Long-term noise monitoring and dynamic noise mapping - a case study

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Summary

This paper presents a unique approach, the practical application of long-term monitoring system to support dynamic noise mapping in a GCC metropolis.

If not used properly, the output of a long-term noise monitoring system is limited to numeric values without leading to any conclusions. To avoid this common failure, the authors established the future goals of the system long before installing it. Locations of the stations, assessment methodology, parameters and indices have been defined; in this way, the system is suitable to fulfill the set-out requirements needed to be an efficient tool for urban planners and designers and support their aim for less noise.

The paper presents beside the installation of the system, the web-based application the authors developed. The application is used for presentation and data storage it also automatically filters the massive amounts of data. Results are assessed with defined noise indices suited for the metropolis. Besides the common terminology employing LAeq, Lmax, Lmin, etc. a Noise Pollution Index was developed and calculated using a web based application. The Noise Pollution Index (referred as NPI) is based on the well-known Harmonica Index.

The use of the simplified database delivered by the system of 10 stations will be mandatory for urban planners and designers. They can now use the valid and reliable data as a common baseline for evaluating the necessary noise mitigation measures. In parallel with the self-developed web interface available for public authorities and residents, we also use an expert background web interface of the SvanNet for calibrating dynamic noise maps.

The developed webpage was also capable of presenting the assessed Key Performance Indicators and the Dynamic Noise Map of the metropolis.

The developed dynamic noise map associated with the system serve awareness raising purposes as the information is available to the public.

1. Introduction

Noise pollution is one of the environmental problems that are generated by the rapid growth. Chronic exposure of high levels of noise not only affects our physical health and hearing, but also our stress levels, productivity and even our mental health. As a matter of fact, in a quiet environment property prices increase. Over the last decade, a significant change was made in Dubai to improve the quality of living in the city with endeavour to maintain the social and economic growth that was achieved to date. The need to address the consequent environmental impact of noise is essential for, the city's development and to achieve Dubai's vision: Developing a Happy and sustainable City.

Our company provides continuous support in terms of noise protection and assessment to Dubai Municipality. In recent years, there have been studies revealing the problematic areas in terms of traffic, industrial and construction noise in the Emirate. As part of the ongoing noise control and management programme to protect the well-being of residents of Dubai, Dubai Municipality's Environmental Planning and Studies Section

proposed to install a fixed and real-time noise monitoring network that continuously monitors noise. Each of these noise monitoring stations are in the Emirate of Dubai at strategically important locations. The data generated by the noise monitoring stations provides a better understanding of the significant and effective methods for controlling noise. Moreover, this serves as a basis in the preparation and verification of action plans as well as in the establishment of the future environmental noise control regulations.

This paper gives an overview on the preparations, planning and implementation of the noise monitoring system of Dubai as well as the applicability of this system for dynamic noise mapping.

