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The HARMONICA project, new tools to assess environmental noise and better inform the public

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Summary

Noise pollution is so pervasive in cities that, most of the time, citizens and policymakers believe it is unavoidable. They can sometimes feel powerless to improve things. To raise awareness of noise pollution, the HARMONICA project has developed and published a new index, called the Harmonica index, as well as innovative and educational tools to better inform the public and to assist decision-making. This new noise pollution index is different to existing indicators as it takes into account both the continuous and the sporadic nature of noise: including background noise and noise peaks caused by aircraft, rail traffic, etc. The public was involved in its creation (a survey of 360 people) to reflect how the general public perceives noise nuisances. As with the measurement of air quality, it uses a simple unit, with a scale of 0 to 10. The new index is used on the website www.noiseineu.eu. For cities, urban communities or authorities with noise monitoring networks, it is easy to join the on-line platform and display measurements using the new index in a harmonized manner. All European cities can contribute to the on-line database of noise abatement solutions, in order to promote effective actions and help each other to draw up their Action plans for implementing European directive 2002/49/EC. There is also a forum dedicated to the use of these new tools and sharing experiences about noise monitoring networks in the FONOMOC network of Eurocities WGN. Launched in October 2011, the 3-year HARMONICA project is supported by the European programme LIFE + Environment.

1. Introduction

Bruitparif and Acoucité are two local French organisations specialising in the observation of environmental noise and specifically involved in facilitating the implementation of European directive 2002/49/EC (commonly abbreviated as END), relating to the assessment and management of environmental noise, in their respective regions. In 2010, they decided to join forces to set up the HARMONICA project. These two noise observatories are both non-profit associations and they assess and monitor the exposure to noise of inhabitants in their respective regions; Ile-de-France for Bruitparif and Greater Lyons for Acoucité.

The acronym HARMONICA stands for HARMOnised Noise Information for Citizens and Authorities. The HARMONICA project aims to develop a new approach: providing information about environmental noise that is closer to what people perceive, and easier for the general public and public authorities to understand, in order to increase assimilation of the issue and to give weight to noise abatement policies.

The two partners applied for a European Union grant under the LIFE + 2010 programme and the project proposal was approved. This 3-year project started in October 2011. The HARMONICA project is also supported by the Working Group Noise (WGN) of EUROCITIES.

2. Context

The creation of the strategic noise maps required by European directive 2002/49/EC has initiated a new dynamic with environmental noise being taken into account by the authorities, and the public being provided with more information on the subject.

Certain local authorities have also promoted the development of noise measurement networks (Madrid, Brussels, Athens, Greater Lyons, Lille, Paris and the Ile-de-France region, among others) to provide decision-makers with reliable information about noise levels and thereby more effectively guide public policies for fighting noise pollution. Carried out alongside noise mapping, and more accurately reflecting the reality of perceived noise, noise measurement helps to make a more accurate diagnostic, to provide information about variations in noise levels throughout the day, and to identify specific events like car horns, and the passage of noisy aircraft, trains, and motor vehicles.

Nevertheless, whether the information about noise is presented in the form of strategic noise maps or in the form of measurement results, it currently remains difficult for people to understand because of the many indicators used (Lden, Ln, LAeq, LA10, LA90, NA, and LAmax, to name just a few), which are complicated to explain and relatively far-removed from inhabitants' perception. Furthermore, the unit used by these indicators - namely the decibel - has the disadvantage of being complex, with the addition of two noise levels expressed in decibels being logarithmic rather than arithmetic. For example, 60 + 60 dB is not 120 dB but 63 dB.

All these reasons make it even more difficult for the authorities and the general public to take ownership of the noise issue.

A survey of 800 people was conducted at the beginning of the Harmonica project, in order to evaluate the general public's current level of knowledge and expectations in terms of information on the noise environment. The results obtained confirmed the idea that the public has difficulty understanding the information about noise currently provided. The survey confirmed that respondents' understanding of acoustics is very fragmented and that they have difficulty estimating noise levels of everyday events and situations. The survey also revealed that the public believes that information about noise peaks that occur during the day would effectively complement the measurement of noise levels.

It was, therefore, becoming essential to provide information that is easier to understand and more closely reflects the reality of noise nuisances as they are perceived by the public.

