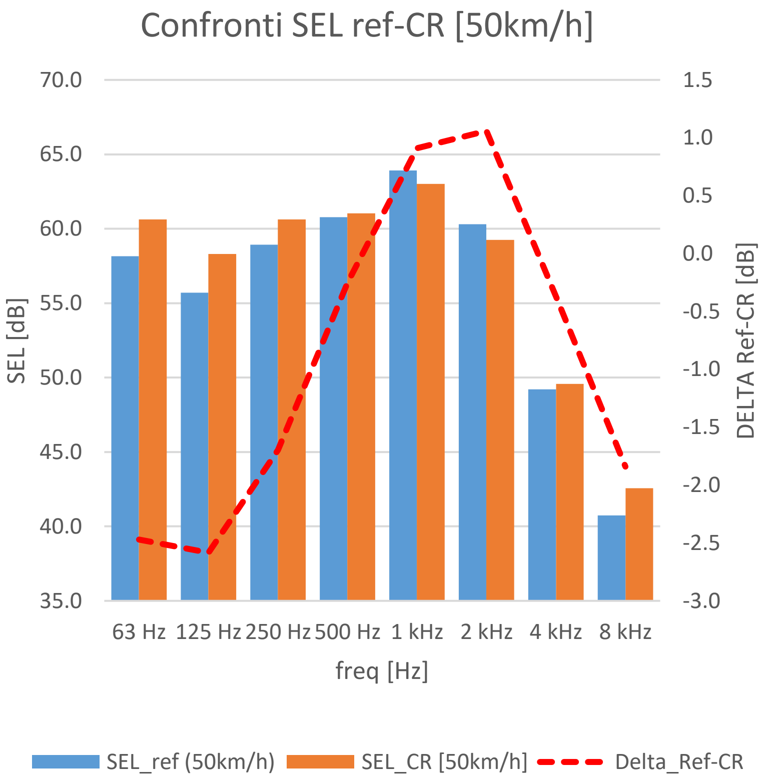
GUIDELINE PREPARATION

CNOSSOS Parameters– Road Surface [*Crumb Rubber*]

The difference between the performance of reference asphalt with that of Crumb Rubber asphalt was researched.

To obtain these values, a function of speed and vehicle type, logarithmic fits were analyzed for the measurement session conducted on 10/15/2021, between comparable vehicles, and deltas were observed.

Histogram with SEL levels calculated from the measurements and indication of the delta between them, calculated as SEL_ref - SEL_CR, for 50km/h is shown.



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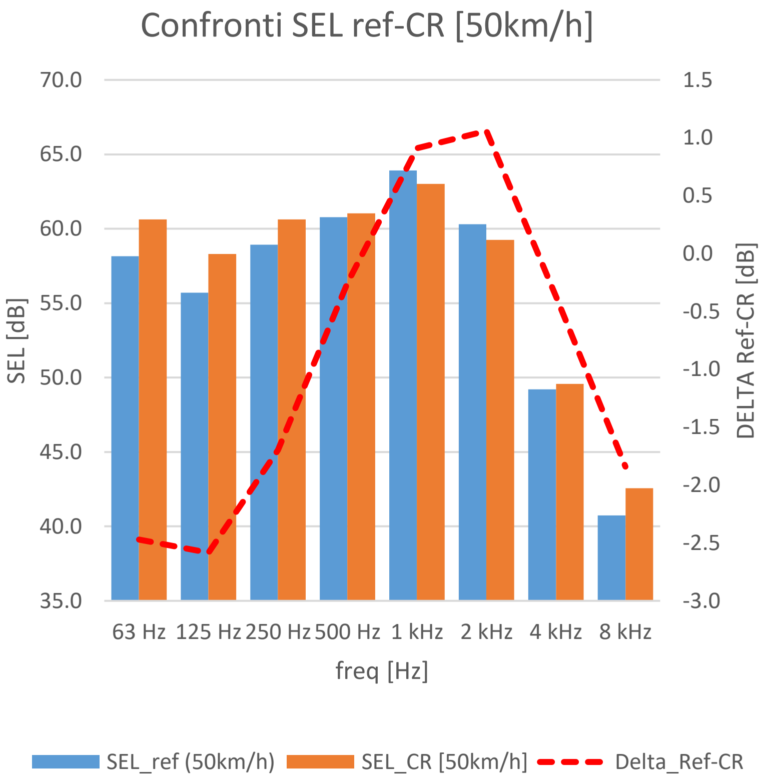
<u>Parametri CNOSSOS – Road Surface [*Crumb Rubber*]</u>

A slight worsening is observed at low and very high frequencies and a slight improvement at center frequencies (1kHz and 2kHz), i.e., the most representative of the noise emitted by motor vehicles.

Given the values of DELTA obtained, the values of the coefficients αi,m and βm that would allow the model obtained by CNOSSOS calculation method to be matched with the results obtained were evaluated by iterative solver using the formula:

$$\Delta L_{WR,road,i,m} = \alpha_{i,m} + \beta_m \times \lg\left(\frac{v_m}{v_{ref}}\right)$$



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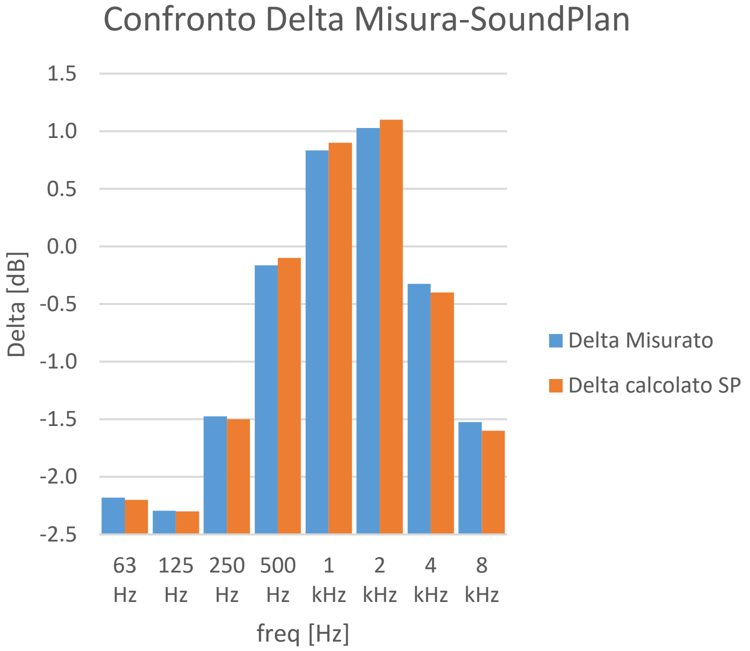
Parametri CNOSSOS – Road Surface [*Crumb Rubber*]

A histogram comparing, at the various frequencies, the deltas calculated by logarithmic fit as outlined above, and the deltas obtained by modeling using SoundPlan8.2, and CNOSSOS method is shown, which demonstrates how the process adopted allowed, against the initial measurement data, to obtain suitable coefficients to describe the operation of the road surface for electric vehicles.



The coefficients obtained through evaluation described above are shown in tabular form.

	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
$\alpha_{i,m}$	2,3	2,4	1,6	0,3	-0,7	-0,9	0,5	1,7
β_m	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0

GUIDELINE PREPARATION

Results Comparison

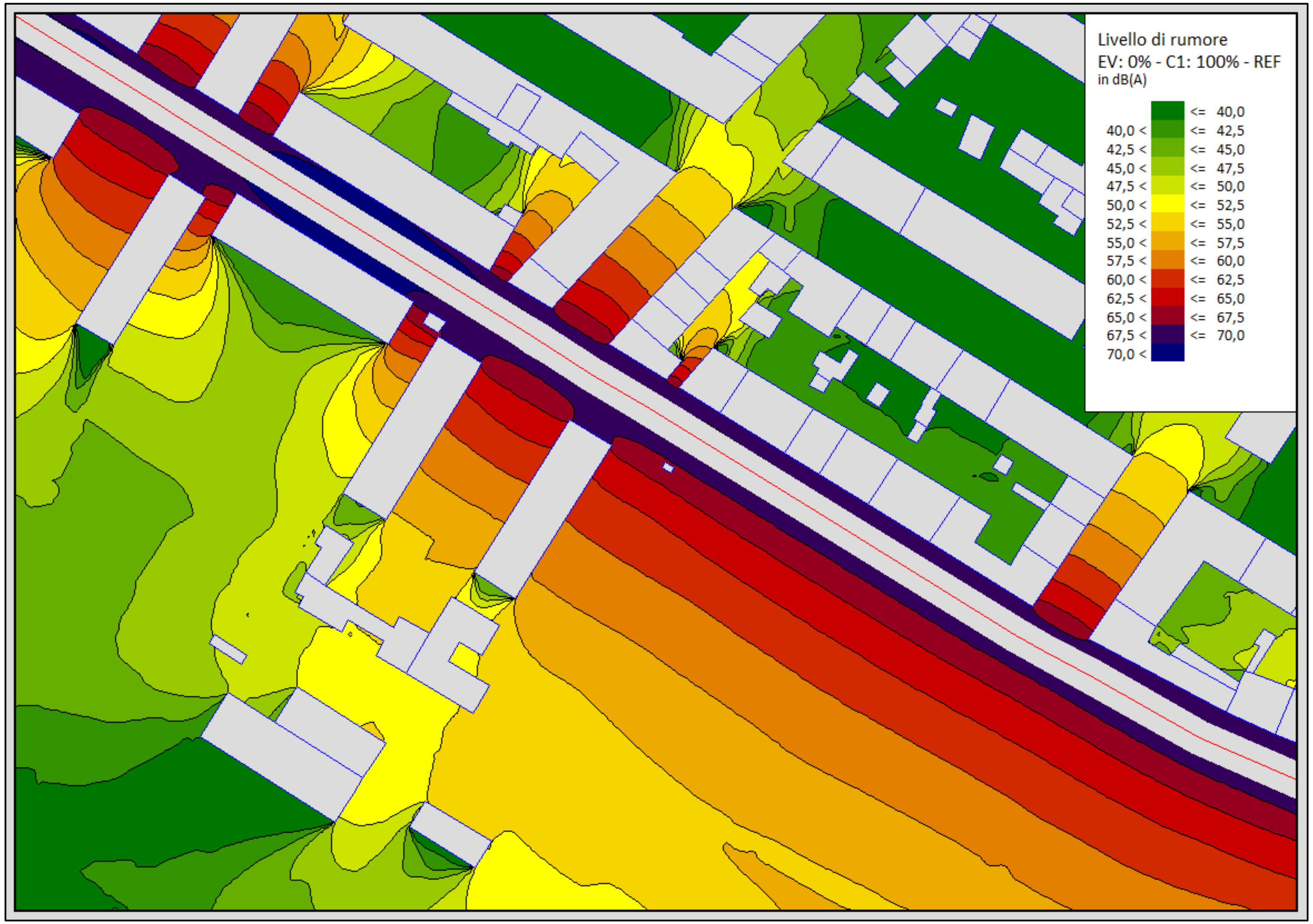
We now report, in tabular and graphical form, simulations carried out in the test area (Paisiello Street), in which different scenarios were carried out, in order to hypothesize what the impact might be, in urban streets, for moderate speeds, of a gradual increase in electric mobility over traditional mobility.

The different scenarios were considered (for a representative reputedly suitable speed of 50km/h), which are shown in tabular form:

I	Tot. Veichle / h	% traditional veichle (Cat1)	% EV(Cat2)	Road Surface*
1	500	100%	0%	Reference
2	500	50%	50%	Reference
3	500	0%	100%	Reference
4	500	100%	0%	CrumbRubber
5	500	50%	50%	CrumbRubber
6	500	0%	0%	CrumbRubber

*:the same CrumbRubber asphalt coefficients calculated on electric vehicles (Cat5) were also considered for conventional light vehicles (Cat1).

GUIDELINE PREPARATION



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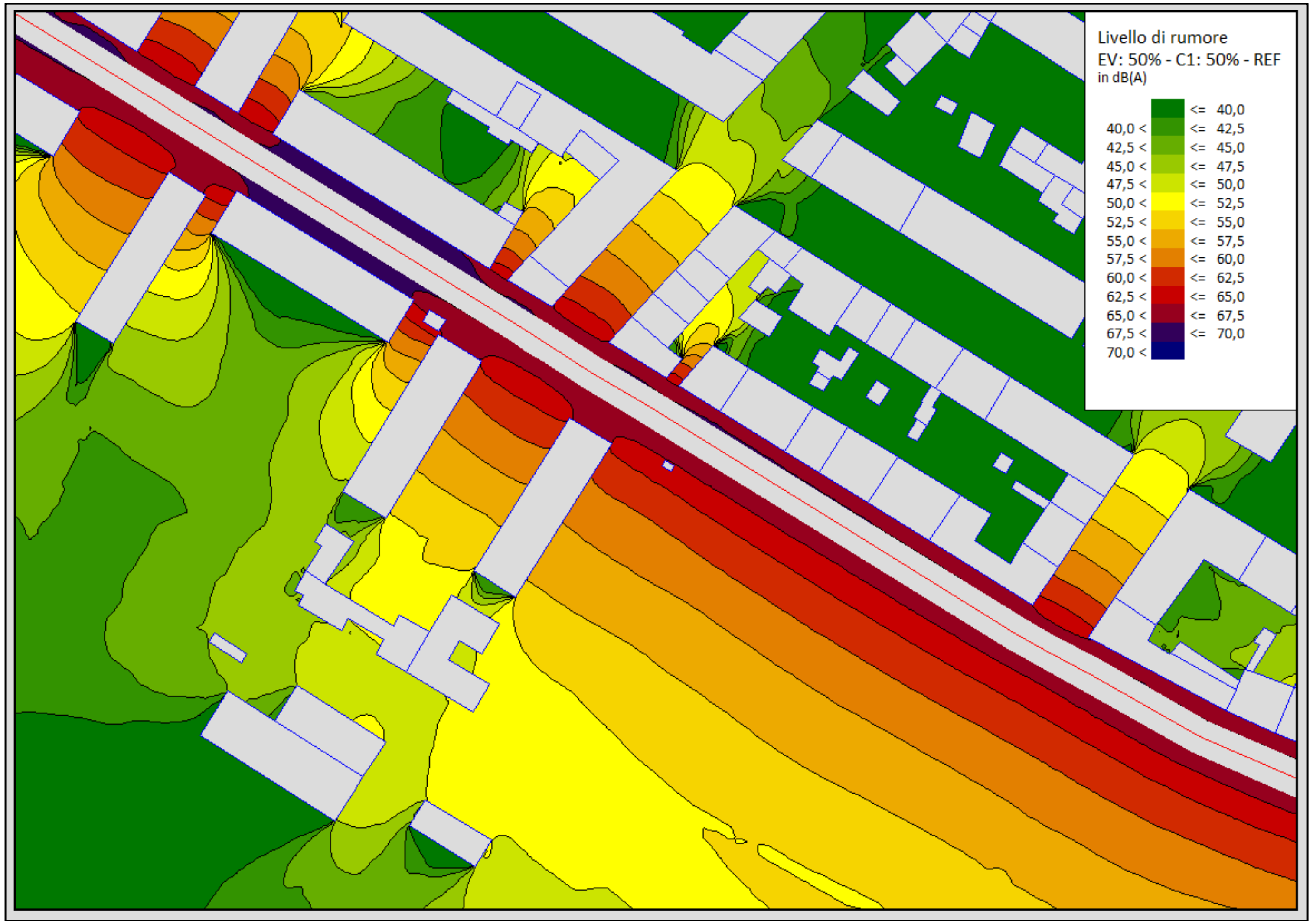

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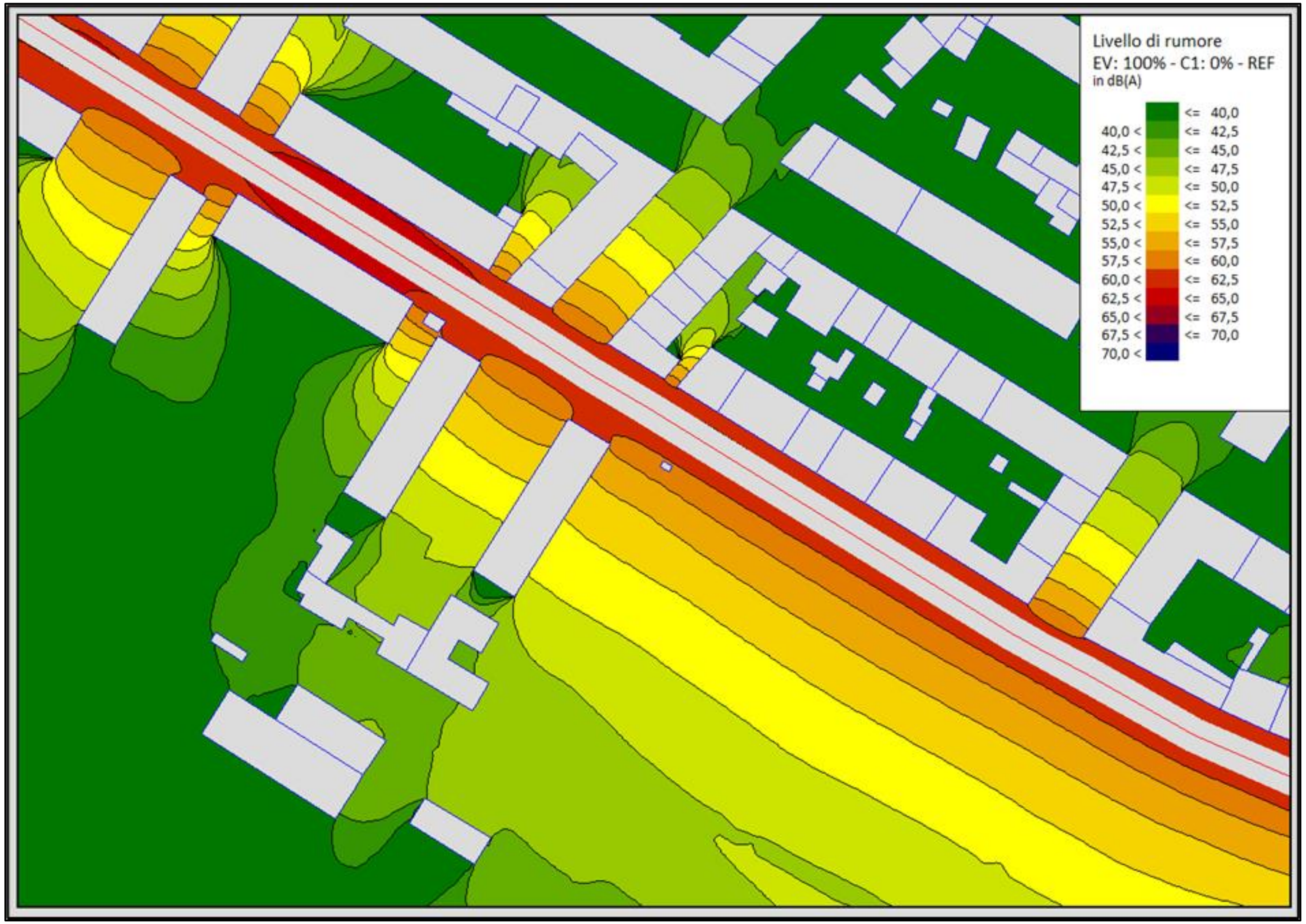

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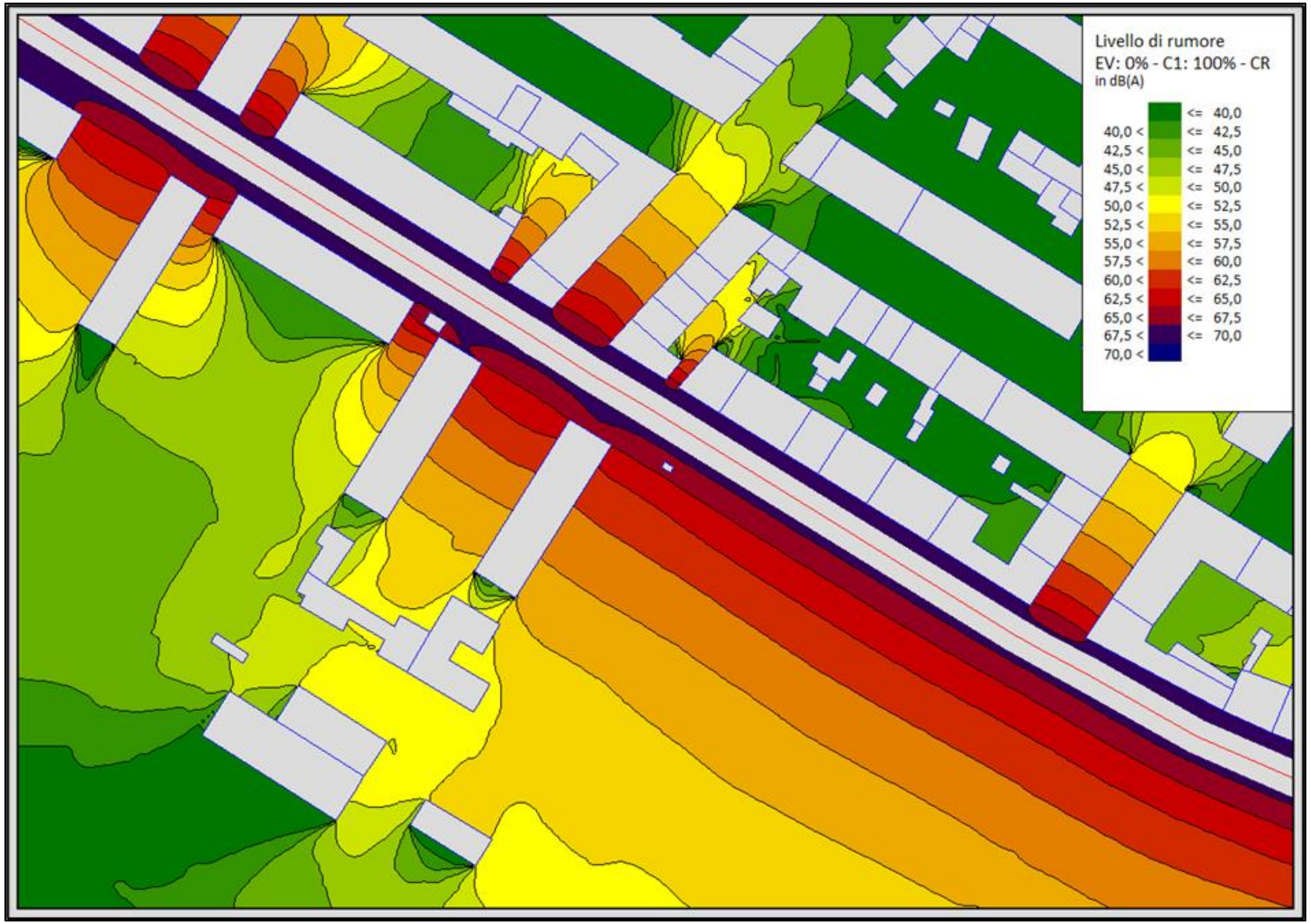

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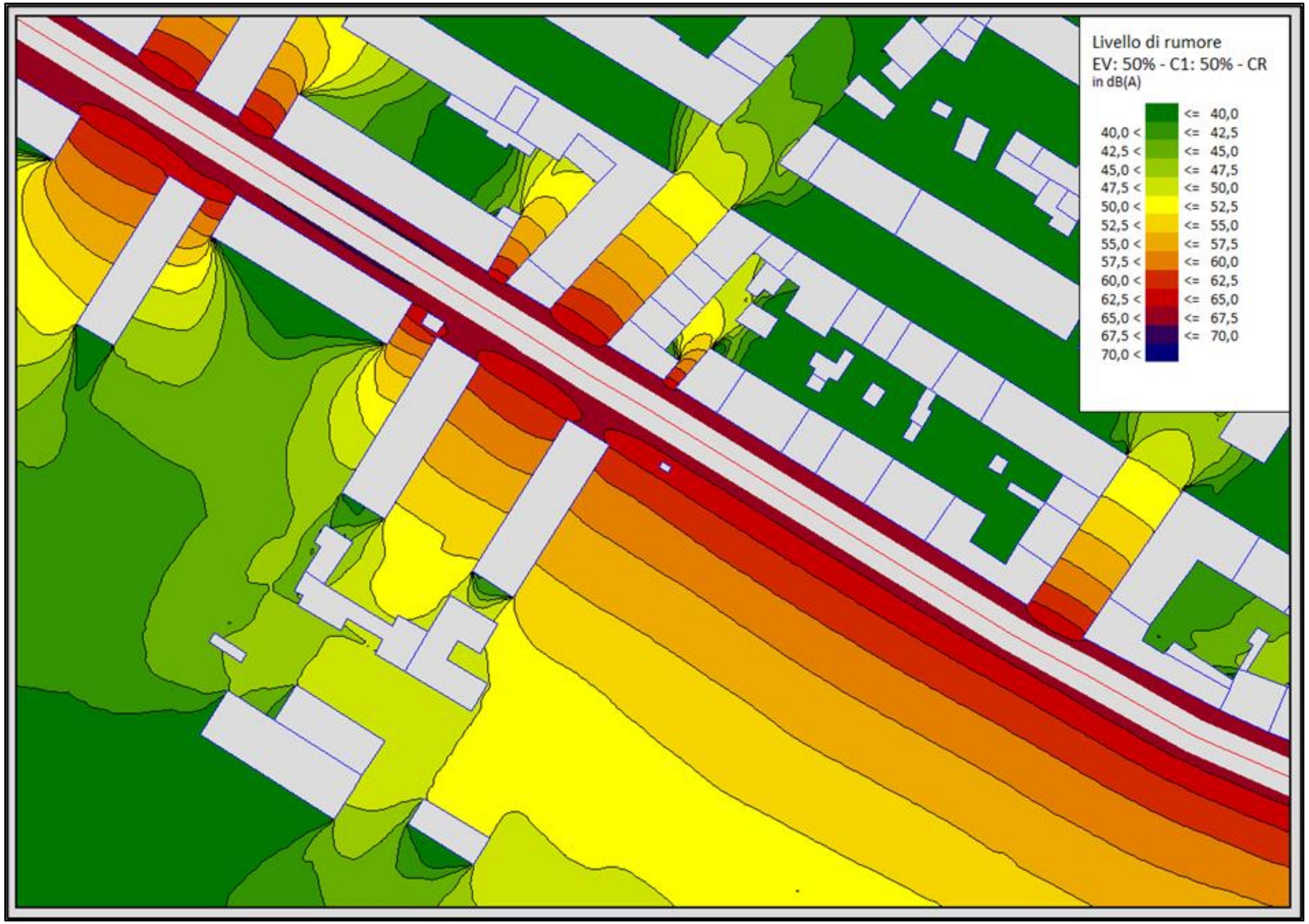

