Traffic Noise influence on Road Network Planning in Portugal

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Abstract

This paper analyses the Portuguese planning system (land use management and road network) development along with population's environmental awareness evolution, especially regarding traffic noise. Until 2000, the ineffectiveness of noise legislation and demographic movements towards the coastline, in conjunction with European funding, created adequate conditions to the enlargement of the Portuguese road network. In 2000 and 2007, were approved the second and third Noise Codes, enforcing municipalities and infrastructure's Authorities to take appropriate measures to reduce noise levels wherever they exceed legal limits; create noise zoning maps, noise maps and noise conflict maps; and standardize noise evaluation parameters and periods.

Keywords: traffic noise, transportation planning, Portugal

1. Introduction

Over the past decades, the Portuguese cities have enlarged, mostly due to migration movements from the eastern to the western part of the country or even from the rural areas to the closest cities. At the same time, as Portugal received European Union funding, the construction of the major road network saw a huge expansion. These two circumstances created

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a complex dilemma on land use definition. On one hand, there was the need to build good transportation infrastructures allowing the movements of people and goods and on the other hand the need to build more dwellings for the increasing population. As the municipalities were not aware of the incompatibility on land use (noise *versus* housing) and thought the closest the housing area was to a highway junction the most excellent it would become, many urban planning errors emerged.

Only on June 1987, the first Portuguese Noise Code (DL n. º 251/1987) was approved, which established some principles in order to prevent annoyance circumstances. It referred the need to make illegal the construction of *sensitive buildings* (dwellings, schools, hospitals, etc) on noisy areas, except on the special condition of reducing exterior noise either on the source or on the receiver (for instance, adapting the facade sound insulation to those circumstances) and with a special authorization of the government. The enforcement of this Noise Code was not efficient and the land use management plans allowed the construction of dwellings, schools, hospitals, etc. on the vicinity of the major roads regardless of noise levels.

On November 2000, a new noise code (DL n. º 292/2000 amended by DL n. º 76/2002, DL n. º 259/2002 and DL n. º 293/2003) was approved. This second code reduced environmental noise level limits, introduced the concepts of "*sensitive zone*" and "*mixed zone*" and, especially, switched responsibilities. On the previous code, the property owner (if on a noisy area) had to reduce noise levels (on the emission, path or receiver) to be able to construct a dwelling. On the present one, the responsibility on reducing noise levels – exterior environmental noise – relies on the infrastructure's Authorities, which means the reversal of responsibility agent. So, there are no restrictions on land use since those Authorities are required to take the proper measures to accomplish the noise limits.

After the approval of the European Directive 2002/49/CE (25th June 2002)[1], the Portuguese government through a preliminary study made by the Portuguese Road Authority (*EP –Estradas de Portugal, E.P.E.*) became aware of the traffic noise issue related to the Portuguese Road System.

[1] Transposed to the Portuguese legal frame on the 31st July 2006 by Decree-Law n.º 146/2006

This paper mentions the relationship between noise and road network planning in Portugal stating some of the reasons to be on a difficult position that may well be similar to many other countries with the same socio-economic development status, in a particular occasion where several municipalities are reviewing their land use management plans.

2. The Portuguese Planning and Road Systems

A road network can be a unique attribute of a historic period or civilization. Whenever is intended to create new urban areas, one of the first operations is the construction of a suitable access. The characteristic of these roads and of the surrounding road network is often related to the "layout" of the territory. The strategic connections provided by this network, between regions, helps on the definition of power relationships on a territory, which means, helps on the hierarchy definition of cities and roads, constituting an important instrument to land use management.[21]

2.1. The beginning

Portugal, as we know it today, had its independence recognized on 1143 but, long before that moment, an ancient road network was created.

Since the Iron Age, the Iberian Peninsula experienced trade exchanges with the Atlantic and Mediterranean communities. However, until the Romans arrived, on the 2nd century BC, there was a lack of hierarchy between the existent urban nucleus and a reduced number of connecting corridors. Even so, in the restructured occupancy model, they decided to make use of the previous territorial systems inheritance integrating them on their new layout. Therefore, they determined the creation of a new urban structure complementing the ancient agglomerations, the commercial places or the defensive constructions with "*prime cities*" and connecting them with a road network, which assisted the definition of the territory hierarchy. As so, the first order roads established the connection between the most important cities (Rome, province capitals

and *conventus*[2] capitals), the second order roads connect the *conventus* capitals to the cities and finally the third order roads depart from these cities to the *villae* and other destinations, which can be seen on Fig. 1.

Originally and even before the arrival of Romans, cities were built on high positions (for defense purposes), on the confluence of roads or on specific locations known for their special interest (commerce, industry, leisure, etc.). With relevance to the actual limits of Portugal, Braga (*Bracara Augusta*), Santarém (*Scalabis*) and Beja (*Pax Julia*) were the most important cities (*conventus* capitals) during the Roman Empire.

Along the Middle Ages, one could assist to the completion of the road network. This legacy derived from the Roman times and was restructured according to the population movements and needs assuming particular relevance on royalty journeys, military expeditions, commercial or religious voyages and on daily activities.

Specially, on the 11th and 13th centuries, one could assist to a demographic explosion and a subsequent "new" occupation of the territory. On those times, were created new agglomerations through the partition of existing urban nucleus, by families' or groups of families' migration movements and even by royal ordinance. By the second half of the 13th century, the agglomerations closest to the coast and harbors assumed an increasing relevance, mostly for economical reasons. The commercial trade on harbors and the following prosperity, with better life opportunities, attract numerous potential inhabitants and this incoming population flow results in the foundation of larger cities. On the following century, emerge the concept of "***metropolitan area***" when several municipalities gather spontaneously to face external threats.

