

Integrating new solutions in action plans for noise reduction

Gaetano Licitra

ARPAT

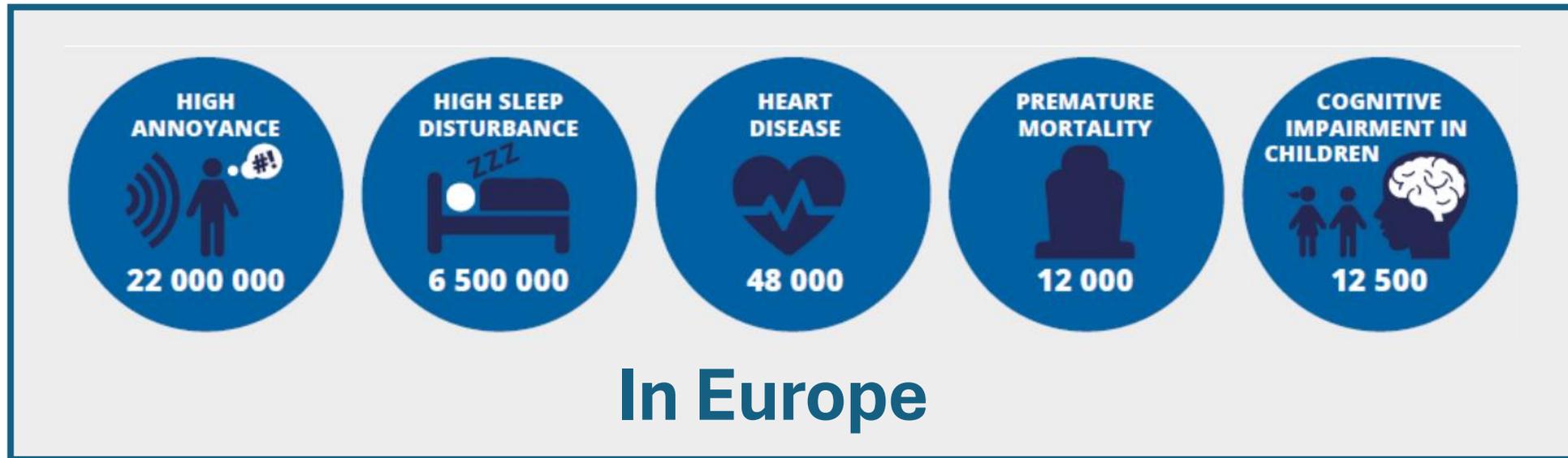
g.licitra@arpat.toscana.it

Outline

1. action plans in urban and suburban areas: different approaches needed;
2. relevant contribution of different sources in complex environment;
3. how to integrate different solutions;
4. Intelligent Transport Systems to reduce noise;
5. Innovative noise barriers.



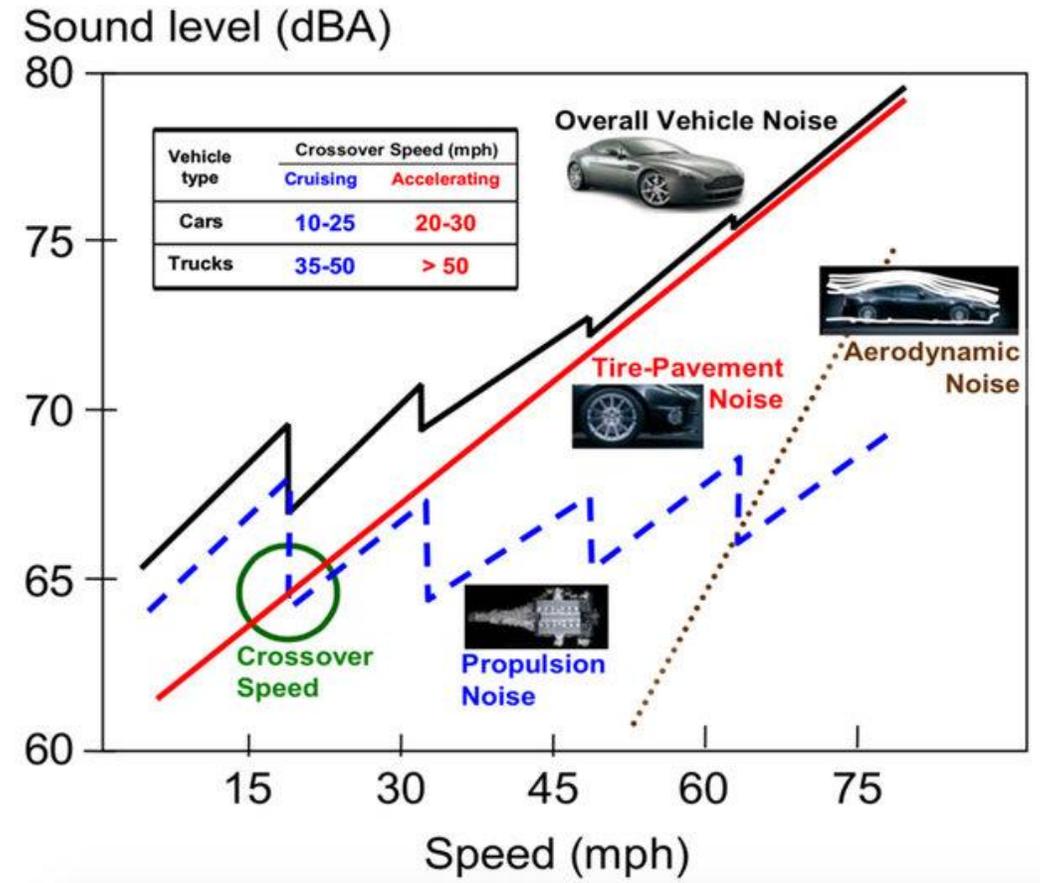
The effects of noise



- Noise is a major **health risk**
- In urban areas, **vehicular noise** is the **most important and impactful source**

Road vehicles' noise

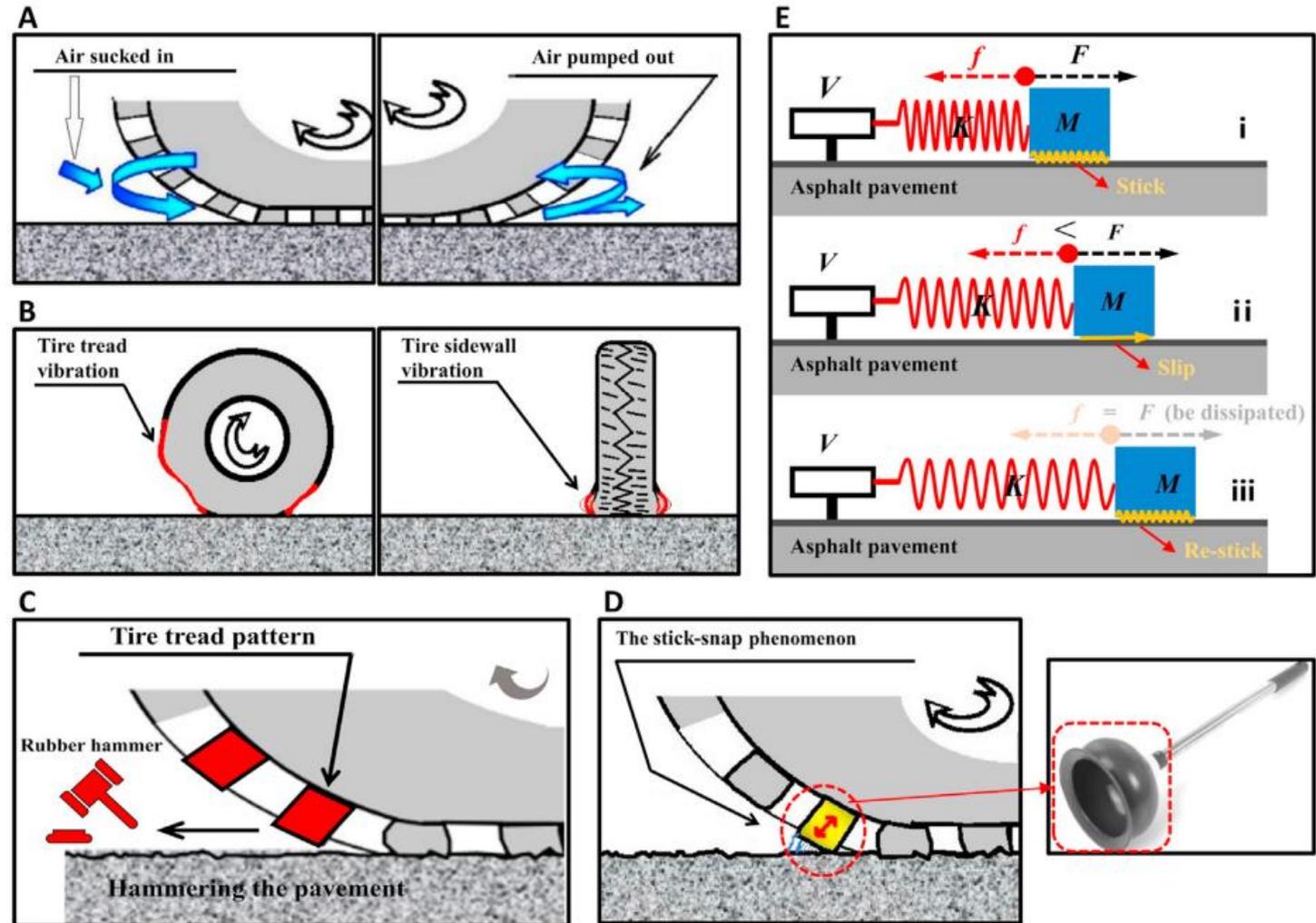
- For $v > 30$ km/h **rolling** noise dominate
 - The **electric** vehicle advantage is quiet up to $v < 30$ km/h
- **Engine** noise is the main source for:
 - Heavy trucks
 - Sport cars
 - Motorcycles



Rasmussen, R., Bernhard, R.J., Sandberg, U., & Mun, E.P. (2007). The Little Book of Quieter Pavements.

Rolling noise

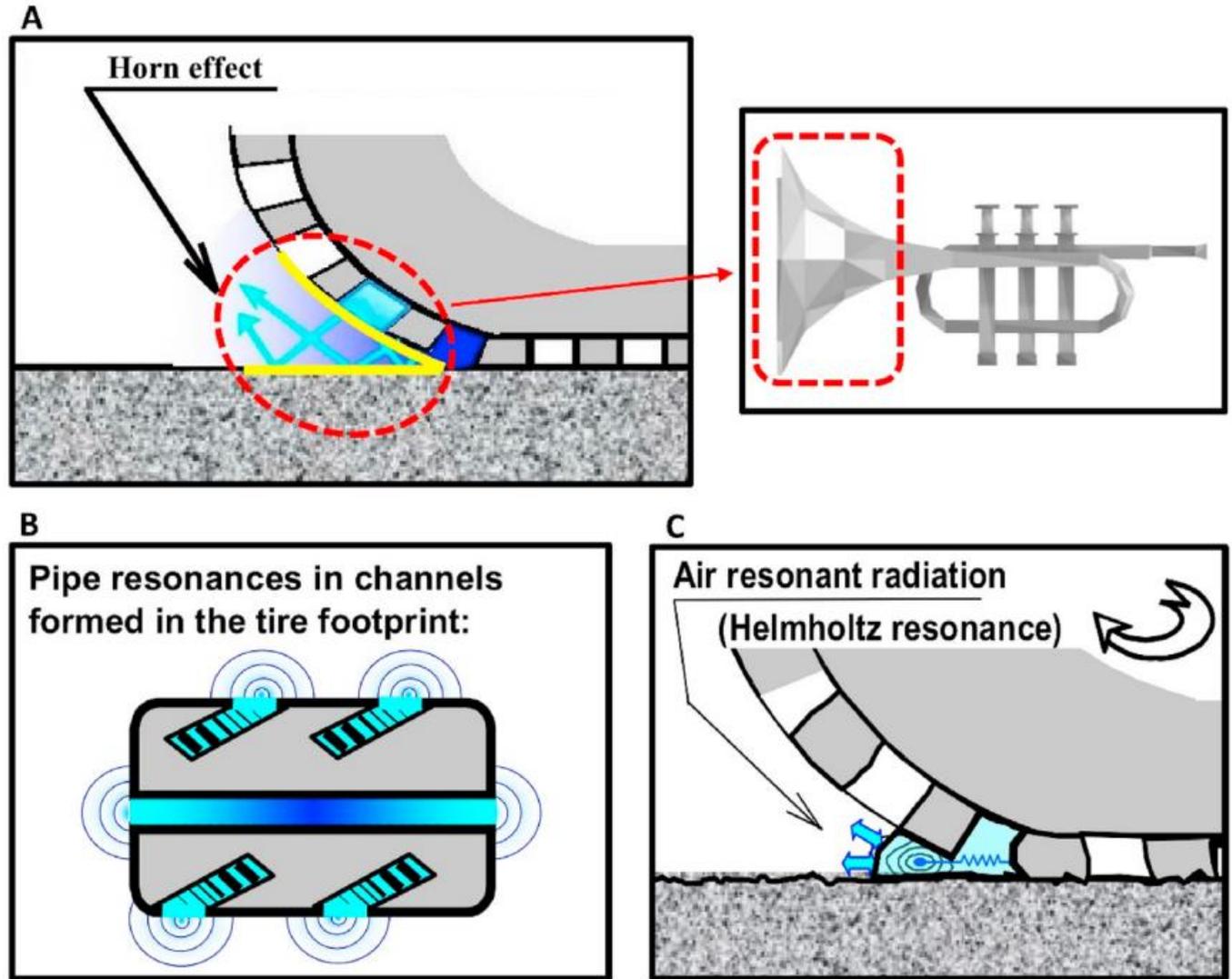
- Is **generated** by the interaction between tire and pavement
- Mechanical vibrations
- Air Pumping
- Micro-adhesion and micro-movements, Stick-slip and Stick-snap