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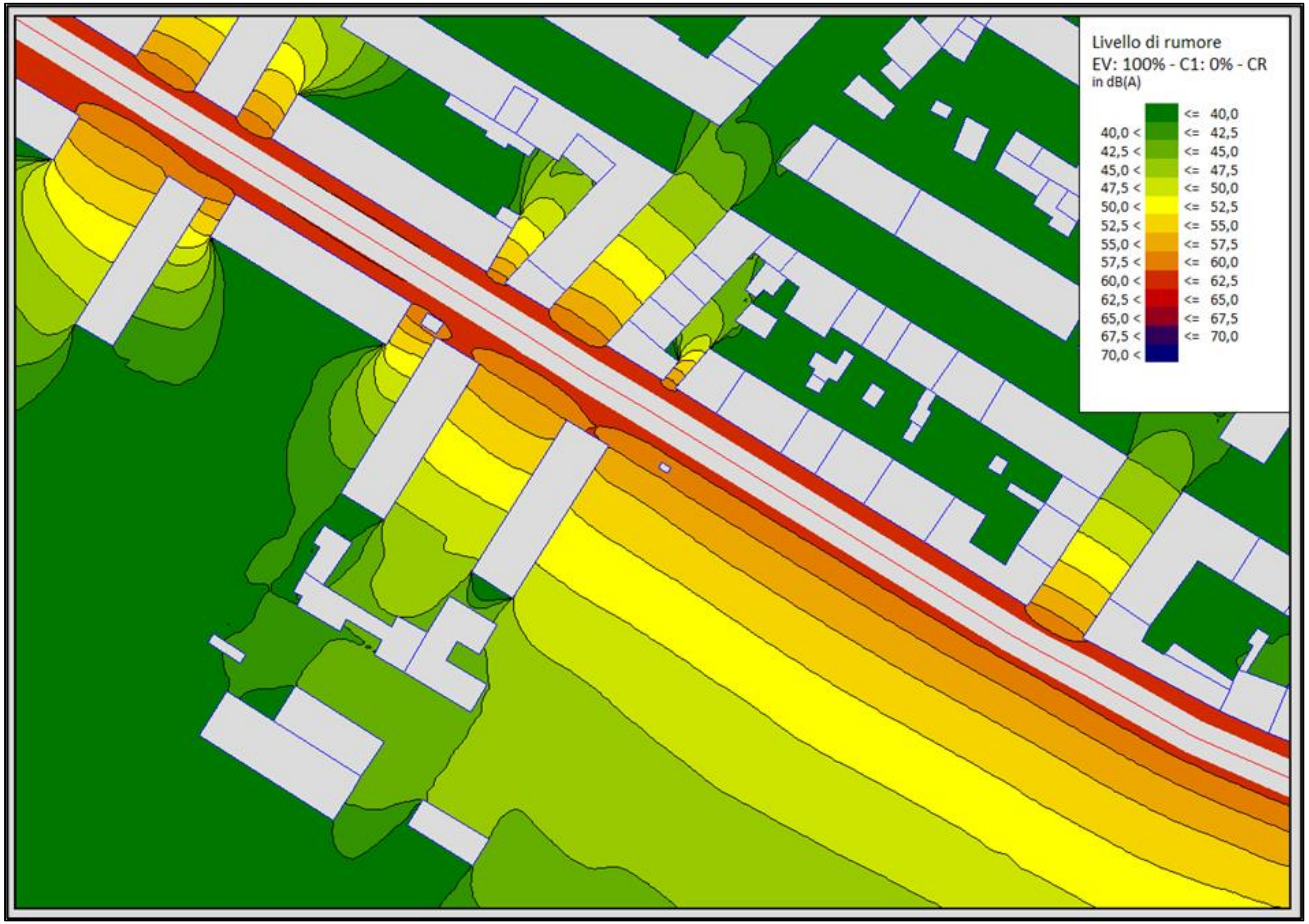

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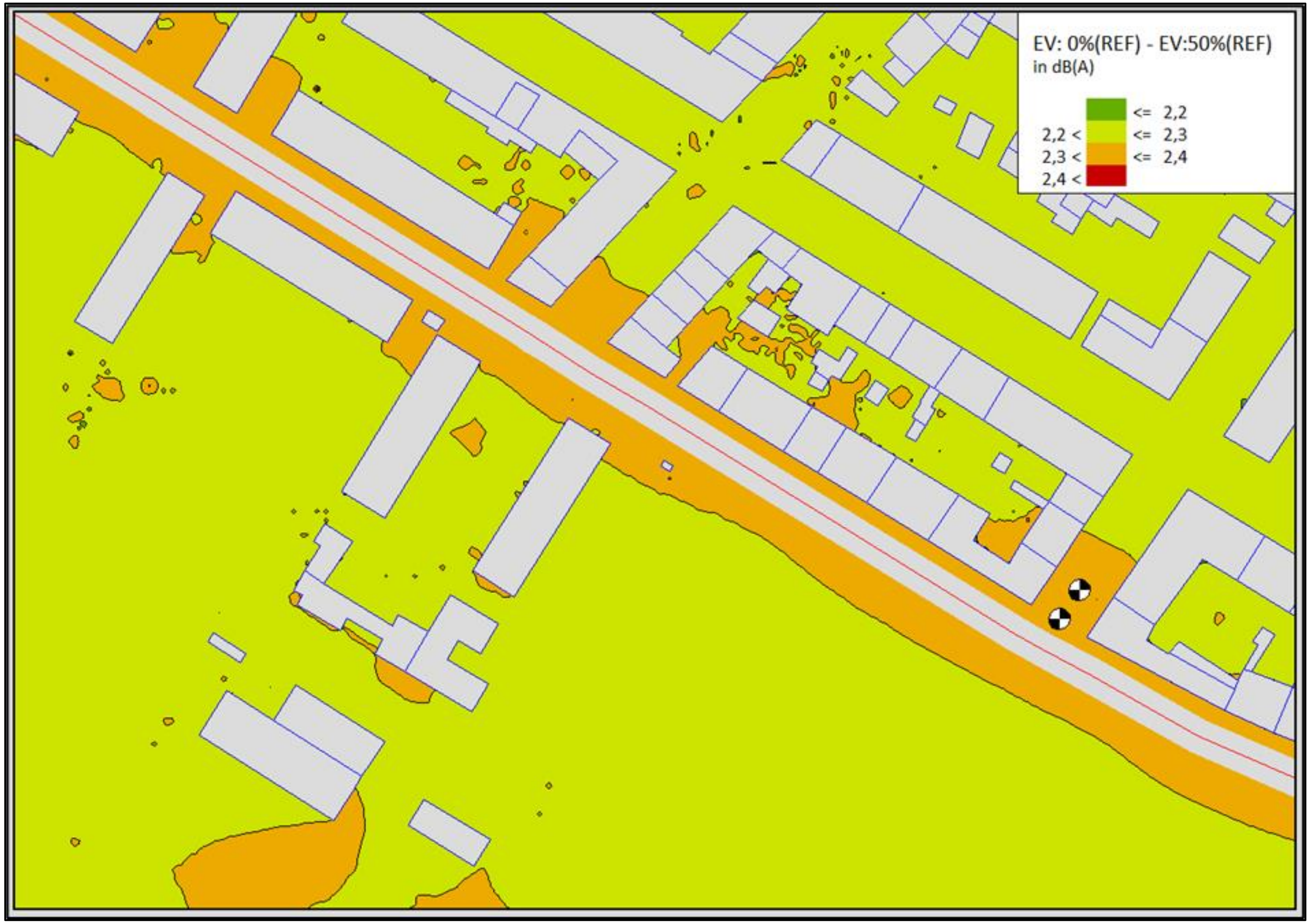

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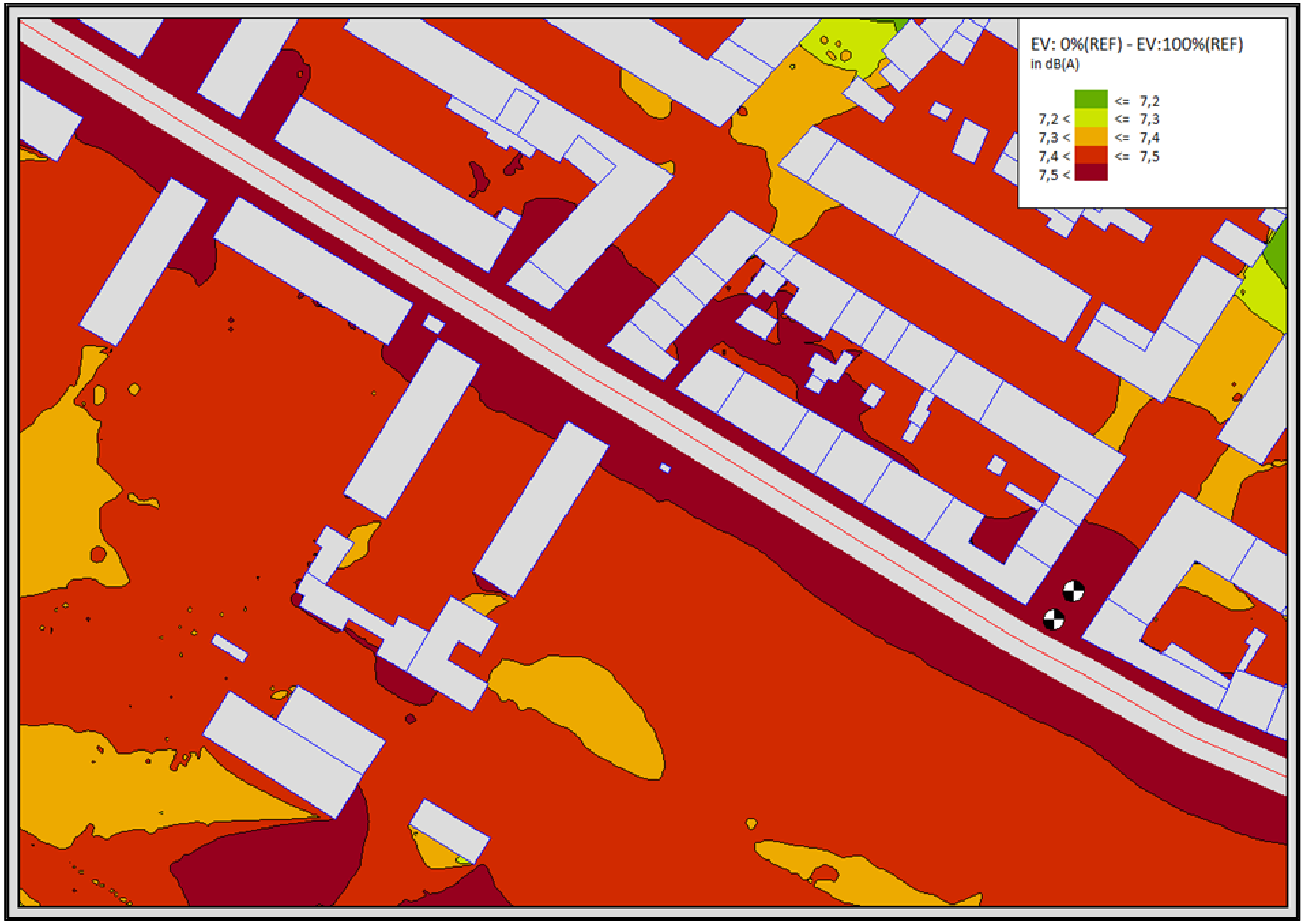

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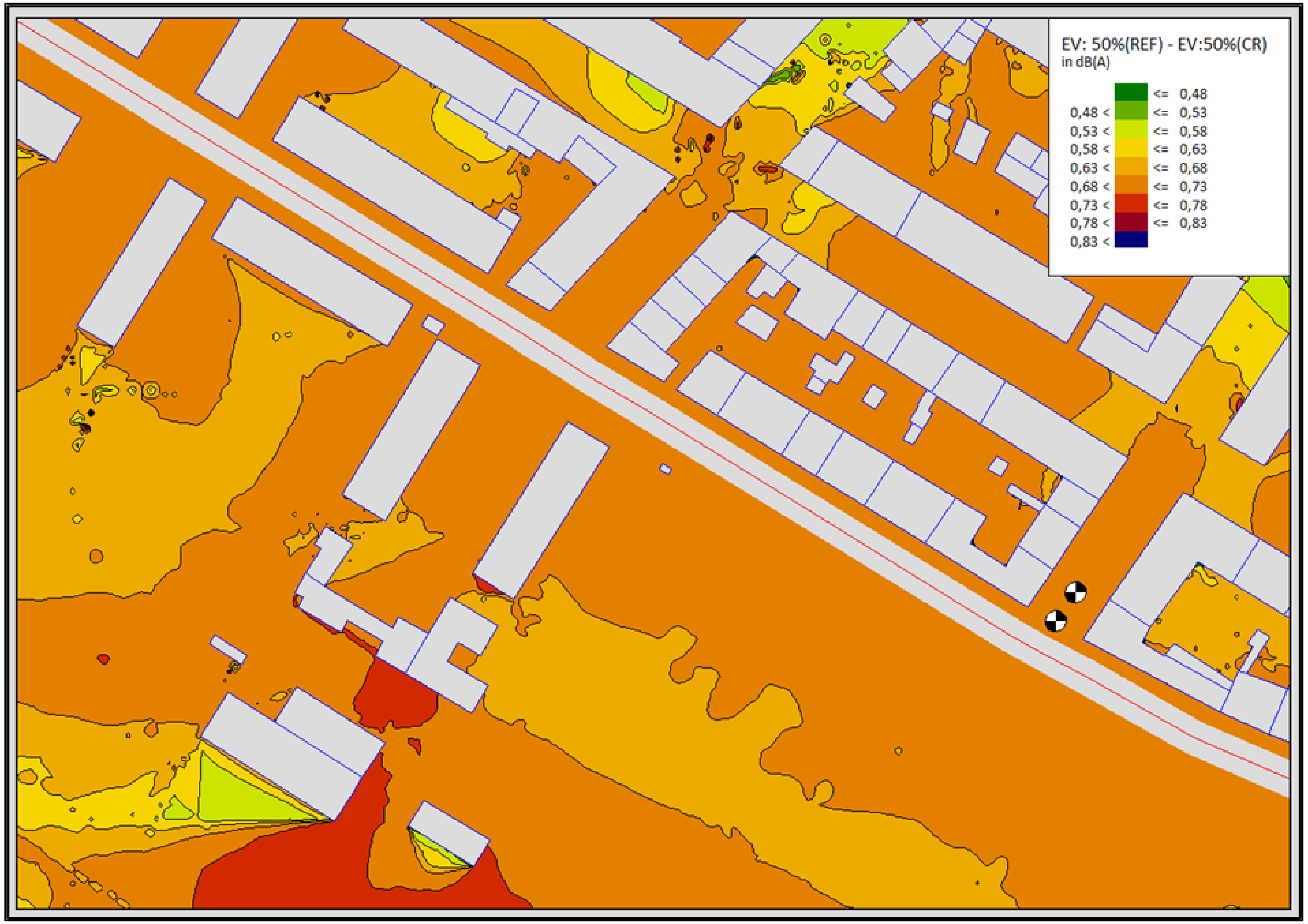


LIFE E-VIA

Electric **V**ehicle no**I**se control by **A**ssessment and optimisation of tyre/ road interaction

www.life-evia.eu

LIFE E-VIA PROJECT
Final event 7TH October 2022 – ExpoMove exhibition Firenze

Vienrose Ingegneria
Soundscape analysis

Noise measurements at the façade and dissemination impacts

Chiara Bartalucci

chiara.bartalucci@vienrose.it

With the contribution of the LIFE programme of the European Union

LIFE18 ENV/IT/000201

The three activities carried out by Vie en.ro.se partner that I am going to present today are:

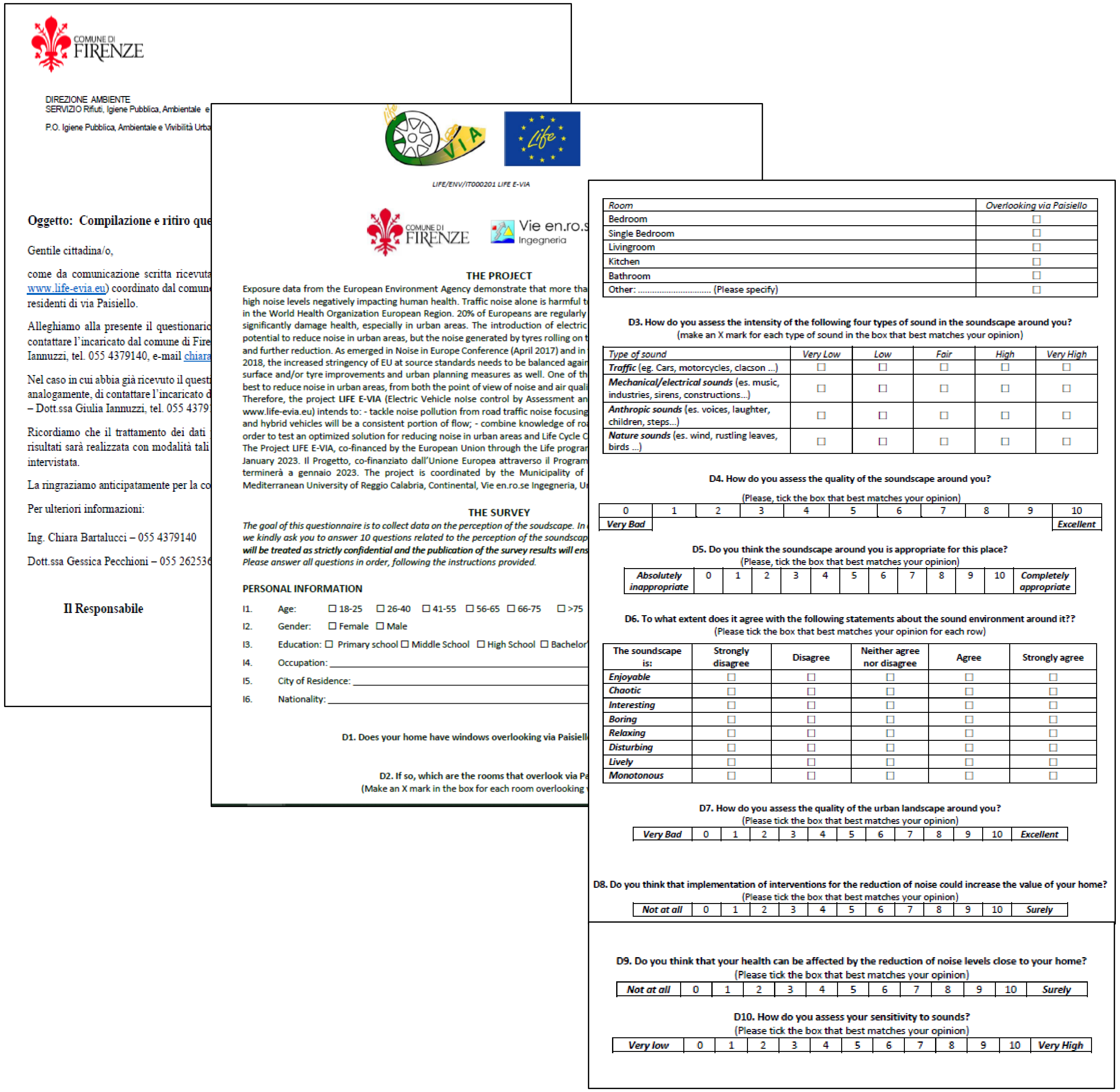
1) Ante and post-operam perceptive survey with residents close to the pilot area

2) Ante and post-operam noise measurements campaign at receivers

3) Dissemination impacts

ANTE AND POST-OPERAM PERCEPTIVE SURVEY

Informative letter and questionnaire – delivering modalities


COMUNE DI FIRENZE

DIREZIONE AMBIENTE
SERVIZIO Rifiuti, Igiene Pubblica, Ambientale e
P.O. Igiene Pubblica, Ambientale e Vivibilità Urba

Oggetto: Compilazione e ritiro que

Gentile cittadina/o,

come da comunicazione scritta ricevuta www.life-evia.eu) coordinato dal comun residenti di via Paisiello.

Alleghiamo alla presente il questionario contattare l'incaricato dal comune di Fire Iannuzzi, tel. 055 4379140, e-mail chiara

Nel caso in cui abbia già ricevuto il quest analogamente, di contattare l'incaricato d – Dott.ssa Giulia Iannuzzi, tel. 055 4379

Ricordiamo che il trattamento dei dati risultati sarà realizzata con modalità tali intervistata.

La ringraziamo anticipatamente per la co

Per ulteriori informazioni:

Ing. Chiara Bartalucci – 055 4379140

Dott.ssa Gessica Pecchioni – 055 26253

Il Responsabile

LIFE/ENV/IT000201 LIFE E-VIA

COMUNE DI FIRENZE — Vie en.ro.se Ingegneria

THE PROJECT

Exposure data from the European Environment Agency demonstrate that more tha high noise levels negatively impacting human health. Traffic noise alone is harmful t in the World Health Organization European Region. 20% of Europeans are regularly significantly damage health, especially in urban areas. The introduction of electric potential to reduce noise in urban areas, but the noise generated by tyres rolling on t and further reduction. As emerged in Noise in Europe Conference (April 2017) and in 2018, the increased stringency of EU at source standards needs to be balanced agai surface and/or tyre improvements and urban planning measures as well. One of th best to reduce noise in urban areas, from both the point of view of noise and air quali Therefore, the project LIFE E-VIA (Electric Vehicle noise control by Assessment an www.life-evia.eu) intends to: - tackle noise pollution from road traffic noise focusing and hybrid vehicles will be a consistent portion of flow; - combine knowledge of ro order to test an optimized solution for reducing noise in urban areas and Life Cycle C The Project LIFE E-VIA, co-financed by the European Union through the Life program January 2023. Il Progetto, co-finanziato dall'Unione Europea attraverso il Program terminerà a gennaio 2023. The project is coordinated by the Municipality of Mediterranean University of Reggio Calabria, Continental, Vie en.ro.se Ingegneria, U

THE SURVEY

The goal of this questionnaire is to collect data on the perception of the soudscape. In we kindly ask you to answer 10 questions related to the perception of the soundscap will be treated as strictly confidential and the publication of the survey results will ens Please answer all questions in order, following the instructions provided.

PERSONAL INFORMATION

I1. Age: ☐ 18-25 ☐ 26-40 ☐ 41-55 ☐ 56-65 ☐ 66-75 ☐ >75
I2. Gender: ☐ Female ☐ Male
I3. Education: ☐ Primary school ☐ Middle School ☐ High School ☐ Bachelor
I4. Occupation:
I5. City of Residence:
I6. Nationality:

D1. Does your home have windows overlooking via Paisiell

D2. If so, which are the rooms that overlook via Pa
(Make an X mark in the box for each room overlooking

Room	Overlooking via Paisiello
Bedroom	☐
Single Bedroom	☐
Livingroom	☐
Kitchen	☐
Bathroom	☐
Other: .... (Please specify)	☐

D3. How do you assess the intensity of the following four types of sound in the soundscape around you?
(make an X mark for each type of sound in the box that best matches your opinion)

Type of sound	Very Low	Low	Fair	High	Very High
Traffic (eg. Cars, motorcycles, clacson ...)	☐	☐	☐	☐	☐
Mechanical/electrical sounds (es. music, industries, sirens, constructions...)	☐	☐	☐	☐	☐
Anthropic sounds (es. voices, laughter, children, steps...)	☐	☐	☐	☐	☐
Nature sounds (es. wind, rustling leaves, birds ...)	☐	☐	☐	☐	☐

D4. How do you assess the quality of the soundscape around you?
(Please, tick the box that best matches your opinion)

0	1	2	3	4	5	6	7	8	9	10
Very Bad										Excellent

D5. Do you think the soundscape around you is appropriate for this place?
(Please, tick the box that best matches your opinion)

Absolutely inappropriate	0	1	2	3	4	5	6	7	8	9	10	Completely appropriate

D6. To what extent does it agree with the following statements about the sound environment around it??
(Please tick the box that best matches your opinion for each row)

The soundscape is:	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Enjoyable	☐	☐	☐	☐	☐
Chaotic	☐	☐	☐	☐	☐
Interesting	☐	☐	☐	☐	☐
Boring	☐	☐	☐	☐	☐
Relaxing	☐	☐	☐	☐	☐
Disturbing	☐	☐	☐	☐	☐
Lively	☐	☐	☐	☐	☐
Monotonous	☐	☐	☐	☐	☐

D7. How do you assess the quality of the urban landscape around you?
(Please tick the box that best matches your opinion)

Very Bad	0	1	2	3	4	5	6	7	8	9	10	Excellent

D8. Do you think that implementation of interventions for the reduction of noise could increase the value of your home?
(Please tick the box that best matches your opinion)

Not at all	0	1	2	3	4	5	6	7	8	9	10	Surely

D9. Do you think that your health can be affected by the reduction of noise levels close to your home?
(Please tick the box that best matches your opinion)

Not at all	0	1	2	3	4	5	6	7	8	9	10	Surely

D10. How do you assess your sensitivity to sounds?
(Please tick the box that best matches your opinion)

Very low	0	1	2	3	4	5	6	7	8	9	10	Very High

A couple of days before the questionnaires' delivering, an informative letter has been provided to residents.

Informative letters and questionnaires have been delivered directly in the residents' mailbox; questionnaires have been collected in the same way after filling.

Ante-operam questionnaire’s structure

Section	Question	Question code
Personal Data	Age	I1
	Gender	I2
	Education	I3
	Occupation	I4
	City of residence	I5
	Nationality	I6
Dwelling Information	Windows orientation	D1
	Rooms with windows on Paisiello street	D2
Perception of Soundscape and Landscape	Intensity of sounds	D3
	Quality of soundscape	D4
	Appropriateness of soundscape	D5
	Characteristics of soundscape	D6
	Quality of urban landscape	D7
Expected effects of planned interventions	Effects on home value	D8
	Effects of noise reduction on health	D9
Sensitivity to noise	Personal sensitivity to noise	D10

COMUNE DI FIRENZE

DIREZIONE AMBIENTE
SERVIZIO Rifiuti, Igiene Pubblica, Ambientale e del Territorio

P.O. Igiene Pubblica, Ambientale e Vivibilità Urbana

Firenze, 20 settembre 2021

Oggetto: Compilazione e ritiro questionario post-operam progetto LIFE E-VIA

Gentile cittadina/o,

come da comunicazione scritta ricevuta lo scorso 5 luglio, nell’ambito del progetto europeo LIFE E-VIA – www.life-evia.eu) coordinato dal comune di Firenze, è in corso un’indagine sulla percezione del rumore rivolta ai residenti di via Paisiello.

In aggiunta al questionario da lei gentilmente compilato a luglio prima che venisse realizzata la stesa di un asfalto ottimizzato per la riduzione del rumore in un tratto di Via Paisiello, le chiediamo cortesemente di compilare un nuovo breve questionario che alleghiamo alla presente.

Per qualsiasi dubbio riguardo alla compilazione può contattare l’incaricato dal comune di Firenze e da Vie en.ro.se Ingegneria (Ing. Chiara Bartalucci e-mail chiara.bartalucci@vienrose.it – Dott.ssa Giulia Iannuzzi e-mail giulia.iannuzzi@vienrose.it, tel. 055 4379140).

Una volta compilato da lei ed eventualmente dai suoi familiari, le chiediamo gentilmente di lasciare i/il questionari/o nella cassetta delle lettere dell’impianto sportivo M. Pacini dell’A.S.D.L.F. Firenze Calcio, in via Paisiello 15r, entro il 28/09/2021.

Ricordiamo che il trattamento dei dati personali avverrà in modo riservato e la successiva pubblicazione dei risultati sarà realizzata con modalità tali da non consentire la riconducibilità delle risposte espresse alla persona intervistata.

La ringraziamo anticipatamente per la cortese e preziosa collaborazione.

LIFE/ENV/IT000201 LIFE E-VIA
Progetto co-finanziato dalla Commissione Europea nell’ambito del Programma LIFE+2018.

COMUNE DI FIRENZE — Vie en.ro.se. Ingegneria

THE PROJECT

Exposure data from the European Environment Agency demonstrate that more than 100 million EU citizens are affected by high noise levels negatively impacting human health. Traffic noise alone is harmful to the health of almost every third person in the World Health Organization European Region. 20% of Europeans are regularly exposed to night sound levels that could significantly damage health, especially in urban areas. The introduction of electric mobility is widely viewed as having the potential to reduce noise in urban areas, but the noise generated by tyres rolling on the road nevertheless needs careful study and further reduction. As emerged in Noise in Europe Conference (April 2017) and in the WHO guidelines published in October 2018, the increased stringency of EU at source standards needs to be balanced against other effective measures such as road surface and/or tyre improvements and urban planning measures as well. One of the solutions universally recognized as the best to reduce noise in urban areas, from both the point of view of noise and air quality, is the introduction of electric mobility. Therefore, the project **LIFE E-VIA** (Electric Vehicle noIse control by Assessment and optimization of tyre/road interaction– www.life-evia.eu) intends to: - tackle noise pollution from road traffic noise focusing on a future perspective in which electric and hybrid vehicles will be a consistent portion of flow; - combine knowledge of road optimization and tyre development in order to test an optimized solution for reducing noise in urban areas and Life Cycle Cost with respect to actual best practices . The Project LIFE E-VIA, co-financed by the European Union through the Life programme, started in July 2019 and will end in January 2023. Il Progetto, co-finanziato dall’Unione Europea attraverso il Programma LIFE, ha avuto inizio a luglio 2019 e terminerà a gennaio 2023. The project is coordinated by the Municipality of Florence and involves as partners the Mediterranean University of Reggio Calabria, Continental, Vie en.ro.se Ingegneria, University Gustave Eiffel and I-POOL.

