NoMEPorts
NOISE MANAGEMENT IN
EUROPEAN PORTS

Good Practice Guide on Port Area Noise Mapping and Management

Technical Annex

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1 Introduction

This technical annex provides acousticians and the port environmental managers with practical guidance on the creation and interpretation of noise maps in port areas. The "Good Practice Guide on Port Area Noise Mapping and Management" is written for port (environmental) managers, policy makers, environmental authorities, spatial planners and strategic decision-makers. As such it can be seen as a generic, principles focused document. This annex provides additional technical detail and focuses on the use of software, gathering information and interpreting calculation results. It is complementary to the Good Practice Guide but it can also be seen as a stand alone handbook. The NoMEPorts studies were made with the software package Predictor (Brüel & Kjær**)**, but the principles and methodology that are presented in this report can be applied while using other noise calculation software packages.

In terms of content, the annex provides technical advice especially with regards to:

- The definition of the boundaries (both geographical and noise sources related) of noise studies in port areas (chapter 2)
- The response options addressing commonly encountered challenges in the phased approach of undertaking a noise mapping task (chapters 3 and 4)
- The means of validating the collected data and the produced noise models (chapter 5)
- The different options for presenting and interpreting noise maps (chapter 6)
- Generic conclusions are provided in chapter 7

The annex is based on the experience gained from the NoMEPorts project partners while undertaking noise mapping tasks in port areas.

The NoMEPorts project consortium consists of:

- Full partner ports: Port of Amsterdam (Project Leader), Port of Civitavecchia, Copenhagen/Malmo Port, Port of Hamburg, Port of Livorno, and Port of Valencia.

- Observer ports: Port of Bremen, Port of Gothenburg, Port of Oslo, Port of Rotterdam and Port of Tenerife.
- The partners were assisted by the EcoPorts Foundation (EPF, project management and dissemination), DGMR, Netherlands (noise specialists), and Cardiff University, UK (scientific coordination).

2 Boundaries of the port area

A common point of debate with regard to port area noise management is defining the boundaries of the area to be managed. Ports may well have clearly defined geographical limits based on legal designation, but when examining noise, one of the more trans-boundary and multi-source environmental aspects, the definition of the boundaries of a noise study in line with the port area physical boundaries does not appear to be a sensible approach. Port noise, the noise coming from inside the port area, influences the surrounding areas that also need to be taken into consideration. The noise study area should therefore include (1) the port area where the noise sources of interest are located, (2) residential and other noise sensitive neighbouring areas influenced by the port, and (3) areas between the port area sources and the neighbouring noise sensitive areas.

The port area can be seen as the area where ships are moored and the loading and unloading of goods takes place. This may provide only a narrow view on the ports' boundaries. Those may be extended to include industrial companies, tenants and operators within the port area. The selected boundaries for an acoustic survey depend on the impact the ports have. If already noise complaints focus on transportation, this matter has to be taken into account. If not so, the boundaries for the acoustic survey may be defined following a more narrow approach. With regard to the surrounding housing areas the nearest facades are the least that must be incorporated in an acoustic survey. The incorporation of further areas outside of the port area physical limits might be also necessary, especially when noise complaints about the port or port traffic give reason to do so. The expected noise levels from the various sources are also of significance. For the purposes of strategic noise mapping, at least the 55 dB L_{den} contours and the 50 dB L_{night} contours have to be presented. Those can be estimated by making initial calculations without screening and reflections from buildings for the residential areas. This will provide information on where the limits of the region of interest may reasonably be located (See Toolkit 1 at the end of this annex, see also GPG WG-AEN paragraphs 1.2 and 1.3).

The following figures demonstrate graphically the selected boundaries for the NoMEPorts noise studies in the Ports of Amsterdam, Hamburg, Livorno, Civitavecchia and Valencia respectively and they reflect the above mentioned principles.

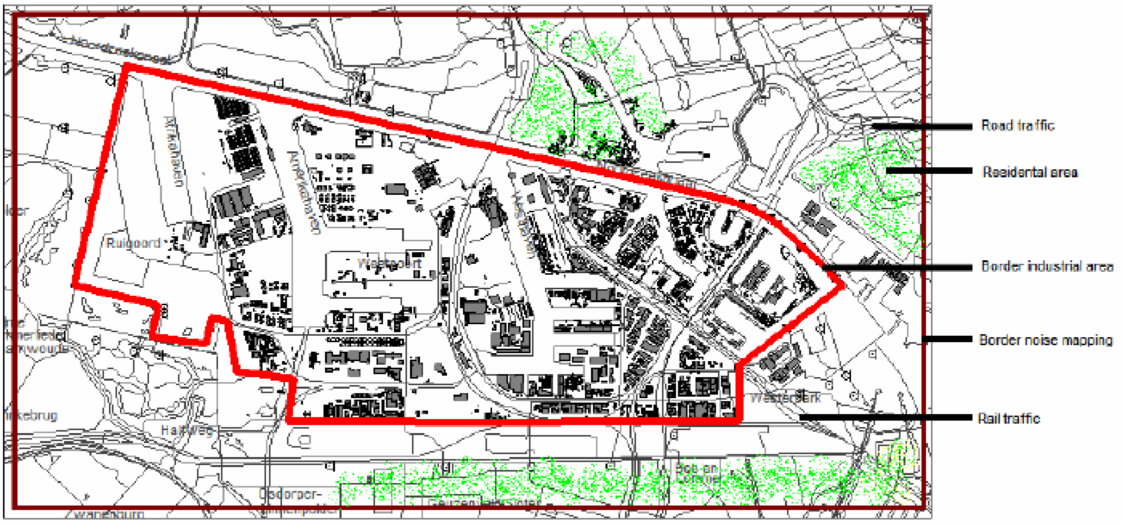


Figure 1: Boundaries of Port industrial area – Port of Amsterdam

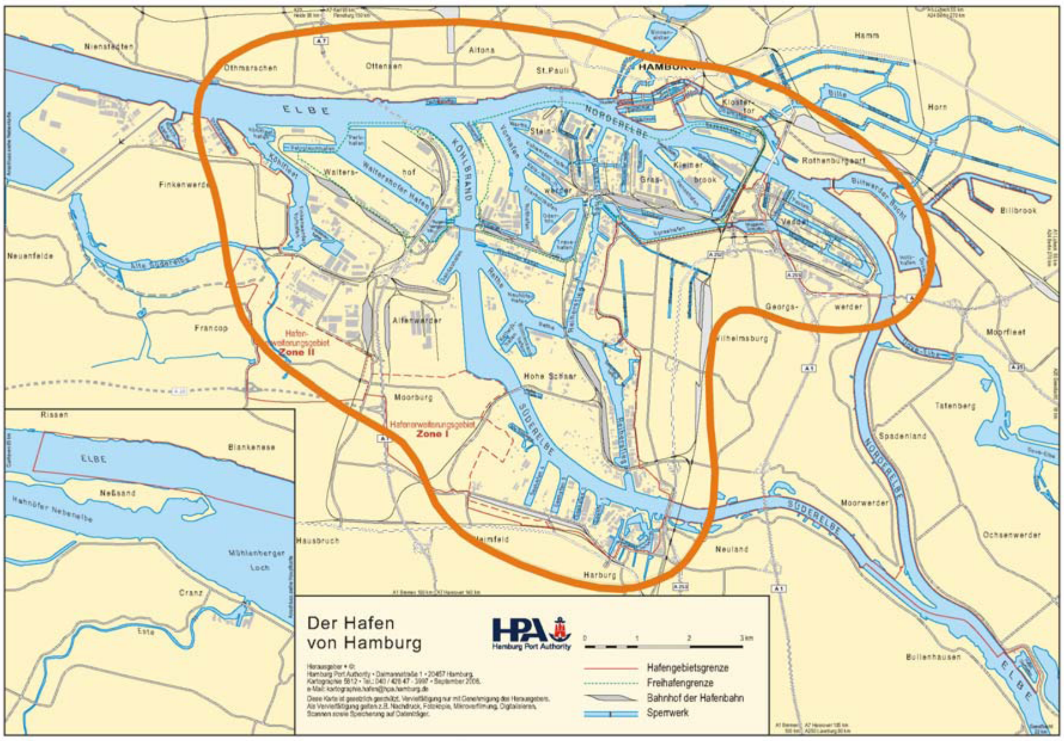


Figure 2: Noise mapping boundaries – Port of Hamburg

Figure 3: Boundaries of Port industrial area – Port of Livorno

Figure 4: Boundaries of Port industrial area – Port of Civitavecchia

Figure 5: Noise mapping boundaries – Port of Valencia

It is important to note that while extending the boundaries of the area of interest; also other noise sources (e.g. traffic noise) in this area may contribute to the overall noise situation. If the noise survey focuses only on the noise levels arising from operations within the geographical limits of the port area, then the influence of other noise sources may be discarded. In order though to assess accurately the noise situation and to plan mitigation measures, the consideration of noise sources only within the port area limits would not be advisable.

