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Determination of a noise emission model for French medium-heavy vehicles

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ABSTRACT

The European Directives 2002/49/EC and 2015/996 provide a common evaluation method (CNOSSOS-EU) for Member States to produce noise maps assessing environmental noise exposure. A French transposition of the Directives specifies the corrective coefficients applicable for the French road network. Previous observations highlighted significant discrepancies between measurements carried out in France on medium-heavy vehicles (category 2) and CNOSSOS-EU. However, this category of vehicles was not specifically considered in the French method NMPB2008 and their actual noise emission is undocumented. Thus, noise emission measurements have been carried out on different types of vehicles in this category (van trucks, dump trucks, bus), exploring a wide range of controlled operating conditions to separate the contributions of propulsion and rolling noise. In a second step, two traffic scenarios of category 2 vehicles, with significantly different proportions of public transport vehicles, are used to determine average emission equations in accordance with CNOSSOS-EU modeling. The noise issue between these scenarios is linked to the propulsion noise contribution, which is of main interest at urban speeds but becomes insignificant at high speeds when rolling noise predominates. The two scenario models are confronted with CNOSSOS-EU variants, including the corrected model now recommended in the French regulation.

Keywords: Medium-heavy vehicle, noise emission, CNOSSOS-EU method
I-INCE Classification of Subject Number: 13

1. INTRODUCTION

European Directive 2002/49/EC of 25 June 2002 on the evaluation and management of the environmental noise [1] requires Member States to produce noise maps assessing exposure to environmental noise, particularly in large urban areas and around major roads, to be updated every 5 years. It was completed in May 2015 by Directive 2015/996

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[2] specifying a common assessment method for all Member States, CNOSSOS-EU. Some corrections have been made in the corrigendum published at the beginning of 2018 [3]. The implementation of this new method is effective for noise mapping from the beginning of 2019. Concerning road noise, an adaptation of the model to the French road network and vehicle fleet was published in June 2018 [4]. In accordance with the national NMPB2008 model, which relies on an extensive database of light and heavy vehicle pass-by measurements on French road surfaces, correction coefficients have been determined per vehicle category and road surface category [5].

The study presented in this paper specifically concerns the noise emission model of medium-heavy vehicles (vehicle category 2 of CNOSSOS-EU), i.e. with a gross weight exceeding 3.5T and equipped with two axles and twin wheels on the rear axle. This vehicle category is actually undifferentiated among heavy vehicles in the French method and no information is available on its specific acoustical behaviour on French roads. In a first step, statistical pass-by measurements on several roads were confronted to the prediction models, pointing out the misadaptation of the French NMPB2008 [6] and European CNOSSOS-EU noise emission models for representing this vehicle category [7]. Thereafter, these have been completed by controlled pass-by measurements involving a sample of medium-heavy vehicles driving at constant speed on the same road surface type and scanning a wide range of real operating conditions, in order to separate the propulsion noise and the rolling noise components. Then, average emission equations have been determined by vehicle subcategories, gathering vehicles with similar acoustic behaviour and referred to by the generic names *dump truck*, *van truck* and *bus*. Traffic noise emission from vehicles of category 2 depends on the balance of these subcategories within the whole category traffic, and may vary according to the road location and area activity. By considering two scenario options of traffic composition of category 2, average noise emission models have been determined. This paper describes the approach and compares the scenarios to the European prediction model versions.

2. NOISE EMISSION MODELS

The method CNOSSOS-EU published in 2015 [2, 3] is currently the reference European version, used as the basis for an adaptation to French traffic and road network specificities through corrective coefficients. An underlying mismatch of the road emission model has recently been raised in 2018 and an updated version of the reference CNOSSOS-EU version is being considered. These various versions are summerised in this section.

2.1. Reference CNOSSOS-EU

The CNOSSOS-EU road noise emission model considers four vehicle categories, according to their mass and axle number [2]:

- category 1: light vehicles, ≤ 3.5 tons
- category 2: medium-heavy vehicles, > 3.5 tons with two axles and twin tyres on rear axle
- category 3: heavy vehicles, > 3.5 tons with three or more axles
- category 4: powered two-wheelers

Category 2, which is at the forefront of this paper, includes a wide variety of vehicles with various uses, bodies and equipment – i.e. delivery-, dump- and garbage trucks, tankers, buses and coaches – as long as they have only two axles.