THE SURVEY

The goal of this questionnaire is to collect data on the perception of the soudscape. In addition to some initial general questions, ***we kindly ask you to answer 10 questions related to the perception of the soundscape close to your home. Your personal data*** *will be treated as strictly confidential and the publication of the survey results will ensure the non-recognition of the responses. Please answer all questions in order, following the instructions provided.*

PERSONAL INFORMATION

I1. Age: ☐ 18-25 ☐ 26-40 ☐ 41-55 ☐ 56-65 ☐ 66-75 ☐ >75

I2. Gender: ☐ Female ☐ Male

I3. Education: ☐ Primary school ☐ Middle School ☐ High School ☐ Bachelor’s Degree ☐ Ph.D. ☐ Master

I4. Occupation: ______________________________

I5. City of Residence: ______________________________

I6. Nationality: ______________________________

D1. Does your home have windows overlooking via Paisiello? ☐ No ☐ Yes

D2. If so, which are the rooms that overlook via Paisiello?
(Make an X mark in the box for each room overlooking via Paisiello)

LIFE18 ENV/IT/000201
LIFE E-VIA PROJECT final event
7 October 2022 - Vie en.ro.se Ingegneria

Post-operam questionnaire’s structure

Section	Question	Question code
Personal Data	Age	I1
	Gender	I2
	Education	I3
	Occupation	I4
	City of residence	I5
	Nationality	I6
Dwelling Information	Windows orientation	D1
	Rooms with windows on Paisiello street	D2
Perception of Soundscape and Landscape	Intensity of sounds	D3
	Quality of soundscape	D4
	Appropriateness of soundscape	D5
	Characteristics of soundscape	D6
	Quality of urban landscape	D7
Traffic Noise	Perceived changes in traffic noise	D8
Effects of realised interventions	Effects on traffic sounds	D9
	Effects of on property value	D10
	Effects on personal health	D11
Sensitivity to noise	Personal sensitivity to noise	D12

Room	*Overlooking via Paisiello*
Bedroom	☐
Single Bedroom	☐
Livingroom	☐
Kitchen	☐
Bathroom	☐
Other: .... (Please specify)	☐

D3. How do you assess the intensity of the following four types of sound in the soundscape around you?
(make an X mark for each type of sound in the box that best matches your opinion)

Type of sound	*Very Low*	*Low*	*Fair*	*High*	*Very High*
Traffic (eg. Cars, motorcycles, clacson ...)	☐	☐	☐	☐	☐
Mechanical/electrical sounds (es. music, industries, sirens, constructions...)	☐	☐	☐	☐	☐
Anthropic sounds (es. voices, laughter, children, steps...)	☐	☐	☐	☐	☐
Nature sounds (es. wind, rustling leaves, birds ...)	☐	☐	☐	☐	☐

D4. How do you assess the quality of the soundscape around you?
(Please, tick the box that best matches your opinion)

0	1	2	3	4	5	6	7	8	9	10
Very Bad										*Excellent*

D5. Do you think the soundscape around you is appropriate for this place?
(Please, tick the box that best matches your opinion)

Absolutely inappropriate	0	1	2	3	4	5	6	7	8	9	10	*Completely appropriate*

D6. To what extent does it agree with the following statements about the sound environment around it??
(Please tick the box that best matches your opinion for each row)

The soundscape is:	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Enjoyable	☐	☐	☐	☐	☐
Chaotic	☐	☐	☐	☐	☐
Interesting	☐	☐	☐	☐	☐
Boring	☐	☐	☐	☐	☐
Relaxing	☐	☐	☐	☐	☐
Disturbing	☐	☐	☐	☐	☐
Lively	☐	☐	☐	☐	☐
Monotonous	☐	☐	☐	☐	☐

D7. How do you assess the quality of the urban landscape around you?
(Please tick the box that best matches your opinion)

D8. To what extent has the noise of traffic you perceived changed in the past months?
(Please tick the box that best matches your opinion)

Increased					*Stable*	*Decreased*				
Very much		fairly		slightly		Slightly		Fairly		Very much
0	1	2	3	4	5	6	7	8	9	10

D9. How do you assess the effects of the re-paving of via Paisiello with the new asphalt on the traffic sound you perceive from your home?
(Please tick the box that best matches your opinion)

Negative					*Irrelevant*	*Positive*				
Very much		fairly		slightly		Poco		Abbastanza		Molto
0	1	2	3	4	5	6	7	8	9	10

D10. Do you think that the implementation of a low-noise asphalt has increased the value of your home?
(Please tick the box that best matches your opinion)

Not at all	0	1	2	3	4	5	6	7	8	9	10	*Surely*

D11. Do you think that your health can be improved by the recent reduction of noise levels close to your home?
(Please tick the box that best matches your opinion)

Not at all	0	1	2	3	4	5	6	7	8	9	10	*Surely*

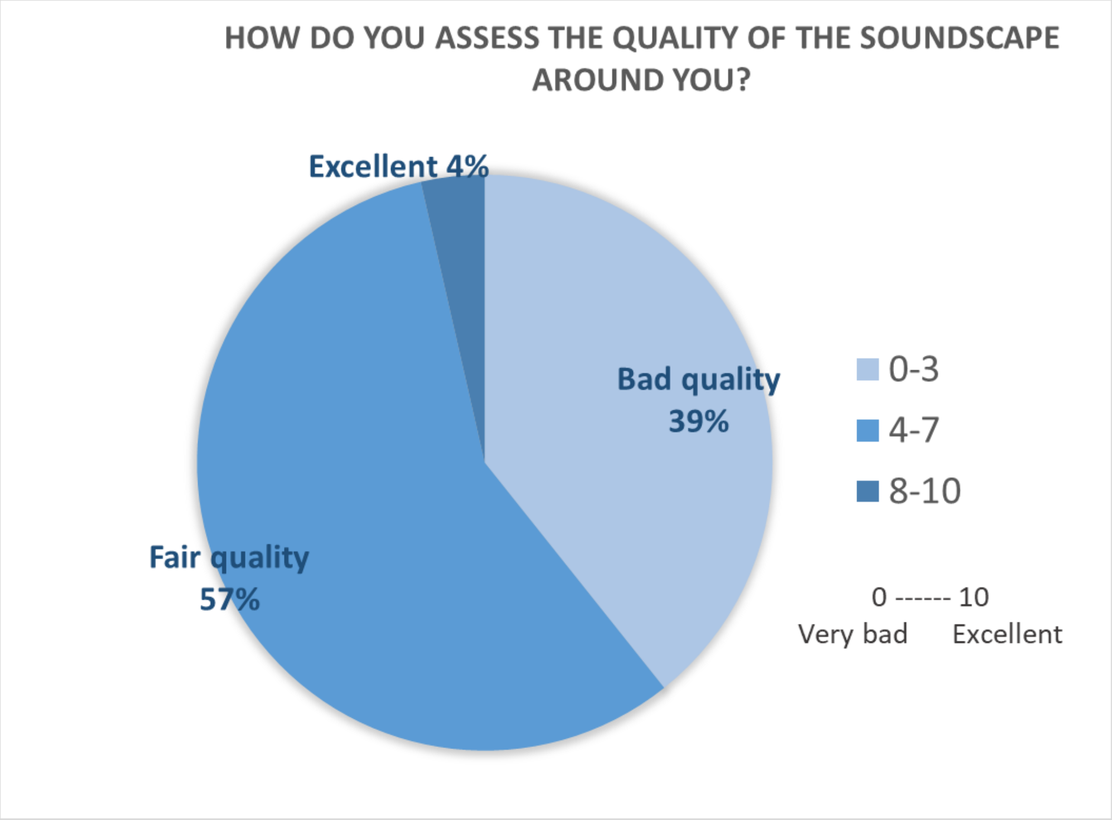
D12. How do you assess your sensitivity to sounds?
(Please tick the box that best matches your opinion)

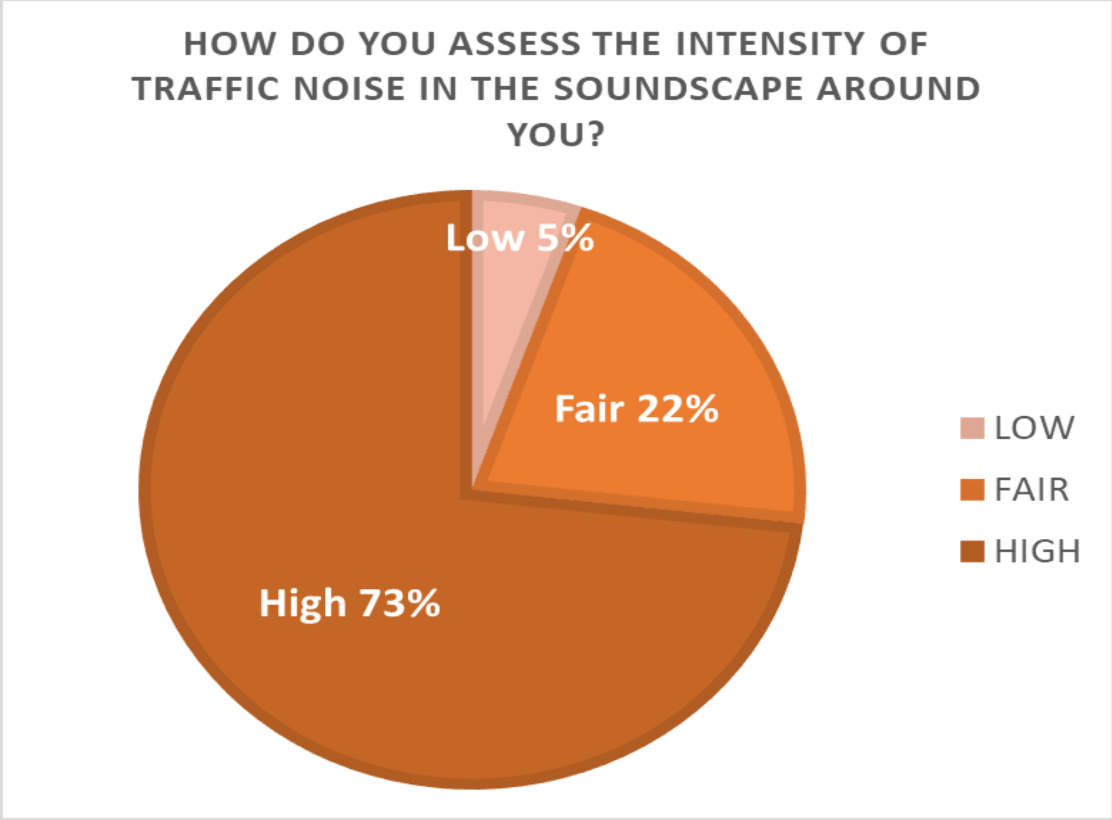
Very low	0	1	2	3	4	5	6	7	8	9	10	*Very High*

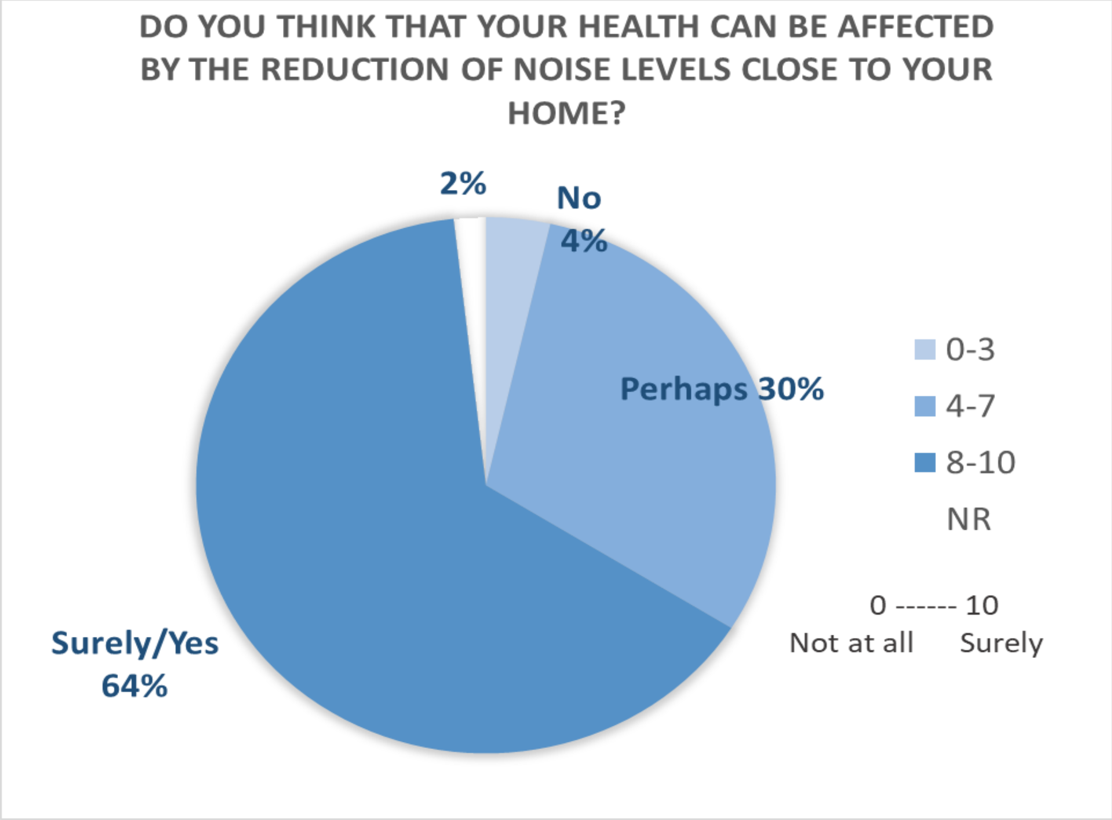
Collected questionnaires

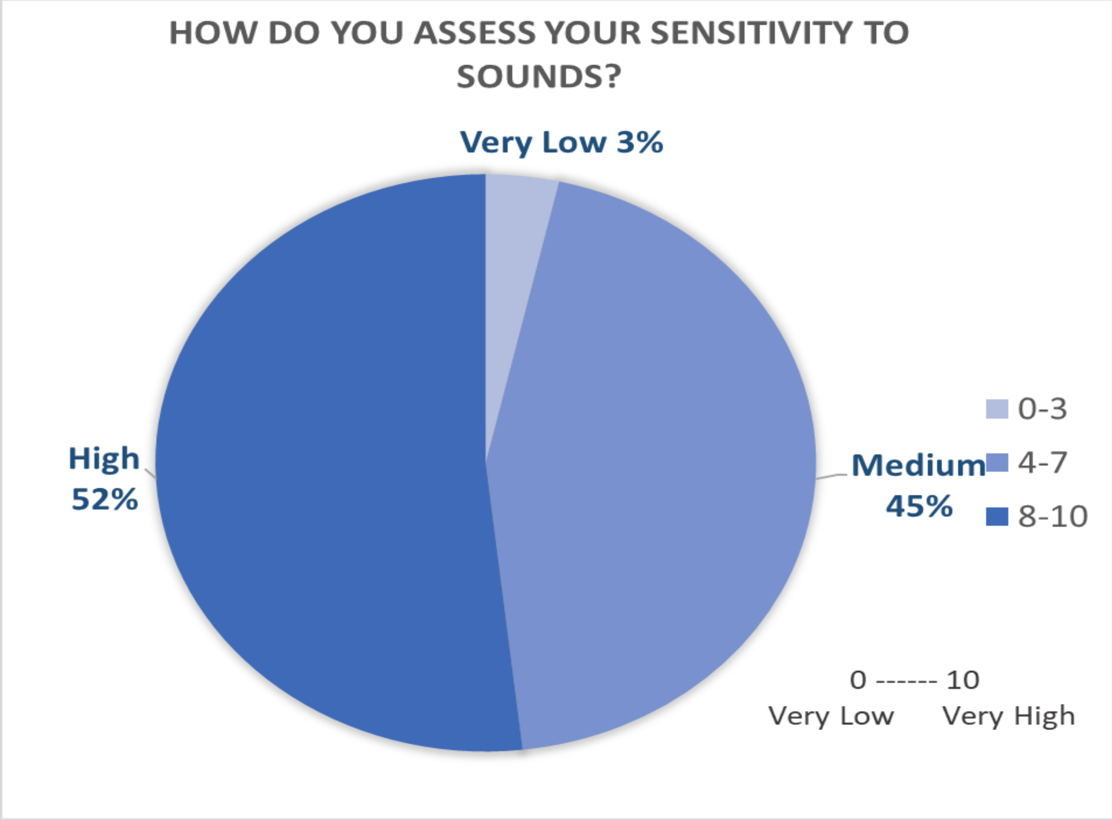
Ante-operam		Post-operam	
Delivered	Filled	Delivered	Filled
92	56	101	56

Ante-operam descriptive analysis

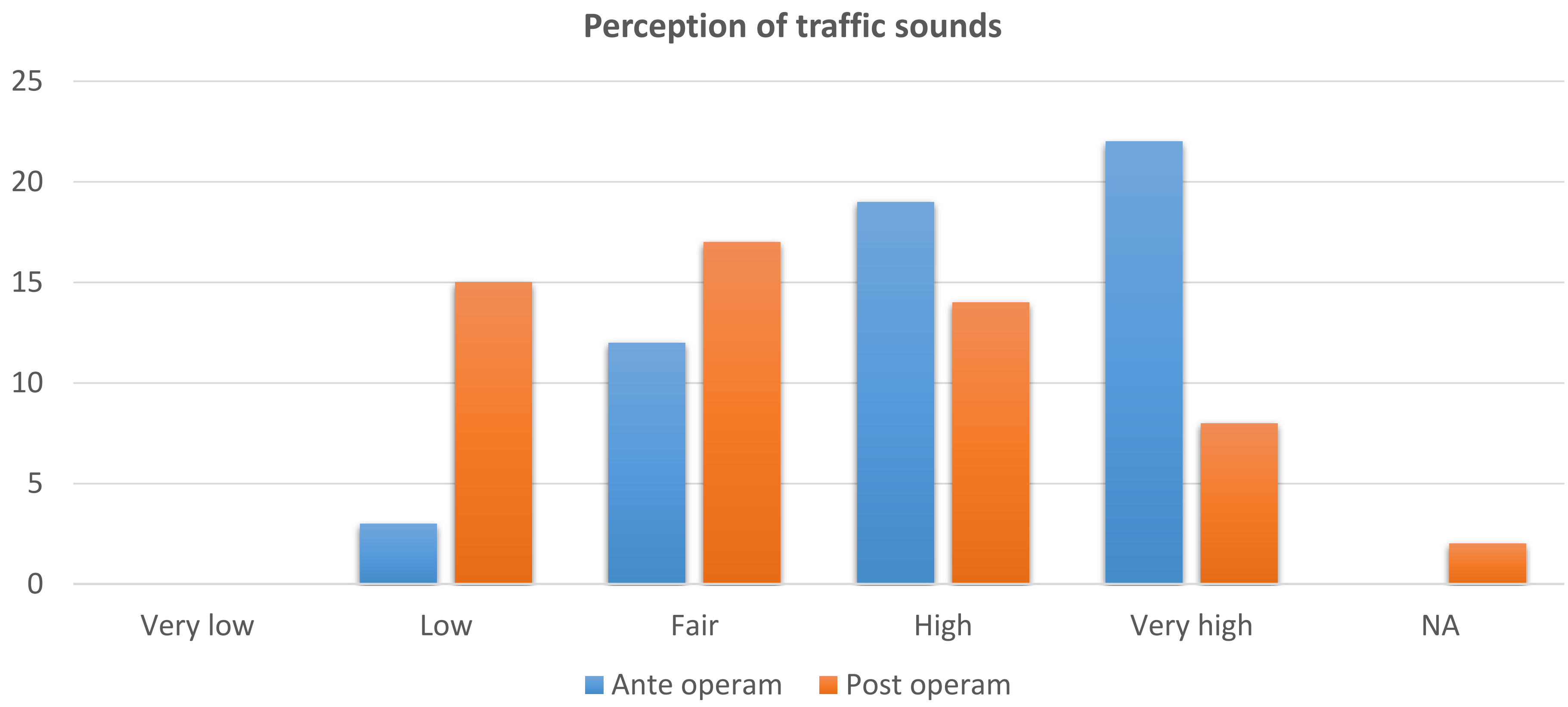


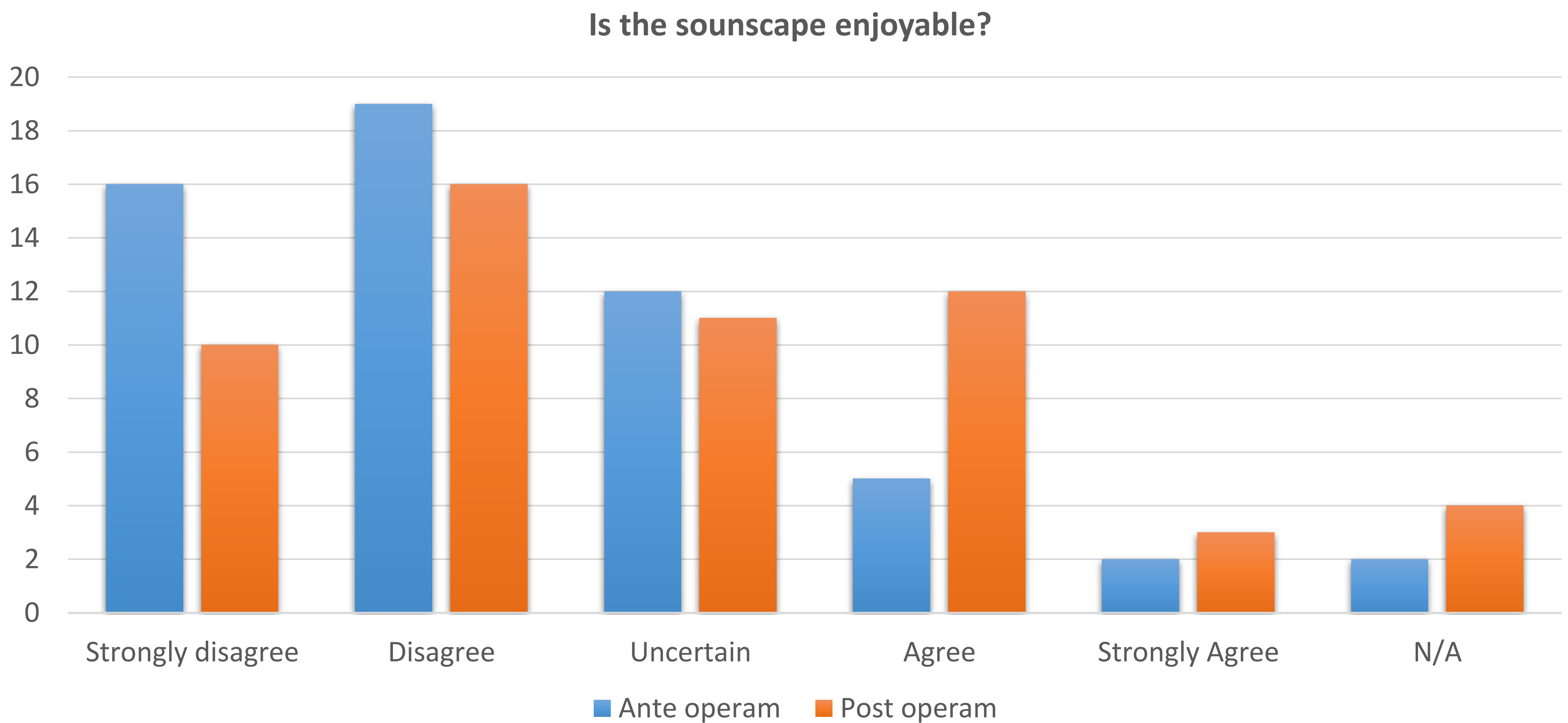




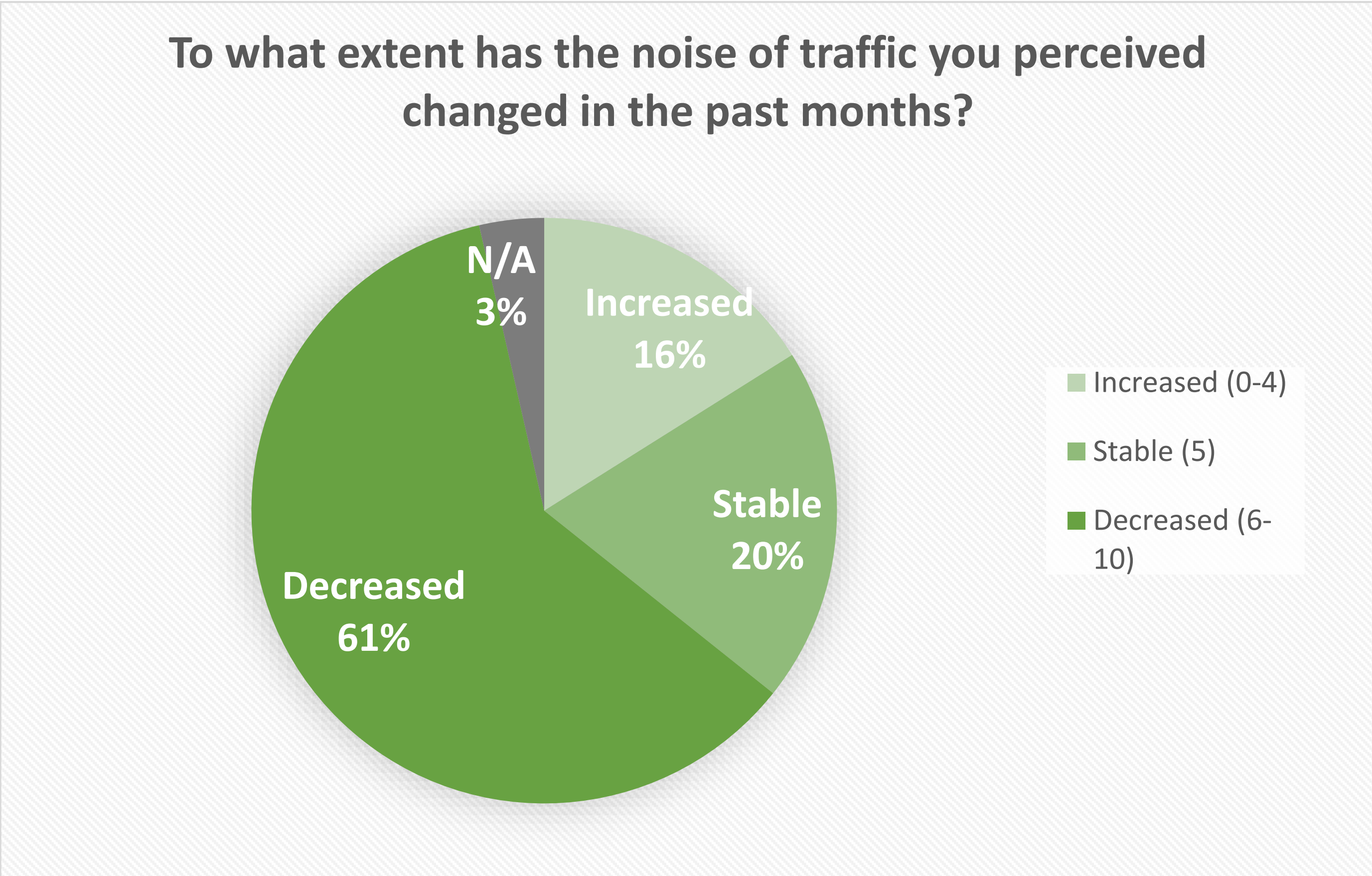


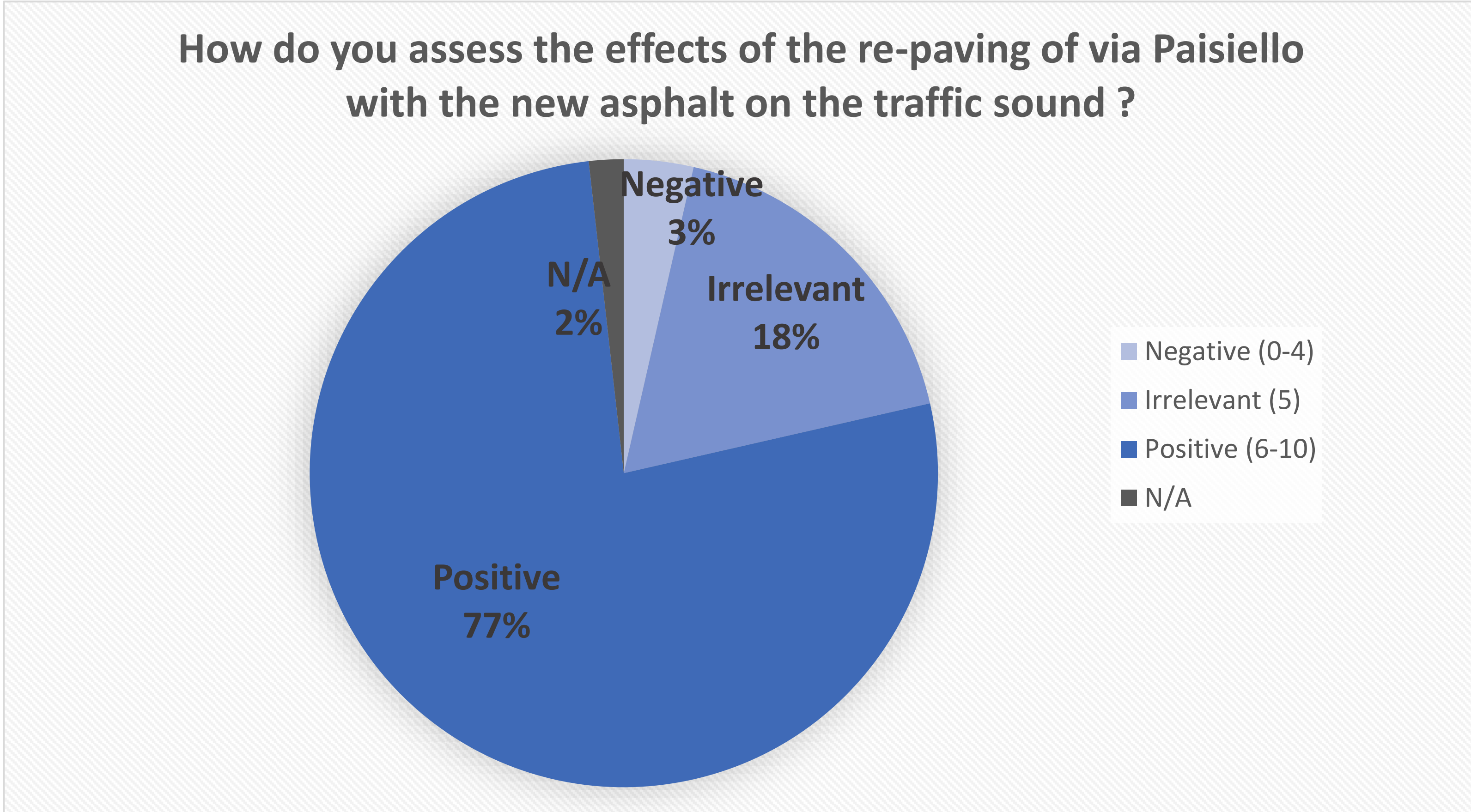
Comparison between ante and post-operam scenarios

