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LIFE SNEAK PROJECT: FIRST RESULTS FROM THE POST-OPERAM MONITORING CAMPAIGNS

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Long-term exposure to noise affects physical and mental health. In Europe, at least one in five person is exposed to high chronic noise levels that can cause adverse health effects. The European Commission's zero pollution plan aims at reducing the negative impacts of exposure to transport noise, considered the major source of noise pollution in both urban and non-urban areas, by 2030.

Moreover, in recent years many cities have introduced tramway systems as a sustainable alternative for urban mobility and to reduce traffic congestion. However, in urban contexts tramways provides a supplementary noise source, especially due to the squeal noise in curves, leading to annoyance due to additional noise and vibrations.

The LIFE SNEAK project "optimized Surfaces against NoisE And vibrations produced by tramway tracK and road traffic" aims at reducing noise inside urban areas, where tram and traffic noise and vibration superpose, by means of low-noise/vibration surfaces and retrofitting solutions having LCC comparable to those of standard surfaces. At the beginning of the project started in 2021, ante-operam activities for the characterization of the selected site for the pilot case in Florence (Via La Marmora) have been performed: internal and external measurements of noise, traffic flows and were carried out in the period February-April 2022. A perceptive survey aimed at understanding how residents, workers in the area perceive noise due to road traffic in the ante-operam scenario was also performed. A system of sound-absorbing panels to be applied on the tram (bogie skirts) has been designed and a low emission asphalt to mitigate air-born noise has been designed and implemented in November 2024. In January/February 2025 the first post-operam noise measurement campaign has been carried out.

First results obtained by the Project are illustrated in the current paper.

Keywords: LIFE SNEAK project, road noise and vibrations, tramway noise and vibrations, noise and vibrations measurement campaigns

1. Introduction

Air and noise pollution are identified by the World Health Organization (WHO) as two of the most critical environmental hazards impacting human health, particularly in urban areas, where approximately 75% of the EU population resides. According to the report recently published by the EU Court of Auditors [1], although air quality is improving across the EU, compliance with standards has not always been achieved or has only recently been attained. In contrast, there are currently no EU-established limit values or reduction targets for noise pollution. Initiatives to fight noise are not prioritized, discouraging Member States from effectively implementing mitigation measures.

The LIFE SNEAK (*optimised Surfaces against NoisE And vibrations produced by tramway tracK and road traffic*) project, coordinated by the Municipality of Florence in partnership with ASSTRA, Ecopneus, MOPI s.r.l, University of Florence - Department of Industrial Engineering, Università Mediterranea della Calabria and Vie en.ro.se Ingegneria s.r.l., started in September 2021 and will end in February 2026 [2]. The idea behind the project stems from the need to design and test solutions to reduce the noise and vibrations caused by the coexistence, in urban contexts, of road traffic and tram passages. This idea has had concrete implementation in Florence, where new tram lines are currently being built on roads also affected by vehicle traffic.

The first LIFE SNEAK intervention was represented by a new low noise paving, designed by the Università Mediterranea della Calabria and MOPI, focused on the reduction of noise and vibration of both road traffic and the new tram line.

Between 11 and 14 November 2024, in the section of Via la Marmora between about street numbers 14 and 28, paving was completed on the new optimised asphalt. In addition, a new traditional asphalt was paved in the section between Piazza San Marco and street number 14 on Via la Marmora, and between street number 28 and the intersection with Viale Matteotti (Fig.1).

Currently, the post-operam scenario analysis is being carried out, for which Vie en.ro.se. Ingegneria has contributed by carrying out environmental noise and traffic volume measurements, vibration measurements in accordance with UNI 9614-2017, and indoor noise measurements, in conjunction with vibrational measurements carried out out outdoors by the University of Florence. MOPI carried out measurements of rolling noise using the CPX method (in accordance with UNI EN ISO 11819-2), road texture (ISO 13473 series) and dynamic stiffness using an instrumented hammer (ISO 7626-5:2019). This analysis is to be completed, in the coming months, with the administration of a post-operam questionnaire to the residents and users of Via la Marmora and with the recording of audio files at the pilot case, in order to assess the main psychoacoustic parameters.