In the NoMEPorts studies, the sources within the port area were included and the transportation routes where port traffic was dominant were also incorporated. It was investigated and found that sailing ships had little influence on the overall noise situation, and therefore ship manoeuvring was not taken in consideration.

3 Noise mapping

This chapter provides technical detail with regard to the phased approach to noise mapping in port areas as this was outlined in the NoMEPorts GPG.

3.1 Generic function of noise mapping

Noise mapping is carried out with the aid of specialised noise prediction software. There are some well known products that can be employed to this aim; for the purpose of the NoMEPorts project the Noise Prediction Software Type 7810 Predictor (Brüel & Kjær**)** was selected**.** It is an advanced noise predicting and mapping software that implements the ad interim calculation models and the emerging Harmonoise/Imagine model. Although that a specific product was selected and used, most of the principles and examples that are discussed in this annex can be applied while working with other noise prediction products. The general schematic function of a noise mapping task is presented in the graph below.

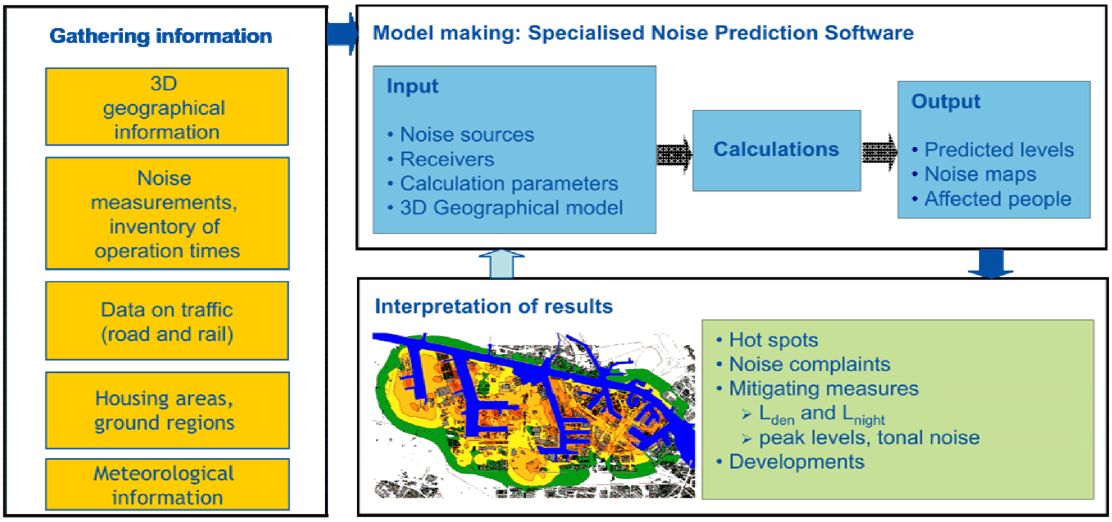


Figure 6: General schematic function of a noise mapping task

The software's input requirements include a 3-dimensional physical model of the area under examination, the inventory and then the modelling of the main noise sources that occur in the area and finally setting up the calculation parameters (meteorological data, locating the calculation points) to be taken into consideration. Outputs of the prediction software calculations could be predictions of noise levels in specific locations in the area and overall colour coded two and three-dimensional noise maps (figure 7).

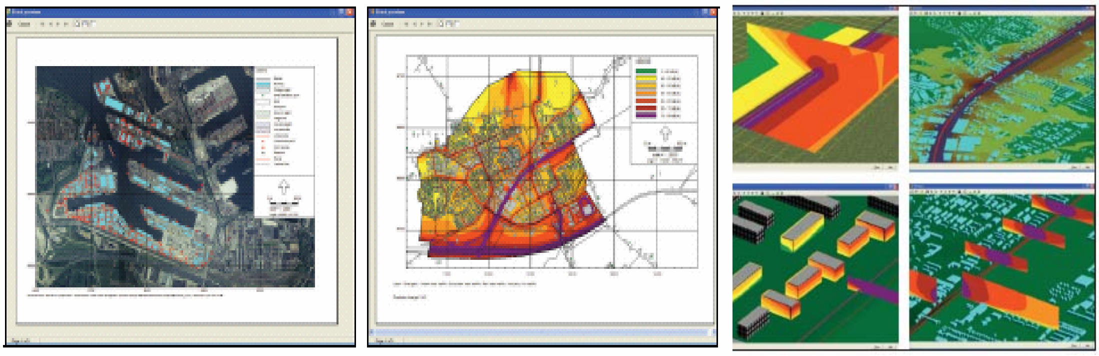


Figure 7: Results' display surfaces of the Prediction software

In the paragraphs that follow the process of noise mapping is discussed focussing on technical aspects, encountered challenges and responses from the experience of the NoMEPorts partners. The different distinct steps followed in terms of decision making, data collection and application are explained. Those include: selecting the appropriate calculation method, building up a three-dimensional model of the area, identifying, collecting relevant data, and then modelling noise sources, setting up the calculation parameters (chapter 4), running the calculations and presenting the results (chapter 6).

3.2 Selecting the appropriate calculation method

The European Parliament, in its reaction to the Green Paper on Future Noise Policy, noted among others the lack of reliable, comparable data regarding the situation of various noise sources in Europe. The Environmental Noise Directive (2002/49/EC) responded to that by defining a common, harmonised set of noise indicators and a common approach to the production and presentation of noise data from the member states. Member states shall produce strategic noise maps for all major roads, railways and airports, and for all agglomerations with more than 250 000 inhabitants. The – minimum - requirements for these noise maps have been specified in Annex IV of the END. It is stated there, that emphasis shall be put on road and rail traffic, airports and industrial activity sites including ports.

In the "Sustainable management of Europe's natural resources" program, under 1.5 (Environmental Assessment), task 3 refers to "Improving current assessment of environmental noise and noise impacts from railways, roads and aircrafts". This indicates that the Commission acknowledges the need for improvement of the existing methods, particularly for noise mapping but also for other purposes.

The purpose of these maps is not only to provide data to the Commission, but more specifically to represent a source of information to the citizens and to form the basis for noise action plans. This requirement sets specific demands to the character of the noise maps and to the way they were produced. In communicating noise maps to the public, the maps should be understandable, straightforward, unambiguous and credible.

The interim computation methods stated in the END are:

- ISO 9613-2 (noise propagation) in combination with other ISO standards for source sound power assessment, for industrial sources,
- ECAC Doc. 29 for aircraft,
- NMPB-routes-96 for road traffic, and
- Reken- en meetvoorschrift railverkeerslawaai '96 for rail traffic

In time, these Interim Methods may be replaced by the methods that are delivered by the HARMONOISE/IMAGINE project. These are aimed to be accurate and reliable methods which represent an important step forward from the above Interim Methods.

In this project, the calculation method HARMONOISE/IMAGINE is used. This has the following consequences:

- Use of advanced calculation method, better results
- Same noise propagation for all types of sources (industry, road and railroad)

- Same type of modelling data for all sources (ground impedance, reflections in facades, screening, etc)
- Long calculation times, since no optimized computation scheme is yet available
- Locally the results may not be used for strategic noise maps for the computation method may be prescribed to another method. The input data can be reused.
- The influence of the meteorological conditions is better incorporated in the Harmonoise/Imagine model. Therefore, the dominant wind directions around the calculation area can be part of the calculations.

3.3 Geographical information

A three-dimensional model of the area under examination forms the base for inserting the various noise sources and then calculating the noise maps in the software. The model should include all sorts of morphological and topographical data together with the main structures (buildings, infrastructure) that are present in the area under study (Table 1).