3. Objectives

The HARMONICA project originated with the following observation: noise pollution and the possibilities for correcting it are insufficiently understood by the general public and authorities. In order to increase assimilation of the issue, and consequently the effectiveness of nuisance prevention or reduction policies, the project suggested the creation of a new, easy-to-understand noise index, similar to the ones used for air quality. Its proposal, the harmonica index, should be closer to the public's perception than the usual averaged indicators. Based principally on measurement data provided by noise monitoring networks, the index should take into account both the overall environmental noise "load" and noise peak-type disturbances over time (noise peaks from sudden sound events that stand out from the background noise: aircraft overflights, trains, especially noisy motor vehicles, horns, etc.) The aim was also to create a database on noise abatement solutions that would be published along with the noise pollution index on an interactive website. At the beginning, the website should be based on the area of experimentation of the two partners (Bruitparif and Acoucité) which covers a total surface area of more than 12,500 km² and a population of 13 million people. But the website aims to integrate progressively the data produced by other European towns with noise monitoring networks. All relevant information should be made available in an easy-to-understand way, and it should facilitate assessment of the impact of noise abatement initiatives. The tools should be assessed by the general public and authorities for the duration of the project to allow their optimisation before being rolled out more widely.

4. The Harmonica index

The initial objective of the Life Harmonica project was to develop a new index for presenting environmental noise levels, that is:

- easy for the public to understand, because it is based on a scale of 0 to 10, rather than decibels ;
- easy to calculate using the type of measurement data usually collected by noise measurement devices, namely the LAeq,1s levels (A-weighted, equivalent continuous sound level for 1s);
- possible to calculate for one-hour time slots;
- relevant in terms of acoustic physics, taking into account the two major components that affect the noise environment: background noise and noise events that exceed this background noise (noise peaks);
- more representative of people's perceptions of their noise environment than the environmental noise indicators currently used in French and European regulations.

4.1. Design Methodology

A three-stage methodology was designed for the creation of the new index.

4.1.1. First step: selection of the parameters for the index

The choice of the parameters involved in the construction of the index was based on a preliminary statistical analysis carried out on a database of elementary acoustic measurements (LAeq,1s) from 24 sites that are representative of the eight main types of noise exposure (land transport noise, air traffic noise, and quiet areas) in a variety of environments (urban, suburban, and rural). The aim was to choose acoustic parameters that would account for a significant proportion of the variability of many of the acoustic indicators.

Around 60 different energy- and event-based descriptors used in the available literature or proposed by the teams were calculated on an hourly basis using this elementary data from all 24 sites. The correlation between the 60 descriptors was studied in order to evaluate the descriptors that were interrelated (redundancy), thereby eliminating those that measure the same thing and defining families of descriptors that are uncorrelated and, therefore, which provide complementary information. This method of statistical analysis is called Principal Component Analysis (PCA).

Using this PCA, it was possible to define two main families of interdependent and complementary physical descriptors, which provided most of the information:

- The background noise
- The noise peaks that emerge from the background noise

Then the teams proposed different suggested indices based on various parameters that describe these two noise dimensions (background noise and noise peaks).

4.1.2. Second step : Consideration of the public's opinion and perceptions

The suggested indices were compared with the public's impressions using face-to-face interviews with 246 residents from 8 areas chosen for the diversity of their exposure to noise, and tests in laboratory conditions (individual interviews following binaural playback) on three groups of respondents: general public, associations, and local authorities (130 people in total).

The aim of this research phase was to evaluate the comprehensibility, the acceptability, and the relevance of the suggested indices and to take into account people's responses in the final design of the index.

