DOI: 10.61782/fa.2025.0054

FORUM ACUSTICUM
EURONOISE 2025

ACCELERATION NOISE FROM ELECTRIC CARS MATTERS

Sacha Baclet[1,2*] **Romain Rumpler**[1,2]

[1] The Marcus Wallenberg Laboratory for Sound and Vibration Research (MWL),
Dpt of Engineering Mechanics, KTH Royal Institute of Technology, SE-100 44, Stockholm, Sweden
[2] Digital Futures and The Centre for ECO^2 Vehicle Design,
KTH Royal Institute of Technology, SE-100 44 Stockholm, Sweden

ABSTRACT

Electric vehicles (EVs) are expected to reduce urban noise pollution due to their quieter operation at low speeds. However, research has shown that EVs produce significant additional noise during acceleration, even at low speeds, primarily due to tyre–road interaction under high torque loads.

This study investigates the impact of acceleration noise on two key exposure indicators—the equivalent continuous sound level (L_{Aeq}) and the number of noise events—using microscopic traffic simulations coupled with noise emission and propagation models.

Acceleration noise was modelled using correction terms for both internal combustion engine (ICE) vehicles and EVs, based on recent literature. Simulations were performed on a real-world microscopic traffic model of Tartu (Estonia), and the fraction of EVs in the fleet was varied.

Results show that neglecting acceleration noise can lead to underestimating L_{Aeq} by up to 4.3 dBA and missing close to half of noise events, particularly in electric fleets. The influence of acceleration noise is more pronounced at louder locations and for high-exceedance noise events. These findings highlight the need to integrate acceleration noise into noise exposure assessments, especially as EV penetration increases in urban traffic.

Keywords: *road traffic noise, electric vehicles, acceleration noise, microscopic traffic, noise mapping*

**Corresponding author*: *baclet@kth.se.*

1. INTRODUCTION

Environmental noise is a major public health concern in Europe. According to the European Environment Agency (EEA), at least 20% of the EU population was exposed to harmful levels of environmental noise in 2019 [1], with road traffic identified as the dominant source, affecting more than 100 million people at levels exceeding World Health Organization (WHO) recommendations [2]. In response, the European Commission's *Zero Pollution Action Plan* sets a goal of reducing the number of people chronically disturbed by transport noise by 30% by 2030 compared to 2017 levels [3].

To support such objectives, accurate assessment of population exposure to traffic noise is critical. In recent years, microscopic traffic simulation models have become increasingly popular in environmental acoustics [4–7]. These models simulate individual vehicle behaviour—including position, speed and acceleration—at fine time scales, and can be coupled with noise emission models to evaluate dynamic and location-specific noise levels. This level of detail enables the computation of traditional exposure indicators, such as the equivalent continuous sound level (L_{Aeq}), as well as advanced exposure indicators, such as the number of noise events experienced by individuals [6–9], and vehicle-specific noise exposure costs [10, 11].

While electric vehicles (EVs) are often expected to reduce urban noise at low speeds due to their quieter engines [12, 13], several recent studies have shown that their noise emissions increase significantly during acceleration, mainly due to increased tyre/road interaction under torque [14, 15]. One contributing factor is that this effect may be more pronounced in EVs than in internal combustion engine (ICE) vehicles, owing to their higher curb weight and instantaneous torque delivery, which increase dynamic loading at the tyre–road interface and may enhance structure-borne noise transmission. Pass-by measurements, carried out in projects such as LIFE E-VIA [16, 17], and other controlled experiments and data analyses [18, 19] have reported noise increases of up to 5 dBA during acceleration compared to constant-speed driving.

However, despite these findings, it remains unclear how such acceleration-related noise affects population exposure estimates when using microscopic traffic simulations. Most existing EV noise emission models are limited to constant-speed conditions and do not account for the dynamic effects of acceleration [20]. As a result, current noise exposure assessments may underestimate the impact of accelerating vehicles, particularly in urban contexts where acceleration is frequent.

