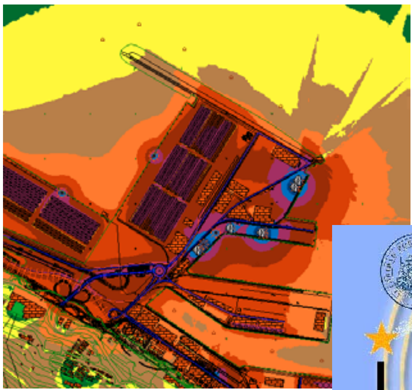
Methodology of Implementation of a System of Follow-up, Assessment, and Control of Noise in Port Surroundings.



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CONTENTS

1 INTRODUCTION

This study frames within the initiatives of the *Area of Environmental Policies of the Direction of Infrastructures and Port Services of Ports of the State* directed to encourage the integration of the environmental management in the management processes of the port operations. In this sense, it agrees with the search of a **sustainable development**, within the action lines of the new policies of future fight against the noise elaborated by the European Union.

As the tools that facilitate these objectives are implemented, the attainment of actings directed to **avoid the appearance of new problems** of acoustic pollution in the environment will be ensured. At the same time, controlled actions that **optimising their benefit-cost** to **diminish the existing impacts** and the **protection of zones** that have a suitable acoustic environment (**quiet zones**) will be encouraged.

A Noise Management Process is compound of different complementary stages that begin with the elaboration of noise maps for the different environmental noise sources and continues with the assessment of a wider conception of the surroundings for the implementation of measures to diminish the noise. And all this with tools that facilitate the access to noise management to technicians of the Port Authorities and Ports of State, encouraging the integration with another aspects and promoting an attitude change and the relation and information sharing between institutions and administrations.

A co-ordination and co-operation philosophy at international, national, regional and local levels will have to be part of the new noise management strategies in the next decade in a world-wide scale.

In Spain noise is between the environmental priorities of the port activities. In this sense, Ports of the State work in the development and implementation of innovative environmental tools, in collaboration with the Port Authorities of different communities to facilitate the environmental control of their activities. Ports of the State are developing the HADA project, within the LIFE program. This study collaborates with this project in relation to the acoustic pollution.

2 OBJECTIVE OF THE REPORT

The main objective of the contract with the Port Authority of Bilbao, called as "Technical Attendance and Provision of a System of noise levels Monitoring in the Port of Bilbao, in agreement with specified in action 2 of task 4041 and in task 4079 of the report of the HADA project (Life 02 ENV/E/000274)", is to contribute to the sustainable development of port infrastructures of Spain through the definition of assessment tools that allow to advance in the elaboration of the diagnosis and the action plans to minimise the acoustic pollution generated by the Spanish ports either in the present scenario as in the future.

The work to develop is structured in the two following phases:

PHASE 1. –Prototype System of Noise levels Assessment and Control

PHASE 2. – Monitoring service of noise levels

Phase 1 implies the design of the acoustic monitoring network of the Port of Bilbao, as well as the analysis of its possible application in other port surroundings. In addition it implies **the definition of a methodology for the assessment of the noise levels produced by the port activities**, with its corresponding application in the Port of Bilbao, Noise Map, Diagnosis and Recommendations for improvement.

Phase 2 consists of the provision of the necessary instrumentation for the implementation of noise levels monitoring system in the Port of Bilbao. This service also includes its maintenance and the training of the personnel of the Port Authority for its correct use.

This report gives answer to the second part of PHASE 1, proposing a Methodology for the Implementation of a System of Follow-up, Assessment and Control of Noise in Port Surroundings.

The processes that are developed in the port surroundings are sufficiently complex, and sometimes adapted to the characteristics or availabilities of each area, that the absolute generalisation of a methodology for all of them is actually impossible to obtain. This document describes the different aspects that have to be taken into account when raising a system of these characteristics, allowing the reflections on particular necessities, and offering general guidelines of application.

3 LEGISLATIVE FRAME

The current legislative and normative trends plead to establish General Frame in which a greater environmental awareness in the Ports is pursued. In this sense:

- **The Code of Environmental Behaviour** from the results of a report in 1996 (see table) recommends "establishing management systems that force the environmental protection as an integral part of the management practice and business."

Problem	Percentage of ports
Dust	57%
Dredging removal	49%
Development of the port (in land)	46%
Dredging	45%
Fishery industries' waste (land)	43%
Development of the port (in sea)	42%
Noise	41%
Water quality	39%
Traffic volume	37%
Risky goods	36%

- **The European Project ECOPORTS**, proposes the development of an on-line Information and environmental management system for the assessment and improval of the environmental actions.

With these premises, and not existing in principle in the environmental port legislation a treatment distinguished for the noise environmental pollution, as departure point of the study, a summary of the applicable general legislative frame concerning noise has been made, that could serve as a basis for an Assessment of Acoustic Impact on port surroundings.

The legislative map distinguishes from an European level to a local level according to the scheme of the figure #1 .

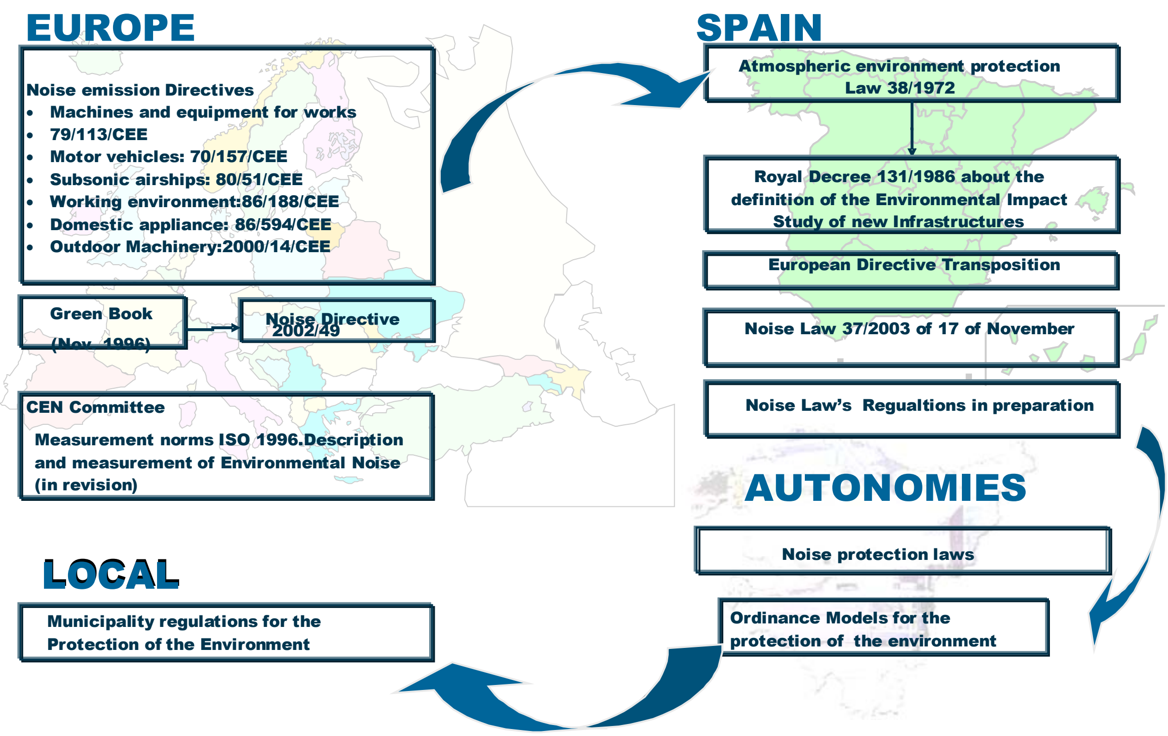


Figure #1. Scheme of the applicable legislation concerning environmental noise.

3.1 *EUROPE: ENVIRONMENTAL NOISE LEGISLATION*

The European policy with respect to noise has been reflected in the approval of a set of documents and directives that regulate noise levels. The directives have as purpose the reduction of the acoustic pollution restricting the noise emission of several types of noise sources:

- Machines and construction equipment
- Vehicles of motor
- Airships
- Labour atmosphere
- Domestic appliance

Between the most significant documents approved by the European Commission appears "The Green Book: Future policy of Fight against the Noise "(November 1996), in which a method for the development of a policy against the noise is established by progressive stages.

In the Green Book it is recognised that noise originated by road traffic, industrial plants and leisure activities is one of main the environmental problems in Europe, constituting, in addition, an important and increasing source of complaints of the population.

As result from the expositions of the Green Book, the Directive publishes in June of 2002 the Directive on Assessment and Management of Environmental Noise (2002/49/CE).