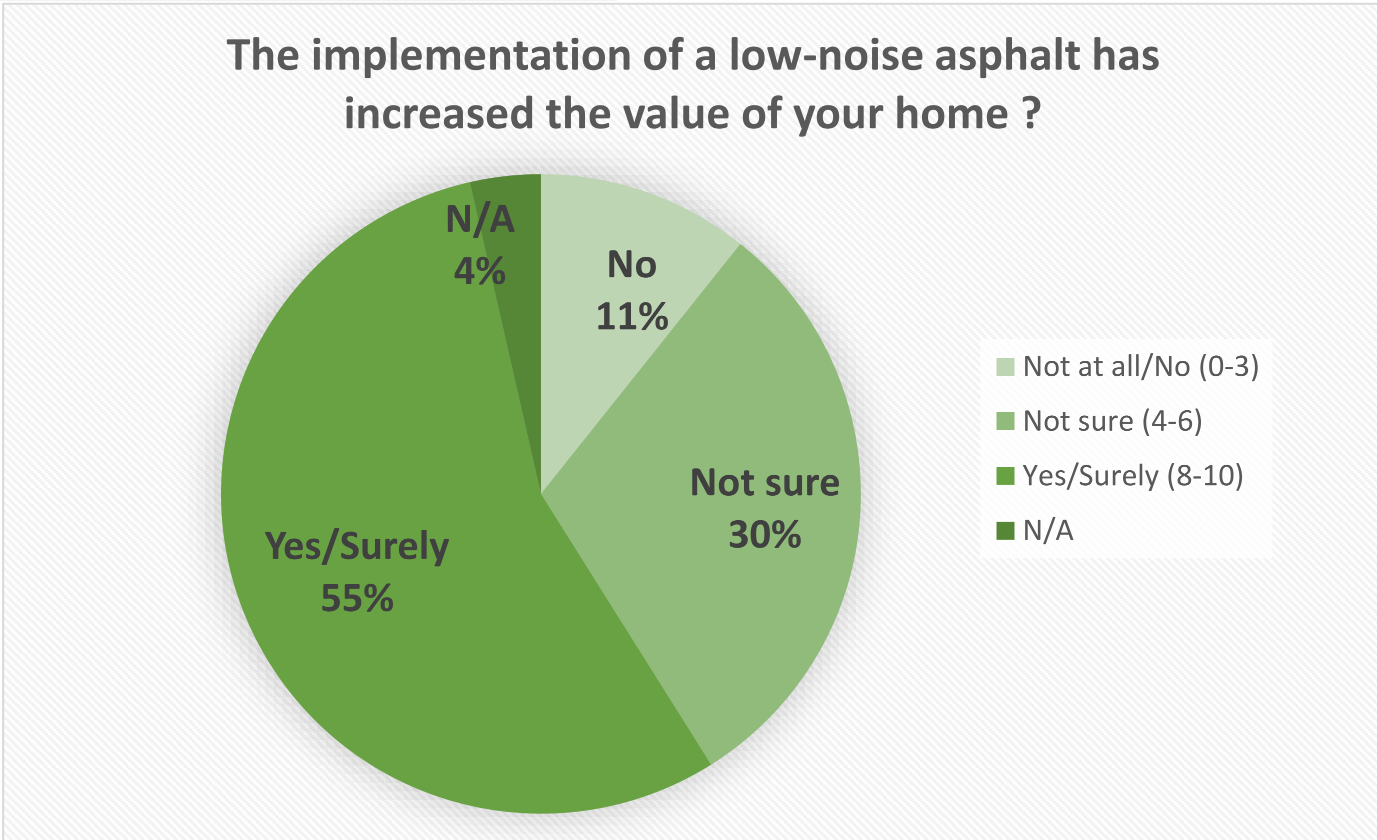




Comparison between ante and post-operam scenarios







Link between Pearson chi-square test and regression model

Variable		χ^2	DoF	p-value
Age		2.3173	5	0.8037
Gender		2.1455	3	0.5428
Education		4.3015	6	0.636
Occupation		7.3956	5	0.1928
Residency		1.1813	2	0.554
Nationality		2.1569	2	0.3401
Windows overlooking via Paisiello		2.7451	1*	0.09755
Rooms overlooking via Paisiello		1.2243	5	0.9425
Intensity of perceived sounds		0.63894	3	0.8875
Perception of traffic sounds		18.153	4*	0.001152
Perception of technological sounds		8.4923	5	0.1311
Perception of anthropic sounds		4.1765	5	0.5243
Perception of natural sounds		3.7271	4*	0.4442
Soundscape quality		11.889	3	0.007774
Soundscape congruence		10.5	3	0.01476
Soundscape attributes		13.709	7	0.0566
Soundscape	Enjoyable	5.4343	5	0.3652
	Chaotic	4.8532	5	0.4341
	Interesting	1.7825	4*	0.7757
	Boring	5.547	5	0.3528
	Relaxing	6.1182	4*	0.1905
	Disturbing	15.221	5	0.009457
	Lively	3.2017	5	0.6689
	Monotonuous	5.3131	5	0.3789
Landscape quality		1.4815	3	0.6865
Sound sensitivity		2.5753	3	0.4618

Pearson chi-square test: some variables turn out to be significantly dependent on situation (ante/post).

To better analyze whether the re-pavement has brought improvements in terms of perception of sounds we use the variable "**soundscape quality**", which is "sensitive" on situation, as dependent variable in a regression model.

With the use of **regression models** we can establish if there are relationships between the response variable ("soundscape quality") and other covariates relating to perceptions of sounds or characteristics of the surrounding environment in the ante/post intervention periods.

Ordinal logit model

$$logit(\text{"soundscape quality"}_{ci}) = \alpha_c - (\beta_1 * traffic\_sounds + \beta_2 * interesting\_soundscape + \beta_3 * nature\_sounds + \beta_4 * relaxing\_soundscape + \beta_5 * sensitivity\_sounds$$

qual_amb	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
traffico						
Unchanged	-7.047367	2.399337	-2.94	0.003	-11.74998	-2.344753
Yes	-8.004159	3.208891	-2.49	0.013	-14.29347	-1.714848
interessante						
Unchanged	5.320089	2.049402	2.60	0.009	1.303335	9.336843
Yes	1.914986	1.556173	1.23	0.218	-1.135057	4.96503
natura						
Unchanged	-.6013872	1.685393	-0.36	0.721	-3.904697	2.701922
Yes	9.055464	3.111493	2.91	0.004	2.957049	15.15388
rilassante						
Unchanged	4.754028	2.527349	1.88	0.060	-.1994857	9.707541
Yes	3.73245	2.311063	1.62	0.106	-.7971497	8.262049
sensibilita						
Unchanged	4.547256	2.190113	2.08	0.038	.2547141	8.839798
Yes	1.598098	1.349631	1.18	0.236	-1.047129	4.243325
/cut1	3.365244	2.201415			-.9494507	7.679939
/cut2	6.073346	2.42071			1.328842	10.81785

Results

- For the **traffic sounds** variable who did not vary the response between the two periods or who responded that they heard **less traffic in the post-intervention** period tended to give a **higher score on the soundscape quality** than those who found a worsening in the traffic perception.

- Instead for the **nature sounds** the model shows that who hear **more the sounds of nature in the post-intervention** period than those who hear them less tend to perceive a **better soundscape quality**.

- Looking at the characteristics of the "interesting" and "relaxing" environment, we notice that in the first case those who find the **environment interesting in the same way** in the two periods compared to those who find it less interesting tend to perceive a **better soundscape quality**. While for the "relaxing" characteristic, those who find the **relaxing environment in the same way or more relaxing in the second period** compared to who find the environment less relaxing tend to perceive a **higher soundscape quality**.

- Finally, those who responded that they were **sensitive to the environment in the same way** tend to perceive a **better soundscape quality** than those who were less sensitive in the second period.

ANTE AND POST-OPERAM NOISE MEASUREMENTS CAMPAIGN

Introduction

In order to obtain an objective basis for the citizens evaluation at a façade level, a **long-term** (2 weeks) ante and post- noise monitoring campaign has been carried out by VIENROSE and I-POOL partners.

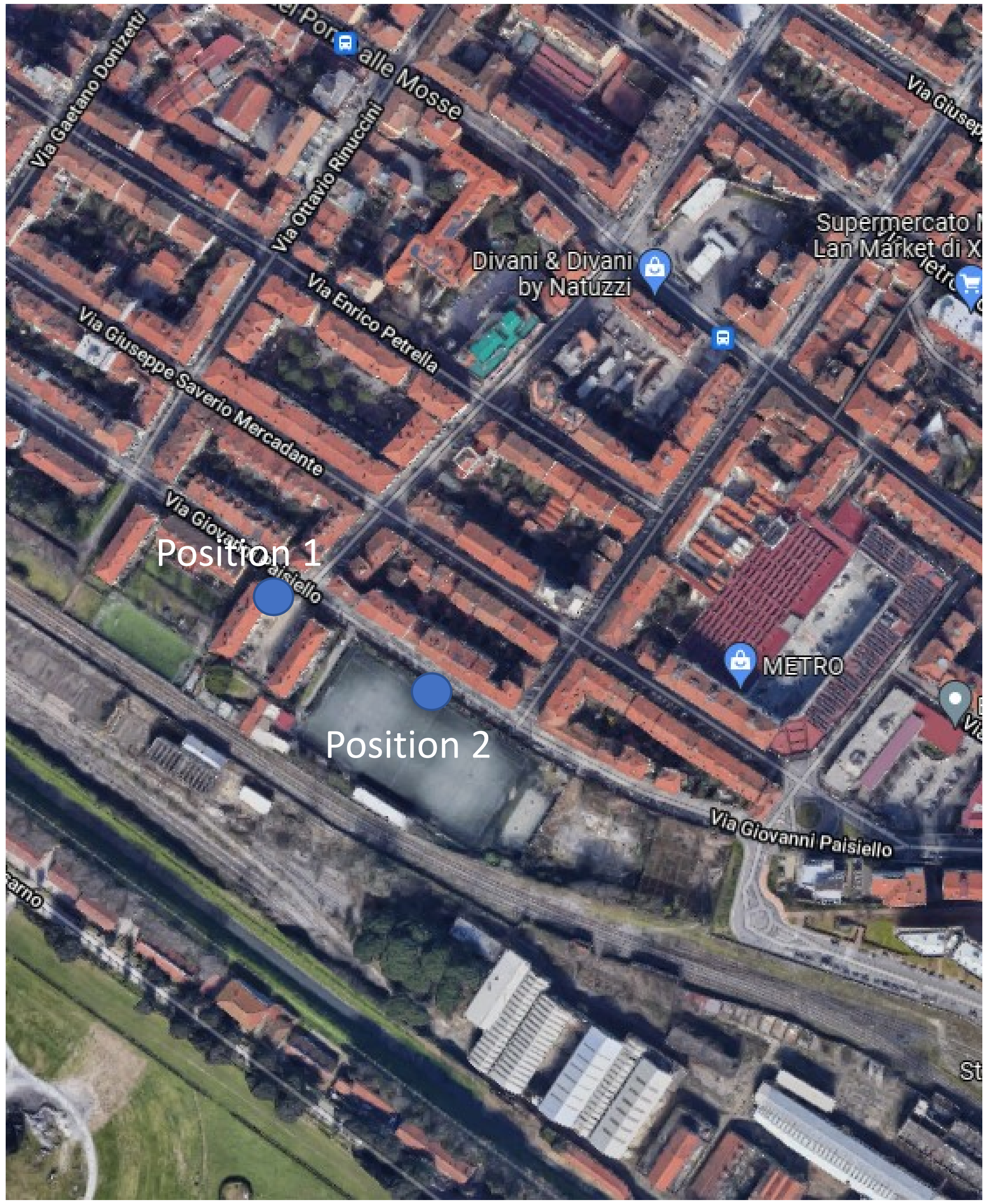
LIFE E-VIA asphalt

Standard asphalt

Introduction

2 monitoring positions have been defined: one in the road section interested by the LIFE E-VIA asphalt (150 m) and the other in the road section interested by the new but standard asphalt (150 m).

A **traffic counter** has been positioned on light poles both in the ante and post-operam phase in similar positions, in order to be able **to weight measured noise levels according to traffic flows in different periods**.



Results

For the two periods: rainy days have been excluded and 4 weekdays have been considered for the comparison; weight according to different traffic flows have been applied.

LIFE E-VIA asphalt		
	Lden	Lnight
Leq (ante-post)	3.4	4.4

New but standard asphalt		
	Lden	Lnight
Leq (ante-post)	0.2	1.5

DISSEMINATION IMPACTS

Website: 12.000 visits and >2.300 users

Social:

- Facebook, 265 sessions and 02:44 minutes as average visit duration
- LinkedIn, 99 sessions and 11:43 minutes as average visit duration

Articles: 26 scientific papers of which 18 presented during conferences (about 900 people reached)

Students directly addressed: 60

Brief articles on Italian magazines mainly concerning the pilot case: 22

Participants to the webinar dedicated to the LIFE E-VIA project (14/5/2021): 130

la Repubblica FIRENZE

04-APR-2021 da pag. 7 foglio 1 Superficie: 7 %

Dir. Resp.: Maurizio Molinari
Tiratura: 0 - Diffusione: 14521 - Lettori: 109000: da enti certificatori o autocertificati

Via Paisiello

L'esperimento dell'asfalto che riduce i rumori del traffico

Ridurre il rumore del traffico nelle strade urbane grazie a un nuovo asfalto a bassa emissione. È l'obiettivo del progetto Life E-Via, che vede Firenze città capofila e caso pilota per la sperimentazione: il nuovo asfalto sarà steso durante l'estate in via Paisiello a San Jacopino. Dopo i test sulle prestazioni, saranno individuate altre tre aree per la sperimentazione in città e poi per la diffusione in Italia e in Europa. «Grazie al progetto Life che come direzione Ambiente ci siamo aggiudicati lo scorso anno - spiega l'assessora all'Ambiente Cecilia Del Re - possiamo dare il via alla sperimentazione del nuovo asfalto anti rumore per contribuire a ridurre l'inquinamento acustico nelle aree urbane». «Partiamo da una viabilità da ripristinare e risanare - aggiunge l'assessore alla Mobilità Stefano Giorgetti - usando un asfalto che riduca i rumori provenienti dalla strada ottimizzando asfalto e pneumatici in virtù dei mezzi che transitano».

ARPAT NEWS

Martedì 30 marzo 2021

LIFE E-VIA: un progetto europeo per città meno rumorose

Tra gli obiettivi principali del progetto la riduzione del rumore da traffico stradale all'interno di aree urbane molto popolate attraverso l'ottimizzazione di superfici stradali e degli pneumatici dei veicoli elettrici. Il caso pilota sarà realizzato in una strada densamente abitata e trafficata della città di Firenze con la stesa di asfalto a bassa emissione di rumore e test legati alla durabilità dell'asfalto.

LIFE E-VIA

Electric **V**ehicle no**I**se control by **A**ssessment and optimisation of tyre/ road interaction

www.life-evia.eu

LIFE E-VIA PROJECT
Final event 7TH October 2022 – ExpoMove exhibition Firenze

Vienrose Ingegneria
Soundscape analysis
Noise measurements at the façade and dissemination impacts

Vie en.ro.se. Ingegneria

Chiara Bartalucci

chiara.bartalucci@vienrose.it

Comune di Firenze · Continental The Future in Motion · Université Gustave Eiffel · iPOOL · Università degli Studi Mediterranea di Reggio Calabria · Vie en.ro.se. Ingegneria

With the contribution of the LIFE programme of the European Union

LIFE18 ENV/IT/000201

Daniele Fornai

Technical Director

Ecopneus Scpa

Firenze, 07/10/2022

E-VIA LIFE Project

NEREiDE
Noise Efficiently REduced by recycleD pavements

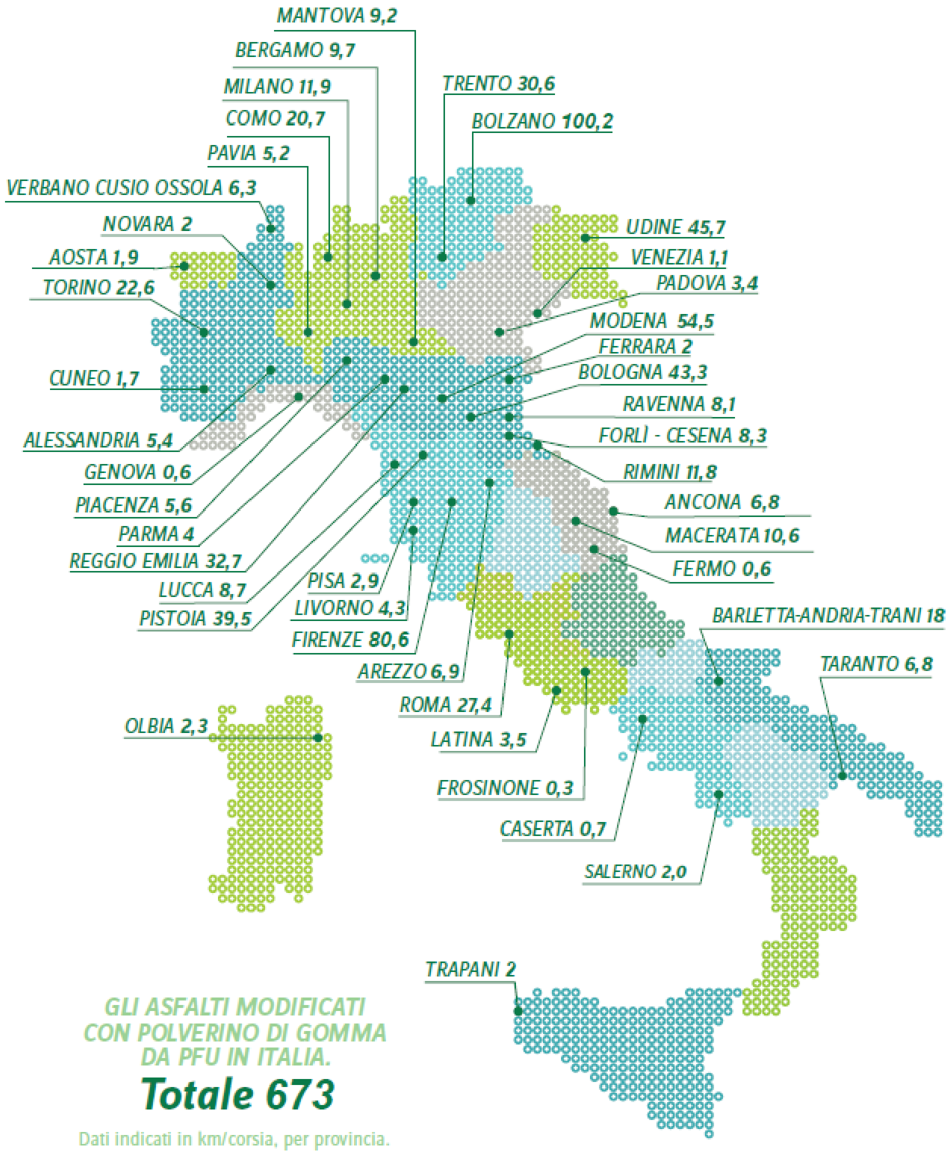
Ridurre efficacemente il rumore con pavimentazioni realizzate con materiali riciclati

Background

- In Italy (2021), only 30% of Reclaimed Asphalt Pavement is recycled, a poor result if compared to the European average (60%) or other virtuous countries (up to 98%).
- About 60% of the End-of-Life Tyres generated in Italy every year (ca. 350.000 ton) are co-incinerated as the market demand for recycled rubber is limited. Most of that “alternative fuel” is recovered in Turkish cement factories.

Background

- Since 2008, more than 670 km of Italian roads have been paved with rubberized asphalts (in Spain more than 7.000 km over the same period).
- Most of the time, rubberized asphalt was chosen to mitigate traffic noise.
- Asphalt Rubber (wet process) and a hybrid-dry technology are used most often.
- Low-noise asphalt layers do not use RAP in order to guarantee an adequate texture.



Objectives of the project

The aim of the NEREiDE project was to assess the **acoustic performance of innovative asphalt pavements,** specifically designed for reducing the traffic noise and characterized by a **high content of reclaimed asphalt pavement (RAP**) and **crumb rubber** recycled from End-of-Life Tyres (ELT).

The expected **goals**:

- to allow the **use of valuable materials** obtained from **waste recycling** (RAP, ELT) thus reducing the consumption of virgin materials (i.e., to promote resource efficiency and waste management);
- to achieve **acoustic performance** better than those currently available, allowing a **significant noise reduction in urban areas** and health improvement;
- **to improve safety** in urban areas by obtaining draining and appropriately textured surfaces;
- **to improve air pollution** and workers' exposure by means of **warm mix asphalt** technologies.

Results

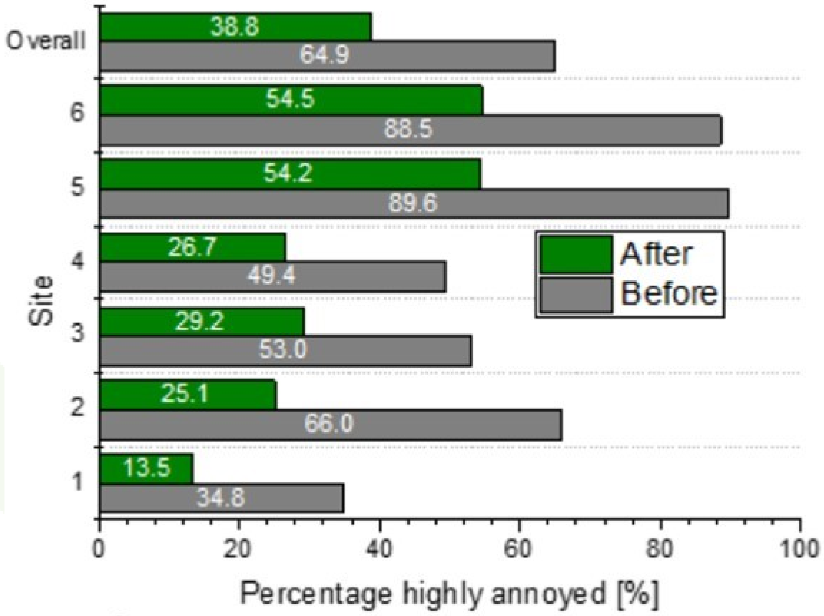
6 new wearing course mixes have been designed:

- ✓ OPEN, GAP and DENSE graded mixtures
- ✓ WET and HYBRID DRY mixes + Warm Mix Asphalt Technologies (**T ≤ 140°C**)
- ✓ Up to **25% of RAP** in wearing courses
- ✓ 42 tons of Crumb Rubber and 327 tons of RAP used in trials (ca. 4 km)
- ✓ **118.000 MJ saved** thanks to Warm Mix Asphalt
- ✓ Good and stable friction

Results

Comparing measures ANTE – POST mitigation actions, it results:

- ✓ **Lden** value measured on each site (each consisting of 6 different trials sections) is equal to **- 3.5 dB for site I and - 4.0 dB for site II**.
- ✓ In terms of disability-adjusted life years (DALY), the total **DALY is reduced by 4**.
- ✓ The psychoacoustic assessment carried out through interviews or questionnaires showed a general positive impact as a lowering of perceived noise.



– Comparison of the percentage of highly annoyed people (after and before)

Results

Other environmental benefits:

- ✓ The Life Cycle Assessment (LCA) showed that the simultaneous implementation of warm asphalt technologies and recycled materials can lead to a **50% reduction** of the environmental burdens, compared to the standard scenario (conventional Hot Mix Asphalt).

- ✓ The use of Warm Mix Asphalt allowed **30% reduction** of the workers' exposure to PAHs and other harmful substances usually present in asphalt's fumes.

A «bonus-outcome»

- In July 2019, an experimental noise requalification plan was coordinated by ANAS and the asphalt mixes developed by NEREiDE and LEOPOLDO projects were tested.
- Thanks to the excellent results of the trials, ANAS introduced two "low-noise rubberized asphalt mixes" into their Technical Specifications:

"one giant leap towards a more circular economy!"