This study investigates the influence of acceleration noise on two key noise exposure indicators—L_{Aeq} and an indicator reflecting the number of noise events—when using microscopic traffic simulations. Existing correction models for the acceleration noise of ICE vehicles, as well as a novel model for the acceleration noise of light EVs [19] are applied to calibrated microscopic traffic simulations, and the resulting exposure indicators are compared to those obtained using constant-speed emission models only.

2. METHODOLOGY

2.1 Microscopic traffic simulation

To evaluate the influence of acceleration noise on exposure indicators, microscopic traffic simulations were carried out using the open-source Simulation of Urban MObility (SUMO) tool [21]. SUMO enables high-resolution simulation of individual vehicle trajectories based on realistic traffic flow dynamics, including car-following, lane-changing, and intersection behaviour.

The model was calibrated on the city of Tartu (Estonia) from measurements carried out using a network of 30 traffic count sensors [6]. A time resolution of 1 second was chosen, and the model was run for 24 hours on a representative weekday. Each trajectory provided a time series of vehicle position, speed, and acceleration, which were subsequently used as input for noise emission and propagation modelling.

An arbitrary portion of 10% of the vehicles were randomly assigned as heavy-duty vehicles (HDVs), while the remaining 90% were considered to be light-duty passenger vehicles (LDVs). The fraction of EVs among LDVs and HDVs was varied simultaneously, from 0% to 30% to 100%.

2.2 CNOSSOS-EU emission model

Noise emissions for each vehicle were first estimated using the CNOSSOS-EU model [22], the official European framework for environmental noise mapping. CNOSSOS-EU computes the sound power level L_W of a moving vehicle by combining the contributions of rolling noise and propulsion noise.

For an ICE vehicle of category m, in frequency band i, the rolling and propulsion noise levels are respectively calculated as

$$L_{WR,i,m} = A_{R,i,m} + B_{R,i,m} \cdot \log_{10}(v), \qquad (1)$$

$$L_{WP,i,m} = A_{P,i,m} + B_{P,i,m} \cdot \left(\frac{v - v_{\text{ref}}}{v_{\text{ref}}}\right), \qquad (2)$$

where v is the instantaneous vehicle speed and $v_{\text{ref}} =$ 70 km/h. The total emission level is then obtained as

$$L_{W,i,m} = 10 \cdot \log_{10}\left(10^{L_{WR,i,m}/10} + 10^{L_{WP,i,m}/10}\right). \qquad (3)$$

As no dedicated CNOSSOS-EU emission model currently exists for EVs, the Category 1 model (for ICE LDVs) was used as a baseline for light EVs, and modified with the correction model proposed by Pallas et al. [13]. For electric HDVs, another correction model was applied to the Category 3 emission model from CNOSSOS-EU (HDVs), based on noise measurements conducted close to the engine of a hybrid truck driving in ICE vs. electric mode [23].

2.3 Correction models for acceleration

To capture the impact of acceleration a on noise emissions, a correction model was applied to the baseline CNOSSOS-EU output:

- for ICE vehicles (LDVs and HDVs), the IMAGINE correction model [24] was used:

$$L^{\text{corr}}_{WP,i,m} = L_{WP,i,m} + c_i * a, \qquad (4)$$

where the c_i are coefficients for each octave band i;

- for light EVs, the newly developed correction model [19], accounting for the increased tyre/road interaction noise observed during acceleration in each octave band, was used:

$$L^{\text{corr}}_{W,i,m} = L_{W,i,m} + \Delta L_i, \tag{5}$$

with

$$\Delta L_i = \max\left(A_{\text{corr},i} + B_{\text{corr},i} \cdot log_{10}(v), 0\right) \cdot \frac{a}{a_{\max}(v)}, \tag{6}$$

where $A_{\text{corr},i}$ and $B_{\text{corr},i}$ are coefficient for each octave band i and $a_{\max}(v)$ is the maximum reachable acceleration of the vehicle considered, at speed v;

- for electric HDVs, due to the lack of a better model, the IMAGINE correction model for ICE HDVs was used.

