Noise mapping of agglomerations: a comparison of interim standards vs new CNOSSOS-EU method in a real case study

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ABSTRACT

Within interim methods, it is commonly accepted that XPS 31-133 guideline, adopted for the prediction of road noise, is the guideline more frequently used to determine the exposure to road noise throughout EU in the past two rounds of EU noise mapping, and it is therefore of paramount relevance to determine the compatibility of the old approach (XPS 31-133) with the upcoming one (CNOSSOS-EU Road). The new method (CNOSSOS-EU) was introduced in order to avoid large differences in predicting noise throughout Member States, but prediction of noise is just the first step in the EU strategy against noise pollution: it must be kept in mind that strategic noise maps are not only used to inform about noise exposure, but should be used by decision-makers to take decisions and produce noise action plans to reduce noise exposure.

The city of Trento, an alpine agglomeration in northern Italy, was chosen by the authors for an experimental comparison between the upcoming CNOSSOS-EU Road and the former Interim method XPS 31-133. A Noise Map of the city was calculated and in this context a comparison of results given by XPS 31-133 and CNOSSOS-EU Road is provided in this paper.

Keywords: Road Traffic Noise   I-INCE Classification of Subjects Number(s): 52.3, 76.1.1

1. INTRODUCTION

The new CNOSSOS-EU (Common Noise Assessment Method for Europe) guidelines have been adopted in July 2014 by the Member States of the European Union within a revision of Annex II of EU Directive 2002/49/EC (END) in order to reach a final agreement on a common method of noise prediction across EU countries.

Although it is likely that interim methods will be used for the next round of Noise Mapping activity (in 2017, as required by the EU Directive), it is advisable that CNOSSOS-EU method be introduced as soon as possible throughout the Member States, as it was demonstrated that Noise Mapping results coming from EU countries obtained using different national methods are not comparable.

None of the countries with national methods could prove the equivalence of their national methods with the interim calculation methods, and the conclusion is that EU was not able to compare data coming from Member States so far.

In 2008, the EC initiated the development of harmonized methods for assessing noise exposure in Europe. In the context of the project entitled CNOSSOS-EU led by the EC's Joint Research Centre (JRC) on behalf of the Directorate General for Environment (DG ENV), the core of the common noise

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assessment methodological framework in Europe started its development in a cooperative process involving many institutions and experts nominated by EU countries. Besides the development of the common noise methodological framework, the CNOSSOS-EU process has also fostered dialogue between the stakeholders involved to face make available to European citizens reliable information on the noise levels they are exposed to and the associated health implications and to draw appropriate action plans for preventing and reducing exposure to harmful levels of noise in a sustainable and resource-efficient way.

Based on the CNOSSOS-EU report (1), the European Commission amended Annex II of Directive 2002/49/EC. The ultimate goal is to have the common noise assessment methodology operational for the next round of strategic noise mapping in the European Union, in 2017.

Now, a question arises: do the current interim methods used so far for strategic mapping give comparable results with the upcoming CNOSSOS-EU methods?

The current action plan for agglomerations and road infrastructures have been developed on the base of strategic noise mapping developed mostly using the Interim French XPS 31-133 method: if the upcoming CNOSSOS-EU Road should give different mapping results, this could mean that the current noise action plans should be revised, and also financial resources assigned to reduce noise exposure should have to be re-assigned or modified.

What if we should find out that the new EU method is likely to give sensible (> 2 dB) differences in mapping equivalent situation? Hence, it seems to be a relevant matter to determine the comparability of these two methods.

2. XPS 31-133 vs CNOSSOS-EU Road

2.1 XPS 31-133 overview

Annex 4 of the END identifies the recommended interim computation methods for strategic noise mapping. The recommended method for road noise prediction is NMPB-Routes-96 (SETRA-CERTU-LCPCCSTB)', referred to in 'Arrêté du 5 mai 1995 relatif au bruit des infrastructures routières, Journal Officiel du 10 mai 1995, Article 6' and in the French standard 'XPS 31-133'. For input data concerning emission, these documents refer to the 'Guide du bruit des transports terrestres, fascicule prévision des niveaux sonores, CETUR 1980". Commission Recommendation 2003/613/EC set out adaptations to the French method which are to be included when used for strategic noise mapping. This work was done by document "Adaptation and revision of the interim noise computation methods for the purpose of strategic noise mapping" by Wolfel et al, in March 2003 (3).