On Modern Times, by the 15th century, is noticeable a massive reduction on farming and forested areas. To avoid their eventual extinction or reduction to an unacceptable level, strict rules were defined for land use development and cities become more crowded. These new "dense" cities, during the Age of Enlightenment, acquired new amenities like public facilities, healthcare services, sanitary infrastructures, etc. Regarding the road network, the road characteristics were improved to face the new circulation requirements (vehicles categories and

[2] Administrative and Judicial districts

speed) by “stretching” the road (reducing the number of curves on the horizontal alignment), repairing or replacing pavement surface coatings and building new bridges. [21]

2.2. The recent evolution

Between 1851 and 1880 with the efforts of the Minister Fontes Pereira de Melo (Engineer) appears the first general structure of the Portuguese road network. Some years later, in 1927, was created the Portuguese Roads Authority (JAE, 20th July 1927) which renewed the road network and raised its extension improving the accessibility (were built over 500 km of National Roads from the **National Roads Plan 1928** - PRN 1928) [22].

In 1933, the road classification system was reorganized and then national road network was classified as 1st class roads, 2nd class roads, municipal roads and vicinal ways (this road network structure is quite similar to the one adopted by the Romans), with a total length of 16900 km.

By the year of 1945, was approved the ***National Roads Plan 1945*** (Decree-Law n. º 34593, 11th May 1945, shown on Fig. 2) [2] maintaining the classification of the national road network in *three categories* (1st class, 2nd class and 3rd class) plus municipal roads and public ways) and expecting to increase the total extension of the road network to 59000 km. This decree also introduced two new concepts:

- **principal itinerary** (associated to 1st class roads);
- **fundamental national road network** (integrating 1st and 2nd class roads).

The 3rd class roads were intended to establish the connection between the fundamental road network and the municipalities, the richest regions, harbors, railway stations and tourist areas. Four years later, on 1949 the ***National Roads Act*** (Law nº2037, 19th August 1949) was created. This piece of legislation refers to JAE organization, roads circulation conditions, road network mapping, protection corridors and land-use restrictions on roads vicinity.

On the following decades, until 1971, the national road network helped on the adjustment of existing imperfections on territorial planning policy and regional decentralization, when the only controlling instruments for land use management were the ***Administrative Code of 1936-***

1940 and the ***Decree-Law n. º 33921/1944*** whose action was bounded to city limits.[1]

Since 1971, with ***Decree-Laws n. º 560/71*** and ***n. º 561/71***, 17th December, the Portuguese municipalities were enforced to have territorial planning instruments, namely, PU (urban development plans, "*Planos de Urbanização*") or even PAT (general urban development plans for territorial areas, "*Planos de Áreas Territoriais*"). These planning instruments meant to guarantee the benefits and comfort for the citizens, regarding their economical and social standards, and the current aesthetics, hygiene and traveling concepts. Along with the PU and PAT, these decrees also introduced another new type of planning instrument – the PP (detailed local plans, "*Planos de Pormenor*").

In 1976, the ***Portuguese Constitution*** [19] also defined some related concepts like:

- "*the right to private property*" and the referring payment of fair compensation on compulsory acquisition for public use purposes (Art. 62);
- "*housing and urban planning*" were it is stated the duty of public administration to define and implement a general national territorial planning policy that guarantee an adequate transportation and public facilities network (Art. 65);
- "*environment and quality of life*" mention the guarantee of a sustainable development as part of public authorities duties, about pollution prevention and control, land-use planning to establish proper locations for activities and a balance between economic and social development, environmental quality of populated areas and urban life and "*To promote the inclusion of environmental objectives in the various sectors of policy*" (Art. 66).

In 1977 and after the approval of the Portuguese Constitution, the ***Law n. º 79/77***, 25th October [16] established the responsibilities of local authorities, as representatives of municipal citizens, on the prosecution of population best interests.

In the same year 1977, JAE informed the Government about the maladjustment of national road network to the current traffic conditions, the ineffective maintenance and the design inadequacy (winding and narrow roads with deeply damaged road surfaces). Recognizing this situation and on the expectation for European funding, the Government decided to amend the previous national roads plan (PRN 1945) based on the excessive density of existing road network, compared to other European countries ([24], see *Table 1*).

In 1982 after giving the municipalities responsibilities on urban development , the ***Decree-Law n.º 208/82***, 26th May [5] was approved and settled guidelines for the use of **PDM** (Municipal Director Plan, "*Plano Director Municipal*") as the key territorial planning instrument and enlightened its particular relation with other territorial plans. The PDM defines the goals for economic and social development of the city on territorial planning. It is an instrument of territory occupation, use and transformation resultant from the different activities developed and a programming instrument of the municipal accomplishments and investments coordinated with "*higher*" planning instruments – regional and national.

In 1985, the Decree-Law n. º 380/85, 26th September 1985 was approved, the new ***National Roads Plan 1985*** (**PRN 1985**, see Fig. 3) in order to assure a proper development of the transportation system, a balanced regional development, reduction of operational costs, improve safety conditions and face the international traffic volume. This plan follows the concept expressed on the previous plan PRN 1945 regarding **Fundamental** (*Principal Itineraries – IP*) and **Complementary** (*Complementary Itineraries – IC* and *other roads*) national roads network and eliminated about 12000 km of roads from the national roads plan. With the entrance of Portugal in the EEC and the subsequent funding availability for infrastructure investment, JAE was able to expand the existing national road network with the construction of the remaining roads, in particular, the ones referred to the fundamental road network.

