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DESIGN OF ACTION PLANS AGAINST NOISE IN NAVARRE, SPAIN

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ABSTRACT

Strategic noise maps bring us information on noise pollution in our towns. Acoustic zonification defines types of acoustic areas in which the territory is divided according to the corresponding objectives of acoustic quality. By crossing both shapes acoustic-conflict areas can be pointed out. These areas are known as Areas with Special Acoustic Protection. In most towns or agglomerations, the number of such areas is very high or, alternatively, they cover large areas. Given that financial resources to eliminate conflict areas are limited, it is necessary to give priority to the adoption of measures to reduce acoustic pollution. Besides the basic criterion of maximize number of people benefited by measures to implement, feasibility and effectiveness criteria should be taken into account. Therefore, some methodology to give priority to possible action plans is required. In the present paper the process carried out in the case of the actions plans against noise designed in the Autonomous Community of Navarre will be presented.

RESUMEN

Los mapas estratégicos de ruido nos ofrecen información sobre la contaminación acústica en nuestras ciudades. La zonificación acústica define los tipos de áreas acústicas en las que se divide el territorio, de acuerdo con los correspondientes objetivos de calidad acústica. Las zonas de incompatibilidad (Zonas con Protección Acústica Especial, ZPAEs) aparecen al cruzar ambos shapes. En la mayoría de las aglomeraciones el número el número de tales áreas es elevado o, alternativamente, cubren grandes espacios. Dados los limitados recursos disponibles para eliminar tales incompatibilidades, es necesario priorizar las zonas de incompatibilidad en la adopción de medidas. Además del criterio básico de maximizar el número de personas beneficiadas por las medidas, criterios de viabilidad y eficacia deben tenerse en cuenta. Por tanto, se requiere alguna metodología de priorización en los planes de acción. En el presente estudio se presenta el proceso seguido en los planes de acción diseñados en la Comunidad Autónoma de Navarra.

1. INTRODUCTION

According to Directive 2002/49/EC [1], Member States had to develop action plans to manage (within their territories) noise impacts and their effects, including noise reduction, if necessary, with respect to: a) areas near major roads which have more than six million vehicles a year, major railways which have more than 60 000 train passages per year and major airports, and b) agglomerations with more than 250 000 inhabitants. Such plans shall also aim to protect quiet areas against any increase of noise. The specific steps of action plans shall be at the discretion of the responsible authorities, but will face in particular the priorities that can be determined as a result of exceeding certain threshold values or by other criteria chosen by the Member States and should be applied in particular to the most impacted areas established in accordance with the corresponding strategic noise maps.

The Law 37/2003 [2] transposed the European Directive into Spanish law, in order to preventing, monitoring and reducing noise pollution. In its article 7 delegates to the Autonomous Communities the classification of acoustic areas, although they have to plan at least the followings: a) Residential areas, b) Industrial areas, c) Recreational and entertainment areas, d) Tertiary areas, e) Health, educational and cultural areas requiring special protection against noise, f) Sectors of the territory concerned to general systems of transport infrastructures, and g) Natural areas requiring special protection against noise pollution. Subsequently, the RD 1367/2007 [3] developed the Law 37/2003. In this Royal Decree criteria are adopted for the delimitation of the different types of acoustic areas. However, the most important aspects of RD 1367/2007 are those relating to the determination of the acoustic quality objectives applicable to acoustic areas (both for outdoor and indoor places) as well as the methods and processes for the evaluation of acoustic indices.

2. STRATEGIC NOISE MAPS OF NAVARRE, SPAIN

Six strategic noise maps were conducted for major roads, with a total of-approximately, 120 km and a strategic noise map for the Agglomeration of Pamplona, with an area of 127.41 km^2 and a population of 280,199 inhabitants [4]. Figure 1 shows the location of the strategic noise maps carried out.

