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CONACUS: PROPOSAL OF SIMPLIFIED ACOUSTIC SIMULATOR FOR URBAN DESIGN

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ABSTRACT

Meeting the comfort standards in urban spaces is a challenging issue that requires active collaboration between multidisciplinary experts in order to form an appropriate "design team" for each urban space. To form a good design team, the architect who orders the urban space needs to know what the key variables are important to define that area. Some simplified evaluations, but based in technical aspects, can be fundamental to establish these key variables for each case of study. In response to this question, this paper proposes an acoustic simulator (CONACUS) based on the simplified application of standard calculation methods. It provides a first information of the acoustic condition in an area, and analyse the relative importance of this acoustical variable, to identify if using precise acoustic models is requires or not. This simulator is based on a web application that allows its use with an internet navigator without installing any specific program. On the other hand, there other possible applications of a simplified Simulator of Acoustics (CONACUS) are explored in this paper. The results obtained with this simulator has lower precision and no legal validation, but it could be used by non-expert technicians and require less calculation times than the commercial calculation models.

Keywords: Acoustic Simulator, Urban Sound Planning, Quiet Areas.
I-INCE Classification of Subject Number: 76

1. INTRODUCTION

Acoustic discomfort in urban places creates difficulties to social interaction affecting the development of cognitive activities (such as reading) and, finally reducing their chances of success.

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In the context of the European Noise Directive 2002/49/EC the European Environmental Agency is emphasizing the need for citizens to have Quiet Urban Areas, that are defined in the QUADMAP LIFE 10/ENV/IT/407 project as urban area whose current or future use and function require a specific acoustic environment, which contributes to the well-being of the population. In a closer legal context, the Decree 213/2012 of noise in the Autonomous Community of the Basque Country develops the concept of Urban Quiet Zone aligned with the European and National legal context.

Currently, most cities are committed to improve the comfort of the urban places, so that citizens perceive those areas as an extension of their residence, contributing to their sense of identity and belonging to the city. Improving comfort to increase the use and enjoyment of public spaces implies incorporating different environmental aspects, especially the sound variable.

Therefore, it is logical that all the stakeholders involved are focusing their attention on solving these problems. On the one hand, municipalities promote that the design and furniture of public places are adapted to the environment conditions, improving the offer of public space to citizens and also quality of life. On the other hand, urban design responsible are devoted to attend to this requirement. However, there are factors that are meant to be solved to achieve this goal: the increase in cost for the projects to provide ad-hoc solutions for each specific environment and the complexity of the acoustic simulation models (which requires experts and large processing and calculation time). Tecnalia has already done some previous studies in collaboration with municipalities in the assessment and design of urban public places. LKS' architecture team works not only in the design of new urban and building spaces, but also in the renovation of the existing environment.

It is in this context that the CONACUS project was created to apply acoustic criteria to create an acoustic web simulator, in collaboration between Tecnalia and LKS, which is interested in providing a differential value to its urban design service being autonomous to develop an analysis of acoustic comfort in public places .

The main objective of this project was the development of an innovative product (acoustic simulator based on the simplified application of END calculation methods)) that analyzes the acoustic comfort of a specific urban places, based on its nearby acoustic conditions.

The result obtained with the acoustic web simulator that provides useful information to make decisions in the design of the uses to be implemented in the place, This simulator provides independency to the LKS architects in order to develop a preliminary acoustic comfort analysis, Nevertheless the simulator has some limitations (that are balance in the context of the being user-friendly) that implies that is not useful to attend to legal requirements.

2. Methodology and development of the Simulator

The basic functionality of the CONACU Simulator is to evaluate the acoustic effect of different elements in the configuration of the sound environment in an urban place. The objective of the development of this simulator has been to have an alternative to the existing acoustic models in the market, which are more sophisticated and require an acoustic expertise for its use.

The principal value of the simulator is its balanced design prioritizing ease of use and reduction of calculation time, to make simulations in simplified urban spaces through a web service.