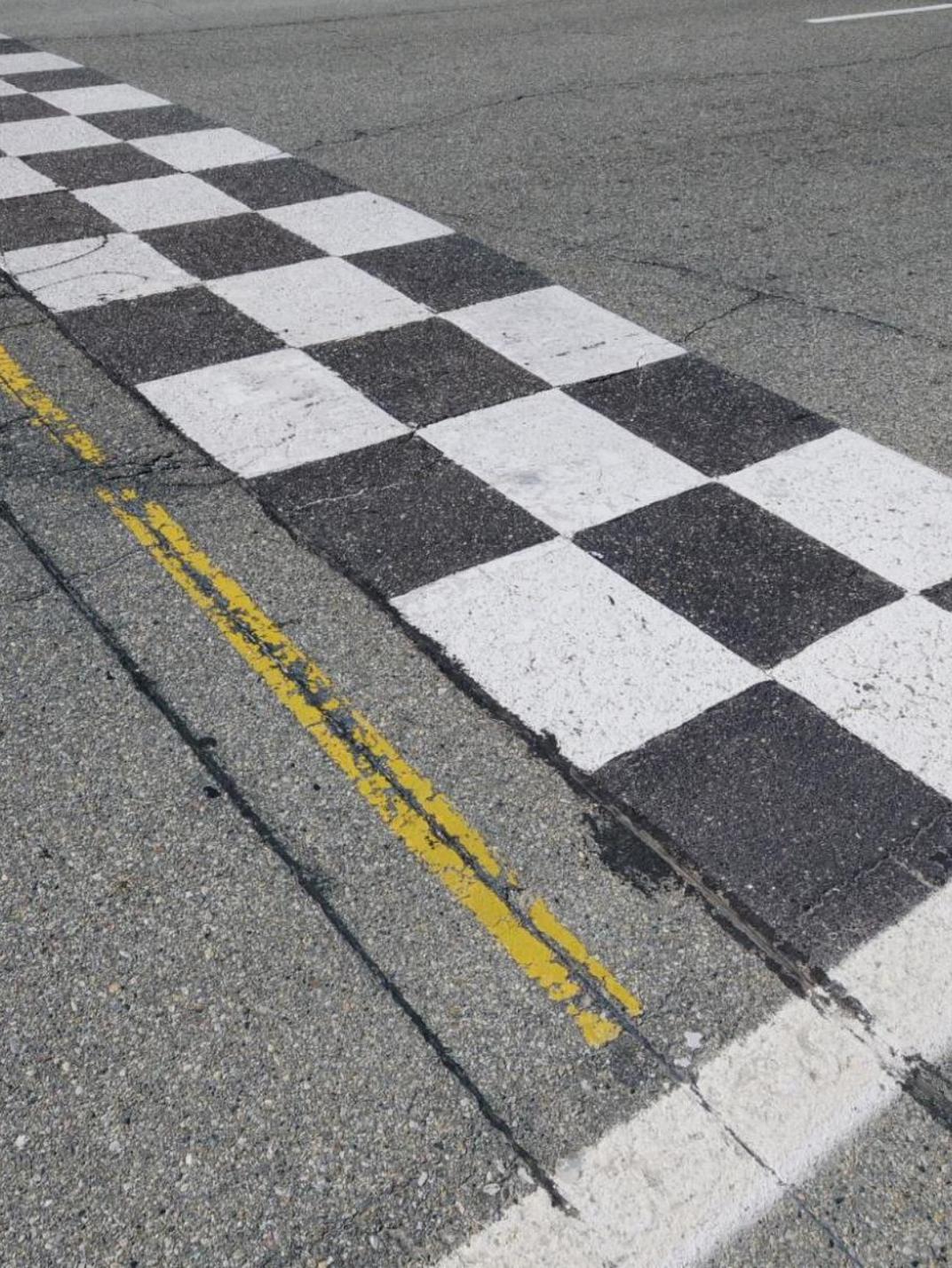


Rolling noise

- **Amplification mechanisms**

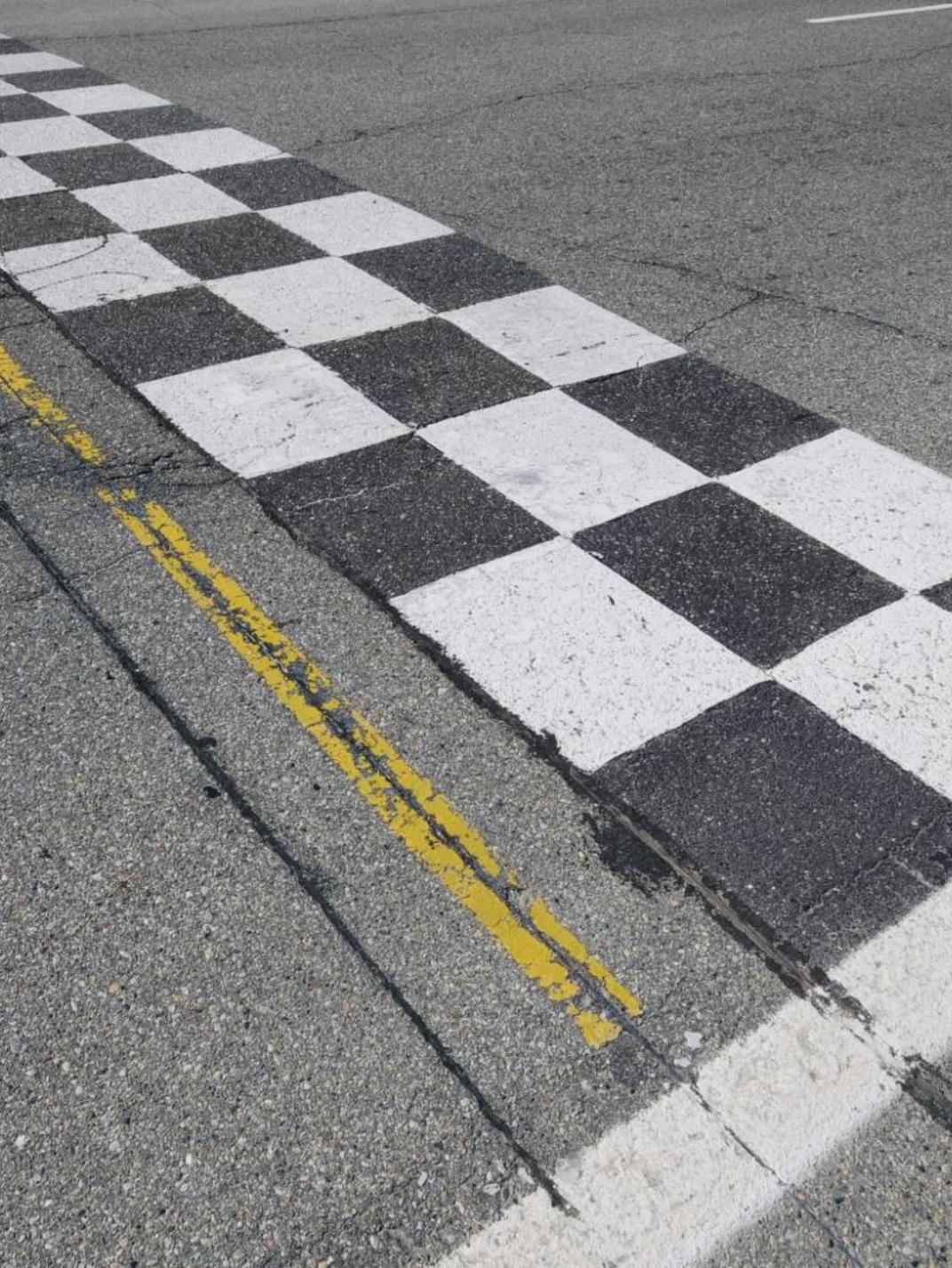
- Horn effect
- Helmholtz resonance
- Wall Resonance
- Cavity resonance





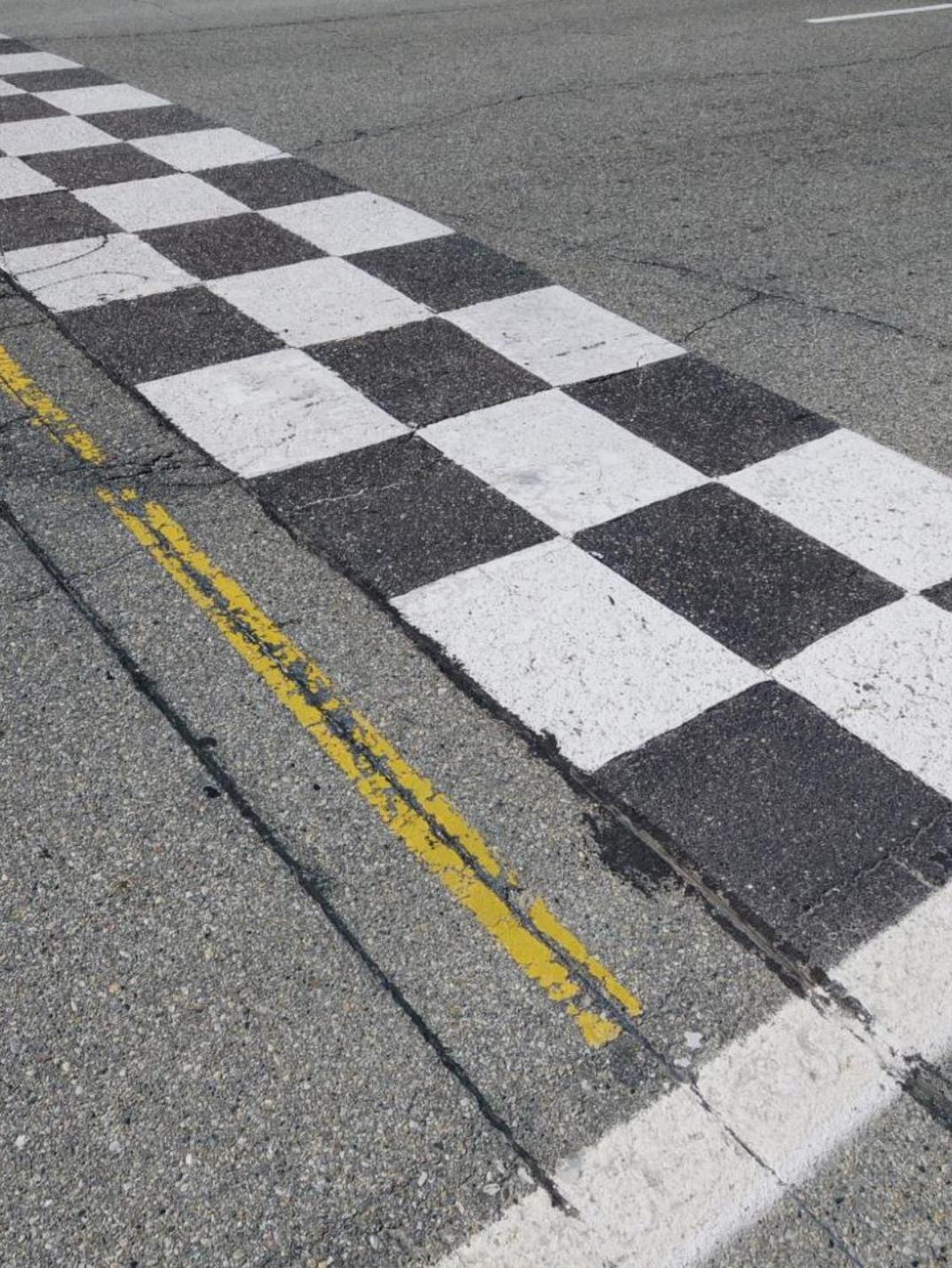
Which pavements and in which context?

