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COMPARISON OF INPUT DATA COLLECTION METHODS FOR ROAD TRAFFIC NOISE MODELS IN RESIDENTIAL AREA

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ABSTRACT

Whether it is NMPB96 or the newer CNOSSOS-EU model, all road traffic noise models require detailed inputs to provide the most reliable estimate of noise exposure.
The present work presents preliminary results of a bilateral project between the Italian National Council of Research (CNR) and Romanian Academy dedicated to the Comparison of different methods for road noise modeling in residential area.
The work presents a comparison of road traffic data acquired in both Italian and Romanian territory with 3 different traffic estimation methods: microwave radar traffic counter, Google API and cameras with recognition by machine learning.

Keywords: *transportation noise, noise mapping, traffic detection, crowd sourced data.*

1. INTRODUCTION

In 2002, the European Commission adopted the Environmental Noise Directive with the aim of preventing exposure, establishing a common methodology and exploring a way to reduce the excessive levels to which the population is exposed. The primary step in noise exposure assessment is acoustic mapping of the main sources (i.e. roads, railways, airports and industries), and this must be performed using a mathematical model. The CNOSSOS-EU method [1] was officially identified in 2015 as the new model to replace the previous NMPB interim method. This revised approach has been formally adopted by the two involved countries and will be mandatory from the 4th mapping round in 2022. The new model offered a great opportunity for European Country and at the same time new challenges in applying a different never tested large scale methodology [2].
Following extensive research, CNOSSOS-EU appears to exhibit certain discrepancies from its predecessor, predicting reduced levels of road traffic noise [3]. The difference can be attributed to several factors, including vehicle categorization and a novel formulation for absorption and diffraction effects. While an offset is expected to have no impact on the noise mitigation phase, it may be particularly relevant for health studies that require accurate noise estimation using validated maps.
In order to achieve this objective, it is imperative to acknowledge the assertion that, within a mathematical model, the quality of an output is contingent upon the quality of the inputs. Consequently, the focus should be directed towards the latter, with the establishment of clear definitions being of paramount importance.
This paper presents the findings from a collaborative study between IPCF, Institute of National Research Council of Italy, and IMSAR, Institute of Romanian Academy. The

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objective of the study was to evaluate the availability of the inputs required for the application of CNOSSOS-EU method in Romania, as well as to compare the results obtained from the NMPB and CNOSSOS-EU with respect to input data collection and results. The present paper offers the initial findings of the project, specifically the outcomes of data acquisition employing diverse methodologies, including microwave radar traffic counters, cameras with machine learning recognition, and Google API with Python script elaborations. Thereafter, a comparison will be drawn between the data sets, in order to ascertain potential discrepancies. Finally, these input data sets will be modelled in software to analyze the differences in terms of the derived noise compared to the actual measurements.

2. METHODS

2.1 Data acquisitions methods

A detailed description of the three methods identified for acquiring input data is presented hereafter. The acquisition of traffic data can be achieved through onsite measurements or remote analysis. Onsite measurements are performed with standard microwave radar traffic counters (TC) or with cameras that are optimized for vehicle recognition in the context of CNOSSOS-EU classification (CAM). The third method involves remote analysis, which exploits Google API traffic data (API). The installation of TC and CAM measurement systems is illustrated in Figure 1. The description will then proceed to detail how data are acquired and the flows derived, and the pros & cons of each methodology.

2.1.1 Microwave radar traffic counter (TC)

TC are situated at the roadside to monitor traffic on a maximum of two lanes. They can be installed in a low position (approximately 50 cm from the road surface) or in a high position (more than 2 m from the road surface) to monitor respectively roads with less or more traffic. As there may be occlusion from vehicles, the upper position should give a better view of the road if there are several lanes in the same direction. This system cannot differentiate between two lanes of traffic in the same direction, and passages are stored together. Traffic counting is based on the length of the vehicle as seen by the radar, so the same vehicle passing at different distances from the radar position will have different length values. Different lengths can be set for different vehicle categories in opposite directions, but not for two lanes in the same direction, so the thresholds between them should be set carefully. On the other hand, the system is very easy to install, it does not store any sensitive data and the analysis is done using spreadsheets.

Figure 1. Monitoring with TC and CAM – Bucharest testbed.

2.1.2 Camera with AI recognition (CAM)

AI-powered cameras are based on the YOLO (You Only Look Once) approach to object detection [4,5]. Vehicles are categorized according to a customized approach to CNOSSOS-EU categories identification. The employment of machine learning ensures the expeditious analysis of traffic flows, while a straightforward on-site measurement procedure enables speeds to be calculated. The system utilized in this study is still required to undergo post-processing analysis in order to obtain flow and speed results, due to hardware constraints. In order to derive speeds, it is necessary to undertake local measurements of the distances between the camera and the road lanes. In order to perform this calibration phase, the road should be temporarily closed. Conversely, cameras have the capacity to detect up to four lanes and divide the flows, rendering them potentially very powerful, even in cases of high traffic volumes.