The acoustic simulator has been created only through web technologies, so it complies with the specification of being multiplatform; with any device that has a web browser you can access the application. The application has a modular structure to be able to load the different modules when its use is necessary. For this purpose, the AMD (Asynchronous Module Definition) technique has been used and implemented using JavaScript libraries. For loading the modules, it has been created a base system with interface and simple functionalities. The modules are loaded in their modular structure when necessary. Each module has its associated web services to communicate with the server. These web services have been developed in Java. The application includes some common use modules (menu, project management, secure login, notification system, user management, etc.) and some simulation specific modules (2D designer, map loader, acoustic simulator, etc.).

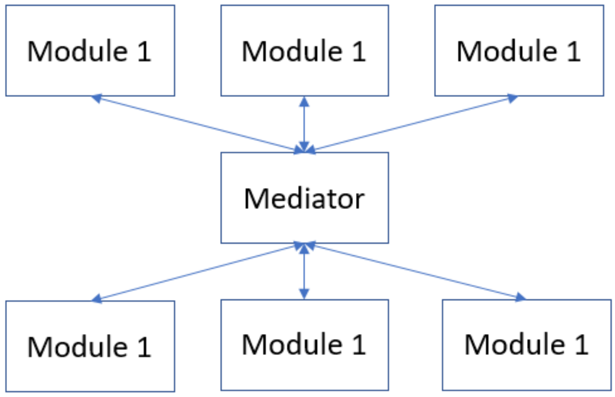

Figure 1 - Modular design of the system with the mediator for communications between modules

The acoustic simulator tool has been developed in two different parts. The client side (Fronted) who is the interface of the multiplatform tool where the different agents of the platform interact; and the server side, (Backend) where the management of the data, its analysis and the acoustic formulation for the simulations are located. These two parts are separated into modules:

- On the client side we will find the simulator interface module that includes the 2D designer module, the simulation display module, the acoustic categorization module for the allocation of emission sources and acoustic barriers, the module for loading plans, login module, user management and project management and communications security.
- On the server side we will find the REST web services to supply data to the client-side modules: as the algorithms for the simulations, including the types of noise emission sources, the web services and the database to save all the needed information. Database has been created with PostgreSQL as a database server. It is free and open. In addition, it offers many advanced options. Several tables have been implemented to feed the different modules

2.1 The modules of the simulator

The general interface module is the main module of the platform. Inside it all the other modules that complete the simulator are integrated. The users interact with the simulator through this interface. In Figure 2 you can see the general appearance of the simulator version:

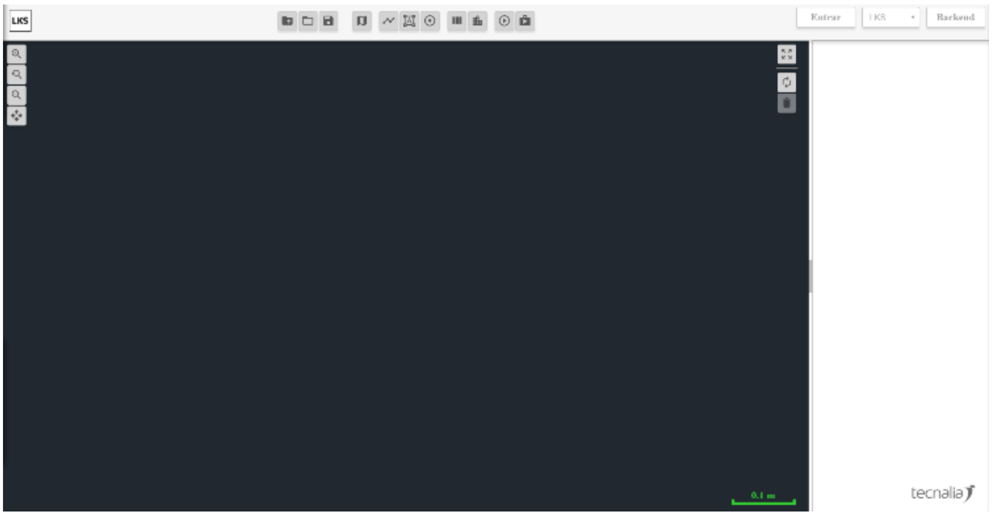

Figure 2 - General interface of the simulator version with integrated AMD modules

• Login Module: The login module is responsible for creating sessions and assigning roles to registered users. Authentication is done by user and password following the security protocol. It has been created an interface so that the user can write his data and be notified if he has entered the data incorrectly. For the security of communications, the HTTPS protocol use guarantees that ensure the communication between server and client circulates in an encrypted way and that it cannot be read by someone who intercepts the communications.