- Action plans in urban and extra urban areas follow different approaches and solutions due to:
 - Different speed;
 - Different composition of the traffic
 - Different distance of houses
 - Possibility or not to act on the propagation



Which pavements and in which context?

- In **urban areas**:
 - speed is generally low,
 - engine noise is dominant,
 - drainage asphalts are easily clogged
 - new optimized textures and new materials are requested and low noise emission pavement are preferred for road with larger speed (greater than 30 km/h)

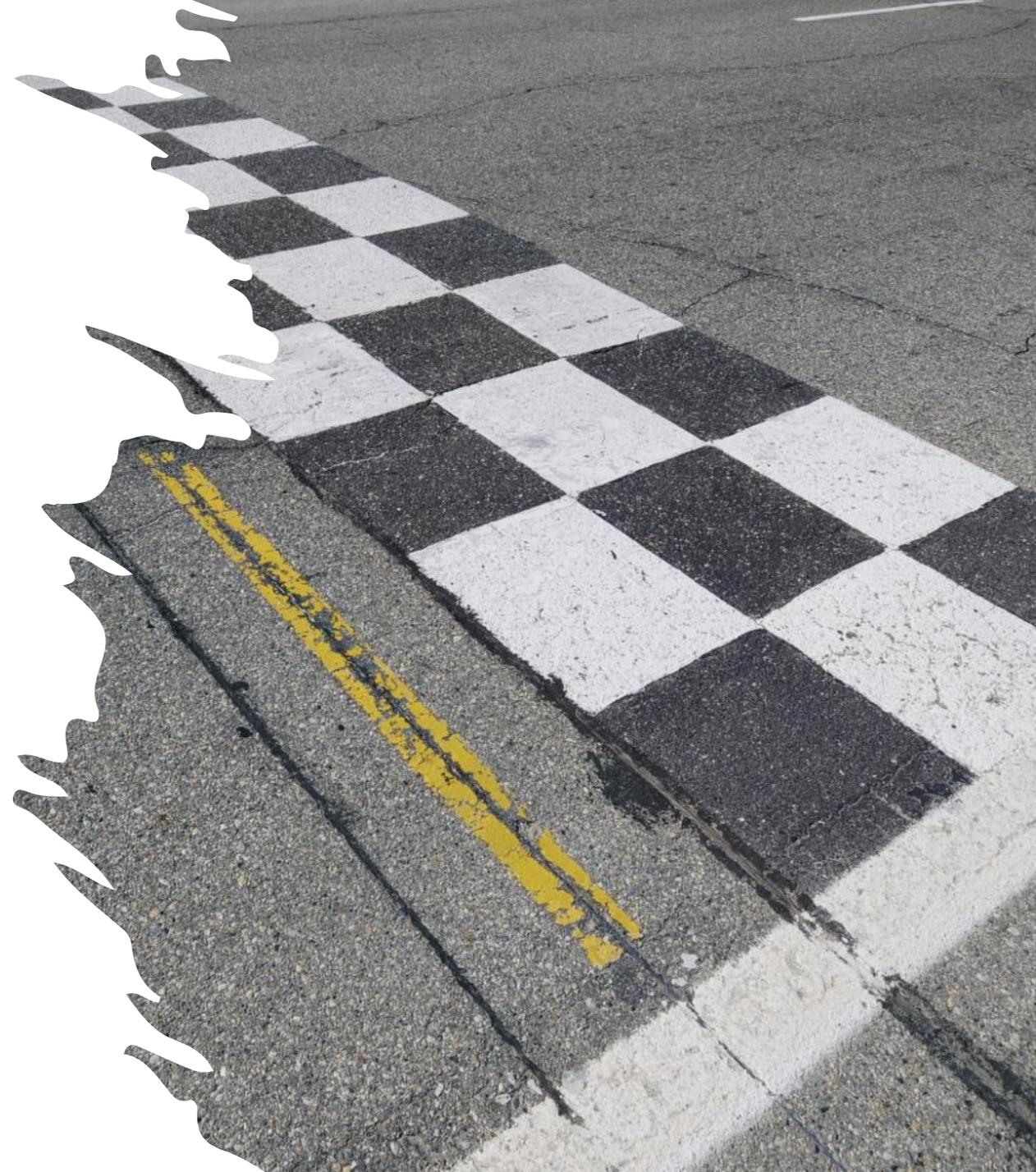


Which pavements and in which context?

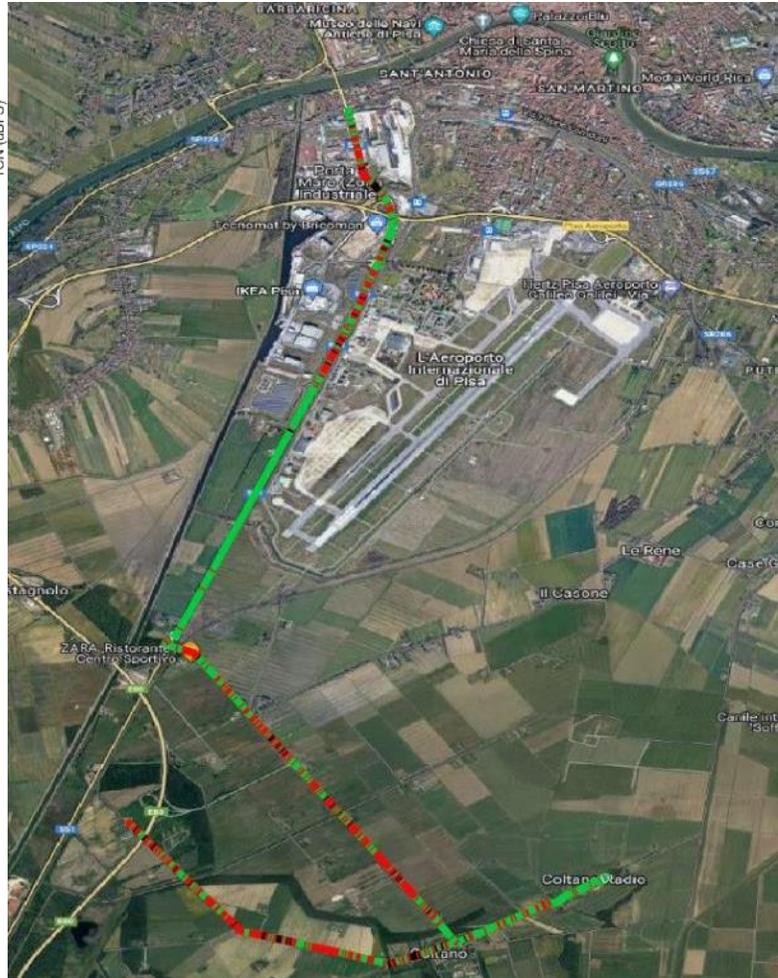
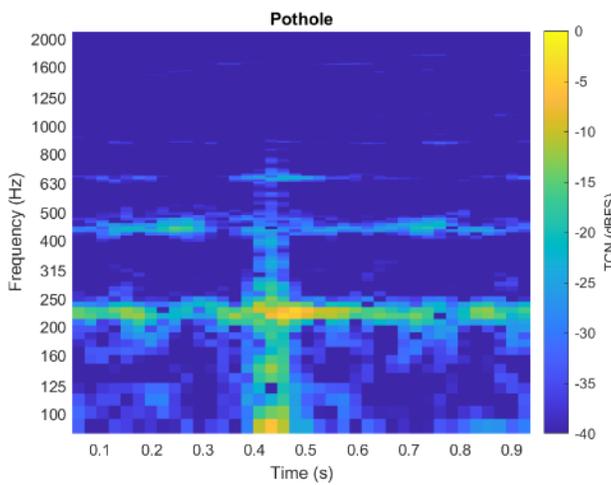
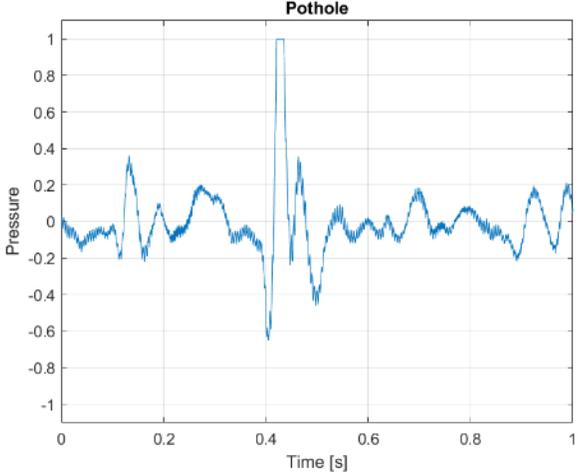
- In **suburban areas**:
 - speed is generally high,
 - rolling noise is predominant,
 - drainage asphalts are easily cleaned by heavy trucks at high speed
 - low noise pavements can help to reduce the height of barriers in an integrated approach

How relevant is the pavement maintenance ?

