# ACOUSTIC MODEL AND NOISE MAP OF A CERN INSTALLATION IMPLEMENTED BY TYMPAN 3.2

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## Abstract

This paper describes the process followed to carry out the acoustic model and noise map of a typical installation of the European Organization For Nuclear Research (CERN), with an important number of sources, using the software TYMPAN 3.2 developed by EDF (Electricité de France). The noise map is validated by comparing to « in situ » measurements. Then, the paper presents an acoustic analysis of the calculated sound levels, describes the acoustic treatments envisaged and evaluates their effects on the noise map. Finally, conclusions are drawn on the application of this type of acoustic tool for dealing with noise impact problems.

## INTRODUCTION

CERN, the world's largest particle physics centre, is currently installing its new particle accelerator, LHC (Large Hadron Collider) [1]. This new generation particle accelerator will become the most powerful ever constructed, with the start up in 2007.

Noise and its impact on the environment is a well know problem of large scale industrial plants. In relation to this subject, CERN has started a noise mapping and modelling study of the 9 access sites to the underground (called LHC Point 1, 1.8, 2, 3,…, 7, 8) that spread out into the populated areas between Geneva and the Jura mountains, where all necessary infrastructures (representing more than 400 acoustic sources to model) for the LHC operation are housed (See Figure 1).

To carry out this project, CERN has followed a partnership with EDF. Thus, CERN has used the software TYMPAN, developed by EDF, to implement the acoustic models and EDF has developed new software versions with program improvements, thanks in part to the CERN feedbacks. This paper describes the acoustic model of a typical LHC Point with cooling towers, electrical substations, transformers, compressor halls for liquid helium refrigerators, pumping substations, ventilation systems and other auxiliary installations.

## DESCRIPTION OF POINT 2 OF LHC

Point 2 is one of the access sites of the LHC and will serve for the future ALICE experiment at LHC. Point 2 is made up of different infrastructures for the operation of LHC and the ALICE experiment and is placed in France (Sergy) as seen in Figure 1. Figure 2 shows an aerial view of Point 2 of LHC.

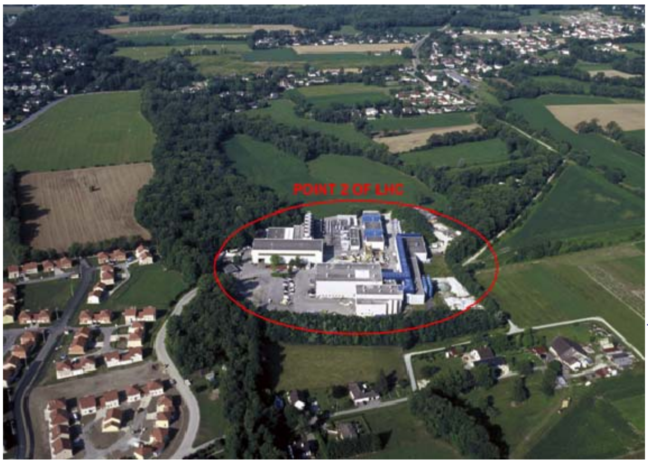


*Figure 2 – Aerial view of Point 2 of LHC.*


*Figure 1 – Location of access Sites (LHC Points) to the underground.*

Close to this Point, a residential area exists (See Figure 2). Thus, it is interesting to know the future acoustic impact of the CERN installation in this area.

The distribution of the buildings (19 elements), the structures (10 elements) and the principal equipment and machines (76 sources) considered in the model are shown in Figure 3.