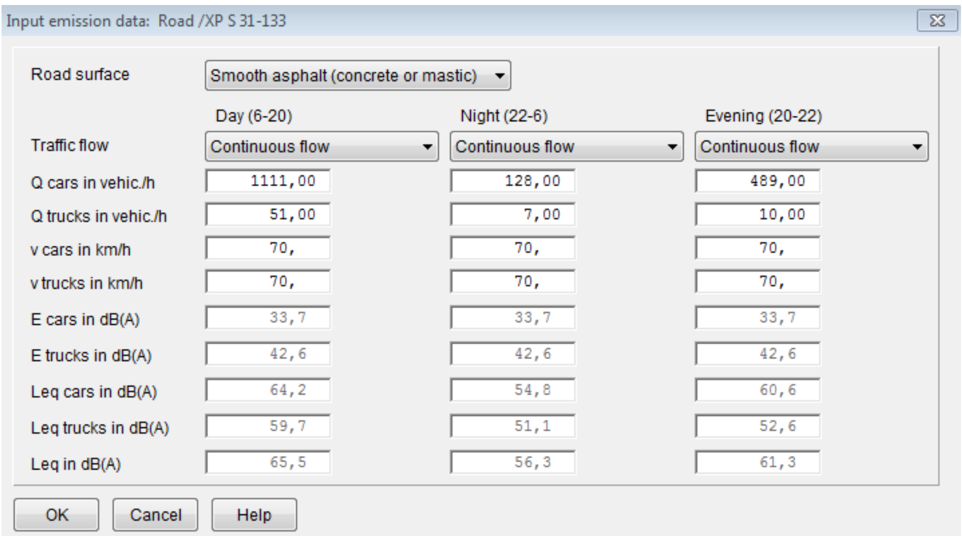

Figure 1 – Input data required for XPS 31-133 road sorce (IMMI® 2016)

The French method describes both emission and propagation of road noise. Emission is mainly based on the Guide de Bruit 1980 and other documents (XPS 31-133-2001, NMPB 1995), that are superseded. France itself updated its method developing a new standard, called NMPB 2008, that differs from the Interim method recommended by EC in 2003.

It must be said that the adaptions required by the document (3) were not completely adopted by EC recommendation: only the subjects related to road surface corrections, meteorological influence, atmospheric absorption and noise indicators definitions were taken into account.

2.2 CNOSSOS-EU Road overview

In CNOSSOS-EU method the road traffic noise source is determined by combining the noise emission of each individual vehicle forming the traffic flow. These vehicles are grouped into five separate categories with regard to their characteristics of noise emission, as described in the following table.

Table 1 – CNOSSOS-EU Road categories of vehicle

Category	Name	Description
1	Light Motor Vehicles	Passenger cars, delivery vans ≤ 3.5 tons, sport utility vehicles (SUVs), multi-purpose vehicles (MPVs) including trailers and caravans
2	Medium Heavy Vehicles	Medium heavy vehicles, delivery vans > 3.5 tons, buses, motor home vehicles, etc. with two axles and twin tyre mounting on rear axle
3	Heavy Vehicles	Heavy duty vehicles, motor home vehicles, buses, with three or more axles
4	Powered Two wheelers	4a Two-, three- and four-wheel mopeds 4b Motorcycles with and without sidecars, tricycles and quadricycles
5	Open Category	To be defined according to future needs

The model defines the instantaneous noise production of a vehicle described by the two main parameters – class and speed – and corrected for several environmental or specific effects. The calculations are performed with separate speeds for each vehicle category.

For each road vehicle, the emission model consists of a set of mathematical equations representing the two main noise sources: rolling noise, due to the tyre/road interaction: it is described as a logarithmic function of the rolling speed, and propulsion noise, produced by the driveline (engine, exhaust, etc.) of the vehicle: it is described as a linear function of the rolling speed.

Correction factors are introduced in the formulations of rolling and propulsion noise, namely the corrections for road surface type, studded tyres, acceleration and deceleration and road gradient effect.

The first two are the main regional effects to be accounted for in the model, they both apply to rolling noise, whilst the latter two apply to propulsion noise. The use of a correction for acceleration effect may be relevant in urban situations (for example, to estimate the effect of “green waves”) and can be accounted for by using a standard correction over a “zone of influence” near intersections. A simple formulation based on a modelling approach is proposed in the JRC Reference report on CNOSSOS-EU (1), to be applied before and after crossings with traffic lights and roundabouts. The correction terms for rolling noise and propulsion noise are linear functions of the distance of the point source to the nearest intersection of the respective source line with another source line and are attributed to all octave bands equally. During phase B of CNOSSOS-EU, it was discussed and agreed to include acceleration/deceleration in the software implementation of CNOSSOS-EU as it may have a significant effect on vehicle noise emission, especially when approaching or departing from road crossings.