3.1.1 Directive of Assessment and Management of Environmental Noise (2002/49/CE)

The new European Directive tries to settle down a common approach to avoid, prevent or to reduce the injurious effects of the exposition to environmental noise on the human health, consisting in: the assessment of environmental noise in the members states with the common methods, and the information to the population about the environmental noise and its effects, understanding by environmental noise all sound not wished or injurious generated by the human activity towards the outside, including noise emitted by transport infrastructures, industrial plants or industrial buildings.

According to the Directive, the noise maps of urban surroundings will be made classifying them in great agglomerations (urban nuclei with more than 250,000 inhabitants), small agglomerations (urban nuclei with more than 100,000 inhabitants and less than 250,000 inhabitants) and surroundings of the great routes of communications.

The Directive of Environmental Noise Management considers as environmental noise sources roads, highways, railways, airports and industrial areas.

The industrial sources to which the Directive makes reference, are those industrial areas included in which the Directive defines as agglomerations (population nuclei of more than 100,000 inhabitants defined by the competent authority). It will be analysed, as with the rest of environmental sources, the repercussion that such sources have in the closest inhabited zones, or in the zones defined as quiet zones that could be affected.

Some of the main new issues related with the assessment and management of the environmental noise that includes the new directive are the following ones:

- A new parameter of assessment of the exposition to the environmental noise is introduced: the average equivalent noise level day-evening-night, L_{DEN}, that complements the parameters usually used such as the average equivalent noise level night, L_{night}. For the definition of this new parameter three representative periods of the day have been defined that in principle will include the following periods:

    - Day, proposed hours: from 07:00 up to 19:00 hours (12 hours)
    - Evening, proposed hours: from 19:00 up to 23:00 hours (4 hours)
    - Night, proposed hours: from 23:00 up to 07:00 (8 hours)

$$L_{den} = 10\lg\frac{1}{24}\left(12*10^{\frac{L_{day}}{10}} + 4*10^{\frac{L_{evening}+5}{10}} + 8*10^{\frac{L_{night}+10}{10}}\right)$$

Where

- Lday is the long term A-weighted sound level defined in the Standard ISO

1996 2: 1987, determined throughout all the diurnal periods of a year.

- Levening is the long term A-weighted sound level defined in the Standard ISO 1996 2: 1987, determined throughout all the vespertine periods of a year
- Lnight is the long term A-weighted sound level defined in the Standard ISO 1996 2: 1987 determined throughout all the nocturnal periods of a year

❖ The noise maps for the assessment of noise in dwellings are raised in some specific conditions different from the used to date: at 4 m height from the ground and a 2 m from the façade.

❖ The incident level on the façade will be considered as the assessment level.

It raises as recommendable methodology, the use of calculation models. During the transition period, until the harmonisation of the models at European level, the Directive recommends the use of some calculation methods depending on the noise source:

Calculation methods recommended by the Directive	
	• Industrial noise: ISO 9613-2 • Road traffic noise: French Norm XPS 31-133, Method NMPB • Railway noise: Dutch Method Standaard-Rekenmethode II • Noise of airships: Document 29 of the ECAC-CEAC

The minimum requirements on noise maps are defined in annex IV of the Directive. Next it is shown an extract:

A noise map is the representation of the data relative to some of the following aspects:

- Existing, previous or predicted acoustic situation expressed as a function of a noise indicator.
- Overcoming of a limit value (' conflict map ').
- Number of dwellings in a given zone exposed to a range of values of a noise indicator.
- Number of affected people (annoyances, alteration of the dream, etc.) in a given zone.
- Relations economic cost-benefits or other economic data about corrective measures or

other measures against noise.

The noise maps will serve as:

- Basis for the data that must be sent to the Commission according to section 2 of article 10 and with the Annex I of the Directive.
- Source of information for the citizens according to article 9 of the Directive.
- Foundation of the action plans according to article 8 of the Directive.

In order to develop the conflict and affection maps the member countries will have to fix limits of exposition to noise specific for each country.

Since it has been indicated, the Directive gathers the obligation to inform to the citizen of the environmental noise levels and the remission periodically of this information to the European Commission proceeding to the periodic update from this information and valuation of the environmental improvements with respect to the selected indicators. As the primary objective of the Directive is the diffusion of the information collected in the maps, either to the public in general as to the European Commission, the analysis has focused in providing information as easily as possible using the latest technologies (Internet and GIS). In order to be able to interact with any kind of related information (traffic, property register, planning, statistics of population or other noise studies) in a transparent form it is recommended the use of standards in formats and in programming languages by the organisms (communication to the commission) that need that information.

The information that must be communicated to the Commission about agglomerations is the following one:

- Brief description of the agglomeration: location, dimensions, and number of inhabitants.
- Responsible authority.
- Programs of fight against the noise executed in the past and current measures to reduce the noise.
- Calculation or measurement methods used.

- Noise levels and associated parameters:

When the calculation interim methods are used :

- Total number of people whose dwelling is exposed to each one of the following ranges of LDEN values in dB at a height of 4m in the most exposed façade :< 55, 55-59, 60-64, 65-69, 70-74, 75-79, > 79, distinguishing road traffic, railway traffic, aeroplane traffic and industrial sources. The numbers will be indicated in hundreds of people.
- Number of people , within each of the mentioned categories, whose dwelling has special insulation against noise and has a quiet facade.
- Number of schools and hospitals exposed to each one of the mentioned ranges of LDEN values, as well as
- The number of students and patients to whom those numbers correspond.
- Total surface (in km^2) of parks that they are in each of those LDEN ranges
- Contribution to those results of the main roads, main railway lines and main airports .
- total number of people (in hundreds) whose dwellings are exposed to each one of the following Lnight ranges in dB at a height of 4 m in the most exposed façade: < 45, 45 - 49, 50 - 54, 55 - 59, 60 - 64, 65 - 69, 70 - 74, > 74, distinguishing road traffic, railway, and aerial traffic and the industrial sources .
- The number of people , within each one of the mentioned categories, whose dwelling has special insulation against the noise and/or has a relatively quiet facade .
- Contribution to those results of the main roads, main railway lines and main airports.

When the common methods are applied the range for the LDEN will extend with the values < 50, 50-54 and will the <55 range will be suppressed, and LNIGHT will be extended with the values< 40, 40-44, and < 45dB range will be suppressed.

A summary of the action plan, of a maximum extent of 10 pages, resultant of the analysis of the noise maps. The action plan will have to fulfil some minimum requirements to be accepted by the commission, that basically will incorporate, in addition to the indications about the results of the noise maps, the situation analyses with respect to health, the determination of problems, the situations to improve and the predicted actings with budgets and evaluations cost - effectiveness and cost - benefit.

Action plans will be spread between the citizens and elaborated on the basis of the definition of quantifiable indicators to diminish the environmental noise. For them, some of the actings mentioned in the Directive are:

- Traffic control
- Land use planning
- Technical measures in the noise sources (pavements, railways)
- Selection of quieter noise sources
- Reduction of the transmission of the sound during the propagation (noise barriers)
- Authorisations for new infrastructures
- Rates and sanctions

For the application of the previously exposed measures the following calendar from the approval of the Directive has been proposed (figure #2).

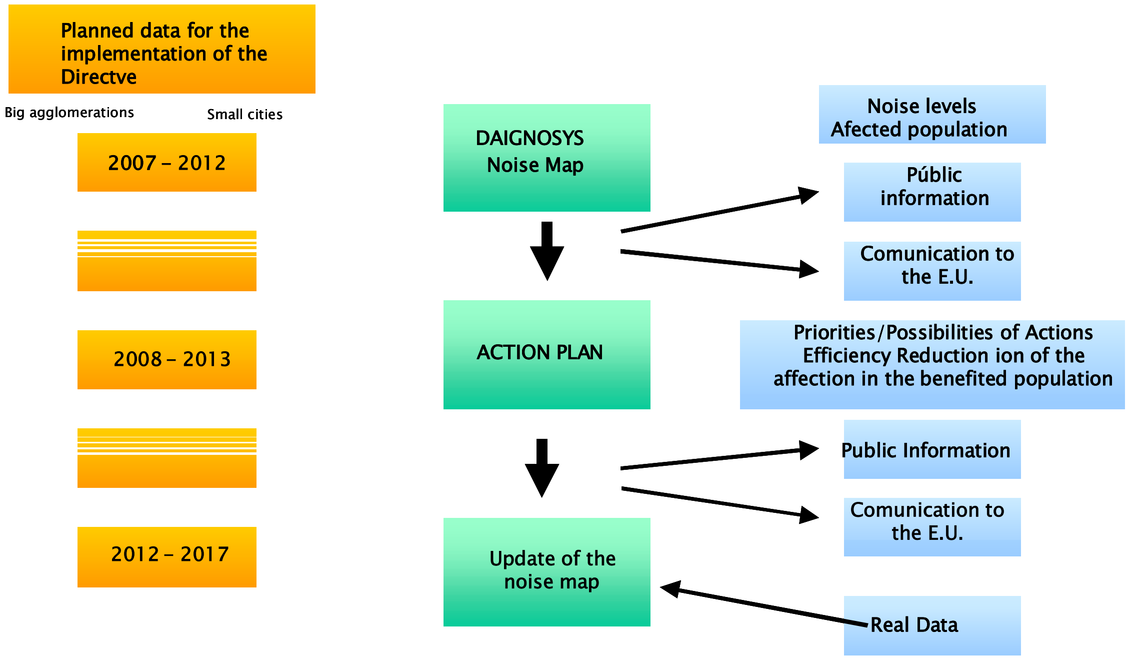


Figure # 2. Calendar of application of Directive 2002/49/CE

It can be verified in the previous graph that after being approved the Directive there is a period of 5 years to send to the commission the results of the noise maps according to the established guidelines and a year more to elaborate the specific action plans.