2.4 CNOSSOS-EU propagation model

The resulting corrected noise emissions were then propagated to receiver positions using the CNOSSOS-EU propagation model, implemented in the open-source software NoiseModelling [25], accounting for geometric spreading, ground effects, air absorption, diffraction and reflection, according to the implementation described in [22].

2.5 Simulation generation

Using this framework, two sets of simulations were conducted:

- One using the uncorrected CNOSSOS-EU model assuming constant-speed emissions;
- One using the corrected model including the acceleration noise correction term.

For each case, the equivalent continuous sound level (L_{Aeq}) and an indicator reflecting the number of noise events exceeding a defined threshold were computed at multiple receiver locations to quantify the impact of acceleration noise on population exposure.

3. RESULTS

To test whether integrating acceleration noise into the emission model of a vehicle fleet has a significant impact on exposure indicators, a preliminary statistical analysis is performed.

First, the number of noise events is measured using the L50EXXG05CL indicator, defined as the number of times the instantaneous noise level crosses a threshold of XX dBA above the median noise level L_{50}, with a minimum time gap of 5s between two successive events and a closed window. The value of the threshold exceedance EXX above L_{50} is varied from 3 dBA (E03, moderate noise event) to 15 dBA (E15, very loud noise event), as recommended by [9]. The number of noise events over 24 hours is averaged over all receiver points, and the fraction of EVs in the fleet is varied from 0.0 to 1.0. The results are reported in Tab. 1.

Table 1: Average number of noise events detected using various L50EXXG05CL indicators varying the exceedance EXX (1^{st} column), various fractions of EVs (EV frac), while considering acceleration noise (Yes) or not (No), and difference between the two (Diff, %).

	EV frac = 0.0			EV frac = 0.3			EV frac = 1.0		
	No	Yes	**Diff**	No	Yes	**Diff**	No	Yes	**Diff**
E03	637	667	**4.7%**	580	641	**10.6%**	401	580	**44.6%**
E05	435	462	**6.2%**	389	441	**13.2%**	249	392	**57.1%**
E10	160	175	**9.7%**	138	163	**18.2%**	70	135	**92.6%**
E15	43	51	**17.3%**	37	45	**21.4%**	17	29	**75.8%**

As may be observed in the table, the average number of noise events detected increases when adding acceleration noise, for all types of noise events (E03 to E15). Several other findings are notable:

- the impact of acceleration noise on the number of noise events is generally larger for louder noise events;
- as the fraction of EVs increases, acceleration noise results in a larger increase in the number of detected noise events, resulting in more than 40% extra noise events with a fully electric fleet.

Then, the 24-hour L_{Aeq} is calculated for each receiver point, and the 10^{th}, 50^{th} and 90^{th} percentiles of the receiver points with the highest resulting noise levels were extracted for each of the two simulation sets. The results are compiled in Tab. 2 for various fractions of EVs.

The main results from this table are the following:

- acceleration noise increases L_{Aeq} at the median receiver point by 2.2 to 4.3 dBA depending on the fraction of EVs;

Table 2: 1-hour L_{Aeq} (dBA) of the 10th, 50th and 90th percentile receiver point for various fractions of EVs (EV frac), while considering acceleration noise (Yes) or not (No), and difference between the two (Diff, dBA).