2.1.3 Google API & Python scripts (API)

Crowd-sourced data can be utilized to estimate traffic volumes. Google API provides travel times through specific calls for selected road stretch (origin-destination). The application of a basic transport equation [6] makes it possible to derive passenger car equivalent flows using Python scripts and then use standard percentages of vehicle categories to derive the flow of each. The API approach has been demonstrated to facilitate the derivation of a substantial database of flows in the absence of on-site measurements. However, it should be noted that API calls do incur a cost (0.01$ for each origin-destination and time). Additionally, transportation functions are incapable of deriving accurate flow in instances of both very high congestion and very low traffic. In both scenarios, the returned travel time, i.e. the speed, is independent of the actual flow, rather dependent upon driver behavior or the overall capacity of the network.

2.2 Testbeds

Two primary testbeds were identified in the project: a mitigated main regional road crossing a small village in Italy (SR 439) and two roads of a residential area in Bucharest (namely a residential road, Strada Secuilor, and the main boulevard, Constantin Brâncoveanu). Table 1 provides a synopsis of the characteristics, while Figure 2 illustrates the locations.

Table 1. Testbeds characteristics

Road, Country	Lanes	Speed limit (km/h)	Distance to houses (m)
Regional, IT	2	50	10-10
Residential, RO	2	30	15-20
Boulevard, RO	4	50	25-25

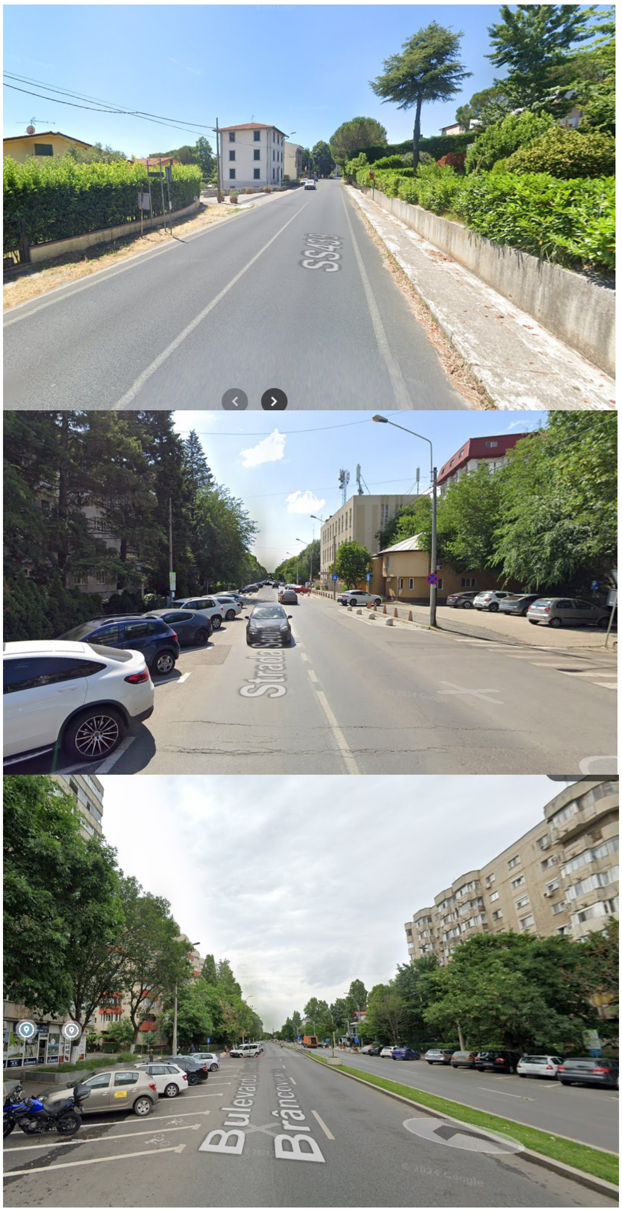

Figure 2. From top to down: SR 439 (IT), Strada Secuilor (RO) and Boulevard Constantin Brâncoveanu (RO).

2.3 Data comparison time base

In the course of the project, a comparison was made of input data gathering methods according to different time bases, depending on the purpose. For the purpose of END noise mapping, it is necessary to compare average day, evening and night-time slices. Furthermore, the 10-minute interval was analyzed in order to verify the suitability of the acquisition methods for advanced dynamic noise mapping, for example to manage congestion and other short-term effects. The focus of this paper is the presentation of results for END noise mapping estimates.

3. RESULTS

3.1 Measurements in testbeds

The first test was carried out in Italy: 24h measurements were taken in Massarosa on the SR439 during April 2024. Second test carried out in Romania: about 24h measurements were performed in Bucharest on the Boulevard Constantin Brâncoveanu and the street Strada Secuilor during September 2024.
All the acquisitions included:
- a roadside AI- camera monitoring all the lanes;
- the call to the API to acquire travel time data every 10 minutes for each direction of traffic;
- a noise level monitoring station.