3.2 SPAIN: ENVIRONMENTAL LEGISLATION

The Law 7/1994 of Protection of the Atmospheric Environment constitutes at state level the reference legislative frame for the regulation of the environmental noise. The law authorizes the Government to establish immision levels.

The Royal legislative Decree and its corresponding Royal Regulation Decree of "Evaluation of Environmental Impact", regulate the exigencies that, in the matter of environmental impact, are due to demand to new infrastructures, forcing to write up a study of environmental impact

- EIA - that includes the necessary corrective measures for noise control.

The European Directives that regulate the emission noise levels have their corresponding transpositions in Royal Decree form.

The regulation of annoying, unhealthy, injurious and dangerous activities (RAMINP) describes as annoying the activities that originate discomfort by noise or vibrations. Its main characteristic is that it authorises the local authorities to the concession and transaction of activity licenses.

The Noise Law 37/2003, of 17 of November, intends to prevent, to watch and to reduce the acoustic pollution, being subject to its prescriptions all the acoustic emitters, either of public property as of private. Within the classification of acoustic emitters gathered in the Law (article 12), the Port Infrastructures are named specifically. Just as for the rest of acoustic emitters, the Government will determine the immision and emission limits.

At this moment, the law is in process of development of the regulations that will support it, establishing the mentioned limits of evaluation, as well as the methods and the rest of information necessary to obtain a homogenous process of evaluation in the State.

3.3 AUTONOMIES: ENVIRONMENTAL LEGISLATION

Some Autonomies, have established their own noise control legislation before the approval of the Noise Law of the State. In all of them the actions to develop are settled down. Amongst them it can be emphasised the determination of the maximum levels of noise and vibration, the definition of quality objectives to adopt and the fixation of limitations or specifications to the city-planning in areas exposed to noise or vibration. Evidently as their date of approval is close to the approval of the Noise Law, they have a great number of points in common.

In a second line of acting, different autonomies have developed municipal ordinance models in which the procedures of measurement and characterisation of noise and its limits of evaluation are gathered.

Finally, in some cases there are only available derivations of the *RAMINP*, in which in the section referred to noise for residential ground it is only indicated the limits that the activities do not have to surpass inside the dwellings.

3.4 LOCAL: ENVIRONMENTAL LEGISLATION

At local level, the figure of the Municipal Ordinance is the one in charge of regulating noise originated by outer sources and noise levels inside the buildings.

The Municipal ordinances are the tools that have really impelled deepening in the study and control of the noise at state level, establishing assessment limits of evaluation, corrective actions and innovative acting lines.

All the activities, facilities and behaviours susceptible to cause annoyances by noise and/or vibration, the new infrastructures submissive to the Study of Acoustic Impact, and the acoustic control of new constructions are within their reach.

They are excluded from their reach the noise of road traffic, railways, public disorders and the annoyances between neighbours (regulated by the Law of Horizontal Protection).

The measurement parameters used to characterise the noise are the SPL (dBA), Equivalent Continuous Level (LAeq, T representative), Maximum Level LAmax (FAST or SLOW) and Ln (percentiles). And to characterise the vibration it is the curve K from norm ISO 2631.

The limits of application in the outer atmosphere are located between the following values:

	LAeq Period Day dB(A)	LAeq Period Night dB(A)
High sensitivity zone sanitary use	50-55	40-45
Medium sensitivity zone, residential use, educational use	55-65	45-55
Low sensitivity zone, commercial, industrial	65-70	60-70

If the existing background noise is greater than the established limit, the new limit is obtained adding 3 dB to the background noise.

The limits increase between 3 and 5 dB for impact noises and they are characterised with the Lmax (maximum level).

For vehicles an emission value between 2 and 6 dBA greater than the officially approved value is accepted.

The limits of application in the inner atmosphere are located between the following values

	LAeq Period Day dB(A)	LAeq Period Night dB(A)
High sensitivity zone, sanitary use	30	25
Residential zone	37-35	27-25
Tertiary zone, offices	45-40	40-35
Equipment zone, commercial	50-45	50-40
Productive zone, industrial	60-55	60-55

In the case of the vibrations, the limit values are:

- Sanitary Use (K ISO); DAY = 2 NIGHT = 1,4
- Tertiary Use (K ISO); DAY = 2-4
- Equipment Use (K ISO); DAY = 4-8
- Productive Use (K ISO); DAY = 8-16

Timetable of application of the ordinances:

	Outer Atmosphere		Inner Atmosphere	
	DAY	NIGHT	DAY	NIGHT
Labour day	7-8 up to 22h	22 up to 7-8h	8 up to 22h	22 up to 8h
Festive day	9-10 up to 23h	23 up to 9-10h	10 up to 23h	23 up to 10h

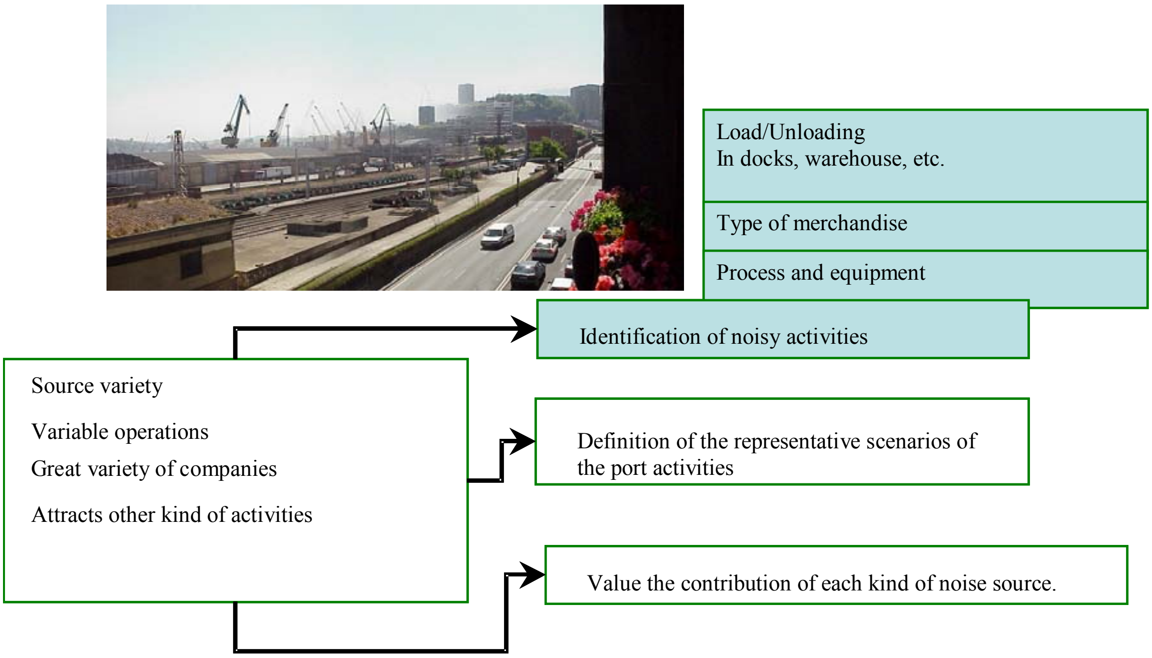
Intermediate hours: 7h up to 8h (day) and 22h up to 24h (night) in labour day and 9h up to 10h (day) and 23h up to 1h (night) festive day.

From the previously exposed, it derives that the accomplishment of an acoustic evaluation applicable to Port Infrastructures, must comply **AT THIS MOMENT** the Autonomic Law's requirements, or in its defect, the Municipal ordinance's requirements, and in the **FUTURE** will have to fulfil the Noise Law of the State and its corresponding Regulations.

As regards to the obligatory nature of the accomplishment of an acoustic study (Noise Map), the port infrastructures within the reach of Directive 2002/49/CE, will be those within the boundary of an agglomeration as defined by the competent authorities.