4.1.3. Third step : Development of the formula of the index

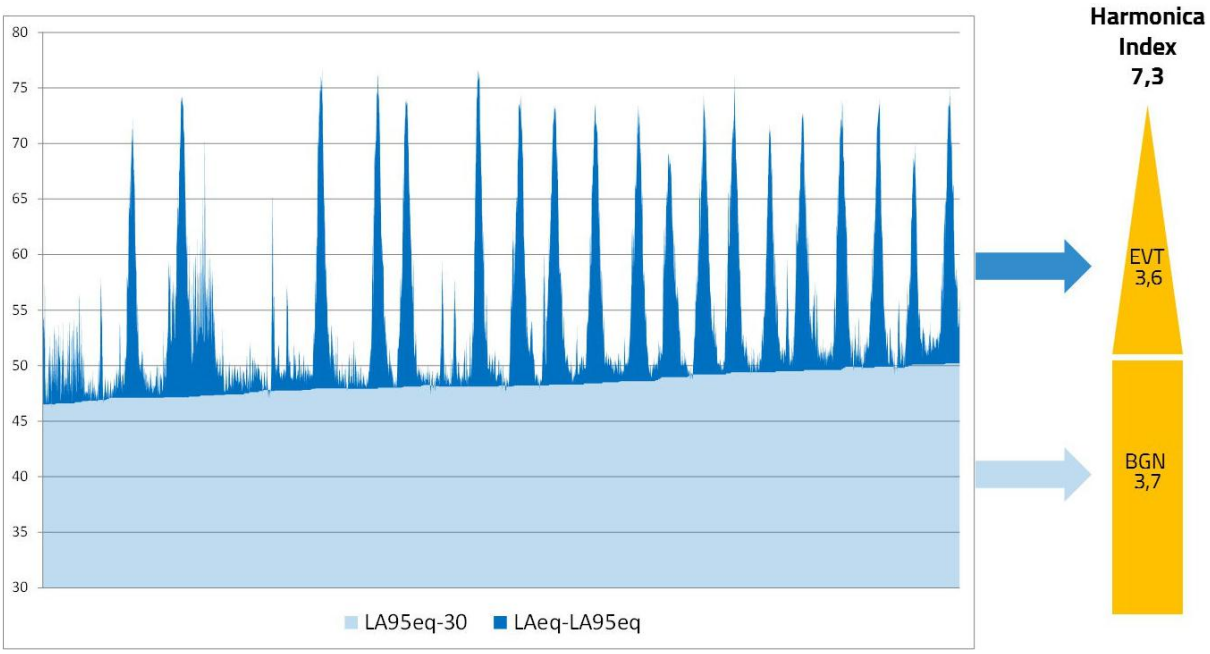

Figure 1 : the Harmonica index for one hour measurement.

The formula for the index was then defined by testing the different descriptors selected in operational conditions, on all the operational measurement data stored by noise observatory Bruitparif and its partner Acoucité, in order to take into account the diversity of environmental noise situations. These tests led to the elimination of some descriptors that proved to be insufficiently robust and the adjustment of the coefficients of the index formula, in order to present the variations in hourly noise levels on a scale of 0 to 10. This last stage resulted in the following formula:

Hourly Harmonica index = background noise sub-index (BGN) + peak noise sub-index (EVT)

The Harmonica index, therefore, is divided into two parts:

A component related to the background noise: BGN sub-index: BGN = 0.2 x (LA95eq - 30) LA95eq is the equivalent background noise level during the one-hour period, the background noise being evaluated every second by the noise level exceeded 95 % of the time during the previous 10-minute period.

An event-related component: EVT sub-index, which represents the acoustic energy provided by noise peaks that emerge above the background noise:

EVT = 0.25 x (LAeq - LA95eq)
LAeq is the equivalent noise level during a one-hour period.

N.B.: Until the end of the Harmonica project (31/12/2014), the calculation of the index is in an experimental phase on Bruitparif's and Acoucité's measurement sites, which are in the Île-de-France region and Lyons metropolitan area respectively, which are the demonstration areas for the Life environment programme's Harmonica project. The formula for calculating the index may be amended at the end of the project.

4.2. Graphical representation

Particular care was taken in designing the graphical representation of the Harmonica index, in order to simultaneously provide several pieces of information about the noise environment in a clear and concise manner.

4.2.1. One score for the noise pollution level

The Harmonica index gives a score of 0 to 10, rounded to one decimal place. The higher the score, the poorer the acoustic environment.

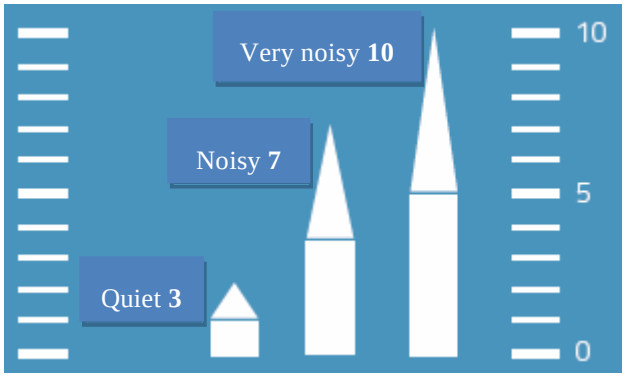

Figure 2: Harmonica index score.