In 1990, was approved the **Decree-Law n. º 69/90**, 2nd March [8] (amended by Decree-Law n. º 211/92, 8th October) replaced DL n. º 560/71 and DL n. º 208/82. This statutory document aims to harmonize the procedures for elaboration, approval and ratification of PDMs, to reinforce population involvement in the process, to ensure the compliance with other territorial instruments and to simplify the revision of the plan.

From 1990 to 1995 and with reference to the road network, were constructed over 800 km of IPs and about 350 km of ICs. This vast expansion of the Portuguese road network resulted from the above-mentioned European Union funding obtained with the Portuguese adhesion to the EEC, on the basis of road transportation dependence for the economical development, the reduction of regional disparities and the integration on the trans-European road network.

In 1996, the need for PRN 1985 revision was announced but only occurred two years later. The approval of the present ***National Roads Plan 2000*** **(PRN 2000**, see Fig. 4), (Decree-Law n. º 222/98, 17th July 1998) defends the maintenance of PRN 1985 main purpose: proper improvement of the transportation system, a balanced regional development, reduction of operational costs, improve safety conditions and face the international traffic volume.

In this new PRN 2000, the national road network (fundamental and complementary road networks) was expanded from 9900 km to 11350 km. It was also introduces a new road classification – ***regional road*** (ER) for which were affected 5000 km of existing "*other roads*", representing the total of 16500 km for the entire road network, and added 10 new ICs and accelerate the economical development in some interior regions. Also included on PRN 2000 is the Portuguese highways network with a total length of 3000 km, which represents 50% of IPs and ICs road networks.

Since 1999, the Portuguese territorial planning system is founded on the territorial management system defined on the **Decree-Law n. º 380/99**, 22nd September with the amendment introduced by **Decree-Law n. º 310/2003**, 10th December. This legal framework of the Portuguese territorial management system involves the coordination of planning instruments at three levels: National, Regional and Local:

- The ***national level*** concerns the territorial planning policy (national program of territorial planning politics – PNPOT, "*Programa Nacional das Políticas de Ordenamento do Território"*), the definition of guidelines for special plans with territorial incidence – PSIT ("*Plano Sectorial de Incidência Territorial*") – and for special territorial plans – PEOT ("*Plano Especial de Ordenamento do Território*", ex.: areas of protected landscape, coastal zone, areas for nature preservation, areas for agricultural purposes …);
- the ***regional level*** emerges through the regional territorial plans (PROT, "*Plano Regional de Ordenamento do Território"*) and;
- the ***local level*** with the inter-municipal territorial plans (PIOT, "*Plano Intermunicipal de Ordenamento do Território"*), Municipal Territorial Plans (PMOT, "*Plano Municipal de Ordenamento do Território"*), municipal director plan (PDM), urban development plan (PU) and detailed local plan (PP).

In 2003, with the **Decree-Law n.º 104/2003**, 23rd May, were extinguished all Regional Coordination Commissions and Regional Directorates for the Environment and Territorial Planning and subsequently created the Regional Development and Coordination Commission (CCDR) as the main link between local and central administration. The CCDR are regional services of the Ministry of the Environment, Territorial Planning and Regional Development (MAOTDR), endowed with administrative and financial autonomy, charged to execute, within the respective geographical areas, the environmental, territorial planning and regional development policies towards a sustainable regional growth. These five CCDRs, indicated on Fig. 5, represent the following five Portuguese regions considered on the continental part of Portugal:

- ***North*** (CCDR Norte);
- ***Centre*** (CCDR Centro);
- ***Lisbon and Tagus Valley*** (CCDR LVT);
- ***Alentejo*** (CCDR Alentejo) and;
- ***Algarve*** (CCDR Algarve).

In the present moment, only three municipalities do not have the first municipal director plan (PDM) approved (see Fig. 6). The reason for that particular situation concerns the date of birth of those new municipalities (1998). As so, their territorial planning policy is based on Preventive Norms derived from the "*parent*" municipalities. Concerning the road network, there is an enormous effort to conclude the road network defined on PRN 2000 until 2015, which represents an average construction capability of 200 km per year to accomplish the remaining 1058 km of missing IPs and ICs. [20], [24]

3. Noise Situation

Before the approval of the first Portuguese Noise Code, in 1987, the existing statutory documents, like the ***Portuguese Constitution*** [19], only mentioned general concepts of well-fare, quality of life, environmental rights, nature and environmental protection and natural resources protection (Art. 9, Art. 66 and Art. 81) referring them as National Authorities duties.

In 1987, the ***Portuguese Environmental Act*** [17](Law n. º 11/87, 7th April 1987) was approved. Following the publication of the Environmental Act, a large number of legal documents were approved, for instance the first Portuguese regulation with reference to noise – ***Decree-Law n.º 251/87***, 24th June 1987 [7] (1st Noise Code, amended by DL n.º 72/92, 28th April 1992 and DL n.º 292/89, 2nd September 1989). The scope of application of this decree concerns housing, industry, commerce and services; equipments; entertainment and recreational activities; noise signals; traffic; and noise generating activities. This decree established some territorial planning constraints for buildings implantation. Urban areas were classified as *extremely noisy*, *noisy* and *low noise* zones based on a statistical level parameter – $\mathbf{L_{A50}}$ – over a daytime (DT: 7 h – 22 h) or nighttime (NT: 22 h – 7 h) period with the limits indicated on Table 3, and considered suitable for buildings construction under the following circumstances:

- on LNZ there are no restrictions for building areas (residential, educational or healthcare buildings);
- on exceptional cases Local Authorities might authorize the construction of this type of buildings – on NZ or ENZ – if the owner shows evidence of noise reduction solutions, either on the noise source or on the building itself or even on the building surroundings.

