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THE ECODRIVE PROJECT: REDUCING NOISE BY TRAFFIC CONTROL AND MANAGEMENT

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ABSTRACT

In the last decades, noise pollution has significantly grown according to the development of society, the improvement of technologies, and the increase of human activities on the territory. Specifically, road traffic is the main source of noise pollution, which is particularly harmful to human health, especially after long-term exposure.
Therefore, the European Union is urging Member States to reduce the number of people exposed to traffic noise by 30% by 2030. The noise produced by vehicles has different origins: the engine, where compressions, decompressions, and bursts take place; the rolling of tires on the pavement, whose noise mainly depends on the surface type and vehicle speed; the vibrations of the car body, and the action of brakes. For these reasons, an aggressive driving style (mainly characterized by higher and variable speeds, fast acceleration, and sharp breaking), can increase the overall noise level of travelling vehicles. Therefore, traffic management and control policies, capable of affecting traffic conditions, are recommended to reduce noise impacts. This paper describes a preliminary traffic control scheme, developed inside the ECODRIVE project. The scope is to create a proper methodology, starting from traffic flow and noise emission models, able to force users to adopt ecological driving styles, thus reducing traffic noise emissions.

Keywords: *noise pollution, traffic management, simulation, traffic emissions*

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1. INTRODUCTION

The development of society occurred in last decades, combined with improvements in technologies and in communications systems has significantly impacted all aspects of society, economics, and human activities. As regards the transportation field, economic growth, the increment in the infrastructure supply, and the continuous advancements in the automotive industry made cars accessible to great part of population, resulting in private transport becoming the most spread mode of transport, especially in Europe. This had negative consequences, affecting both mobility, with increased congestion and accidents on roads, and environment, with increased pollutant emissions from motor vehicles. These latter constitute the greatest challenge for Authorities to date, especially after the European Green Deal that urges Member States to take actions for reaching the "Zero Emissions" target. Among the main types of pollutants caused by transportation, as reported in [1], noise is known as "the unseen pollutant" and its long-term effects can be highly harmful to human health, the environment, and ecosystems as well. The last quinquennial Report on the Implementation of the Environmental Noise Directive [2] clearly reports that "*noise is the second most important environmental disease factor in the EU (after air pollution)*" and that the reduction in the number of people exposed to traffic noise by 30% in 2030 is unreachable if proper actions will not be taken. The reduction of noise produced by transportation can be achieved by acting on different factors. In ECODRIVE the attempt is to reduce noise emissions through different policies of traffic management and control, with the aim of forcing road users to take sustainable behaviours.
This paper is divided into 4 sections: in the next paragraph (Section 2) the theoretical framework and the literature review are briefly described, while the following section

(Section 3) is devoted to the description of the ECODRIVE project, and the applied methodology. The last part of the paper (Section 4) sums up the purposes of the project and briefly reports outlooks or possible improvements to the whole simulation system.

2. LITERATURE REVIEW

Noise pollution can be defined as any introduction in the external environment of an unwanted and disturbing sound that induces disturbance or annoyance in humans, urban activities and ecosystems [1]. In urban and industrialized areas, there are different noise sources due to human activity on territory. Among them, the most relevant are [3]: industrial, commercial, and craft activities, domestic life, and transportation. In order to reduce the number of people exposed to noise, many efforts were made by public authorities. For example, the European Commission enacted different regulations to force Member States to find new solutions for keeping the noise levels under the established thresholds.

Transportation is a major contributor to the generation of noise, especially in big cities. If rail and air traffic noise is discontinuous and generates nuisance in the areas surrounding stations and airports, road traffic noise is present everywhere ad affect wider zone of urban, suburban and residential areas. Different factors are responsible for traffic noise, that involve all aspects of the road system [4]:

1. Traffic factors, which include traffic volumes, traffic speed, vehicle composition, the share of heavy vehicles, congestion and bottlenecks;
2. Road factors, that involve the type of road surface, grade, geometry, presence of intersections and noise barriers;
3. Vehicle factors, such as type of engine and fuel, age of the vehicle and state of maintenance;
4. Human factors which include: driving habits and the experience of the driver.

All the possible solutions adopted to mitigate noise may act on either one or a combination of these factors. For example, a study reported in [5], identifies two different types of noise reduction measures:

- At-source measures: noise emissions can be reduced at their source, implementing measures directly related to vehicles, tyres, road surface, and traffic;
- End-of-pipe measures: the abatement of noise is obtained by reducing the number of exposed people, using anti-propagation or insulation solutions.

However, the same study clearly states that the first type of measures, that reduces the overall emissions at the source, are preferable to the end-of-pipe measures, which act at a local level.

In order to assess noise from road traffic, different gradually accurate models were developed over the years [6]-[8]. All these models use the same fundamental variables, even if linked through different relationships:

- Q: traffic volumes (usually measured in veh/h);
- V: traffic mean speed (usually measured in km/h);
- D: distance from the source (measured in m).