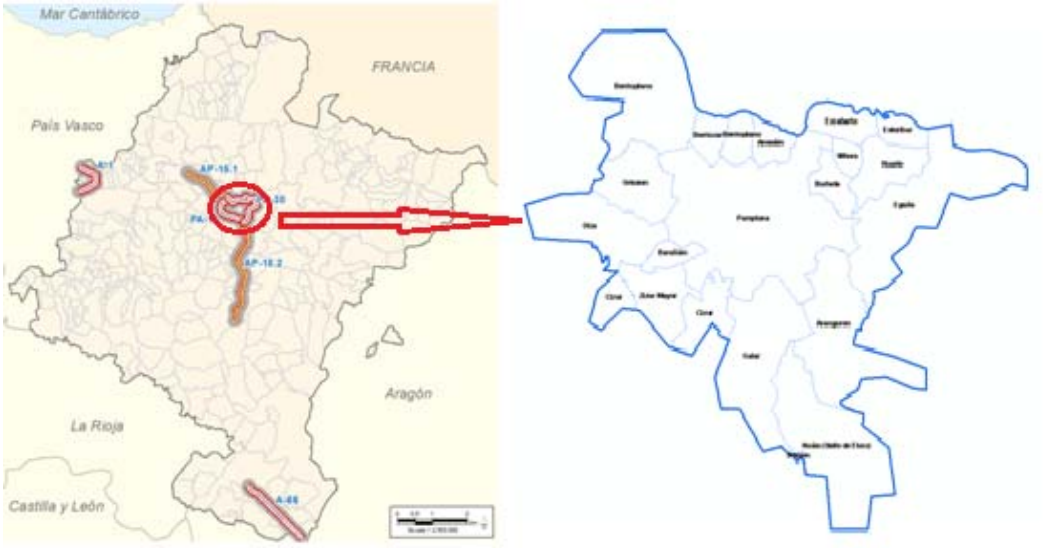

Fig 1. Location of strategic noise maps of major roads and the Agglomeration of Pamplona in Navarre, Spain.

With respect to the affected population, the results showed that seven hundreds of people are exposed to levels above 65 dBA for the index Ld and 31 hundreds of people are exposed to levels above 55 dBA for the index Ln, with respect to the six strategic noise maps of major roads. In the Agglomeration of Pamplona, such values are, respectively, 259 and 364, also in hundreds. The cause of such levels is due (in a percentage above 99%) to road traffic.

3. ACOUSTIC CLASSIFICATION AND INCOMPATIBILITY AREAS

By working together with each and every one of the local governments, the acoustic classification of the territory was carried out. In addition to the minimum acoustic classification prescribed by the Law 37/2003, rustic areas were added. Acoustics zonification was carried out in the area bounded by the acoustical servitude zones of the major roads as well as the agglomeration of Pamplona. For all Navarre next areas were classified (Table 1):

Table 1. Classified areas by uses

Acoustic class	Classified area (has.)
Healthy-Educational-Cultural (SDC)	524
Residential (RES)	3.176
Recreational and entertainment (REC)	348
Tertiary(TER)	742
Industrial (IND)	1.929
Infrastructures (INF)	1.027
TOTAL	**7.746**

Placing the shape of the noise maps on top the shape of the acoustic zonification, conflict areas were pointed up, i.e., areas where the acoustic quality objectives set out in Annex 2 of RD 1367/2007 are exceeded. Incompatibility zones were determined by either the overcoming of the Ld index or the Ln index. The Le index was not explicitly considered because it has the same objectives than the Ld index and its time length is much less representative than the Ld. From the remaining conflict areas, only those considered to be representative, i.e., affecting a surface area equal to or greater than 50 m^2 were selected. Finally, only areas exceeding at least 2 dB the quality acoustic objectives were considered. Besides the affected area and the amount of dB in which the acoustic quality objectives are exceeded, conflict areas include the affected population, data available from the cadastre. This will help when making ranking or prioritization of the conflict areas. Figure 2 shows an example of incompatibility areas.

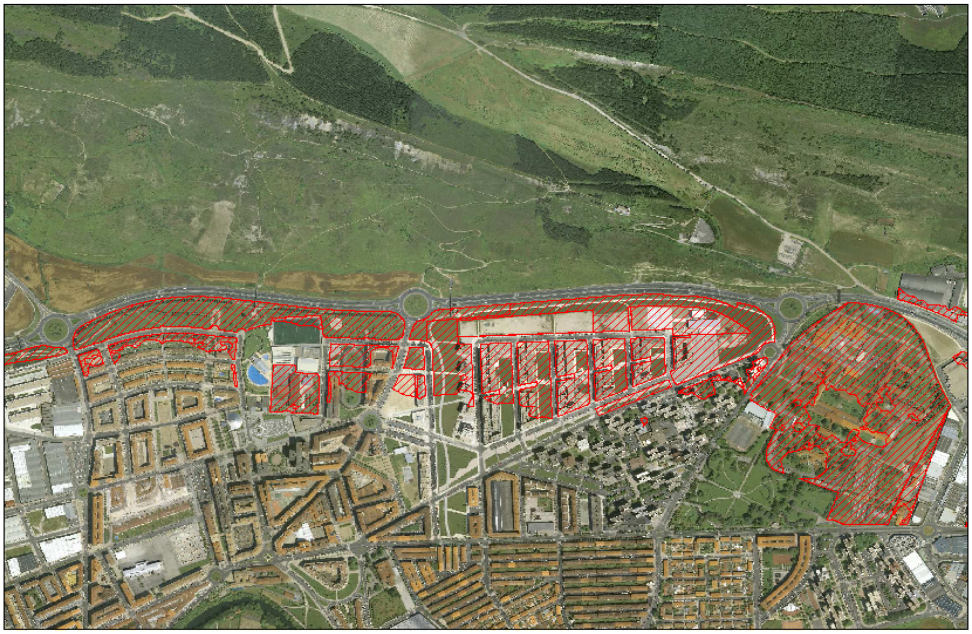

Fig. 2. Example of conflict areas (major roads)

As final result of the crossing of shapes, a total of 1,532 incompatibility areas were found, distributed as it is shown in Table 2.