Any vehicle is modelled by a single omnidirectional point source, located 0.05 m above ground. Its acoustic power specified in the octave bands [63 Hz - 8 kHz] under reference conditions (constant speed, flat and dry road, air temperature of 20°C and a virtual road surface corresponding to an average of DAC 0/11 and SMA 0/11). If conditions deviate from these, correction coefficients shall be used.

In each octave band i, the total radiated power of the point source $L_{WT,i}$ is composed of a propulsion noise component $L_{WP,i}$ and a rolling noise component $L_{WR,i}$ – all depending on vehicle speed v – specified by four coefficients:

$$L_{WT,i}(v) = L_{WR,i}(v) \oplus L_{WP,i}(v) \tag{1}$$

where the operator $\oplus$ stands for the energetic sum of both components and:

$$L_{WR,i}(v) = A_{R,i} + B_{R,i} \log\left(\frac{v}{v_{ref}}\right) \tag{2}$$

$$L_{WP,i}(v) = A_{P,i} + B_{P,i}\frac{v - v_{ref}}{v_{ref}} \tag{3}$$

The coefficients $A_{R,i}$,$B_{R,i}$, $A_{P,i}$ and $B_{P,i}$ are given in Table F-1 of the Directive [2], for a reference speed $v_{ref} = 70$ km/h.

Corrective terms $\Delta L_{WR,road,i}$ and $\Delta L_{WP,road,i}$ are available for rolling noise and propulsion noise respectively, so as to take into account the effect of the road surface on vehicle noise emission:

$$\Delta L_{WR,road,i}(v) = \alpha_i + \beta \log\left(\frac{v}{v_0}\right) \tag{4}$$

$$\Delta L_{WP,road,i}(v) = \min\{\alpha_i; 0\} \tag{5}$$

the latter being designed to account for the effect of absorbing surfaces on propulsion noise. Values of the coefficients α_i and β are given in Table F-4 of the Directive for each vehicle category on various Dutch road surfaces. For each road pavement, it should be noticed that the corrective coefficients for medium-heavy vehicles are always identical to those of the heavy vehicles, reflecting a similar noise level impact of a road surface change for both categories.

The corrective coefficients α_i and β are the means of action to adapt the model to the French road surfaces.

2.2. French adaptation CNOSSOS-FR

The French prediction method NMPB2008 was implemented as a transitional method for the previous rounds of strategic noise map production, pending the availability of the common European method. The propagation part of CNOSSOS-EU is quite similar to the French approach, but the respective road noise emission models differ with regard to the vehicle classification and to the sound power levels, among other things. Indeed, NMPB2008 identifies only two types of vehicles: light vehicles and heavy vehicles [6], the former matching with CNOSSOS category 1 and the latter with category 3. In addition, it clusters and ranks road surfaces into three groups, R1, R2 and R3, from the quietest to the noisiest, each one split in drainage or non-drainage surfaces. NMPB2008 was built on a wide set of national measurements and is considered as representative of the vehicle fleet driving on the French road network.

An adaptation of CNOSSOS-EU to the French context has been proposed by calculating correction coefficients α_i and β that best match CNOSSOS to the NMPB2008 model, respectively for vehicle categories 1 and 3 and each road surface cluster [5]. For the undocumented French category 2, the adaptation has taken the same approach as Table F-4 of CNOSSOS-EU by replicating the correction coefficients available for category 3 [4]. This French adaptation is named CNOSSOS-FR in this paper.

It should be noted that, in road and vehicle conditions similar to the reference conditions of CNOSSOS-EU, the use of uncorrected CNOSSOS-EU greatly undervalues French noise emission levels. This results in the production of quite significant correction terms, even for low-noise surfaces.