4.2.2. Two shapes to distinguish between the contribution of background noise and noise peaks

The graphical representation of the index is in two parts, a triangle on top of a rectangle, in order to clearly translate its two components:

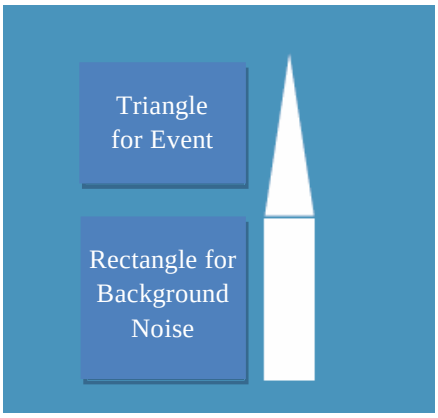

Figure 3: The two components of the Harmonica index.

The triangle represents the event-based component (EVT), related to noise dynamics and the number of noise peaks that disturb the peace.

The rectangle represents the component related to background noise (BGN).

4.2.3. Three colours indicate the situation compared to threshold values

The colour of the index (green/orange/red) indicates how the noise environment compares to the WHO's environmental quality objectives and the values recognised as critical for noise. These colours also take the time of day into account, as people are more sensitive to noise at night.

Colour	Day from 6 am to 10 pm	Night from 10 pm to 6 am
	between 0 and 4	between 0 and 3
	between 4 and 8	between 3 and 7
	over 8	over 7

Figure 4: Three colours

4.2.4. Four kind of calculation periods per day

The Harmonica index is calculated for hourly time slots for every noise measurement terminal in the networks and towns that are part of the Noise in EU European information platform.

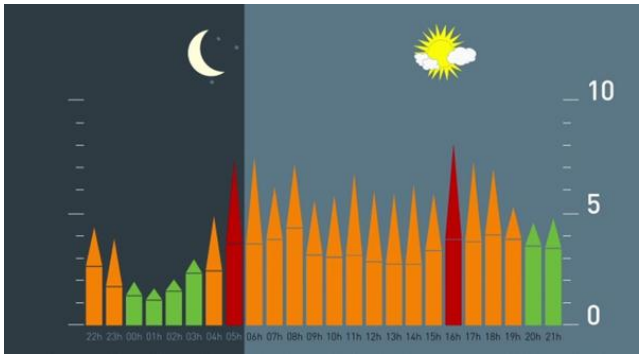

Figure 5: Example of hourly variation of the Harmonica index over a 24h period.

Three average values are also calculated every day: one for the day period (6am - 10pm), one for the night period (10pm - 6am), and one for the entire day (24h).

5. New tools for the public and authorities

A new website has been successfully created during the project: **www.noiseineu.eu.** Aimed at both the general public and the authorities responsible for managing the issue of noise nuisances, http://www.noiseineu.eu boasts a variety of content and features that allows anyone to:

- better understand the issue and challenges of exposure to environmental noise in Europe;
- improve the significant advance provided by the Harmonica index in terms of information on environmental noise and the consideration of how noise is perceived by different individuals;
- access the index's results from noise measurement terminals in several major European towns;
- access detailed initiative sheets on concrete measures taken by local authorities and their partners;
- envisage initiatives to implement as part of Directive 2002/49/EC/

5.1. The website: www.noiseineu.eu

The website www.noiseineu.eu comprises several different general sections with clear and exhaustive editorial content about noise in Europe, the new Harmonica index, its contributors and how to join the project. In addition, users can access the two technical modules and their useful user interfaces.

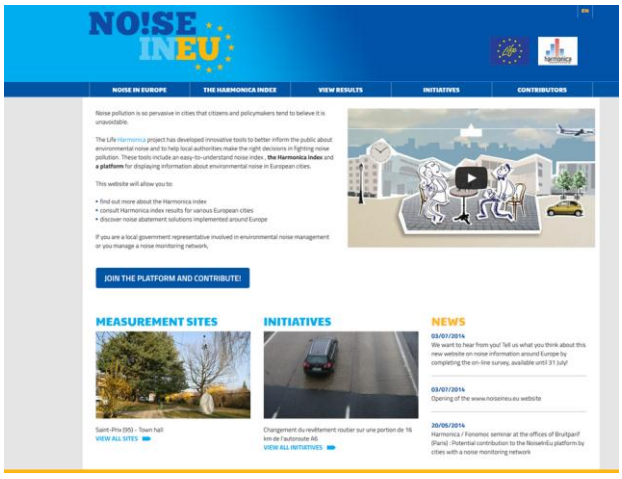

Figure 6: Home page of the Noise in EU website.

