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# END NOISE MAPPING 4th PHASE IN ITALY: EXPERIENCES AND DIFFICULTIES

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## ABSTRACT

The work presents the fourth edition of the elaboration of the Acoustic Mappings of the main road axes of municipal competence with vehicular transits exceeding 3 million vehicles per year with the modifications due to the introduction of the new noise determination method CNOSSOS - EU, mandatory from 31.12.2018 in a uniform manner for all processing, and the updating of the guidelines of the Ministry of Ecological Transition (March 2022) relating to the preparation and delivery of digital documentation and metadata of Acoustic Mappings and Strategic Acoustic Mappings (Legislative Decree 194/05).
The IMMI software, updated according to the latest innovations introduced by directives 2020/367 and 2021/1226, has made it possible to adapt the results of exposure to noise of the population to European requests.
Problems relating to model setting data will also be addressed, such as pavement, traffic, building and population data which, if not homogeneously received by the managers, could alter the uniformity of the results.
The authors analyzed the impact of the new regulations on a large number of real cases (over 15 acoustic mappings of municipally managed road noise sources and an agglomeration).

**Keywords:** *Acoustic Mapping, CNOSSOS-EU, IMMI, road noise*

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## 1. INTRODUCTION

The European Directive 2002/49/CE, implemented by the Italian State with Legislative Decree 194/2005, established to provide from 2007 and every 5 years an acoustic characterization of the national territory through the elaboration of acoustic maps and strategic acoustic maps leading to the development of coordinated action plans. The aim is to mitigate environmental noise following common criteria among the member states. [1, 2]
European Directive 2015/996 introduces the requirement for the use of the new CNOSSOS-EU calculation method starting from December 31, 2018. [3]
The news involving the fourth edition of Acoustic Mappings also regards the mechanism of digital information exchange. For this reason, Guidelines for the generation and submission of digital data were published by the Ministry of Ecological Transition in March 2022, in alignment with the guidelines released by the European Environmental Agency. [4]
Repetition of the Acoustic Mappings every 5 years facilitates the continuous updating of the characterization of the territory. This means disponing of up-to-date input data crucial for obtaining representative results.
The aim of this study is a comprehensive analysis of the Acoustic Mappings development process, pointing out the innovation required for the fourth edition (2022-2023), as well as the main difficulties and critical issues identified studying many real cases. The focus of this analysis is on road noise that not exclude changes also for other type of noise source (railway, industry, aircraft noise).

First, CNOSSOS calculation method is detailed according to the latest EU Directives.
An insight in the innovation in digital data generation and transmission to the European Commission follows.

The focus than shifts towards real applications, that involve definition of input data and modelling and parameter definition using an appropriate calculation model.

The input data are critically analyzed since they influence the quality and reliability of the results.
The final stage of the study deals with the main difficulties emerged.

## 2. CNOSSOS -EU

The CNOSSOS-EU calculation method, introduced by Directive 2015/996 and become mandatory for Acoustic Mappings, underwent substantial changes with Directives 2020/367 and 2021/1226 that improved the accuracy of noise prediction.
Directive 2020/367 replaces Annex III of the END Directive defining the methods for the determination of health effects of noise.
Directive 2021/1226 modifies Annex II of the END since technical and scientific progress required adaptation of the methods of determination. Clarifications of the formulas used to calculate the noise propagation, update of the tables to the latest knowledge and improvements of the description of the calculation steps are the main adaptations implemented.
Focusing on the modelling of road traffic and its effect on noise emissions, the directives introduce the traffic correction that accounts the subdivisions in specific vehicle classes, speed, and flow. Additionally, the directives propose a more detailed model considering the effect of road surface on noise emission. These parameters lids to a more realistic representation of traffic noise. [3, 5, 6]

The reference for CNOSSOS-EU road noise is directive 2015/996, more in detail:
**Chapter 2.1: General disposition**
**Chapter 2.2: Road noise**
Here is the description of the noise source with the classification of vehicles in 5 classes associated to different characteristic of noise emission. The road is represented by a linear sound source with sound power per meter in frequency. The equations for the calculation of emission are reported in this chapter.
Different contributions are considered such as: rolling noise, propulsion noise, acceleration/deceleration near intersections, type of road surface.
**Chapter 2.5: Calculation of propagation**
**Chapter 2.8: Association of noise levels and population in buildings**
The directive also guides in defining the number of habitants per building in different scenario of detail of data available. Moreover, specific indication on the position of receiver point on building façade and the statistic of exposition of people to different noise level are presented.
This topic is now improved by directive 2121/1226. [3, 6]

