Informing the public on noise impacts through the web-GIS Dynamap software application

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Summary
Public information on noise impacts is one of the most problematic objectives of the environmental noise directive 2002/49/EC that authorities responsible for providing strategic noise maps shall face. In order to facilitate public information, a web-GIS software application has been developed within the Dynamap project. The DYNAMAP project is a LIFE project aimed at developing a dynamic noise mapping system able to detect and represent in real time the acoustic impact of road infrastructures. To that end, the project involves the design of a complex monitoring network and communication devices, as well as the implementation of an advanced management and reporting platform to update noise maps and inform the public on noise issues.
To guarantee the full effectiveness of this application, a group of selected users will be monitored to check their aptitude in managing the system and help developing a user-friendly interface for public information. Tests will be also administered to the general public to evaluate the system versatility and its contents comprehensibility.
In this paper a detailed description of the web software application, of the indicators used to ease public information and of the tests prepared to check recipients ability in managing and consulting the system is given.

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1. Introduction

The DYNAMAP project (Dynamic Acoustic Mapping - Development of low cost sensors networks for real time noise mapping) is a LIFE project aimed to develop a dynamic noise mapping system able to detect and represent in real time the acoustic impact of road infrastructures. Scope of the project is the European Directive 2002/49/EC relating to the assessment and management of environmental noise (END) [1-2], enforcing Member States to provide and update noise maps every five years in order to report about changes in environmental conditions (mainly traffic, mobility and urban development) that may have occurred over the reference period.
The Directive 90/313/EEC3 [3] enforces also public authorities to give free access to environmental information, setting out the basic terms and conditions on which such information should be made available. According to this directive, Member States shall ensure that public authorities make environmental information available to any natural or legal person at his request and without his having to prove an interest. They shall also define the practical arrangements under which such information is effectively made available and shall take the necessary steps to

provide general information to the public on the state of environment by such means as the periodic publication of descriptive reports. To that end, in the Dynamap project a user friendly interface and tools have been developed, so as to make the information gathered by the system usable on a large scale.
In the attempt to facilitate public information and to help delivering simplified and easy to read noise maps, the project also includes the development of a straightforward noise indicator for the general public and authorities responsible to take ownership of noise related issues. The implementation of a new disturbance index, based on the Harmonica Index developed in the framework of the LIFE HARMONICA project, has been investigated [4].
In addition, in order to optimize the communication features of the software application, the project includes a series of tests to assess users ability in accessing information and managing the system.

1.1. The Web GIS software application

The core idea of the Dynamap project is based on the possibility of implementing dynamic noise maps by summing up several source related noise maps together, each one scaled by the system according to continuously measured noise data. Basic noise maps have been prepared using commercial calculation models as a function of some environmental parameters affecting noise propagation, such as meteorological conditions [5-6] and road traffic distribution. Dynamic noise maps are accomplished with a newly developed software application, whose main role is to scale the pre-computed partial noise maps as a function of the noise levels detected by the monitoring devices, sum them together to achieve the updated noise map and publish the results as colored geo-referred noise maps in a user friendly format [7].
This new application will be integrated in the "Dynamic maps" page of the Dynamap website [8] where a geographic map will show the location of the sensors installed in both Milan and Rome pilot areas (Figure 1). Clicking on the map, the online tool will be opened showing the data related to the selected area.
The software platform implements a double access function with high and low privileges to protect sensitive information.
The high privilege access (full access to the information stored in the platform) is reserved to authorized stakeholders and allows to plot Leq dynamic noise maps, historical data, some statistics and additional parameters linked to the sensors installed in each monitoring station (Figure 2).