Table 1: Geographical data requirements

- Spot heights and contours
- Residential and industrial buildings (including height dimensions)
- Other obstacles in the study area (e.g. containers' formations)
- Location of noise sources: industry, main roads, secondary roads and railways.
- Location of noise sensitive areas (schools, hospitals, recreational areas)

Ideally this model would be already available in the port in compatible formats with the prediction software (usually AutoCAD or GIS). In that case the model can easily be imported into the software following the guidelines of the software's manual. Otherwise, such a three-dimensional model needs to be built. One option is building up the physical model using the AutoCAD or GIS software packages and then importing it to the prediction software. The second option is building up the model using the features of the prediction software itself, when available, although it may not represent the better choice, especially for mid-large complexity mapping area (see also Toolkit GPG WG-AEN pages 11-16). The data requirements for such an approach are summarised in table 2.

Table 2: Data requirements for building up a 3-D model within the prediction software

Data requirements for building up the 3D physical model	Justification
A two-dimensional map of the area under study (in Bitmap format)	To be imported in the prediction software and be used as a background for building up the three-dimensional model
Detailed topographical data of the area (relative and absolute heights, location and dimensions of buildings and infrastructure)	The core data in order to transform a two-dimensional model into a three-dimensional one
Data concerning the types of material in area surfaces, buildings and infrastructure	Each material has a different behaviour when it comes to noise reflection or absorbance and therefore the software requires that kind of information for every surface or structure in the model

Some NoMEPorts partners faced some challenges while attempting to import dxf-files in the Predictor environment.

- "In the Copenhagen case, the data was taken from 2-D maps produced by the port, because the 3-D city maps were too complicated and too time consuming to import in a satisfactory manner. Altitudes and surface types were then manually added. This was the most efficient way to produce the model but it was still very time consuming. Importing dxf-files in Predictor (used as wall paper for the digitizing of buildings etc.) raised huge problems because some of the AutoCAD objects were miss-interpreted by Predictor. Furthermore some ghost points caused Predictor to assume that the model to be very large (3-400 km). These points were not recognized by AutoCAD or by the Predictor's Zoom to fit option but were taken into account causing the program to respond slowly" (Port of Copenhagen).

Those challenges lead them to choose the option of building up the 3D-model using a 2-dimentional map as the starting point. Some of the main challenges encountered while following such an approach and the response to those challenges are summarised in the following table.

Table 3: Challenges while building up a 3-D model within the prediction software

Main challenges	Response
Importing the 2D bitmap file to the Predictor: A bitmap's file dimensions are described by a pixels' ratio (e.g. 3911*2221 for one of the maps that was used). Predictor requests from the user during the importing process the file's coordinates. If those are given as they appear in pixels (3911*2221) the software "reads" the pixels as being meters. In other words the software in importing the above map assumed that its dimensions where 3991*2221 meters which was incorrect.	The meters' ratio (2640*1500) of the imported file should be inserted instead of the pixels' one. In an accurate electronic file (not stretched) the actual ratio should be equal in pixels and in meters. In the case of the map we used 3911/2221 (pixels' ratio) equals 2640/1500 (meters' ratio) which are the correct map dimensions in meters.

Creating the morphology of the ground (height lines): Due to the basic modelling functions in the Predictor some complications occurred with regard to the accuracy in entering the different height lines to the model.	Simplified forms can be used with regard to the morphology when differences in height are considered to be insignificant. This is possible in the case of areas where small height differences are observed between one point and another.
Dealing with complicated infrastructural forms: Due to the modelling functions in the Predictor some complications occurred with regard to the accuracy in building representations of complicated infrastructural forms (balconies, watching towers, covered truck gates, container cranes)	Simplified forms may be used in line with the Predictor software's modelling capabilities.
Representing the containers' formation in the model: Containers are placed one on another creating stacks of different heights. At any given time the formation of the containers has got a different shape. The challenge is finding a way to represent those dynamic structures in one single model. This is considered essential as the containers' formation has a significant influence with regard to the noise dispersion.	Two possible responses: 1. Making an assumption with regard to the containers' formation based on the average container handling volume throughout a year as a percentage of the total handling capacity of the container terminal. 2. Running a series of calculations using different scenarios for different containers' formations.

The geographical data has to be as simple as possible: only the outer contours of a physical object are relevant, the inner lines only slow down the making and calculation of a model. While modelling container formations for instance, containers (figure 8) should no be modelled one by one but as a contour around a line of containers with a height that is the average over a year (figure 9).

Figure 8: Container stacks in port area

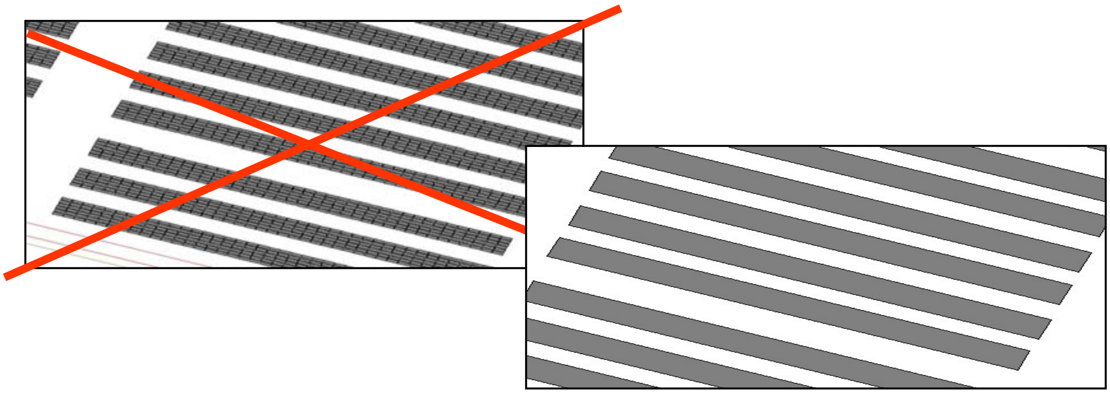


Figure 9: Modelling the formation of containers (only use outer lines)

3.4 Inventory, data collection and modelling of noise sources

An inventory of the main noise sources in the area under study is the logical precondition in any attempt of producing a noise map. The process of modelling noise sources involves decision making in two levels: first in selecting the appropriate modelling option for each identified source and secondly in collecting the relevant noise data that would allow attributing noise values to each source. The Harmonoise-NoMEPorts calculation method offers a variety of options for modelling noise sources (roads, rail, point source, line source, moving source, area source) and the decision is left to the user and depends on the nature of the actual sources. In any case the user has to provide the necessary information that would determine the noise values (sound power levels) for the noise sources under examination. In most of the cases this process involves noise data collection. The following tables 4 and 5 summarise some of the data requirements for modelling industrial and traffic related sources respectively.

Table 4: Data requirements for modelling industrial noise sources

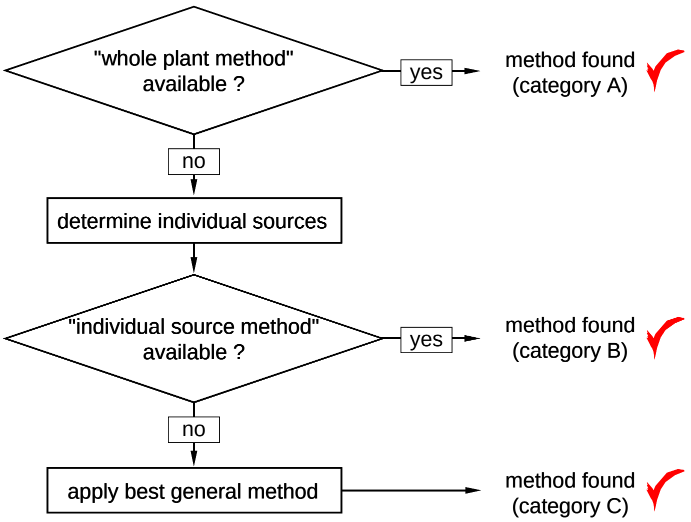
- Location of every relevant industrial source (cargo handling, container handling, cranes, vehicles, auxiliary equipment, etc.) including height
- Working hours of every source taken into account for day, evening and night period
- Sound power level of each industrial source