4 DIAGNOSIS METHODOLOGIES

The noise problem in Ports is considered from the perspective of a situation with a great variety of sources of variable operation, which can induce an important set of representative scenes of the operation of the port.



It is known that the assessment or diagnosis of an acoustic impact can be oriented from two main ways of acting, and each one with its followers and detractors. On one hand, there is the most traditional way, based on the accomplishment of noise measurement by means of more or less complex Monitoring Systems. On the other hand, it is the use of prediction models of specific acoustic impact for each type of source.

As a function of the followed objectives, the most suitable configuration of the two ones, or even a combination of both can be raised. In the following sections, it is shown a vision of the two ways of acting, presenting its pros and cons, as well as a general guide of application.

4.1 MONITORING SYSTEM

4.1.1 What is a Sound Level Monitoring System?

Basically, it consists of a set of terminals of sound levels gathering, connected all of them to a central unit, with a multiple function to store, analyse and to serve the information processed in suitable formats.

The specific objectives of a Monitoring System (or Network of Monitoring) are defined considering aspects such as:

- Determination of the degree of fulfilment of noise levels according to applicable legislation.
- Observing trends of the evolution in the time
- Determination of alert situations
- Evaluation of injurious effects on the people
- Informing people, etc.

Exactly, on the case of Port Activities, the election of the equipment of the Monitoring System would be based on the fulfilment of the double objective of:

- Represent the sound levels of a set of operations developed in the port area, which can characterise the acoustic environment of a certain area at any time of the day or the night.
- Establish a **control system that** in conjunction with a Noise Map alerts of the possibility of an acoustic impact in the residential zones when the measured levels associated to a certain activity of the port overcome the sound limits.

The definition of the M.S. is based on giving answer to a series of questions:

- Number of terminals, the location, use and operability of them (fixed or mobile) considering the concrete sources and their future evolution, as well as the presence of present or future urban zones (new urbanisation).

- Acoustic parameters to be measured and the measurement protocols. Therefore, the specifications of the Directive of Assessment and Management of Environmental Noise (2002/49/CE)will be taken into account. The measurement protocols also will take care of the specifications of the Spanish, European and international norms on environmental noise.

- Viability to apply uniform criteria that can entail an important diminution of maintenance costs and a more effective management. The equipment of the M.S. will have to be guaranteed by means of fulfilment of state and international norms and through its international recognition and guarantee of operation in similar experiences.

- Necessities of computer tools for the data processing of the different stations for the calculation of the indexes, representations of evolution, statistics and elaboration of result reports. The capacity of these tools will be valued to provide these result reports in compatible formats with web pages for its possible spread.

- Different data transmission alternatives as the connection via switched telephone, RDSI and GSM.

- Valuation of the quality of the data that is considered basic for the good operation of the system by means of preventive and corrective maintenance of the network that incorporates calibrations of equipment, protocols in case of failures and repairs, as well as detection of erroneous values, etc.

- Consider the human resources that are necessary for the management and operation of that network.

- Considering compatibilities and complementary developments of integration of the M.S. in more extensive networks (for example the atmospheric pollution network) and in systems of integral monitoring (for example, platforms of geographic information systems GIS).

The use of Monitoring Systems is a practice relatively extended in the urban surroundings (examples: Madrid, Bilbao, Barcelona, Valencia), generally accompanying another type of environmental monitoring (air), and in the control of very located noise sources as the takeoffs and landings of aircrafts (AENA).

4.1.2 Scaling of a Monitoring System

The first point indicated in the previous section for the definition of a M.S. has been the **number** of terminals/monitors of the network, and their **location.** Maintaining relation with the double objective that has been mentioned, the answer to both questions is based on two main options:

1. *Monitoring of sound levels of immission (receivers in dwellings) or emission (close to sources)?* The positioning of the monitoring stations in the residential zones with greater degree of exposition to the noise originated by the port activities, obviously offers the possibility to receive in real time, the acoustic impact that is being generated on the dwellings.

   Nevertheless, it is not very common to find an area of dwellings or buildings with special sensitivity to noise (schools, hospitals, culture centres...) that are only exposed to the influence of port activities. Since the presence of other noise sources of environmental nature (roads, railways...) is very common, they interfere in the result of the measurements, and it is complicated to carry out a direct assessment of the particular impact of the port.

Even in case of having the ideal situation in which the works of the port appear like the main noise source, when establishing a program of noise mitigation for an hypothetical acoustic impact, the difficulty to differentiate the contributions of a certain source between the set of activities is added.

Finally, and due to the subjective nature of noise, it is difficult to predict the effect, well of alarm or of confidence that would cause the presence of measuring equipment on the population.

On the other hand, the location of the monitoring stations in the proximities of certain sources, although it does not facilitate direct data of affection (with the problems that have been mentioned), it allows to make a continuous monitoring of its operation. Therefore it will be possible to establish maximum limits of emission, and therefore, it will allow detecting uncommon variations as a function of the registered sound levels.

In addition, the use of this second option of equipment location together with a Noise Map can allow the estimation of possible impacts in areas of the port surroundings.

2. *Fixed or mobile station networks?* A more or less dense network of fixed monitoring stations can, at a certain moment, with the support of a limited number of complementary measures of short duration, get to allow the generation of the Noise Map of the Port. As an example, the experience of the municipality of Madrid can be mentioned, where applying this methodology the updating of its Noise Map has been recently finished.

   In a changing surrounding like a port area, it is probably of a greater utility to have a set of mobile equipment in a mobile route through different locations in the port, which allows to value the variability of sound levels.

   Even if the fixed network is more comfortable (the movement of the mobile equipment requires a certain effort and the necessity of appropriate surroundings in order to locate it), it is evident that the economic cost is different in comparison with mobile equipment.

Once again, the starting objective raised for the M.S. will condition the decision in one or another sense.

4.1.3 General Criteria for the Location of a Monitoring System

From a ***point of view of the needs***, the three following possibilities represent an obvious visualisation of the aspects that have been exposed previously and that identify a Monitoring System.

a) If there is a precise problem in a certain area and with a certain source, the location of two synchronous equipment in the proximities of the source and in the proximities of the affected zone, could serve to determine the overcoming of a limit and associate it to a certain moment of the process. Therefore, corrective and/or sanctioning measures can be applied.
b) If there are multiple problems, the same process of point a) can be applied, extending it to each case. In this point, the use of mobile equipment seems to be the most recommendable acting.
c) If there are not specific problems (identifying the problems as the complaints of the surrounding population of the Port), the M.S. could be oriented towards the travelling control of the noise sources closest to the population or zones of future residential development, in order to control that noise levels remain in a range where they don't originate complaints.

Once the objective of the M.S and its general location are identified, ***from a practical point of view***, a set of indications concerning acoustic and operative issues can be given, in order to decide its concrete location.

a) Natural and artificial screenings have to be avoided, i.e. the vision between the microphone of the monitoring station and the source has to be direct.
b) It is preferable to select high locations to allow the fulfilment of the previous point, and to

allow the establishment of relations with sound levels at other points, because without the presence of the elements at ground floor (buildings, materials...) it is easier to establish these relations.

c) The presence of reflecting elements in the surroundings of the microphone has to be avoided. The influence of the façade of the building will be considered, taking into account the appropriate corrections in case of being required by the applicable norm.

d) Whenever it is possible, the influence of sources from outside the port will be avoided, orienting the microphone.

e) The monitoring equipments in continuous have batteries that allow to work during limited periods of time with no connection to the network. The batteries are only used as preventive solution in case of a cut in the electrical provision. The usual way of operation requires the permanent connection, so an accessible and safe tension point is fundamental.

f) Both fixed and mobile equipments have a central unit of reception, storage and transmission of information that is collected in a solid box which is prepared to allow to operate when there are problems. In spite of it, due to the continuous transit of merchandise (trucks, fenwick, trains...), in a port area it is recommendable to protect this box, placing it in high point.

4.1.4 Configuration of a Monitoring System

Once the location of the equipment of the Monitoring System is chosen, the most appropriate internal configuration has to be raised according to the specific objectives. The basic aspects that have to be taken into account are the following:

- **Acoustic parameters**. Generally, a system with these characteristics uses a wide catalogue of acoustic parameters (L_{eq}, L_{max}, L_{min}, $L_{pk(Peak)}$, $L_{(SPL)}$, $L_{(Inst)}$, L_N) and the most suitable for each case is chosen. Frequency weighting (A, C, L) and time weighting (step (F), show (S), impulse (I)) are appliable in all of them.

  Certain acoustic parameters can be obtained in overall level and in frequency bands. The second option is used in particular cases of study of the action of a certain source, in the search of solutions or in the sanctions for the presence of tonal components.

A standard configuration will be usually composed by the Continuous Level Equivalent (L_{eq}) and by the Maximum Level (L_{max}).