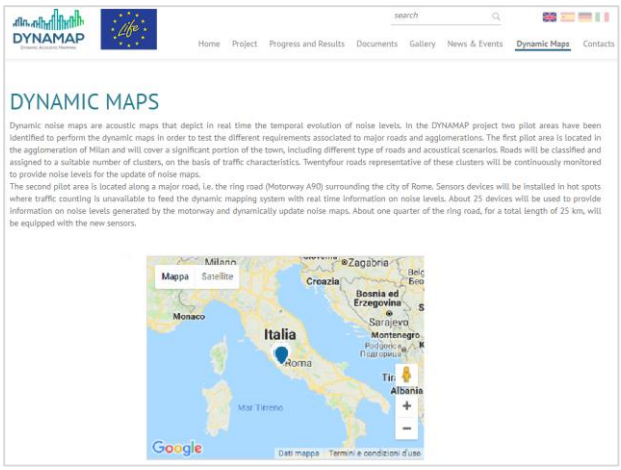

Figure 1. "Dynamic maps" page on the project website.

The low privilege access level is open to the general public, and allows to plot only noise maps in terms of the new disturbance index, as better explained in the next paragraph. In Figure 3 a general view of the user interface designed for the general public is shown. Further studies to optimize the platform are underway.
The online web-GIS software application will be adjusted as reported in Figure 4: on the right side the dynamic map in terms of disturbance index will be reported, while on the left side information about the selected building will be shown, such as the indicator hourly values. In this frame also information about Action Plans will be reported to inform the public about planned or accomplished mitigation measures in critical areas. Noise mitigation measures will be plot on the map and a popup will show the related main information. An educational area with information and advice to help reducing noise levels and descriptive documents will be also published.