The first technical module gives online access to a platform publishing the results of environmental noise measurements from active noise monitoring terminals and specific (short-term) noise surveys using the Harmonica index. All the results are available in the "view results" section.

The second technical module gives access to an online database of noise abatement solutions: best practices implemented by cities and national or local authorities in Europe. These noise abatement solutions can be found in the "initiatives" section.

Both results on environmental noise measurements and information on noise abatement solutions are available directly from the home page, by clicking on the " view results" and "initiatives" links.

To help users understand the new "Harmonica noise index", in addition to the editorial content that features on the site, users can watch an informative and humorous animated film on the home page and in the relevant section. The animated film has been also posted on YouTube to reach a wider audience: https://www.youtube.com/watch?v=q6crbXu0pq4

5.2. The web platform for displaying results from noise monitoring terminals by using the Harmonica index in Europe

To facilitate the implementation of the Harmonica Index, project coordinator Bruitparif has set up a calculation service which can be found on www.noiseineu.eu. It is designed as a dynamic calculation platform offering up-to-date noise data using the Harmonica index as an efficient way of presenting the noise situation across European cities.

In this module, the Harmonica index is calculated on an hourly basis and requires at least 80% of available LAeq,1s noise values to be calculated. Average values for the Harmonica index are then calculated for day-time, night-time and 24-hour periods.

5.2.1. User interface specification

By zooming or clicking on the icons on the map, it is possible to see the Harmonica index results for various measurement sites in towns and regions that contribute to the Noise in EU platform. The information is delivered on an hourly basis or as an average for the day-time (6 am - 10 pm), at night (10 pm - 6 am) or for the entire day (24h). The interface also allows to easily compare the results of the index between several sites and/or several time periods.

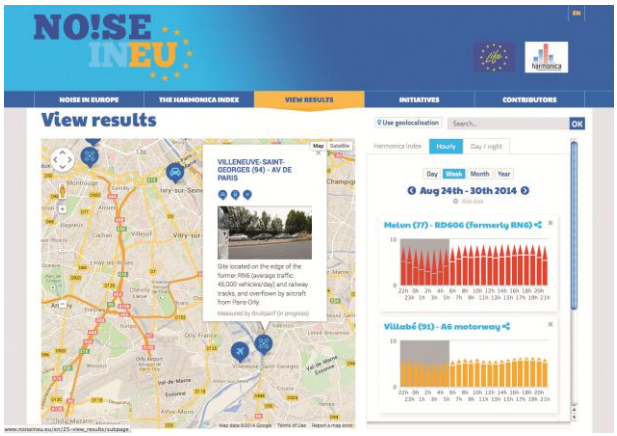

Figure 7: Noise measurement results.

5.2.2. Demonstration phase

For the project's demonstration phase, the new harmonica index has been set up in both the partners' noise monitoring networks, with more than 60 noise measurement terminals in their respective regions, the Île-de-France region and the Greater Lyons metropolitan area. This wide area of experimentation covers a total surface area of more than 12,500 km² and a population of 13 million people. Bruitparif operates around 50 terminals in the Île-de-France region with 10 more operated by Acoucité in the Greater Lyons area.

5.2.3. The next step

Acoucité is currently conducting a survey to assess the impact of the news tools with the general public and authorities on the experimentation territory. The results will be shared at the closing event on 9 December 2014, in Brussels.

The platform aims to integrate data produced by other European towns with noise monitoring terminals. To facilitate access for other contributors, a public FTP server has been set up to push data. This means there is no need for contributors to deal with security issues or to open access to their own information systems.

5.3. The online database of noise abatement solutions: Sharing best practice at European level

Beyond the scientific challenges related to the effectiveness of the Harmonica index, the project promoted by the European Union also aims to share and promote noise abatement initiatives carried out by the project's various partners in European towns.