Table 2. Conflict areas in the strategic noise maps of Navarre, Spain

Acoustic class	**Number**	**Area (m^2)**
Healthy-Educational-Cultural (SDC)	222	1,876,951
Residential (RES)	1,163	3,794,215
Recreational and entertainment (REC)	8	48,501
Tertiary(TER)	46	159,018
Industrial (IND)	93	357,772
TOTAL	1,532	6,236,457

To summarize (and based on Ln index) the study highlighted that the total area affected by incompatibilities in the full scope of strategic noise maps in Navarre is 624 has, i.e., an 8% of the total classified area. Also, in the Agglomeration of Pamplona, the number of people living in conflict areas is 36,384, which represents a 13% of the population included in the urban agglomeration.

4. PRIORITIZATION CRITERIA FOR THE DESIGN OF ACTION PLANS

Incompatibility areas detected in both the Agglomeration of Pamplona and in the major roads were prioritized using a criterion based, on the one hand, in the amount of affection, and, on the other hand, in the technical feasibility and effectiveness of corrective measurements. The harmonization of plans can lead to important savings in terms of costs for design and realization of designed solutions [5].

4.1 Major roads

In order to prioritize incompatibility areas three parameters were introduced:

.- *Incidence*. That is a function of both the number of people affected and the amount of the exceeded level.

.- *Feasibility/effectiveness*. Depending both on the complexity of the performance and on the reduction produced by the mitigation action.

- *Priority*. Based on the above two parameters is assessed as “high”, “medium” or “low” and will serve as final indicator of the classification.

In the case of acoustic areas classified as RES, the value assigned to the parameter *incidence* was evaluated by calculating the product of the number of people affected by the amount of exceeded level with regard to the quality objective. Depending on the value of this parameter incidences were classified as "low" (value of the parameter between 0 and 25), "medium" (value of the parameter between 25 and 100) and "high" (value of the parameter greater than 100). Furthermore, incidence was classified as "high" for all the acoustic areas classified as SDC where the quality objective was exceeded. The remaining acoustic areas (RET, REC and IND) were considered with affection "low".

With regard to the parameter *feasibility/effectiveness,* were classified as "high" those situations where it is easy to place a barrier and the result is highly effective. Those where there are elements that complicate the placement of a barrier or topographic configuration reduces the effectiveness of it, were rated as "average". Finally, were classified as "low" those situations where either it is very difficult to place a barrier or its implementation would be very inefficient. The final criterion adopted to assess the priority of the conflict areas was as follows: only those areas with incidence "high" and *feasibility/effectiveness* “high" were classified as "high" priority for action plans. The remainders-according to the two criteria discussed above, were classified as "medium" or "low" priority. As final result seven areas of incompatibility with "high" priority were found, being four of them of SDC class and three of RES class, affecting-in the last case, to a total of 1,013 people. For all of them, specific action plans were designed, consisting in installation of sound barriers eliminating the incompatibility.

4.2 ACP

In the same way was proceeded for the ACP. Priority was classified as "high" for all the great SDC acoustic areas: hospitals and universities. In order to prioritize the RES areas, the criterion was to define an incidence index calculated by adding (for grids of 100 x 100 m) the number of people affected by the amount-in dB, in which the sound quality objective was exceeded. Depending on the value of this parameter, incidences were classified as "low" (value of the parameter between 1 and 100), "medium" (value of the parameter between 100 and 400) and "high" (value of the parameter greater than 400). Figure 3 shows the results obtained for the central area of the ACP.