Through the project management module, the users can see all their projects in the table and can open or delete them, whereas the user with the administrator's role can see all the projects created. In addition, a module has been developed to obtain all the project data (2D design configurations, created elements, active user, etc.) and save them correctly in the database.

Figure 3 - Login interface and project management

• Map loader module: To load the urban plans of AutoCAD in the 2D designer, an exporter has been developed. It can convert the information obtained from AutoCAD DWG files in SVG format. This new format SVG (Vector Scalable Graphic) supports HTML5 and offers vector images that can be resized without losing quality.

The end of this module is to add to the 2D design the information obtained as background to make the urban acoustic design.

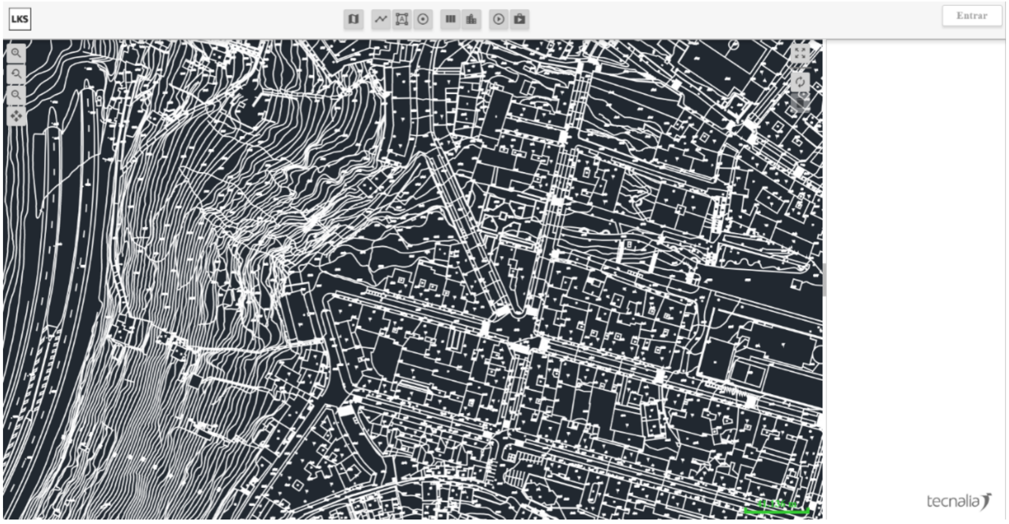

Figure 4 - AutoCAD drawing loaded in the 2D designer

• 2D Design Module: it has been created module called 2D designer to create the designs by the users.

This designer will have the ability to represent and interact with 2D objects using 100% web techniques. For this purpose, all the necessary functionalities have been implemented for the design. The results are visualized within the HTML5 drawing canvas.

In the 2D designer has been implemented the Fabric.js library in order to draw areas. Each area represents a noise emitting focus and has its associated properties; such as: dimensions, category, type, if it is active for the simulation and the name. In the 2D designer, the vertices of the areas are drawn, the lines that join the vertices and the distance between the vertices is marked.

These distances are calculated using the sizes of the loaded AutoCAD file and are represented in meters. The vertices can be selected and moved to edit the sizes and shapes of the areas. When a broadcast area is selected, all its data and the categorization module are displayed, so the user can edit the properties.