## 3. GUIDELINES OF THE MINISTRY OF ECOLOGICAL TRANSITION

Regulation (EU) 2019/1010 of the European Parliament and of the Council of 5 June 2019 establishes that digital datasets must be produced in compliance with the provisions of Directive 2007/2/EC (INSPIRE) and transmitted to the European Commission, for via MiTE, through the mandatory digital information exchange mechanism called Reportnet 3.0. Reportnet 3.0 is the new generation platform for reporting environmental data to the Agency and allows to fulfill the many communication tasks with the European Commission. [4]
The Guidelines “Specifiche tecniche per la predisposizione e la consegna dei set di dati digitali relativi alle mappature acustiche e alle mappe acustiche strategiche (D.Lgs. 194/2005)” by the Ministry of Ecological Transition are the reference document in Italy for the preparation and transmission of digital data sets in a harmonized way to the other member state. The release of March 2022 introduces new data models which meet both END and INSPIRE requirement.
The full data model covers all END reporting obligations used as a basis for defining individual data model packages, interconnected to allow the combination of data from different data streams. The data models of interest in the frame of Acoustic Mappings are those related to notification of sound sources (DF1_5) and to Acoustic Mappings and Strategic Acoustic Mappings (DF4_8). [4]

### 3.1 Spatial data

One of the most evident changes compared to the 2017 edition is the requirement to compile data sets in GeoPackage GIS format with specific characteristic.
GeoPackage is a file format that permits to store, access, and share geospatial data. It can contain several tables and geospatial layers. This enables to gather all the information in one single data set.
Model DF1_5 is related to the road sources to be notified. Information about road position, traffic, length is here specified.

Every single major road axis is identified by a unique road identifier. This code, even though maintaining the same END unique code, underwent a revision.
Models DF4_8 represent acoustic mappings. Polygonal and linear geometries are contained in two different GeoPackage with the same structure.
Each GeoPackage contains the geometries of the isophone calculated for Lden and Lnight, tabular information about calculation methods, type and code of the local administrative unite involved, references, as well as exposure value in terms of people, dwelling and surfaces exposed to different noise levels.
Another innovation compared to the previous editions consists of returning the number of people and dwellings in unit instead of round up to hundred. [4]

Each data set must be transmitted with the relative metadata. The importance of metadata is emphasized by the new guidelines since they provide essential information related to data propriety, accessibility, identification, genealogy, quality, and usability. The guidelines give instruction for compilation of metadata according to the update INSPIRE and RNDT technical guide.
For each manager an IPA identification code is defined to be used as a prefix in the composition of the unique identifiers of the metadata. [7]

Thus, the Technical Specification released by the Ministry of Ecological Transition in March 2022 provides standardized procedures for digital data generation aimed to ensuring homogeneity in data delivery.

## 4. CASE STUDIES

The present study is support by 15 acoustic mappings of municipally managed road noise sources and an agglomeration redacted from March to October 2022.
The main road axes mapped are situated in Lombardia.
The prosses of mapping development can be summarize in the following steps:

- data retrieval: traffic, population, geo-topography;
- data validation and arrangement to the required parameters;
- phonometric survey;
- model implementation and calibration;
- grid and façade calculation;
- generation of digital data according to reference guidelines.

### 4.1 Input data

*4.1.1 Traffic*

Traffic data are provided by the roads managers.
In most cases traffic analysis is derived by urban planning tools, such as PUMS, PUT, PGTU.
In four cases traffic data belongs to specialistic studies on a local scale or monitoring survey in previous years.
Just in one case the traffic data are obtained from specific surveys for acoustic mapping.
Regardless data source, the available data format often requires approximations or esteem to refer data to the parameters required by CNOSSOS. See Fig. 1 for the percentage of study cases with data referred to vehicles category related at least to 3 of the CNOSSOS categories. Refers to Fig. 2 for percentage of cases with data format that permits to evaluate the traffic in the time period required (day, evening, night).
In the other cases the vehicles classes are reduced to light and heavy vehicles and the traffic flow is referred to rush hour or average daily traffic.