In fact, as reported in [4], noise levels tend to increase as the total number of vehicles and speed increases.

In more recent years, the European Union has tried to provide Member States with a standard methodology for assessing noise emissions. This led to the development of the CNOSSOS-EU model [9]-[11], which estimates traffic noise from a combination of rolling noise $L_{WR\,f,m}$ (as in Eqn. (1)) and propulsion noise $L_{WP\,f,m}$ of vehicles (as in Eqn. (2)).

$$L_{WR\,f,m} = A_{R\,f,m} + B_{R\,f,m} \cdot \log(v_m/v_{ref}) + \Delta L_{W\,R\,f,m}(v_m) \quad (1)$$

$$L_{WP\,f,m} = A_{P\,f,m} + B_{P\,f,m} \cdot (v_m - v_{ref}/v_{ref}) + \Delta L_{W\,P\,f,m}(v_m) \quad (2)$$

Where:

v_m is the mean speed of traffic;

v_{ref} is the reference speed equal to 70 km/h.

Values of coefficients $A_{R\,f,m}$, $B_{R\,f,m}$, $A_{P\,f,m}$ and $B_{P\,f,m}$ and the equation for estimating the correction factors are reported in [11]. The values obtained by these equations are combined considering the number and the types of vehicles traffic stream is composed of, as reported in the specific European Directive [11].

3. THE ECODRIVE PROJECT

Verified the need of keeping noise levels below certain thresholds, specific actions have to be taken for reducing noise emissions. In ECODRIVE the attempt is to implement some policies for reducing the overall emissions from road traffic. As these policies directly act on speeds, volumes, and traffic flows, they can be classified as at-source measures.

The ECODRIVE project is based on a simulative approach and has been broken down into three parts. The first part has been already completed and was fully dedicated to an in-depth review of the fundamental theoretical models needed to build a simulation tool. The second part, still ongoing, focuses on the building and the calibration of the test network. Some preliminary policies of traffic

management will be subsequently applied, with the aim of testing their impact on emission reduction. The implementation of the policies will continue in the third part of the project, together with the analysis of the results.

3.1 The test network

The road segment chosen for the experimentation is the South-Eastern quadrant of the A90 (commonly known as GRA), the most important urban ring-shaped freeway of the city of Rome. It is one of the main arteries of the Italian capital's road system and its South-Eastern zone turns out to be the busiest one, with traffic volumes that settle around 5000 veh/h in each direction [13]. Maybe for the high volumes on the road, or for the infrastructure's geometry, characterized by the presence of junctions every 2 km, the GRA is always affected by congestion or the presence of accidents, which are troublesome in terms of viability, social and economic costs, and environmental impacts. For all these reasons, the A90 road seemed to be the most suitable road for the project's purposes. For better control over the interventions' effects, the analysis was focused on a single quadrant, which appears to be the most problematic.

3.2 The methodology

In the first part of the project, a simulation model was created, to reproduce how a traffic stream flows on the road segment. The type of aggregation applied is of microscopic nature. This choice induces different complexities in the problem, but, on the other hand, makes the differentiation of the interventions on each vehicle class possible. The IT tool chosen for the microsimulation is PTV Vissim™ [14], which allows to obtain the characteristics of the traffic flow as outcomes. These outputs, especially speeds and volumes, are used to feed the emission models. After the application of proper policies, the assessment of emissions is repeated, and the efficiency of the tentative policy is discussed. For the emission calculation, the European standards models are used for both air (COPERT methodology [15]), and noise (CNOSSOS-EU model [11]).

3.3 The policies' choice

It is important to highlight that the ECODRIVE project was thought for the reduction of both noise and atmospheric emissions (e.g., emission of CO_2 or NOx from internal-combustion engines), thus the choice of the proper policy constitutes a delicate step of the project. For example, previous studies on the effect of speed's variations of a traffic stream, such as [5] or [12] allowed to understand that the reduction of the speed limit has positive effects on noise reduction, but this is not always true for atmospheric emissions (or fuel consumption as well). This is because noise increases linearly with increasing speed, while pollutant emissions decrease when speed initially increase but rise again when values of speed become higher. Therefore, traffic noise management cannot be separated from air quality management and their different trends must be considered when choosing the policies, as their impact must be the result of an optimization between noise and air pollution reductions. To date, two different kinds of traffic schemes are thought to be implemented within the project: variations in speed limits and flow management. The ECODRIVE project's purpose intends also to intervene on the human components of the transportation systems. Human drivers are responsible for the control of the main variables such as speed, acceleration (or deceleration as well) and headway. As mentioned in the previous section, speed is the most influencing variable for noise emissions, and it will be the first variable affected by the attempted policies. Changes in speed indirectly affect also accelerations and decelerations. As the number of vehicles is strongly related to the increase in emissions, another traffic scheme to test is flow management, for directly acting on traffic volumes moving on the road network. Despite the scientific evidence [4] on the close relationship between noise emissions and meteorological conditions (temperature, humidity, etc…), these are not considered within the project.