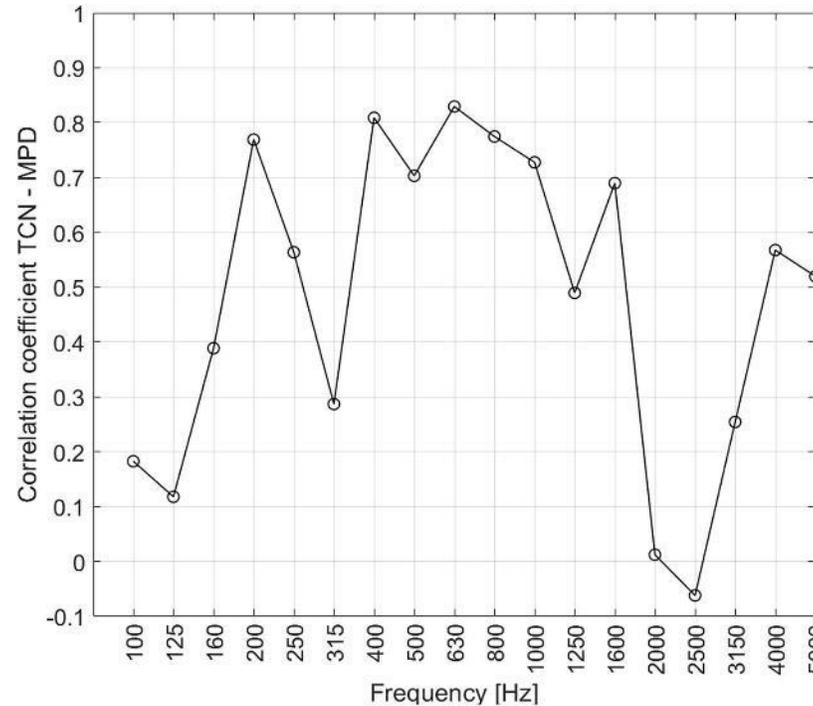
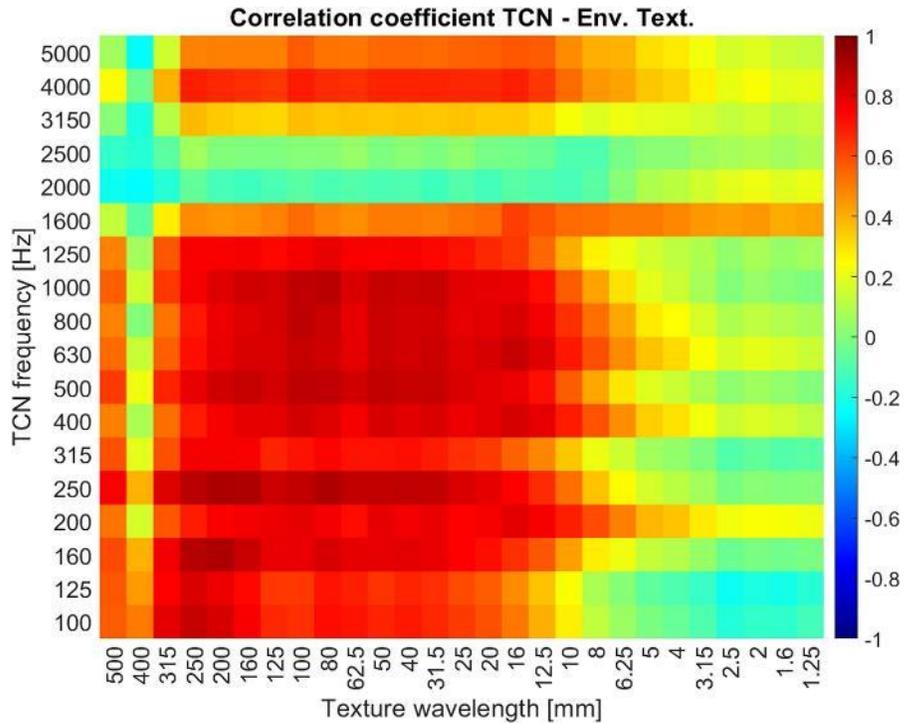
- EU significantly reduce the emissions of new vehicles
- Nothing done on road maintenance
- Noise maps don't consider the health status of pavements
- This leads to a difference of several dB(A).



Noise mapping of pavements



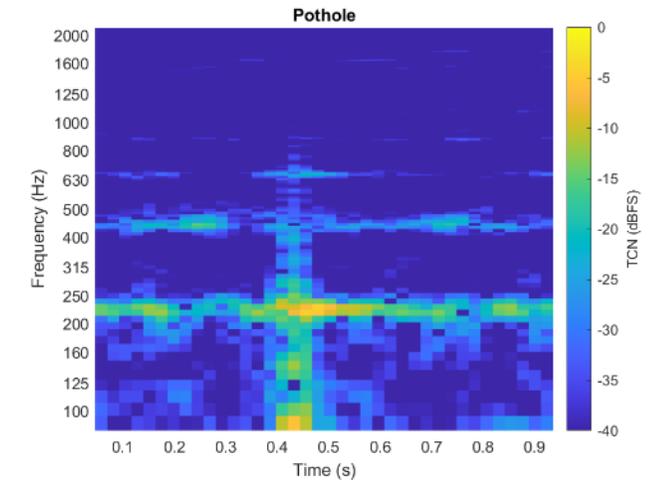
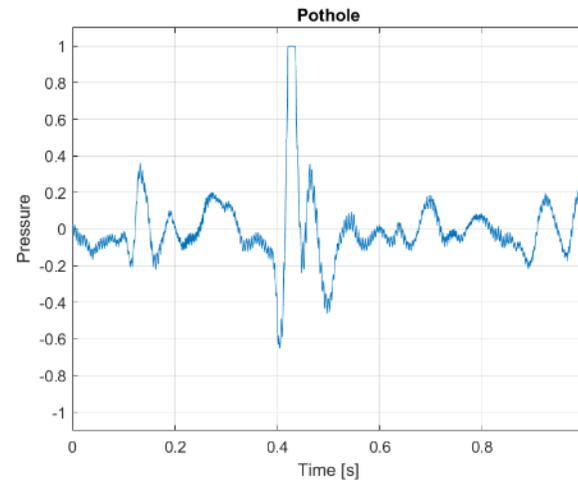
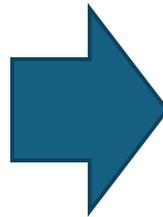
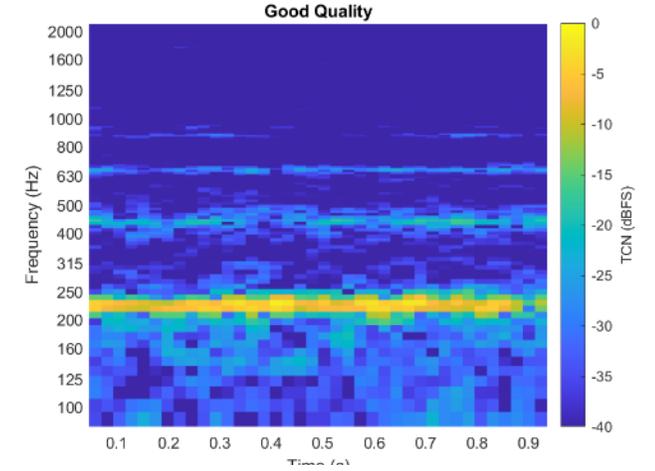
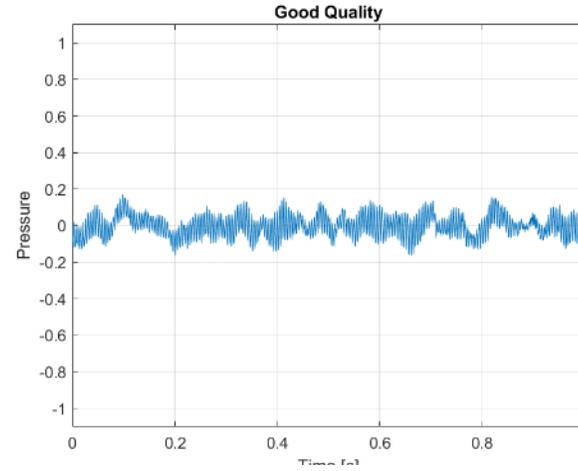
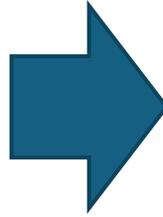
Correlation between Tyre cavity noise (TCN) and the road texture



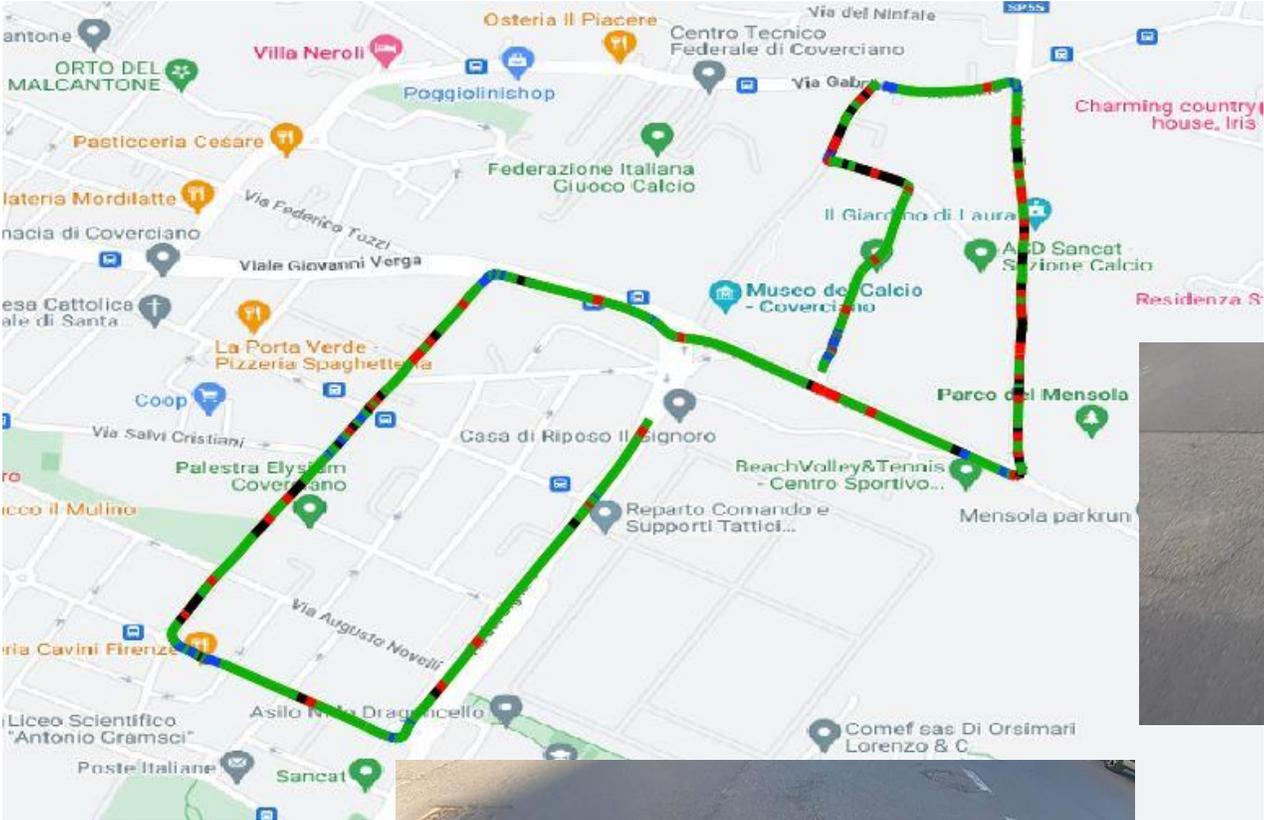
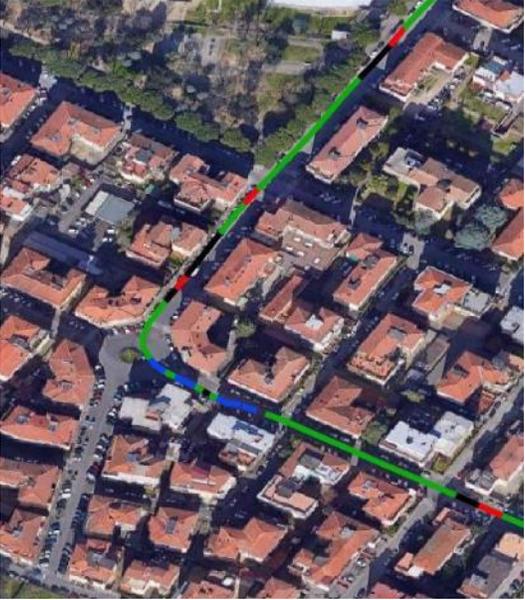
High correlation $r > 0.7$ between TCN e texture for frequencies 160 Hz-1600 Hz

Del Pizzo, Bianco, Moro, Schiaffino, Licitra,
Relationship between tyre cavity noise and road surface characteristics on low-noise pavements,
Transportation Research Part D: Transport and Environment (2021).