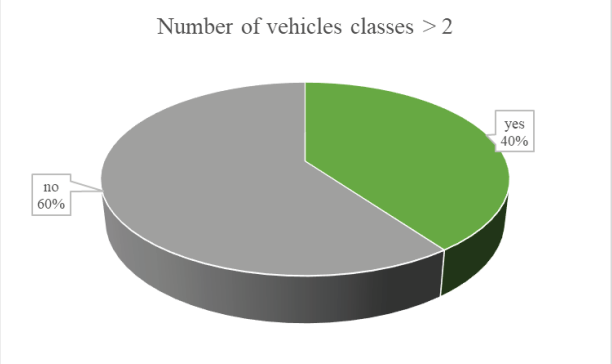


**Figure 1.** Percentage of study cases with data available for a number of vehicle classes > 2

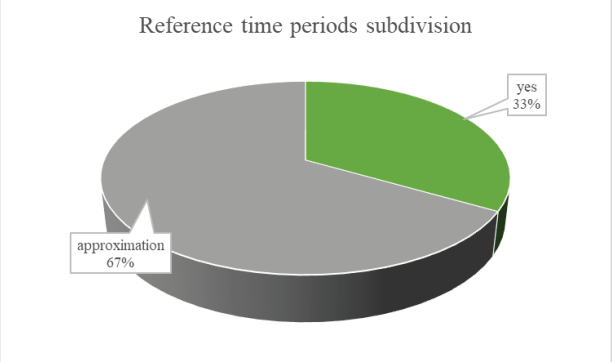

**Figure 2.** Percentage of study cases with availability of data suitable to characterize reference time periods (day, evening, night)

*4.1.2 Population*

Availability of up-to-date population data are verified with the competent registry office. If accessible, data are given in form of number of resident people per civic number on the road under investigation. In such a case than that tabular values have to be linked with building but not always is easy to find a georeferenced connection. See Fig. 3 for percentage of study cases with municipal population data available.
In any way, it is often necessary to elaborate ISTAT census data to estimate the number of people per building. ISTAT data ensure a wide and homogeneous distribution of population data.
Since the last census is dated 2011, the data obtained is increased on the basis of the present total resident population at municipal level to rescale values to an up-to-date scenario. Municipal population data, if available, are used to verify the estimated values.

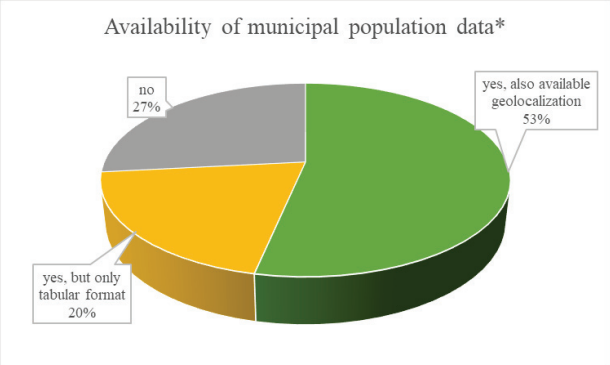


**Figure 3.** Percentage of study cases with data at local scale available (*data referred to buildings with access situated on the roads under investigation).

*4.1.3 Geo-topography data*

Contour lines and volumetric units of buildings are extracted from geo-topographical database (Geoportale Regione Lombardia, update 2021). These georeferenced vector layers contain elevation values necessary to the assessment of terrain altimetry and building heights. Also, information about buildings use is matched through processing in a GIS environment.

### 4.2 Calculation software

IMMI is a software widely adopted for modeling environmental noise. The latest update of IMMI implements the CNOSSOS-EU calculation method as defined by directive 2015/996 as well as the improvement introduced by directives 2020/367 and 2021/1226.
Regarding Acoustic Mappings IMMI provides a complete modeling workspace allowing users to profit of the full potential of the CNOSSOS-EU calculation method. [8]

IMMI allows to import detailed road traffic data, that includes traffic flow and vehicle speeds entered for the 5 CNOSSOS category of vehicles. The road is further more characterized by the type of surface, associated to the database of specific coefficients. This data are used to calculate road noise levels based on the CNOSSOS-EU method.