Table 5: Data requirements for modelling traffic related noise sources

- Location of roads and road surface (e.g. asphalt, bricks)
- Road traffic data: number of vehicles (light, medium or heavy) per hour for each time period (day, evening, night), average speed.
- Location of railways
- Railway traffic data: number of trains of each category per hour for each time period (day, evening, night), average speed, rail support (wooden or concrete sleepers, etc) and data on rail track (joined rail, switches and crossings, etc)

It is important to ensure the reliability and accuracy of the noise and operational data collection. Inaccuracies during the data collection phase can result in poor quality maps that in turn could impair the value of action plans derived from their interpretation. Noise data for industrial sources can be obtained by means of direct noise measurements or by using default values (permits, limits, specifications) and available noise source databases (e.g. Imagine database – SourceDB). Direct noise measurements, using established techniques and specialised equipment and software, are considered to be the most accurate option. However, measurements can be time consuming and often technically complicated (ideally, a source should be isolated from any other background noise for measurement to be considered accurate). The IMAGINE project has investigated over 100 methods for measuring the sound power levels in the report IMA07TR-050418-MBBM03 "Measurement Methods". The next part is extracted from this report:

"This report summarizes the results of subtask 7.1 "Measurement methods" of the IMAGINE project Work Package 7 "Industrial noise" and addresses the so-called end user who wants to take measurements on industrial noise sources to determine input data for noise mapping purposes. It provides a compilation of existing international and national standards, classified in three categories that can be applied to such measurements. It also provides basic information and criteria which can be used to decide which method is best applicable to the specific source / source type in question, leading the end user through a three-level approach to find a suitable method. In addition, the report points out shortcomings, limitations, possible improvements and special aspects with respect to the requirements for noise mapping input and gives general hints and warnings that can be of use in that context."



On the other hand, the use of default values and databases offer an easier but less accurate approach. The following figure 10 is extracted from the Imagine source-Db database and it represents the entry "dockside cranes". An estimated sound power level value of 110dB is advised by the database for this sort of cranes.

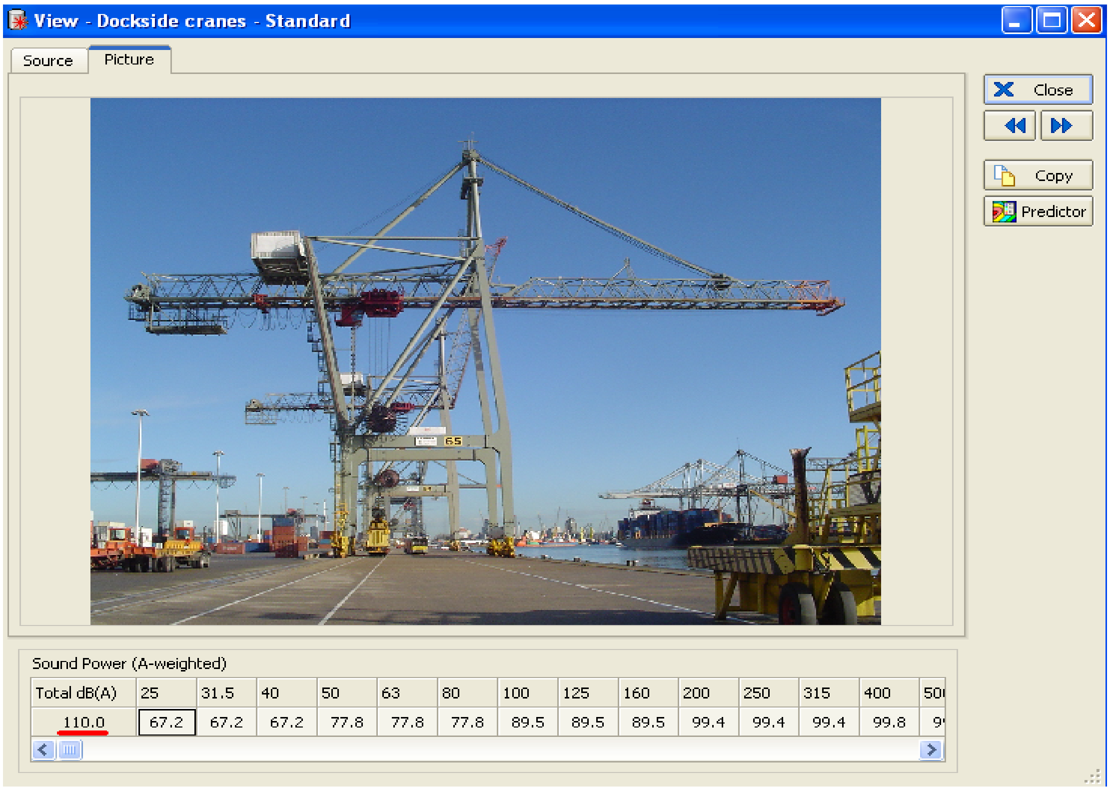


Figure 10: The entry "dockside cranes" in the Imagine Source-dB Database

Validation of this type of data can be performed by means of measurements for a small sample of the dominant sources from the complete noise data set. Another validating approach with regard to operational data collection may be to cross-correlate information provided by different authorities and sources. The validation related issues are examined in detail in chapter 5 of this annex.

The noise data collection can also be time consuming. Therefore, after making an inventory of all noise sources, a screening for significance is suggested in order to avoid unnecessary or insignificant noise data collection. For example, in the case of noise coming from ships it may be suggested that the total time during which a ship is sailing near the port area is insignificant in comparison with the time that the ship is berthed. This might result that ship manoeuvring is excluded from the scope of strategic noise mapping. The same holds for the sound power levels (SPW's) of specific sources in combination with their operational hours. If a source is in operation during all day with a SPW of 110 dB(A), a second source nearby with an SPW of 90 dB(A) will probably, mind distance/frequency/screening, have no influence. For the Westport-area in Amsterdam, it was found that excluding the 45% of the noise sources resulted in a maximal error/variation of 0,4 dB. For strategic noise mapping this reduced accuracy can be considered acceptable. But in the action planning phase, more accurate input data might be required. This is because the source reduction on the most relevant and dominant noise sources may lead to the rise in importance of sources that originally had a minor influence. Reducing the number of sources may reduce input data as well as calculation time (see also Tookit 2 at the end of the annex and Toolkit GPG WG-AEN 10.5).

When modelling traffic, it should be taken into account that (see also Toolkit GPG WG-AEN roads 2-7, railways 8-10):

1. One of the main noise sources in port areas is related to trucks transportation of goods in, out and internally the port area. Passages outside the port area are only accounted for if their contribution to the noise emission of the road is significant, i.e. the port related traffic emission is at least equal or higher than the emission without the port related traffic. Traffic volumes can be inferred by port gate data information of TEU movement/tons of goods exchanged. As a last option, direct counting of traffic on selected spots can be planned, extrapolating average yearly values.
2. It should be also noticed that some amount of road traffic is completely internal to the port and refer to container movements between wharf and import/export stoking area or railway exchange terminal. A certain level of knowledge of operational activities is necessary in order to estimate shuttle transits as well as operating times for reach stackers, docking and stacking cranes, inside a container terminal area.

3. Light traffic can in general be neglected, if unknown, because heavy traffic usually dominates. However, in certain situations, considering also reciprocal position of sources and receivers should be accounted; this is generally the case of ferry areas, where a considerable amount of vehicle movements are expected.
4. Railway connections are generally better accounted for than road traffic; it should also be noted that often railway tracks running into the port are devoted exclusively to port activities. It seems therefore appropriate to include railway tracks outside the port area until their junction to the general purpose railway line.
5. The ships' contribution to environmental noise comes primarily from the operation of internal combustion engines. It was noticed that noise emission during berthing periods is generally dominating over the noise emission during navigation, because of the relative time periods of those operations. Generally it may be relatively simple to extract docking time occupation, starting from Port Authority information. Sometimes the data may also provide additional information, such as ship size, that can be used in order to achieve better accuracy in noise prediction.