- **Report intervals**. The equipment is able of storing sound levels reports of time intervals between 1 second and several hours. For long-term monitoring (1 year), considering that the objective is to assess the variability of the sound environment of an area, it is common to use a one-hour interval. In case of considering a detailed follow-up of a certain source or activity, the report intervals can be reduced, being also common an interval of 10 minutes.

- **Unloading intervals.** The information stored in the terminals will be unloaded automatically to the central unit in programmed intervals. Although the terminals have considerable capacity for storing the information, it is convenient to download it twice or three times per day in order to avoid an excessive accumulation of information.

4.2 MODELLING METHODOLOGIES

4.2.1 Prediction models of acoustic impact

The main reason to choose this methodology is that once a model with an acceptable precision is obtained, apart from the knowledge of the sound levels of the considered area, it is possible to assess the variation of some parameters that affect on the noise levels, land-planning changes can be analysed, or the sound impact due to a certain project can be predicted.

In order to achieve a knowledge of noise, it is important to carry out a study that considers the influence of, at least, the most characteristic parameters to obtain the sound levels generated by each source in order to determine how contributes each source.

There are several models in different countries. As it has been explained in the introduction, although the European Directive about Assessment and Management of Environmental Noise admits that none of the methods used nowadays satisfies the requirements established by it, it defines some interim calculation methods for those countries which do not have their own official methods. In the case of industrial sources, this method is **ISO 9613-2, 1996.** In the case of road traffic it is the French norm **XPS 31-133, NMPB Method.** In the case of railway noises it is **the Dutch Method, Standaard-Rekenmethode II**.

The application of this calculation methods to the propagation between sources and receivers in an urban environment is very complex and requires the use of acoustic calculation models. These models analyse the sound propagation paths, they study the factors to bear in mind in each case, and apply the formulas defined in the calculation methods to obtain the sound pressure levels in the receivers defined to characterise the surroundings. Some of the methods that are available currently in the market are: IMMI, MITHRA (CADNA), SOUNDPLAN, LIMA, PREDICTOR.

A prediction model is applicable either for the study of an acoustic situation of a certain area (acoustic impact study) as for the study of extensive areas (Noise Maps).

4.2.2 Modelling process

The steps that have to be followed in a modelling process are organised in a set of complementary actions that led to the achievement of the acoustic diagnosis of a certain area. The steps to follow are:

1. **Cartographic base preparation:** The geographical simulation of the area under study must be build up, considering all the elements with influence in the sound propagation: form (isolines) and types of ground (acoustic absorption level), as well as buildings and obstacles (screenings, reflection and diffraction of sound).

The digital acoustic model of the port is particular in each port and depends on the operations and locations of the sources that exist or may exist. Thanks to that, a simulation of any operation in the port can be made.

2. **Identification of sources.** First of all, qualitative criteria have to be set in order to identify the most important port operations considering their potential to generate sound and depending on the type of source (punctual, linear or area source). In order to do that, a general description about each of them and their operating way in the space and time is carried out. For instance a description of these operations could be made by means of:

- Loading and unloading of the material as a function of the type of material and the equipment used.
- Movement of load in the wharves, using the same criteria.
- Vehicle alarms and machinery in the wharves.
- Entrance and exit of loads transported by train or truck.
- Activities in workshops and ships of the port.

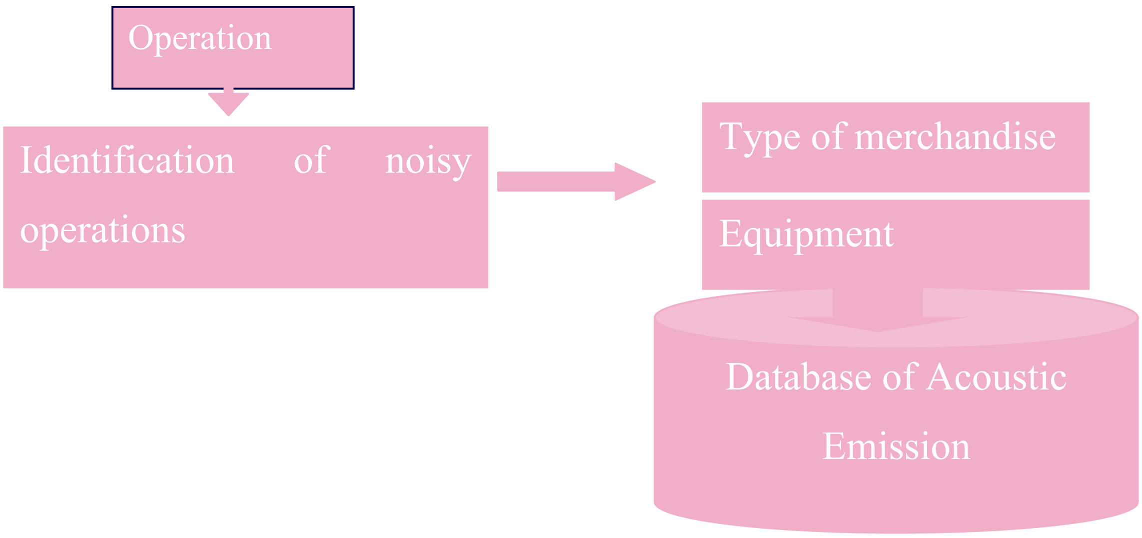
The inventory of noisy operations that have to be considered will be defined by the processes with high capacity to generate noise in a precise moment, by activities of greater number of movements or tons moved, by night activities, and finally, by activities developed near to residential areas.

3. **Definition of the acoustic emission.** For each noise source and according to the associated

method (ISO 9613-2, 1996, French Regulation XPS 31-133, NMPB Method. Netherlands Method, Standaard-Rekenmethode II), the information that allow characterising its acoustic power level will be gathered.

Therefore, if the sources are identified as industrial, the international regulations stated in the European Directive for industrial source emission will be applied in a simplified way: ISO 3740 or ISO 8297 series. Moreover, it is important to take into account the specifications of the Directive 2000/14/EC transposed by the Royal Decree 212/2002 of 22nd of February on sound emissions on the environment generated by determinate equipment for use outdoors.

For the emission of the transport network (railways and roads) related to the port activity, and for the application of the methods mentioned in the Directive: *Guide du bruit des transports terrestres*, for roads, and SRM II, for railways, the information about trucks gauging and annual average of train traffic will be gathered.



The Database of Acoustic Emission of Noisy Port Operations is the tool that will allow characterising the capacity to make noise of the more relevant operations, either because they play an important roll in the port or because they occupy a big area on the port.

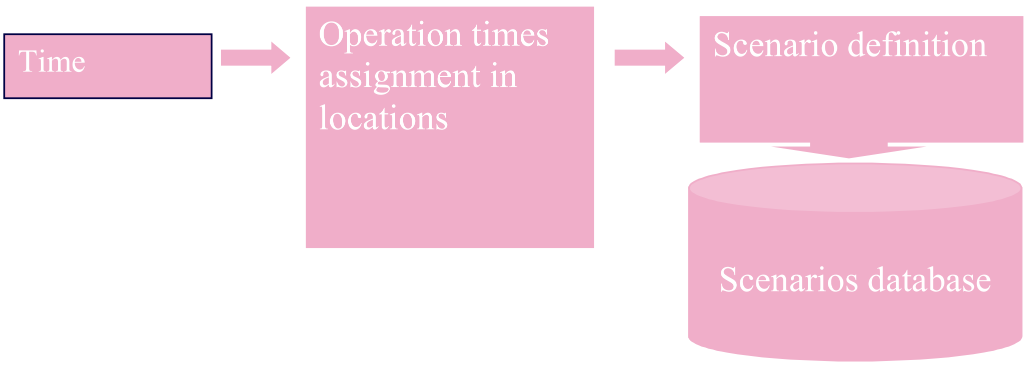
This characterisation is independent of the surroundings, location and operation periods. Therefore, it will be suitable for the use in different ports, to obtain from locations and hours scenarios, its representative average emission levels.

4. **Establishment of calculation scenarios.** The activities developed in different wharves of the port areas are very variable. Therefore, to analyse the noise they generate, different representative scenarios will be defined and agreed with the Authorities of the Port. The definition of a representative scenario consists of the enumeration of port operations, its locations and operation hours, which make it possible to characterise its sound impact in the surroundings.

It is appropriate to establish these study scenarios:

- Scenario of levels associated with the **average activity** of the port. In order to do it, statistical data of the movement of each type of material and the way they are loaded and unloaded will be analysed.
- Scenario of the **maximum level** of noise generated by the port. The effect of the highest noise levels generated by each type of activity will be analysed.

The meteorological conditions are an additional factor that has to be considered in the scenario definition. Since the wind direction and the thermal inversion effect due to changes in the temperature are very important in the propagation on sound levels, it is proposed to combine the previous scenarios with the theoretical meteorological conditions proposed by the Directive 2002/49/CE, and the most usual meteorological conditions in the area under study. Therefore, it will be very useful the information given by the meteorological station of the port.