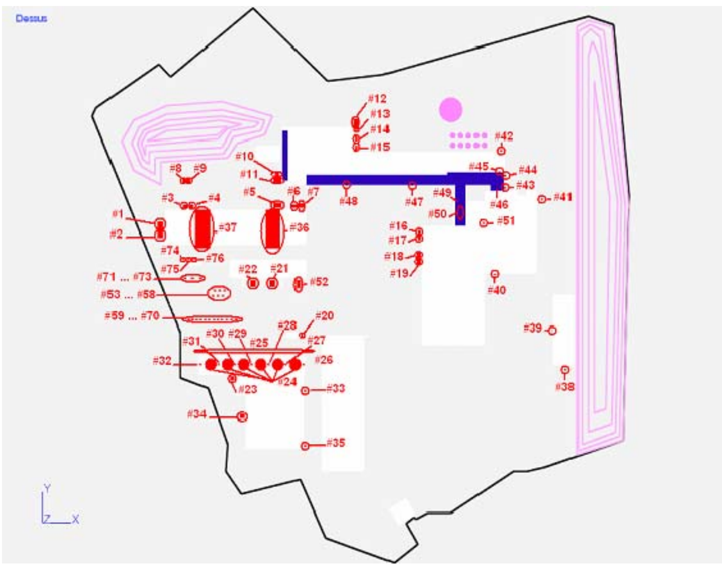


*Figure 3 – Buildings, structures, principal equipment and machines considered in the acoustic Model of Point 2 of LHC.*

## PRINCIPLES OF THE ACOUSTIC SOFTWARE USED [2]

The acoustic model of Point 2 of LHC was developed with the acoustic estimation software TYMPAN 3.2. This software has been developed by EDF to: carry out noise mappings, control the noise impact and validate possible solutions. The acoustic models achieved with this software are based on simplified and standardized methods: ISO 9613-1 [3], ISO 9613-2 [4] and NMPB [5].

This software allows in particular to take into account the following elements: the directivity of the sources, the geometry of the sources, operation modes of the sources, the radiation of a source through the walls of a building, the principal phenomena of propagation (atmospheric absorption, ground effect, reflections on the walls), the diffraction by the obstacles of complex form (walls, buildings and topography), the influence of the weather conditions (by a simplified model of propagation in favourable conditions).

The calculation proceeds in 2 phases. The first consists in modelling, by a distribution of elementary sources, the radiation of more or less complex sources. The second phase consists in calculating the transfer function between each elementary source and the points where one wishes to calculate the noise level: measuring points.

Once the sources have been defined, the propagation calculation is made successively for each couple elementary source – measuring point, taking into account the wave attenuation from the result of the preliminary geometrical calculations.

## PROCESS APPLIED TO DEVELOP THE ACOUSTIC MODEL

The process to carry out the acoustic model of Point 2 of LHC to get a prediction of the future sound levels consists of the following steps:

- Geometrical definition and location of buildings and equipments of the Site
- Geometrical definition of the Site limits
- Implementation of the topography (natural acoustic walls, hills…)
- Definition of the ground type
- Definition of the meteorological aspects
- Acoustic characterisation of buildings (absorption coefficient, transmission lost…)
- Acoustic characterisation of equipments and machines (directivity, spectrum of sound power level…)
- Definition of the control points and the acoustic mesh applied
- Validation of the model by site measurements.

## MEASUREMENT CAMPAIGN TO GET THE DATA OF ACOUSTIC SOURCES

For new equipment and machines, the supplier provides the acoustic information, sound pressure or power level distribution as a function of frequency in specified frequency bands (spectrum of frequency), characterizing its sound emission.

However, this information is not available for all the cases, especially for existing installations with old equipment. There are other cases that, for the characteristics of the noises sources, the sound levels must be obtained by measurements.

In order to define the different noise sources, a measurement campaign using the sound level meter “Investigator Type 2260” was developed following the standard ISO 3744 [6] to get the sound power level from the measurements of sound pressure level. This International standard specifies a method for measuring the sound pressure levels on a measurement surface enveloping the source, and for calculating the sound power level produced by the source. The computation of sound power level from sound pressure level measurements is based on the premise that the sound power output of the source is directly proportional to the mean-square sound pressure averaged over time and space.