Concerning the gradient, its correction is based upon a “per lane” approach, therefore in the case of a bi-directional traffic, the flow should be split into two components and corrected half for uphill and half for downhill. When the source line represents a one way flow, the gradient correction is applied without the need to split the flow.

In the case of powered two-wheelers, two separate subclasses are defined for mopeds and more powerful motorcycles, since they operate in very different driving modes and their numbers usually vary widely.

A fifth category is foreseen as an open class for new vehicles that may be developed in the future and may be sufficiently different in their noise emission to require an additional category to be defined. This category could cover, for example, electric or hybrid vehicles or any futuristic vehicle.

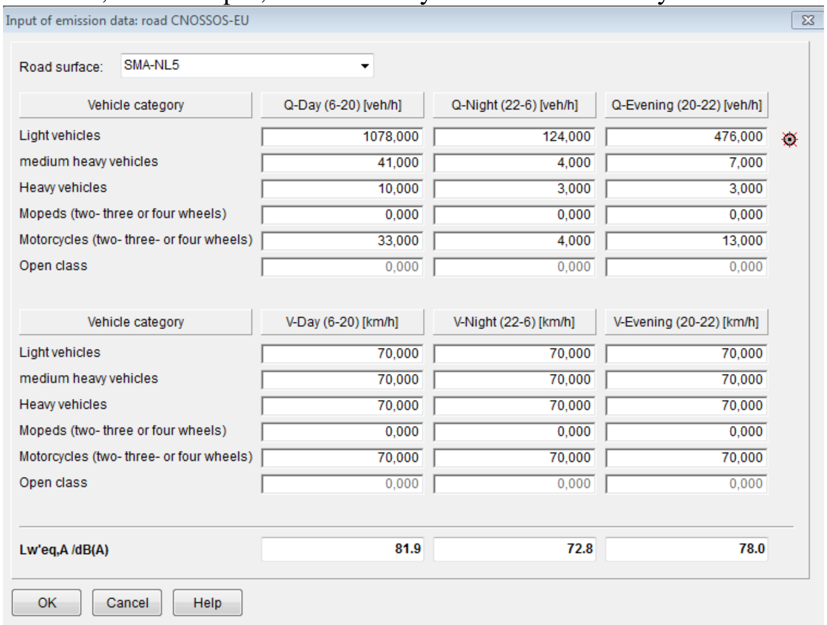

Figure 2 – Input data required for CNOSSOS road sorce (IMMI® 2016)

2.3 Conversion of databases

The introduction of new prediction methods means that the existing data, collected during past years of noise mapping activity, need to be converted to the new categories, or acquired if necessary.

In general, look up tables are presented for vehicle classes and road surface coefficients: the following table is an example of look-up table used to convert NMPB '96 data – forming the basis of EC recommended interim method for road noise – into CNOSSOS-EU Road data (4).

Table 3 – Conversion of vehicles data from NMPB 96 to CNOSSOS-EU Road

CNOSSOS Category	Definition of CNOSSOS category	NMPB96 Category
1	Light Motor Vehicles	100% Light Vehicles
2	Medium Heavy Vehicles	50% Heavy Vehicles
3	Heavy Vehicles	50% Heavy Vehicles
4	Two powered wheelers	n.a.
5	Others (hybrid, electric…)	n.a.

Table 4 – Conversion of data NMPB 96 to CNOSSOS-EU Road

CNOSSOS Category	NMPB96 category
NL11	Rough Texture Paving Stones (+6dB)
NL10	Smooth Texture Paving Stones (+3dB)
NL08	Cement Concrete and corrugated asphalt (+2dB)
NL05	Smooth Asphalt (0 dB)
NL13	Porous Surface (-1 to -3 dB dependent on speed)

2.4 Need for additional "new" data

The definition of the model for the vehicle noise emission requires new parameters, that are not commonly available so far.

The model of source emission is based on the definition of "Rolling Noise" and "Propulsion Noise", but these quantities are defined through a set of parameters derived from an extensive work undertaken in the context of previous EU project such as HARMONOISE, IMAGINE and more. Rolling noise is dependent on road surface correction, and the availability of such corrections is limited so far.