Concerning road and rail infrastructures, responsible Authorities must have the purpose of preventing traffic noise, in order to not restrict existing or foreseen uses on surrounding areas and, if necessary, to promote noise mitigation measures.

Few years later, in 1990, was transposed to the Portuguese legal frame the European Directive n. º 85/337/CEE, 27th June 1985 through the ***Decree-Law n. º 186/90***, and **Regulatory-Decree n. º 38/90**. [9][10] This piece of legislation refers "*human environmental factors*" such as landscape, natural or built heritage and pollution (***noise***, chemical composites, effluents and residues and radioactive substances). About *noise* it is defined the obligation to establish noise limits, noise reduction on source, noise propagation reduction and adequate land-use policy.

The second Noise Code, ***Decree-Law n. º 292/2000*****, 14th November 2000** [14] **(RLPS)** had the same scope of application of the previous one but changed the acoustical parameter from L_{A50} to $\mathbf{L_{Aeq}}$. As fundamental principles, it stated the importance of an interaction between noise

reduction strategy, territorial planning, economic, and social development policies to guarantee the appropriate environmental noise conditions on urban areas devoted to housing, educational or healthcare facilities or even on resting spaces. Namely, stated the need for an appropriate land-use planning, especially with housing, employment and leisure activities, through the introduction on the municipal *Map of Constrains* (for all Municipal Directory Plans (PDM) revised after the approval of this Decree) of a new restriction – ***Noise Zoning: Mixed*** and ***Sensitive Zone***, referred to the following forms of occupancy within a certain area:

- ***Mixed Zone***: coexistence of housing occupancy with other uses
- ***Sensitive Zone***: include hospitals, schools, housing (exclusively), religious buildings and public facilities en route for a quiet environment

The associated L_{Aeq} noise limits were reduced by 10 dB (regarding the "*old*" L_{A50} limits) as indicated on Table 4.

Municipalities are also advised to produce Municipal Noise Maps (MNM, see Fig. 7 complemented by Table 5) before the definition of Noise Zoning, in order to decide whether a Municipal Noise Reduction Plan (MNRP) was required. For prevention purposes (Art. 4), the RLPS impose some circumstances for land subdivision schemes, previous information request, building permits and authorization for use. On each of those phases, petitioners are required to join a noise map extract (when it does not exist, an acoustical data report), then an acoustical study and finally a certificate that guarantee the full accomplishment of RLPS and all the related legal documents. As mentioned before, whenever noise limits are exceeded, RLPS required ***municipal noise reduction plans*** (Art. 6) whose implementation might be phased, considering the exceeding level (zones where the exceeding environmental noise level is greater than 5 dB(A) should be the first priority).

For ***transportation infrastructures*** the only requirements were the accomplishment noise zoning limits on correspondent areas (indicated on Table 4) for either existing roads, new or renewed roads, which means the implementation of noise mitigation measures wherever those limits are exceeded. On existent roads, conflict situations should be identified and ***monitoring plans*** or ***noise reduction plans*** ought to be done.

In 2006, was approved the ***Decree-Law n. º 146/2006***, introducing the European Directive 2002/49/CE, 25th June into the Portuguese legal frame. This decree introduces several changes:

- a new acoustical parameter, L_{den};
- three reference periods
  - *day (07:00 – 20:00);*
  - *evening (20:00 – 23:00);*
  - *night (23:00 – 07:00).*
- strategic noise maps;
- action plans;
- public information and participation.

As for most of the European countries, the Portuguese noise legislation did not fulfill all these new requirements and so, in January 2007, was approved the third Noise Code, harmonizing the acoustical parameters, the reference periods and the noise zoning limits (indicated on Table 7), broadening the number of municipalities with a noise map (all municipalities ought to have one and some – the agglomerations (over 100.000 inhabitants) – should have a strategic noise map), introducing the concept of an environmental noise report or each municipality every two years, and enforcing the need for Municipal Noise Reduction Plans (or Action Plans for agglomerations). Concerning the transportation infrastructures and whenever is identified a non-legal situation (noise limits are exceeded) noise mitigation measures are required and should be implemented on the following order:

- on the source;
- on the path;
- on receiver.

Previously, the possibility to minimize noise on the receiver (façade insulation) was not a legal option and, even now, it should only be used as last resource when all the other possible actions were taken and when exterior noise does not exceed L_{den} = 60 dB(A) and L_n = 50 dB(A).

4. Noise Legislation *versus* Road Network Planning

As an ancient country, with a long history, Portugal has many antique town and smaller agglomerations that later became immense conurbations or cities together with the natural evolution of the road network. It is surprising to see now (or not so much attending urban progress) that the main road corridors from Roman times are quite similar to today's network, as it is shown on Fig. 8.

Along the times, the routes opened by the roads have become the most solicited areas for the construction of new dwellings, especially for the proximity to the road itself, the transportation system, the social and health equipments or even for better commercial opportunities. As on earliest times, there were no mechanical vehicles, the occurrence of other vehicles was sporadic and the circulation speed was extremely low, there were no significant repercussions to build those dwellings almost "on the road" both for local residents or for road users.

With technical evolution, the circulation vehicles achieved the capacity to travel larger distances in shorter periods of time and, as natural consequence, the existing roads revealed their inaptitude to the contemporary circulation conditions not only for technical reasons but also due to deficient circulation safety. Technicians faced then a new problem: "*how to develop a* 'very old' *road network extremely constrained by side urban occupation*?"