2.3. Modified version of CNOSSOS-EU

Some errors have recently been identified in the derivation of the sound power coefficients given in Table F-1 of CNOSSOS-EU, partly resulting from a mismatch between the respective propagation models of Harmonoise/IMAGINE and of CNOSSOS-EU [8]. Among other issues, the need for an update of Table F-1 has been pointed out and discussed in 2018 within a European working group for being included in a revision of the Annex [9]. This affects the coefficient A for both the propulsion and rolling noise components, without changing the B coefficients and therefore the component dependence on speed [8]. For vehicle categories 2 and 3, upgraded coefficients provide higher overall sound power levels by 2 to more than 3 dB(A) depending on speed. This modified CNOSSOS version is named CNOSSOS-2018 in the present paper.

2.4. Comparison of the models for vehicle category 2

By likening the reference surface of CNOSSOS-EU to the non-drainage group R2 of the French classification, the previous models can be compared for vehicle category 2, namely:

- CNOSSOS-EU in reference conditions
- CNOSSOS-FR for a non drainage R2 surface
- CNOSSOS-2018 in reference conditions

For an easier comparison with the subsequent measurement data, the quantities represented are A-weighted maximum pass-by levels (L_{Amax}) on a receiver located at a distance of 7.5 m from the road axis and a height of 1.2 m, the source and the propagation being in accordance with the CNOSSOS-EU approach.

For a dense road surface, CNOSSOS-EU and CNOSSOS-FR noise emission models have identical propulsion noise components and differ by their rolling noise contribution. CNOSSOS-2018 is different from the preceding ones both in the propulsion and the rolling noise components. CNOSSOS-EU gives the lowest rolling noise contribution, while CNOSSOS-FR provides the highest one and a steeper increase. The total noise shows variable differences between models over the speed range, according to the predominance of the propulsion noise and the rolling noise contribution in the octave bands (Figure 1).

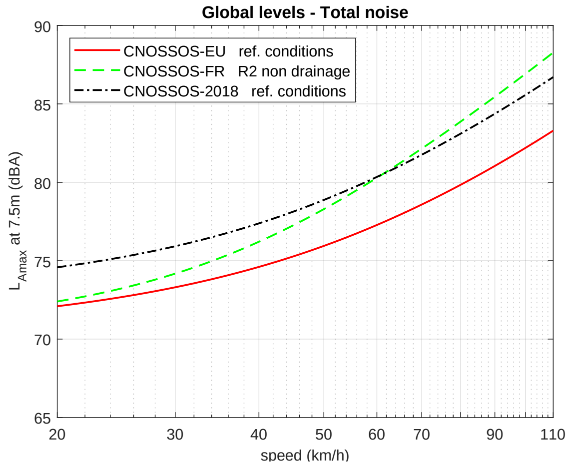

Figure 1: Comparison of the overall noise emission models for vehicle category 2, A-weighted global noise levels at 7.5 m

From previous phase of the study, noise measurements performed on traffic of category 2 showed that CNOSSOS-EU undervalues actual noise levels, in global levels and in most octave bands. However, the model CNOSSOS-FR seemed to produce level predictions compatible with the measurements [7]. With CNOSSOS-2018 as well, these models will be compared to measures taken from medium-heavy vehicles in controlled conditions and to specific models built on traffic composition scenarios.

3. DETERMINATION OF THE NOISE EMISSION EQUATION OF A CONTROLLED VEHICLE

All the controlled medium-heavy vehicles have been measured under very close conditions and similarly analysed. An instance is illustrated in this section.

3.1. Measurement

In this example, the vehicle is a van-type rigid with a gross weight of 12 tons, in good maintenance state and with a relatively low mileage considering common truck use. It was equipped with tyres of dimension 245/70 R 19.5 and a 6-speed gearbox. The gear ratios and the axle ratio are known. It was loaded with a mass placed on its back axle, corresponding to a mass to power ratio of 42.5 kg/kW.

The pass-by measurement procedure is based on standard NF S 31119-2 [10], similar to ISO 11819-1 [11] but for controlled vehicles. Three microphones spaced by 10 m were located on each track side, at a distance of 7.5 m from the track axis and a height of 1.2 m. By each pair of facing microphones, an infrared cell provided information on the vehicle speed. The track surface was a dense asphalt concrete (DAC 0/10). The air temperature was variable from to 17 to 22°C according to the mix of clouds and sun. No temperature correction has been made on the acoustic data.