2.5 When the output of a noise mapping can be considered accurate?

Mapping accuracy is generally important when the assessment being undertaken is linked to targets, where comparison with limits is being undertaken or when post result analysis is to be carried out to abstract results for other purposes. The factors affecting mapping accuracy within END context are mainly: technical matters, economic impact, public perception.

In other words, if the output of a noise map is not sufficiently accurate to allow a ± 2 dB accuracy, we are not able to divide the results into crisp 5 dB wide sets, and this results in unuseful output.

More, we know that is highly desirable to achieve accurate and robust results simply because EU is investing heavily in the process of noise mapping and noise action plans, and there are many figures demonstrating the cost of noise per dB (for road transport the use of the median value change in noise perceived by households of 25 EUR per dB (Lden) per household per year). Which means that a prediction error of some dB could heavily influence the EU budget for noise actions.

3. A REAL CASE STUDY OF CNOSSOS-EU vs. XPS 31-133 COMPARISON

3.1 Description of the case study: the agglomeration of Trento

Trento is an Italian city located in the Adige River valley in Trentino-Alto Adige/Südtirol in Italy. It is the capital of Trentino. In the 16th century, the city was the location of the Council of Trent. Trento is an educational, scientific, financial and political centre in Trentino-Alto Adige/Südtirol, in Tyrol and Northern Italy in general. The city contains a picturesque Medieval and Renaissance historic centre, with ancient buildings.

The township of Trento encompasses the town centre as well as many suburbs of extremely varied geographical and population conditions (from the industrial suburb of Gardolo, just north of the city, to tiny mountain hamlets on Monte Bondone). Various distinctive suburbs still retain their traditional identity of rural or mountain villages. The overall population is 117.000 inhabitants, and it covers an area of 160 km^2.

3.2 Input data used for the prediction model

Flow traffic data for noise mapping activity were taken from the available data from a network of traffic counting devices spread throughout the territory of Trento Municipality.

The traffic flow counting stations collect data continuously and are mainly used for the traffic management. The *peripheral devices* (n. 59) have been located in strategical position in peripheral positions to catch informations on the traffic flows entering and exiting the urban center, while the *internal devices* (n. 33) have been placed in correspondence of traffic lights in order to have real time information on the congestion of the traffic inside the city.

The "peripheral devices " measure continuously (every minute) the traffic flows, collecting type and speed of passying-by vehicles, classifying them into 8 different classes. The internal devices are often located in the vicinity of roundabouts and traffic lights, and for these devices only a count of traffic flow is available, since the classes of vehicles and their speed is of little significance for traffic management inside the city center.

The noise mapping model was implemented using a whole year of traffic data (2013), averaging data on an hourly base differentiated for the three periods day- evening-night.

In order to have traffic flows for all major roads, it was decided to simulate missing data using a well-known technique based on the continuity of hydraulic flows to extend the value of the traffic flow on the entire road network, excluding only roads with negligible flows (<25 vehicles/h during daytime).

Where an extension of the simulation technique was considered not enough accurate, the data were completed with local survey and manual counts, with the cooperation of 15 people with a good knowledge of the territory. For the roads where the data came from an internal traffic devices it was necessary to estimate the percentage of heavy traffic starting from the percentage of the total flow measured with the external devices more significant for that area, i.e. a location of an access road.

Unfortunately, the classification of Trento system doesn't allow to have a precise idea of what "truck" means (it is not correlated to any precise parameter like the weight), so it was not possible to classify the heavy vehicles with scientific criteria.

Since it was not possible to have a speed data for all of the roads, it was decided to use the maximum speed allowed on each road.

After having collected the traffic information, it was necessary to convert the data coming from the traffic management system into the categories used by the guidelines (XPS 31-133 and CNOSSOS-EU Road).

Table 5 – Traffic flow data classification of Trento Municipality and equivalence with Noise Guidelines

Vehicles class	Description	XPS 31-133
1	Car	Light Vehicle
2	Car+Trailer	Light Vehicle
3	Bus	Heavy Vehicles
4	Truck 2 axles	Heavy Vehicles
5	Truck (2 axles) +Trailer	Heavy Vehicles
6	Multiple axles Truck	Heavy Vehicles
7	Van	Light Vehicle
8	Motorcycle	Light Vehicle

Terrain data were collected using regional available databases, that allowed a very detailed modeling of surface, with a detail of equal height contour lines up to 1 m. Building heights and population associated data was provided using the informations of Trento Municipality, in SHP format. A detailed activity was developed on IMMI software to model embankments and cuttings, bridges, existing noise barriers and tunnels.