5. **Sound levels propagation.** The study of sound propagation in open field has been the object of numerous investigations in which different calculation methods quantifying diverse effects that have influence on the propagation were created (section 4.2.1). In general, these effects are limited to the following attenuations: geometrical divergences due to the distance between the source and the receiver; Air absorption; Ground absorption; Reflections on surfaces close to the source or receiver; and finally, the effect of sound diffraction on obstacles found in the propagation path.

- Geometrical divergences (A_d): attenuation due to the distance between the source and the receiver.

- Air absorption (A_a): energy loss caused by the particles present in the atmosphere.

- Ground absorption (A_g): attenuation related to the kind of ground and to the height of the transmission path between the source and the receiver.

- Reflections (A_r): contribution to the level on the receiver of the transmission paths that have suffered reflections on surfaces close to the source or receiver.

- Barrier (A_b): Attenuation due to the effect of sound diffraction on obstacles found in the transmission path.

The generic formula that describes the calculation of sound immission levels could be the following:

$$L_p = L_W + A_d + A_a + A_g + A_r + A_b$$

That way, the noise level at reception, L_p, is obtained by applying the attenuations produced by each one of the considered effects on the emission level.

6. **Representation of results.** A Noise Map, in a general definition, is a set of graphic and numerical information, which represents the acoustic situation of a certain area. The acoustic model obtains the noise levels that characterise the considered assessment periods of the day in each one of the reception points of the net defined a priori. From the external noise levels, the isophonic lines are created in 5dB ranges corresponding to the noise levels of each kind of source considered in the different assessment periods.

The maps which represent the noise levels of the port environment at 4 metres above the ground and, at least, for these parameters (Directive 2002/49) will be represented:

- Continuous equivalent noise level day-evening-night LDEN and
- Continuous equivalent noise level night LNIGTH

In order to complement the analysis of the situation, a study of noise levels on building façades at different heights will be carried out. In buildings that are sensitive to noise located in the urban environment of the port some receivers will be located too. From this noise levels the impact on all the buildings of the surroundings can be represented. The results are similar to the ones obtained in an environmental noise measurement in accordance with the ISO 1996 norm.

One of the advantages when using prediction models is that in the reception points, the different source’s contribution to the overall level can be analysed, in order to establish the relation between sources and receivers obtained from the propagation conditions laid down by the study.

7. **Valuation of the impact.** This last step is very common in every diagnosis methodology, and it is based on the comparison between the obtained sound levels with some assessment criteria that usually are a set of acoustic limits.

4.2.3 What is a Modelling?

The use of prediction models together with advanced representation systems such as GIS systems (Geographical Information Systems) will involve the most up-to-date Acoustic Diagnosis processes. These are usually materialised in computer science applications that:

- Allow checking and updating the noise levels of a certain environment.
- Generate graphical representations of noise levels on cartographic bases (Noise Maps and Strategic Maps).
- Are based on advance technologies: Geographical Information System (GIS) and Noise Prediction Models.
- Facilitate the preparation of Action Plans to minimise acoustic pollution, and citizens' access to the information about noise in their environment.

The general scheme of a Noise Management System, which is structured according to the used Legislation, Users, Tools and Models, is represented in the next Figure:

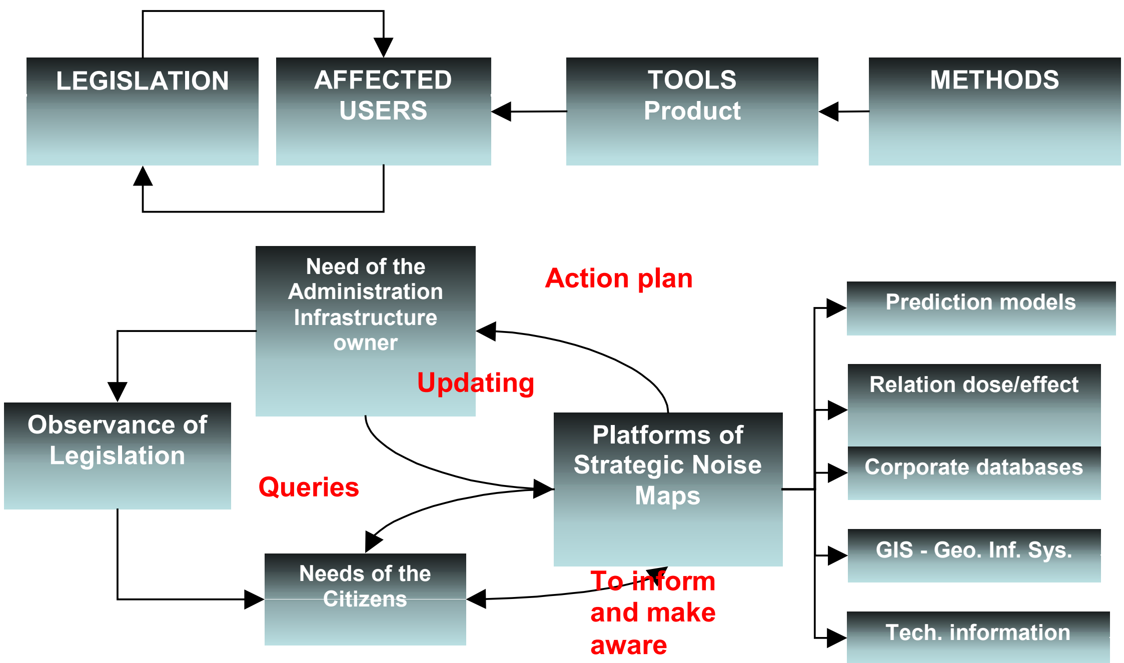
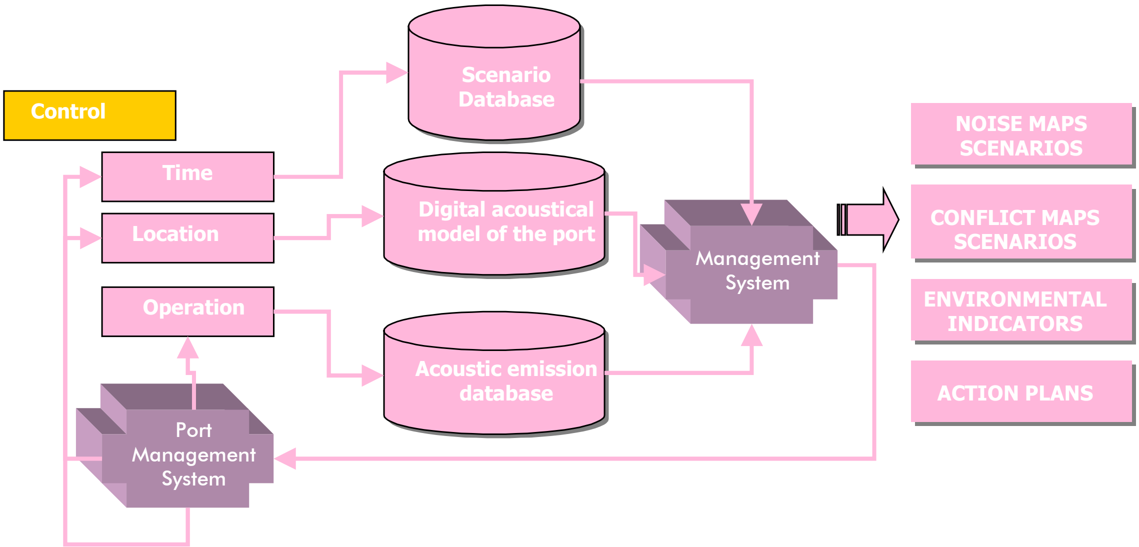


Figure #4. A basic scheme of a Noise Management System

Finally, the Noise Management System would be more effective, if the necessary aspects for a modelling process will be integrated with the Port Management System.

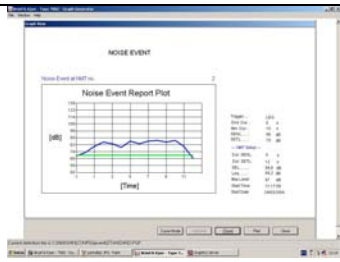


In this way, the noise management of port activities would be carried out in a harmonised way in all the Spanish ports. That would allow guaranteeing that the results obtained in impact valuations would be comparable. Moreover, it would make it possible to reuse the information about similar port operations.