	EV frac = 0.0			EV frac = 0.3			EV frac = 1.0		
	No	Yes	**Diff**	No	Yes	**Diff**	No	Yes	**Diff**
$L_{Aeq,P90}$	42.4	43.2	**0.8**	41.4	42.6	**1.2**	38.0	41.2	**3.1**
$L_{Aeq,P50}$	51.0	53.2	**2.2**	50.0	52.4	**2.4**	46.6	50.8	**4.3**
$L_{Aeq,P10}$	63.6	71.1	**7.5**	62.6	70.9	**8.3**	58.7	67.5	**8.8**

- the increase in L_{Aeq} due to acceleration noise is much higher for the loudest locations ($L_{Aeq,P10}$, +7.5 dBA to +8.8 dBA) than the quietest ones ($L_{Aeq,P90}$, +0.8 dBA to +3.1 dBA);
- as the fraction of EVs increases, the impact of acceleration noise on L_{Aeq} increases.

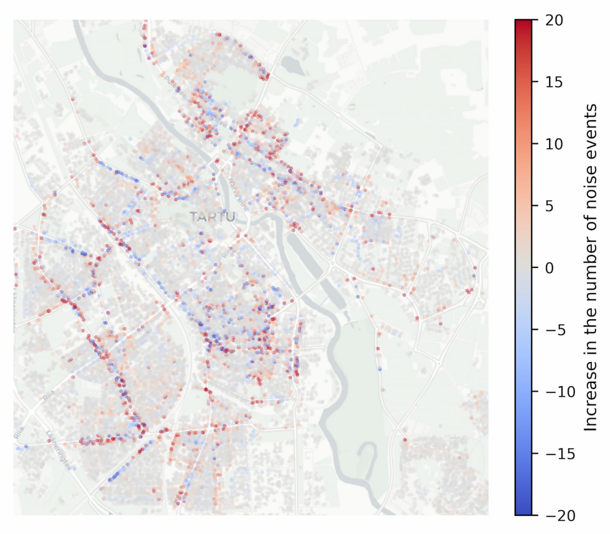
To observe the geographic spread of the impacts of acceleration noise on exposure indicators, the increase in the number of loud noise events, measured using the L50E10G05CL [8, 9] indicator (number of noise events crossing 10 dBA above the median noise level, with a minimum time gap of 5s and a closed window) and the increase in the average noise level L_{Aeq} are plotted for a 1-hour time segment (16:00–17:00) in Figs. 1 and 2, respectively, for a fleet of 100% ICE vehicles, and a fleet of 100% EVs.

Multiple observations may be made from these plots:

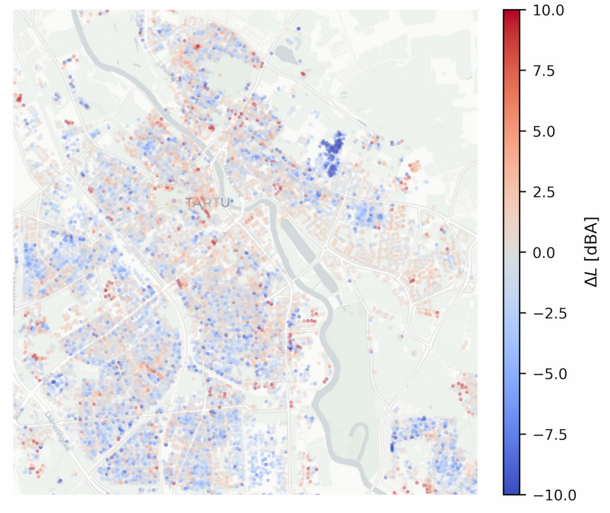
- when acceleration noise is accounted for, the increase in the number of noise events is mostly visible in close proximity to primary or secondary roads;
- the increase in L_{Aeq} is more uniform, with no clear areas emerging as being more impacted by acceleration noise;
- in the case where the fleet is 100% electric, the impact of acceleration noise is much larger than when the fleet is 100% ICE.

4. DISCUSSION

From the results detailed in Section 3, it appears that acceleration noise has a significant impact on noise exposure indicators.