In addition to handling input data and performing noise calculations, IMMI also offers tools for analyzing the results.
The calculation can be performed by grid calculation and façade calculation.
Grid statistics facilitates the calculation of area in $km^2$ in each range of sound levels.
Moreover, since every building can be characterized by building use and number of inhabitants, this permits to immediately elaborate the statistics of exposure population required by the directives previously mentioned from the results of façade calculation.

### 4.3 Results analysis

The different unit of representation between the fourth edition and the previous acoustic mappings leads to an approximate comparison.
Also, statistics for the determination of exposure value as defined by the directive 2021/226 conduces to differences from the results compared to past.
However, results obtained with CNOSSOS method show a general reduction and redistribution of exposed people in the sound level ranges. People exposed to high levels are usually lower than in the previous report.

## 5. CRITICAL ISSUES ENCOUNTERED IN THE FOURTH EDITION OF ACOUSTIC MAPPINGS

The main challenge in the acoustic mapping development process is linked to input data quality and reliability.

Primarily road traffic data, base for the definition of road noise emission.
Almost in every study case the analysis of traffic data revealed difficulties related to partition in CNOSSOS vehicle classes and/or to definition of traffic flow in the reference time periods. Consequently, esteem and approximation have to been made.
Still in relation to traffic data, in many cases the model input data are the same used in the previous mappings in 2017. In the worst cases data are even more obsolete, dated before 2010.

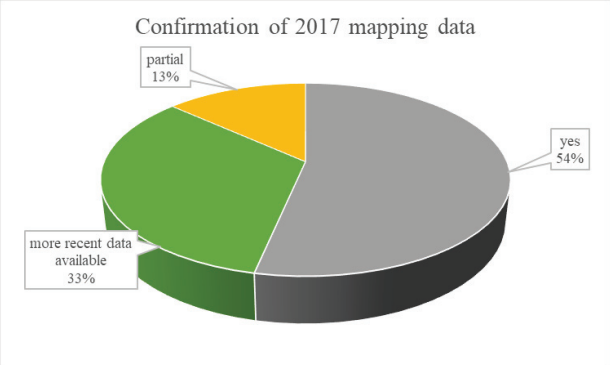


**Figure 4.** Percentage of study cases with updating of data with respect to the previous mapping

Regarding population, ISTAT data from 2011 census are widely used in the studies since they provide a full and homogeneous spatial coverage. Though the data are rescaled to current scenario by proportion to present total population, the urban transformation during the years could have change population distribution. This can lead to inaccuracy in the redaction of Action Plans that follow Acoustic Mappings.

Last but not least, the emission of the new guidelines near the schedule delivery data at the end of March brought revolution in digital data structure and composition not easy to implement in short time.

## 6. CONCLUSIONS

CNOSSOS-EU calculation method provides a robust and reliable framework for the control and mitigation of environmental noise. In addition, the repetition of the mapping and action plan process every 5 years enable to keep noise management constantly updated.

Nevertheless, another key aspect for achieving representative results of the actual situation is the input data, first of all traffic data and population.
The study points out a general inappropriate definition of traffic data. In the future, efforts must be made by the administrations to collect data at an adequate level of detail.

Hopefully for the next cycle of Acoustic Mappings procedures will be consolidated and effort will be made by administrations to ensure reliable data representative of the real scenario.

## 7. REFERENCES

[1] European Union (2003). Directive 2002/49/EC relating to the assessment and management of environmental noise.

[2] D.Lgs. 194/2005. Implementation of Directive 2002/49/EC relating to the assessment and management of environmental noise.

[3] European Union (2015). Directive 2015/996 establishing common noise assessment methods according to Directive 2002/49/EC.

[4] Ministry of Ecological Transition (2022). Technical specifications for the preparation and delivery of digital data sets relating to acoustic mapping and strategic acoustic maps (Legislative Decree 194/2005).

[5] European Union (2020). Directive 2020/367 amending Annex III to Directive 2002/49/EC of the European Parliament and of the Council as regards the establishment of assessment methods for harmful effects of environmental noise.

[6] European Union (2020). Directive 2021/1226 amending, for the purposes of adapting to scientific and technical progress, Annex II to Directive 2002/49/EC of the European Parliament and of the Council as regards common noise assessment methods.

[7] Ministry of Ecological Transition (2022). Technical specifications for the compilation of metadata relating to digital datasets relating to acoustic mapping and strategic acoustic mapping (Legislative Decree 194/2005).

[8] IMMI software. https://www.immi.eu/