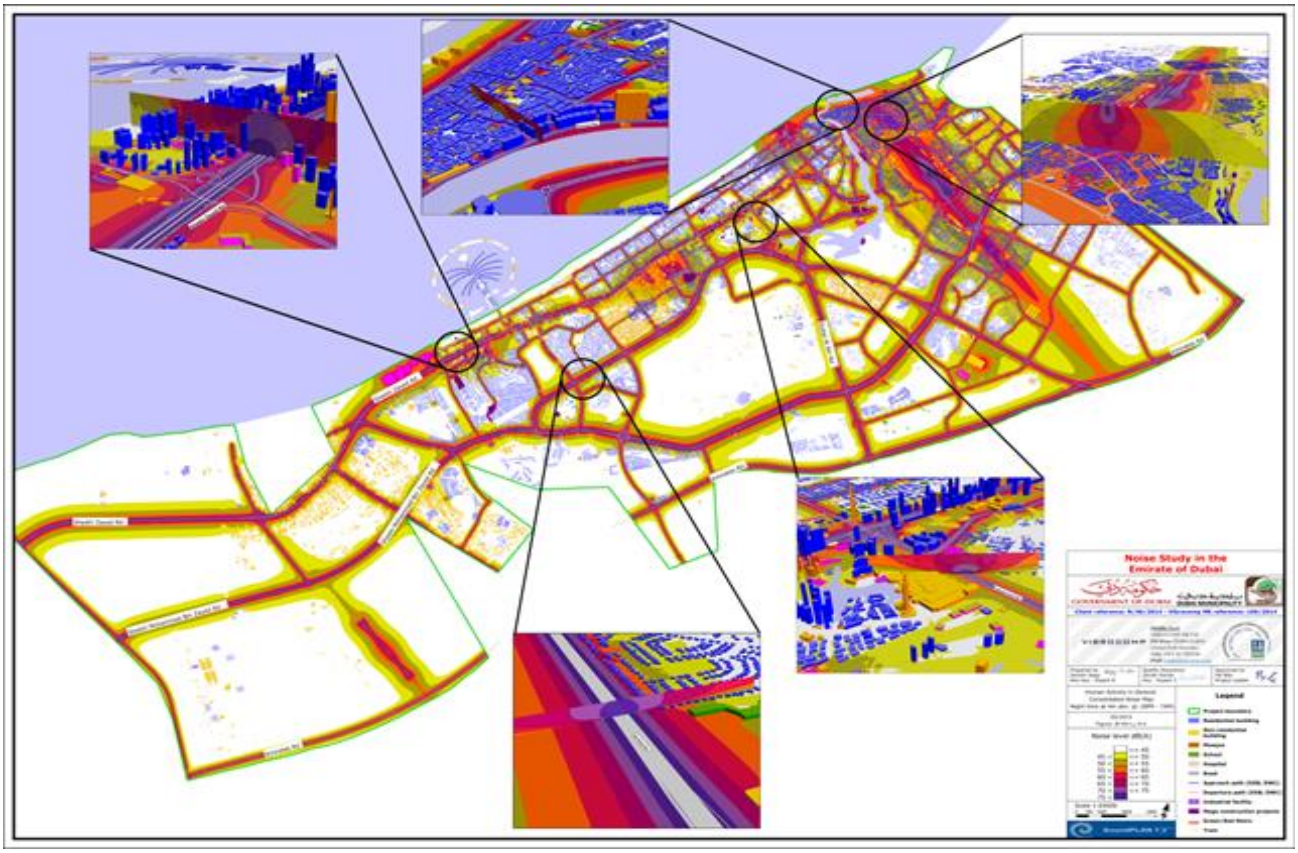

Figure 1. One of over 300 noise maps prepared for the Emirate of Dubai.

2. Preparations before the installation of the system

2.1. Long-term goals

Based on international benchmarking, the most important aspect for the authors was to set out what the commissioned noise monitoring station network will be utilized for. One of the most common mistakes upon designing such networks is that the established system does not provide relevant results and does not support decision-making – i.e. it fails to fulfill the main goal of the long-term noise monitoring system.

The authors studied the operation of international examples, summarized pro-s and con-s and optimized them to design the best system for Dubai. Locations of the noise monitoring stations were selected based on a detailed assessment. During the Noise Study for the Emirate of Dubai, over 400 measurements were conducted in the Emirate as well as a full noise map was prepared. (Methodology was equivalent to the noise mapping methodology as described in 49/2002 EC directive, but with the help of the large number of measurements the authors defined calculation standards for appropriate noise prediction in the GCC region). Based on the outcome of these results, the main noise sources and most problematic places were identified providing a basis for site selection.

2.2. Site selection

Based on the noise maps, different areas were proposed for the installations. The exact areas were chosen in close cooperation with Dubai Municipality to fulfil the requirements for long-term noise monitoring.
After the initial site inspections, design drawings for each location was prepared. These designs took all possible noise sources (including HVAC devices, transformers, etc.) into account so that the "unwanted" noise sources could be excluded.
Based on the preliminary inspections, stations were installed to be suitable for two types of noise sources; road traffic noise and aircraft noise. A year later, the noise stations were relocated so the noise stations were suitable for measuring industrial noise sources and monitoring the quiet residential areas. Many requirements were assessed during site verification – e.g. it was a must to have much lower background noise levels so that the noise sources can be differentiated.