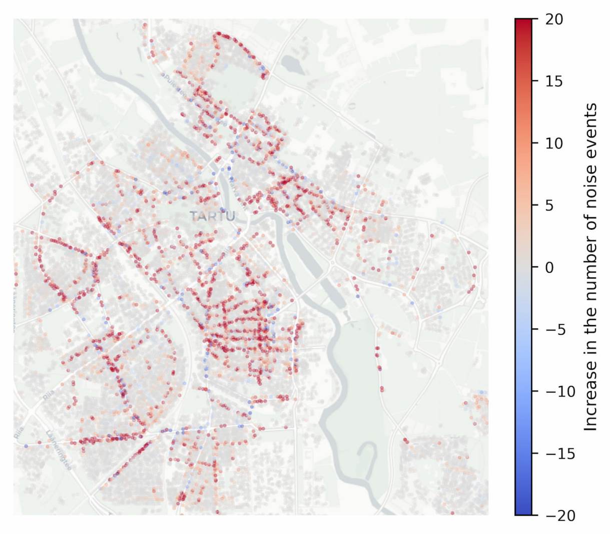


(a) Noise events (E10)

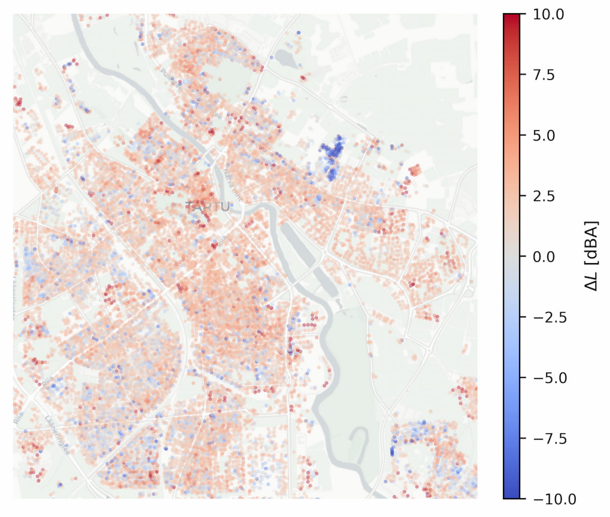


(b) L_{Aeq}

Figure 1: Increase in (a) the number of noise events (L50E10G05CL) and (b) the 1-hour L_{Aeq} due to acceleration noise with a 100% ICE fleet at 16:00–17:00.



(a) Noise events (E10)



(b) L_{Aeq}

Figure 2: Increase in (a) the number of noise events (L50E10G05CL) and (b) the 1-hour L_{Aeq} due to acceleration noise with a 100% electric fleet at 16:00–17:00.

For a fleet of vehicles powered by ICE, the modelled impact of acceleration noise appears relatively limited on the number of noise events ($< 10\%$), except for very loud noise events (E15, +17.3%). For noise levels (L_{Aeq}), the modelled impact seems slightly more marked, with a 2.2 dBA increase for the median receiver point, and especially for the 10% loudest receiver point, where the increase reaches 7.5 dBA.

With a mixed fleet of EVs and ICE vehicles, or a fully electric fleet, the impacts of traffic noise generally decrease, with, expectedly, a lower number of noise events and lower average noise levels. However, in this case, the impact of acceleration noise is shown to be much more significant for all indicators, with a considerable impact on the number of noise events and on L_{Aeq}.

These results suggest that accounting for acceleration noise is already important when modelling noise exposure from a fully ICE vehicle fleet, but may be critical with vehicle fleets that include EVs.

However, it should be noted that the two correction models for acceleration noise used in the present contribution (IMAGINE and the 2025 correction model for light EVs [19]) have been established independently, using different methodologies, on fleets of vehicles from different eras. The differences highlighted here, in particular between fleets of ICE vehicles and EVs, may be partly due to imperfections in the models themselves rather than only differences between actual noise emissions.