Summarising, the following table presents some of the main lessons learned from the noise data collection process by the partner ports of the NoMEPorts project:

Table 6: Lessons learned during data collection

Data collection – lessons learned: • Data collection requires good collaboration between all the involved parties, authorities, companies and agents. The composition of a local working group consisting of these parties is therefore of great importance for the efficiency of noise data collection. • The noise data collection can be a time consuming exercise. In order to get a realistic approach on noise data collection, it is necessary to get an overview over the input data requirements and availability. It is also important to designate responsibilities for the different noise data sets. • After making an inventory of all noise sources, a screening for significance is advised in order to avoid unnecessary data collection. • Gaps within the noise data can be filled by default values (e.g. Imagine source databases) or following experts' advice.

3.5 Grouping of noise sources

For purpose of convenience it is practical to group the sources so that the results can be separately presented as noise coming from industry, roads and railways, etc. A step further can be taken to (sub)group all the sources of each company, resulting in a quick understanding of the most dominant companies in terms of noise emission. If applied, the noise limits for each company can also be examined. This allows noise control and noise management at the single company level. Displaying separately the group results for industry, roads, railways and airplanes is in line with the presentation and display requirements of the European Noise Directive.

4 Defining calculation aspects and parameters

Once the morphology is built and the noise sources are simulated the user of prediction software is asked to locate receivers and grids to the model and to set the calculation parameters.

4.1 Grids and receivers

The receivers and grids are setting up the points where the calculation of the noise levels will take place. The receivers could be placed at single points of noise interest (e.g. facades of the front houses of the neighbouring residential areas). The grids are horizontal or vertical surfaces that consist of a network of receivers. The colour coding that appears after the calculation of the model actually applies to the defined grid surfaces.

The number of grid points determines the calculation time. For study purposes it is advisable to apply a coarse grid (e.g. 200*200m) in order to get faster results. For example for determining the boundaries of the noise study, it is better to start with a coarse large grid and determine the area where L_{den}> 55 or L_{night} > 50 dB. In addition, a coarse grid (e.g. 100*100m) may be applied on the port industrial area, since the relevance of a finer grid is not great in this area. However, the European Commission via the END directive calls a detailed analysis regarding the evaluation of the number of people that are affected by noise and this requires fine and dense grids (e.g. grid spacing of 10 or 25m) to be applied at the residential areas. The GPG WG-AEN also recommends grids of such density to be applied on those areas (e.g. facades of the front houses of the neighbouring residential areas). This may lead to long calculation times, but in order to calculate the number of people exposed in certain classes of noise this is necessary, especially for densely built and populated areas.

Going further into technical aspects, it is interesting to note that grids around line sources like roads and railways may cause the so called “noise islands” effect (figure 11).

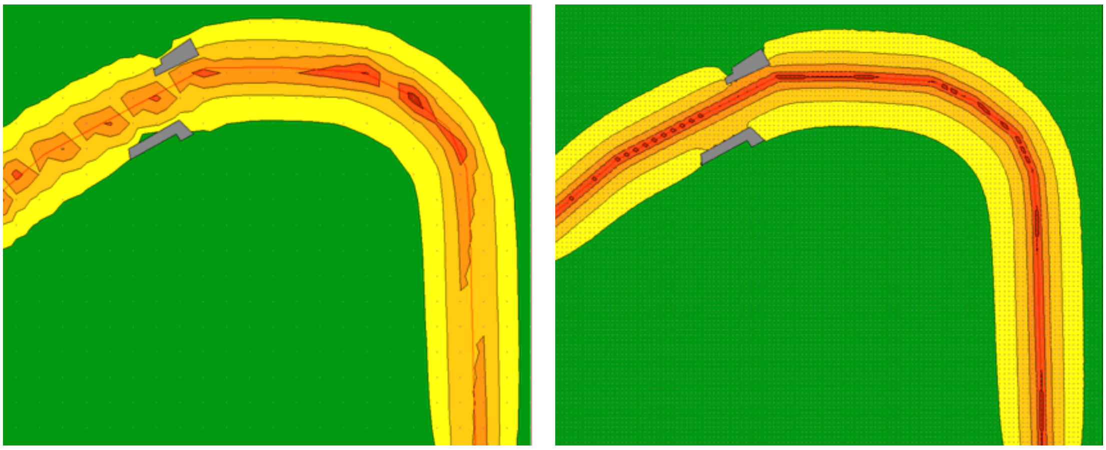


Figure 11: Effect of different grids while applied for the same line source (noise islands)

This problem is caused by insufficient sampling. A solution towards producing better presentable results can be to increase the grid density. Reducing the grid spacing though, from 50 to 10 meters would increase the calculation time by a factor of 25. And still these “noise islands” can be visible, but smaller. A better solution is applying a grid that is parallel to the line source (figure 12). This can lead to reduced computation time as well as better looking results.

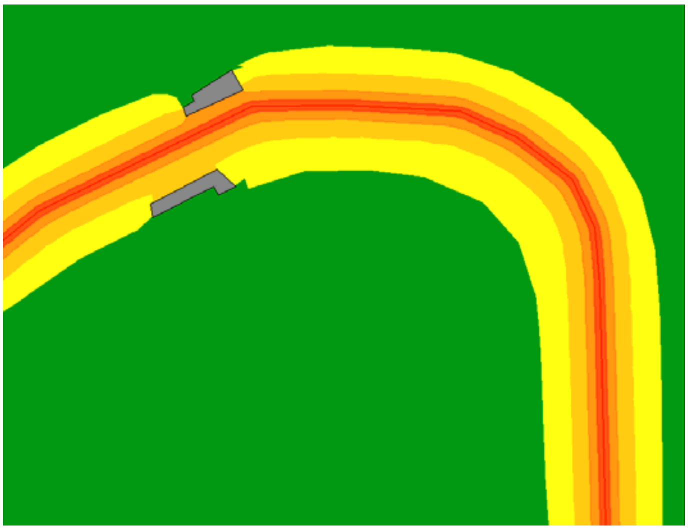


Figure 12: Grid parallel to the line source

Another miscalculation may be caused by coherent superposition of area source and receiver grid; this appears when area sources are internally represented by a regular grid of point sources, whose spacing is identical to the one chosen for the receiver grid. In that case the predicted noise levels just above the area source appear to be abnormally high. The problem may be tackled by using different spacing for area source and receiver grid (best results can be obtained using prime numbers for grid spacing). The examples below (figure 13) demonstrate the effect. An area source and a grid area are used for the prediction of noise levels coming from a specific type of activity. In the first case a grid spacing of 40 meter is chosen for both grid and area source spacing. In the second case the area source is determined by 37-meters spacing, while in the third case it is simulated by 23-meters spacing. The differences in the presented results are obvious.

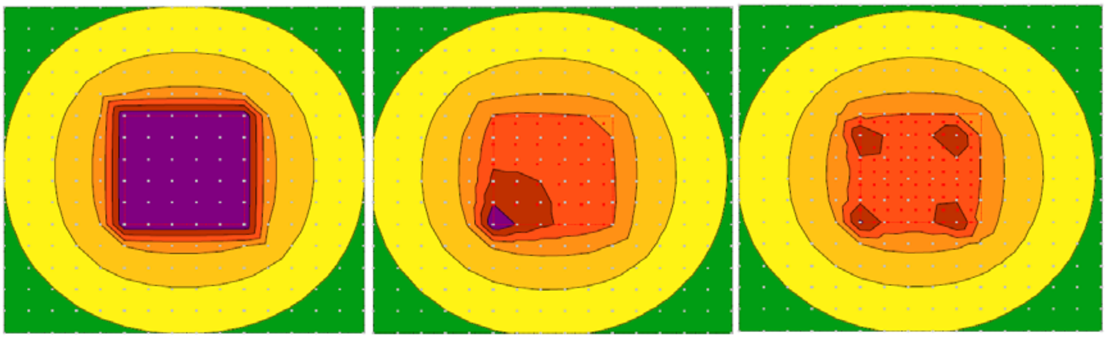


Figure 13: Different results for the same area source with different selection of grid spacing (from left to right - 40*40m, 37*37m, 23*23m)

During the process of producing noise the maps it might become necessary to modify the shape and density of the applied grids. It is important to know that changing the grid density, has an impact in the distribution of grid points and the final results. The following figure (figure 14) demonstrates that shifting a 500 meter grid (the blue points) may significantly change the looks of a contour plot. In order to get accurate results, the grid spacing must be adjusted to the accuracy one wants to have on a certain point. So if contours are needed for interpreting the noise levels near a source or housing area, the grid size has to be chosen accordingly. Normally grid spacing near residential areas are chosen to be 10 to 25 meters.