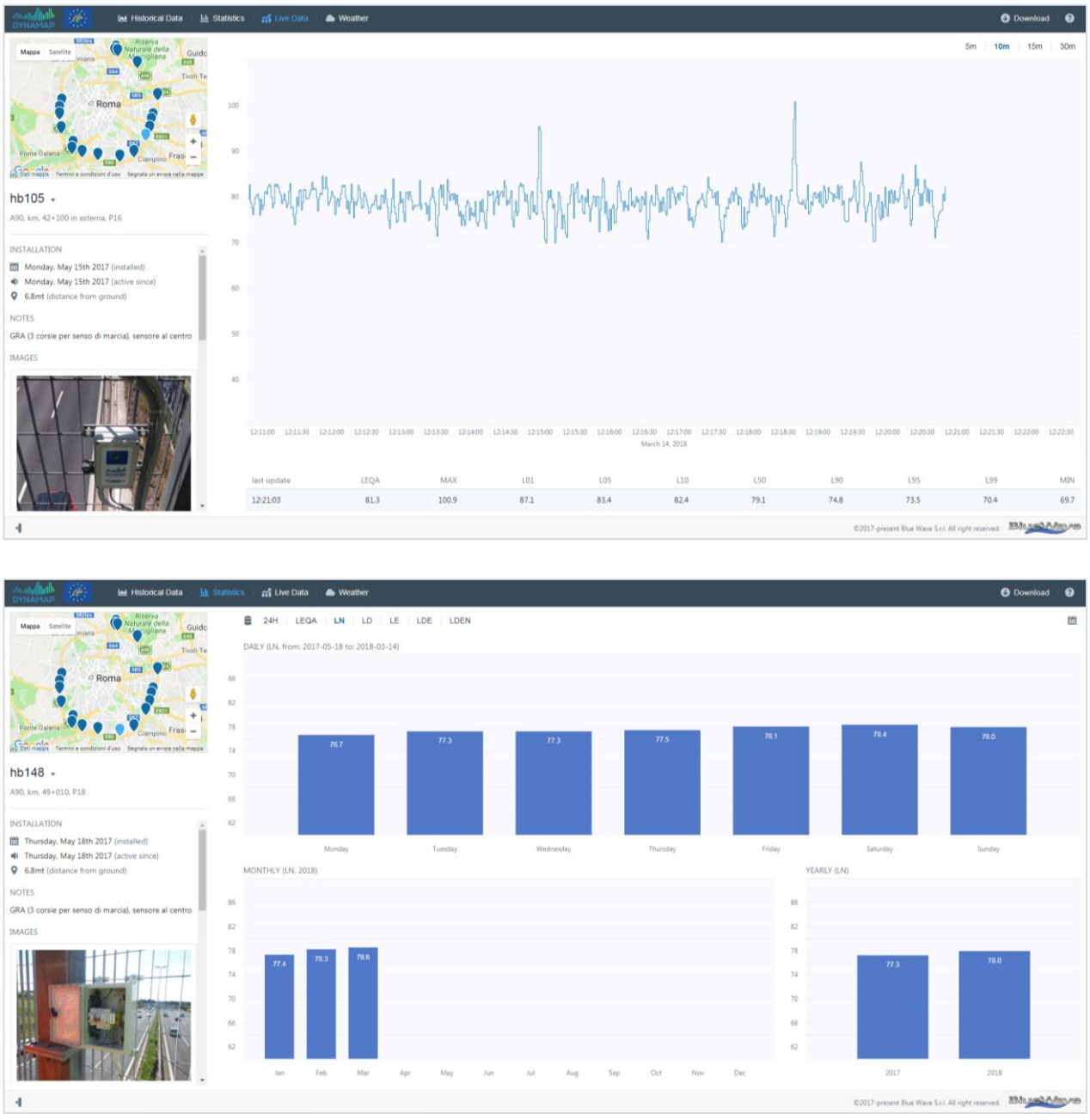

Figure 2. Screenshots of the NOISEMOTE application showing live and statistical data.