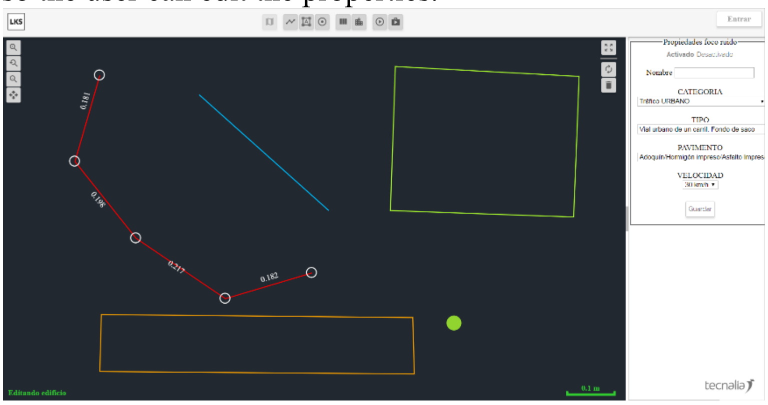

Figure 5 - Four source of noise emission and one acoustic barrier drawn in the 2D designer. The selected emission area has visible its vertices, its distances and the associated form for its categorization.

• Simulations Module: this module is the responsible for collecting and sending the data of the emission areas and the acoustic barriers drawn in the 2D designer to the server through the REST calls. In the backend, the simulations corresponding to the data obtained are carried out, returning the results with REST services to the module on the client side. Finally, the results are drawn as areas of influence in the 2D designer.

To draw these areas of influence algorithms have been developed using the same library used in the 2D designer. This module can also save all the simulations carried out in a project and allows the user to select and visualize them one by one in the 2D designer.

In the following figure, three noise emission sources have been simulated with their areas of influence. Each area of influence takes into account the obstacles that the sound may have (acoustic barriers or barrier elements such as buildings) that the user has previously drawn. The result is shown in uniform color and shows the user the areas that are under the influence of more than 65 decibels during the day or 55 decibels during the night.

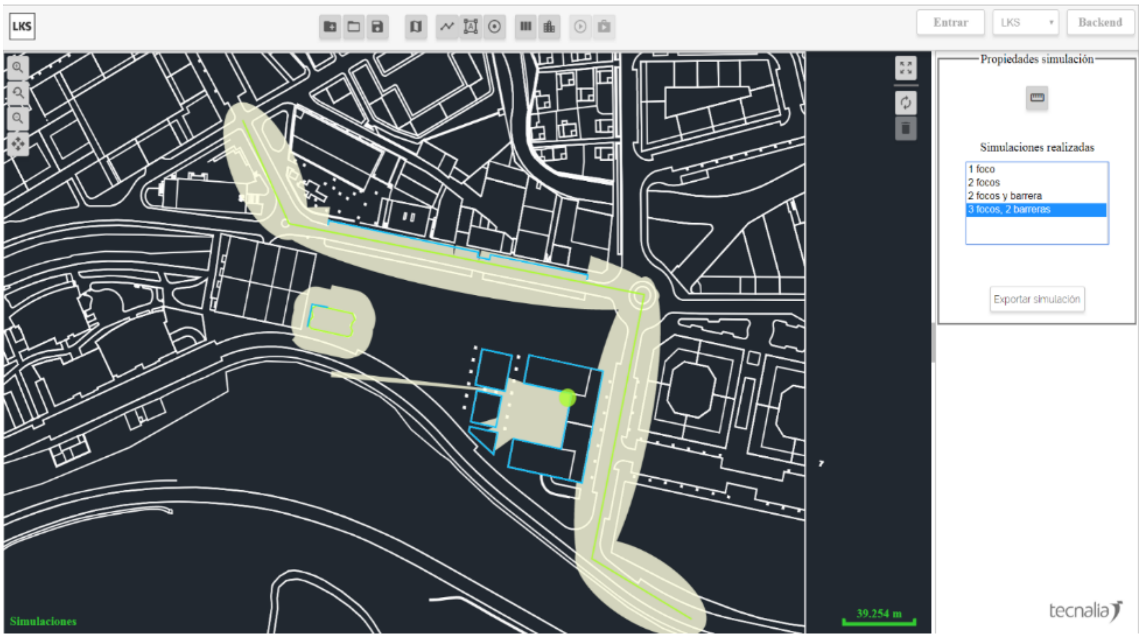

Figure 6. Example of acoustic simulation

• Noise reduction devices Module. In this module the following elements have been implemented following the diffraction methodology:

CATEGORY	Type
Noise reduction devices	Building
	Planter 1,2 meters high
	Noise barriers 2 meters high
	Noise barriers 3 meters high
	Noise barriers 4 meters high
CATEGORY	Type
Forest and vegetable element	Forest (35 meters wide)
	Embankment (less than 1,8 meters)
	Embankment (more than 1,8 meters)
	Green noise barrier 3 meters high

Table 1. Types of elements of noise reduction device module.