Thank you for the attention!

Daniele Fornai
d.fornai@ecopneus.it

ECOPNEUS

LIFE E-VIA PROJECT

Final event 7th October 2022 – ExpoMove exhibition

Fortezza da Basso, Florence

LIFE SNEAK PROJECT

“OPTIMIZED SURFACES AGAINST NOISE AND VIBRATIONS PRODUCED BY TRAMWAY TRACK AND ROAD TRAFFIC”

Francesco Borchi

UNIVERSITÀ DEGLI STUDI FIRENZE

DIEF DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

This project has received funding from the European Union’s Life Programme under Grant Agreement N° **LIFE20 ENV/IT/000181**

General information

PROJECT LOCATION: Florence (Italy)

DURATION

Start: **01/09/2021** End: **31/08/2024**

PROJECT'S PARTNERS

Coordinating Beneficiary:

Comune di Firenze

Associated Beneficiaries:

- **ASSTRA Associazione trasporti**
- **Ecopneus s.c.p.a.**
- **MOPI s.r.l.**
- **Università di Firenze**
- **Università Mediterranea di Reggio Calabria**
- **Vie en.ro.se Ingegneria s.r.l.**

This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

Overall objective

Reduction of noise from roads in densely populated urban areas, where tram and road traffic **noise** and **vibration** superpose, by means of low-noise/vibration surfaces and retrofitting solutions having life cycle costs comparable to those of standard surfaces.

Solutions to be tested in the pilot area:

- **Low-noise pavings to reduce noise and vibrations due to road traffic noise**
- **Bogie skirts, sound-absorbing panels, and watering spray systems to reduce tram noise**

This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

Expected impacts

Reduction of:

1. Annoyed people, about 2.000 people will be positively affected by **road noise reduction (Lden/Lnight reduction of at least 3 dB(A))**

2. **CPX@50 km/h 3.5 dB(A)**

3. **Tram noise reduction from 5 dB (in terms of broad band reduction) up to 20 dB (at specific frequencies by using solutions able to cancel the squeal noise source)**

4. **Vibration levels for bystanders and dwellers in terms of vibration magnitude of 5%**

5. CO_2 emission in the pilot construction: 62%

6. People annoyed: at least 25% of the sample

7. Life cycle cost of the low-noise surfaces: 10%

8. Worker exposure to asphalts fumes: 62%

This project has received funding from the European Union’s Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

Policy implications

- Implementation and updating of the **Directive 2002/49/EC** especially regarding the definition and realization of noise Action Plans, by providing innovative solutions to concurrently mitigate noise produced by road traffic and tramways

- Contribution to the **Directive 996/2015/EC** concerning the CNOSSOS noise assessment method

- Contribution to provide updated results regarding **citizens perception** of noise and vibrations due to tramways and road traffic, evaluating Psychoacoustic parameters

- Contribution to the assessment of **vibration impacts of optimized** asphalts which is not deeply addressed from a legislative point of view

This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

Case study (Via la Marmora)

- Road traffic + buses at speed between 20 and 50 km/h in both southbound and northbound directions

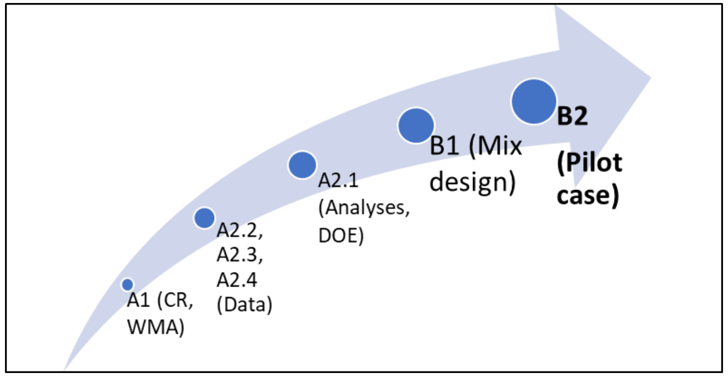
This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

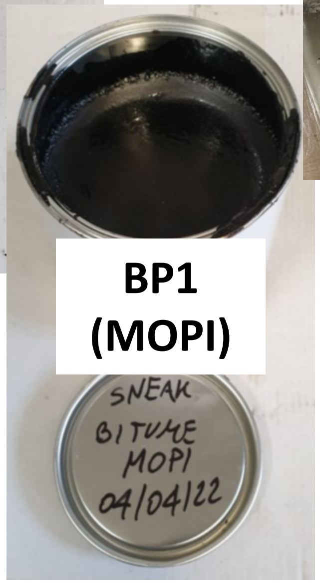
Road traffic: low noise/vibration pavings design

This project has received funding from the European Union's Life Programme under Grant Agreement N° **LIFE20 ENV/IT/000181**

some pictures (1/8)

Material and consumables supply





BP1 (MOPI)

B50/70 + LowTherm4G

Design of the Experiments (DOE) to set up the job mix formula (JMF):

- <u>**Reference mix**:</u> **B50/70-6.35**=B50/70+Aggregates+Filler; HMA
- <u>**Mix with bitumen from MOPI:**</u> **BP1-6.35**=B(MOPI)+Aggregates+Filler; WMA
- <u>**Mix with bitumen and LowTherm4G:**</u> **B50/70-6.35-LT**=B50/70+LowTherm4G+Aggregates+Filler. WMA

Symbols. B=Bitumen; 50/70=Penetration grade; 6.35=Percentage of bitumen by weight of the mixture; HMA=Hot Mix Asphalt; WMA=Warm Mix Asphalt.

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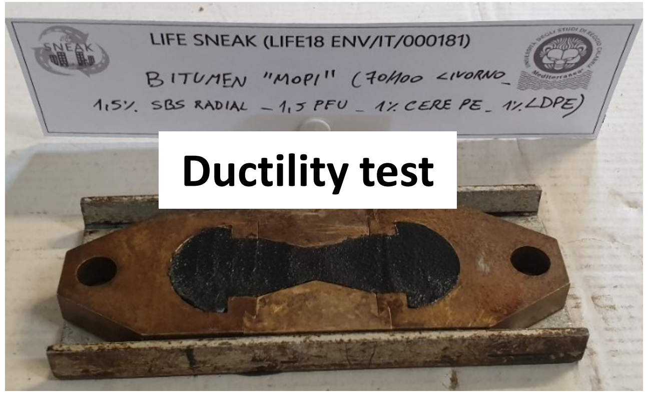
some pictures (2/8)

Tests on bitumens



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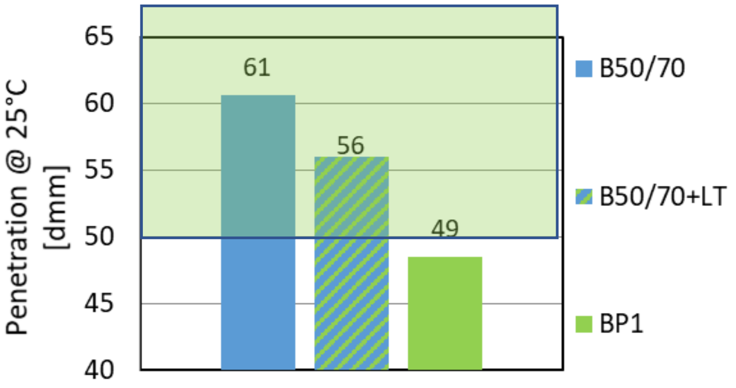
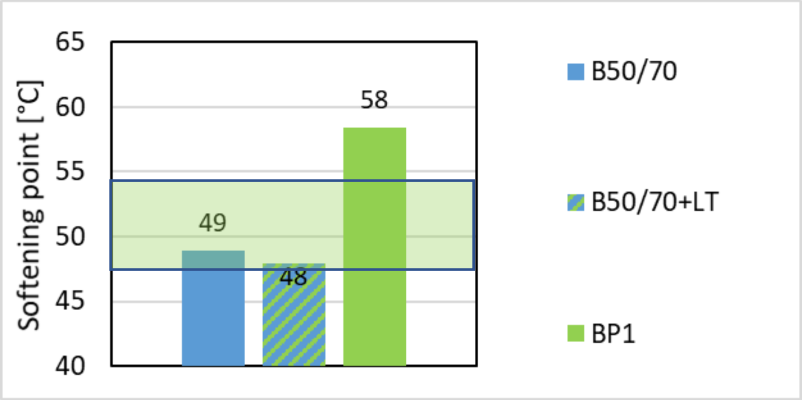
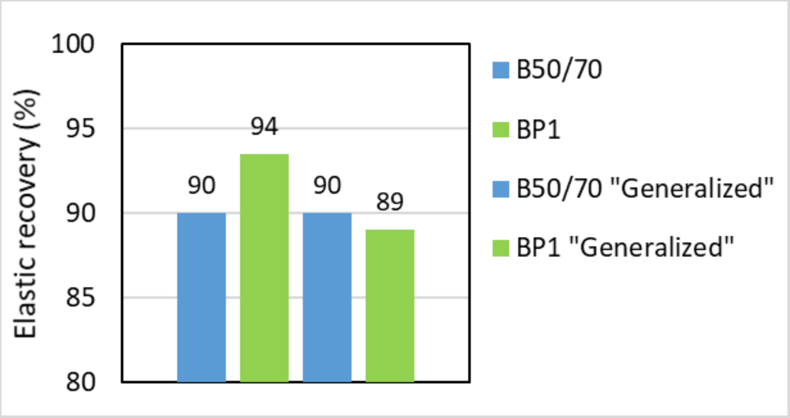
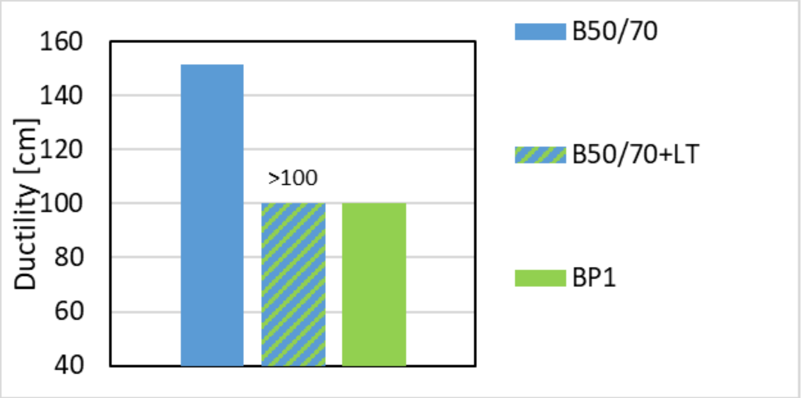
some pictures (3/8)

Tests on bitumens (Preliminary results)







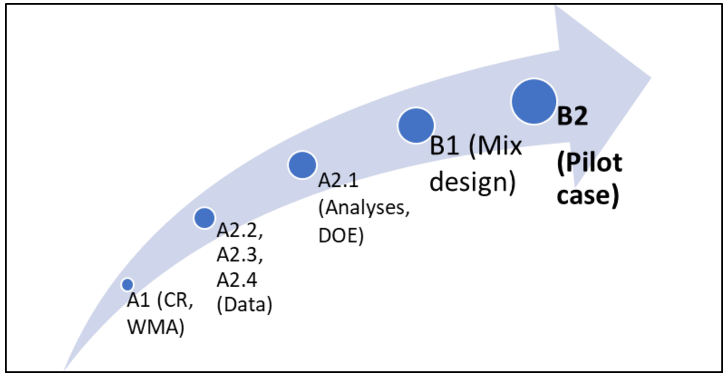


*Capitolato speciale d'appalto ANAS. 2022.

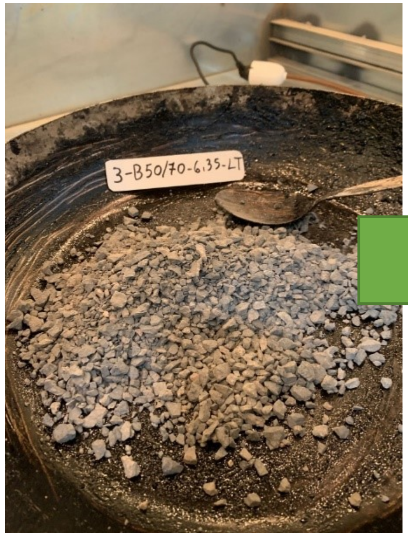
This project has received funding from the European Union’s Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

some pictures (4/8)

First set of specimens



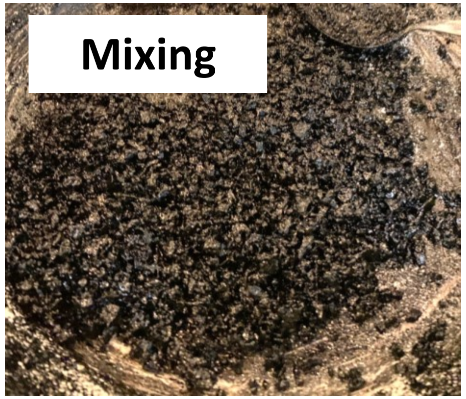
B50/70-6.35-LT=B50/70+LowTherm4G+Aggregates+Filler.

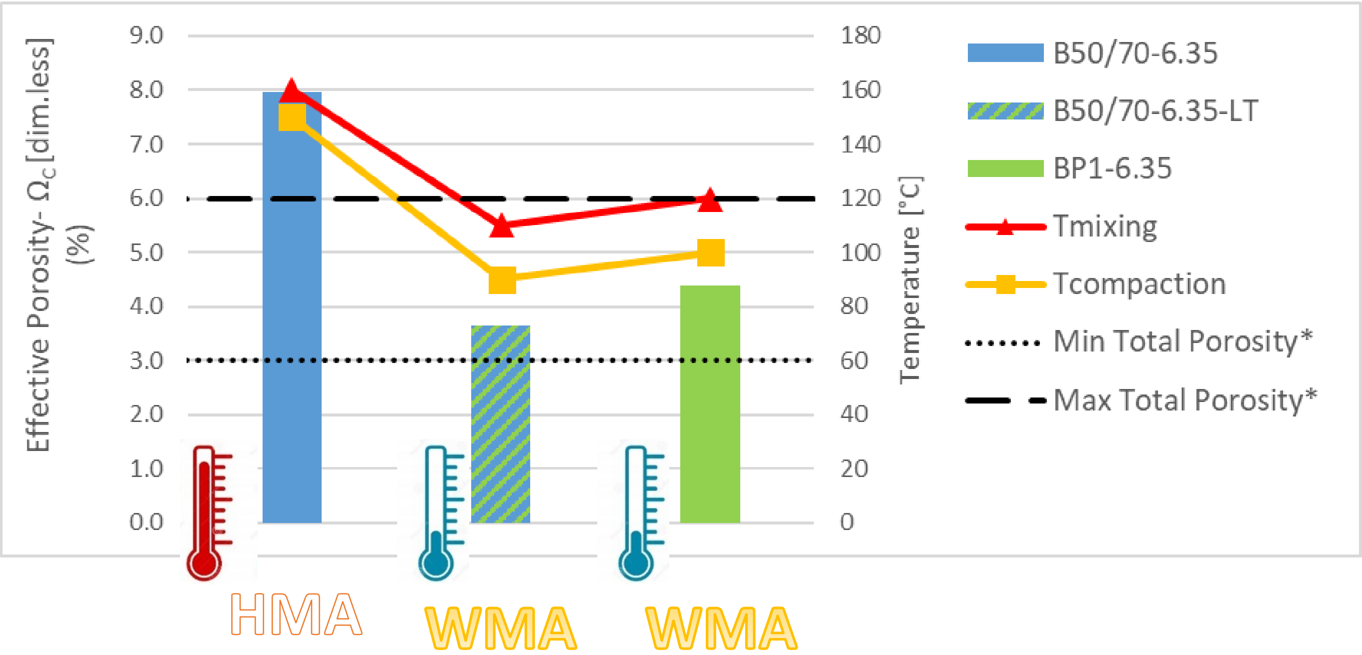


This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

some pictures (5/8)

First set of specimens (Preliminary results)





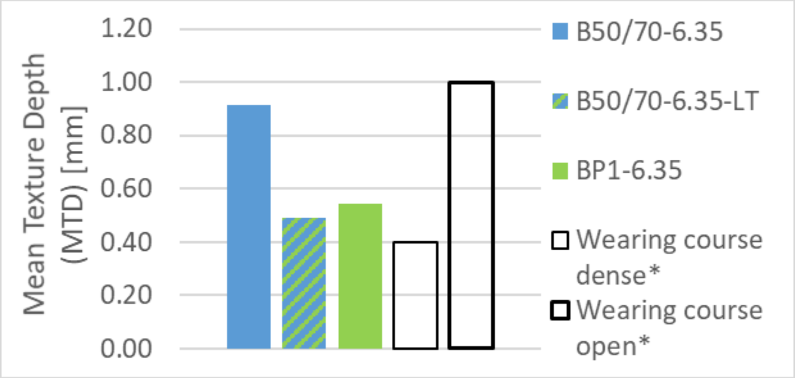
* Valli Zabban. 2020. Capitolato per CONGLOMERATO BITUMINOSO di USURA con BITUME MODIFICATO SOFT.

This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

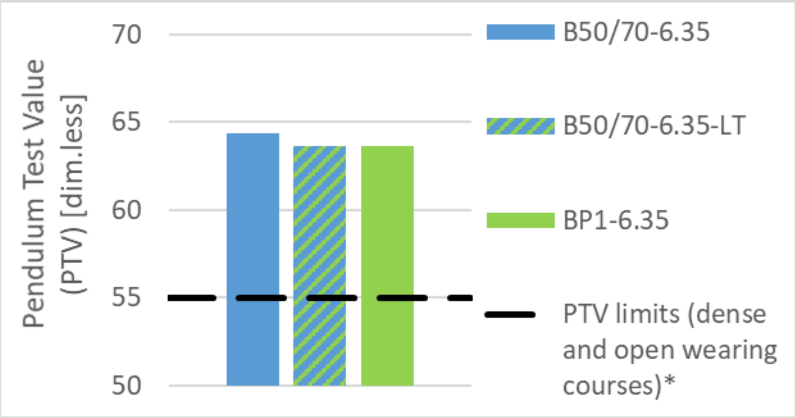
some pictures (6/8)

First set of specimens (Preliminary results)

Sand patch method (macro-texture)



British pendulum test (micro-texture)

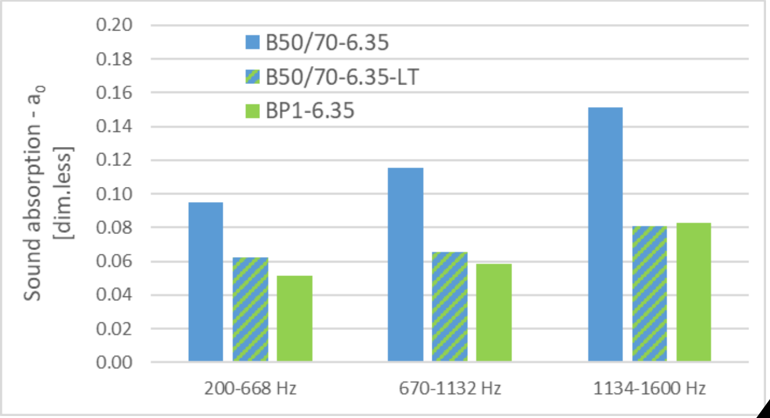


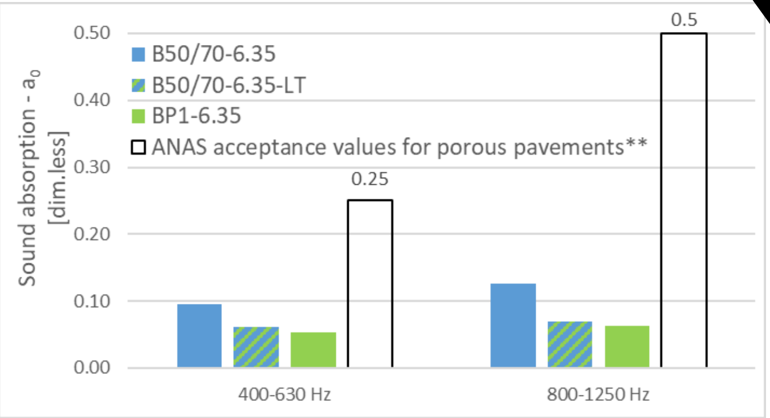
*Capitolato speciale d'appalto ANAS. 2022.

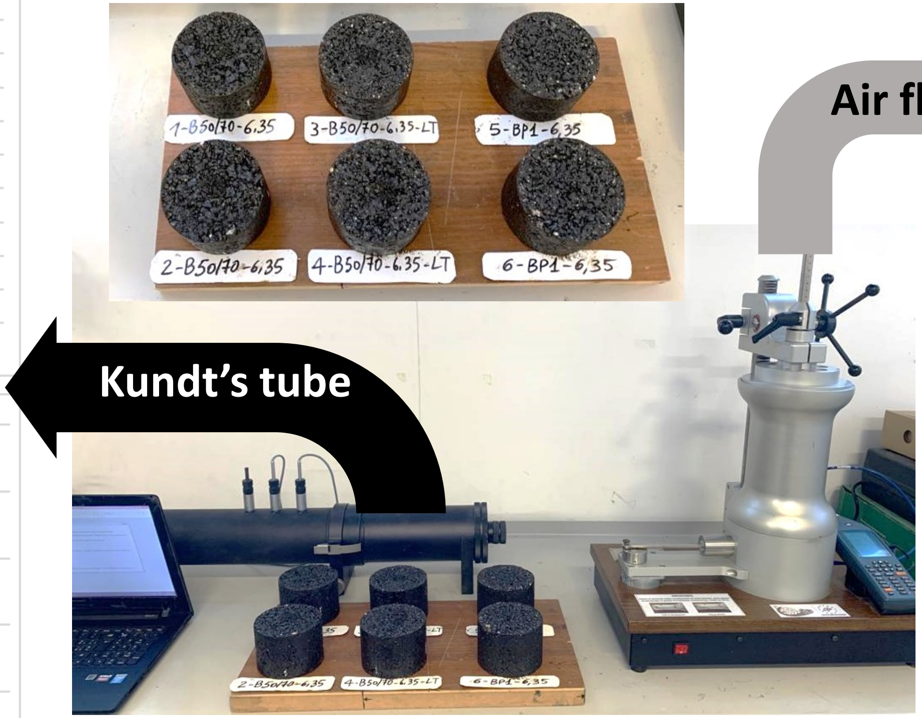
This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

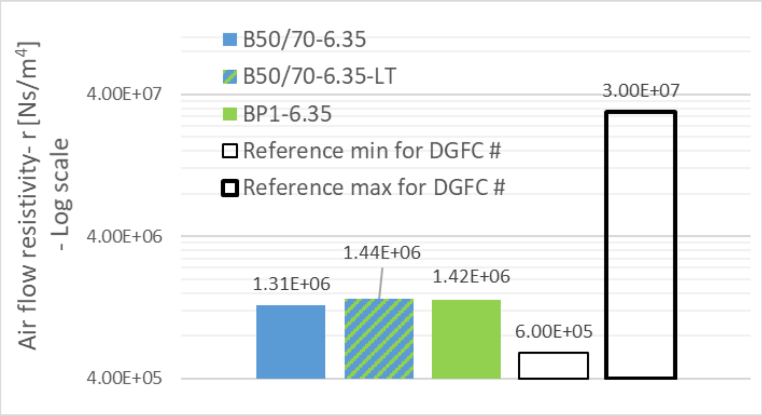
some pictures (7/8)

First set of specimens (Preliminary results)









** Capitolato speciale d'appalto ANAS. 2022.

\# Praticò et al. Estimating the resistivity and tortuosity of a road pavement using an inverse problem approach. Congress ICSV24, 2017.