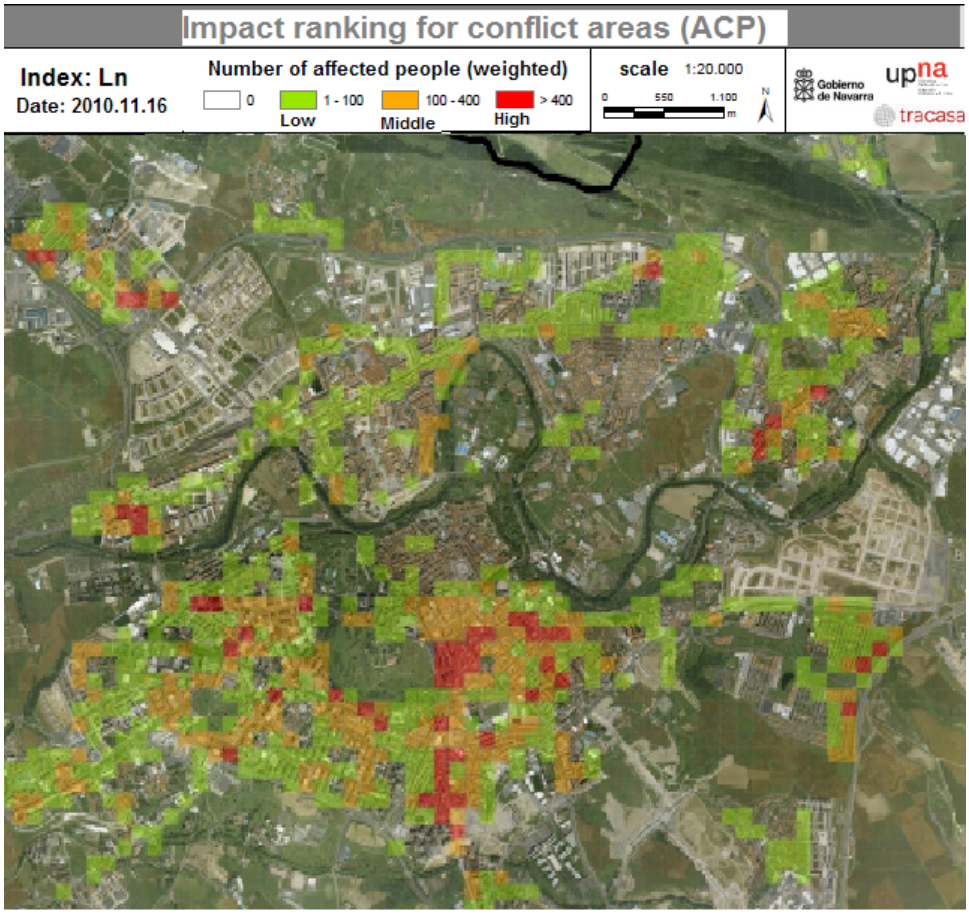

Fig.3 Grid of impact ranking (ACP)

Areas with the highest percentage of affected population (red and orange in figure 3) are located along roads with heavy traffic and *reverberant* urban configuration, with buildings on both sides of the road. These areas have to be of high priority for the development of action plans, although they are main and essential roads (at now) for mobility.

The action plans developed for conflict areas within agglomerations present much more difficulties than those required for major roads. Usually, they are consolidated urban frame, with high population density and several roads/streets with high traffic density. The two main tools in these cases for reducing the noise are a) to pedestrianize and b) To state "Area 30", giving priority to public transport (electric or hybrid if possible) in front of private transport. Both involve to present alternatives for the existing mobility, issues hard to reconcile. The action plans designed for the ACP were based in such aspects.

Several actions against noise had been carried out in the ACP along the last twenty years as a result of the first acoustic map carried out in Pamplona, in 1989 [6]. In the mid nineties it came into operation bypasses in Pamplona, avoiding the transit of heavy vehicles through the city. Also the rearrangement of traffic (one-way streets, removing of traffic lights, construction of traffic circles, etc.) reduced the noise pollution. Subsequently, a large part of the old city was converted in pedestrian area. Today, a total of 712,560 m^2 are pedestrian areas. The installation of five public elevators (overcoming different elevations) link neighborhoods and makes easier pedestrian mobility. All these steps, together with the statement of "Area 20" (in the old town) and "Area 30" (in the first and second urban expansions of the city), have resulted in a considerable reduction of the noise pollution in the city. Specifically, a 41% (in energetic terms)

by comparing the results of acoustic maps carried out in Pamplona in 1989 and 2009 [7]. In contrast, the acoustic pollution in the surrounding areas-where bypasses run, had a noticeable increase.

CONCLUSIONS

Action plans are important tools to reduce noise in our agglomerations. By crossing the land acoustic classification with the noise maps, incompatibility areas are detected. Given the large number of incompatibilities as well as the limited financial resources, some criteria to prioritize conflict areas are needed. The criteria used in the design of action plans against noise in Navarre have been shown in this study. They have been based in the prioritization of the most sensitive areas (S/D/C) and the parameter obtained by multiplying the number of people affected by the amount of the increase of the acoustic quality objective, in the case of residential (RES) areas.

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