As examples of these situations, we have National Road 1 (NR 1 - first road of the new era PRN, connecting Lisbon and Porto), NR 13 (North coastline) and NR 125 (Algarve coastline).

Once the need for new roads with a highway profile type (minimum of two lanes in each direction) was identified, with severe restrictions concerning the horizontal and vertical alignment design, there was the perception of upcoming difficulties. In several conditions was required to invade new territory and in other ones to "devastate" some dense urban areas (like the cases of Lisbon and Porto with the inner city road rings).

At the present time, due to the past land-use management "errors" and to the lack of synchronization between land-use and noise requirements, there are a large number of municipalities willing to eradicate traffic passing by from their city centers. On these

municipalities, grown on roadside along numerous decades, people began to complain about their quality of life – or, with a more accurate meaning, the “lack” of quality.

In fact, with reference to noise, there is no evidence of concern about the "*noise issue*" until 1987 – Portuguese join the EEC – when began the obligation to transpose some European Directives (ED) to the Portuguese legal system (i.e. ED n. º 85/337/CEE, Environmental Act). As so, there was the need to regulate *noise*, as one of human environmental parameters and then the first statutory document was issued (1st Noise Code, RGR – DL n. º 251/87). Before that moment, there was only a general perception about welfare and quality of life that was not noticeable on existent territorial planning instruments, for instance, on urban development plan (PU). After 1987, spite the approval of the *Noise Code* and the *Noise Classification* of urban areas, the new approved plans (see Fig. 1 and Table 1), such as Municipal Director Plans (PDM), still did not have any noise restriction to urban expansion expressed on Municipal Constraints Map.

The situation persisted until 2000, with the approval of the second Noise Code (RLPS – DL n. º 292/2000), there was only noticed the existence of a statutory document for noise when someone complained about noise annoyance or on the environmental impact assessment studies done for the major transport infrastructures subsidized by the European Union. When it comes to land-use constraints, the only evidence were the heavy industrial sites placed outside the urban limits defined by municipalities. All the rest, light industries, services, schools, hospitals, housing and transportation systems coexisted on the same space.

Since then, some PDMs reached their revision deadline time (10 years after approval) and began their revision procedures (see Fig. 9 complemented by Table 6). Those municipalities that started revision process before RLPS approval were not obliged to accomplish RLPS new requirements and remained with no noise constraints regarding land-use management. All the others, with PDM under revision or still active, will have to fulfill those requirements. As starting point, most municipalities are undertaking Municipal Noise Maps (see Fig. 7 complemented by Table 5), which will help to understand their municipal noise status.

At this point, and considering *Mixed Zones* and *Sensitive Zones* concept and the related

environmental noise levels, the municipalities are advising their technicians to classify most new municipal urban areas as "Mixed Zones" based on different activities coexistence. As result, the number of Municipal Noise Reduction Plans (MNRP) required for the entire country will decrease (as well as the mandatory noise mitigation measures) because the maximum environmental noise level allowable will be 10 dB(A) higher than the limit to Sensitive Zones (L_{Aeq} = 65/55 dB, daytime/nighttime period). This is an important issue as *noise restrictions* will take part of *Municipal Constraints Map* and will become a legal instrument with strong reflections on land use management and on municipal economy as the noise reduction plans will have to involve municipal finance resources and interfere with construction potential of some areas.

In July 2006 and January 2007, were approved the transposition of END and the third noise code. These legal documents will have an important impact on land use instruments as it states the obligation of the municipalities to produce noise maps (regular or strategic), allow public information and participation and create action plans to prevent annoying noise exposure or, when the situation demands, to reduce environmental noise levels.

5. Portugal *versus* other European countries

As Portugal, all other European countries had to adjust their legal instruments to the ***European Noise Directive*** (END - 2002/49/CE, 25th June, see Table 8). Since 2002, in particular, those countries transposed the END to their legal framework (which, in most cases, implied the adjustment of acoustical parameters and reference periods) and began to develop or update their noise maps.

Contrary to the current situation in Portugal, several other countries as France, United Kingdom, the Netherlands and more recently Italy, already have implemented a Noise Zoning Classification (in some cases decades ago), mostly due to territorial planning purposes. The existence of those constraints to building construction activity reduced the annoyance occurrences and also the cost of noise mitigation measures, as the number of dwellings affected

by excessive environmental noise is less significant.

The natural comparison between Portugal and some European countries often occurs among the southern Europe ones (Spain, Italy, Greece or even France) as the weather conditions, dwellings characteristics, driving and circulation patterns, territorial occupancy and exterior use of private and public spaces is favored by those excellent weather conditions. Under those circumstances, one could consider Portugal has invested many resources; most of the Portuguese principal and complementary itineraries are built and properly protected regarding traffic noise annoyance. This should not be interpreted as a disproportionate consideration of minimizing activities. There is a lot to be done specially on municipal level where the present noise status is not known yet, as several municipalities are finishing the preparation of Noise Classification Maps and Noise Conflict Maps, in order to analyze future actions to reduce city environmental noise.