5. CONCLUSION

This study evaluates the impact of acceleration noise on noise exposure indicators using microscopic traffic simulations and the CNOSSOS-EU noise assessment framework. By applying correction models for acceleration noise to both ICE and electric vehicles, it was shown that the inclusion of acceleration-related noise emissions has a notable effect on both the equivalent continuous sound level (L_{Aeq}) and the number of noise events.

For ICE fleets, the increase in exposure indicators due to acceleration noise was shown to be moderate but non-negligible, with L_{Aeq} increasing by over 2 dBA and noticeable increases in the number of loud noise events. In contrast, for fleets with high EV penetration, the impact of acceleration noise was shown to be substantially greater, with increases in L_{Aeq} of over 4 dBA at median locations and more than 8 dBA at the loudest ones, along with up to 93% more high-exceedance noise events.

These results suggest that the role of acceleration noise may become increasingly important in the context of EV adoption. Incorporating acceleration noise into road traffic noise modelling is essential for accurately assessing population exposure, especially when using microscopic traffic simulations in urban environments where acceleration events are frequent.

The findings made in this contribution are based on correction models for acceleration noise, but future measurement campaigns would be valuable to validate and further support these results.

6. ACKNOWLEDGMENTS

The authors gratefully acknowledge the financial support from Digital Futures (DIRAC, GEOMETRIC and SENZ-Lab projects), Formas (Grant 2021-01532), Stockholm Region (Grant 2021-0317), the Richert Foundation (Grant 2021-00697).

7. REFERENCES

[1] European Environment Agency, *The European environment – State and outlook 2020: Knowledge for transition to a sustainable Europe*. Luxembourg: European Environment Agency, 2019.

[2] World Health Organisation, *Environmental noise guidelines for the European region*. World Health Organisation. Regional Office for Europe, 2018.

[3] European Commission, "Pathway to a Healthy Planet for All: EU Action Plan 'Towards Zero Pollution for Air, Water and Soil'," 2021. COM(2021) 400 final.

[4] A. Can, L. Leclercq, J. Lelong, and J. Defrance, "Accounting for traffic dynamics improves noise assessment: Experimental evidence," *Applied acoustics*, vol. 70, no. 6, pp. 821–829, 2009.

[5] V. Le Bescond, A. Can, P. Aumond, and P. Gastineau, "Open-source modeling chain for the dynamic assessment of road traffic noise exposure," *Transportation Research Part D: Transport and Environment*, vol. 94, p. 102793, 2021.

[6] S. Baclet, K. Khoshkhah, M. Pourmoradnasseri, R. Rumpler, and A. Hadachi, "Near-real-time dynamic noise mapping and exposure assessment using calibrated microscopic traffic simulations," *Transportation Research Part D: Transport and Environment*, vol. 124, p. 103922, 2023.

[7] T. Van Renterghem, V. Le Bescond, L. Dekoninck, and D. Botteldooren, "Advanced noise indicator mapping relying on a city microphone network," *Sensors*, vol. 23, no. 13, p. 5865, 2023.

[8] A. Brown and B. De Coensel, "A study of the performance of a generalized exceedance algorithm for detecting noise events caused by road traffic," *Applied Acoustics*, vol. 138, pp. 101–114, 2018.

[9] S. Baclet and R. Rumpler, "Performance of a generalised algorithm for the detection of noise events from road traffic in a real urban area: A simulation study," *Applied Acoustics*, vol. 228, p. 110337, 2025.

[10] J. Nygren, S. Boij, R. Rumpler, and C. J. O'Reilly, "Vehicle-specific noise exposure cost: Noise impact allocation methodology for microscopic traffic simulations," *Transportation Research Part D: Transport and Environment*, vol. 118, p. 103712, 2023.

[11] J. Nygren, V. Le Bescond, A. Can, P. Aumond, P. Gastineau, S. Boij, R. Rumpler, and C. J. O'Reilly, "Agent-specific, activity-based noise impact assessment using noise exposure cost," *Sustainable Cities and Society*, vol. 103, p. 105278, 2024.