Tyre Cavity Noise



Case Study: Firenze - Coverciano



Monitoring pavement condition:

Good

Bad

Pothole



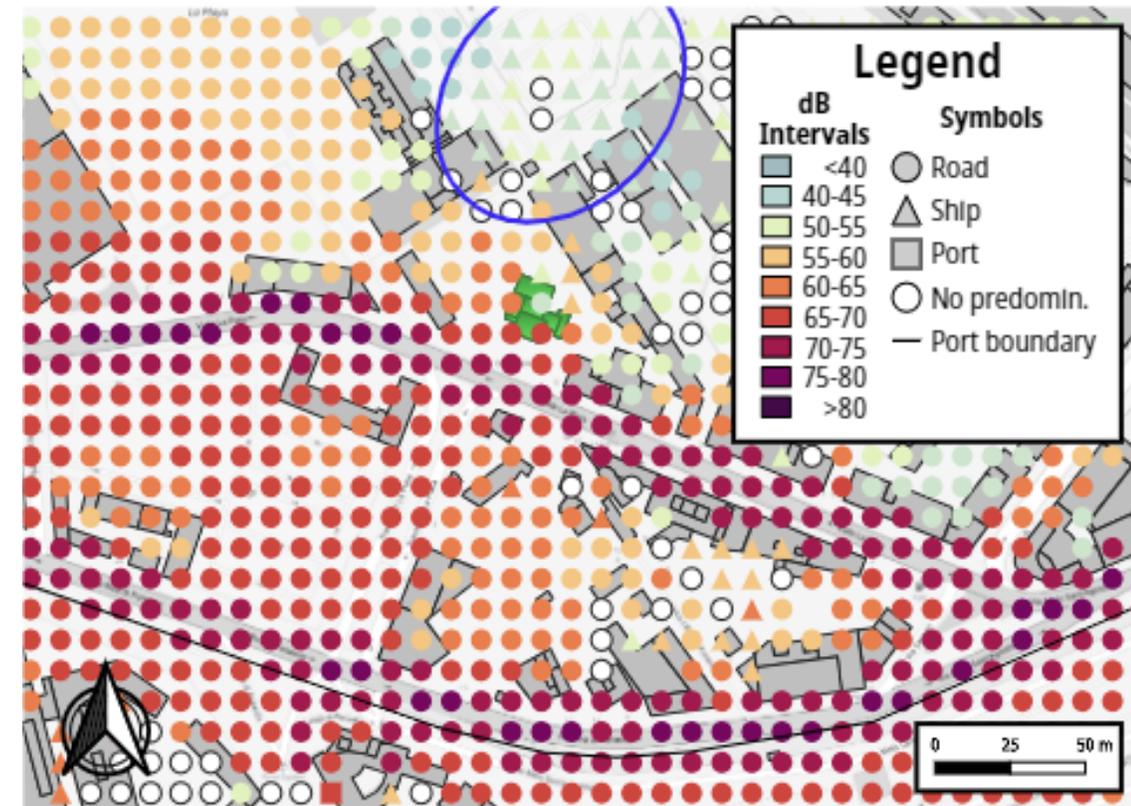
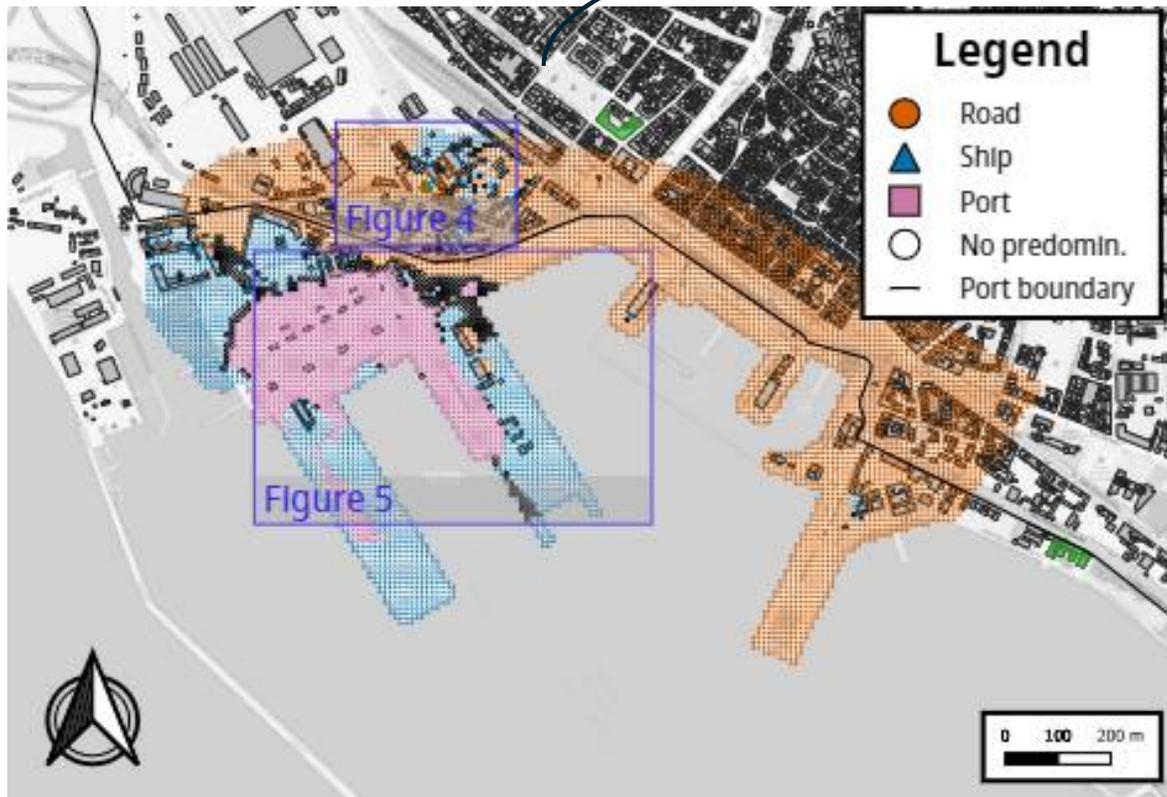
Complex scenarios

- Multiple sources can overlap
- Harbors are an example of many sources: industrial, infrastructural (road, railway, ship movement and stationing, etc);
- Road traffic induced from the port adds up the city traffic;
- So, we need :
 - new tools for identifying relevant sources
 - multifaceted solutions



Complex scenarios: the Noise Sources Predominance Maps

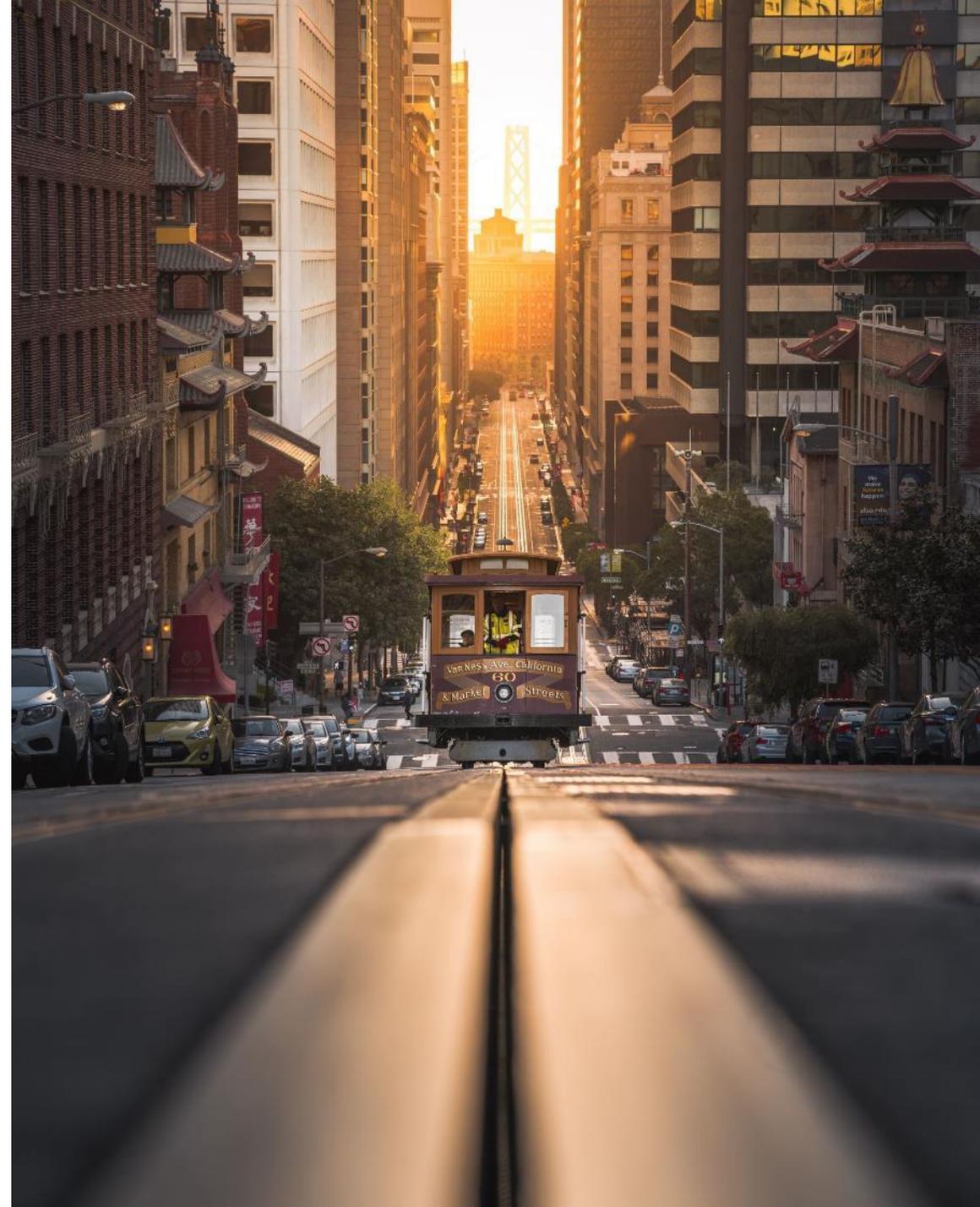
- Experience in port noise led to the definition of innovative maps that allow to identify **the most relevant source**³



³Licitra G, Bolognese M, Chiari C, Carpita S, Fredianelli L. Noise Source Predominance Map: a new representation for strategic noise maps. *Noise Mapping*. 2022; 9(1): 269-279. <https://doi.org/10.1515/noise-2022-0163>

Complex scenarios

- Roads and railways run often together
- One of the aim of **Life Silent** is to developed a method to harmonize noise mitigation solutions with a **holistic approach**, thus improving the effectiveness and efficiency of the overall mitigation action.
- Which is the best actions?
Who pays, what?



Candidates sites - Life SILENT



7 Candidate sites
were selected

Candidates sites - Life SILENT

Elements analysed:

- multiple main road sources
- different height of house elevation
- Relative position of houses to infrastructures
- distance between the two infrastructures
- **sensitive receivers**



Which integrated solutions in such complex scenarios?

- **Life Silent** proposes a combination of solutions:
 - low barrier close to the railway with a new design (metamaterials) to increase absorption;
 - pavement using recycling materials (rubber from used tyre)