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[25] Source: Vasco Gil Mantas, Vias romanas de Portugal, p. 408 (Fig. 4: Mapa de situação) in António Nunes Pinto. *"A propósito dos pequenos bronzes figurativos romanos: itinerários difusores"* in *J-G. Gorges* et ali*i (eds.)* V Mesa Redonda Internacional sobre Lusitania Romana (Cáceres-2002) : Las comunicaciones*, Min. Cultura, Madrid 2004; pp. 391-408*

Table 1
Roads Network Density (1984)

Country	Population density (persons/km^2)	Total Roads Length Index (km/1000 persons)	National Roads Index (km/1000 persons)
Belgium	322.8	12.9	1.4
Denmark	118.7	13.7	0.9
France	99.8	14.6	0.6
Germany	245.5	8.0	0.7
Italy	189.0	5.2	0.9
Portugal	108.0	4.8	2.0
United Kingdom	238.0	6.3	0.3

Source: Zúniga J., 1994

Table 2
Number of PDM's approval, regarding ratification year

Year	PDM approvals	Year	PDM approvals	Year	PDM approvals
1985	1	**1992**	6	**1998**	5
1986	1	**1993**	22	**1999**	8
1987	1	**1994**	87	**2000**	5
1989	1	**1995**	104	**2001**	1
1990	1	**1996**	8	**2002**	3
1991	1	**1997**	22	**2003**	1
Municipalities without PDM: 3					

Table 3
Maximum Noise limits for Noise Classification (1st Noise Code)

Noise Classification	Daytime period (7 h – 22 h)	Nighttime period (22 h – 7 h)
Low Noise Zone (LNZ)	$L_{A50} \leq 65$ dB	$L_{Aeq} \leq 55$ dB
Noisy Zone (NZ)	65 dB < $L_{A50} \leq 65$ dB	55 dB < $L_{Aeq} \leq 65$ dB
Extremely Noisy Zone (ENZ)	$L_{A50} > 75$ dB	$L_{Aeq} > 65$ dB

Table 4

Maximum Noise limits for Mixed and Sensitive zones (2nd Noise Code)

Form of Occupancy	Daytime period (7 h – 22 h)	Nighttime period (22 h – 7 h)
Mixed Zone	L_{Aeq} = 65 dB	L_{Aeq} = 55 dB
Sensitive Zone	L_{Aeq} = 55 dB	L_{Aeq} = 45 dB

Table 5
Municipal Noise Map's (MNM) approval

Year	Noise Maps	Year	Noise Maps
No known MNM	59	**2003**	52
MNM elaboration	126	**2004**	23
MNM approval	2	**2005**	16
2002	1	**2006**	2
(Data under collection)			

Table 6
Municipal Director Plans (PDM) under revision

Year	PDM revision	Year	PDM revision
No known revision	94	**2002**	3
PDM under revision	172	**2003**	1
1999	2	**2004**	1
2000	2	**2005**	2
2001	2	**2006**	2

(Data under collection)

Table 7
Maximum Noise limits for Mixed and Sensitive zones (3rd Noise Code)

Form of Occupancy	Full day period (0 h – 24 h)	Nighttime period (23 h – 7 h)
Mixed Zone	L_{den} = 65 dB(A)	L_n = 55 dB(A)
Sensitive Zone	L_{den} = 55 dB(A)	L_n = 45 dB(A)
Sensitive Zone close to an existent major transportation infra-structure	L_{den} = 65 dB(A)	L_n = 55 dB(A)
Sensitive Zone close to a major transportation infra-structure during design stage (not valid for airports)	L_{den} = 60 dB(A)	L_n = 50 dB(A)
Sensitive Zone close to a major airport infra-structure during design stage	L_{den} = 65 dB(A)	L_n = 55 dB(A)
Non classified zones	L_{den} = 63 dB(A)	L_n = 53 dB(A)

Table 8
Noise Maps and Noise Action Plans in Europe

Country	Year of transposition	municipalities			Noise maps	Action plans
		≥ 250.000	≥ 100.000	total		
Austria		2	3	84	1	
Belgium		2	4	589	1	
Bulgaria	2005	3	6	287		
Cyprus		-	2	196		
Czech Republic		3	2	130	1	
Denmark		1	3	111	1	1
Estonia	2007	1	1	227		
Finland		1	5	431	1	
France		24	30	2380		
Germany		27	54	2073	1	
Greece		2	6	1034	33	16
Hungary		1	8	289		
Ireland		1	1	165		
Italy	2003	12	31	8101	1335	
Latvia		1	1	77		
Lithuania		2	3	103		
Luxembourg		-	1	12		
Malta		-	-	68		
Netherlands		4	21	443	28	
Poland		12	27	2478		
Portugal	2006	3	8	308	200	2
Romania	2005	8	17	268	1	
Slovakia		1	1	138		
Slovenia		-	1	210		
Spain	2003	12	42	329		
Sweden		3	9	290	1	
United Kingdom		17	48	434	2	
England		*13*	*44*	*354*		
Scotland		*2*	*2*	*32*		
Northern Ireland		*1*	*-*	*26*		
Wales		*1*	*2*	*22*		
(Data under collection)						

Figure Captions

Fig. 1 – Roman roads in Portugal. Source: Mantas (2002)

Fig. 2 – National Roads Plan (PRN) 1945

Fig. 3 – National Roads Plan (PRN) 1985

Fig. 4 – National Roads Plan (PRN) 2000

Fig. 5 – Portuguese Regions (CCDR)

Fig. 6 – Municipal Director Plans (PDM) approval year

Fig. 7 - Municipal Noise Map (MNM)