[12] E. Hammer, S. Egger, T. Saurer, and E. Bühlmann, "Traffic noise emission modelling at lower speeds," in *Proceedings of the 23rd International Congress on Sound and Vibration*, (Athens, Greece), July 2016.

[13] M.-A. Pallas, M. Berengier, R. Chatagnon, M. Czuka, M. Conter, and M. Muirhead, "Towards a model for electric vehicle noise emission in the European prediction method CNOSSOS-EU," *Applied Acoustics*, vol. 113, pp. 89–101, 2016.

[14] C. Hoever, A. Tsotras, M.-A. Pallas, and J. Cesbron, "Factors influencing tyre/road noise under torque," *INTER-NOISE and NOISE-CON Congress and Conference Proceedings*, vol. 265, pp. 3683–3690, Feb. 2023.

[15] U. Sandberg and J. Ejsmont, *Tyre/road noise reference book*. Informex, 2002.

[16] J. Cesbron, M.-A. Pallas, S. Bianchetti, P. Klein, V. Cerezo, A. Moro, and F. Bianco, "LIFE E-VIA: electric vehicle noise control by assessment and optimisation of tyre/road interaction, report B2," Deliverable Report LIFE18 ENV/IT/000201, Action B2, LIFE E-VIA Project, UNI EIFFEL, CRD, IPOOL, UNIRC, May 2022. Final version, 13-05-2022.

[17] M.-A. Pallas, S. Bianchetti, A. Le Bellec, and J. Cesbron, "Investigation of electric vehicle noise sources on low-noise road surfaces," *INTER-NOISE and NOISE-CON Congress and Conference Proceedings*, vol. 265, pp. 5518–5529, Feb. 2023.

[18] D. Schweizer, E. Bühlmann, T. Saurer, J. Mercuriali, D. Milo, M. Strickler, and A. Stöcklin, "Noise emissions: What to expect from electric vehicles compared to combustion vehicles?," in *Proceedings of the 29th International Congress on Sound and Vibration (ICSV 29)*, (Prague, Czech Republic), July 2023.

[19] S. Baclet, J. Cesbron, P. Aumond, A. Can, and R. Rumpler, "A correction model for the noise emissions of light electric vehicles during acceleration [under revision]," *Applied Acoustics*, 2025.

[20] Z. Lan, M. Yuan, S. Shao, and F. Li, "Noise emission models of electric vehicles considering speed, acceleration, and motion state," *International journal of environmental research and public health*, vol. 20, no. 4, p. 3531, 2023.

[21] P. A. Lopez, M. Behrisch, L. Bieker-Walz, J. Erdmann, Y.-P. Flötteröd, R. Hilbrich, L. Lücken, J. Rummel, P. Wagner, and E. Wießner, "Microscopic traffic simulation using SUMO," in *The 21st IEEE International Conference on Intelligent Transportation Systems*, IEEE, 2018.

[22] S. Kephalopoulos, M. Paviotti, and F. Anfosso-Lédée, "Common noise assessment methods in Europe (CNOSSOS-EU)," 2012.

[23] S. Venkataraman and R. Rumpler, "Acoustic study of nighttime deliveries in stockholm within the project civitas eccentric," in *Forum Acusticum 2020, Lyon, France, 7-11 December 2020*, 2020.

[24] B. Peeters and G. v. Blokland, "Imagine: Improved methods for the assessment of the generic impact of noise in the environment. the noise emission model for european road traffic," Tech. Rep. IMA55TR-060821-MP10, IMAGINE Project Consortium, M+P, January 2007. Deliverable 11 of the IMAGINE project.

[25] E. Bocher, G. Guillaume, J. Picaut, G. Petit, and N. Fortin, "Noisemodelling: An open source GIS based tool to produce environmental noise maps," *ISPRS international journal of geo-information*, vol. 8, no. 3, p. 130, 2019.