## MODEL OF POINT 2 OF LHC AND HIS VALIDATION

As introduced in previous sections, to carry out the acoustic model, the buildings and equipment of Point 2 of LHC were defined from the geometrical and the acoustic point of view. In addition, to complete the model, the topography was implemented (two natural walls around the Point 2 of LHC) and finally the houses around the Site were defined only from the geometrical point of view (just to define their positions around the Site). The Figure 4 shows the model of Point 2 of LHC.

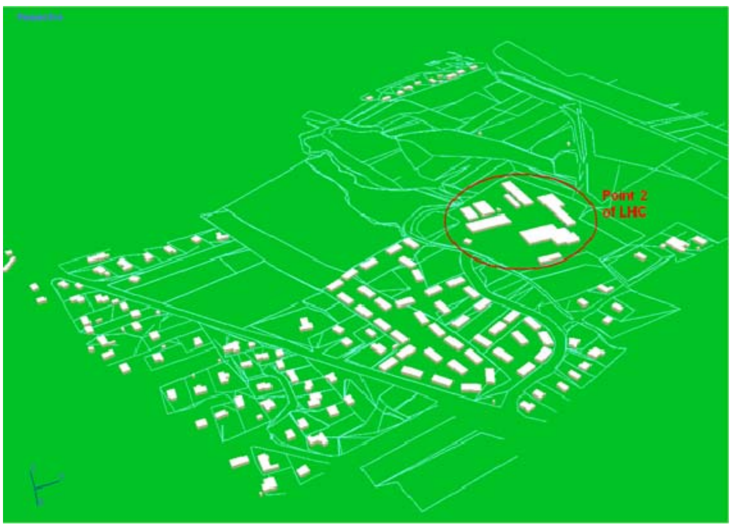


*Figure 4 – Model of Point 2 of LHC.*

Once the acoustic model was obtained, different validation points, with height 1.3 m, were defined strategically distributed around the Site (See Figure 5) to validate the theoretical model obtained. Thus, the sound pressure levels obtained with the simulation and the experimental sound pressure levels were compared to evaluate the acoustic model.

The validation measurements were not done at once as for the time being not all equipment is running (LHC will run at 2007), but these individual tests made it possible to fix the model and obtain the global validation.

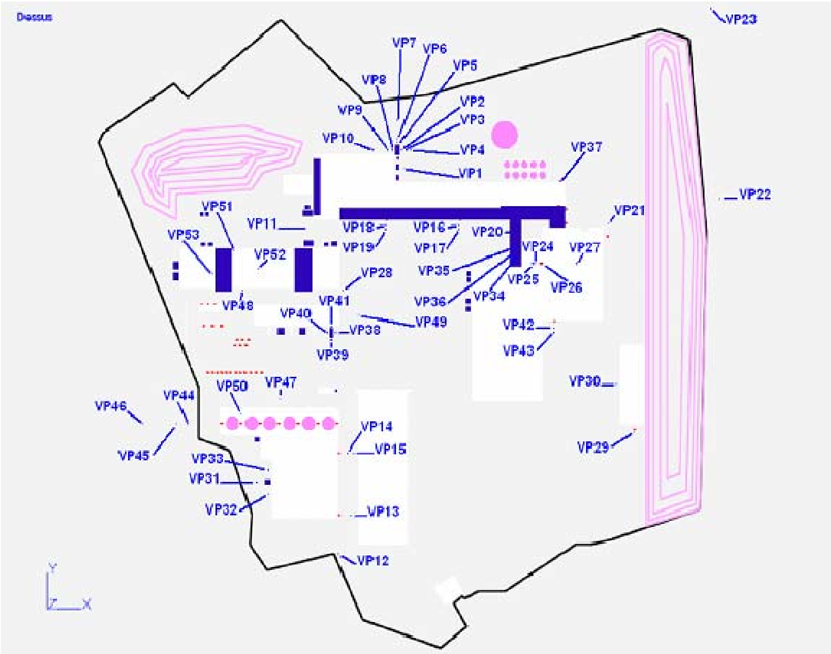

*Figure 5 – Validation points in the acoustic model of Point 2 of LHC.*

The results obtained for all the validation points show errors around 1 dB(A), thus we can support the good model obtained.