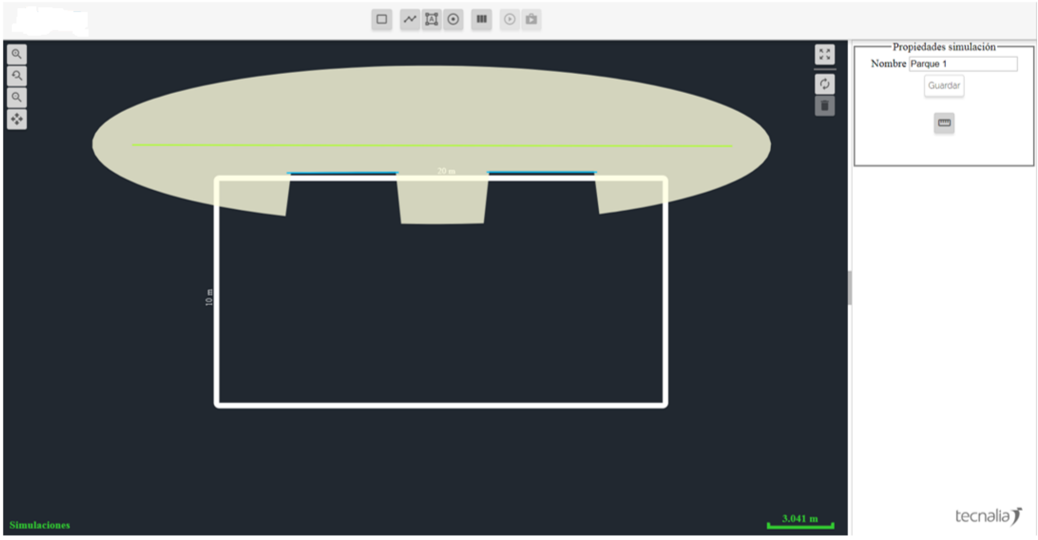

Figure 8. Example of simulation using noise reduction device module.

• Simulations exported in PDF module: The application gives the possibility of generating PDF format of the different simulations carried out with the simulator, so that the user can have a deliverable report of their designs. For this purpose, the client part of the application sends both the data of the selected project and the data of the simulation to the server.

The result is a pdf file that shows: the loaded plane and the result of the acoustic simulation including the legend of the elements generated in the design of the urban space.