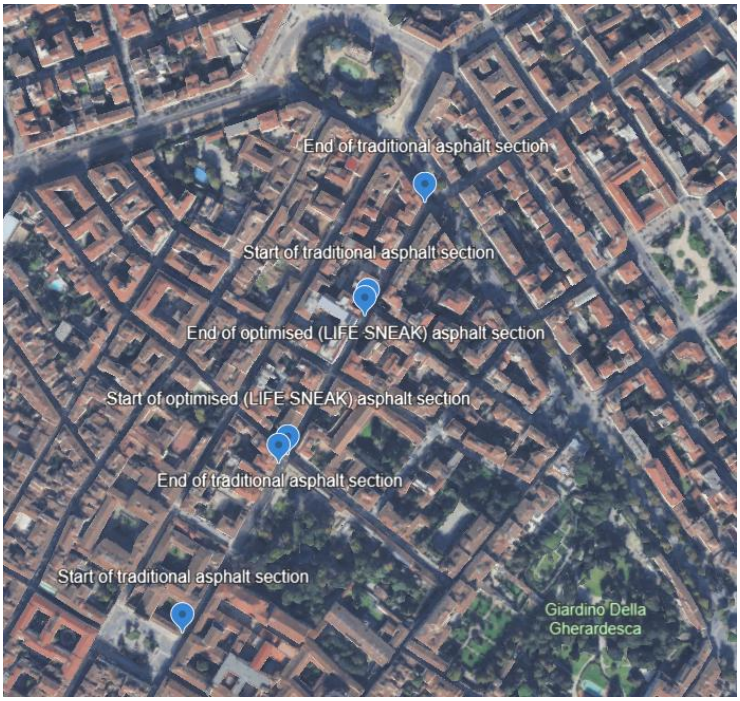

Figure 1: Identification of sections where traditional and optimised (LIFE SNEAK) asphalt was laid.

Finally, the second LIFE SNEAK intervention is represented by a new bogie cover solution designed by Department of Industrial Engineering of the University of Florence with the aim of reducing tram noise. The new bogie skirts were prototyped and finally verified on May 2024.by

In this paper, some preliminary results are presented with regard to the post-operam measurements of noise and vibration in the indoor environment, texture and mechanical resistance and to the bogie skirts experimental test.

2. Post-operam measurements campaign design and implementation referring to the low noise paving intervention

The post-operam measurement campaign was carried out in January-February 2025 at three locations (corresponding to those also chosen for the pre-operam campaign): Castelnuovo High School (P01), the residential building at no. 30 Via la Marmora (P02), and the ‘Giardino dei semplici’ south of Castelnuovo High School (P03).

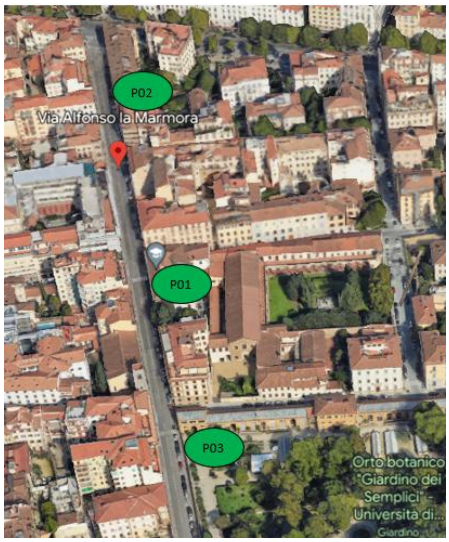

Figure 2: Measurement positions – source Google Earth.

2.1 Results of noise and traffic volume measurements

The measurement campaigns carried out for the noise component included the installation of two long-term (weekly) monitoring stations at measurement points P01 and P02. In parallel, a traffic flow survey was carried out by means of a radar station. Fig. 3 show some installation examples for noise and traffic measurements.

Figure 3: Measurement positions (noise and traffic).

Table 1 shows a summary comparison of the average LAeq levels for the daytime and night-time period for the two asphalt types.