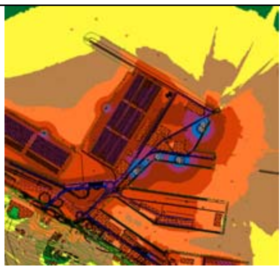
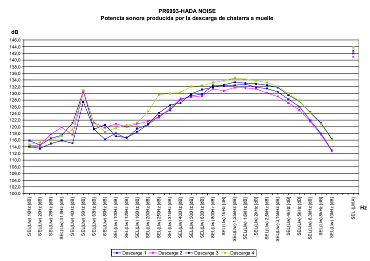
While the tools and instruments that facilitate this objective are implemented, the attainment of actions directed to avoid the proliferation of new acoustic pollution problems in the environment will be guaranteed. Moreover, they will facilitate the control of the activities in order to optimise its benefit-cost in order to minimise the current impacts and the protection of areas with an appropriate acoustic environment (quiet areas).

4.3 COMPARISON BETWEEN DIAGNOSIS METHODOLOGIES: Measurements vs. modelling

In the following schemes there is a list of advantages and disadvantages that result from the application of each diagnosis methodology.

MONITORING SYSTEMS		
		

Advantages	Disadvantages
○ Direct measurements with results in real or quasi-real time ○ It can function as an alarm system when limit levels are overcome ○ Well-known technology ○ Uncertainty control in the equipment	○ The results depend on meteorological conditions ○ Results of a small area ○ Starting investment and later maintenance. ○ Influence of environmental sources that are not related to the object of the measurement

MODELLING	
	

Advantages	Disadvantages
○ Simulation of existing and fictitious scenarios ○ Assessment of improvements obtained with corrective actions ○ Results in a bigger area ○ Possibility of integration in Strategic Management Systems	○ It works with average situations. ○ It is based on mathematical equations with the simplifications that involves.

The reciprocal compensation of the possible deficiencies of each diagnosis methods seems to recommend the combined use of both. That way, on the base of a Noise Map developed with prediction models (adjusted with actions obtained from the Monitoring System) with an appropriate number of terminals, an exhaustive control on different port activities can be carried out in order to avoid and/or correct the possible acoustic impacts.

The specific extent of the monitoring station network will depend on each port environment, on the different noise sources, on its positions with regards to urban areas, quantity of complaints, etc. It would be reasonable to start the structuring of the System with no more than two units and increase the number according to the needs.

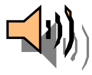
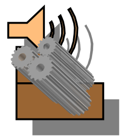
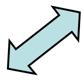
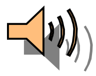
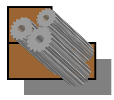
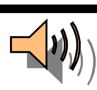
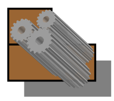
5 NOISE SOURCE INVENTORY IN PORT SURROUNDINGS

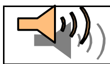
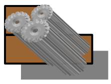
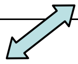
No matter which acoustic diagnosis method we choose, it is important to carry out an identification process or a noise source inventory. Though it can seem obvious, it will allow to concentrate the efforts and resources in those that are more relevant.

The structure of the port system belonging to the State consists of 27 Port Authorities distributed along the Spanish coast.

Figure #5: Port Authorities in Spain (website of the Ports of the State)

From the information about the activities usually carried out in those 27 Ports, a classification of noise sources that can be identified in port activities has been carried out. They have been grouped together in accordance with **three priority levels.**

Priority level	List of noise/activity sources	Source
HIGH	Iron scrap (unloading from boats to wharf and loading from wharf to truck)	
	Iron and steel products	
	Containers	
	Fitting-out, repair and scrapping	
	Ship construction	
	Truck traffic	
	Railway	
MIDDLE	Free-port warehouse (depending of the type of merchandise)	
	General Merchandise (non-ferric metals, wood, paper, paste...)	
	Ro-Ro berths	
LOW	Liquid bulks with and without special installations	
	Solid bulks with and without special installations (concrete, cacao, coffee, coal, manures...)	
	Oil products due to special installations	
	Fishing: market, refrigerators, ice plant...	
	Passengers: ferries, cruise ships	
	Sports fleet	

	Noise source characterised as PUNCTUAL
	AREA noise source.
	Noise source characterised as LINEAR.

Obviously, apart from the priority level assigned to a certain source, its potentiality to generate an acoustic impact will depend on its relative position in relation to inhabited areas.

In the **figure #6,** there is an example of a port area divided in areas which are classified according to the three priority levels: HIGH (red), MIDDLE (yellow) and LOW (green). Both the roads and the train railways are considered in one or another group, depending on the daily traffic volume and the average train movements.

Figure #6: Identification of noise sources in the Port of Bilbao. Classified by priority.

6 ACOUSTIC CHARACTERISATION OF NOISE SOURCES

From the noise levels originated by one activity/noise source of the port in a concrete station of a monitoring system, the evolution of this source can be studied, and relations between noise levels and determined parameters (number of containers, ton/year, and number of movements...) that define the source can be found, characterising acoustically some way the noise source.

This way, in theory depending only on the results from the monitoring system, a "system of prediction" of impacts could be defined, with which possible variations of noise levels based on variations in the parameters that define the activity of the source can be defined.

Actually, the set of variables that take part is too ample to guarantee that the predictions are made with a reasonable precision. Generally, it is when raising a diagnosis based on models when the acoustic characterisation of sources really has meaning.

But, also in this case, the characterisation process can be solved with different degrees of precision, based on the complexity of application, the confidence in the wished results and the cost.

In the following Table 7 options or levels of characterisation are shown, valued as a function of the three mentioned variables: complexity, confidence, and cost.

The valuation has been represented by means of a star code, in which 5 is the maximum and the 1 the minimum.

Acoustic Characterisation Level	Complexity	Confidence	Cost
Complete Area. Use of standard ISO 8297:1994 (Determination of acoustic power levels of industrial plants multisource for the assessment of sound power levels in the environment).	****	***	***
Power of each source. Use of data provided by the manufacturer.	**	*****	*
Power of each source. Use of the set of standards ISO 3740: 2000 (Determination of acoustic power levels of noise sources)	*****	*****	*****
Power of each source. Use of the noise power limits gathered in the Directive 2000/14/CE (Noise emission in the environment due to the machines of outdoors use), in case that the sources are included in the Directive.	**	**	*
Power of each source. Using a simplified adaptation of norms ISO 3740.	****	****	***
Databases. Equipment and noise sources similar to the ones of study.	**	**	*
Use of values by defect (Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure). Power level (Lw) by m^2 for day, evening and night: 65 dB(A)	**	*	*

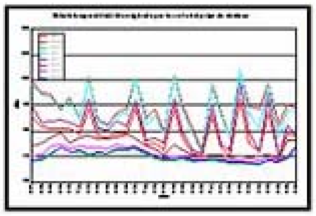
In a process of acoustic diagnosis, it will be difficult to find a situation in which data of acoustic power of each noise source are available. On the other hand, the application of the first level of characterization entails a degree of important difficulty in surroundings next to other environmental noise sources (urban roads of traffic, city centre, industries...), and the procedures established in the norms of third level are sometimes very difficult to apply or inapplicable.

Because of this the application of the fifth level of characterisation is very common (in blue), as it is a balanced commitment between quality of results and difficulty of application.

Basically, the process consists of the accomplishment of noise levels measurements in the surroundings of the considered sources, sufficiently close to the source to avoid external influences. The measurements have to be carried out preferably in 1/3-octave bands, gathering the operative cycles of each noise source. In the following scheme the process is shown step by step.

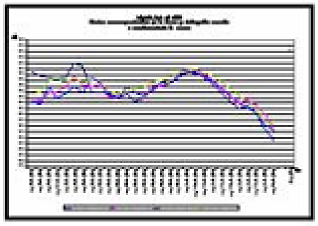
First Step

Analysis of the evolution of the activity
Determination of the noisiest events and its duration. Establishment of complete cycles of activity



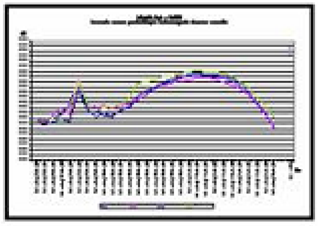
Second Step

Punctual measurements of noise levels in frequency bands, to characterize each noisy event or cycle of operation



Third Step

Spectrum of the noise emission of the cycles and events



Fourth Step

Extension of the noise emission of the cycles and events, to the noise emission of the defined scenarios based on n repetitions of both.

L_w (dBA)	63Hz	125Hz	250Hz	500Hz	1KHz	2KHz	4KHz	8KHz	Σ
Tipo OA	97	106	113	121	127	128	127	121	**133**
Tipo 12	100	103	108	116	121	122	120	113	**127**

Figure # 7: Noise levels registered during the measurement campaign in the Port of Bilbao.

7 VALUATION CRITERIA

The valuation of a potential acoustic impact towards the outside must be based logically on the fulfilment of the current environmental legislation, as it has been indicated in the section 3. - LEGISLATIVE FRAME. In the case of port activities, it will be the future regulation of the Noise Law (37/2003), and currently the corresponding autonomic law or in its defect the municipal ordinances.