Constant speed pass-bys were carried out in 5 or 10 km/h steps from 15 to 90 km/h. As far as possible two different engaged gears were tested for each speed setpoint, the *adapted gear* (most natural gear for the speed) and the *inferior gear* (one gear lower, thus involving a larger rpm). Besides direct but imprecise rev counter reading, knowledge of the powertrain mechanical characteristics makes it possible to calculate the engine rpm from the speed, in front of each microphone.

3.2. Determination of the vehicle noise emission equation

In accordance with CNOSSOS prediction model the analysis is carried out in octave bands from 63 Hz to 8000 Hz. By considering the valid constant speed measurements from all microphones, the vehicle noise emission equation in each octave band i is determined by optimising parameters of a noise level model $L_{Amax,i,mod}$, using a least squares criterium between the set of measured levels $L_{Amax,i,meas}$ and the model $L_{Amax,i,mod}$:

$$\min \|L_{Amax,i,meas} - L_{Amax,i,mod}\|^2 \tag{6}$$

In this model, given by Equation (7), the total noise is the sum of a propulsion noise component depending on engine speed (Equation 8) and of a rolling noise component depending on vehicle speed (Equation 9).

$$L_{Amax,i,mod}(N, v) = L_{A,prop,i}(N) \oplus L_{A,roll,i}(v) \tag{7}$$

$$L_{A,prop,i}(N) = L_{0,A,prop,i} + \alpha_{A,prop,i} \log\left(\frac{N}{N_{ref}}\right) \tag{8}$$

$$L_{A,roll,i}(v) = L_{0,A,roll,i} + \alpha_{A,roll,i} \log\left(\frac{v}{v_{ref}}\right) \tag{9}$$

where N_{ref} and v_{ref} are respectively the reference engine speed and the driving speed, and the operator $\oplus$ stands for energetic summation.

The experimental investigation of more than one engaged gear at most speeds provides a wider engine rpm range for an improved optimisation. Except for the lowest octave band 63 Hz and also 125 Hz at a lower level, which include narrowband components switching from one octave to another with increasing speed, this model fits quite well to the octave band data and global data.

Thereafter, considering the common *adapted gear* driving conditions, a one-to-one relationship links vehicle speed to engine rpm $N_{adapt}(v)$. Thus, the noise emission equation of the vehicle at *adapted gear* depends on the sole variable v, using the previously optimised coefficients $L_{0,A,prop,i}$, $\alpha_{A,prop,i}$, $L_{0,A,roll,i}$ and $\alpha_{A,roll,i}$ (Equation 10).

$$L_{Amax,adapt,i}(v) = \left[L_{0,A,prop,i} + \alpha_{A,prop,i} \log\left(\frac{N_{adapt}(v)}{N_{ref}}\right)\right] \oplus \left[L_{0,A,roll,i} + \alpha_{A,roll,i} \log\left(\frac{v}{v_{ref}}\right)\right] \tag{10}$$

In a similar way an emission equation in *inferior gear* can be expressed for the selection of one gear lower. The global emission model, recomposed from the eight octave bands, is presented in Figure 2, in which pass-by measurement data for the various gear ratios are also plotted. The discontinuities observed on the propulsion noise and, consequently, on the overall noise are related to the gearbox shifts which imply large engine rpm changes.

The same operation has been performed with each vehicle tested. The propulsion and the rolling noise components of each vehicle in *adapted gear* will be used to determine average contributions from a set of vehicles.