Fig. 8 – Roman road network *versus* PRN 2000

Fig. 9 - Municipal Director Plans (PDM) under revision

Fig. 1

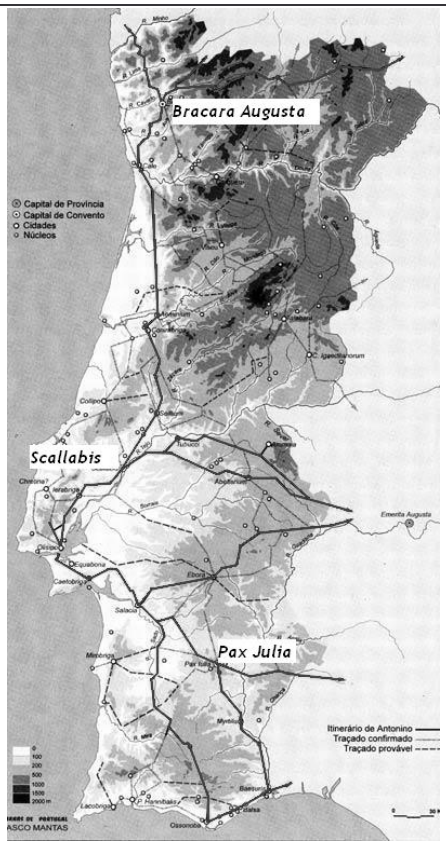

Bracara Augusta
Scallabis
Pax Julia
Capital de Província
Capital de Convento
Cidades
Núcleos
Itinerário de Antonino
Traçado confirmado
Traçado provável

Fig. 2

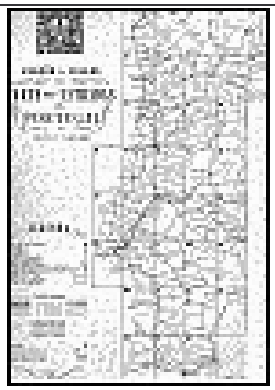


Fig. 3

Fonte: JAE/MEPAT, 1997: 45

Fig. 4

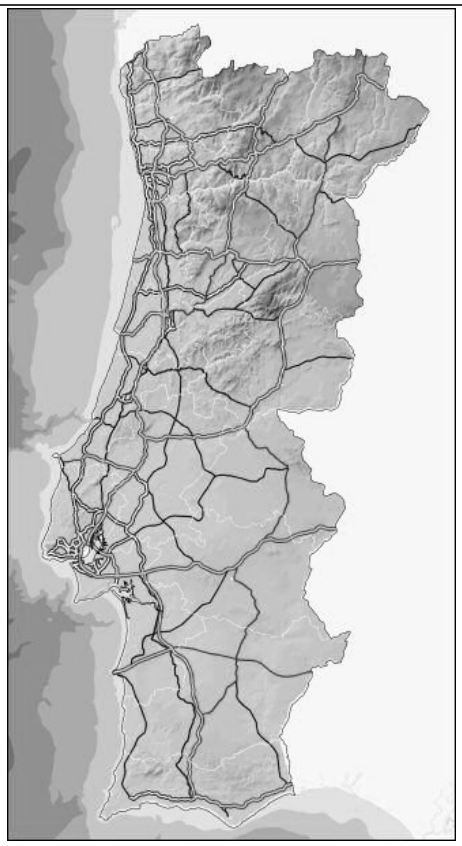


Fig. 5

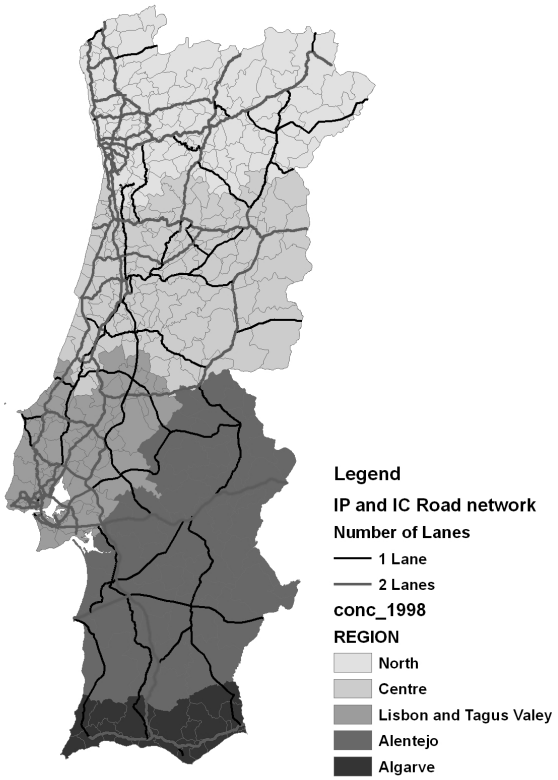

Legend
IP and IC Road network
Number of Lanes
1 Lane
2 Lanes
conc_1998
REGION
North
Centre
Lisbon and Tagus Valey
Alentejo
Algarve

Fig. 6

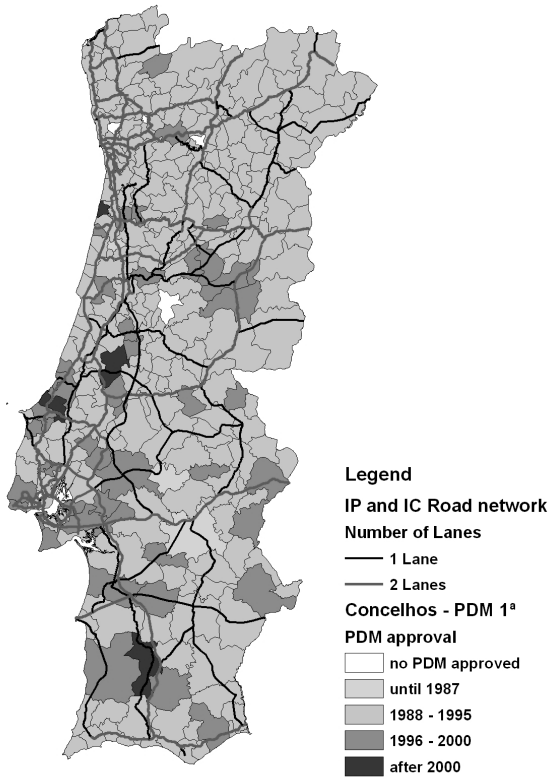

Legend
IP and IC Road network
Number of Lanes
1 Lane
2 Lanes
Concelhos - PDM 1ª
PDM approval
no PDM approved
until 1987
1988 - 1995
1996 - 2000
after 2000