Figure 2. Noise monitoring station network of Dubai

2.3. Choosing the most appropriate device for the measurements

Many manufacturer offer long-term noise monitoring devices, mostly with similar conditions in the market. Despite this, choosing the most appropriate equipment for this project was demanding, not only that the equipment must withstand extreme local meteorological conditions (with temperatures being occasionally close to 50°C and sometimes high humidity) but they must also fit into the local landscape and contribute to the overall look of Dubai. The instrument shall be small and easy to operate remotely.

Besides the above requirements, as Dubai is also moving towards the usage of renewable energy, the system had to rely solely on solar power. A solar system was designed to ensure the stations receive power even during the winter months. In addition, the system also had to have a backup battery for the instrument to protect the monitoring station's internal battery and components from damage due to the excessive heat in Dubai.

The chosen types were EU instruments designed to operate in extreme climate conditions. The instrument selected received special a heat reflecting paint and turned out to be an ideal choice for unattended permanent environmental noise measurements.

2.4. Contribution to urban planning – first steps

This project is part of long-term noise control campaign, its outcomes were linked to urban planning. The monitoring results provide baseline for future developments, e.g. noise insulation or traffic on the road network should be designed to protect the well-beings of residents.
Locations of new sensitive developments, should be selected based on the results of the noise monitoring network. Areas having excessive noise levels should not be selected for residential developments, only for industrial or commercial purposes.

3. Assessment of the monitoring results

3.1. The developed web-based application

Presentation of the results is a key factor in the success of the project. A two-fold system was designed and implemented for this purpose. Detailed and raw data were made available only for authorized personnel whereas general results are shared with the public. Besides the common terminology employing LAeq, Lmax, Lmin, etc. a Noise Pollution Index was developed and calculated using a web based application. The Dubai Noise Pollution Index (referred as NPI) is based on the well-known Harmonica Index developed during the HARMONICA project in the EU(1). The index was tailored to suit Dubai's local conditions.

The application was developed to display the NPI and to provide better understanding of the noise situation to the public. The index, based on the Harmonica Index, consists of two components a component related to background noise (marked with BGN) and a component related to events, representing the noise peaks (marked with EVT). Adding these components together leads to the NPI which has a scale between 0 and 10.

Based on the requirements set out together with Dubai Municipality, the developed webpage was also capable of presenting the assessed Key Performance Indicators and the Dynamic Noise Map of Dubai.

3.2. Key performance indicators

Besides the parameters and dynamic noise map set out in Chapter 3.1 key performance indicators (referred as KPIs) have been assessed to provide more understandable values, they have been suited to be representative for Dubai conditions.

LKZ (LärmKennZiffer)

LärmKennZiffer(2) (LKZ) describes the effects created by noise exposure in a road. It was utilized in many action plans in Germany and throughout the EU. It combines the noise exposures in the road with the number of people affected. The assessed noise indicator is a product of exceeding a limit value of noise disturbances and the people affected, it is high in places where high residential density and high noise level come together.