3.3 Calibration of the model

The prediction model was calibrated carrying out a series of 24h noise measurements in 10 different sites. The results were processed and a comparison was done with the calculation results with the Interim guideline XPS 31-133. The deviations between measured and predicted results was in the range ± 3,0 dB for all of the calibration locations, with only one exception, that was justified for an error of speed input of the light vehicles.

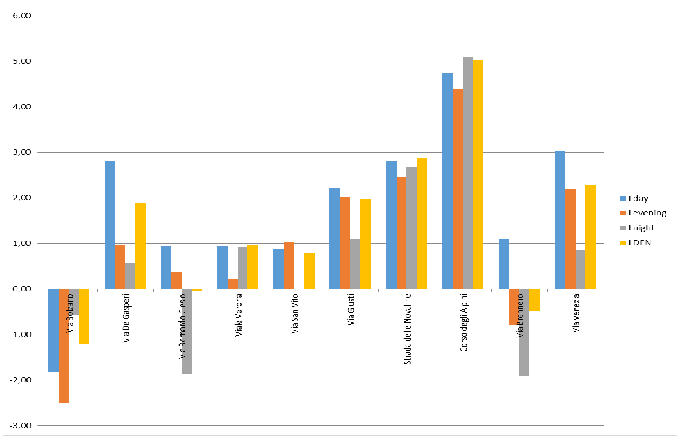

Figure 3 – Calibration of the predicting model

Table 5 – Calibration of the prediction model: measurements vs. XPS 31-133 results

Site	Lday	Levening	Lnight	LDEN
Via Bolzano	-1,82	-2,50	-0,58	-1,21
Viale Verona	0,94	0,23	0,92	0,97
Via San Vito	0,88	1,04	0,00	0,80
Strada delle Novaline	2,82	2,47	2,69	2,88

As can be seen from the above figures, there is a good agreement between measurements and prediction.