5.3.1. A collaborative database

To make it easier to diffuse and include as many initiatives as possible, the database is available online through the dedicated web portal www.noiseineu.eu. The initiatives listed in this database are not in competition and there is no ranking. This database essentially aims to list all the available data in a single place. A collaborative platform, open to all the stakeholders involved in fighting noise nuisances, this database allows users to share information and is intended to facilitate decision-making by bringing together experiences, innovations, and action plans.

Figure 8: Redevelopment of General Lattore square in Bilbao.

5.3.2. A vast range of achievements

Any initiatives that aim to reduce environmental noise nuisances can be included in the database. These initiatives are divided into three main types: First of all, the reduction of nuisances at their source, whatever the initial cause (e.g. transport, technology, commercial or industrial activities, recreational noise, etc.). Secondly, developments that aim to limit the propagation of noise or reduce people's exposure to it. And finally, raising awareness so that those who generate the noise take the issue into account and manage it better, in order to prevent risks.

The database is structured in such a way as to promote different types of noise abatement solutions, depending on their source:

- Road traffic noise, whatever the environment: urban traffic, expressways, motorways, etc.;
- Rail traffic noise produced by mainline trains, express urban networks, metro, tramways, etc.;
- Air traffic noise caused by commercial airlines, light aircraft, helicopters, or military flights;

- Industrial/construction/commercial noise;
- Recreational noise, which can occur both during the day and at night;
- Quiet areas: in terms of their creation, preservation, and improvement;
- Town planning and development;
- Prevention and raising awareness, in any form.

Figure 9: Low noise road surfaces on the Paris ring road.

For now, the database essentially features initiatives that have been inventoried and documented in the regions of the Harmonica project's two partners, namely Île-de-France and Greater Lyons. It also contains initiatives carried out in towns in south-eastern France that enjoy the support of Acoucité, as well as initiatives in the cities of Bilbao and Florence, which are Bruitparif's partners in the Quadmap project (a project dedicated to the subject of quiet areas). The number of initiatives presented on line will increase progressively thanks to the contribution of all European stakeholders. It is very easy for the representatives of a local authority or transport infrastructure company to promote the initiatives carried out in their area of jurisdiction, using the initiative sheets**.**

6. Getting involved in and Joining the Noise in EU community

To circulate the information as widely and as easily as possible, all European cities and organisations are encouraged to join on www.noiseineu.eu and to provide information about their noise monitoring networks and their innovative noise abatement actions.

Experimenting with the Harmonica index and enriching the platform with data from noise measurement sites is very easy.

To calculate and publish the Harmonica index in an area, requires only acceptance of the platform's conditions of use and sending data in the required format. All data transfer, including the conversion of values (LAeq,1s) into the Harmonica index, is done by the platform and the noise data are automatically being made available alongside other European towns that are part of the network, in a simple and comparable format.

If a local authority doesn't have noise measurement data for its town or region, but still wants to share the noise abatement initiatives that have been implemented, that is quite possible by simply completing the form template, available on the site and returning it, with any documents and illustrations, by email to the following address: join "at" noiseineu.eu. Initiatives will then be put on line as soon as possible.

Joining the Noise in EU community group allows to:

- **test** the Harmonica using noise measurement data;
- **improve** and clarify information on environmental noise intended for the public, thanks to an easy-to-understand graphical representation of the noise data;
- **contribute** to the enrichment of a European platform for information on noise for sharing knowledge and experiences, in order to make a benchmark tool for enabling the general public and authorities to take ownership of the noise issue;
- **share** experiences and increase operational resources for fighting noise pollution, through consultation, and by the enrichment of the on-line initiative database;
- **meet** other towns and organisations working to preserve the noise environment in Europe, and share ideas with them during meetings.

More information can be obtained by going to the "join us" section of the www.noiseineu.eu website.

7. Preliminary conclusion

Until the end of the Harmonica project in December 2014, the calculation of the index is in an experimental phase. It is being calculated for Bruitparif's and Acoucité's measurement sites, in the Ile-de-France region and Lyons metropolitan area respectively, which are the Harmonica project's demonstration areas. The formula for calculating the index may be amended at the end of the project. In the meantime, all the tools created (the website, the online platform for displaying measurement results, and the online database of noise abatements solutions) are already available and operational. On 9 December 2014, an event will be held in Brussels (at the Museum of Natural Science) as part of the EU's LIFE programme, presenting the results of the Harmonica project and the next steps for its many contributors using these new tools and methods.

Acknowledgements

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