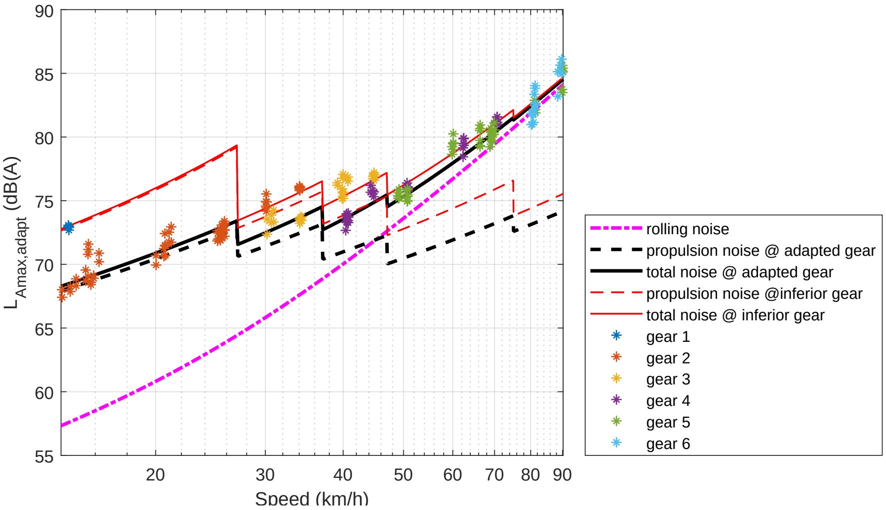

Figure 2: Noise emission of one vehicle of category 2, A-weighted global noise levels at 7.5 m – Model noise components in adapted gear *and* inferior gear *driving conditions (lines) – Noise levels measured in the various gear ratios (∗)*

4. NOISE EMISSION BY MEDIUM-HEAVY VEHICLE SUBCATEGORY

Several types of medium-heavy vehicles have been tested. They have been grouped in subcategories, designated with the generic names *van truck*, *dump truck*, *bus*. This classification was motivated by noticing some homogeneity within a subcategory but significant differences between them. First, a mean emission law is determined in each subcategory by energetically averaging propulsion noise components on the one hand and rolling noise components on the other hand per octave band, on the common speed test range. The average in global levels is obtained by summing the octave band averages. Then, in section 5 these will be combined according to traffic mix scenarios in order to derive an average noise emission of a vehicle of category 2. All vehicles had an internal combustion engine and were tested at one of two sites with a DAC 0/10 road surface.

The total number of vehicles tested is still limited, since seven vehicles could be assessed in depth. However, this is of the same order as the heavy vehicle sample used in its time for supporting the propulsion noise component of NMPB2008 [6].

Van trucks Intended for the delivery of packaged goods, box trucks form a significant part of medium-heavy vehicles. Detailed noise emission data is available from four trucks of two makes and different models, either with a rigid or a curtain sided load space. They have various characteristics in terms of gross weight, age and mileage. They are all equipped with a 6-speed gearbox, but with distinct ratios and therefore gear shifting at different speeds. The tyres are diversified in wear, dimensions and makes, including winter and retreaded ones. The vehicles were loaded such that the mass to power ratio was close to the recommendation of standard ISO 362 for noise certification, which requires 50 kg/kW. Information in the 8000 Hz octave was unavailable for one of them, without much significant impact on the recomposed global noise level.

Dump trucks Two dump trucks, used for the transport of bulk materials for public works, have been tested. They had different tyre makes and dimensions, engine powers, ages and both were equipped with a 8-speed gearbox. They were running empty. These vehicles are relatively noisy, mainly due to propulsion noise.

Bus Only one vehicle was available in this category, representative of a urban bus in new condition. It was equipped with a 6-speed gearbox and its maximum speed was limited to 70 km/h. It turned out to be relatively low-noise, behaviour which should be controlled with other buses or coaches.

Subcategory comparison

The average noise emissions in each subcategory are compared in Figure 3, in relation to the three prediction models described in section 2.