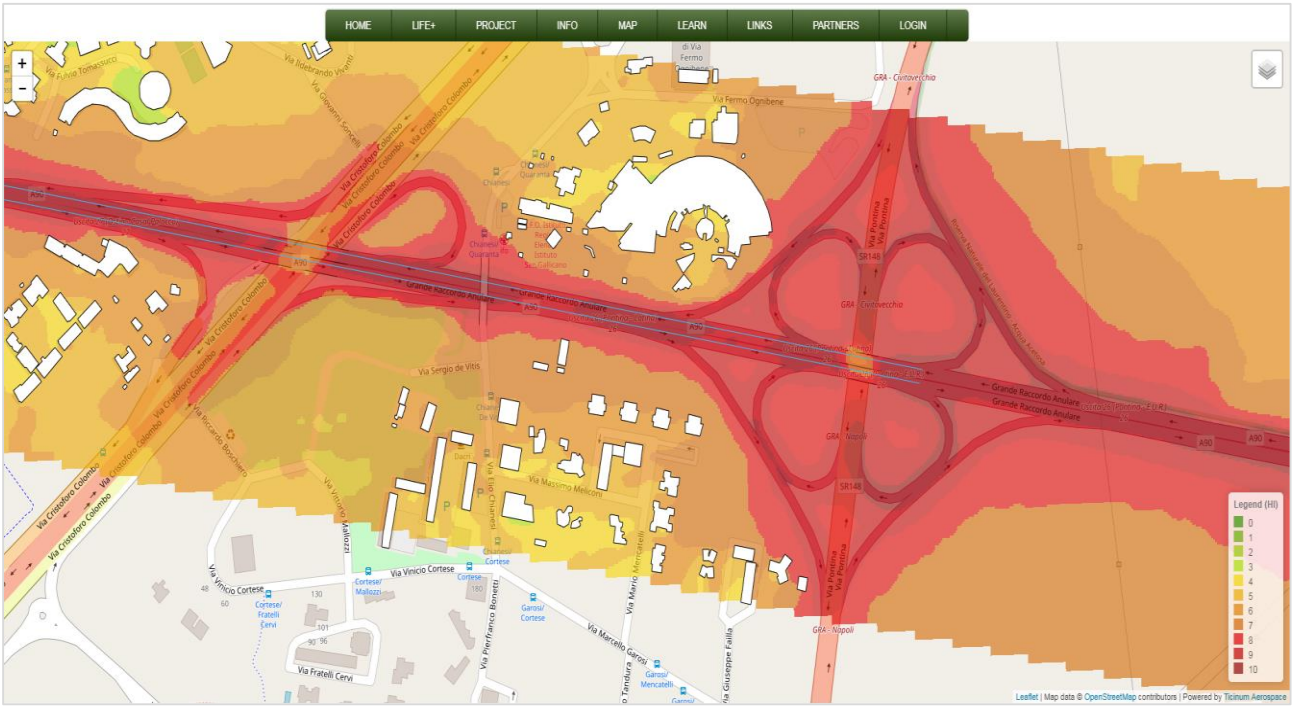

Figure 3. Screenshot of the current dynamic maps mask.