Fig. 7

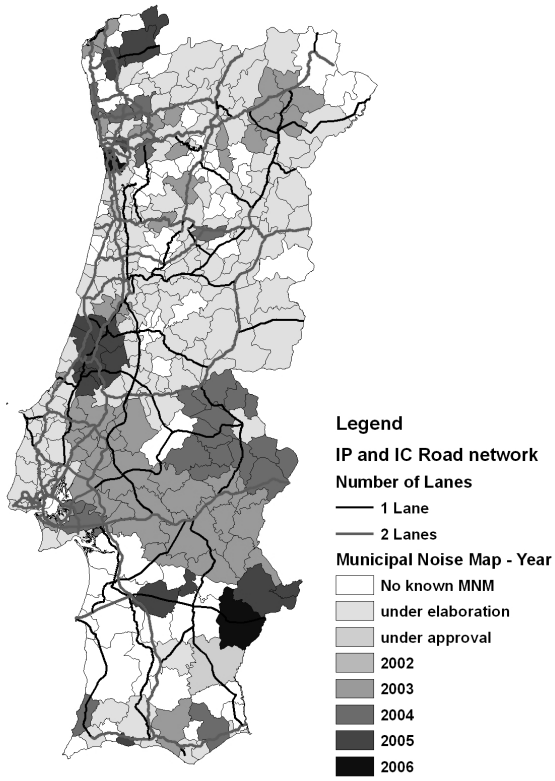

Legend
IP and IC Road network
Number of Lanes
1 Lane
2 Lanes
Municipal Noise Map - Year
No known MNM
under elaboration
under approval
2002
2003
2004
2005
2006

Fig. 8

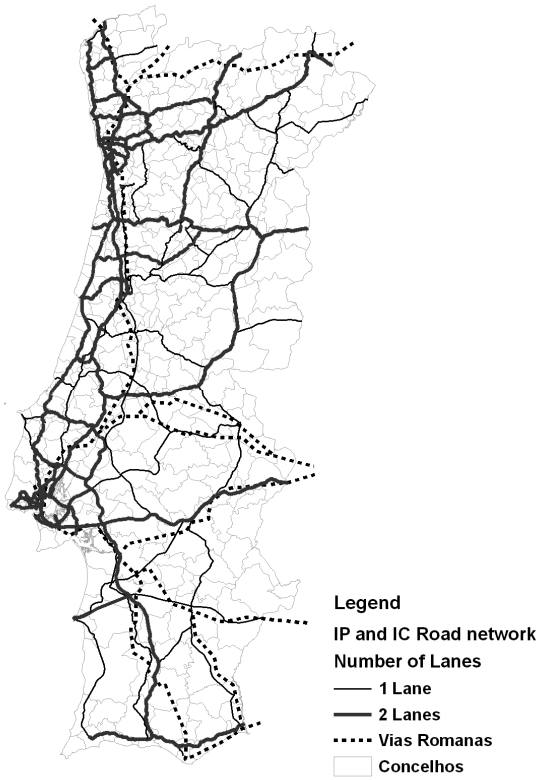
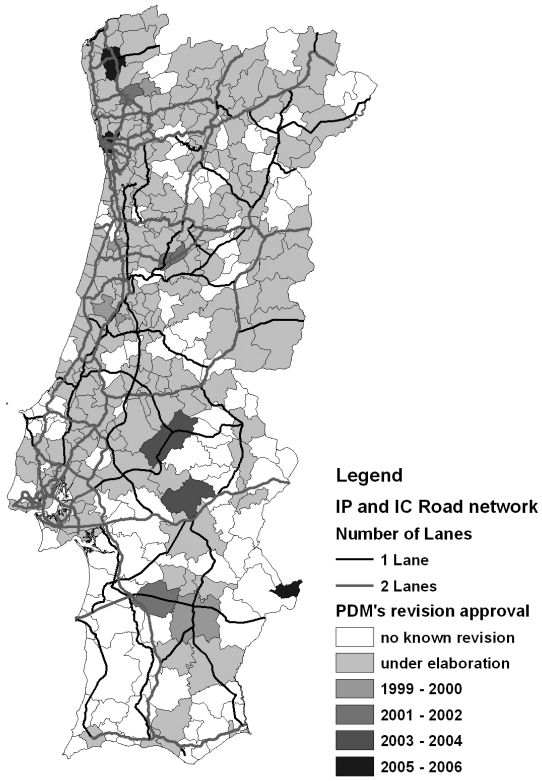

Legend
IP and IC Road network
Number of Lanes
1 Lane
2 Lanes
Vias Romanas
Concelhos

Fig. 9


Legend
IP and IC Road network
Number of Lanes
1 Lane
2 Lanes
PDM's revision approval
no known revision
under elaboration
1999 - 2000
2001 - 2002
2003 - 2004
2005 - 2006