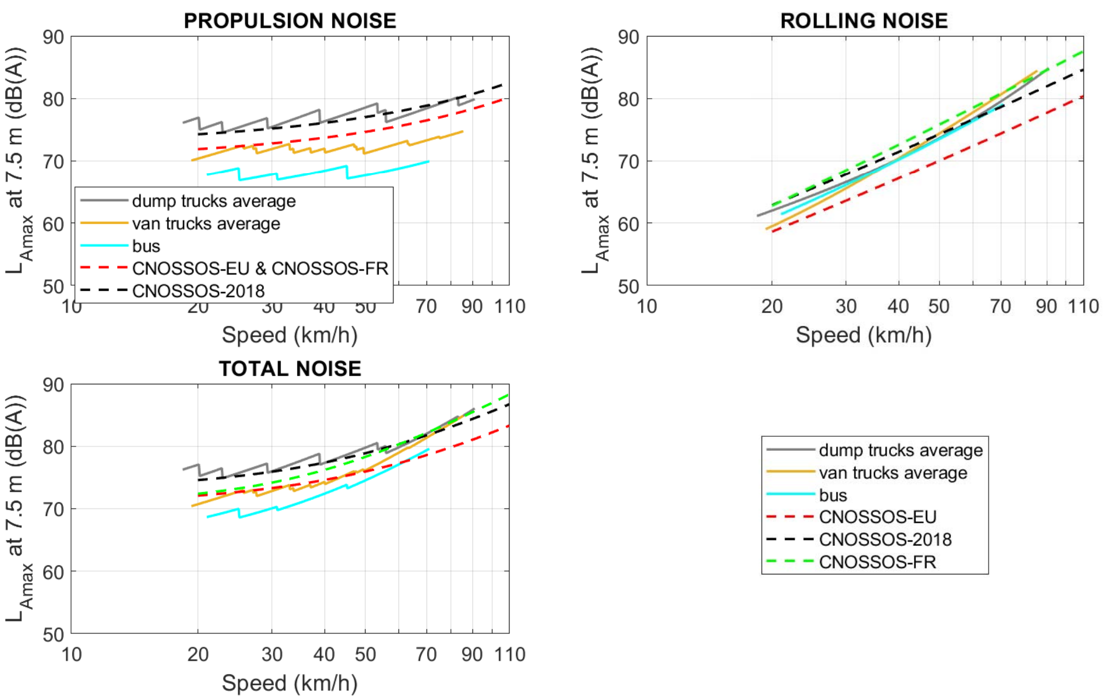

Figure 3: Average noise emission by subcategory and noise prediction models, A-weighted maximum global noise levels at 7.5 m – Propulsion noise (top left), rolling noise (top right), total noise (bottom left)

Concerning propulsion noise, averaging tends to smooth out the vehicle-specific discontinuities spread over the speed range. Propulsion noise differences provide an obvious subcategory ranking *dump trucks* > *van trucks* > *bus* and may exceed 8 dB(A) between the average *dump truck* and the *bus*. *Van trucks* approximately lie at mid-range within this extent. Since the rolling noise components of the subcategories are relatively homogeneous, the same ranking is found on total noise at least up to 60 km/h beyond which rolling noise contributes to blur differences. Anyway, the bus remains the quietest over its whole operating speed range.

None of the three prediction models may adequately represent the total noise from the whole category, due to the wide discrepancies observed. Although one or the other prediction model may coincide with average *van truck* measurements in some octave bands, they overestimate *van truck* propulsion noise in global levels, and even more for CNOSSOS-2018. This has a corresponding impact on total noise levels. *Dump truck* propulsion noise outperforms predictions in most octave bands, at a lesser level with CNOSSOS-2018. In contrast the *bus* propulsion noise is lower than the prediction models in all octave bands, with the same behaviour transferred on total noise.

In octave bands, the relevance of either prediction model may vary with frequency. However in global levels, whereas CNOSSOS-2018 happens to be the most appropriate for *dump truck* subcategory, CNOSSOS-EU better reflects *van truck* behaviour below 50 km/h. Considering that rolling noise significantly contributes at high speeds, CNOSSOS-FR seems a relevant candidate prediction model for rolling noise.

Thus, the noise emission range – mainly controlled by propulsion noise – is quite wide between hypothetical extreme scenarios of a medium-heavy traffic, composed either only of *dump trucks* (for example near heavy industrial areas or quarries) or only of *buses* (in residential areas). An actual traffic composition lies somewhere in-between and the distribution between subcategories is essential for determining the representative average vehicle noise emission.

5. MEDIUM-HEAVY TRAFFIC NOISE EMISSION

The determination of the noise emission model representative of French vehicles of category 2 results from assumptions on the traffic composition, weighting the noise emitted by each subcategory. However, this composition may significantly vary with infrastructure, for instance a street in the city centre, an urban road-way or an interregional highway. Defining a noise emission model of an average vehicle relies on a compromise to represent the various realities.