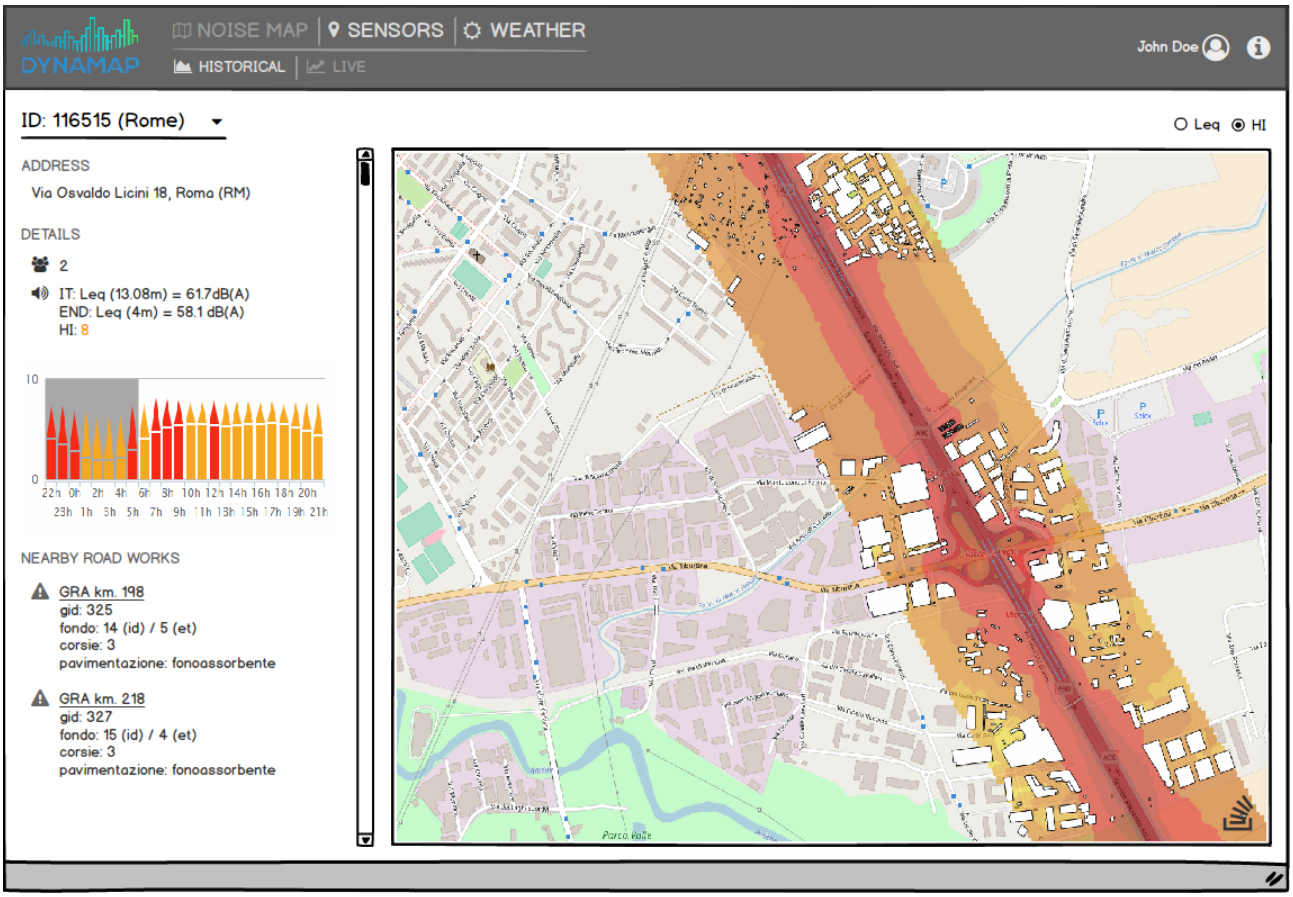

Figure 4. Example of the improved online tool for dynamic noise maps presentation.

1.2. The Harmonica Index

In the attempt to facilitate public information and to help delivering simplified and easy to read noise maps according to END specifications, the Dynamap project includes the development of a new disturbance index. Since LAeq and Lden values, representing the average noise level over a given period on a logarithmic scale, are too complex indicators to be easily understood by the general public and authorities responsible to take ownership of noise related issues [4], a different indicator should be used to simplify noise maps presentation. To that end, the Harmonica index, developed in the framework of the LIFE HARMONICA project, was analyzed in order to investigate its suitability to real time noise maps. To improve public comprehension on noise issues and impacts, the Harmonica project suggests the creation of a simple noise index, taking into account the main components that influence noise perception, namely the background noise and the peaks related to noise events emerging from background noise. The Harmonica Index gives a score from 0 up to 10, rounded to one decimal place. The higher the score, the poorer is the noise environment. In Figure 5 an example of the graphical representation of the Harmonica Index is reported [9].

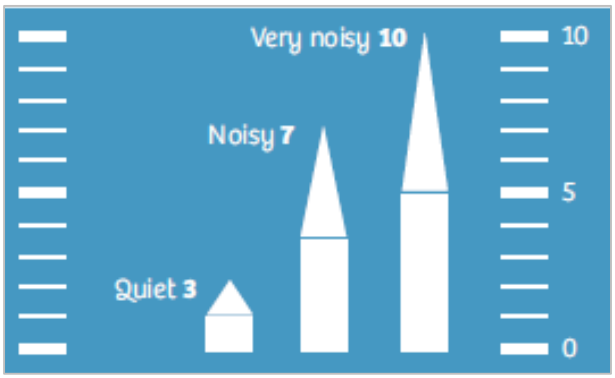

Figure 5. Example of the graphical representation of the Harmonica Index.

The noise impact is also emphasized by the adoption of a three color scale (green, orange and red) that takes into account the time of day in order to reflect people increased sensitive to noise perception at night. Green is used when the Harmonica Index is lower than 4 at daytime and 3 at night. The latter correspond to values at which the WHO indicates the noise is likely to provide sleep disturbance. Orange is used when the index is between 4 and 8 during the day, and between 3 and 7 at night. Red is used when the index is greater or equal to 8 during the day or 7 at night. These values correspond to noise levels of 70 dB(A) and 65 dB(A) respectively, that are considered as being the critical thresholds for exposure to noise [10].
In Figure 6 an example of the colored graphical representation of the Harmonica Index is shown.
The Harmonica Index was applied to both the pilot areas of Rome and Milan in order to investigate its potential as simplified indicator for real time noise maps. The results achieved show that the Harmonica Index has a quite narrow dynamic range, varying from 0.5 to 1 unit in the suburban area of Rome (Figure 7), and from 2 to 2.5 units in the urban scenario of Milan, that makes it unsuitable to real time noise maps, at least in its original formulation.