## NOISE MAP OF POINT 2 OF LHC

Once the acoustic validation of the model was done, an appropriate acoustic mesh was defined to get the noise map. Figure 6 shows the sound levels calculated for Point 2 of LHC.

The model obtained shows the noise impact of Point 2 of LHC to the surroundings. To reduce the acoustic levels of some critical regions, a study of the sources with a significant influence was made to evaluate possible individual treatments to be applied.

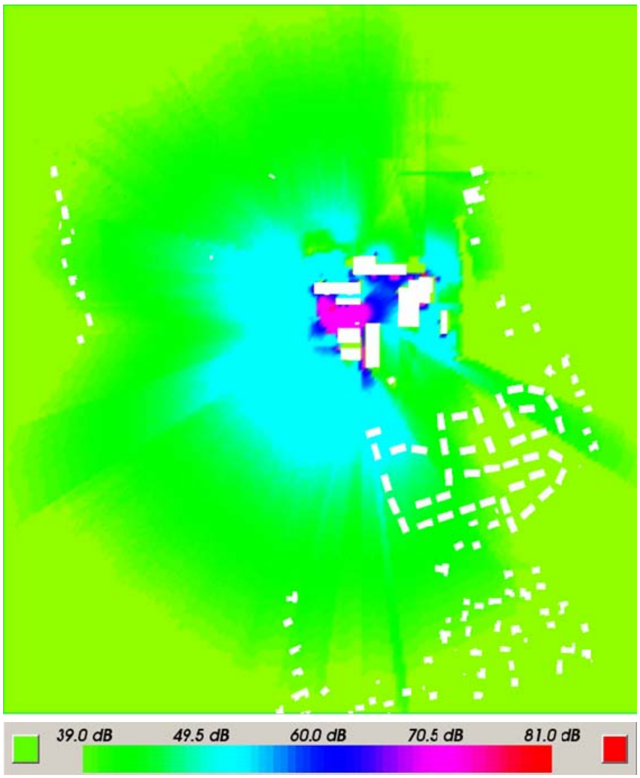


*Figure 6 – Noise Map of Point 2 of LHC and his surroundings.*

## ACOUSTIC TREATMENTS EVALUATED TO POINT 2 OF LHC

The following 4 individual treatments were studied to: a) the cooling towers, b) the technical gallery for the cryogenic pipes between two buildings, c) the ventilation hole of a cooling system, d) the electrical sub-station (See Figure 7).

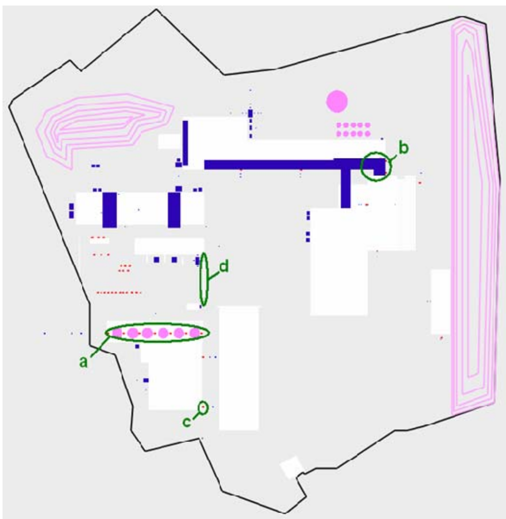


*Figure 7 – Acoustic treatments applied to 4 sources of Point 2 of LHC.*

The acoustic treatment studied for the cooling towers was to install an acoustic silencer in the fan of each tower. Considering the relevant parameters (flow rate, temperature, head losses…) to select the appropriate model, six circular silencers (one for tower) would be installed. With this treatment, the attenuation expected by the supplier to the sound power level of each tower is up to 38 dB(A).

The technical gallery for the cryogenic pipes is placed on the roof of two buildings. The acoustic treatment studied was to apply an acoustic enclosure with a sound absorbing material (glass or mineral wool fibres, polymer foams…) to the noisy region of the technical gallery. For this case, the attenuation expected by the supplier to the sound power level of the source is up to 30 dB(A).