It is important to underline that each policy involves two choice levels: the first one is the policy that better suits the project's objectives and, the second one, refers to the choice of affecting the whole traffic stream or just specific vehicular classes. Both can be chosen a priori or influenced by simulation outcomes.

4. CONCLUSIONS AND OUTLOOKS

In the previous sections of this paper the importance of facing the environmental impact due to the transportation systems (and to road traffic in particular) has emerged. In the ECODRIVE project, the aim is to reduce the overall emissions of the private transport sector, by forcing drivers to take more sustainable behaviours. This is meant to be achieved through the implementation of adequate traffic management and control policies, which affect either driving characteristics (such as vehicle speed), modifying user's behaviour while he is on the road, or the number of vehicles, by managing inflows and outflow, or distributing

the demand on alternative paths, when required by traffic conditions. The effects of these policies can lead to identifying other types of traffic management policies to test, eventually coupled with the previously described ones. The most delicate step of the project was the choice of the proper policies to test on the network, able to face both air and noise pollution. The ECODRIVE project is currently in its second phase, where a simulation model is being designed for testing the intervention's effectiveness. At the end of the building and calibration steps, the first policies will be tested. In the third part of the project, the tested policies will be implemented, and the results achieved analyzed to check the viability of traffic management and control policies as effective environmental mitigation measures.

5. REFERENCES

[1] V. R. Harnapp: "Noise Pollution", *GeoJournal*, vol. 14, no. 2, pp. 217-226, 1987.

[2] European Commission: "Report from the Commission to the European Parliament and the Council on the Implementation of the Environmental Noise Directive in accordance with Article 11 of Directive 2022/49/EC", 20th March 2023, https://environment.ec.europa.eu/system/files/2023-03/COM_2023_139_1_EN_ACT_part1_v3.pdf (Accessed on 20th April 2023)

[3] V. B. Omubo-Pepple, M. A. Briggs-Kamara, I. Tamunobereton-ari: "Noise Pollution in Port Harcourt Metropolis: Sources, Effects and Control", *The pacific Journal of Science and Technology*, vol. 11, no. 2, 2011.

[4] T. Subramani, M. Kavitha, K. P. Sivaraj: "Modelling of Traffic Noise Pollution", *International Journal of Engineering Research and Applications (IJERA)*, vol. 2, no. 3, pp. 3175-3182, 2012.

[5] L. C. den Boer, A. Schroten: "Traffic Noise Reduction in Europe: Healt effects, social costs and technical and policy options to reduce road and rail traffic noise", Report of *CE Delft: Solutions for environment, economy and technology*, Delft, Netherlands, 2007.

[6] C. Steele: "A critical review of some traffic noise prediction models", *Applied Acoustic*, vol. 62, pp. 271-287, 2001.

[7] H. N. Rajakumara, R. M. Hahamalinge Gowda: "Road Traffic Noise Prediction Models: A Review", *International Journal of Sustainable Development and Planning*, vol. 3, no. 3, pp. 257-271, 2008.

[8] N. Garg, S. Maji: "A critical review of principal traffic noise models: Strategies and implications", *Environmental Impact Assessment Review*, vol. 46, pp. 68-81, 2014.

[9] S. Kephalopoulos, M. Paviotti, F. Anfosso-Lédée: "Common Noise Assessment Methods in Europe (CNOSSOS-EU)", *JRC Reference Reports*, 2012.

[10] S. Kephalopoulos, M. Paviotti, F. Anfosso-Lédée, D. Van Maercke, S. Shilton, N. Jones: "Advances in the development of common noise assessment methods in Europe: The CNOSSOS-EU framework for strategic environmental noise mapping", *Science of the Total Environment*, vol. 482-483, pp. 400-410, 2014.

[11] European Directive 2015/996, of 19th May 2015, for the implementation of the Directive 2002/49/CE.

[12] D. J. Sun, Y. Zhang, R. Xue, Y. Zhang: "Modeling carbon emissions from urban traffic system using mobile monitoring", *Science of the Total Environment*, vol. 599-600, pp. 944-951, 2017.

[13] ANAS, Italian FS Group, https://www.stradeanas.it/it/le-strade/la-rete-anas/i-grandi-itinerari-anas/grande-raccordo-anulare-di-roma-e-autostrada-roma-%E2%80%93, (Accessed on 24th April 2023).

[14] M. Fellendorf, P. Vortisch: "Microscopic traffic flow simulator VISSIM", in J. Barcelò (ed.) *Fundamentals of Traffic Simulation*, *International Series in Operations Research & Management in Science*, 145, 2016.

[15] EMEP/EEA: "Air pollutant emission inventory guidebook", 2019.