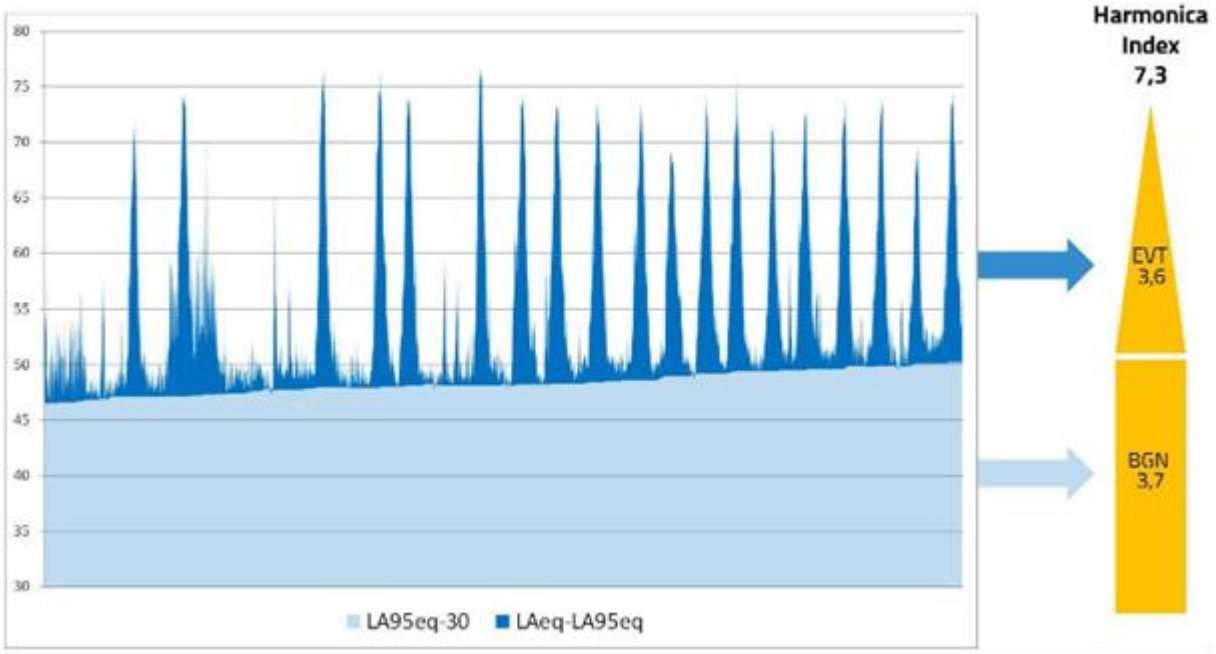

Figure 3. The Dubai Noise Pollution Index

Highly annoyed (%HA)
Studying this indicator(3) synthesis curves were prepared for noise annoyance from aircraft, road traffic and railway noise, with 95% confidence intervals taking into account the variation between individuals and studies. These curves were based on studies examined for which Lden (and Ldn), and the percentage of "highly annoyed" persons (%HA) meeting certain minimal requirements could be derived, augmented by a number of additional studies. The percentage of "highly annoyed" persons (%HA) was defined as a function of noise exposure indicated by Lden.

Figure 4. The goal of the publicly available website incl. the results is to inform the public and to support designers

Noise and Number Index (NNI)
Originally devised by the Wilson Committee on Noise in Britain(4), the Noise and Number Index is an attempt to measure the subjective noisiness of aircraft. It uses the PNdB as a basis and additionally takes into account the number of aircraft per day (or night) as a key annoyance factor. It must be noted that the NNI is an empirical formula.

3.3. Use of the results for urban planning for Dubai

Proper urban planning and architectural design can help to reduce the effects of noise. The noise levels inside buildings can be reduced with different passive methods such as noise abatement windows, building walls with high insertion loss. Another way to reduce noise conflicts is to have proper traffic planning. In that case the smart traffic control system working. However, those tools can only be applied cost-effectively if valid and reliable input data is available.
Urban planners and designers in Dubai are now advised to apply the results of the noise monitoring stations for future developments as with the system installed a unique baseline is set up.
Each of the stations' results is specific for an evaluated area. Dynamic noise maps that synchronize with noise monitoring and traffic data illustrate the noise load change, its daily flow, and the effects of altered traffic or extraordinary events. These results are now available for urban planners and designers to achieve the needed noise comfort in their developments.

Recommendations are as follows:

- Mitigation:
  Immediate action: Traffic control system - which restricts traffic to the road bypassing the city
  Long-term action:
  Simple smart urban planning: more bypass roads and noise walls planning

- Adaptation:
  E. g. Carama school: timetable conversion - tailored to flight overloaded periods