Noise diffractor



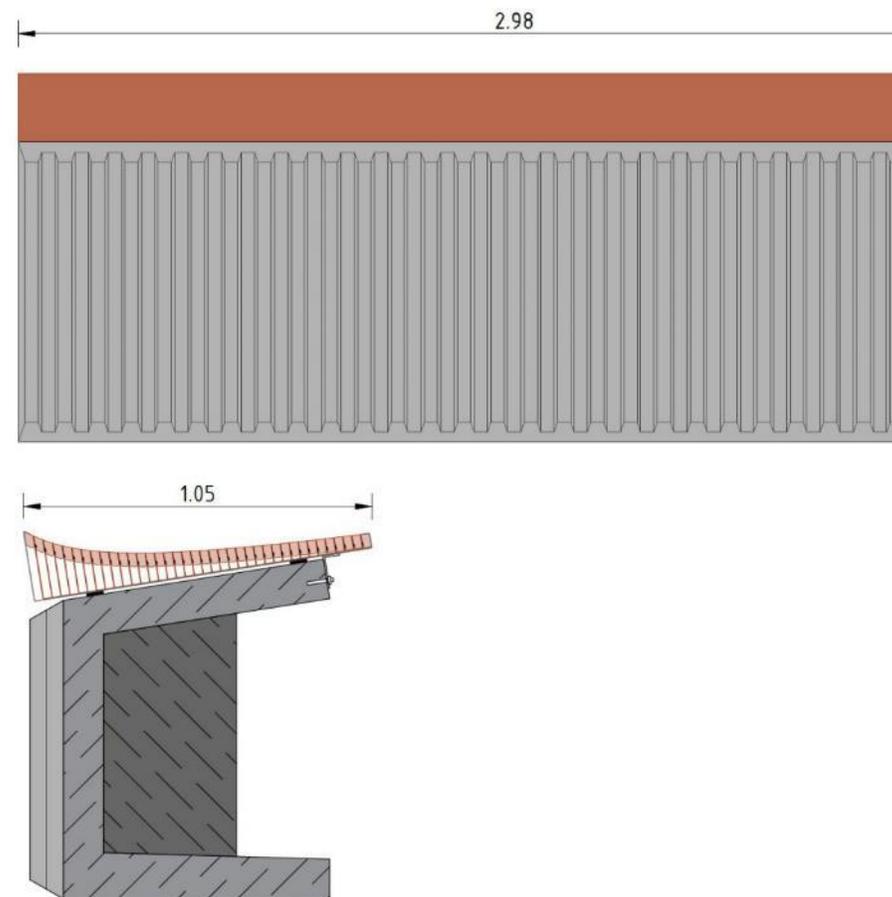
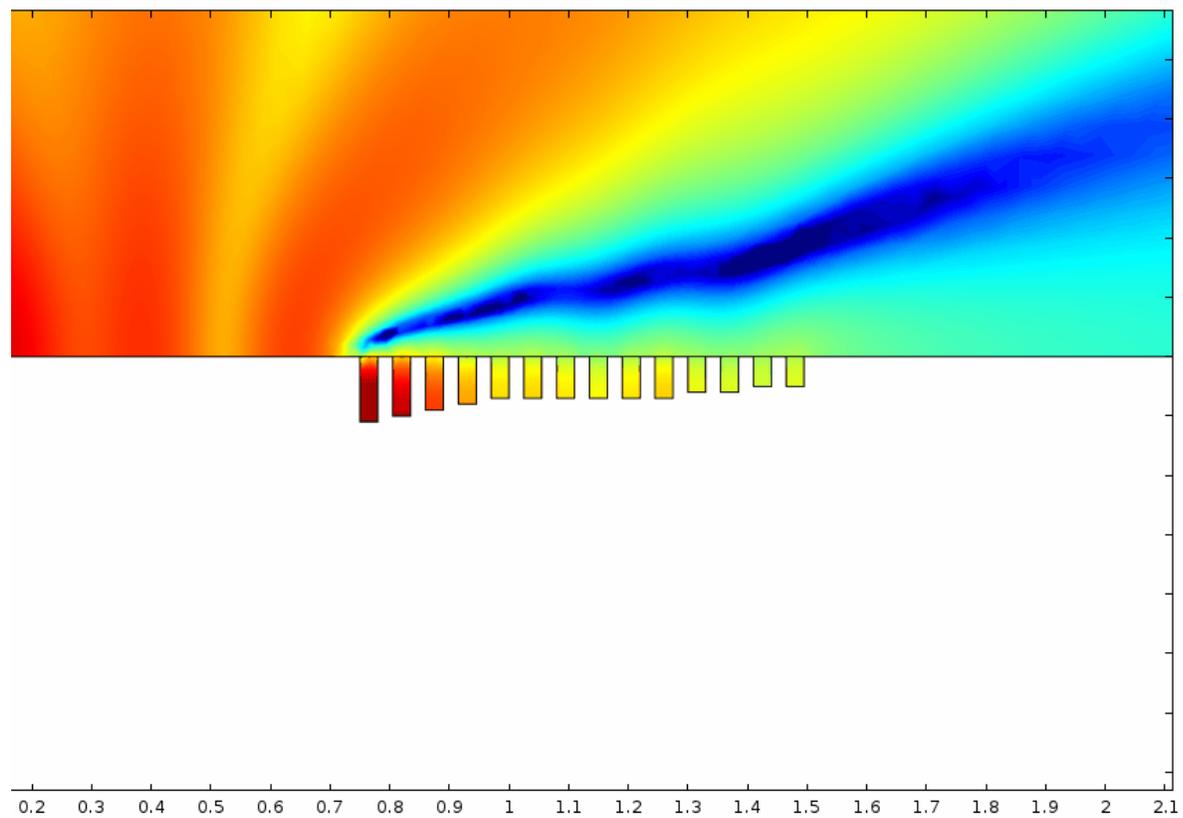
Due to resonance in the cavities, the sound waves are deflected in an upward direction, with 2.5 dB(A) of noise reduction

Reduction frequency range: 800 – 1200 Hertz

A diffracting element alongside a major road

Source: <https://www.4silence.com/whisstone/>

Multiple diffractors



Innovative Solutions

- WHISSPER - fighting traffic noise exposure by diffraction



Advantages and limits

• Advantges

- Duration more than 30 years, compared with low noise pavement
- Reduced visual impact
- Possible combination with other solutions (barrier and low noise pavements) to reduce the height of the barrier in highly exposed site

Limits

- Accurate modelling for providing effective reduction performance in wide frequency band and at large distance
- Space available along the side of the road
- Cleaning of the structure to avoid clogging and decrease of performance
- Cost of maintenance

Pavement +....

- When low noise pavements are not enough to reduce exposure levels exceeding the limits, many different combinations of other actions could be implemented:
- + barrier (pavements could reduce the height of it)
- + diffractor along the road

Or trying to **reduce the speed** changing road design or by means a different **traffic management**.

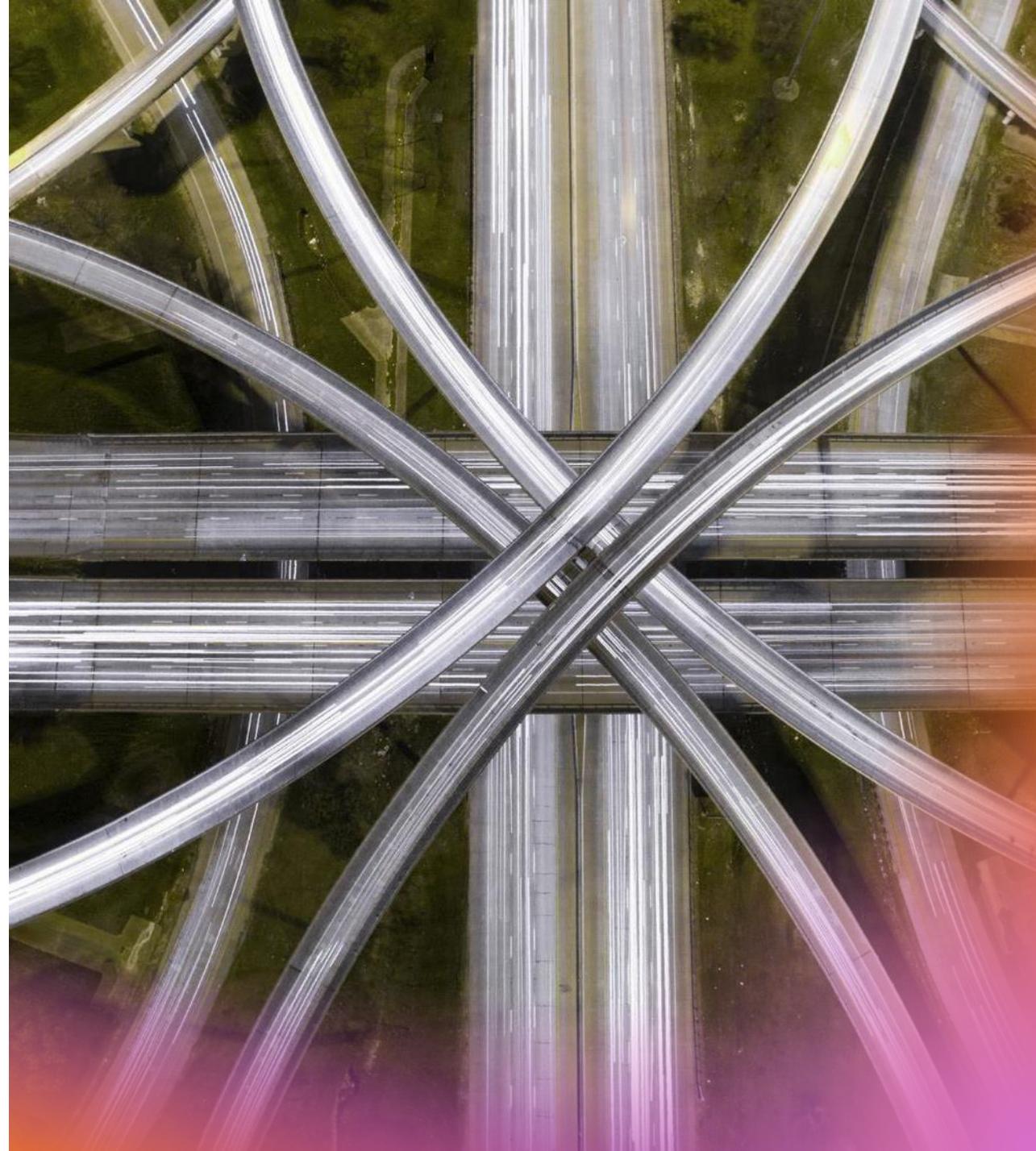


- **Road design:**

- Zig zag road
- Roundabout
-

- **Traffic management**

- Green waves
- Speed limit and control
- Intelligent Transport System
- Zone 30



Speed bumps and bollards

- Noise reduction from 5 dB (speed cushion) to 7 dB (speed bumps) due to speed reduction
 - Isolated speed bumps are counterproductive
 - Braking and acceleration (+2 to +4 dB)
 - Crash noise (up to + 10 dB for heavy vehicles)
- It is preferable to place them in pairs at a controlled distance



Narrowing of the roadway

- Up to 2 dB reduction*
 - Traffic Islands
 - Parking
 - Cycle paths
 - Reserved lanes for public transport
- Retrofitting of bike lanes reduces noise by 1 to 3 dB(A) **

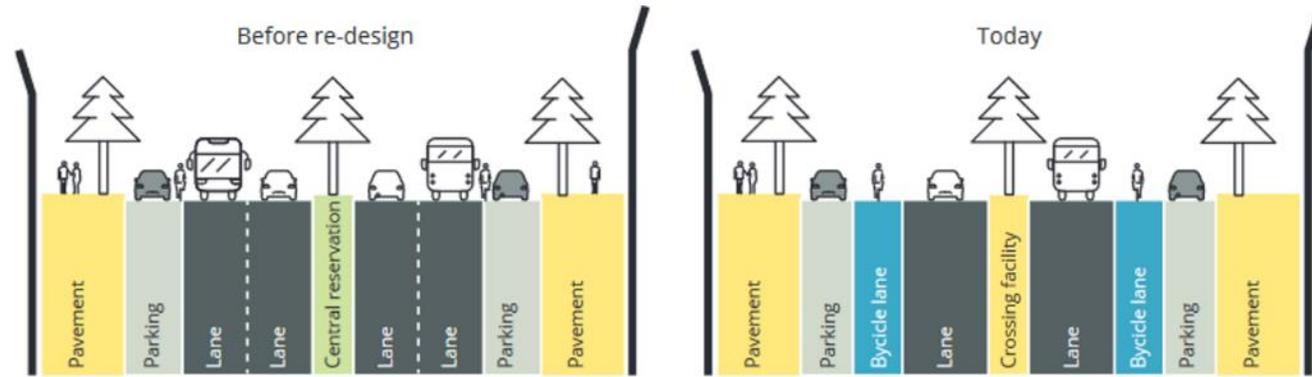


*Plan des mesures d'assainissement du bruit routier selon OPB art. 19, République et canton de Geneva, 1998.

**Levental, M., Lutte contre le bruit dans le milieu urbain, Journées d'automne de la SSA, Sion, 2002.

Case study - Berlin

- **500,000** people above 50 dB at night
- Two-lane roads in each direction, with traffic <20,000 per day, were reduced to single lanes
- Vehicles moved to the middle of the road, moving it away from residential buildings.