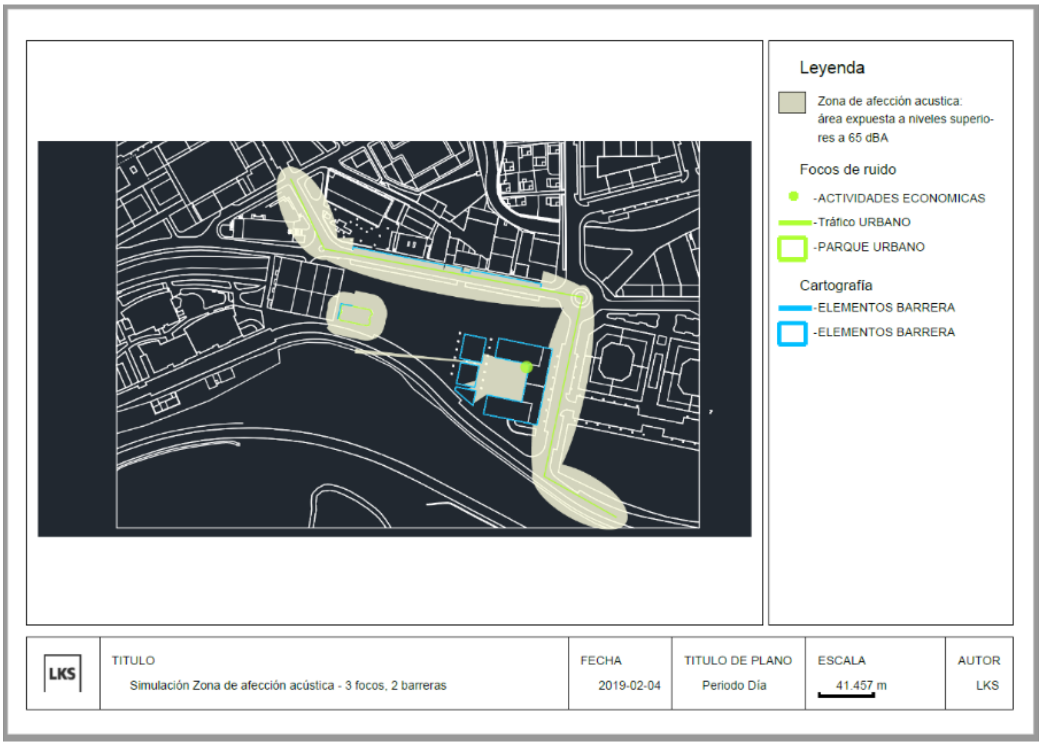

Figure 9. PDF of the simulation with the acoustic legend and the size of the drawing

Other modules developed in the base system have been:

• User management module: a module to add new users to the platform, assign roles and edit their data; name password, email, etc.

• Notification system module: to notify the user of alerts that will help the use of the simulator by displaying texts at the bottom of the screen.

2.2 Simulation algorithms

During the development of the backend of the platform, it has been implemented a database with web services with the corresponding tables and relationships between the different modules.

In addition, in this part of the simulator, it has been introduced the acoustic formulation, to make simplifications in: the simulation algorithms for the characterization of noise emitting sources, in the noise reducing elements (acoustic barriers) and in the acoustic propagation of noise sources.

For the scope of the simulator algorithms have been implemented that synthesize and estimate the acoustic behavior in urban environments. The acoustic algorithms are implemented on the server, using the JAVA language, responding to requests received by the client through web services.

Categorization module: It has been created an interface that shows a form with the different categories and types that the acoustic emission sources may have, including the acoustic barriers, created in the 2D designer.

The interface of the module has been fed using JavaScript and the data of the categories is obtained from the server through web services type REST.

The main acoustic sources in cities have been considered as input data of acoustic emission: urban traffic, railways, industry, human activity, etc. For each acoustic source, different propagation conditions have been selected in the simulator and different properties according to their own characteristics.

Therefore, for the calculation of the acoustic power of the acoustic sources selected, the following methods have been used for the evaluation and management of noise.

- For Road Traffic: CNOSSOS-EU method.