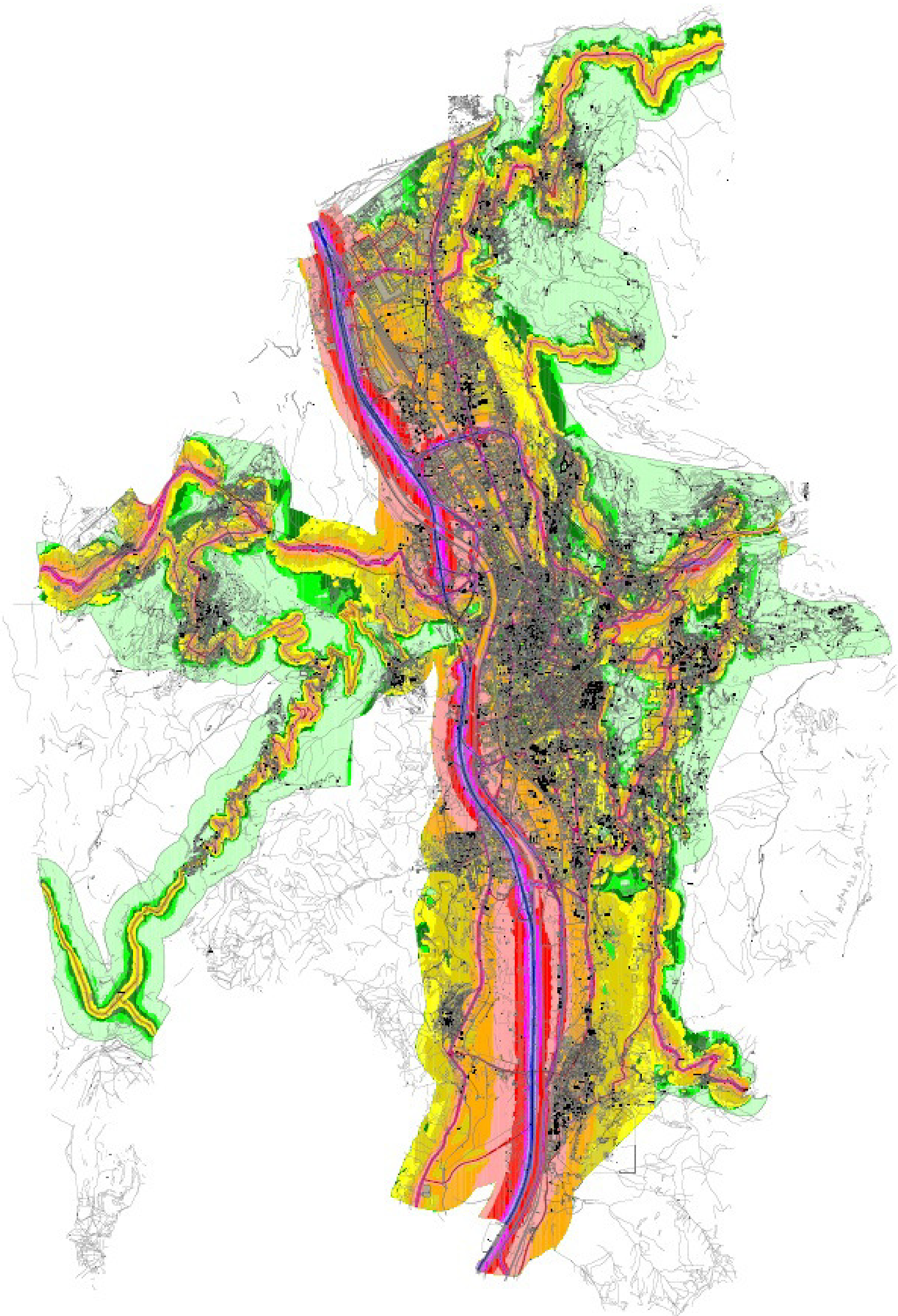

Figure 4 – Trento Noise Map (IMMI® 2016)

4. RESULTS OF THE COMPARISON CNOSSOS-EU Road vs XPS 31-133

It was decided to compare the results given by two guidelines in four different locations shown in Figure 5. The chosen locations were also used for the calibration of the model, thus for these locations we have real data measurements (limited to 24 hours) as well.

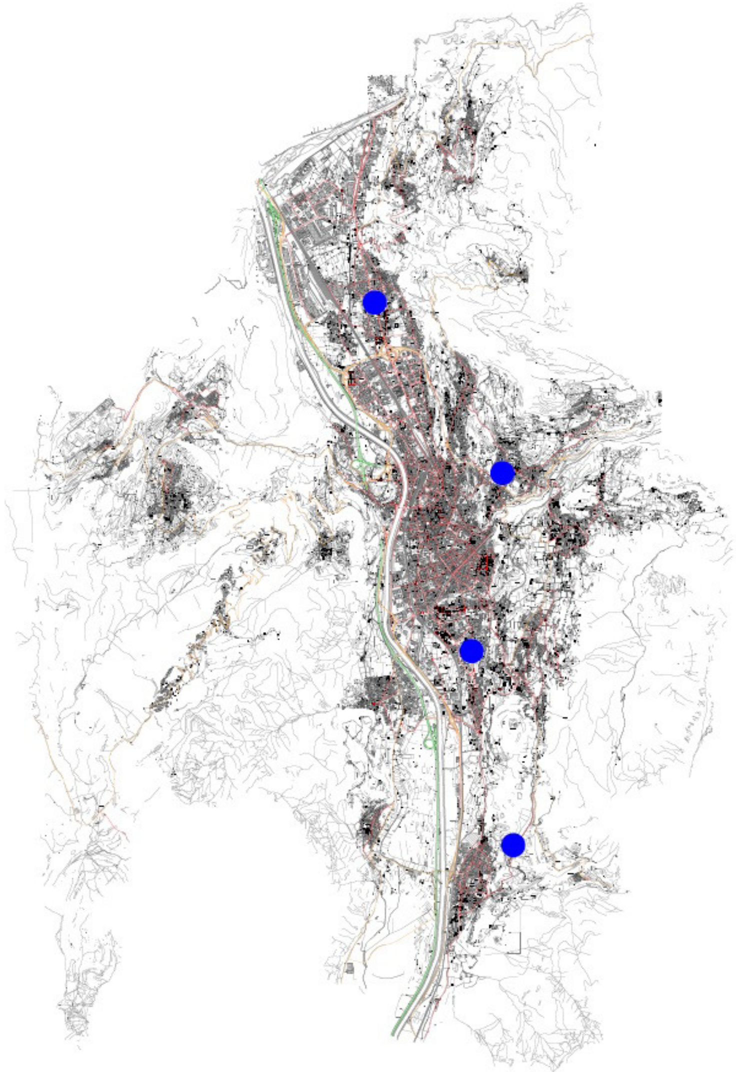

Figure 5 – Locations chosen for the comparison XPS 31-133 vs. CNOSSOS-EU Road

In order to convert data for CNOSSOS calculation the following equivalence was applied:

Table 5 – Traffic flow data classification of Trento Municipality and equivalence with Noise Guidelines

Vehicles class	Description	XPS 31-133	CNOSSOS-EU Road
1	Car, Car+Trailer, Van	Light Vehicle	50% Light Vehicles
2	Bus, Truck 2 axles, Truck (2 axles) +Trailer, Multiple axles Truck	Light Vehicle	50% Heavy vehicles
8	Motorcycle	Light Vehicle	Motorcycles as given by flow traffic data

For road surface it was decided to assign smooth asphalt for XPS 31-133 and NL05 for CNOSSOS-EU Road.

Table 6 – Deviation of results between measured values and XPS 31-133 guideline

Site	Description	Lday	Levening	Lnight	LDEN
Via Bolzano	Major road, 2 carriages, 2 lanes each	-1,2	-0,4	-1,2	-0,5
Viale Verona	Main urban road, 2 lanes, 2 directions	1,6	0,9	1,6	1,1
Via San Vito	Urban road, 2 lanes, 2 directions	1,4	1	1,4	0,7
Strada delle Novaline	Extraurban road	1,9	1,7	1,9	1,2

Table 7 – Deviation of results between measured values and CNOSSOS-EU Road guideline

Site	Description	Lday	Levening	Lnight	LDEN
Via Bolzano	Major road, 2 carriages, 2 lanes each	-2,5	-3,1	-2,2	-2,6
Viale Verona	Main urban road, 2 lanes, 2 directions	-2,9	-3,2	-3	-3
Via San Vito	Urban road, 2 lanes, 2 directions	-4,1	-3,9	-5	-4,4
Strada delle Novaline	Extraurban road	-1,8	-2	-3,4	-2,3

The guidelines give, as expected, different results: XPS 31-133 tipically overestimates, with a deviation of maximum +2 dB (Lden) over the four locations, whereas CNOSSOS-EU Road understimates, with a maximum of – 5 dB (Lden).

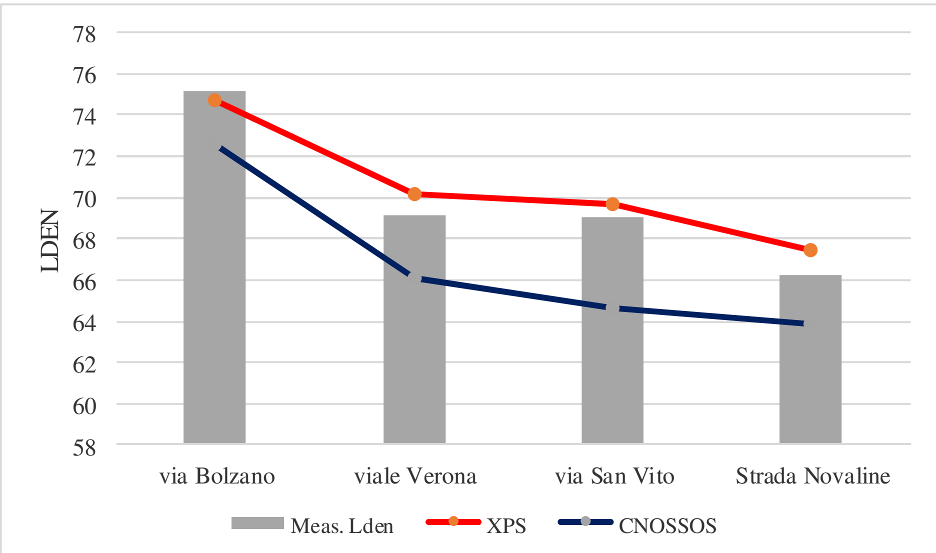

Figure 6 – Comparison of results given by XPS 31-133 and CNOSSOS_EU Road for n.4 test locations

If we compare the predicted results of XPS 31-133 and CNOSSOS-EU Road, it is clear that we should expect a remarkable difference for the absolute difference, in the range 1 – 5 dB, as shown in Table 8.. If the predicted results provided by CNOSSOS-EU in the four test locations used for the guidelines comparison should give the same results applied to the whole Trento map, it is clear that we should expect to find maps with a relevant reduction of noise levels, in the range 1-5 dB, and consequently we would have a significant reduction in the number of people exposed to noise.