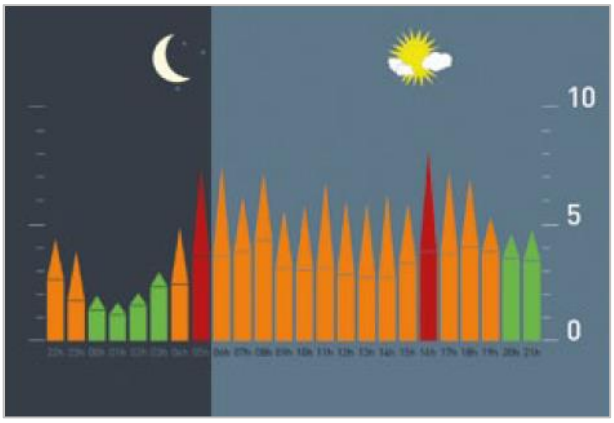

Figure 6. Example of the coloured graphical HI representation in a 24 hour period.

To overcome this problem, the original formulation of the Harmonica Index has been modified by introducing an instant value that opportunely integrated in an hourly period provides the original value of the Harmonica Index. The instant value is given by the equation (1), where L_{A95} is calculated starting from the instant values of $L_{Aeq,1s}$ included in a mobile temporal window of ten minutes updated with a frequency of 1 second.

$$HI_{inst} = [0.2 * (L_{A,95} - 30)] + [0.025 * (L_{A,ea} - L_{A,95})] \quad (1)$$

In this way it is possible to report the instant fluctuations of the index, that now show a wider dynamics, and calculate the standard Harmonica Index by integrating the single terms in the hourly

period as reported in the original formulation of the index.

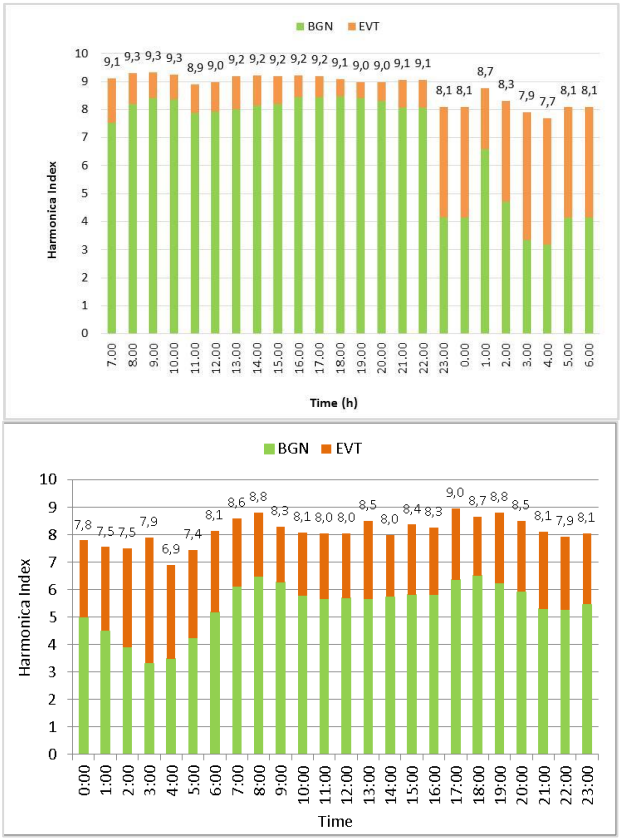

Figure 7. Harmonica Index values in Rome (upper grafh) and Milan (bottom graph) pilot area.

However, it should be noted that the dynamics of the instant index depends on noise levels variations and on the integration time used to update data. This mean that the instant value of the Harmonica Index can be applied to real time noise maps only if the integration time is less than 60 s, as longer integration times reduce the dynamics of the signal and consequently limit changes in the noise impact representation (Figure 8).

This specification is met in the pilot area of Rome, where the updating frequency of the noise maps is 30 s. In the pilot area of Milan, where the updating frequency varies from 5 minutes to 60 minutes, the instant value of the Harmonica Index can be reasonably applied only to receivers placed close to the monitoring devices, where noise levels are detected and updated with a frequency of 1 s.

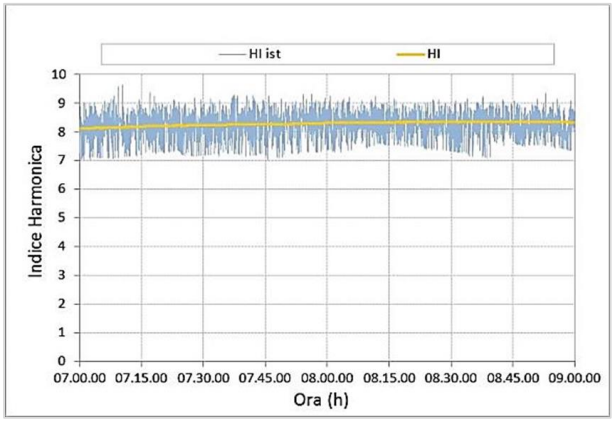

Figure 8. Harmonica Index vs. Istant HI values in Rome pilot area.

1.3. The test phase

To guarantee the full effectiveness of the web-GIS application, in the Dynamap project a specific action is foreseen to check users' ability in accessing information and managing the system

Tests will be administered to both the general public and selected stakeholders to evaluate the system versatility and its contents comprehensibility. The general public will be able to view noise maps in real time and query the system to depict, in graphical mode, the environmental data stored in the system, while stakeholders will be able to see additional information, such as real time, historical and statistical data, as well as accessing the system configuration parameters.

Two test steps are foreseen. The first step includes two sessions, with a time gap of one month, to check users ability in learning and managing the Dynamap tools.

For each session two kind of tests will be prepared. The first type of test aims at assessing users ability in managing the system and will be addressed to 4 officials for Milan pilot area and 10 for Rome.

These users who will manage the Dynamap system and control the devices for noise levels monitoring, setting and modifying the configuration parameters for maps updating, will start to use the system after a specific training course and will have an available technical manual of the web-GIS application.

The test will include direct observation of users ability in managing the system and the compilation of a technical evaluation form and it will be assisted by software experts and developers.

The second type of test will be addressed to stakeholders and the general public (50 people for each pilot area). Citizens will be able to view dynamic noise maps in graphical form and query

the system to view historical data. They will also be able to consult the simplified instructions for the system use published on the platform.
In this case, the test will require a remote access to the system through the project website and the compilation of a short questionnaire to acquire information about users reactions. The questionnaire will include questions on project tools capability of raising people awareness on noise through freely accessible information and communication from the website, such as educational applications to explain citizens roles as subjects exposed to noise, but also as generators of noise, information on noise effects on health, environmental laws, the influence of driving habits on noise levels, the exposure to noise and the solutions that could be applied to abate noise (comparison between different scenarios).
The testing activity will be accomplished through an iterative process where the user response will be evaluated: questionnaires results will therefore be used to undertake corrective actions to the Dynamap system to meet users requirements to fine-tune the web-GIS application in order to make its use simple and at the same time effective in relation to the project objectives. At the end, the final assessment of the Dynamap system interface will be provided.
As a secondary objective, the project includes also the monitoring of action plans for Rome pilot area, to check the effectiveness of information delivered to the public and verify their actual participation in selecting and adopting proper noise mitigation measures.
To this end, Rome action plans were published on the DYNAMAP platform, suitably adapted to facilitate public participation in the selection of noise mitigation actions, in compliance with the requirements of the European Directive 2002/49/ EC [1]. Information material was also included in the platform to inform citizens about main strategies for noise reduction in the acoustically critical areas and to stimulate their participation in the action plan. The questionnaire shown in Table I has been prepared in order to stimulate citizens to express their assessments on pollution impacts and their opinions on mitigation measures proposed.

Table I. Questionnaire to be submitted to citizens.

CONSULT AND PARTICIPE IN THE ACTION PLAN

You opinion is valuable. No one better than those who live in acoustical polluted areas are able to assess noise mitigation measures reported in the Action Plan and to suggest changes or alternative actions. So, please, click on the map and see the planned solutions. Participate in the design phase by filling in the questionnaire and contribute with your opinion to make the environment more comfortable.

ACTION PLAN QUESTIONNAIRE

1. Which kind of noise do you perceive?
   a. Road
   b. Railway
   c. Aircraft
   d. Industrial
   e. Anthropic
   f. Other

2. How much do you feel annoyed on a scale from 0 to 10, where 0 indicates no disturbance and 10 excessive noise?

3. Click on mitigation action foreseen in your area and express your opinion:

Do you think that the planned mitigation action is appropriate?	YES	NO
Do you think it is possible to implement other kind of mitigation actions?	YES	NO

If yes, which ones? Please provide a summary description in the box below.

2. Conclusions

The DYNAMAP project is a LIFE project aiming at developing a dynamic noise mapping system able to detect and represent in real time the acoustic impact due to road infrastructures (dynamic noise maps). Dynamic noise maps are achieved by updating pre-calculated basic noise maps as a function of sound pressure levels and weather conditions, provided by an automatic monitoring system, made of customized low-cost sensors and of a software tool implemented in a general purpose GIS platform.

In this paper the main functionalities of the developed web-GIS platform and related tools for public information have been investigated.

The web-GIS platform is able to read data coming from the system and depict noise values as colored geo-referred noise maps in a user-friendly format. The platform will be integrated in the "Dynamic maps" page of the Dynamap website

Since L_{Aeq} and L_{den} values are too complex indicators to be easily understood, a different indicator is used to simplify noise maps presentation in order to ease public comprehension on dynamic noise maps. To that end, a new disturbance index, called Instant Harmonica index, was formulated and applied to the two pilot areas in order to investigate its suitability. At the moment analysis results allows to implement the index only in Rome pilot area, while in Milan further analysis are needed.

In order to improve the software application communication features, the project foresees tests phase where users' ability in accessing information and managing the system will be checked.

Acknowledgement

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References

[1] 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).

[2] D.Lgs. 08/19/2005 n.194. Attuazione della direttiva 2002/49/CE relativa alla determinazione e alla gestione del rumore ambientale, Gazzetta ufficiale della Repubblica Italiana n° 222, (2005).

[3] Directive 90/313/EEC3 of the European Parliament and of the Council of 07 June 1990 relating to the freedom of access to information on environmental issues. Official Journal of the European Communities, L158, (1990).

[4] P. Bellucci, G. Brambilla, A. Bisceglie, L. Peruzzi, G. Zambon: Analisi degli indicatori del rumore da traffico stradale per la comunicazione al pubblico. In: Proceedings of 44° Congress of the Italian Acoustic Association, Pavia 7-9 June 2017.

[5] P.Bellucci, L.Peruzzi, F.R.Cruciani: Implementing the Dynamap system in the suburban area of Rome. In: Proceedings of Internoise 2016, Hamburg 21-24 August 2016.

[6] G.Zambon, R.Benocci, A.Bisceglie, H.E.Roman: Milan dynamic noise mapping from few monitoring stations: statistical analysis on road network. Proceedings of Internoise 2016, Hamburg 21-24 August 2016.

[7] A.Cerniglia: Software per l'aggiornamento dinamico delle mappe e relativa piattaforma GIS. In: Proceedings of 44° Congress of the Italian Acoustic Association, Pavia 7-9 June 2017.

[8] www.life-dynamap.eu

[9] Methodological Guide, Use of tools developed in the Life Harmonica project. [Online.] available: http://www.noiseineu.eu/link/gm.

[10] F.Mietlicki et Al., www.noiseineu.eu: New tools to inform the public about environmental noise in cities and to assist decision making. Proceedings of Euronoise 2015, Maastricht, the Netherlands, 31 May – 3 June, (2015)