CATEGORY	Type of road	Road surface type	Speed
Urban traffic	One-way street. Dead-end roads	Rough paving stone	30 km/h
	One-way street. Dead-end roads	Cement concrete	30 km/h
	One-way street. Dead-end roads	Cement concrete	50 km/h
	One-way street	Rough paving stone	30 km/h
	One-way street	Cement concrete	30 km/h
	One-way street	Cement concrete	50 km/h
	One-way street	Cement concrete	70 km/h
	Service roads. 2 directions	Rough paving stone	30 km/h
	Service roads. 2 directions	Cement concrete	30 km/h
	Service roads. 2 directions	Cement concrete	50 km/h
	Service roads. 2 directions	Cement concrete	70 km/h
	Collecting roads, 2 lines	Cement concrete	30 km/h
	Collecting roads, 2 lines	Cement concrete	50 km/h
	Collecting roads, 2 lines	Cement concrete	70 km/h
	Collecting roads, 4 lines	Cement concrete	30 km/h
	Collecting roads, 4 lines	Cement concrete	50 km/h
	Collecting roads, 4 lines	Cement concrete	70 km/h
	Small main roads, 2 lanes	Cement concrete	50 km/h
	Small main roads, 2 lanes	Cement concrete	70 km/h
	Small main roads, 2 lanes	Cement concrete	90 km/h
	Main roads, 4 lanes	Cement concrete	50 km/h
	Main roads, 4 lanes	Cement concrete	70 km/h
	Main roads, 4 lanes	Cement concrete	90 km/h
	Highway (Average Daily Traffic Intensity 16000), 2 lanes	Cement concrete	90 km/h
	Highway (Average Daily Traffic Intensity 16000), 2 lanes	Cement concrete	120 km/h
	Highway (Average Daily Traffic Intensity 16000), 4 lanes	Cement concrete	90 km/h
	Highway (Average Daily Traffic Intensity 16000), 4 lanes	Cement concrete	120 km/h
	Highway (Average Daily Traffic Intensity 32000), 2 lanes	Cement concrete	90 km/h
	Highway (Average Daily Traffic Intensity 32000), 2 lanes	Cement concrete	120 km/h
	Highway (Average Daily Traffic Intensity 32000), 4 lanes	Cement concrete	90 km/h
	Highway (Average Daily Traffic Intensity 32000), 4 lanes	Cement concrete	120 km/h
	Highway (Average Daily Traffic Intensity 64000), 2 lanes	Cement concrete	90 km/h
	Highway (Average Daily Traffic Intensity 64000), 2 lanes	Cement concrete	120 km/h
	Highway (Average Daily Traffic Intensity 64000), 4 lanes	Cement concrete	90 km/h
	Highway (Average Daily Traffic Intensity 64000), 4 lanes	Cement concrete	120 km/h

Table 2- Table of selected acoustic categories for urban traffic

- For Rail Traffic: the national calculation method of the Netherlands, published in "Reken - in Meetvoorschrift Railverkeerslawaai '96, Ministerie Volkshuisvesting, Ruimtelijke Ordening in Milieubeheer, 20 November 1996".

CATEGORY	Type	Frequency
Railway traffic	Disk-braked and brake-padded passenger trains	Every 10 minutes
	Disk-braked and brake-padded passenger trains	Every 30 minutes
	Disk-braked and brake-padded passenger trains, slow trains and and freight trains	Every 10 minutes
	Disk-braked and brake-padded passenger trains, slow trains and and freight trains	Every 30 minutes
	Disk-braked InterCity	Every 30 minutes
	Disk-braked InterCity and freight trains	Every 30 minutes
	Tram trains	Every 10 minutes
	Tram trains	Every 15 minutes
	Urban subway	Every 5 minutes
	Urban subway	Every 10 minutes

Table 3- Table of selected acoustic categories for railway lines

- For Noise of Economic Activities and other sound sources: Measurement database made by Tecnalia.

CATEGORY	Type
Economic activities	Workshops, Stores, Supermarkets. Area of each activity less than 300 m^2
	Workshops, Stores, Supermarkets. Area of each activity exceeding 300 m^2, with loading and unloading zone
	Factory, plants or other activities with noise sources outside such as engines, air conditioning equipment, etc.
	Companies: Steel, Metallurgical, Cement, Forges, Steelworks, Petrochemicals
Pedestrian street	Commercial
	Street with hospitality industry: day period.
	Street with hospitality industry: day/night period with terrace
Urban park	Playground
	Outdoor sport equipment
	Natural
Others	Car Park
	Water fountain jet

Table 4- Table acoustic categories selected for economic activities

From the sound power of these acoustic source, the method of calculation of acoustic propagation described in ISO 9613 is taken as a reference to analyze the acoustic impact of them in the urban spaces that can be integrated in the simulator.

The attenuations considered in this simplified algorithm have been: attenuation due to divergence and attenuation due to atmospheric absorption. Meteorological correction has been established always like unfavorable night period.

3. DISCUSSION AND LIMITATIONS

The simulator provides a solution for architects to have a user-friendly tool to integrate acoustic comfort in urban design analyzing their acoustic comfort. Based on these results, the first design variables are obtained to place, for example, activities or equipment that require acoustic protection in areas without acoustic impact. Whereas, areas with acoustic impact will require a detailed acoustic study, for the design of alternatives or noise reduction devices.