Table 8 – Deviation of results between XPS 31-133 and CNOSSOS-EU Road guideline

Site	Description	Lday	Levening	Lnight	LDEN
Via Bolzano	Major road, 2 carriages, 2 lanes each	1,3	2,7	2,7	2,1
Viale Verona	Main urban road, 2 lanes, 2 directions	4,5	4,1	3,2	4,1
Via San Vito	Urban road, 2 lanes, 2 directions	5,5	4,9	4,6	5,1
Strada delle Novaline	Extraurban road	3,7	3,7	3,2	3,5

Trento has a total population of 116.000 inhabitants, and the predicted figures show that a 10% of the population is exposed to Lden levels in the range 65-67 dBA. If we could now extend CNOSSOS-EU results to the whole results of the noise map, it would result that the most exposed people would be no more exposed to such levels, with a consequent change in the action planning to fight noise.

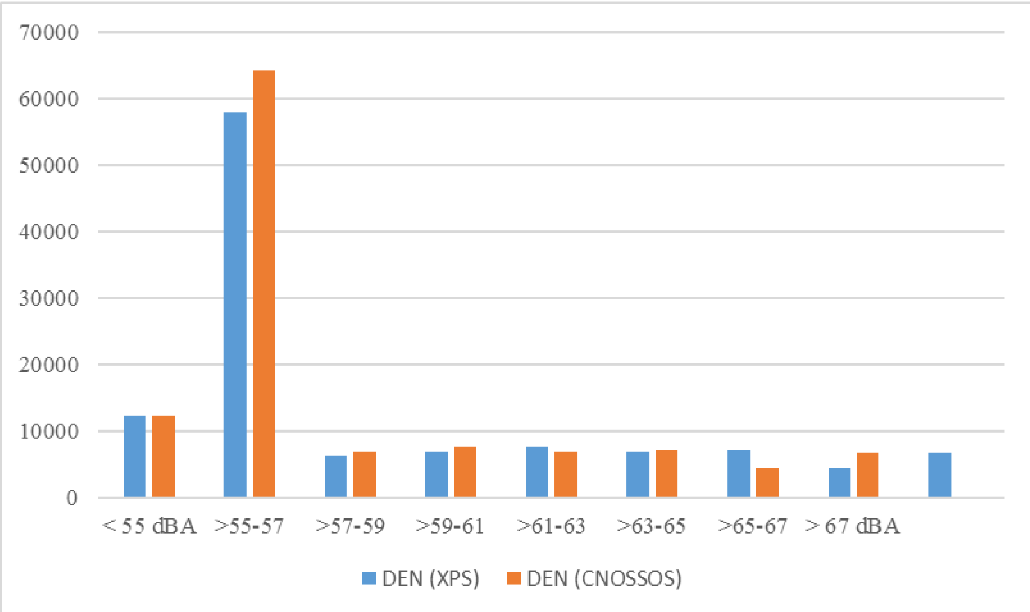

Figure 7 – Comparison of noise exposure of population figures (Lden) applying different noise calculation guideline to Trento agglomeration

5. CONCLUSIONS

This paper presented the noise mapping of the city of Trento, performed by using the Interim Methods recommended by EU in Directive 2002/49 and its amendments, namely XPS 31-133 guideline for road noise. The predicting model was calibrated through a series of in-situ measurements, and there was a good agreement between measurement results and predicted levels.

In view of the application of the new European model CNOSSOS-EU, it was decided to compare the results of the map, in some significant test points, with the predicted values obtained with the new European model. The comparison results showed that significant deviations in the range of -1 to -5dB are possible. If these results should be confirmed, a significant reduction of the number of people exposed to noise might derive from the application of the upcoming CNOSSOS-EU Road guideline.

REFERENCES

1. Kephalopoulos S. et al. Common Noise Assessment Methods in Europe (CNOSSOS - EU) EUR 25379 EN. Luxembourg: Publications Office of the European Union, 2012, 180 pp.
2. Kephalopoulos S. et al 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, ELSEVIER, vol 282-283, June 2014
3. Adaptation and revision of the interim noise computation methods for the purpose of strategic noise mapping - Final Report Part A Reference: B4-3040/2001/329750/MAR/C1- Commissioned by: EUROPEAN COMMISSION DG Environment
4. Shilton S, , Anfosso Ledée F. Conversion of existing road source data to use CNOSSOS-EU Proc. EURONOISE 2015, Maastricht 2015.