Table 1: LAeq, comparison of weekly average level in P01 and P02.

	P01		**P02**	
	Lden (dBA)	Lnight (dBA)	Lden (dBA)	Lnight (dBA)
Average weekly values ANTE-OPERAM	69,7	61,2	67,9	59,6
Average weekly values POST-OPERAM	61,6	53,2	63,9	55,8
Average weekly difference between ANTE and POST-OPERAM	**8,1**	**8**	**4**	**3,8**

As far as traffic volumes are concerned, the scatter chart (reporting for each transit the length of the vehicle and the speed) shows the differences between the different categories of vehicles. Indeed, from the performed analysis of the sample of vehicles in north direction during the ante-operam campaign it is possible to clearly observe that:

• the 100-250 cm length range includes two-wheeled vehicles, (below 30 km/h mainly velocipedes).
• the 350-600 cm length range includes cars, whose average speed is of 30-50 km /h.
• buses are included in the 900-1600 cm length range, and their average speed is between 30-40 km/h.
• over 1600 cm in length there are unrepresentative samples including vehicles in a column or transiting simultaneously on the two directions, in this case the radar system has detected the total length.

Figs. 4 and 5 show the comparison between the scatter plots achieved respectively in the ante and in the post-operam scenarios. From the ante-operam scenario to the post-operam one, there has been a 60% reduction in average daily traffic, with light vehicles in particular. The number of buses has almost entirely been replaced by trams.

Figure 4: Scatter analysis – ante-operam.

Figure 5: Scatter analysis – post-operam.

Table 2 summarises the results of the ante- and post-operam campaigns of rolling noise measurements using the CPX method at the reference speed of 50 km/h.

Table 2: LAeq, comparison of weekly average level in P01 and P02.

Asphalt	**L_{CPX}**	**$\sigma(L_{CPX})$**	**GPP+1 Limit**	**$L_{CPX,max}$**	**GPP+2 Limit**
LIFE SNEAK	86.8 ± 1.2	0.6	91.0	87.5 ± 0.8	92.0
Ante Operam 1	92.4 ± 1.0	0.8	94.0	93.6 ± 0.6	95.0
Ante Operam 2	91.2 ± 1.0	0.5	94.0	91.7 ± 0.3	95.0

2.2 Results of vibrational measurements

The carried out monitoring campaign also included, in the same sections where the noise measurements were taken, measurements of vibrations both outdoors at the roadside and indoors, the latter to assess the disturbance according to UNI 9614 [2]. In addition to the tram passages, for the purposes of comparison with the ante-operam scenario, the passages of 6 buses per measurement station were measured. According to UNI 9614: 2017, the reference value for the assessment of vibration annoyance in an indoor environment is the value of the frequency-weighted vibration with a Wm weighting curve. Fig. 6 show some installation examples for vibrational measurements.

Figure 6: Measurement positions (vibrations).

The following table shows the results obtained at the outdoor and indoor locations in sections P01 and P03, in terms of mean acceleration and standard deviation. Section P02 was not taken into account for the comparison, as it had proved to be different from the other investigated sections in terms of both wearing course and binder in the ante-operam measurements.

Table 3: Average acceleration and standard deviation, comparison of vibrational (internal) measurements.

	Acceleration [mm/s^2] 1 - 250 Hz					
	P01			**P03**		
	Ante-operam BUS	Post-operam BUS	Post-operam TRAM	Ante-operam BUS	Post-operam BUS	Post-operam TRAM
Average value	2,6	0,8	1,1	1,0	0,9	1,0
σ	0,7	0,2	0,3	0,3	0,3	0,3
Max statistical value (M+1.8*STD)	3,9	1,1	1,6	1,6	1,5	1,5

Table 4: Average acceleration and standard deviation, comparison of vibrational (external) measurements.