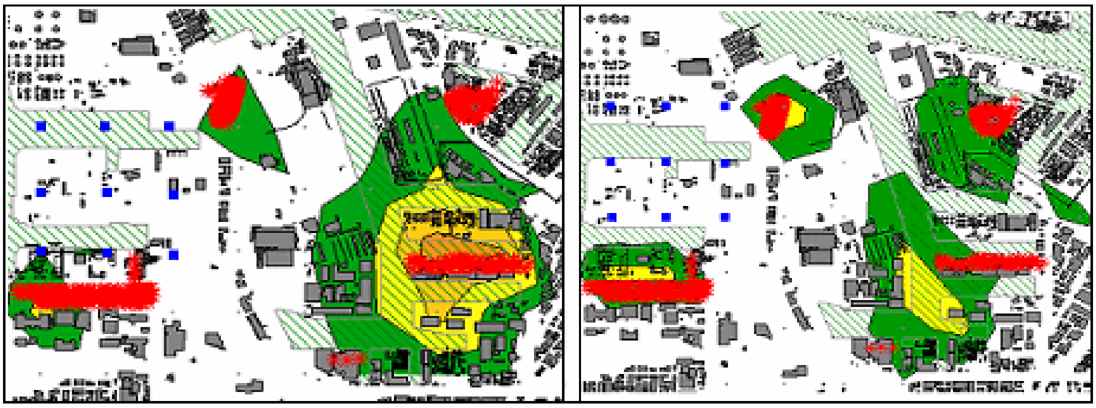


Figure 14: Impact of grid density on final results

4.2 Colour coding for the noise contours

The colour coding that was used by all NoMEPorts partners in order to display the noise contours in a uniform and comparable way is presented below for both L_{den} and L_{night}.

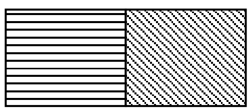
From	To	fill color
55,0	60,0	
60,0	65,0	
65,0	70,0	
70,0	75,0	
75,0	80,0	
80,0	100,0	

From	To	fill color
50,0	55,0	
55,0	60,0	
60,0	65,0	
65,0	70,0	
70,0	75,0	
75,0	80,0	
80,0	100,0	

Figure 15: NoMEPorts colour coding for the noise contours (L_{den} and L_{night})

The noise contours could also be displayed for colour blind people. This can be achieved by using

- only contour lines with their respective lables
- using different hatches per area's instead of colour filled areas



- use colour schemes with a increasing grey scale when plotted on a black and white printer

4.3 Calculation parameters

Next step after locating the grids and receivers is to set the calculation parameters. Those mainly include technical information and meteorological data (figure 16).

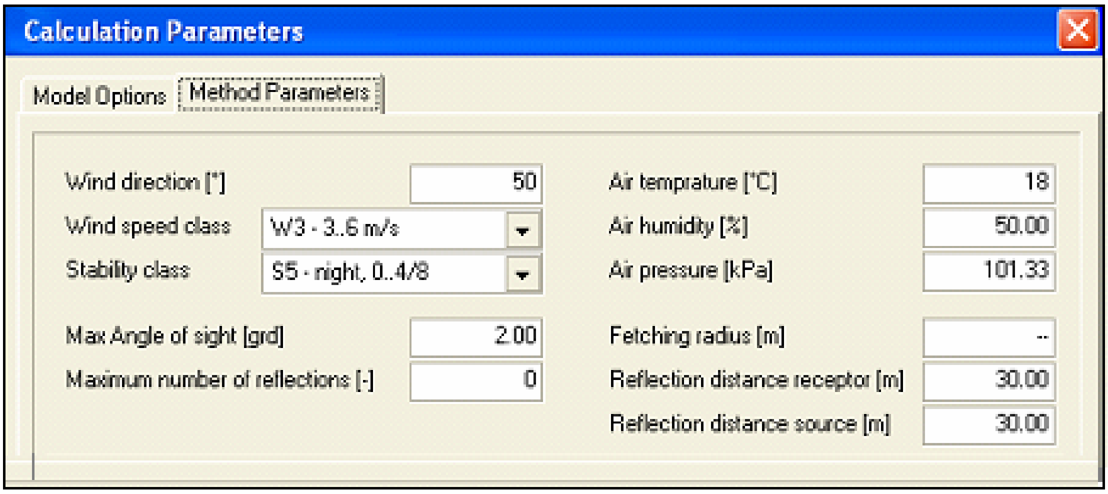


Figure 16: Calculation parameters

Meteorological conditions should be chosen to reflect the annual averages for the area of study. It is therefore necessary to collect data in order to extrapolate acoustic-meteorological information (for instance wind and stability class used by the Harmonoise/IMAGINE prediction model) in terms of frequency of occurrence. Noise prediction model should be run, at least, in the statistical most occurring condition. If such a study cannot be performed, a “favourable condition” should be set into the calculation parameters, resulting into a rough noise level increment of 2-3 dB in respect to the neutral propagation condition (see also Toolkit GPG WG-AEN 17-18).

In the default settings no value is filled in at the “Fetching Radius”, which means that all items (sources and objects) that are fully or partly within the fetching radius of a receiver are taken into account. To reduce the calculation time the Fetching Radius can be set on 2000 meters. When taking a smaller radius it is possible that accuracy of the calculation will decrease.

4.4 Running calculations

Calculations in prediction software might be time consuming depending on the total number of noise sources and physical or other features in the models to be calculated. To speed up calculation times it is wise to examine if the input data is both relevant and significant (e.g. noise sources, buildings - see paragraphs 3.3 and 3.4 of this annex). The choice of the number of calculated reflections is also relevant. Surely for road traffic, with often parallel buildings along the sides, calculating only one reflection may seem to be insufficient. But the interim methods do not take into account that only a small part of the total sound wave is reflected. This leads to unrealistic higher noise levels by increasing the number of reflections. For the Harmonoise/Imagine model this is not the case, because it incorporates the Fresnel zone for each reflection. Outputs of the calculations are the predictions of noise levels in selected areas or points of interest, 2-dimensional and 3-dimensional noise maps. In order to reduce calculation times software developers have made it possible to share computer calculation power over a network. In general the total calculation time on one computer can be divided by the total number of computers, if these computers have the same calculation speed.

5 Validation of results

A critical success factor of a noise mapping task is the reliability of the data sets to be used as input for the model. Inaccuracies during the part of data collection may result in unreliable noise maps. There are several ways for validating a noise model. One option is the validation of the input data sets. Another option is measuring noise in selected locations and then attempting a comparison between the predicted and the measured noise levels. The validation by means of selected measurements could provide the means for accessing the accuracy of noise maps, but it can not identify the causes of potential inaccuracies. The validation of the input data sets can be a more feasible tool to check where the problem generates.

5.1 Validation of input data

The validation of input data may result in a laborious task if it is to be performed on the complete data sets. Some kind of sampling would therefore be advised. Random sampling or sampling of the most significant input data could be selected (e.g. in terms of noise levels produced or effects to the exposed population).

While examining the reliability of noise data it is important to focus on both the source sound power level and its operational characteristics (e.g. timetables, volumes). The technical specifications of the machinery and equipment used could provide the sound power levels, and well established noise emission databases (e.g. Source dB – Imagine project) can also be of use. For more complex situations, specifically designed noise measurements can be performed. In that case the machinery or equipment under question can be isolated from other noise sources, and a set of measurements in selected distances from the machinery can take place. The measured values could then serve as an input to specialised software (e.g. Acoustic Determinator, Bruel & Kjaer) in order to estimate the sound power level of the source under question.

The examination of the operational characteristics of noise sources can be performed by performing selected checks and validation measurements (e.g. road traffic volume and composition through a specific road section). Another approach may be to cross-correlate information provided by different sources and verify their compatibility. For example, the number of ships that are berthed on a specific pier may be provided by both the terminal operator and by the port authority.