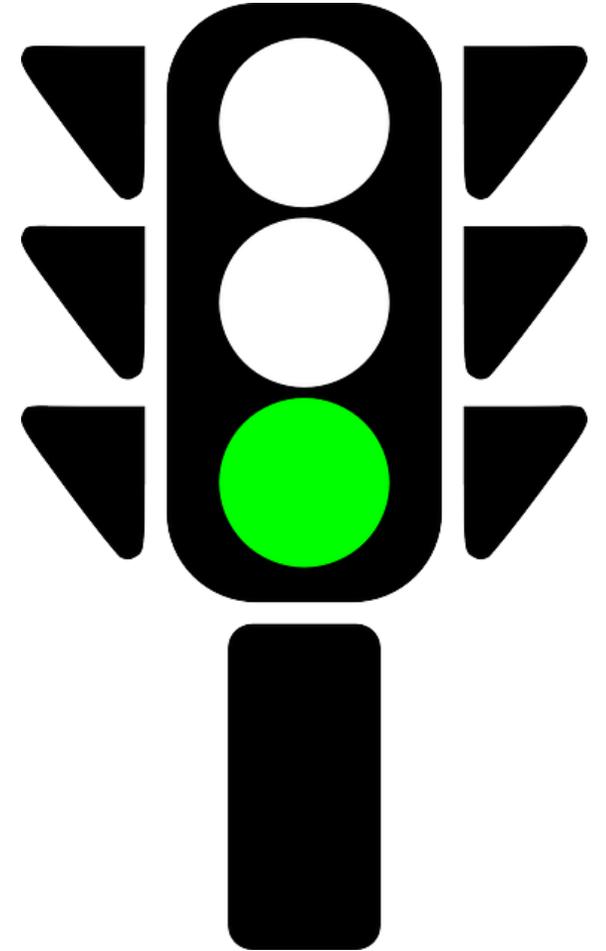
- The number of people exposed reduced by more than **50,000**.

Traffic light intersections

- Installing a traffic light at an intersection can lead to a reduction of 1 to 2 db

Green Wave

- Allows level decreases of **up to 2 dB***
- **Red Wave**
 - It allows you to decrease the travel speed at night



*Levental, M., Lutte contre le bruit dans le milieu urbain, Journées d'automne de la SSA, Sion, 2002.

Roundabouts

- Roundabouts can lead to a **decrease of 2 to 4 dB** compared to traffic light

Compared to an uncontrolled intersection:

- Slows down heavy vehicles without installing speed bumps (**-5 to -10 dB**)
- Increases the noise exiting the roundabout (from **+3 to +8 dB**)



Restricted Traffic Zones



- Restriction of night traffic led to a reduction of **up to 6 dB** in Baden-Württemberg
- In Hong Kong and Geneva, selective night-time restrictions produced **2 to 5 dB** reduction
- In Italy and France, reductions of between **3 and 8 dB** were observed by closing some roads

Zone 30

- Areas of the city with a limit of 30 km/h to facilitate coexistence with bicycles and pedestrians
- Improving road functionality and safety
- Reduce air, noise and visual pollution



Zone 30 - Road accidents in Italy

In the first half of 2022,
in average every day
there were

With an increase compared to 2021 of:



+24,7%



+25,7%



+15,7%

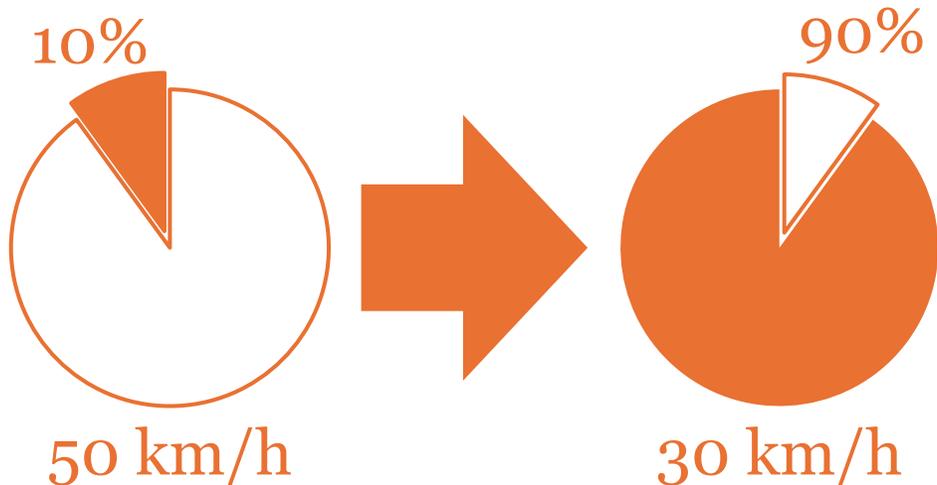


happen in the city

Zone 30 - Increased security

- Reducing speed **halves braking distance** and increases chances of survival

Probability of survival

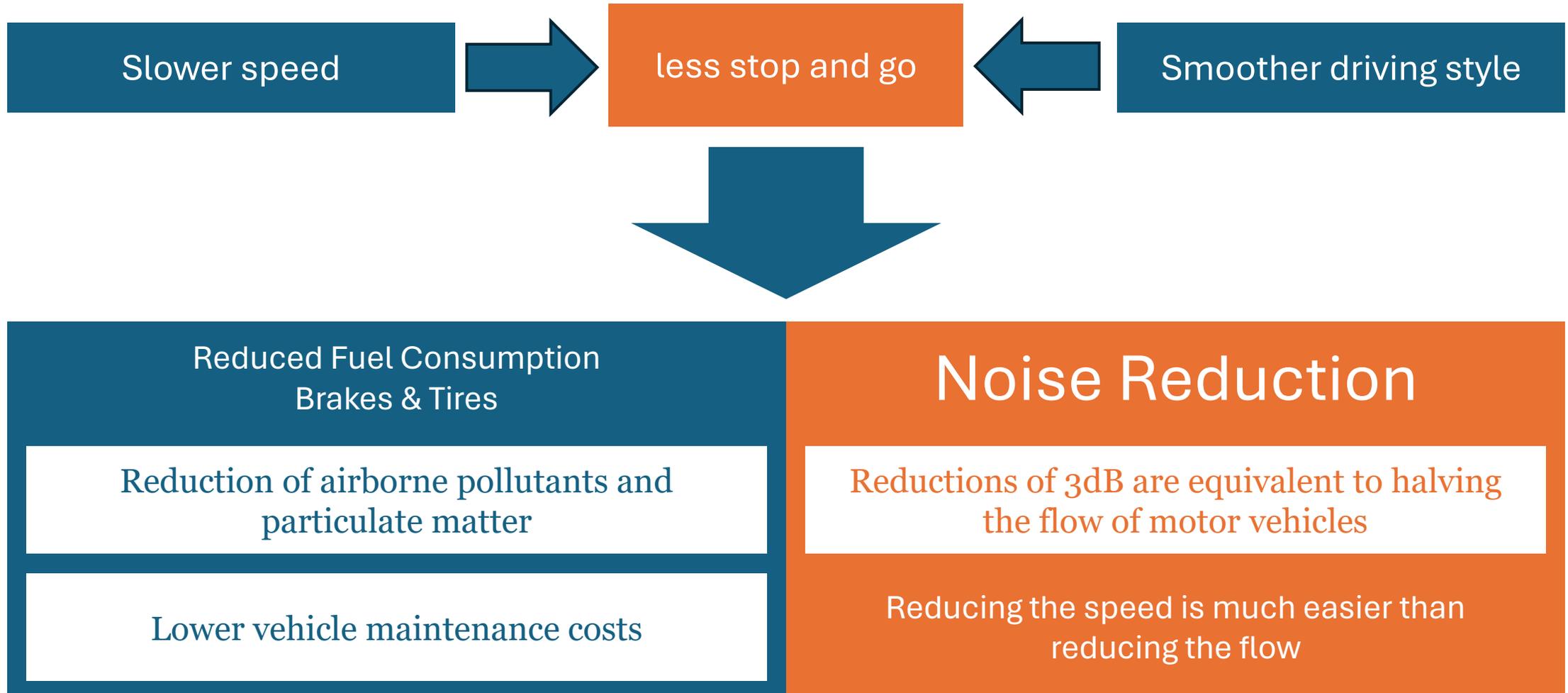


European objective

-50%

Fatalities on the road by 2030

Zone 30 – Less pollution



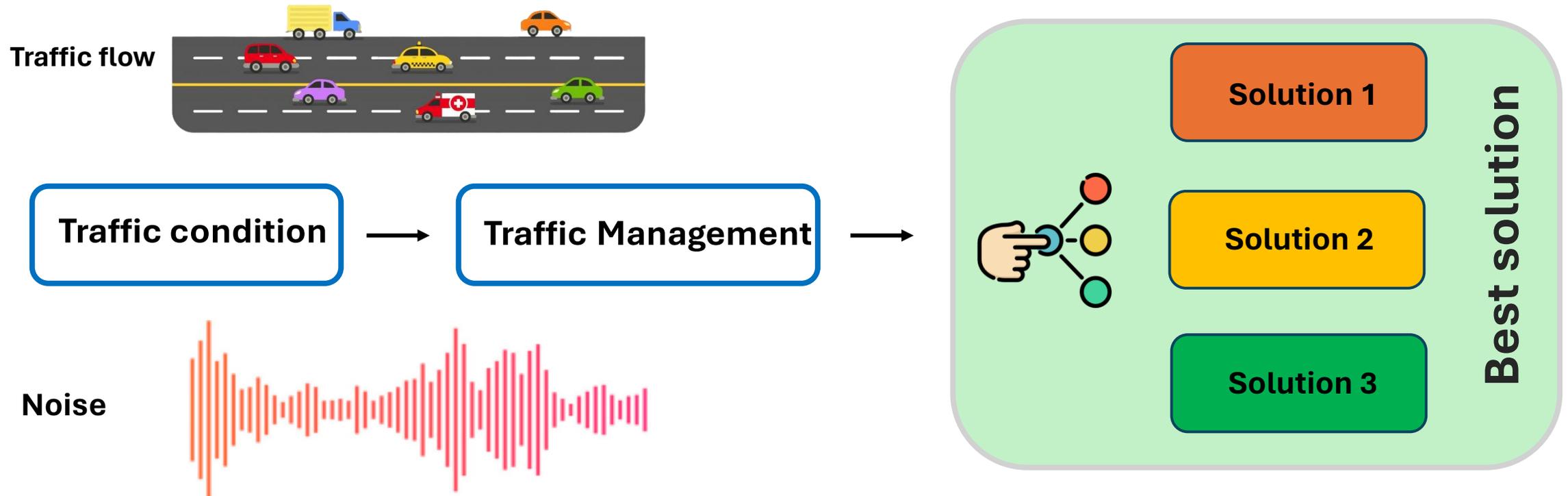
Traffic Management Option

Traffic model can implement appropriate traffic interventions according to changes in network routing, or to the distribution of vehicular flows on specific road branches

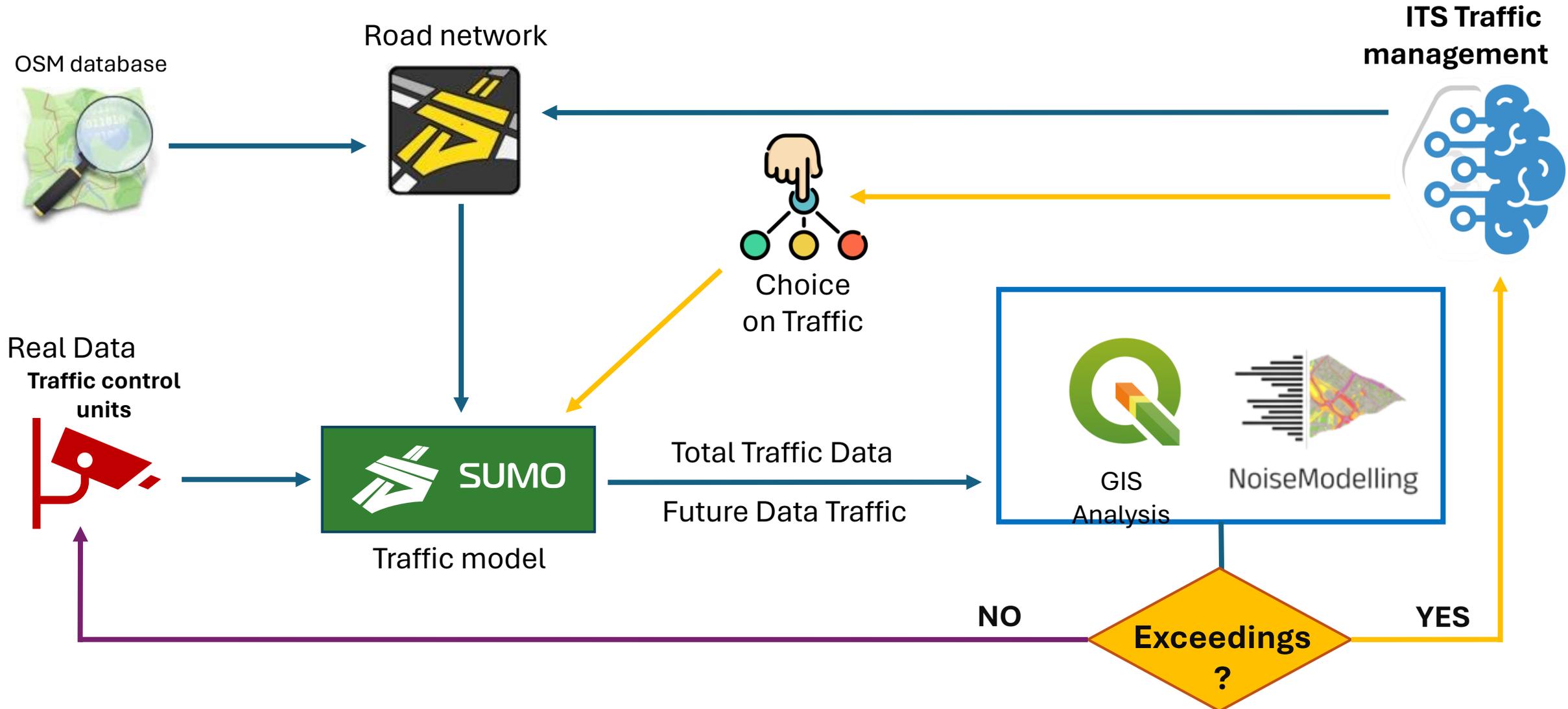


Traffic Management Implementing

Choosing to adopt vehicular traffic management through a dynamic model not only allows the road network to optimize travel time, but also to be able to manage the environmental impacts due to noise