Available traffic countings do not generally separate heavy vehicles from category 2 and 3 as defined in CNOSSOS, let alone subcategories. In order to perceive this traffic variability and its noise impact on the description of an average vehicle, subcategory counting has be punctually performed at four locations. These short-term daytime counts, carried out on working days, cannot definitely be representative of the Annual Average Daily Traffic on these road segments, neither of the traffic diversity on other roads and should be considered for indicative purposes only.

5.1. Approach

A traffic composition of category 2 is defined by:

- a proportion n_v of *van trucks* (including refrigerator trucks),
- a proportion n_d of *dump trucks* (including tank-, flatbed-, container-, refuse trucks),
- a proportion n_b of *buses* (urban buses and coaches)

with $n_v + n_d + n_b = 1$.

For a traffic composition (n_v, n_d, n_b), in each octave band i the propulsion noise of an average vehicle $\overline{L}_{prop,i}(v)$ is the weighted energetic mean of each subcategory propulsion noise, in the common speed interval. The next step consists in calculating the optimal coefficients $\hat{A}_{P,i}$ and $\hat{B}_{P,i}$ of an emission model given by the CNOSSOS equations, fitted to the noise level $\overline{L}_{prop,i}(v)$ (Equation 11). The same approach is carried out for rolling noise and gives $\hat{A}_{R,i}$ and $\hat{B}_{R,i}$ from $\overline{L}_{roll,i}(v)$.

$$\left[\hat{A}_{P,i}, \hat{B}_{P,i}\right] = \min_{A_{P,i},B_{P,i}} \left|\overline{L}_{prop,i}(v) - A_{P,i} - B_{P,i}\left(\frac{v - v_{ref}}{v_{ref}}\right)\right|^2 \quad (11)$$

$$\left[\hat{A}_{R,i}, \hat{B}_{R,i}\right] = \min_{A_{R,i},B_{R,i}} \left|\overline{L}_{roul,i}(v) - A_{R,i} - B_{R,i}\log\left(\frac{v}{v_{ref}}\right)\right|^2 \quad (12)$$

5.2. Traffic scenarios and associated noise models

Road function turns out to be unimportant for the overall noise emission. From the four traffic counting sites, two groups stand out particularly, each including two sites with dissimilar functions. The key distinguishing factor between the two groups is the proportion of public transport vehicles, with a direct impact on the propulsion noise component but a lower one on rolling noise. Consequently, two typical scenarios are retained (Table 1) for propulsion noise while rolling noise component is common to both.

Table 1: Proportion of vehicles in each subcategory

Scenario	n_v	n_d	n_b
1	61 %	34 %	5 %
2	27 %	20 %	53 %

The noise emission model associated with each scenario, extrapolated up to 110 km/h, is drawn in Figure 4. Since differences between scenarios affect propulsion noise only, total noise acoustically differs at low speed but not at high speed. With a high proportion of public transport vehicles, propulsion noise dominates up to 46 km/h, then rolling noise prevails. If the public transport ratio is low, rolling noise dominates from 52 km/h. This seems reasonable at the light of road noise knowledge. On the contrary, CNOSSOS-EU global rolling noise reaches propulsion noise contribution at about 100 km/h only and rolling noise is of the same order of magnitude as propulsion noise at the best, even at the frequencies where its contribution is known to be strong.

The propulsion noise difference between scenarios is almost constant over the whole speed range, equal to 1.6 dB(A) in global levels. This gives a varying difference on total noise, from 1.6 dB(A) at low speed and decreasing to become insignificant at high speed. It remains over 1 dB(A) up to 40 km/h (Figure 4, right).