5.2 Validation measurements

Validation measurements can take place at selected spots of interest (e.g. near the housing areas or at the boundaries of the port area). It should be noticed that the goal of the strategic noise maps is to display the yearly averaged noise levels. Therefore the validation measurements should be done long term or made during "selected" circumstances (usually favourable noise propagation condition) and then projected as the annual average of noise emission and propagation condition. Furthermore, it should be acknowledged that noise maps indicate trends more than actual noise figures and that their main function is to demonstrate problem areas. Nevertheless, it is considered useful to examine the noise mapping outcomes (predicted, estimated values) in line with some actual values.

5.3 Whole model validation

The IMAGINE project has made an effort in making a method for validating predicted noise models. This method is reported in report D5 - Determination of Lden and Lnight using measurements - IMA32TR-040510-SP08. In the following paragraph the introduction to this method is given.

"This method describes how to determine Lden and Lnight, as defined by the European directive 2002/49/EC, by direct measurement or by extrapolation of measurement results by means of calculation. The measurement method is intended to

be used outdoors as a basis for assessing environmental noise and for verifying the quality of predictions. The method can also be used for monitoring purposes.
The method is flexible and to a large extent the user determines the measurement effort and, accordingly, the measurement uncertainty, which has to be determined and reported in each case. Often the measurement results have to be combined with calculations to correct for operating or propagation conditions different from those during the actual measurement. In each case the long term equivalent sound pressure level is calculated by taking into account the frequency of occurrence of the different operating and propagation conditions. For each of these conditions the sound pressure level is measured or calculated. In principle two different methods are described: Long-term and short-term measurements. However, in practice, a combination of these will often be used. Short-term measurements involve measurements under specified source operating and meteorological conditions and the measurement results have to be used with a calculation method in order to determine the Lden-values. Long-term measurements on the other hand involve measurements during a time long enough to include variations in source operating and meteorological conditions. Thus the measurement results are more accurate and can be used with much less corrections than those of short-term measurements. This is a frame method, which can be applied on all kind of noise sources, such as road and rail traffic noise, aircraft noise and industrial noise."

6 Presentation and interpretation of results

The issues of presenting and interpreting the results of noise mapping in port areas is efficiently addressed within the NoMEPorts "Good Practice Guide on Port Area Noise Mapping and Management" (see GPG sections 3.3.5, and 4.2). For reasons of avoiding repetition, only additional technical detail is provided here regarding especially the calculation of the number of people that are affected by noise in port areas.

6.1 Number of people affected

The data requirements in order to calculate the number of inhabitants exposed to port noise depends on the desired level of accuracy. Data availability constraints impact the accuracy of such calculations. For strategic noise mapping and according to the END (Annex VI), the figures regarding the estimated number of people affected by different classes of noise must be rounded to the nearest hundred (e.g. 5200 = between 5150 and 5249; 100 = between 50 and 149; 0 = less than 50). For achieving that level of accuracy it is possible to make calculations using the number of inhabitants per street/neighbourhood or per district. If the aim is to produce even more accurate results, then ideally, the number of inhabitants per each dwelling under question should be known.

The noise levels on the facades of houses can be calculated by making contour calculations. With a grid spacing of 10 to 25 metres this will result in accurate calculations of noise levels at the facades of dwellings. But still a lot of computation time is spend on grid points where no people are living. In addition, attention should be paid on the calculated reflections on the façade. Grid points are randomly located and usually at a certain distance from the façade (see figure 17). Thus, the calculated noise levels at those grid points are influenced by both the incoming and the reflected noise energy. When following such an approach it is therefore suggested to reduce the calculated values at the grid point of interest by 3dB.

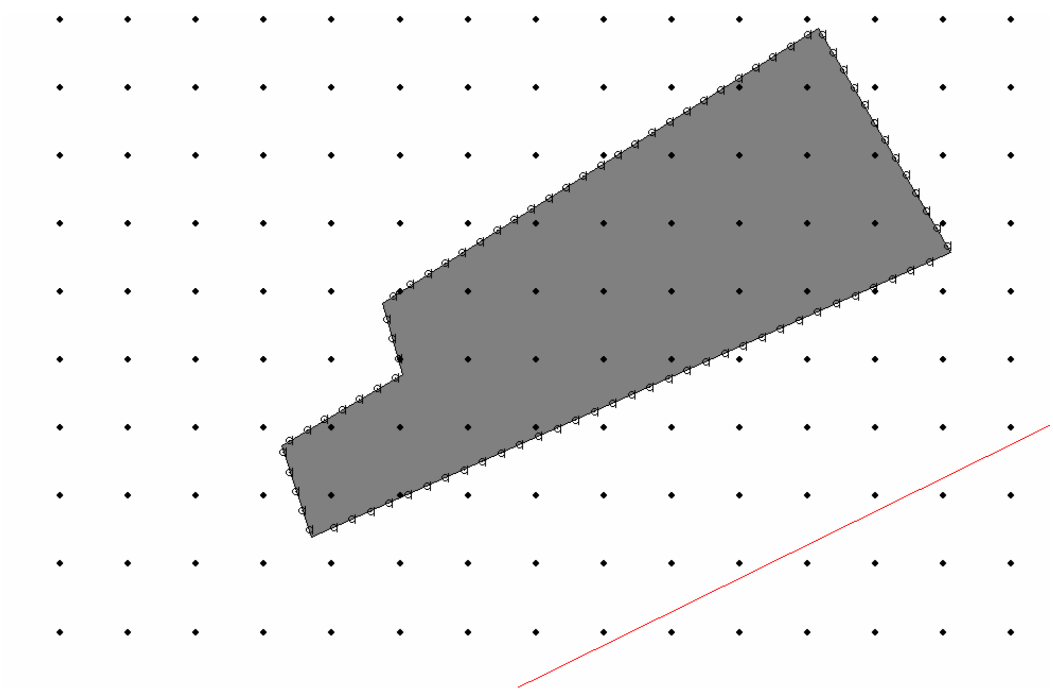


Figure 17: The two options for calculating the noise levels reaching a dwelling (either applying a fine grid, either placing receivers on and around the dwelling's surfaces)

Another way is to calculate the noise levels at the facades only. This can be achieved by placing receivers on the façade and around the buildings' surfaces (see figure 17). This will give reliable and in some cases faster results. The GPG WG-AEN recommends this approach and points out that a 3-meter spacing between receivers can be considered as appropriate (see also Toolkit GPG WG-AEN 19-21). In any case the noise value to be taken into account for each dwelling exposed to noise is, according to the END, the highest calculated value at the dwelling's most exposed façade.

Regarding the results' display of such an analysis several graphical options are available. The examples that follow demonstrate different display options of the results regarding the estimated number of people that are exposed in certain noise classes. The examples are taken from noise studies undertaken under the umbrella of the NoMEPorts project in the ports of Livorno, Amsterdam, and Valencia.

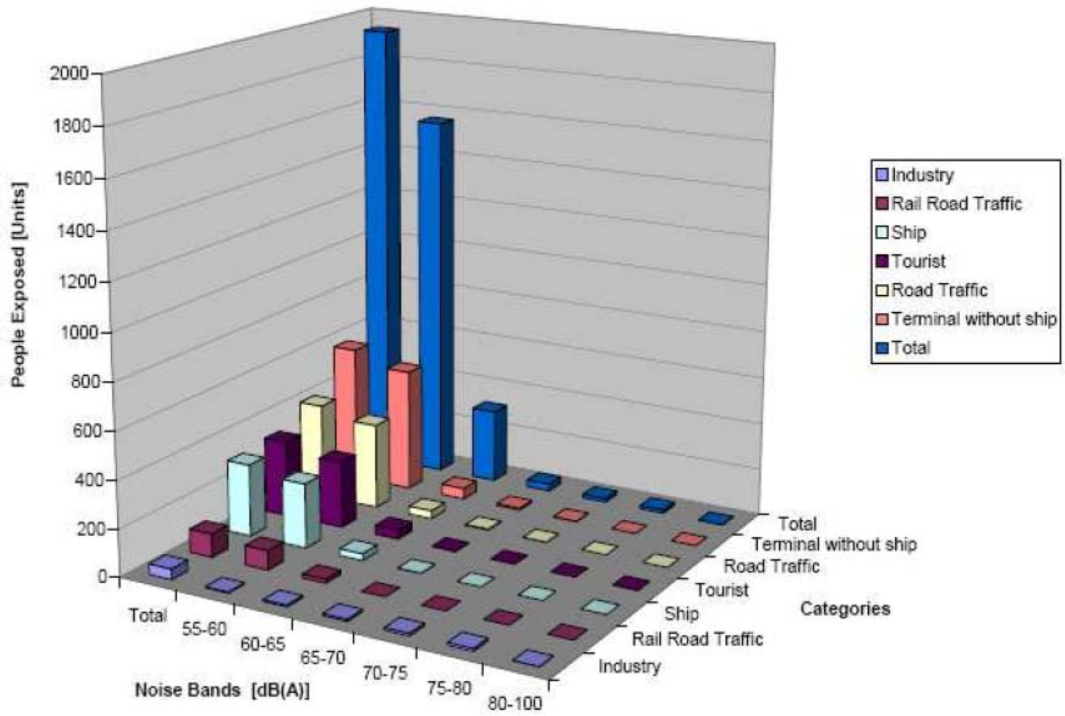


Figure 18: Port of Livorno – Display of the number of people exposed to different noise classes