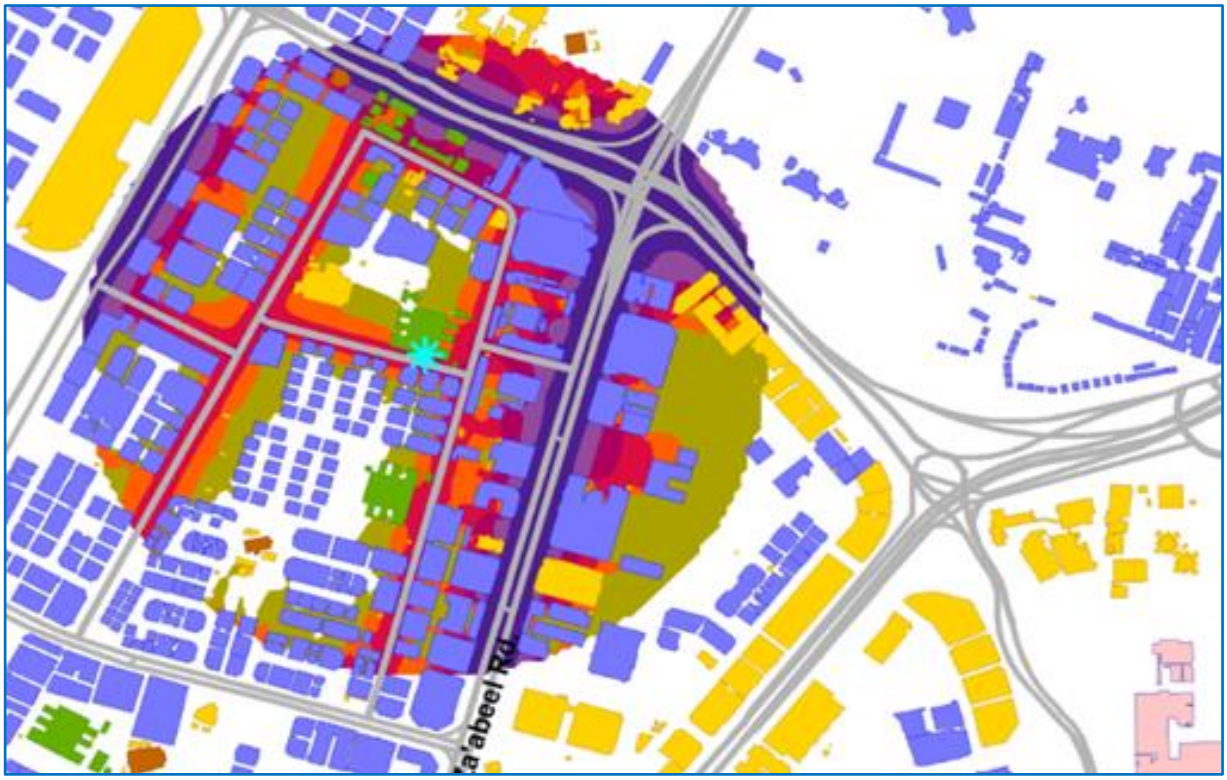

Figure 5. Example of a dynamap “hotspot”

By commissioning more noise monitoring stations, the database could be more accurate and more areas can be covered by the noise monitoring network. This database also contributes to avoid future conflicts; it clearly indicates where not to design further sensitive premises as well as an accurate indication of where noise conflicts are to be solved.

4. Conclusions

Noise is becoming a more and more severe issue globally. Dubai Municipality and the authors of this papers are pioneers in the GCC region to handle environmental noise on a strategic level. Conducting awareness raising campaigns and designing strategies, action plans.

Solutions such as noise barriers are yet to be accepted by the public and decision makers in the region, but by utilizing proper urban planning as a major tool for noise mitigation, measures can be taken to significantly improve the noise situation and quality of living in the Emirate. The noise monitoring system, the evaluation and the presentation of the results as described in this paper is a milestone in delivering unique noise data to support urban planners and designers to achieve the needed acoustic comfort in their developments.

References

[1] Mietlicki C., Mietlicki F., Ribeiro C., Gaudibert P., Vincent B. The HARMONICA Project, New Tools to Assess Environmental Noise and Better Inform the Public; Proceedings of the Forum Acusticum; Krákow, Poland. 7–12 September 2014.

[2] Eggers S. Evaluation of noise mitigation measures: Common methods and a novel approach, Proceedings of the Inter-Noise 2016; Hamburg, Germany. 21–24 August 2016.

[3] Position Paper on Dose Response Relationships between transportation noise and annoyance. European Commission, 2002.

[4] Wilson Committee on the Problem of Noise, Noise: Final Report, Cmnd 2056, London, HMSO, 1963, p. 208.