There were followed the methodological prescriptions detailed in the legislation: Decree 213/2012 on acoustic contamination in the Basque Country. These emission assessment methodologies are represented by three evaluation indicators also set by the legislation: Lday (over the 7:00 to 19:00 hours), Levening (over the 19:00 to 23:00 hours) and Lnight (over the 23:00 to 7:00 hours).

The evaluation of the impact has been made according to the acoustic quality objectives set by this legislation for urban public areas (parks, squares, etc.) in residential areas: 65 dBA, for the day and evening period and 55 dBA for the night period. In all cases, the simulation module calculates the three areas of affection (for each of the three periods: day, afternoon and night) but only represents the one that is acoustically more unfavorable.

3.1 Limitations

There are several limitations which need to be considered when discussing the design of the simulator. First of all, there infinities a limited number of sources available for the user to choose from database that can not be customized by the user.

The acoustic simulator does not implement the attenuations due to ground effect and the effect of reflections of the sound. This is because of the complexity of 3D modeling and in order to reduce calculation times. A simplified approach of the diffraction of the sound has been implemented in the noise reduction device module.

The results obtained by the simulator have no legal validity. Despite its limitations, the results obtained from the simulator offer a first approximation to integrate the acoustic variable in the urban design and provides to architects the opportunity of being autonomous to integrate sound dimension as a variable to make decisions regarding urban design.

4. CONCLUSIONS

In the framework of this project Tecnalia and LKS have developed an acoustic web simulator called CONACUS. This simulator, with the previously detailed limitations, allows to the users a simplified acoustic evaluation of urban places. It is the factor which makes this tool for use for professionals, such as town planners and architects. This simulator is based on a web application that allows its use with an internet navigator without installing any specific program.

The main functions developed in simulator have been: web access, loading of maps in DWG format, creation and design of noise emission and noise reduction devices, realization of simplified acoustic simulations with short calculation times, visualization and export of results in PDF format.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

1. QUADMAP Project. Quiet Areas Definition and Management in Action Plans, Final Report Covering the Project Activities from 01/09/2011 to 31/03/2015. 2016 Available online: http://www.quadmap.eu/wp-content/uploads/2016/01/Final Report_QUADMAP_technical.pdf (accessed on 2 November 2016)

2. Yang, W.; Kang, J. *"Acoustic comfort evaluation in urban open public spaces"*. Appl. Acoust. 2005 66, 211–29.

3. Herranz-Pascual, K.; García, I.; Aspuru, I.; Díez, I.; Santander, A. "*Progress in the understanding of soundscape: Objective variables and objectifiable criteria that predict acoustic comfort in urban places"*. NoiseMapp. 2016, 3, 247–263.

4. Herranz-Pascual, K.; Gutiérrez, L.; Acero, J.A.; García, I.; Santander, A.; Aspuru, I. "*Environmental comfort as criteria for designing urban places"* in Proceeding of Architecture, Education and Society, Barcelona, 4-6 June 2014.

5. Aspuru, I. Fernandez, M. García, I. Herranz-Pascual, K. "*Soundscape within the strategy of Bilbao city to improve Quality of Public Spaces*", AIA-DAGA, Merano (2013).

6. ONU "*Las ciudades seguirán creciendo, sobre todo en los países en Desarrollo*" Organización de las Naciones Unidas, 16 May 2018, New York [accessed on 23/01/2019: https://www.un.org/development/desa/es/news/population/2018-world-urbanization-prospects.html
7. Decreto 213/2012, de 16 de octubre, de contaminación acústica de la Comunidad Autónoma del País Vasco. Basque Legislation for Noise.
8. Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise. Official Journal of the European Communities, L189/12, (2002).
9.Commission Directive (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council. vol. L 168.
10. Beristain, J.; Arenaza, X.; Prieto, I. "*X3D based playground configurator". *Web3D '13 Proceedings of the 18th International Conference on 3D Web Technology, Donostia-San Sebastian, 20-22 June 2013.