For the ventilation hole of the cooling system, a ventilation silencer was studied. Considering the relevant parameters (flow rate, temperature, head losses…) to select the appropriate model, a rectangular silencer would be installed. With this treatment, the attenuation expected by the supplier to the sound power level of the source is up to 40 dB(A).

The acoustic treatment studied to reduce the influence of the electrical sub-station was to build an acoustic barrier. This barrier would be placed in the north limit of the electrical sub-station, its dimensions would be: height 5.5 m, length 33 m and thickness 0.1 m. The attenuation expected by the supplier behind the barrier is up to 15 dB(A).

Figure 8 shows the noise map of Point 2 of LHC with the implementation of the treatments considering the attenuation expected by the suppliers.

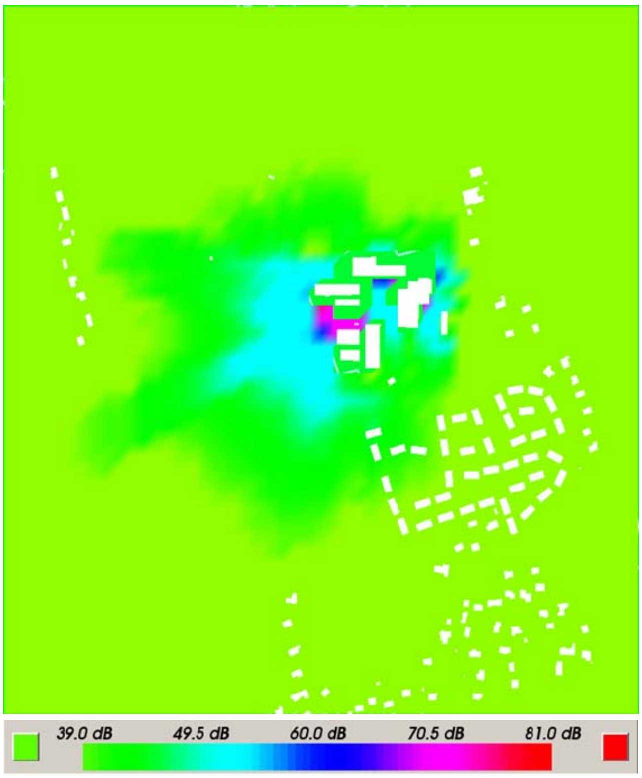


*Figure 8 – Noise Map of Point 2 of LHC with the acoustic treatments.*

This study considers the most favourable case with the attenuation expected by the suppliers for a standard situation. Specific supplier valuations for each case would be used to carry out subsequent studies.

## CONCLUSIONS

An acoustic model of Point 2 of LHC has been developed and validated by measurements obtaining differences around 1 dB(A).

An acoustic study has been made to identify the critical areas around Point 2 of LHC and the sources with a higher influence.

An analytical evaluation of potential solutions for acoustic treatments of Point 2 of LHC has been done; ensuring the noise impact of the LHC installation to the environment can be reduced to an acceptable level.

The utilisation of these programmes to estimate sound pressure levels is interesting to carry out noise mappings and control the future noise impact.

The acoustic model gives the chance of studying the noise influence of each source in the model, in such a way that it is possible to identify the more noisy sources.

With these prediction tools it is possible to apply individual treatments to the acoustic sources and validate potential solutions.

The development of an acoustic model of these characteristics needs many theoretical and experimental data (topographical, geometrical, acoustic…).

The validation process take a long time to carry out because it is necessary to take many measurements and fix the model to the real case.

## REFERENCES

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[4] ISO 9613-2:1996 “Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation”
[5] “Bruit des infrastructures routières”, NMPB Routes (1996)
[6] ISO 3744:1994 “Acoustics - Determination of sound power levels of noise sources using sound pressure - Engineering method in an essentially free field over a reflecting plane”