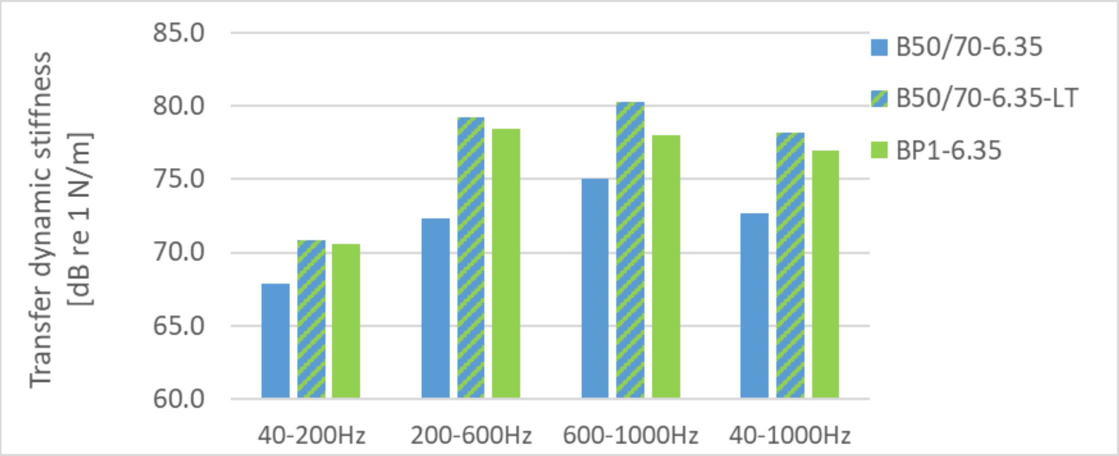
This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

some pictures (8/8)

First set of specimens (Preliminary results)

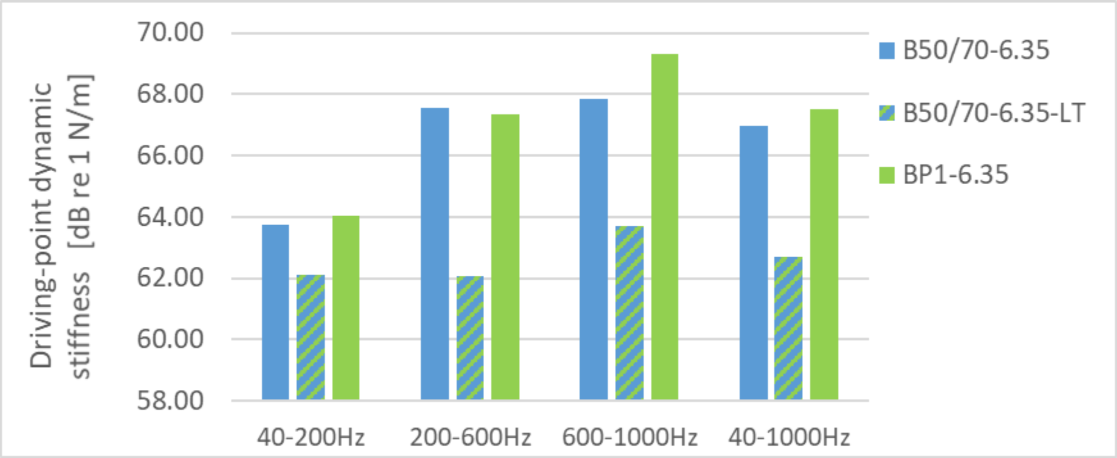
Impact hammer test (TRANSFER IMPEDANCE)

Accelerometer + Impact hammer



Impact hammer test (DRIVING-POINT IMPEDANCE)

Impedance head + Impact hammer



This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

Tram Noise: on-board solutions design

UNIVERSITÀ DEGLI STUDI FIRENZE
DIEF
DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

Tram Noise

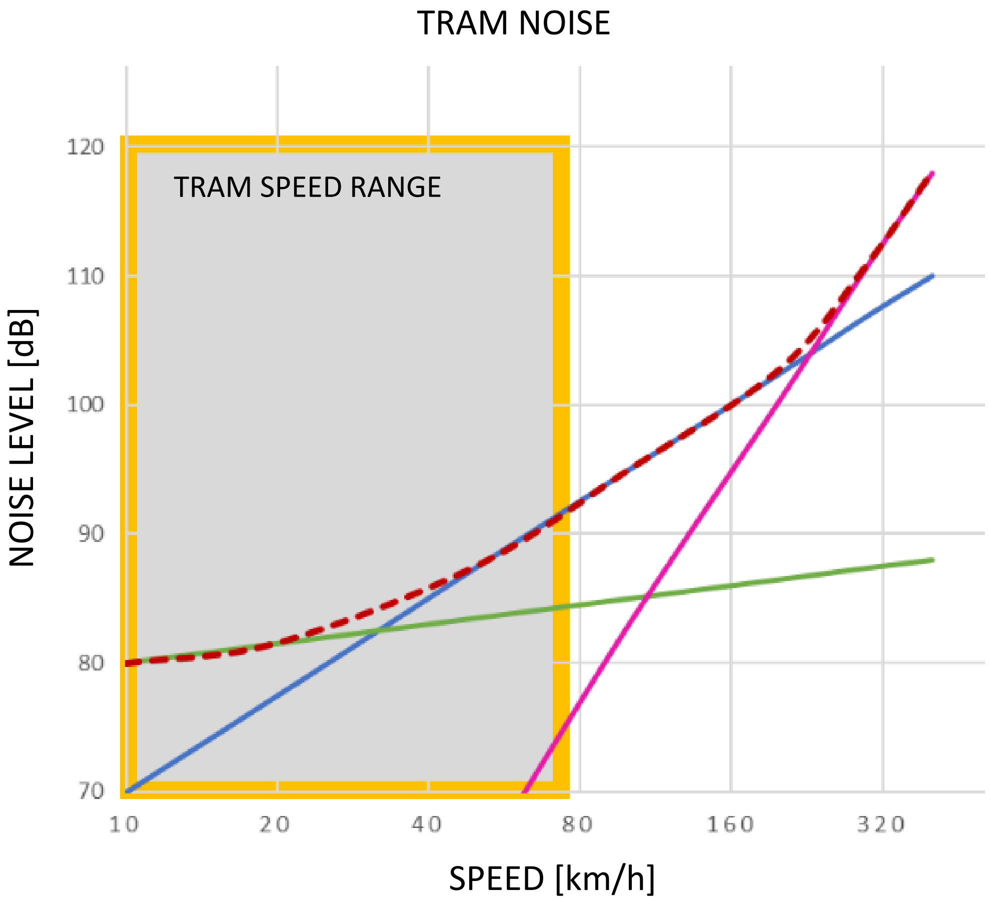
- engine noise
- rolling noise
- aerodynamic noise
  - Negligible in the tram speed range
- Stops-related noise (braking/starting)

CURVING NOISE

- Flanging noise
- **Squeal noise**

SPEED & ROUTE

2-4kHz / >100dB



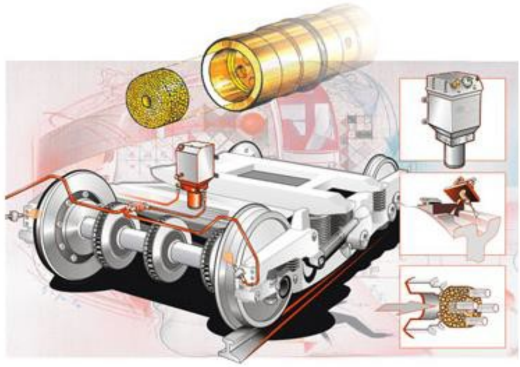
This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

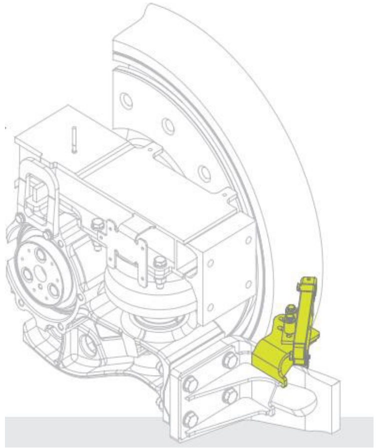
Possible on-board solutions - SoA

On-board (installed directly on the tram vehicles) – 2 typhologies:

1. Lubrification -> prevent the causes from which squeal phenomena stems from:
   - Solid lubrification = generally graphite sticks
   - Liquid lubrification = liquid dispensed to the wheel by a dedicated system
2. Acoustic barriers -> **bogie skirts** -> mitigate the propagation of squeal noise and all sources present in the wheel area (squeal noise, rattling and clanking, braking, engine, rolling)

Tram bogie skirt





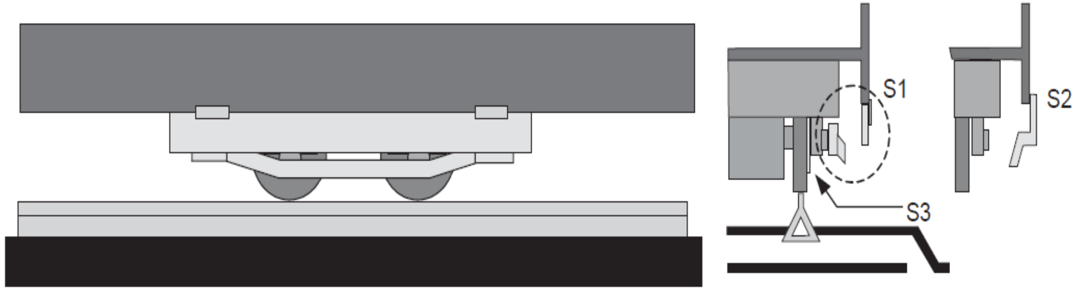
Liquid and solid lubrification systems

This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

Bogie skirts - SoA

Scientific literature reports that:

- an absorptive barrier is typically 3-4 dB(A) more effective than a reflective barrier;
- a standard bogie cover is not effective in reducing noise, since it can become a secondary source of noise, while a cover enriched with acoustic functions allows significant sound attenuation (-5:-15 dB(A));
- the adoption of bogie shrouds together with low height barriers comports an expected wheel noise reduction of 8-10dB(A). This potential has been reported also in [41].

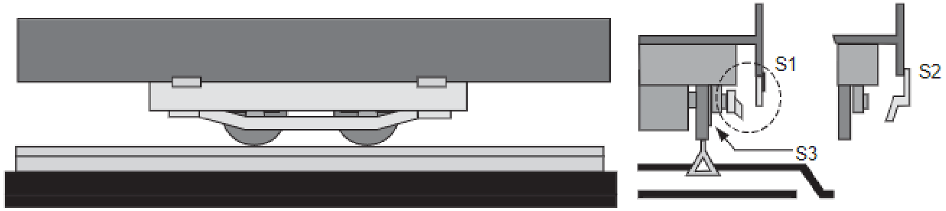


Front and side view of baseline skirt model (S1) with one carbody-mounted and one bogie-mounted part. Alternative skirt models S2 and S3 are included in side view only.

This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

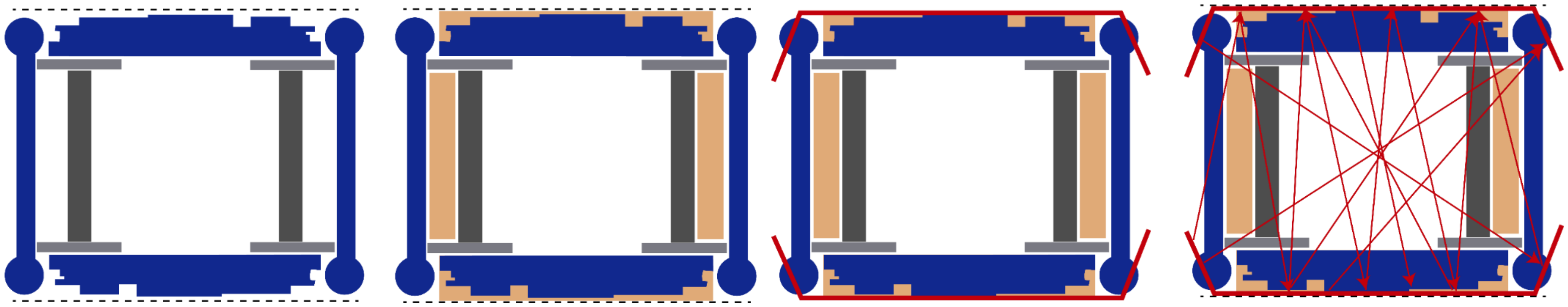
Bogie skirts development

1. Study of existing solutions
2. Study of Florence Tram bogie configuration & constraints
3. Possible areas of intervention
   1. Development of a reflecting/absorbing strategy



3 geometries of tram bogie skirt tested in [1]

Reflecting surfaces — Occupied bogie volumes — Possible areas of intervention



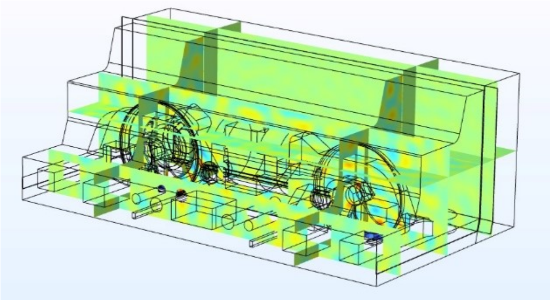
[1] Frid, A.: Skirts and barriers for reduction of wayside noise from railway vehicles - An experimental investigation with application to the BR185 locomotive, Journal of Sound and Vibration, 267, 2003.

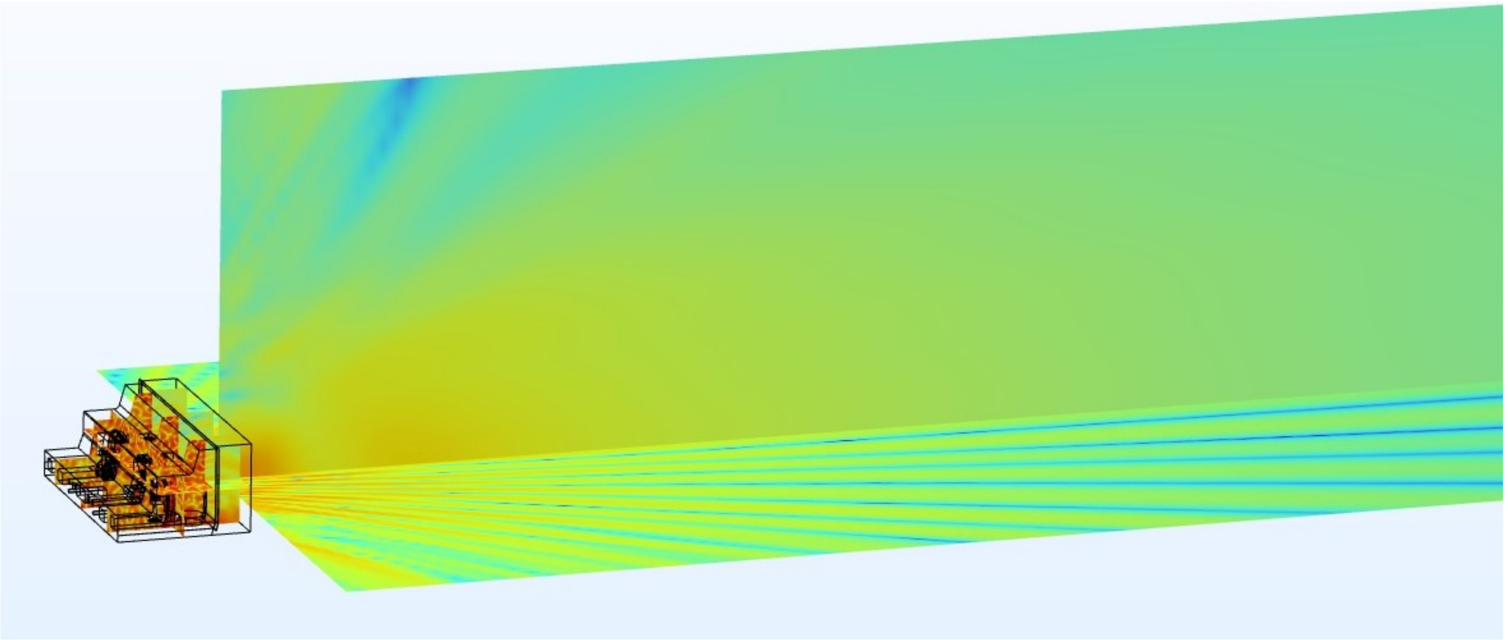
This project has received funding from the European Union’s Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

Candidate intervention area

This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

Preliminary FEM Acoustic model of the boogie area





COMSOL MULTIPHYSICS®

This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

Conclusions

New solutions to reduce noise and vibrations due to road traffic and tramways are investigated.

Designing of the new paving solution started from the state of the art (e.g. low noise paving defined into E-VIA project), aiming to obtain reductions in terms of both noise and vibration levels.

Referring solutions developed for tram noise (bogie skirts and sound absorbing panels), significant noise attenuations are expected according to current simulations results.

Within the beginning of 2023 the designing phase is expected to be concluded and preliminary test will be started.

This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

Thank you for your attention!

Email Address: francesco.borchi@unifi.it

https://www.lifesneak.eu/

This project has received funding from the European Union's Life Programme under Grant Agreement No **LIFE20 ENV/IT/000181**

COOL & LOW NOISE ASPHALT PROJET *LIFE*

Acoustic performance of low noise pavements in the city center of Paris

LIFE E-VIA PROJECT / FIRENZE / 7th october 2022

Antoine PEREZ MUNOZ - Bruitparif

VILLE DE PARIS BRUITPARIF COLAS EUROVIA VINCI

Ce projet est financé par le fond européen *Life*
LIFE16/ENV/FR/000384

1

Context and issues

Exposure to road traffic in the city of Paris

13% Parisians exposed to road noise levels that exceed French limit values (Lden)

6% Parisians exposed to road noise levels that exceed French limit values at night (Ln)

88% Parisians exposed above WHO recommendations

Paris road noise maps - 2015

Road noise in Paris : a complex issue

62% of Paris inhabitants declaring themselves as very and somewhat annoyed by noise (CREDOC Study for Bruitparif, 2016/2021)

Due to improvements on engine acoustic emissions, actions aiming to reduce rolling noise (road requalification, anti-noise road surfaces…) have greater effects even at fairly slow speeds like 30 km/h for private vehicles.

Yet, people significantly complain about motorcycles and high noise peaks (quoted as the most annoying among transports sources for 61%).

2

The Cool-&-LoW Noise asphalt project

LIFE PROJECT: Cool & Low Noise Asphalt

Period : 01/07/2017 to 30/06/2023

Coordinator : City of Paris

Associated partners : Bruitparif / Colas / Eurovia

Budget : 2,345 M€

Cofunding at 60% by the European Commission

PARIS

BRUITPARIF

COLAS

EUROVIA VINCI

Université Paris Descartes
(thermal monitoring)

Cool & Low Noise Asphalt : the project's objectives

Noise aspect

Reduce the noise pollution generated by road traffic on urban roads thanks to these new pavements

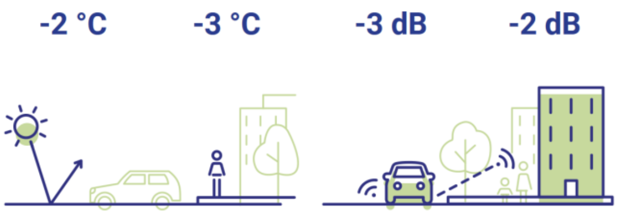
By reducing the noise emitted by the contact of vehicle tires with the asphalt (rolling noise)

Thermal aspect

- Mitigate the effect of Urban Heat Islands (UHIs)
- By testing the surface water retention capacities, the micro-climatic impacts generated by their spraying with non-drinkable water during hot periods, and the effects of their color (albedo) on heat restitution.
- The new coatings tested show a micro-granularity allowing to retain a water film which will refresh the air by evaporating

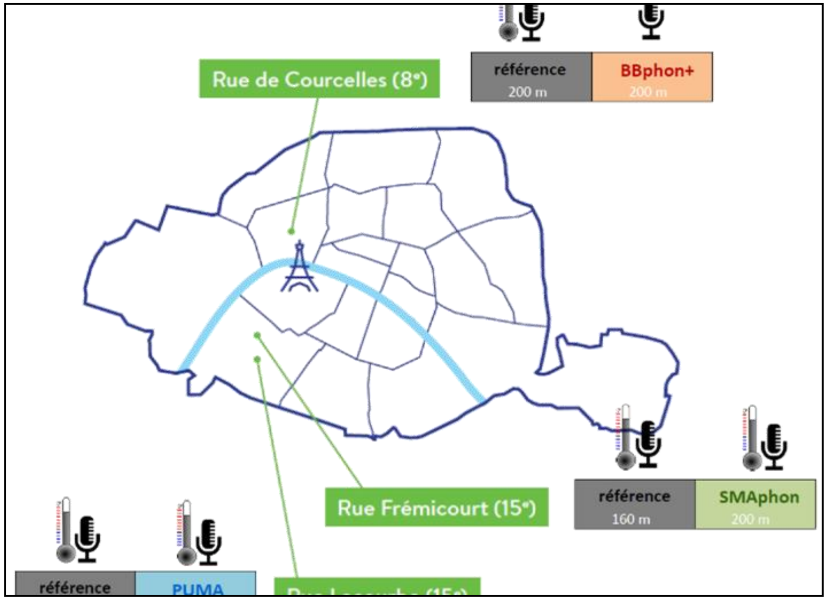
Durability aspect

- Reinforce the durability of these coatings in terms of their acoustic, mechanical and thermal properties
- While limiting their additional cost compared to conventional coatings, in order to promote the dissemination of these solutions in urban areas



Cool & Low Noise Asphalt : 3 pilot sites in Paris

- Strong noise exposure
- High density of population
- Speed limitation : 50 km/h
- Oriented E/W for the thermal purposes
- Road works already planned
- Other criteria (light or no slope, non-drinkable water available…)



400 m long per site
200 m standard pavement
200 m with experimental formula

Long-term monitoring
Continuous meteorological sensors
Continuous acoustic sensors on facades
+ periodic campaigns using CPX method
Periodic mechanical tests in order to monitor the durability of the new asphalts

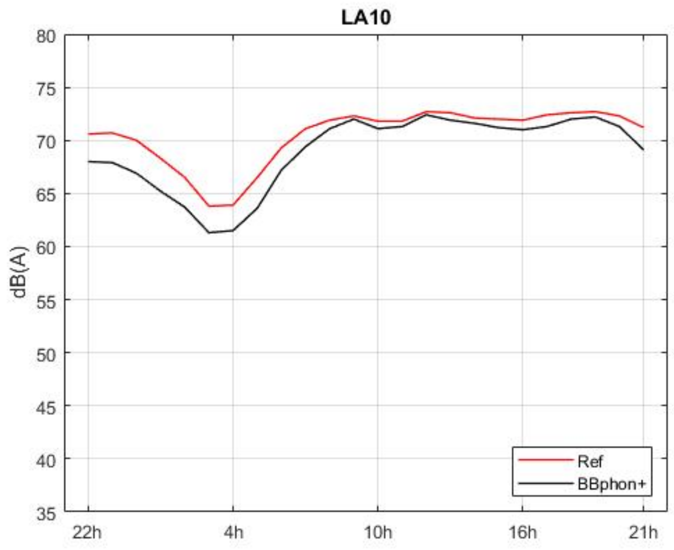
Cool & Low Noise Asphalt : schedule

Site	Address	Measurement start	Type of coating	Roadworks date
FREMICOURT	37, rue Frémicourt	28/03/2018	Acoustic : SMAPhon	31/05/2018
	13, rue Frémicourt	12/04/2018	Reference	
LECOURBE	214, rue Lecourbe	11/07/2018	Acoustic : Puma	30/07/2018
	236, rue Lecourbe	11/07/2018	Reference	
COURCELLES	62, rue de Courcelles	11/07/2018	Acoustic : BBPhon +	24/09/2018
	88, rue de Courcelles	11/07/2018	Reference	

3

Results

Façade buildings : results



Reductions in rolling noise clearly observable during the passage of isolated vehicles at night :

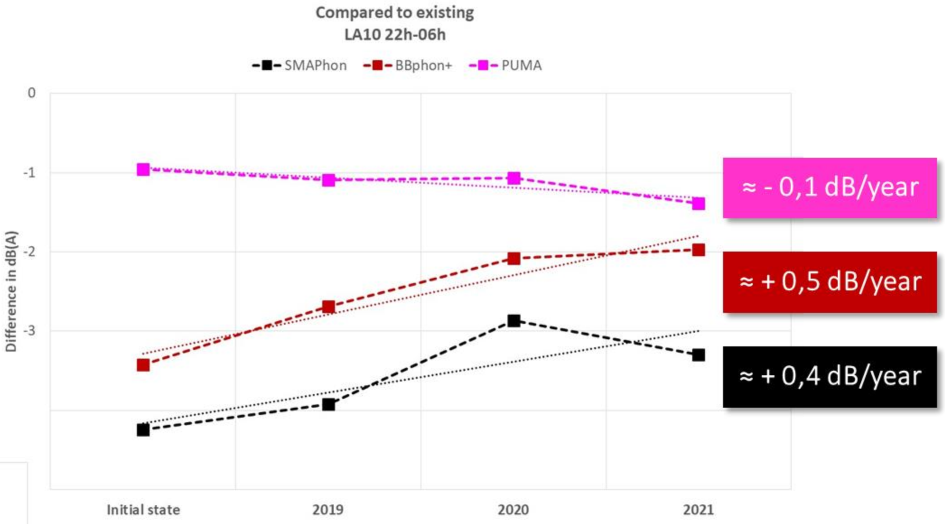
-Road traffic speeds relatively higher

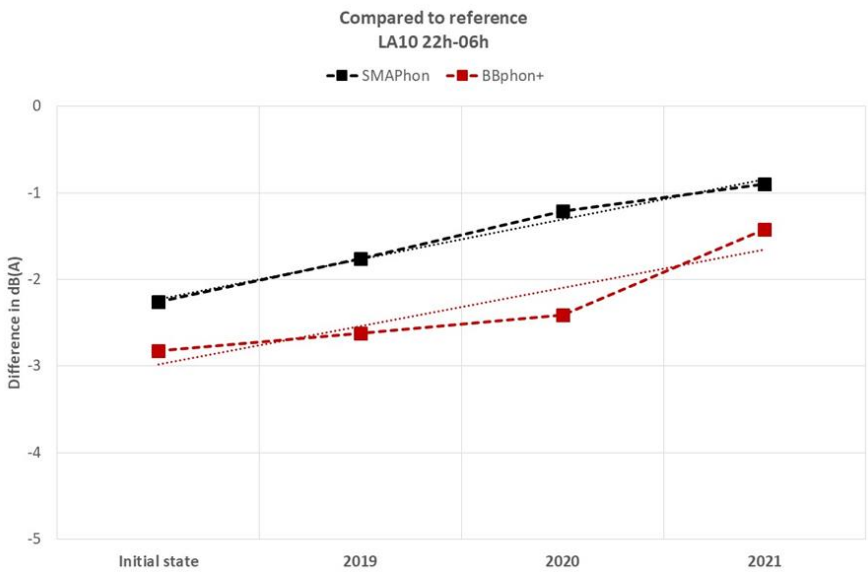
-Other sources of noise reduced (construction work, human activity, etc.)

LA10 22h-6h indicator clearly reflects the reduction associated with rolling noise

For the other periods of the day, the acoustic indicators show a reduced benefit.

Rolling noise reduction in dB(A) with new asphalt mixes





Δ LA10 22h-6h (Façade)
with temperature correction 0,1 dB/°C

CPX measurements : results

The project objectives in terms of reducing rolling noise compared to standard solutions have almost been achieved for the SMAphon and the BBphon +.

-5 dB(A) compared to the existing in 2019 and –1 dB(A) in 2022.
-3 dB(A) compared to reference in 2019 and –1 dB(A) in 2022.

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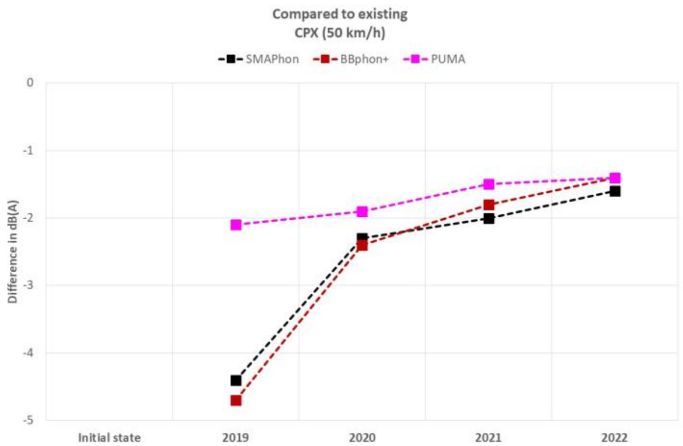
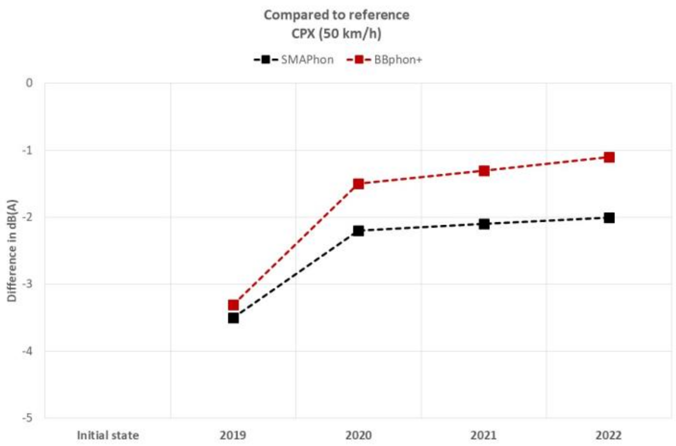




Cool & Low Noise Asphalt: results

Noise reduction in dB(A) with new asphalt mixes (facade all noise sources combined) : around 0,5 dB(A) for SMAphon and Bbphon+

Δ LAeq 22h-6h Facade compared to the reference	2018	2019	2020	2021
SMAphon	-1,3	-1,1	-0,7	-0,6
Bbphon+	-1,4	-1,1	-1,1	-0,5
PUMA	-	-	-	0,9

Cool & Low Noise Asphalt: results

<u>Survey of users and residents of Frémicourt Street</u> (October 2019)
63% noted a reduction in road noise following the change of road surface
Among them, 67% consider this reduction to be medium or significant

<u>Survey of users and residents of the 3 pilot sites</u> (September 2021)
85% are in favor of extending the solutions to other Parisian sites.
73% have an overall positive assessment of the project.
<u>Reasons of dissatisfaction :</u>

- *motorcycles noise…*
- *parts of the streets with cobblestones*
- *portions too short to be efficient*

Long-term monitoring will document the evolution of acoustic and thermal performance over time (After-Life – 5 years).
Economic additional cost of less than 10% compared to a standard coating
Products integrated into the pavement catalog of the City of Paris
Solution already implemented on other sites in Paris and Turin
Quantification of socio-economic impacts under assessment

COOL
& LOW NOISE
ASPHALT PROJET LIFE

www.life-asphalt.eu

Thank you for your attention !

Ce projet est financé par le fond européen Life
LIFE16/ENV/FR/000384

NEMO

Emissions and noise monitoring: a focus on pilot projects

RP1 consortium meeting

M1-M18

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement n° 860441.

Firenze 7 ottobre 2022

PROJECT LIFE E-VIA

Electric mobility and low-noise asphalts: the results of the LIFE E-VIA project and contributions from other projects

Networking per la riduzione del rumore e delle emissioni:

i progetti pilota

Gaetano Licitra - ARPAT

Sistema Nazionale per la Protezione dell'Ambiente

ARPAT
Agenzia regionale per la protezione ambientale della Toscana

REGIONE TOSCANA

NEMO:

Noise and Emissions Monitoring and Radical Mitigation

NEMO will create and test a **completely new remote sensing technology** that can measure noise and emissions from individual road vehicles and trains in real time, along with the multispectral camera technology to measure emissions from cruise ships. The system will make possible a limited access or charging system based on actual environmental impacts.