Furthermore, the standard positioning of traffic counters was subject to variation across different roadways, with the objective of ensuring safety and optimizing traffic flow monitoring. The low position was utilized in Italy, while the high position was employed in Romania. Two traffic counters were installed to monitor the Boulevard; however, technical issues resulted in the failure to capture data from one of the four lanes. Consequently, the data from one of the lanes was doubled to account for the technical issues (modified data are marked with "*" in the following).

3.2 Comparison of average day evening night periods

In order to facilitate a comparison of the accuracy of the modelling process, the derived traffic data are compared in terms of flows and average speed in the three different time slices (day, evening and night) and on the three roads in each direction. The categorization of data is conducted in accordance with the CNOSSOS-EU classification system, which designates categories 1 as light vehicles, category 2 as medium trucks, category 3 as heavy vehicles (excluding urban areas in Romania, where heavy vehicles are not present), and category 4 as two-wheelers.

Acquisitions have demonstrated that the impact of categories other than light vehicles is negligible. Figure 3 illustrates the subdivision of traffic flows according to AI-camera data, for each designated time slice and testbed.

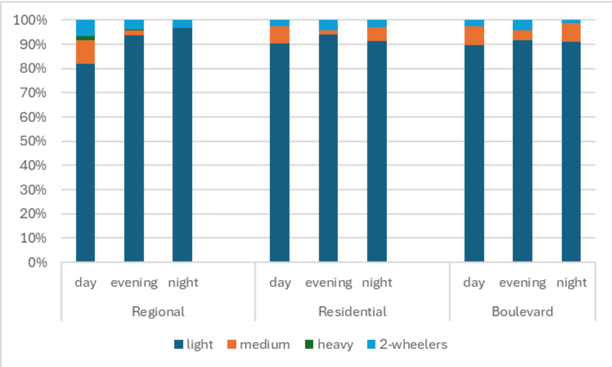

Figure 3. Vehicles categories subdivisions in flows for the three testbeds.

Therefore, the comparison of flows is reported only for light vehicles, as this is sufficient as a proxy for the expected noise differences. Tables 2, 3 and 4 present the estimated flows per hour for the three time slices and for all roads and directions according to the three input gathering approaches.
It is evident that the night-time slice of the Italian testbed reports significantly divergent values for the API method. This discrepancy can be attributed to the different method used to derive the flows: in Italy, the transport parameters were set to the same value in all time slices, whereas in Romania they were varied to reflect the different transport conditions in each time slice.

Table 2. Estimated light vehicles - day

Road, Country	TC	CAM	API
Regional, IT	332	310	350
	296	324	320
Residential, RO	114	166	169
	281	338	285
Boulevard, RO	459	614	603
	442*	704	704

Table 3. Estimated light vehicles - evening

Road, Country	TC	CAM	API
Regional, IT	207	236	369
	131	162	357
Residential, RO	86	107	201
	223	232	188
Boulevard, RO	449	542	558
	290*	506	601

Table 4. Estimated light vehicles - night

Road, Country	TC	CAM	API
Regional, IT	38	41	348
	37	52	323
Residential, RO	18	22	136
	38	39	121
Boulevard, RO	131	108	183
	177*	217	360

4. CONCLUSIONS

This work has presented the first results of a bilateral project between Italian National Research Council and Romanian Academy. While the whole project aims to analyze the effects of mapping road traffic noise with input gathered with different traffic flow measurements methodologies, the present work shows the results in terms of traffic counts from the testbeds situated in Italy and Romania. Three different methods were simultaneously used, and it results that when the traffic is low, the microwave traffic counter (TC) and camera with artificial intelligence recognition (CAM) methods are similar. CAM generally exhibits higher flows, which should be more realistic than the TC ones. The third approach, Google API approach, necessitates meticulous validation but could serve as a viable method for high traffic roads and average estimates. The transportation parameters that are conducive to deriving API data are the focus of ongoing research in related projects. Regarding noise mapping models, all methods are deemed suitable for deriving comparable noise levels during the day. For other time periods, the use of CAM is recommended, or, alternatively, TC, though only for low-traffic areas. Further analysis will allow for the establishment of variability in noise results due to the input data collection methods and the noise model applied (CNOSSOS-EU or interim NMPB method).

In order to achieve this objective, the remaining of the project will consist of a comparative analysis of the noise emissions of individual vehicles will be conducted. This will facilitate the verification of the similarity between the Italian and Romanian fleets. The measurement approach delineated in [7] will be utilized, and the potential establishment of NMPB or CNOSSOS-EU weighting coefficients for light vehicles will be considered.

5. ACKNOWLEDGMENTS

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