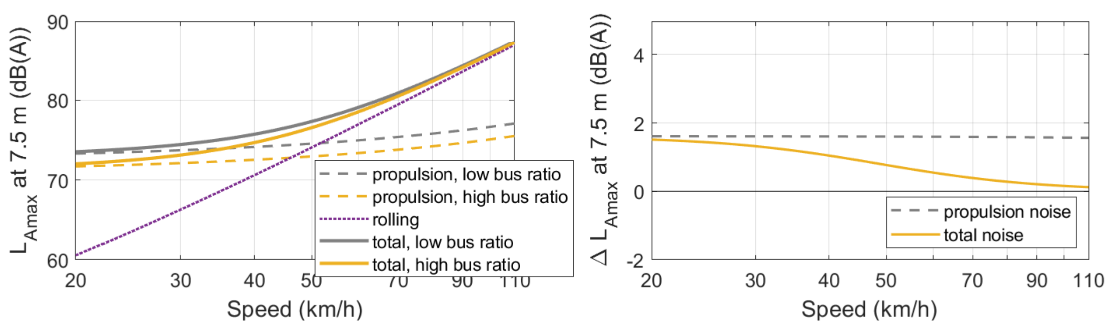

Figure 4: Global noise emission of an average medium-heavy vehicle according to scenarios, A-weighted maximum global noise levels at 7.5 m – Left: noise model – Right: noise difference between scenarios

5.3. Comparison to CNOSSOS

Considering the road surface of the test sites, both scenarios are compared to CNOSSOS-EU and CNOSSOS-2018 in reference conditions, and to CNOSSOS-FR with the road surface group R2 non-drainage (Figure 5). The relevance of the CNOSSOS versions with the average models associated to the two scenarios depends on trafic distribution and speed.

CNOSSOS-EU is well adapted to the scenario with a high public transport ratio up to 40 km/h but undervalues the other scenario by 1 to 1.5 dB(A). In both cases it undervalues noise emission at high speeds, up to 4 dB(A) at 110 km/h and road corrective terms are required.

CNOSSOS-2018 overestimates overall noise emission, up to 1.6 dB(A) at low and medium speeds with a low public transport ratio and up to 2.8 dB(A) if this ratio is high. Thus, its application would be tricky in this case since corrective terms provide no mean of reducing propulsion noise level contribution.

CNOSSOS-FR is now recommended for new noise mapping rounds. Its ability to correctly figure the noise situation is essential. On the present experimental test basis, for the road category R2 non-drainage, it happens to be an acceptable compromise for both scenarios in urban conditions. In a typical urban scenario with a high public transport ratio, overestimation is lower than 1 dB(A) at 20-30 km/h and smaller than 2 dB(A) over the whole speed range. If the public transport ratio is low the noise prediction error remains within ± 1 dB(A) up to 50 km/h and does not exceed 1.3 dB(A) at medium and higher speeds.

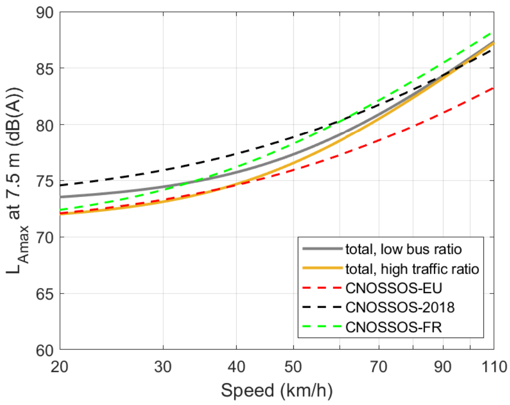

Figure 5: Comparison of the overall noise emission models for an average vehicle of category 2, A-weighted global noise levels at 7.5 m

6. CONCLUSIONS

The present study carried out detailed noise measurements on a series of controlled medium-heavy vehicles to document the French unreferenced noise emission of this vehicle category. By considering three subcategories, an average vehicle from two traffic composition differing by their ratio of public transport vehicles has been considered, with a noise issue occurring at urban speeds only. It turns out that the potentially updated CNOSSOS-EU version as discussed in 2018 overestimates noise emission up to 2.8 dB(A) if the bus proportion within category 2 traffic is high. For the road surfaces DAC 0/10 tested, the CNOSSOS version adapted and now recommended for French roads gives noise emission predictions within ±1 dB(A) up to 50 km/h if the bus ratio is low, up to 30 km/h if this ratio is high. At most speeds, it overvalues global noise levels without exceeding 1.8 dB(A).

7. ACKNOWLEDGEMENTS

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