The new technologies will be tested and validated in several European cities, as a tool to control noise and air quality and reduce damage to people and the environment.

https://nemo-cities.eu/

NEMO:

Noise and Emissions Monitoring and Radical Mitigation

www.nemo-cities.eu

May 2020 – April 2023

Project funding:
€ 6 564 892,50

18 partners
11 countries

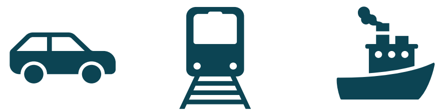
7 demo sites

Integration

- **Physical**: road infrastructure
- **Virtual**: IT platform, V2I-I2V, sensors synchronization

Vehicle Sensing

- **Exhaust** emissions
- **Noise**



Mitigation

- New **asphalts** & multifunctional **barrier** to reduce/absorb noise & emissions

From OPUS RSE presentation at ACUSTICAT 2022 (https://www.opusrse.com/)

NEMO’s main objectives

- To develop a new, ready-to-use technology to measure environmental impacts, such as air and noise pollution of road and rail traffic
- To integrate the new technologies into existing infrastructures to offer a complete turn-key monitoring solution
- To create an *IT service* where collected data from the system is connected and analyzed to inform vehicle operators and road or rail authorities about pollution levels and potential restrictions or charges.

https://nemo-cities.eu/

NEMO’s main objectives

- To develop mitigation solutions such as green noise barriers and road surface designs to reduce vehicle noise emission and prevent most microplastics from tires’ wear and tear to reach the marine environment

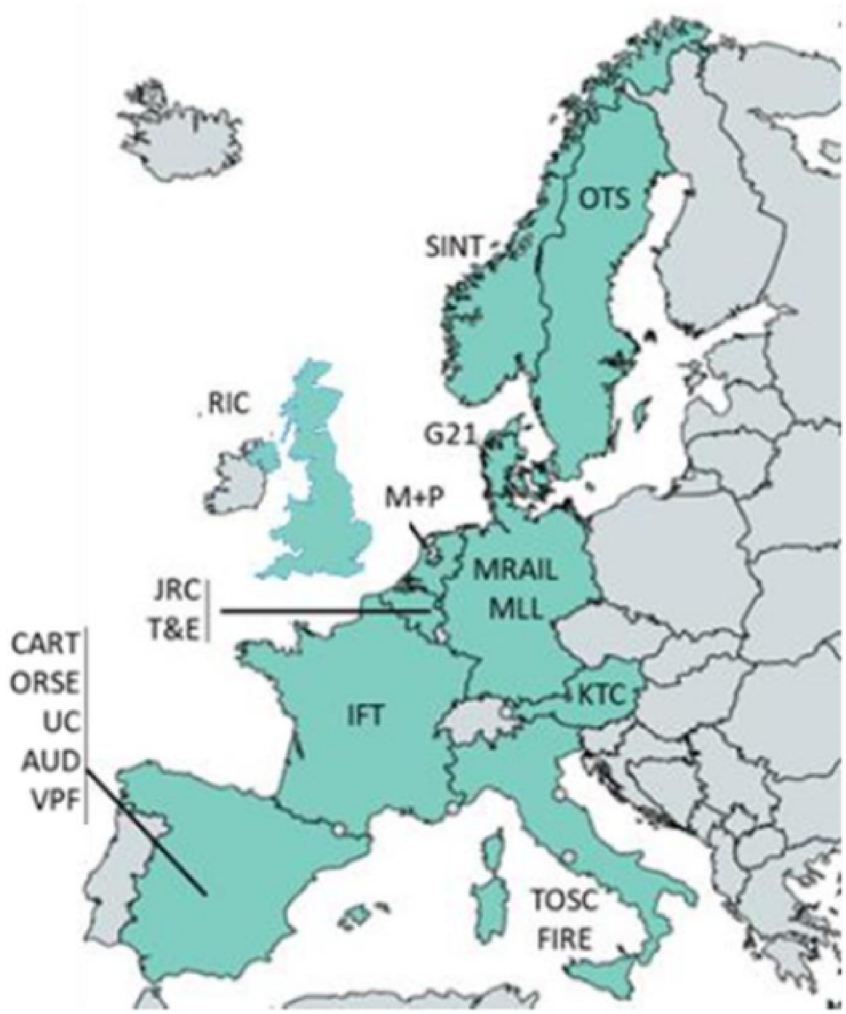
- To validate the new noise and emission remote sensing technology and the mitigation solutions in several European locations, as a tool to control the acoustic and air quality and reduce the damage on people and environment.

- To develop standardized measurement methodologies to ensure reliability of collected data and harmony with existing methods for vehicle inspections

https://nemo-cities.eu/

Partners

#	Organisation name	Country
1	Fundación CARTIF **(coordinator)**	ES
2	M+P Raadgevende Ingenieurs Bv	NL
3	Muller-BBM GmbH	DE
4	Muller-BBM Rail Technologies GmbH	DE
5	Agenzia Regionale per la Protezione Ambientale Della Toscana	IT
6	Sintef AS	NO
7	Gate 21	DK
8	Université Gustave Eiffel	FR
9	Universidad de Cantabria	ES
10	Opus RS Europe S.L.	ES
11	Comune di Firenze	IT
12	European Federation for Transport and Environment	BE
13	Ricardo AEA Ltd.	UK
14	Opus Technology Solutions AB	SE
15	Kapsch TrafficCom AG	AT
16	Fundación Valenciaport	ES
17	Joint Research Centre (European Commission)	BE
18	Audiotec Ingeniería Acústica S.A.	ES



from Kickoff meeting presentation – 26 maggio 2020

Partners

NEMO

Project coordinator: CARTIF

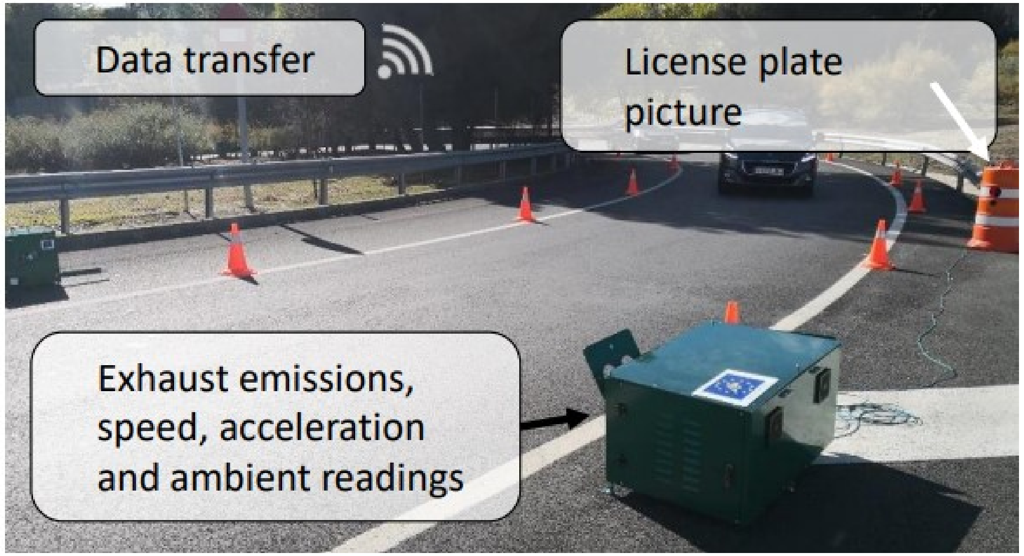
[TECHNOLOGY CENTRE] CARTIF
MÜLLER-BBM
MÜLLER-BBM RAIL TECHNOLOGIES
ARPAT
SINTEF
GATE 21
Université Gustave Eiffel
UC UNIVERSIDAD DE CANTABRIA
OPUS RSE
COMUNE DI FIRENZE
TRANSPORT & ENVIRONMENT
RICARDO
OPUS
kapsch
FUNDACIÓN VALENCIAPORT
Audiotec
European Commission Joint Research Centre

from Kickoff meeting presentation – 26 maggio 2020

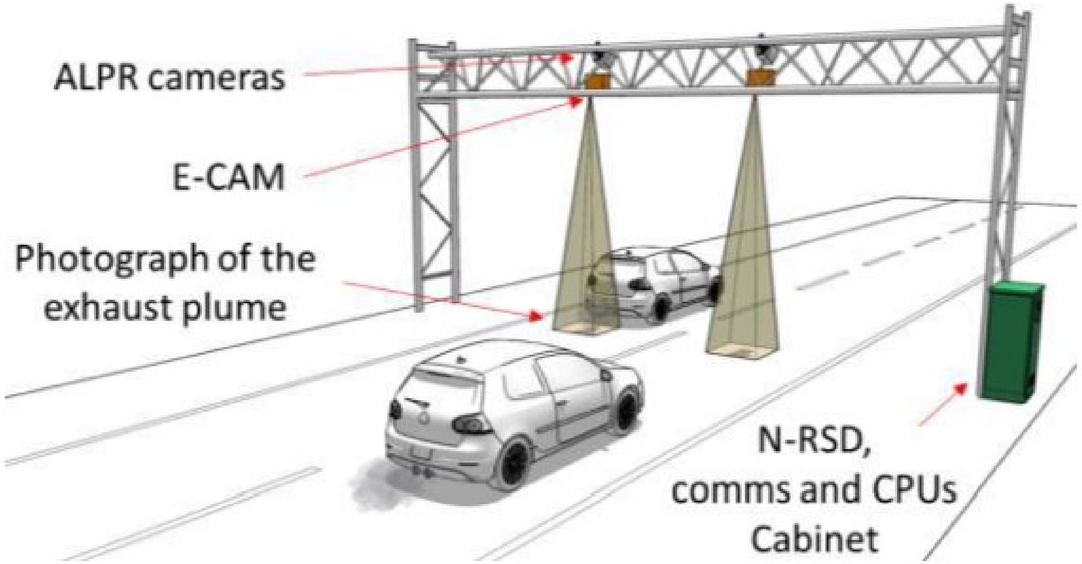
Aims:

- Integrating measurements systems (air and noise) in the transportation infrastructres
- Implementation of scalable mitigation solutions reducing noise impact and improving air quality in cities
- Development of systems for the enforcement against high-emitters in LEZ or other sensitive areas

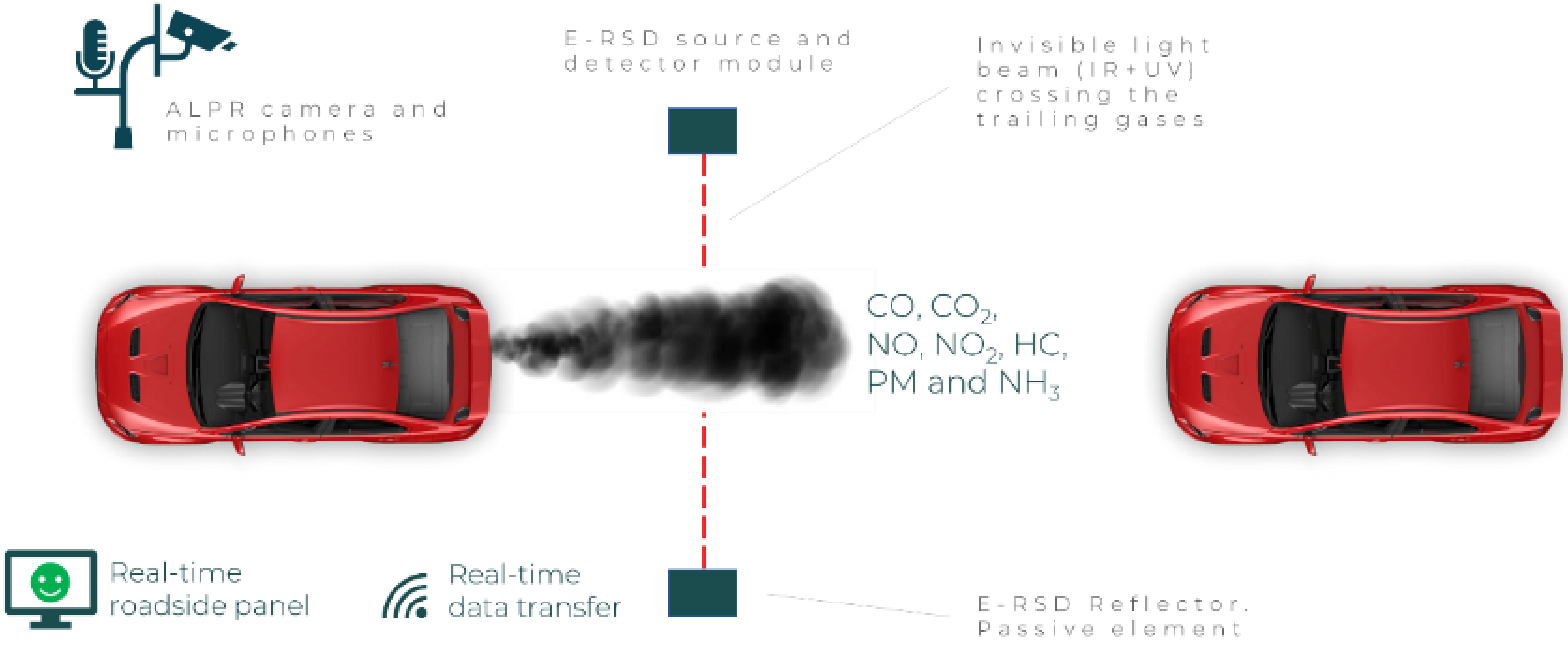
E-RSD



N-RSD



Remote sensing technology



From OPUS RSE presentation at ACUSTICAT 2022 (https://www.opusrse.com/)

Pilot projects (ARPAT WP leader)

Work Done

Pilot projects:

Pilot projects
General information:

General objective:

Validate the new Noise and Emission RS technology and the mitigation solutions in several European locations, as a tool to control the acoustic and air quality and reduce their damage on people and environment. Test feasibility for rail vehicles and for shipping.

Specific objectives:

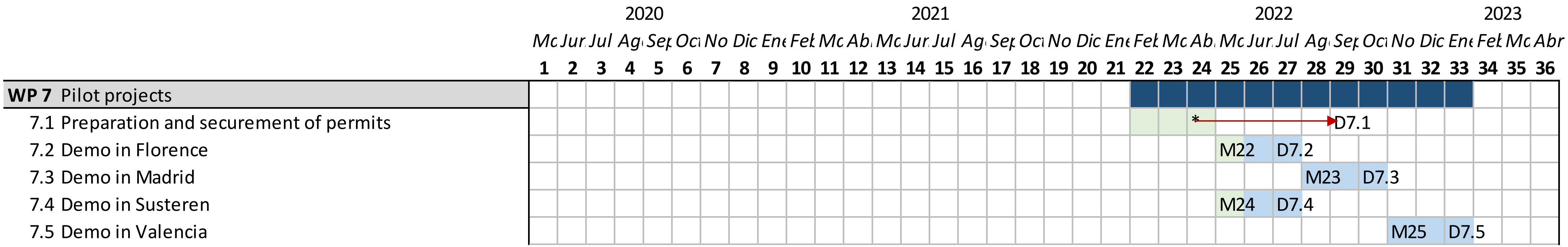
- Reallife pilots in 3 cities (Florence, Madrid and Valencia) and in 1 railway line (Susteren) to demonstrate NEMO solutions and the implementation of a standardized methodology. The pilots will be carried out together with local administrations and related stakeholders, to guarantee the smooth execution of each activity, to put in motion the required mobility policies and to monitor the impact and results of the pilots.

General information:

Duration: M22 - M33

Partners involved: CART, M+P, MLL, MRAIL, TOSC, SINT, G21, IFT, UC, ORSE, IND, FIRE, T&E, RIC, OTS, KTC, VPF, JRC, AUD

Gantt



Real-life environments

Florence

- The demo in **Florence** will be focused on urban road traffic.
- ARPAT and the municipality of Florence (FIRE) will lead this demo.

- Their direct involvement will facilitate the entire execution of the demo, granting permits, providing technical data of the identified vehicles and sending notifications to the drivers.

- This demo is focused on the implementation of HE identification programs in combination with existing LEZs in Europe.

- One mixture of NEMO's urban porous asphalt will be tested in a road city as well.

https://nemo-cities.eu/wp-content/uploads/2022/07/NEMO_Demo-Press-Kit_v1b.pdf

Real-life environments

Madrid

The demo in **Madrid** will be focused on urban and peri-urban road traffic. An integration of the β Prototype in a gantry of the major motorway that surrounds the city (M-30) will test a fixed monitoring scenario.

This demo will be complemented with the LEZ “Madrid Central”, which will be improved with Remote Sensing.

In addition to the above, the mitigation potential of the multifunctional barrier in real conditions will also be assessed in a real road

https://nemo-cities.eu/wp-content/uploads/2022/07/NEMO_Demo-Press-Kit_v1b.pdf

Real-life environments

Valencia, Spain

The demo in Valencia will be focused on railway traffic emissions and sea traffic noise and emissions.
The port of Valencia is the main port in the Mediterranean in container traffic and the fifth in Europe26. In 2018, 6,048 ships arrived at the Port. All the trains that arrive at the port (+3,600 per year) are diesel and will remain diesel for at least the next decades.

The E-RSD will be a system that can be integrated into the railway environment. The E-RSD cross-rail configuration will be mounted with the laser crossing the track at a height of approximately 5 meters to measure gaseous emission by diesel traction.

The E-CAM will be deployed on the port ground to measure the emissions form large ship cruises. The lessons learned in this experiment will be transferred to other transport modes.

https://nemo-cities.eu/wp-content/uploads/2022/07/NEMO_Demo-Press-Kit_v1b.pdf

Real-life environments

The Netherlands

The demo in the **Netherlands** will be focused on railway traffic noise.
The N-RSD will focus on detecting noisy wagons in a train. Freight trains are composed of a series of wagons and some of these may be significantly noisier than average.

NEMO's solution will establish noise emissions from individual wagons in a train and thereby be able to identify the high emitters. Photocells and force sensors in the rail will determine the speed of the passing train and the position of each wagon.

The identification of the vehicle in terms of UIC registration shall be done either by the code readable through RFID or by optical reading of the displayed code at the side of the passing wagon. The system will operate on both tracks with opposing directions

https://nemo-cities.eu/wp-content/uploads/2022/07/NEMO_Demo-Press-Kit_v1b.pdf

Noise monitoring

inter.noise
21-24 AUGUST
SCOTTISH EVENT CAMPUS
GLASGOW
2022

Classification of noisy vehicles from unsupervised measurements

Bert Peeters[1]
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The Netherlands

Ard Kuijpers[2]
M+P
Wolfskamerweg 47, Vught
The Netherlands

Rotterdam

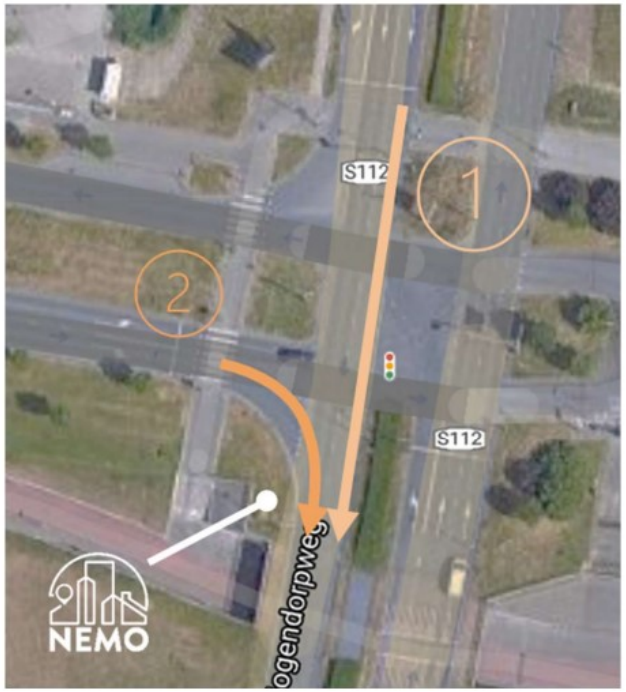
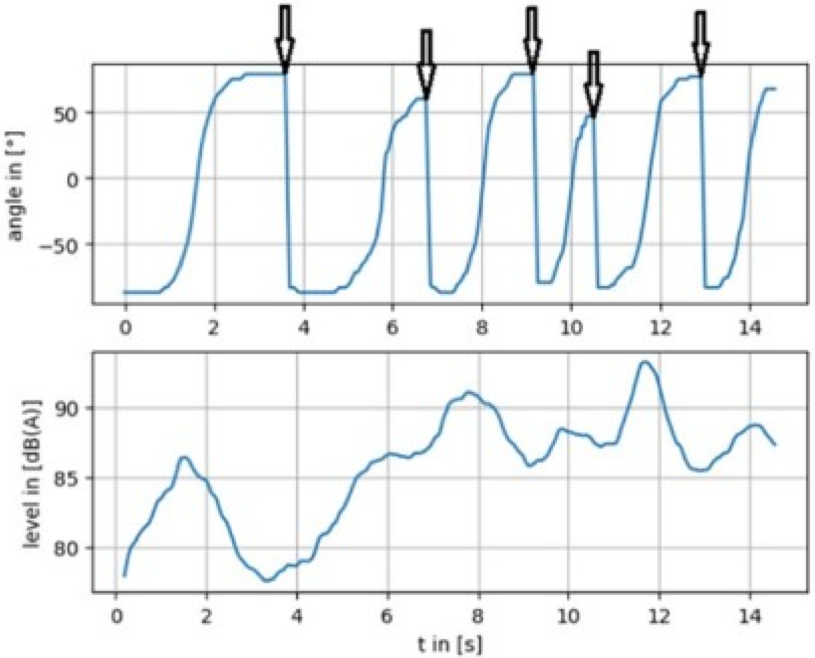


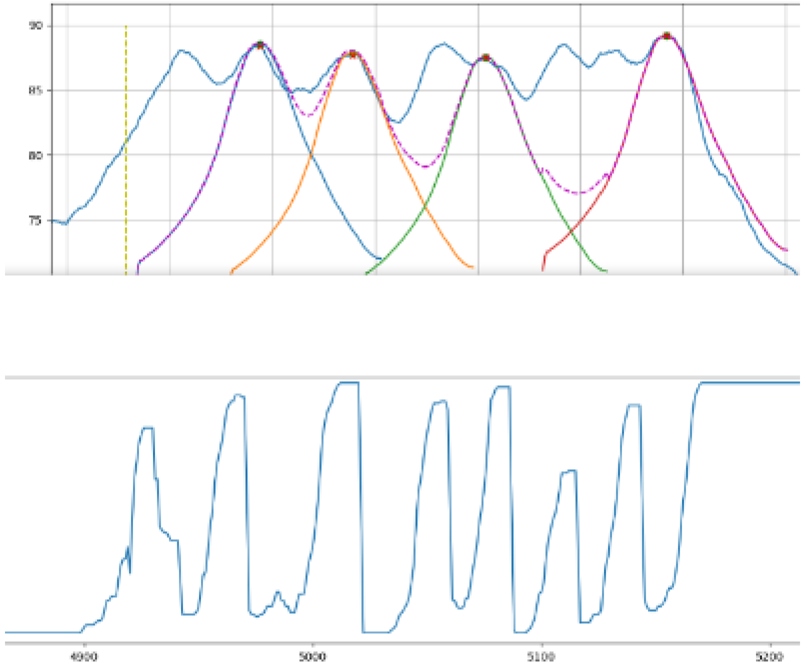
Figure 1: The NEMO noise-RSD measurement setup in Rotterdam, October 2021

From OPUS RSE presentation at ACUSTICAT 2022 (https://www.opusrse.com/)

Noise monitoring

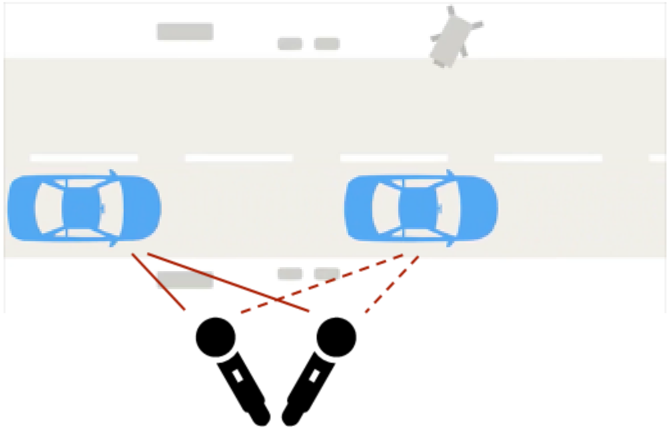


Vehicle separation



Peak level correction

- ✓ Source localization
- ✓ Distance measurement



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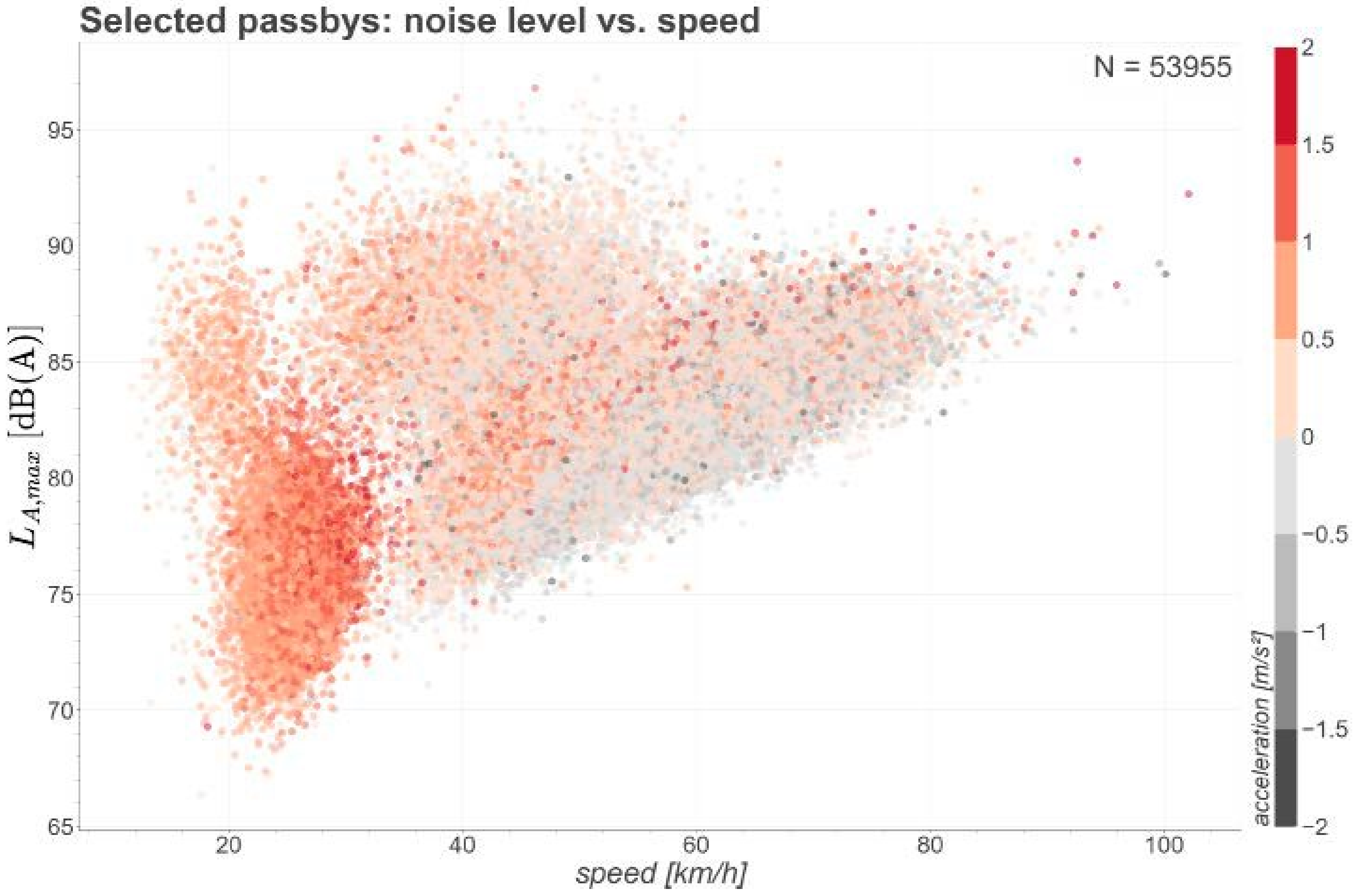
Noise monitoring

Rotterdam



From OPUS RSE presentation at ACUSTICAT 2022 (https://www.opusrse.com/)

Noisy vehicle ≠ Noise driving

High emitter = vehicle making (much) more noise than "*expected*"?

