IMPLEMENTING THE HARMONICA INDEX IN THE DYNAMAP PROJECT

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Dynamap is a LIFE project aimed to develop a dynamic noise mapping system, able to detect and represent in real time the acoustic climate of road infrastructures. Dynamic noise maps are accomplished by simply scaling pre-calculated basic noise maps, prepared for different noise sources, traffic and weather conditions, as a function of the sound pressure levels detected by low cost monitoring sensors installed along the road network. The update of the noise maps is achieved through a WEB GIS software application able to read and process data coming from the system, and finally depict the noise values as coloured geo-referred noise maps in a user-friendly format. As one of the objectives of the project is to ease public information and communication on noise impacts, the use of a simpler indicator in addition to the traditional L_{eq} was investigated.

The development and approval of a noise index intended for the general public was at the heart of the European Life Environment Harmonica project, where innovative tools were developed to better inform the public about environmental noise and to help local authorities in the decision making process. To improve public comprehension on noise issues and impacts, the Harmonica project suggests the creation of a simple noise index. In this paper the application of the Harmonica Index to noise maps presentation is investigated and the results of preliminary tests are reported.

Keywords: dynamic noise mapping, public information.

1. Introduction

LIFE-DYNAMAP, acronym of Dynamic Acoustic Mapping, is a project aimed to develop a dynamic noise mapping system able to detect and represent in real time the acoustic impact due to road infrastructures (www.life-dynamap.eu). The scope of the project is in line with the European Directive 2002/49/EC relating to the assessment and management of environmental noise (END) [1], enforcing Member States to provide and update noise maps every five years in order to report changes in environmental conditions (mainly traffic, mobility and urban development) that may have occurred over the reference period. The preparation and update of noise maps using a standard approach usually requires the collection and processing of many data, that makes the standard procedure time consuming and costly with a significant impact on the financial statements of the authorities responsible for providing noise maps. Therefore, cheaper solutions are required in order to reduce the cost of noise mapping activities.

To meet such requirements and the growing demand of information about noise pollution, the Dynamap project foresees the development of an automatic noise mapping system delivering short-term (real-time dynamic noise maps), as well as long-term noise assessments (annual evaluations). Despite real time noise maps are not explicitly required by the END, their automatic generation is estimated to lower the cost of noise mapping by 50% with added significant benefits for noise managers and receivers, such as the possibility of providing updated information to the public through appropriate web tools or the opportunity to abate noise with alternative measures based on traffic control and management [2].

In order to decrease the cost of the entire mapping process, the DYNAMAP project involves the development of customized low cost devices to gather and transmit data, and the implementation of a simple GIS based software application to update the noise maps with reduced calculation load.

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 also the development of a user friendly tool to report noise pollution and other environmental issues. Since L_{Aeq} and L_{den} 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 [3], a different indicator should be used to simplify noise maps presentation. To that end, the new disturbance index, developed in the framework of the LIFE HARMONICA project, the so called Harmonica index, was applied in order to investigate its suitability to real time noise maps.

2. The HARMONICA index

The development and approval of a noise index intended for the general public was at the heart of the European Life Environment Harmonica project [4], where innovative tools were developed to better inform the public about environmental noise and to help local authorities in the decision making process. 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 index quantifies noise perception on an hourly basis through a score on a linear scale ranging from 0 to 10.

The mathematical formulation of the index is based on $L_{Aeq,1s}$ values and it is formed by two terms [5]:

- a component related to the background noise (BGN) (1):

$$BGN = 0.2\left(L_{A95eq} - 30\right) \tag{1}$$

  where L_{A95eq} is the equivalent background noise level over an hour period, the background noise being evaluated every second by the noise level exceeded 95% of the time during the 10 minutes period before;

- an event related component (EVT), that represent the acoustical energy of the noise events emerging from background noise (2):

$$EVT = 0.25\left(L_{Aeq} - L_{A95eq}\right) \tag{2}$$

  where L_{Aeq} is the hourly equivalent noise level.

The sum of these two components delivers the Harmonica Index (HI) (3):

$$HI = 0.2\left(L_{A95eq} - 30\right) + 0.25\left(L_{Aeq} - L_{A95eq}\right) \tag{3}$$

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 Fig. 1 an example of the graphical representation of the Harmonica Index is reported [3]. As it can be seen, the graphical representation is also divided into two parts:

- a rectangle, denoting the component related to background noise;
- a triangle, denoting the event-based component, related to the noise dynamics and the number of noise peaks that emerge above background.

The noise impact is also emphasized by the adoption of a three colour 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 [3].

In Fig. 2 an example of the coloured graphical representation of the Harmonica Index is shown.

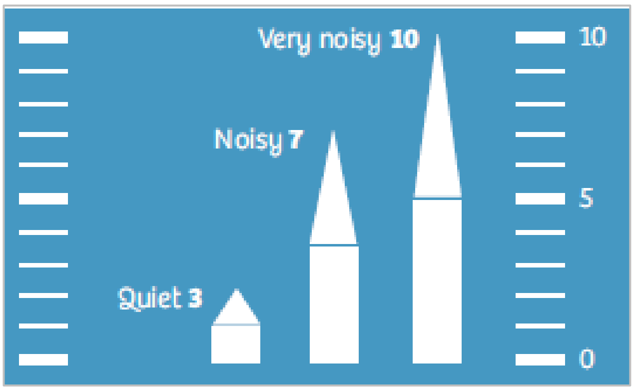

Figure 1: Example of the graphical representation of the Harmonica Index [3].

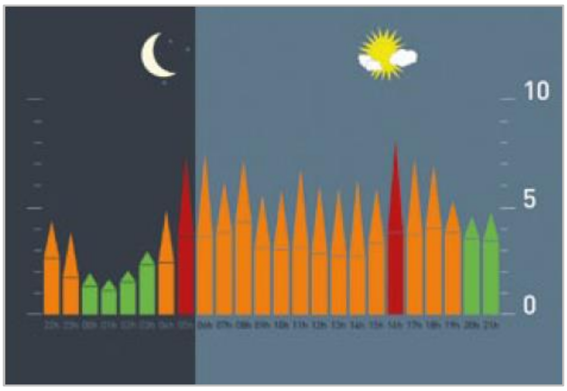

Figure 2: Example of the coloured graphical representation of the Harmonica Index in a 24 hour period [3].

3. Implementing the HARMONICA index in the DYNAMAP project

In the attempt to ease public information and to help delivering simplified and easy to read noise maps according to END specifications, the Harmonica Index was applied to investigate its potential as simplified indicator for real time noise maps. Two case studies related to the most common environmental scenarios were identified within the pilot areas of the Dynamap project. The first pilot area is located along a major road, i.e. the ring road surrounding the city of Rome, while the second pilot area is located inside the agglomeration of Milan, in a significant portion of the town. The two pilot areas show peculiar territorial and environmental characteristics, that affect the way noise impacts are calculated and perceived by people, as well as the way information can be transferred to the general public.

3.1 The case study of Rome

The pilot area of Rome is located along the ring road that encircles the city. The ring road is a six lanes motorway (Motorway A90), 68 km long, skirting many suburban areas where noise levels were found to impact critically on the residents. Critical areas are characterized by the presence of single or multiple noise sources, such as railways, crossing and parallel roads [6].

In order to check the suitability of the Harmonica Index in real time noise mapping, two test sites (see Fig. 3) with different traffic behaviour were chosen. Data collected during a preliminary monitoring campaign, performed to calibrate the source model, were used for testing.

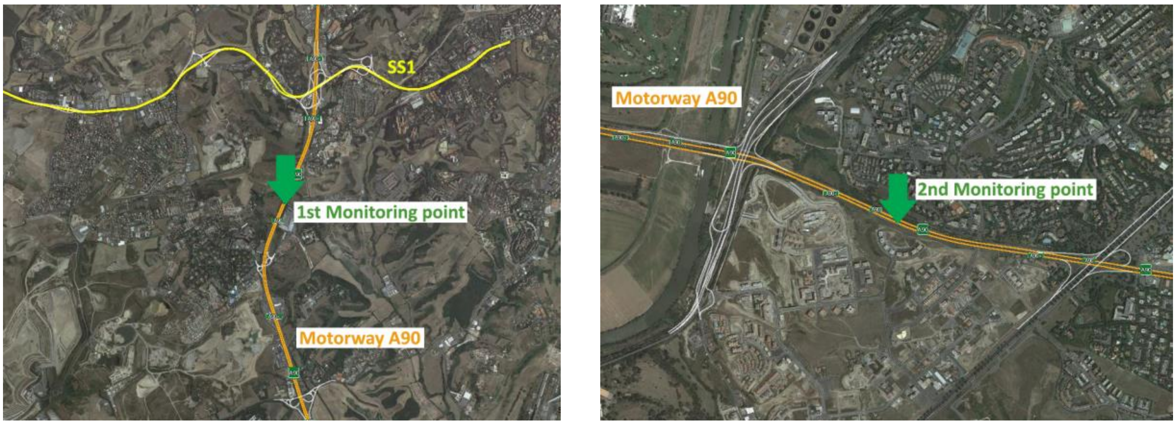

Figure 3: View of the monitoring points in Rome chosen to apply the Harmonica Index.

The noise trends, measured at the two test sites for 24 hours are shown in Figs. 4 and 5. Noise trends, calculated as instant (1 second integration time) and hourly L_{Aeq}, have been analyzed in order to identify the dynamic of sound pressure levels. Both instant and hourly L_{Aeq} were calculated as mobile average starting from a sampling frequency of 100 ms. The graphs also report the value of $L_{A95,eq}$ that has been calculated according to Eq. (1), with a mobile statistics over a 1-hour period.

As it can be seen from Figs. 4 and 5, the noise dynamics varies approximately from 30 to 40 dB during the day, and from 40 to 50 dB at night.

In Figs. 6 and 7 the graphs reporting the calculated Harmonica Index referred to daytime and night-time periods are illustrated in their dynamic and static representation. This figure highlights that the Harmonica Index has a trend similar to hourly L_{Aeq}, but with a narrow dynamics of about 0.5 at daytime and of about 1.0 at night. This leads, on the basis of the Harmonica Index nuisance colour scale, to a static representation of the noise impact, regardless the actual dynamic trend of the sound pressure level (Figs. 4 and 5).

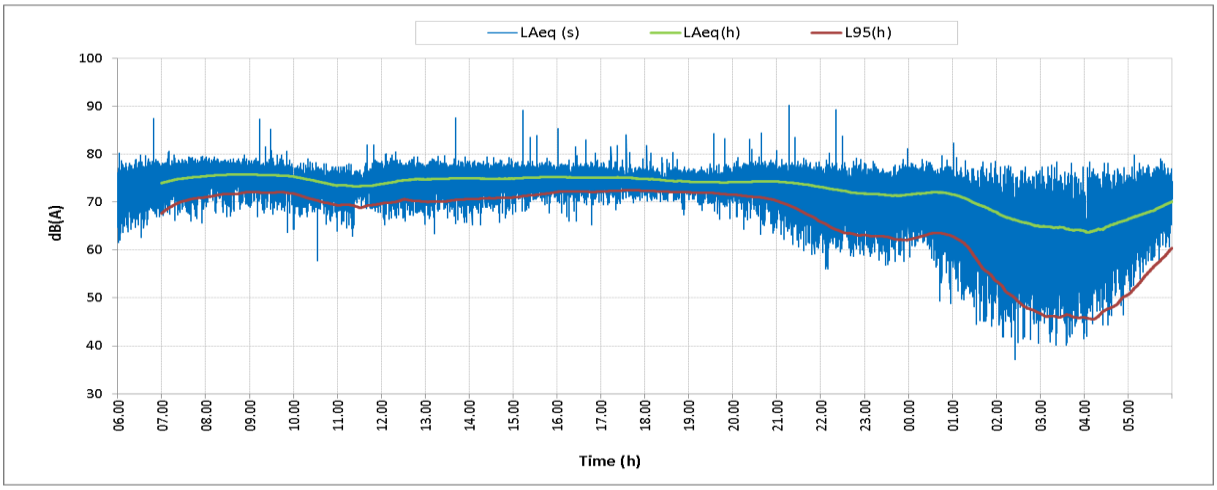

Figure 4: Noise trends measured at the first site at daytime (left) and night-time (right).

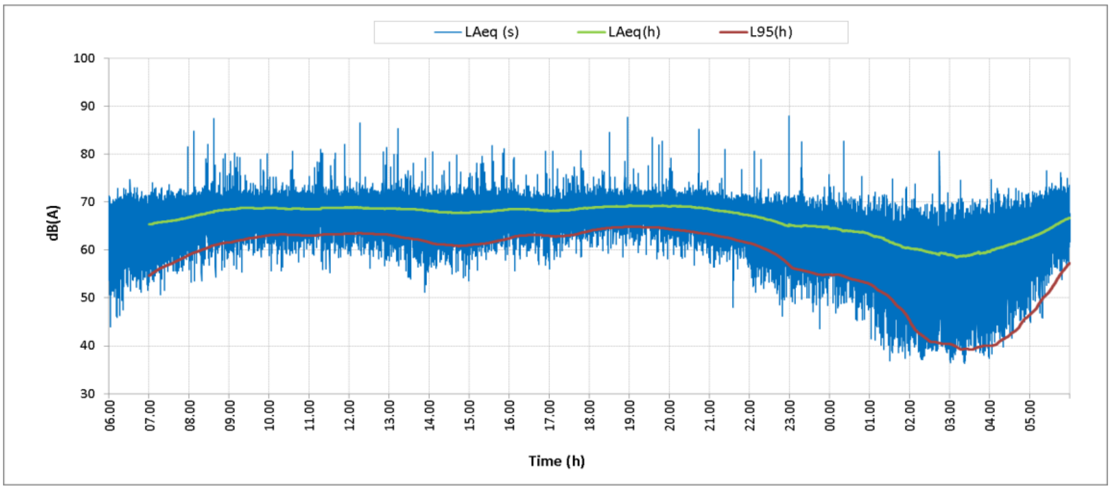

Figure 5: Noise trends measured at the second site at daytime (left) and night-time (right).

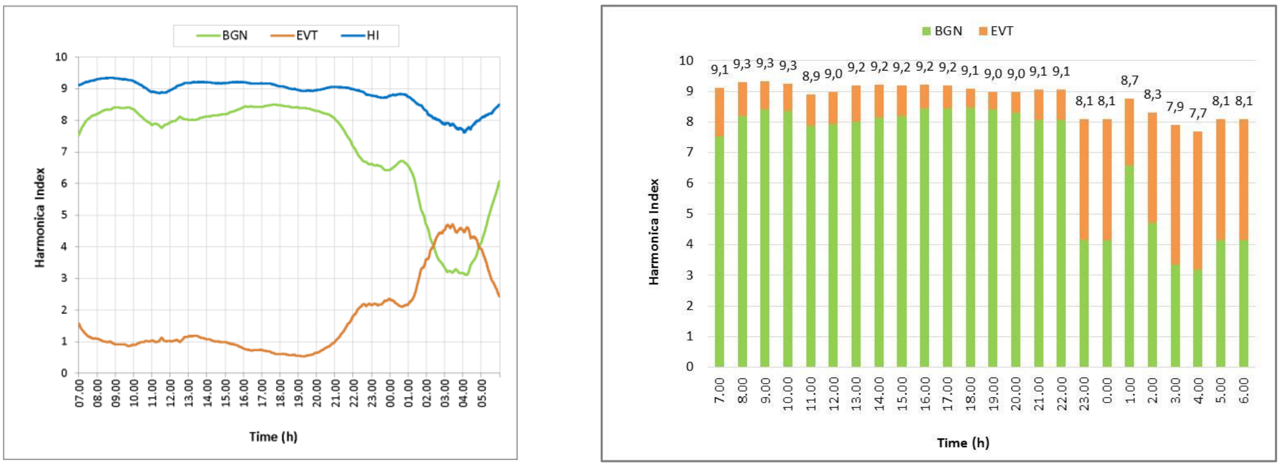

Figure 6: The Harmonica Index related to the first monitoring point in its dynamic (left) and static (right) representation.

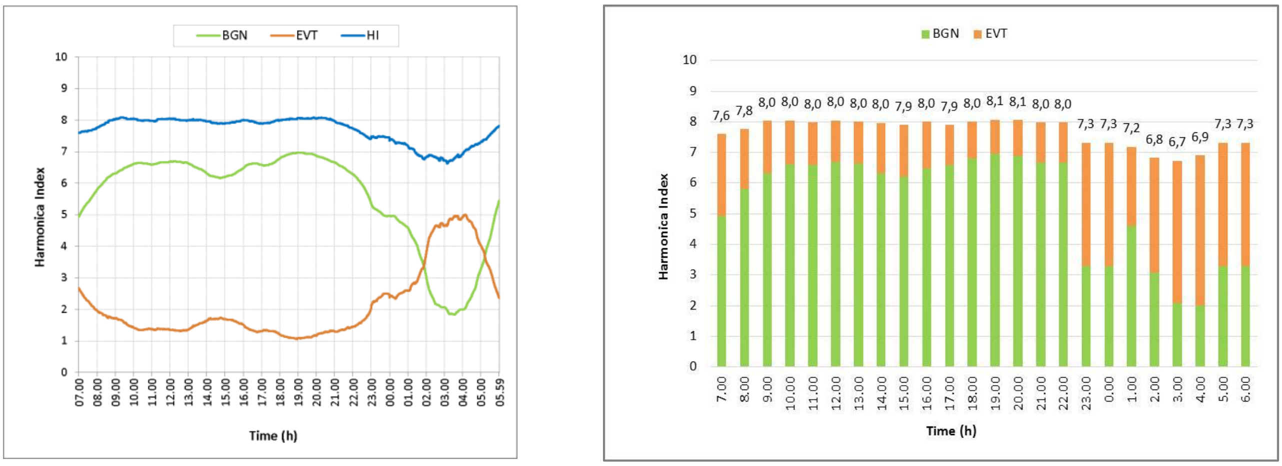

Figure 7: The Harmonica Index related to the second monitoring point in its dynamic (left) and static (right) representation.

3.2 The case study of Milan

The pilot area of Milan consists in a portion of the whole municipality, namely District 9, selected through a multi-criteria procedure.

District 9 is located in the northern part of Milan and has a population of about 180.000 residents, mostly annoyed by road traffic noise. This area includes many different noise sources: a complex road network, made of major and secondary roads, anthropic activities, technical equipment, anomalous events related to traffic, etc.

A monitoring network has been planned to be installed in the framework of the Dynamap project to detect local noise levels trend and to update noise maps all over the pilot area [7][8][9][10].

Two test sites with different traffic behaviour were chosen for the application of the Harmonica Index in urban environment: *Viale Sarca*, a primary road, and *Via Livigno*, a secondary road. Data were collected during a preliminary monitoring campaign performed to gather information on road noise within the pilot area [11]. In Figs. 8 and 9 the noise trends measured at the two test sites are reported as $L_{Aeq,1sec}$ and hourly L_{Aeq}, calculated with a mobile integration time, over a 24-hour period. The graphs also report the value of $L_{A95,eq}$ that has been calculated according to (1), with a mobile statistics over a 1-hour period.

As it can be seen, the noise dynamics is wider at the second test site (secondary road), where traffic flow is lighter and less continuous (in particular during the night period), than at the first site (major road).

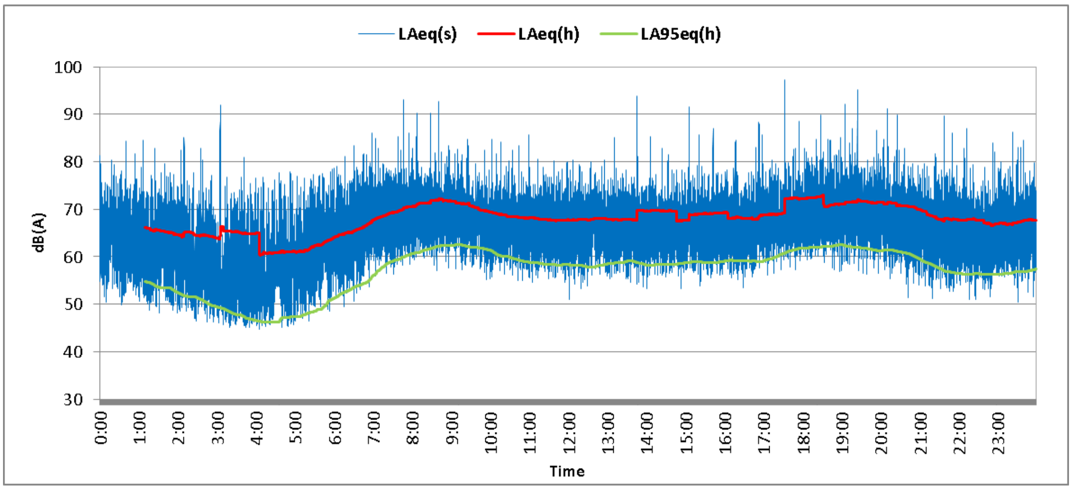

Figure 8: Viale Sarca - Noise trends measured

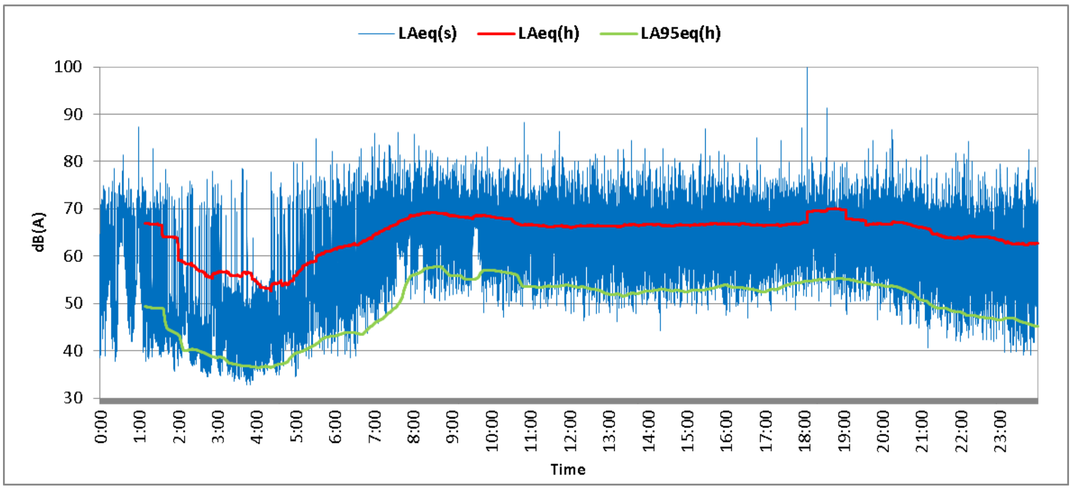

Figure 9: Via Livigno - Noise trends measured

In Figs. 10 and 11 the graphs reporting the calculated Harmonica Index referred to the two test sites are shown. The left side graph shows the dynamic version of the Harmonica Index, where sub-indicators BGN and EVT are calculated on a mobile 1-hour period. The right side graph, instead, reports the static hourly Harmonica Index values.

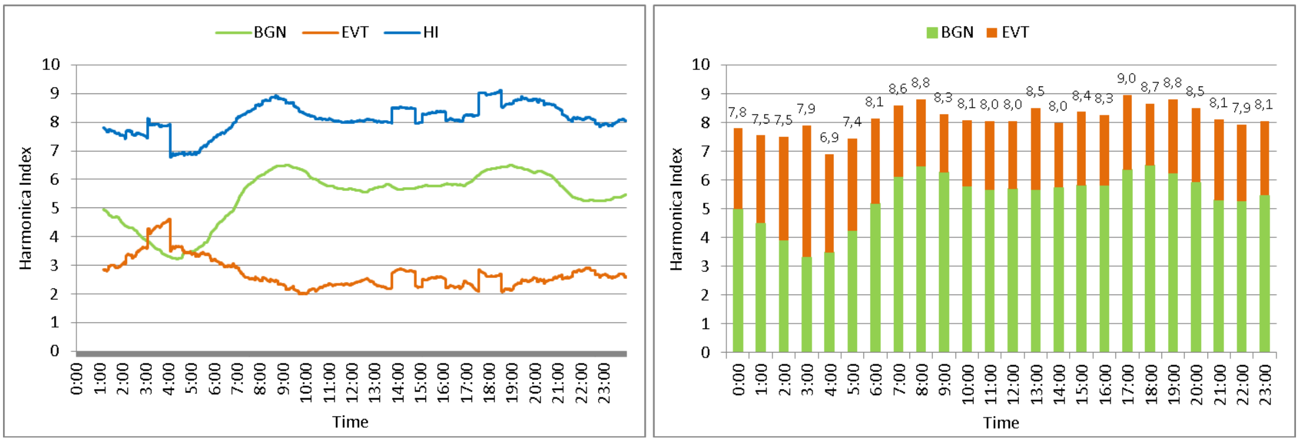

Figure 10: Viale Sarca **-** The Harmonica Index in its dynamic (left) and static (right) representation.

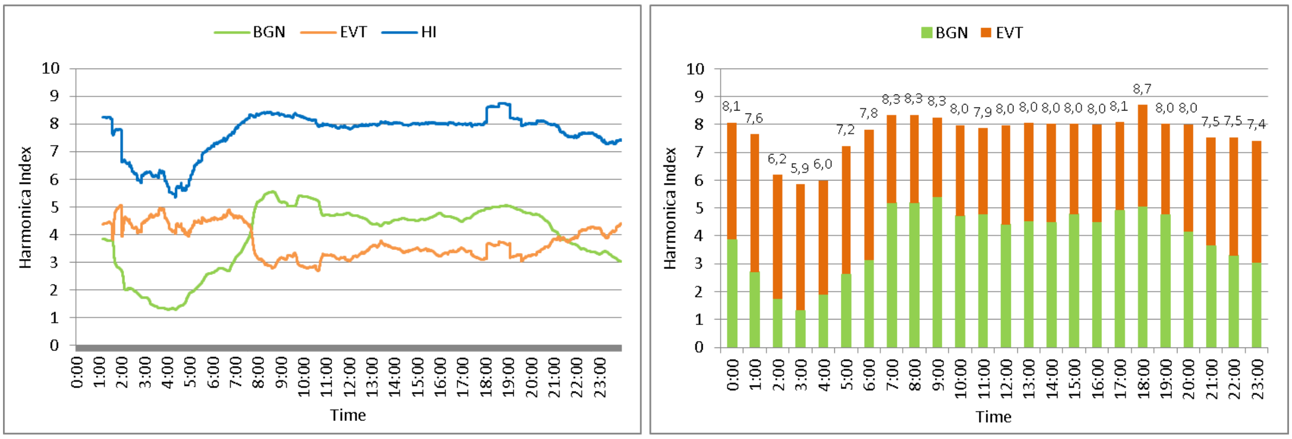

Figure 11: Via Livigno - The Harmonica Index in its dynamic (left) and static (right) representation.

These figures highlight that the Harmonica Index has a trend similar to hourly L_{Aeq}, but with a narrow dynamics of about 2 - 2.5. The wider dynamics, compared to the sites in Rome, could be explained by the higher variability of the urban traffic flow and by the occurrence of significant anomalous events. As a consequence of the mobile integration time used in the dynamic representation, the influence of anomalous noise events leads to a "stepped" curve that is not representative of the real noise trend.

4. DISCUSSION AND CONCLUSIONS

In this paper the application of the Harmonica Index to dynamic noise maps presentation was investigated in the framework of the Dynamap project. To that end, the Harmonica Index was applied to four selected test sites, located inside the two pilot areas of Rome and Milan, to check its suitability in reporting the noise impact to the general public and authorities responsible to provide strategic 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 case study of Rome, and from 2 to 2.5 units in the case study of Milan, that makes it unsuitable to real time noise maps, at least in its original formulation. However, further studies are in progress to check the applicability of the Harmonica index in dynamic mode. These include the use of different integration times and the identification of correlation functions able to keep the information on noise perception contained in its original formulation.

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