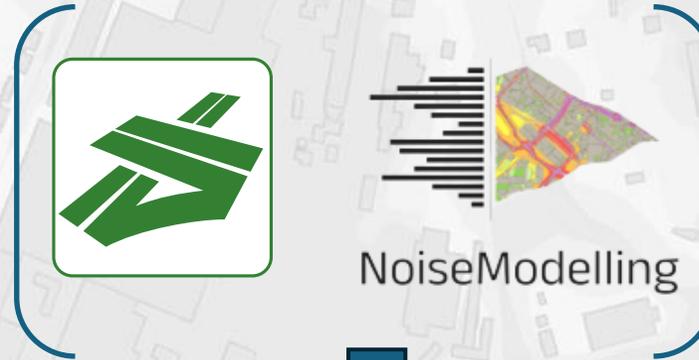


Project scheme



REAL-TIME SCENARIOS AND DATA

Scenario



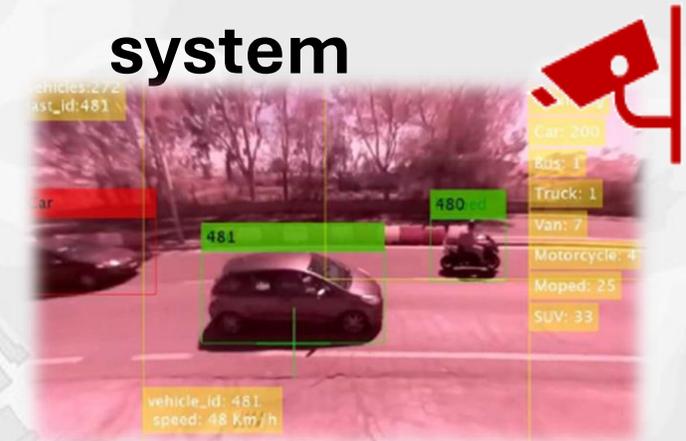
Real time
system



noise exposure



Analysis of the situation and alternative traffic route solutions



Identification/attribution of CNOSSOS categories to vehicles using recognition software (AI)

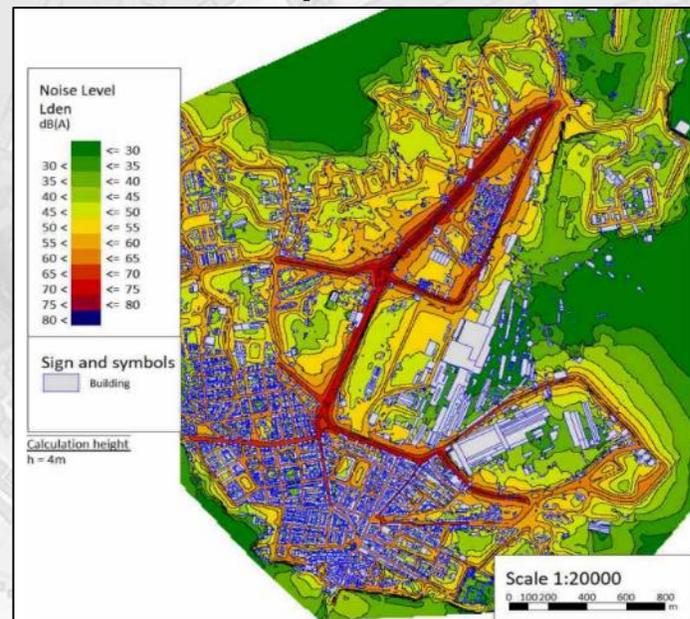
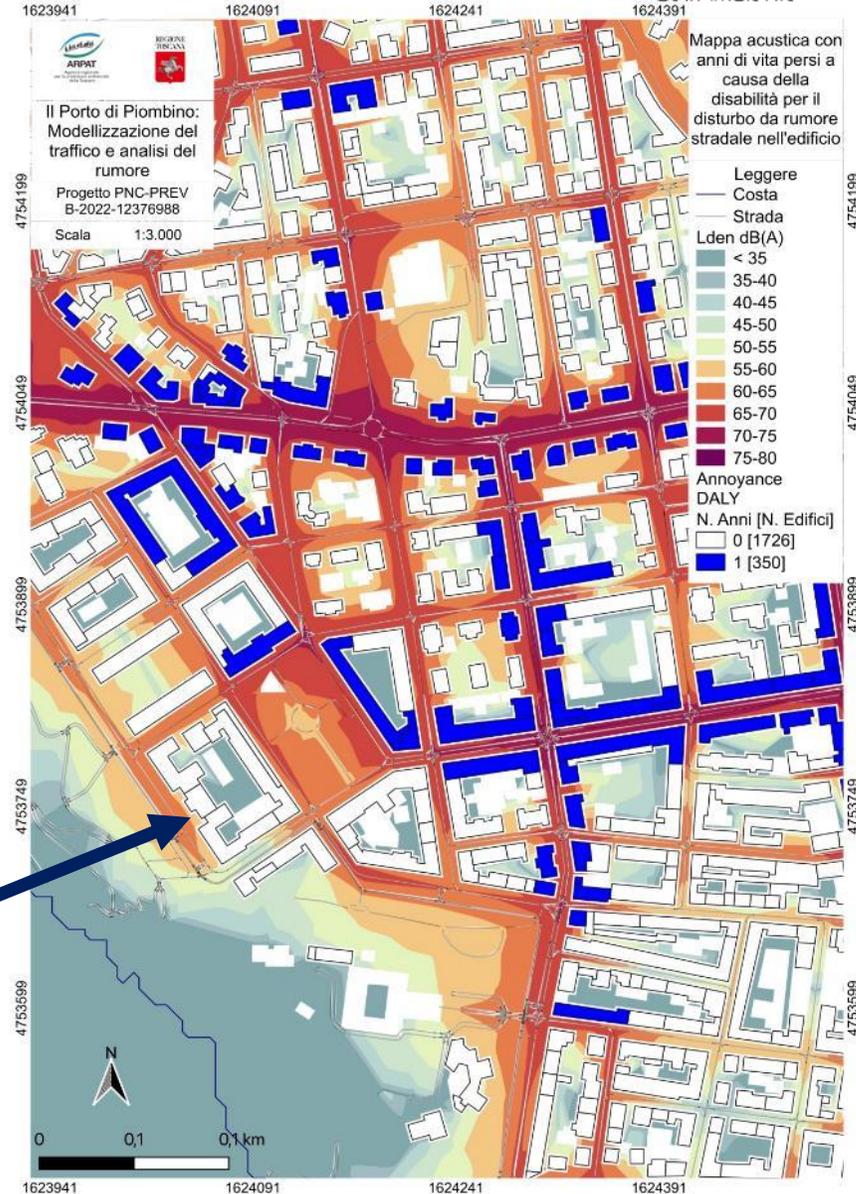
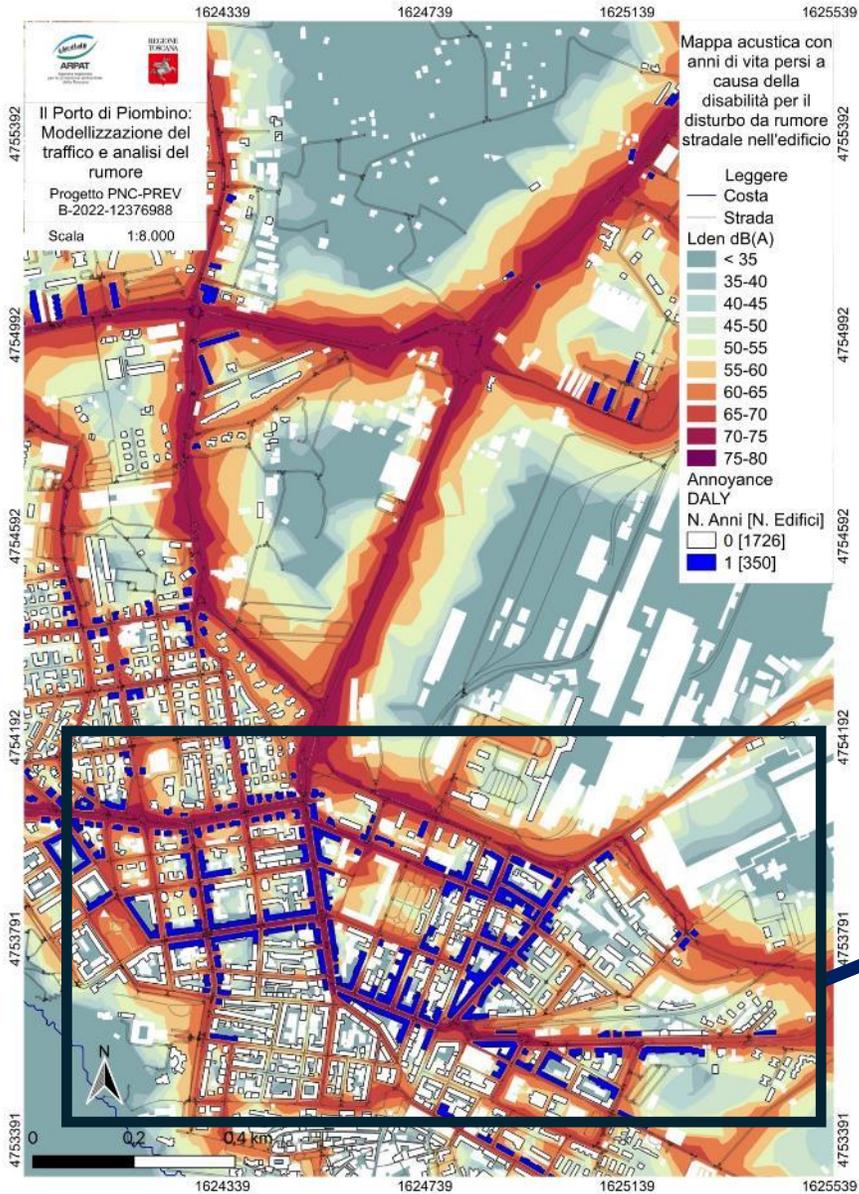


Figure 13. Noise maps of Piombino with L_{den} indicator for 2019.

NOISE MAPPING (Lden) WITH LIFE LOST YEARS FOR ROAD NOISE ANNOYANCE (DALY)



Conclusions

- Noise action plans on urban and suburban roads benefit by low noise pavements
- Road maintenance is key
- Using a holistic approach, the noise reduction in complex scenarios becomes cost-efficient and effective
- Guidelines for administrations could be produced by the European Commission and and by collaborative projects in the framework of Life and Horizon EU.





Thank you for
your attention