	Acceleration [mm/s^2] 1 - 250 Hz					
	P01			**P03**		
	Ante-operam BUS	Post-operam BUS	Post-operam TRAM	Ante-operam BUS	Post-operam BUS	Post-operam TRAM
Average value	48.1	4.8	12.9	19.1	15.2	23.2
σ	15.2	1.1	4.3	13.6	12.6	10.1
Max statistical value (M+1.8*STD)	75.4	6.8	20.6	43.5	37.8	41.5

2.3 Mechanical Impedance Measurement Results

Table 4 summarises the results of the post operam measurement campaign, comparing them with those of the ante operam one. I

n particular, the results obtained on three measurement points are reported: the first two points are located on the experimental pavement of the LIFE SNEAK project, while the third point refers to the ante operam campaign.

Table 5: Ante- and post-operam mechanical impedance comparison.

Asphalt	**K [MN/m]**	**Delta k [MN/m]**	**Confidence interval**
LIFE SNEAK	80,5	9,6	95%
LIFE SNEAK	89,5	1,7	95%
Ante-operam	127,1	7,7	95%

3. Experimental results about the intervention for tram noise reduction

The University of Florence, in collaboration with Pantecnica s.p.a, designed and tested new tram carriage covers (bogie skirts) to reduce the acoustic impact caused by engine, rolling and squeal noise. The research led to the creation of prototype enclosure systems that were tested on some vehicles of the Florence tramway, with the collaboration of GEST s.p.a., both in stationary and running conditions, showing noise reductions of up to 4 dB. The noise reductions were determined according to a new experimental procedure based on the comparison of two experimental scenarios, one with tram equipped by standard cover and the other with tram equipped by the new designed cover.

Figure 7: Bogie skirts test.

4. Conclusions

The activities of the LIFE SNEAK project reached a crucial implementation phase: optimised asphalt was laid in a section of Via la Marmora in Florence and new, but traditional asphalt was laid in two at-tight sections. Preliminary results from the recently conducted post-operam measurement campaign for noise and vibration monitoring outside and inside buildings exceeded expectations. In fact, the project target envisaged a reduction in noise levels expressed in terms of Lden/Lnight required by the END [3] of at least 3 dB(A) and the obtained noise reductions are 8.1/8.0 dB(A). Concerning the rolling noise measurements carried out with the CPX method, the data show that the optimised LIFE SNEAK pavement is characterised by LCPX values well below the GPP limits, providing a significant acoustic benefit in terms of reduced levels (of the order of 4-5 dB(A)), compared to the ante-operam condition. In terms of vibrations, against a 5% reduction target expressed in terms of vibration magnitude (m/s^2) with respect to the reference mix and structure, a reduction of approximately 70% was achieved in the section affected by the optimised asphalt with respect to vibrations caused by the passage of buses.

Concerning the mechanical impedance, the results show a significant reduction of the dynamic stiffness values compared to the ante-operam condition: from values of about 130 MN/m to values of 80-90 MN/m. The traffic surveys also confirmed the expected results: a general reduction in the number of vehicles in transit, in particular light vehicles, and the almost complete replacement of bus passages with tram passages.

Also the benefit of the new bogie skirts is in line with expected results, since a benefit of 3 dB was expected on the straight stretch and 5 dB on curves where squeal noise is also present. In fact, reductions of 2-3 dBA referring to the straight stretch sources (engine noise, rolling noise, braking noise) and up to 4 dB referring to the squeal noise (characterized by a noise contribution at 2.5 kHz) were demonstrated.

In the coming months, the processing of the data collected during the post-operam measurement campaigns will be completed, the questionnaire on the subjective perception of noise and vibrations will be administered, and audio recordings will be made with Ambisonics instrumentation for the evaluation of psycho-acoustic parameters.

Finally, on 8 and 9 May, a project workshop will be held in Milan, organised over two half-days, during which the topics of ‘Recycled rubber and noise remediation: sustainable solutions between projects, experiences and case studies’ and ‘The LIFE SNEAK project: combined interventions for noise and vibration reduction in urban contexts’ will be discussed.

ACKNOWLEDGMENTS

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REFERENCES

1 European Court of Auditors, special report 02/2025: “Urban pollution in the EU – Cities have cleaner air but are still too noisy”, Publications Office of the European Union, 2025.

2 https://www.lifesneak.eu/

3 Directive 2002/49/EC ‘Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise.