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SOME EXPERIENCE IN CONTINUOS NOISE MONITORING

Andrea Cerniglia[1] and Natalia Alekseeva[2]

[1]Euroacoustic srl, Avigliana, Italy, a.cerniglia@euroacoustic.com
[2]Togliatti State University, Togliatti, Russia, Alekseeva@tltsu.ru

Abstract

With modern noise monitoring system is possible to collect enormous amount of noise data. After few years of experience in this field, some intresting results are presented, both in terms of data interpretation, and data syntesis

1. INTRODUCTION

Modern noise monitoring system can collects very detailed noise data, which can brings to a very extensive understanding of noise phenomena. However, some data syntesis and a few basic knowledge are required to obtain the desidered information. This work describes how is possible to detect different kinds of noise events from time-frequency diagrams, coming from data acquired with modern noise monitoring techniques. More in details, sonograms and percentilograms will be described and widely used in the paper.

2. CITYNOISE SYSTEM

All the data presented in this paper was collected with CityNoise System, which is a powerful noise monitoring system, able to collect and automatically publish on the Internet real-time noise data. More in details, the system can collect one 1/3 octave Leq spectrum per second, without any limitation of memory amount, because of the web-based data storing. The system was extensively described on various papers [1][2][3], and it is visible at work on the Internet, at www.citynoise.net .

3. TIME-FREQUENCY DATA REPRESENTATION

Dealing with noise data, means facing with something that very often change both in time and frequency domain during the measurement. In other words, due to the possible non-stationary noise, the spectrum can continuosly change during the time. By performing a detailed analysis

of this behaviour, it is possible to understand what noise is related to.
Unfortunatly both a piece of paper and the screen of a PC are, from representation point of view, two dimentional object which are not so good to represent three dimentional data as values vs frequency vs time. However, few tricks to represent three dimention data on two dimention support were found during the past; animated display, waterfall diagrams and coloured data display are some examples which can overcome this problem; although all of them can be used, sonogram is maybe the most readable graphic, and for this reason is widely used around the world. Figure 1 shows the relation between waterfall display and sonogram (on the left), and the sonogram of piano arpeggio and piano C Maj accord (on the right); in the piano arpeggio picture, is intresting to note the similarity of the diagram with a music score.

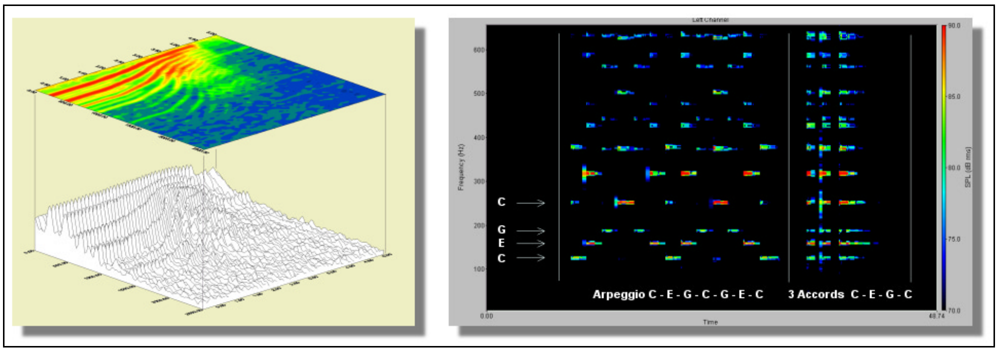

Figure 1: relation between waterfall and sonogram (left), and sonogram of piano (right)

4. EXPERIMENTAL DATA

Noise monitoring sonograms are normally represented with 1/1 octave or 1/3 octave bandwidth, so the x-axis represents time, the y-axis represents 1/n bands, and the colour (z-axis) represents levels. The represented values can be of different types as Fast, Slow, Leq, or even Ln (in this last case the diagram can be named *percentilogram*). If not differently written, all next pictures represents 1/3 octave Leq spectra, with a sample rate of 1 second. Figure 2 shows the effect of a train passage. In the picture, on the left, is possible to recognise the bell of the railway-road crossing (1 to 5 kHz), which rings four minutes before the train passage, and then the train itself (in the middle of the picture). The passage was very early in the morning, the train was a very short commuters train, and there was not other events.

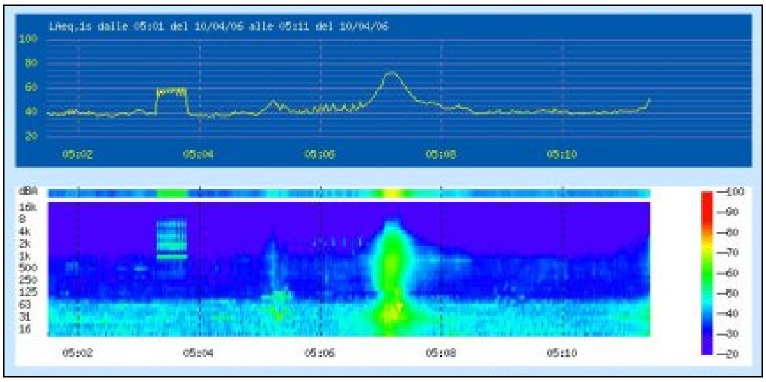

Figure 2: bell and short train passage

Figure 3 shows the same monitoring station at a different time; In the picture is possible to recognise the bell again, some traffic noise, and a long train (maybe goods train), with the locomotive in front of it (the red spot).

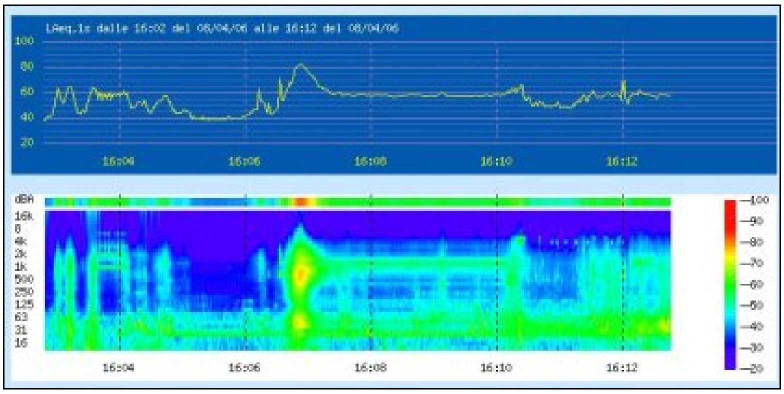

Figure 3: traffic, bell, and long train passage with front locomotive

Figure 4 shows the city clock bell which rings at 10:00 am (it is possible to count ten rings). Spectra of the bell is not so different from the one presented in previous image, it is just shifted to the lower part of the spectrum because of different kind of bell.

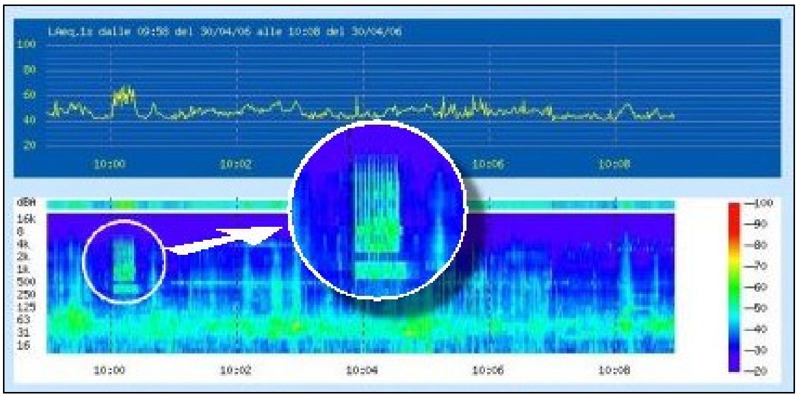

Figure 4: city time bell at 10:00 am

Figure 5 shows an airplane passage. In the picture is possible to recognise the doppler effect due to the motion of aircraft (the components moves from higher frequencies to lower frequencies).

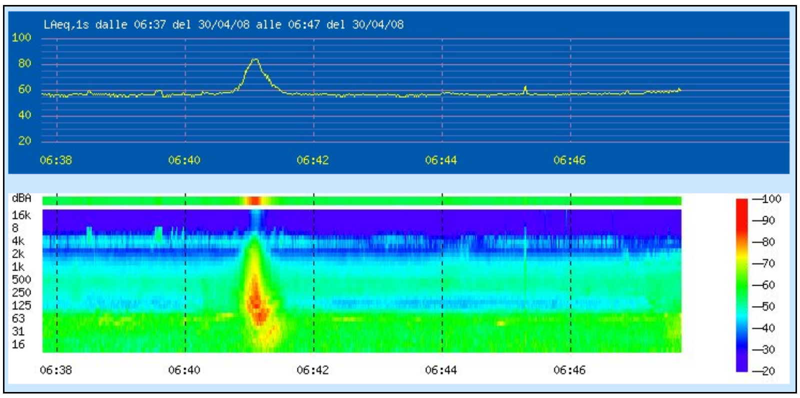

Figure 5: doppler effect of an aircraft

Figure 6 shows a measurement taken during the night in countryside. In the picture it is possible to recognise cricket sounds (12.5 kHz) which stops when an aircraft coming (on the right, with doppler effect again, more longer then in figure 5 because of the greater distance), and starts again once the aircraft is left.

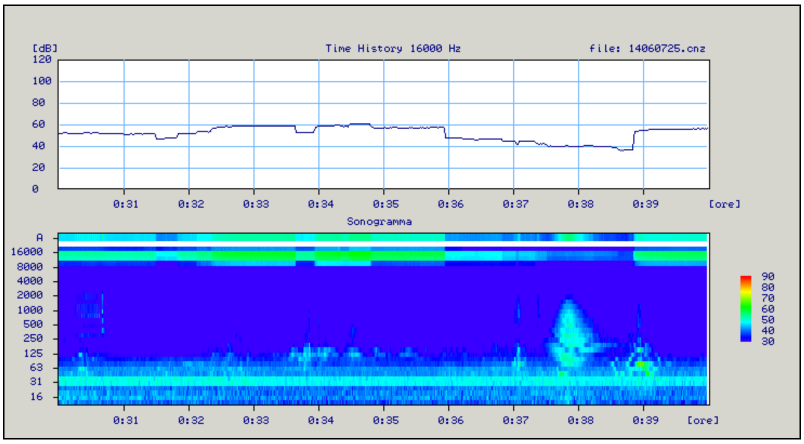

Figure 6: crickets and aircraft

Figure 7 shows the effect of a sweeped siren in traffic city. The 'sine' in the sonogram, fading at its ends due to changiing distance of the source, shows how the frequency of the siren change during the time, from higher to lower frequency and then higher again,.

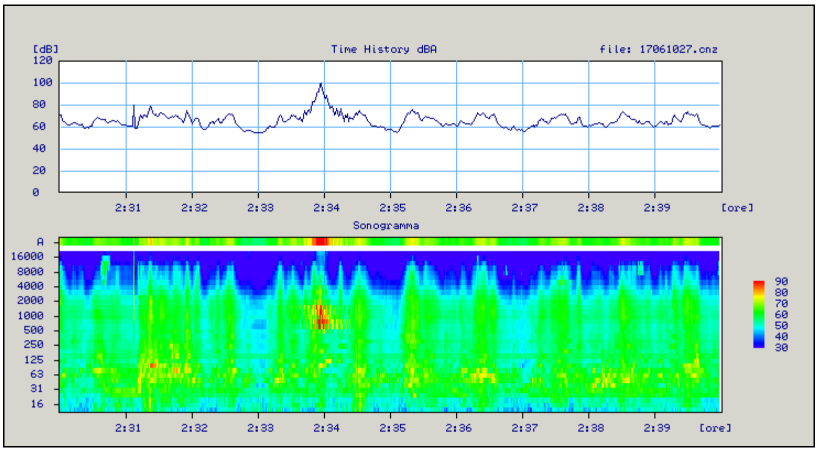

Figure 7: sweeping siren in city traffic

Figure 8 shows the singings of birds at sunrise (3kHz, and after a while also 2kHz). Different kind of birds emits different sounds (frequencies), althought patterns are easy to be identified.

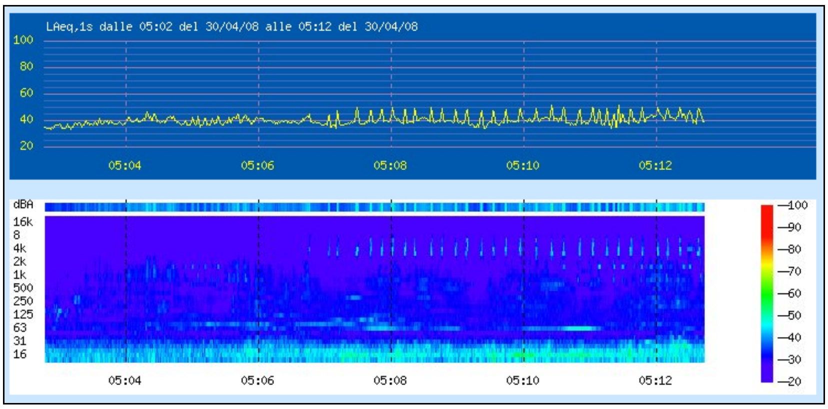

Figure 8: early birds at sunrise

Next picure, figure 9, is related to the same position as previous one, but 20 minutes later. Now the birds singing is much more evident.

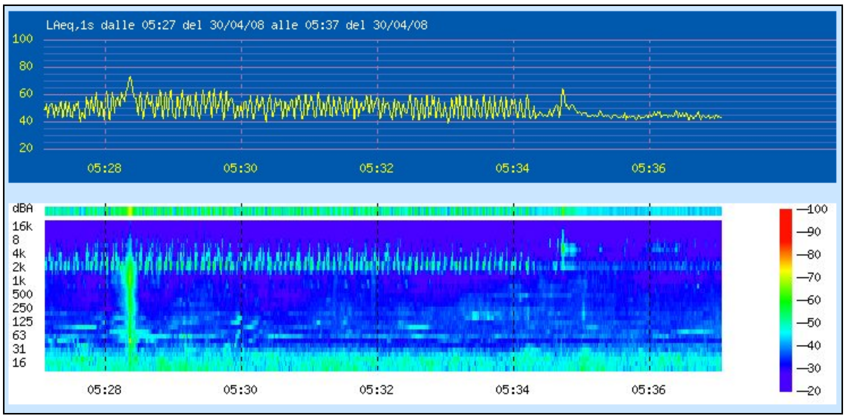

Figure 9: birds again

Figure 10 shows again the same monitoring station, 25 minutes later than figure 8. Now all the birds waked-up, and is possible to see a very clear horizontal band on the sonogram related to them.

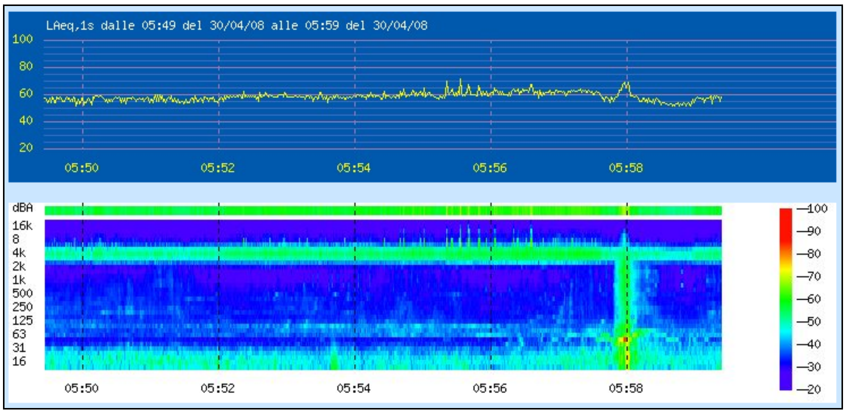

Figure 10: festival of happy birds

Figure 11 shows a thunderstorm on two stations about 6 km far away. The thunder cames firstly to station showed in the upper image, and few second later in the second one (this is visible from the time axis, and even from the level which is higher in the first station). In the second position it was raining a lot (wide band noise between 250 and 10kHz), while in the first position the rain was poor. The reason for the 'vertical' line associated with the thunder, is because an impulse (like the thunder is) contains almost all frequency for a limited period of time.

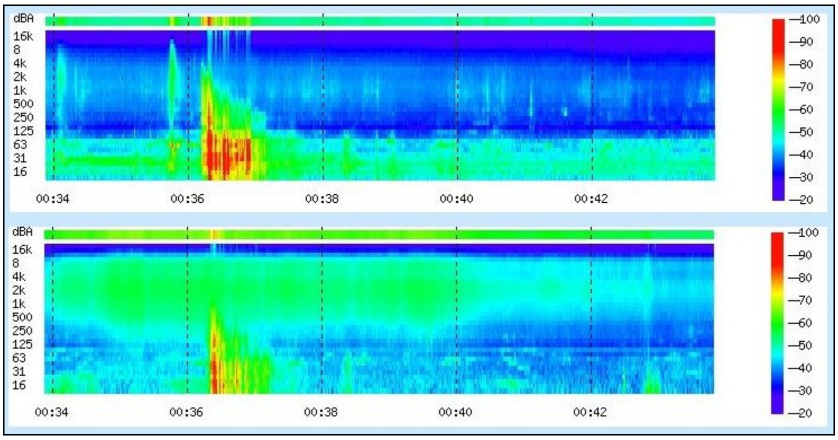

Figure 11: Thunderstorm on two stations 6 km far away

5. DATA SYNTESIS

While it can be very intresting to look at all data in order to identify sources and take actions, sometimes it is necessary to syntetize big amount of data, in order to achieve a complete view of the acoustical sistuation of a site at a glance. One powerful tool that can helps is what is called *percentilogram*, which is derived from an interpolation of cumulative diagram vs frequency vs time. This kind of graphic represent the history of a certain Ln spectrum (based on a defined time interval, i.e. 1 hour or less) over a certain measuring period.

Figure 12 shows the L95 percentilogram (1 hour basis) over one day of analysis in a small village. L95, which is the level overcame for 95% of the measuring time, is representative of background noise thus, from the graphics, is easy to identify the noise coming from workers who leave the village by car in the morning, and come back in the evening (the monitoring station was not so close to the road, so only low frequencies are visible with the selected scale).

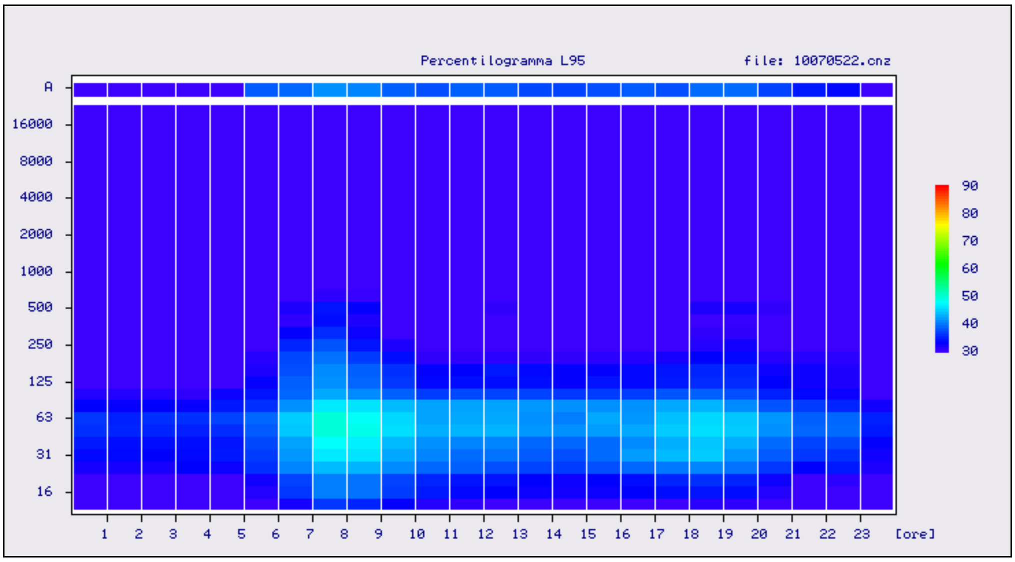

Figure 12: L95 percentilogram over one day of analysis, in a small village (1 hour basis)

Figure 13 shows L10 for the same period. L10 is the level which was overcome for 10% of the measuring time, so it can be related with the most recurring high level. In the picture is possible to identify some anthropic noise during lunch time (12-13), dinner time (19-20) and after dinner (21-22), in the range between 300 and 1600 Hz. In the diagram is also possible to see very clearly the bird singing at sunrise (4-5), and less clearly during all the day, in the range between 1600 and 4000 Hz. The picture shows also something that should be investigated more in detail in 500Hz band.

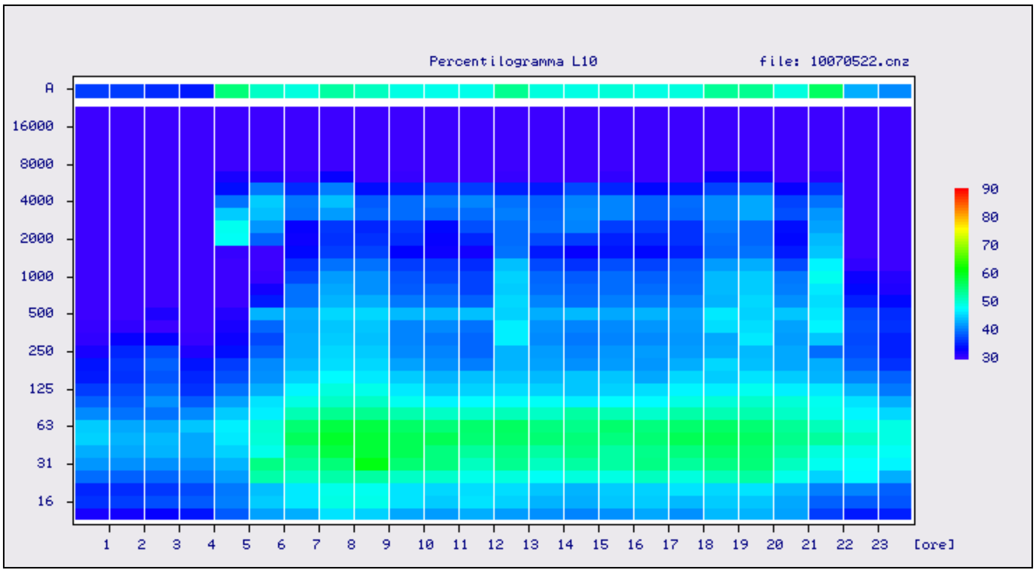

Figure 13: L10 percentilogram (1 hour basis), same measurement as Fig. 12

Figure 14 shows Leq sonogram from the same measurement, and with same time basis. It can be seen how, with such representation, it is more complicated to separate the different phenomena in the considered measurement.

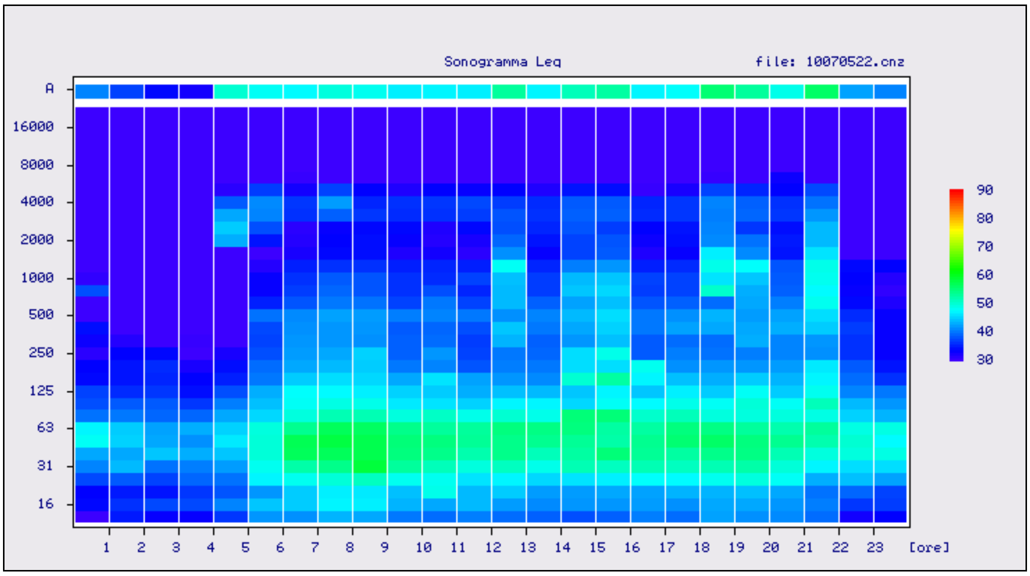

Figure 14: Leq sonogram (1 hour basis), same measurement as Fig. 12

6. CONCLUSIONS

Continuos noise monitoring is a powerful tool for environmental noise investigation, and it is even much more powerful when associated with an efficient software able to present data in many different ways, that can be more easly interpretated from technicians. Sonogram can helps to a clear understand of what takes part in the forming of final Leq, while percentilograms are very powerful tools capable to syntesize big amount of data in few diagrams more easly readable and understandable.

7. REFERENCES

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