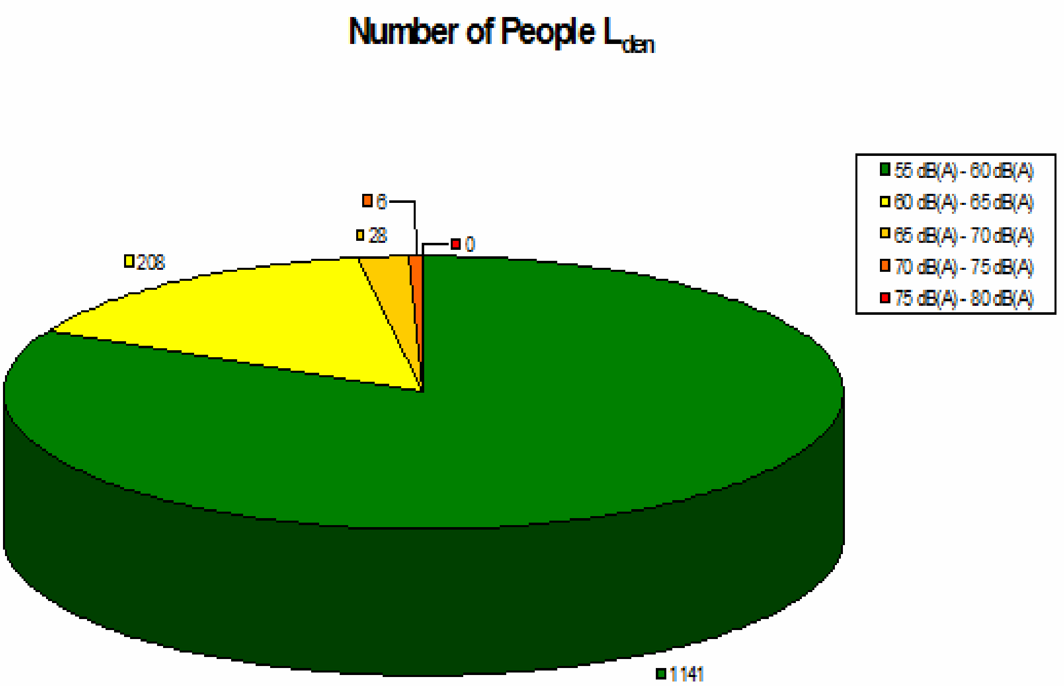


Figure 19: Port of Amsterdam - Number of people exposed to different noise classes

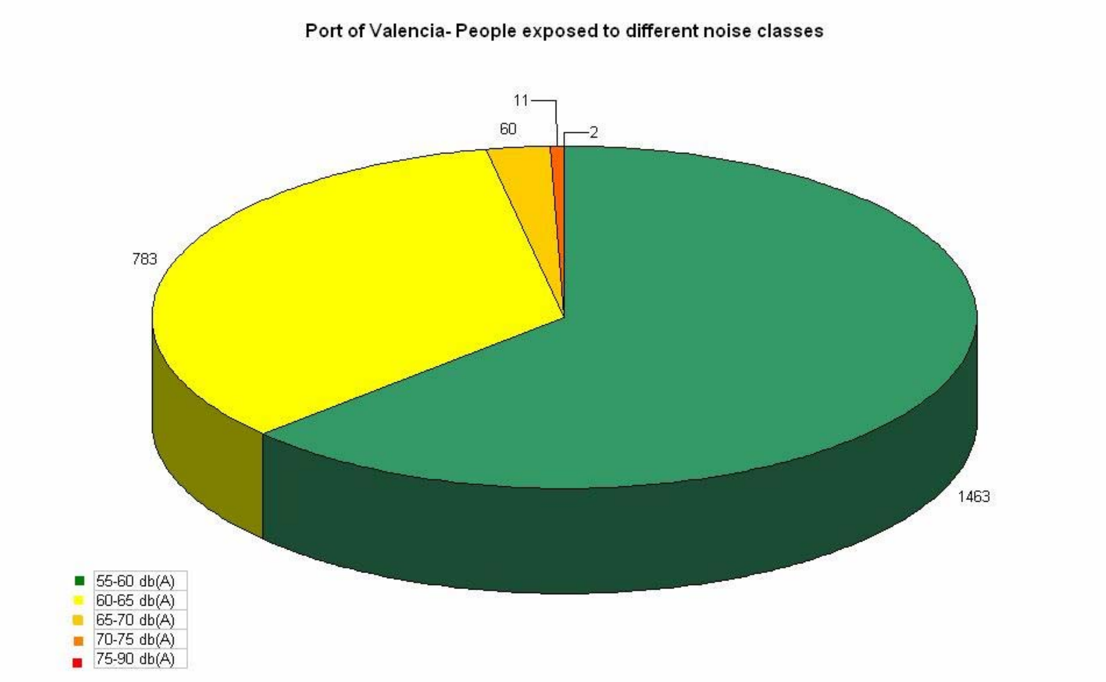


Figure 20: Port of Valencia - Number of people exposed to different noise classes

Sometimes a global overview is sufficient enough to see how many people are exposed to noise. An easy way to calculate the amount of people is using Predictor Analyst (application of Predictor). By importing a shapefile or a textfile with geographical information like locations and number of inhabitants, Predictor Analyst will calculate the exposed number with help from the calculated contour which is imported as well.

7 Conclusions

Making noise maps requires a team of people to do the job. This team consist of a variety of people who can take care of the following tasks:

- Gathering information on sources (sound power levels, position, operating times, number of vehicles , etc)
- Information on maps, DXF-files (buildings, ground regions, etc), inhabitants, noise sensitive areas/buildings
- Gathering information on new developments (housing areas, changes within the industry or traffic)
- Making a noise model (present and future situation)
- Presenting information for the present and future situation

The efforts of this team can be used for managing noise around a (port) area. This can be done by setting up noise limits and apply these in the software.

Toolkits

The toolkits that are presented here are not the result of deep scientific research but the common opinion of a group of experts. Not the absolute numbers are important but the comparison between the different methods makes the difference.

Colour code to rate Tools					
complexity	**colour code**	**accuracy**	**colour code**	**cost**	**colour code**
simple	△	Low	> 5 dB	inexpensive	△
-		-	4 dB	-	
-	◇	-	3 dB	-	◇
-	⬠	-	2 dB	-	⬠
-		-	1 dB	-	
sophisticated	⬡	High	< 0.5 dB	expensive	⬡

Toolkit 1

Noise effected area			
Method	**Compl.**	**Acc.**	**Cost**
Use whole agglomeration model, start with coarse grid, find area effected by Lden> 55 or Lnight > 50 and refine calculation to this area	⬠	< 0.5 dB	⬠
Use model without objects and coarse grid to define area effected by Lden> 55 or Lnight > 50 and refine calculation to this area	△	1 dB	△

Toolkit 2

Acquiring of Sound Power Levels including working hours			
Method	**Compl.**	**Acc.**	**Cost**
Measurements	⬠	2 dB	⬡
Measurement of dominant sources, extended up with the SourcedB or equivalent sound power database	◇	3 dB	◇
Use of Sound Power Database only, no knowledge of working hours	△	> 5 dB	△