- To determine a 'normal' level $L_{Amax,ref}$ per vehicle category
- High emitter if $L_{Amax,ref} \ll L_{Amax,meas}$

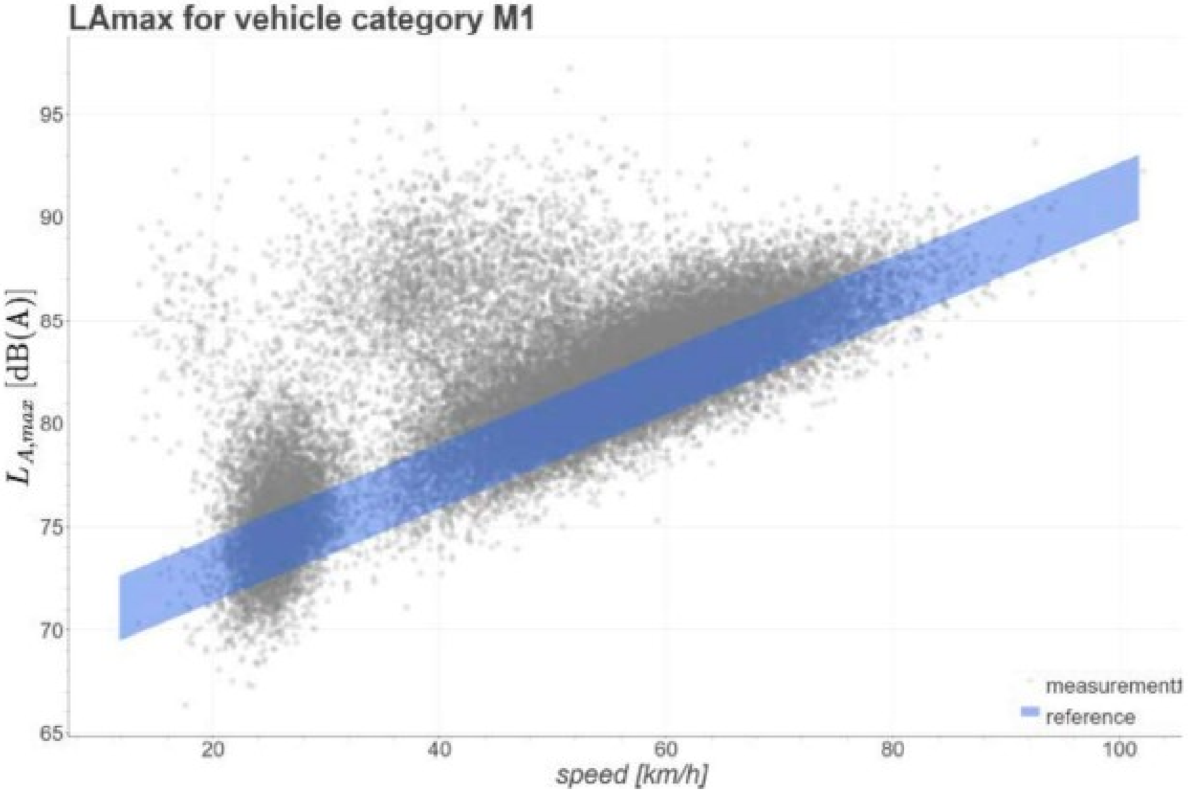
Consider **driving style:**

- fast acceleration is not forbidden
- noisy *drivers* or noisy *vehicles* require different measures
- to enable relation with type approval

inter.noise 21-24 AUGUST SCOTTISH EVENT CAMPUS GLASGOW 2022

Noise monitoring

Rotterdam

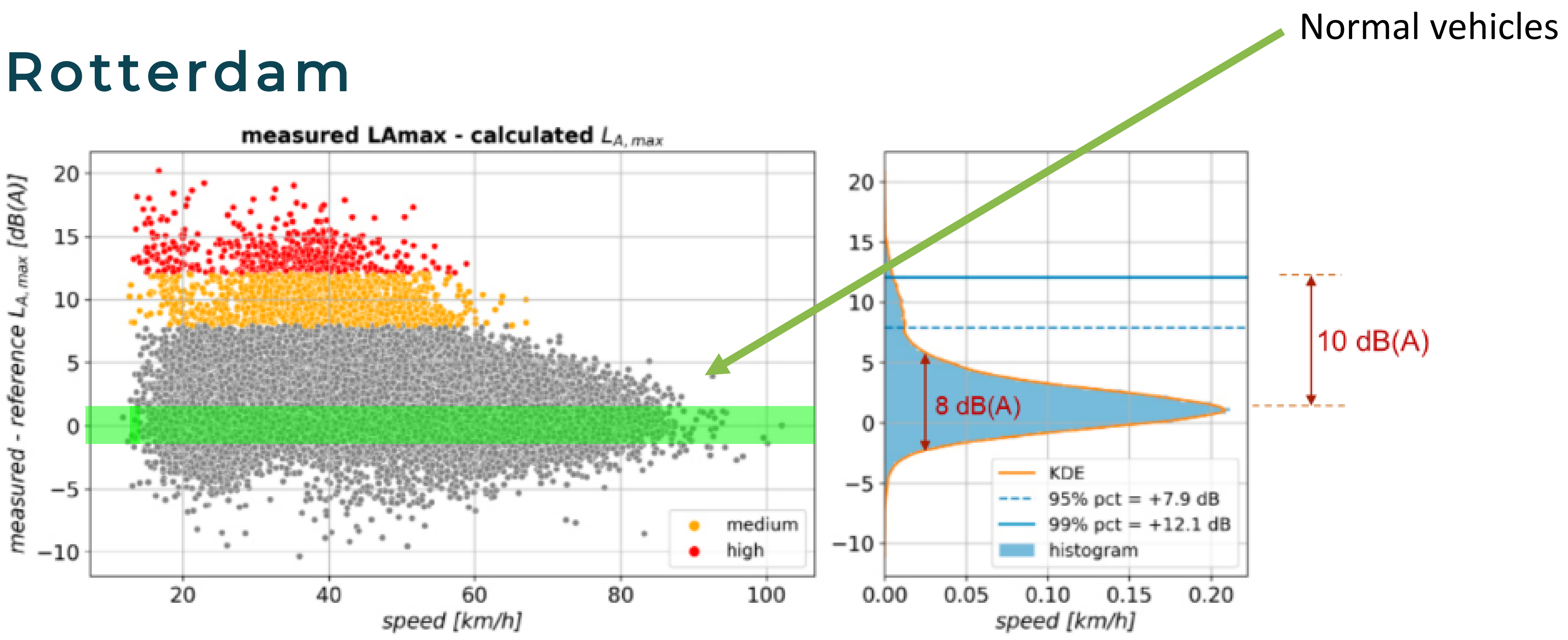


$$L_{Amax,ref}(v,a) = c_0 + c_v \cdot v + c_a \cdot a$$

The coefficients c_0, c_v and c_a are different for each vehicle category (M1, N1…)

Noise monitoring

Rotterdam

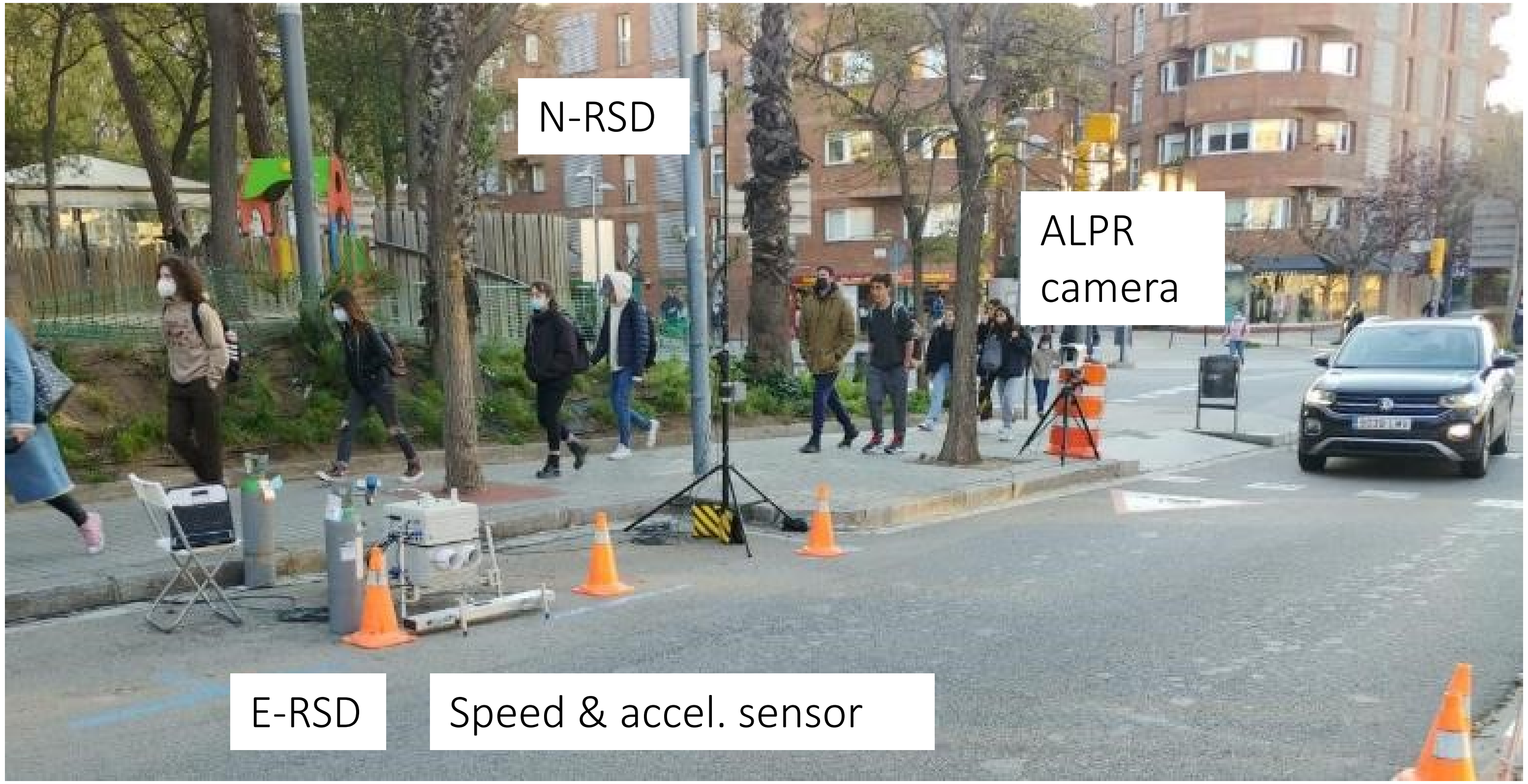


- Some vehicles are **15 to 20 dB(A)** louder than similar vehicles under similar conditions (speed, acceleration)
- Highest 1% is **10 dB** louder than the majority –> these are all passenger cars!

From OPUS RSE presentation at ACUSTICAT 2022 (https://www.opusrse.com/)

Noise monitoring

Barcelona



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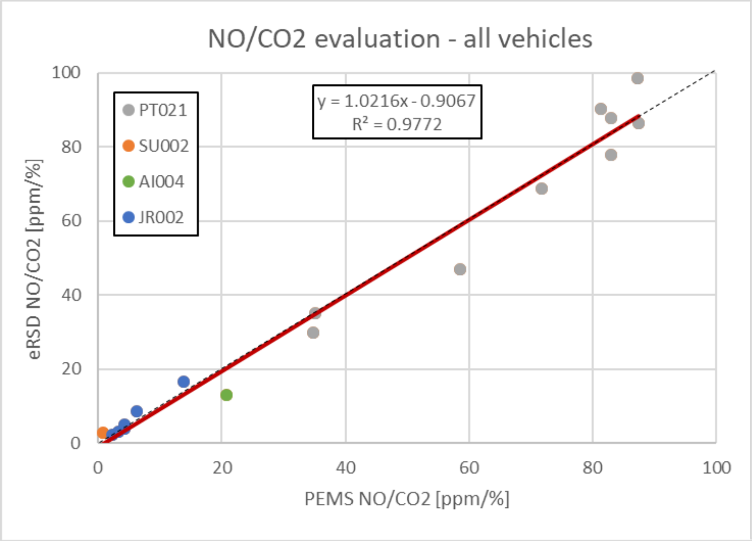
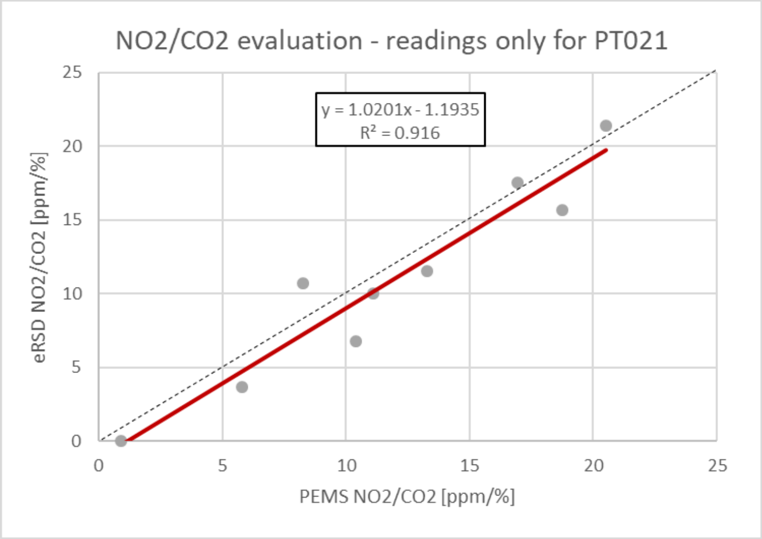
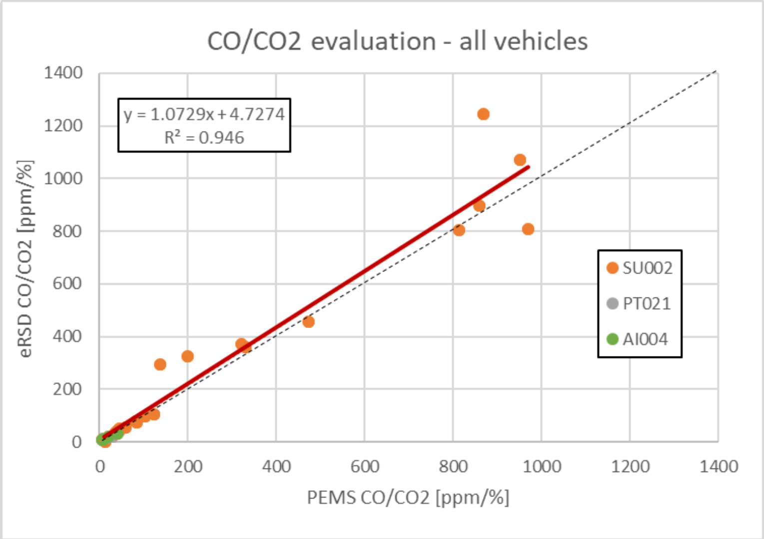
Emissions measurements: main achievements so far

Emissions remote sensing







- Evaluated by JRC vehicle emissions laboratory at Ispra.
- Excellent correlation between PEMS-equipped vehicles and the sensor.

From OPUS RSE (https://www.opusrse.com/)

Florence

Urban road traffic: The demo project will test a dynamic remote sensing system in an urban environment. It will deploy a crossroad configuration of the remote sensing devices.

Initial characterization: The dynamic, portable system has been deployed in different locations of the city in order to demonstrate the flexibility and ease of use of the system and to initially characterize the emissions and noise of the fleet of vehicles circulating in Florence. Meanwhile, ambient air quality has been monitored with general air quality sensors.

Pavement validation: A pavement test section will be implemented by the municipality of Florence in a city street. The porous asphalt mix will be tested, and real-life performance will be evaluated.

https://nemo-cities.eu/florence/

Demo in Florence

Work Done:

"Parco delle Cascine"

Florence

Demo in Florence

Work Done:

"Parco delle Cascine"

Florence

Demo in Florence

Work Done:

E-RDS: more than 2 weeks
N-RSD: from 14/06 to 21/06

Laying of new pavement in September
Air quality measurements in August

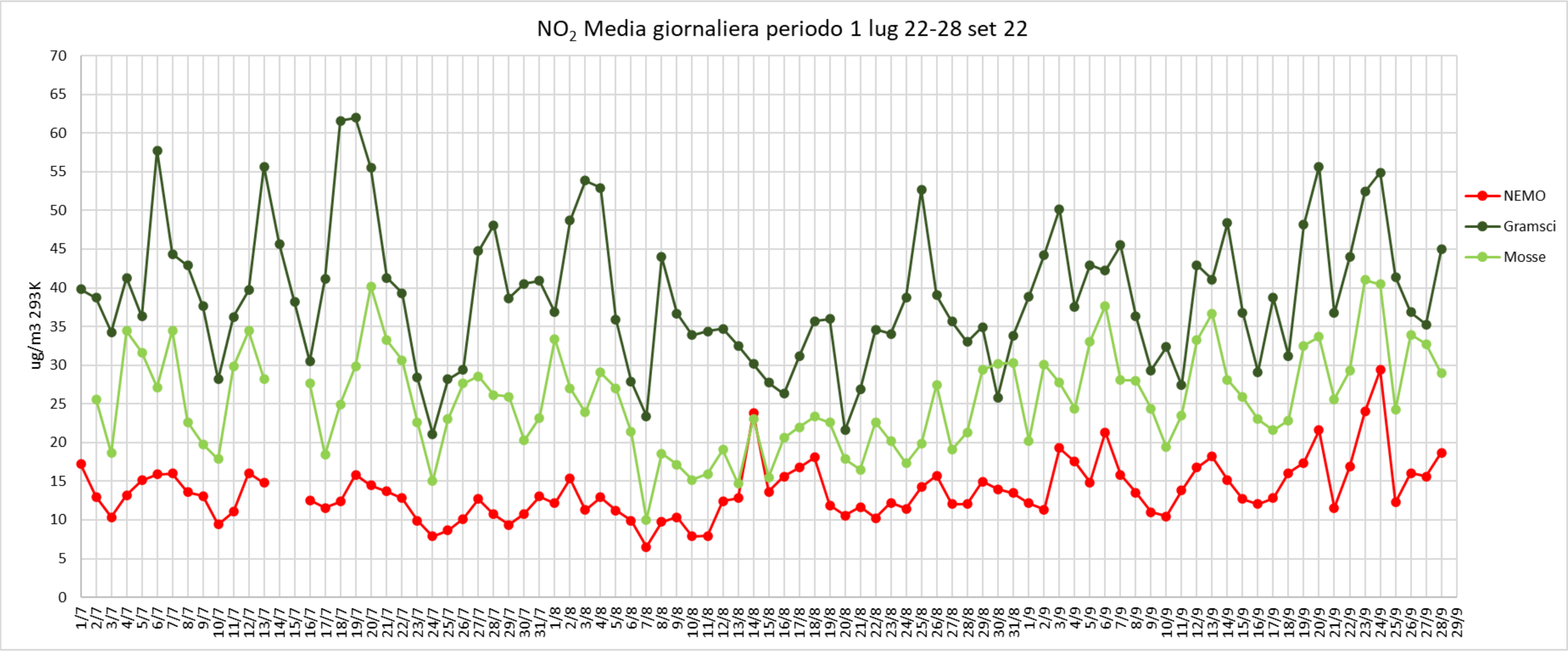
Added value: experience exchange between ARPAT and Polish Ministry of the Environment in a TAIEX event in Florence

Demo in Florence

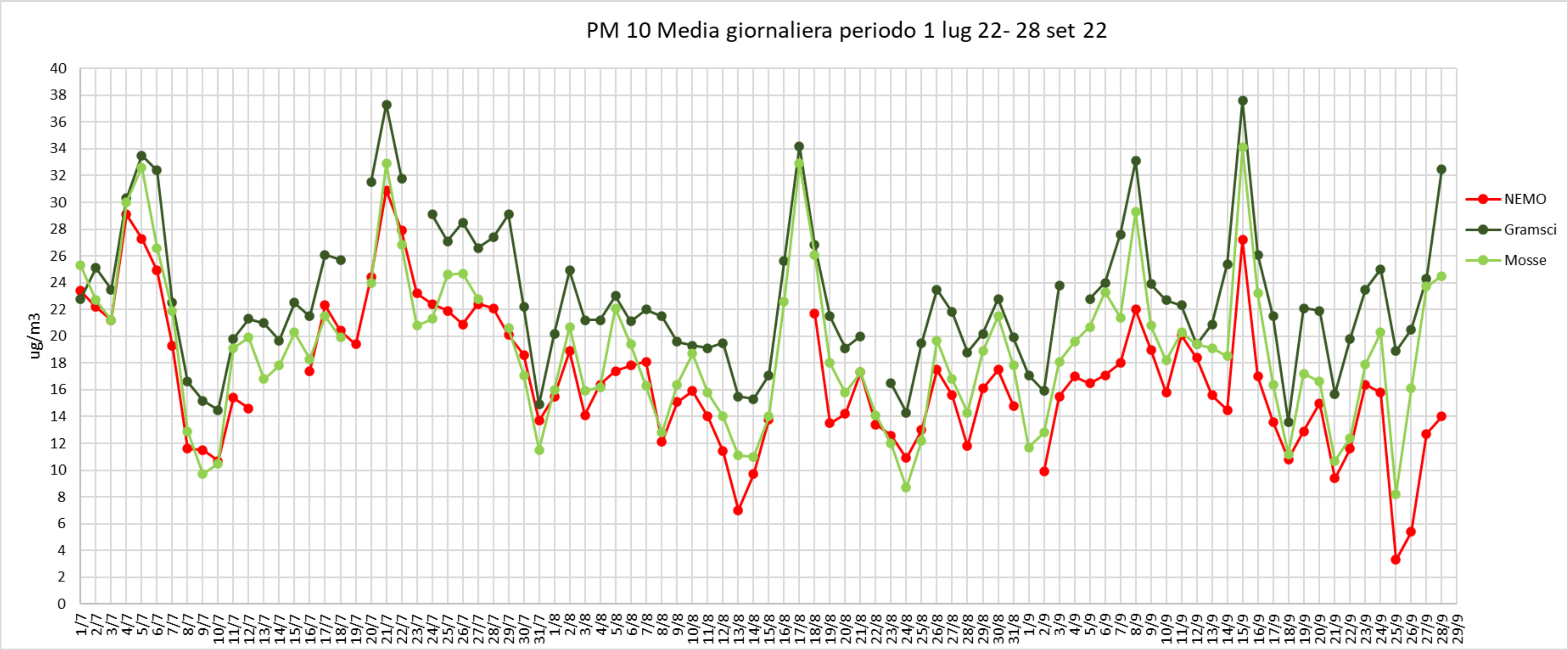
Work Done: E-RSD and air quality measurements with ARPAT mobile laborarory according to the Italian legislation

Added value: NO-NOx-NO2 (UNI EN 14211:2012), PM10 (UNI EN 12341:2014), SO2 (UNI EN 14212:2012), CO (UNI EN 14626:2012), O3 (UNI EN 14625:2012)

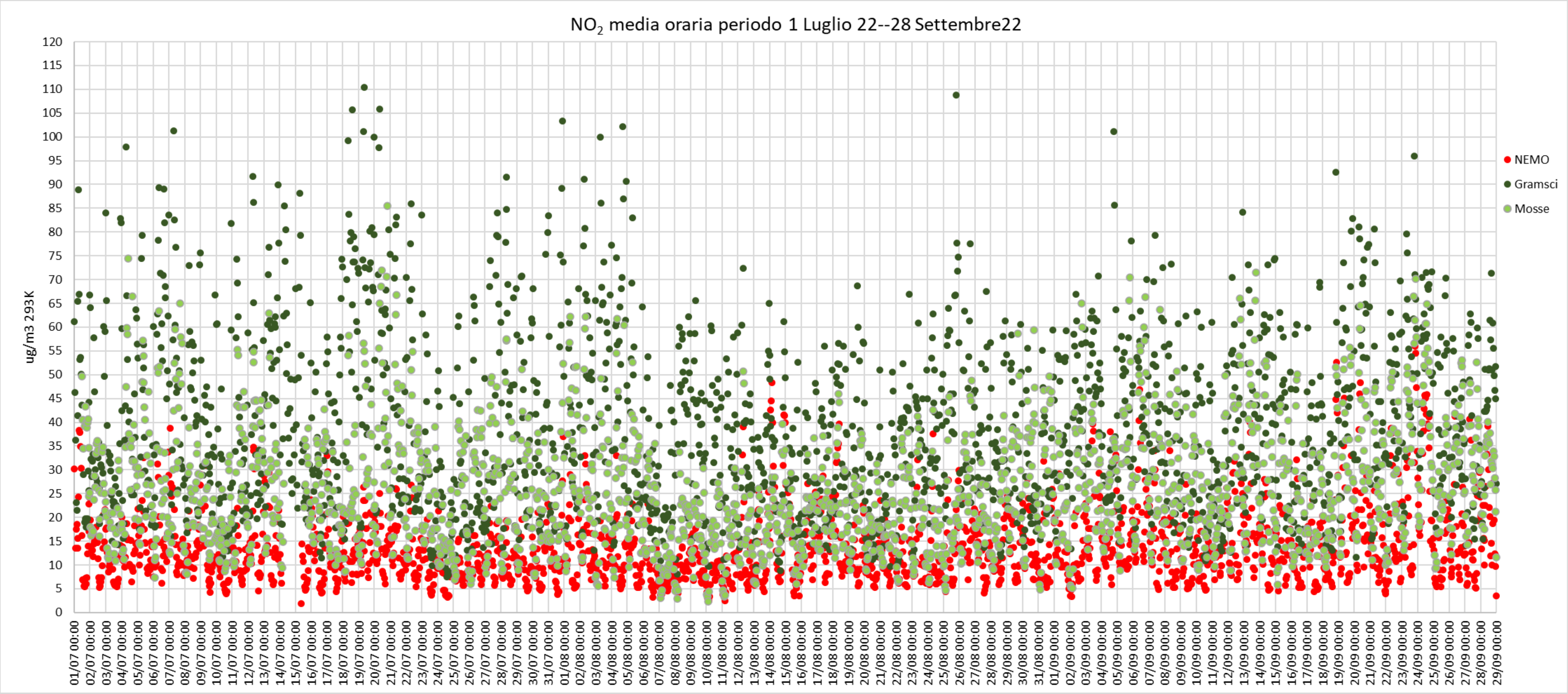
Demo in Florence:
mean values NO_2



Demo in Florence:
mean values PM$_{10}$



Demo in Florence: *data variability*



Demo in Florence:
mean values in different areas

Sampling period

- from: 1 luglio 2022
- to: 28 settembre 2022

Parameter	Mean				Max		
	NEMO	Gramsci	Mosse		NEMO	Gramsci	Mosse
NO_2 ($\mu g/m^3$ 293K)	14	39	26		29	62	41
PM 10 (µg/m3)	17	23	19		31	38	34

Grazie

https://nemo-cities.eu/

Social media

You can also follow us and connect on social media.

LinkedIn: https://www.linkedin.com/showcase/nemo-cities

Twitter: https://twitter.com/NemoCities

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