Any of them raises the assessment/valuation in the overcoming of certain external limits. The limits depend on the acoustic land use and on if the situation is consolidated or planning.

Taking these limit values as a valuation criteria, a Port Authority can try to establish intermediate initiatives, all of them directed to facilitate their attainment.

a. Limitation of noise emission of machines/sources. The equipment used in the port surroundings, should be adjusted as far as possible to the last technological innovations on acoustic attenuation. In the first place, to guarantee the fulfilment of the Directive 2000/14/CE (Noise Emissions in the environment due to the Machines Used outdoors), of those machines abided by its scope of application. And secondly, to encourage the use of quieter equipment and techniques, for example by means of the offer of monetary incentives or another kind of incentives to the Management Companies.

b. Processes or activities with limit noise levels. By this principle, the area of the Port is structured as an industrial estate, being each Concessionaire responsible for the noise levels that originate in the limit of their parcel. This initiative requires of a previous study that allows establishing the noise level in the limit of the parcel that guarantees the fulfilment of the general criterion of inmision.

c. Limit noise levels in the perimeter of the port area. The same principle of the previous point is raised but in this case applied to the whole set of activities in the Port. The difference with respect to the previous point, is that while in the previous case the Concessionaire can carry

out micro-actions or local actions to obtain the objective, in this case the Port Authority can raise macro actions that imply simultaneously to more than one activity.
In comparison to the general criterion of immision, this presents the advantage to make the forecast and control of the impact from the same property of the Port, not being necessary the access to the potentially affected zone, nor the interaction with the population.

8 APPLICATION OF CORRECTIVE MEASURES

An analysis of corrective measures directed to the attainment of a certain degree of acoustic attenuation, it is always considered from three points of view: EMITTER, PROPAGATION PATH, and RECEIVER.

The actions accomplished on the EMITTER are generally the most complicated to implement, but with which the most outstanding results are obtained. In more or less industrial environments, the actions directed to the EMITTER usually are in contrast to the usual dynamics of the productive processes. For this reason, their application, although technically possible, is usually discarded as first option.

Secondly, actions to be applied in the PROPAGATION PATH can be raised. Structurally, this type of corrective measures is centred in the interposition of elements (acoustic barriers) that interfere in the transmission of the sound between the emitter and the receiver. The maximum effectiveness of this type of solutions, takes place when they are located near the source or the receiver. Both cases usually are little habitual, either by the same interference mentioned on the productive processes, or by the rejection of the population to a distorting element near their house. The most extreme case of acting on the PROPAGATION PATH, corresponds with the redistribution (or distribution in origin) of the structures that conform the port area (buildings, markets, warehouses...) so that they act like acoustic barriers.

As last option of corrective measures, actions on the RECEIVER are usually undertaken. Basically, they consist of the acoustic rehabilitation of the most affected façades (change of windows). Its effect is only facing the interior of the building, and evidently they stop being effective if the windows remain open (summery period).

Evidently, corrective solutions or measures, that with universal character can be directly applied to any problematic of noise in port surroundings, are not technically definable, still more considering that the validity or not of a same system depends to a great extent on the particular characteristics of each surroundings: position and height of the noise sources, direction with respect to the potentially affected zones, operation hours, distribution of buildings and screening elements, volume of activity.

As a guide, in the following table a set of different types of corrective measures have been gathered, distinguished as far as possible to the case of a port, and as in the case of the acoustic characterization of noise sources, valued in the three categories of complexity, quality of results, and cost.

	Typology of Corrective Measures	Complexity	Quality	Cost
EMISSION	**Actions on the emission: modifications in the noise source**: Covering and correct closing of equipment and auxiliary facilities. Improvement of the free-port warehouse buildings' sound insulation where noisy movements are made (example pig iron) Use of the quietest equipment/machines of the market (vehicles of maintenance, Fenwick, trastainers, internal locomotives...) Selection of acoustic signals´ emission frequencies, that contribute to a faster attenuation with the distance (high frequency).	***	****	***
	Actions on the emission: good practices in the handling of equipment. Unloading of containers, scrap iron, trunks, iron and steel material from the smaller height possible. Even, the use of automatic systems that manage the unloading as a function of an altitude control.	**	****	*

	Typology of Corrective Measures	Complexity	Quality	Cost
	Action on the emission: access roads to the port Placing of porous surfaces in the access and exit roads of the port, and request of its placing in the public property sections Request of preventive maintenance in the railways of the surroundings of the port (rail roughness, elastic anchorages), elimination of track joints etc.	***	**	***

	Typology of Corrective Measures	Complexity	Quality	Cost
PROPAGATION PATH	**Action on the propagation path: location of sources.** Raise the operation of scrap iron load in trucks locating the scrap iron pile in such way that screens the dwelling zones. Load the trains from the opposite side to the direction of the houses, so that the own wagons are acoustic barriers. Study of new locations, adding the acoustic component in the design of the distribution of activities, buildings, zones of storages, etc.	*****	**	*
	Action on the propagation path: acoustic barriers The most common use of the acoustic barriers is its application in the limits of railroad and traffic roads. The effectiveness of these measures varies depending on the relative position between the source and the zones to protect. Although they can be raised as local solutions, the same linear acoustic barriers are not so effective in the case of punctual noise sources (scrap iron load and unloading), sometimes having to reach important heights (higher than the meeting point of the unloading).	****	***	****

	Typology of Corrective Measures	Complexity	Quality	Cost
RECEPTION	**Actions on the receiver: rehabilitation of façades** As a function of the received noise levels in façade and of the composition in frequencies of them, different glass combinations are considered in order to offer the sufficient sound insulation so that in the interior (houses, schools ...) comfortable sound levels are obtained.	**	***	*****
	Actions on the receiver: neighbouring actions Very satisfactory results in the reduction of local complaints have been obtained, when in forecast of exceptional noisy events (for example the nocturnal unloading of a boat), a policy of a priori information to the neighbours of the fact has been followed	**	***	*

9 CONCLUSIONS

In the last years the noise has become the environmental factor that has experienced a greater increase in the repercussion degree on the public opinion, and consequently, it has become a fundamental aspect in the strategic plans of potential noise sources' management. In this group, we can find the Port Authorities.

With the generic name of "Methodology of Implementation of a Follow-up, Assessment and Control System of Noise in Port Surroundings" different existing alternatives to fulfil this objective, and the aspects that must be consider when deciding one or another option have been gathered.

In summary, some of the treated aspects are the following ones:

1. Fulfilling of the Directive of Evaluation and Management of Environmental Noise (2002/49/CE), and of the Noise Law (37/2003). The port infrastructures that are included within an agglomeration will have to make the corresponding Noise Map according to the established terms in the Directive and the Law.

2. An acoustic diagnosis can be raised by means of the implantation of a Monitoring System (noise levels gathering terminals), by means of the use of acoustic impact prediction models, or by means of the combination of both.

The first method has the advantage of the continuous follow-up of noise levels, but the second has the possibility of generating real and/or fictitious scenarios. Both can complement each other, reinforcing each one the deficiencies of the other.

3. In a Monitoring System, the number and type of terminals to use, and the suitable location of the same ones must be decided. All depends on the goal pursued with the system and on the peculiarities of the concrete port. In any case, in surroundings with activities and locations

of variable noise sources, the use of sampling mobile equipment seems to be an appropriate option.

4. Like all modelling process, the modelling of a port's acoustic impact, has as primary objective the planning of corrective measures (in case of being necessary), by means of the simulation of alternative scenarios.

In this process, a correct acoustic characterisation of each source of noise is necessary, from which the noise emission or acoustic power level is obtained, and a faithful representation of the noise sources' operation cycles. The set of both allows representing the activity of the Port from the acoustic point of view.

The last evolution in this field is oriented towards the integrated Management Systems, in which the modelling and the measurements are combined with tools of geographic representation (GIS) to facilitate the consultation, management, updating, and decision making.

5. With the exception of the particular cases that can appear in each Port, the main noise sources are the same in most of the port surroundings, being the metallic elements movements (containers, steel workers, scrap irons ...) and the traffic of trucks and trains those that present the greater possibility of originating acoustic impacts.

6. In theory, it can be considered that the attenuation of noise levels originated by each one of the existing sources in a Port is possible. In practice, its application is in many occasions limited by the own way of operation of the Port. This principle of contrast is very common in industrial surroundings, reason why the applicable corrective measures are often centred in the own receiver, although this is by principle, the less desirable action.

In spite of this vision, that can seem somehow pessimistic, it can't be forgotten that simple actions related to the habits in the ways of operation of the workers of the Port, or considering the acoustic point of view in the planning or reconstruction of a certain surface, can suppose substantial improvements, that will not only affect in the acoustic environment in the zones of influence of the port area (neighbouring), but in the own workers of the Port.

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