



### An innovative approach for long-term environmental noise measurement: RUMEUR network in the Paris region

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#### Summary

Bruitparif is a non-profit organisation that aims to answer to the legitimate expectations of Paris Region inhabitants to get reliable information on the noise levels they are exposed to.

Therefore Bruitparif is setting up an innovative urban noise monitoring network and a platform to consult data called RUMEUR. It pursues a triple goal: understanding phenomena, assessing actions against noise and communicating in all transparency information on the sound environment in Ile-de-France. The system adapts to the various stakes, with permanent stations to monitor on the long term road, rail and air noise, and short-term campaigns to assess the impact of major events or characterise specific environments. Officially launched in 2008, the network is currently made up of 45 long-term monitoring terminals and 350 short-term noise measurements, with a specific focus on aircraft noise.

It brings together advanced technologies such as identification of sound events, innovative logistics solutions for long-term measurements thanks to small solar panel measurement units or original urban equipments.

All the collected data and calculated values are viewable through a web application. Bruitparif designed a unique graphical representation that gives the ability to "deep zoom" in the acoustic data. People can experience the noise fluctuations per second in fine details as well as long-term trends. Different noise indicators are published: average levels by periods as well as the precise characteristics of noise events, especially for aircrafts. Thus the data coming from RUMEUR are much closer to the nuisances perceived by local residents than the noise maps generated through modelling.

The treatment and analysis of data collected allowed the observatory to produce reports for the authorities and associations concerned. As a mean to characterise the noise exposure of the population objectively, the observatory became a true decision-making tool to support public authorities in the implementation of noise policies.

#### 1. Introduction

Bruitparif is a collegiate association that brings together all noise control stakeholders in the Îlede-France region (government agencies, local authorities, bodies that manage infrastructure and economic activities and environmental defence and consumer protection associations). As a non-profit organization, Bruitparif aims to answer to the legitimate expectations of Paris Region inhabitants to get reliable information on the noise levels they are exposed to. Bruitparif started therefore developing a noise watchdog over the Paris region (12000 km<sup>2</sup>, 12 millions of inhabitants) by setting up an innovative urban noise monitoring network and a platform to consult data called RUMEUR. This article presents a description of the network and of the information platform.

#### 2. Why a measurement network?

Although they represent a first evaluation, maps produced by modelling cannot, however, be entirely true to what is actually happening in the field. Indeed, noise maps generally reflect average situations and cannot yet really reflect the sporadic nature of certain noises: occasional, sudden noises like car horns, emergency vehicles passing, deliveries, and the succession of noise peaks related to air and rail traffic... Nor is modelling a suitable solution for roads in dense urban areas, where driving speeds are not fixed (frequent accelerations / braking due to traffic lights or congestion, etc.).

Thus, measurement appears useful in order to complete the information provided by modelling and to better understand and characterise environmental noise on a given site. Noise measurement provides precise information on noise variations over time, on a second-by-second basis. It highlights a lot of information that is not provided by noise maps produced using modelling, based on average levels. This information includes, among other elements, the daily and weekly noise variation cycles, how noise nuisances change over time, the distinction between background noise and noise peaks produced by car horns or the passage of air, rail, or noisy road traffic.

Noise measurement results are generally better understood by the public as they are closer to the reality of the nuisances perceived. A tool for the objective characterisation of the public's exposure to noise, a measurement network is also a real decision aid tool to help the public authorities implement their noise nuisance prevention policies. It is intended as a way of raising awareness of the noise issue and a communication tool aimed at every member of the public.

# 3. What are the objectives of the Bruitparif's noise measurement network?

The development of the Bruitparif's noise measurement network addresses three main challenges:

#### The challenge of understanding phenomena:

- Better understand the factors that have an influence on noise (traffic conditions, weather parameters, urban fabric, etc.).

- Monitor changes in noise over time relative to changes in technology, travel, social expectations, etc.

- Obtain exposure data for performing epidemiological studies on noise and health or studies on the socio-economic impacts of noise.

- Complete the noise mapping process on the basis of validation or calibration data for the noise maps established by modelling.

- Promote an understanding of the effects of transport in terms of noise as well as pollution, its impact on the environment, etc., to make it easier to control and pool these effects.

#### The challenge of evaluating actions:

- Document the impact of the measures taken on an on-going or occasional basis and evaluate the effectiveness of these actions.

- Anticipate, track and capitalise on knowledge during the implementation of major projects.

- Obtain indicators for tracking the impact of the use of noise criteria in travel and spatial planning policies.

## The challenge of providing and disseminating information:

- Respond to one of the key concerns of residents concerning the quality of their way of life and their health.

- Provide clear, transparent and independent information to the public on the current status of and changes to the acoustic environment-

Provide citizens and the various stakeholders in the fight against noise pollution with the means to understand and analyse noise nuisance.

- Allow for a more precise and targeted quantification of noise exposure than is possible using maps based on modelling.

- Compile statistics on the acoustic environment in the Paris region.

#### 4. How was the network designed?

Noise is a particular type of pollution that is much more area-based than others, e.g. air pollution. Sources of noise generally have a more local impact, measured sound levels decrease quickly depending on the distance from the source and line of buildings may, for example, be sufficient to protect against noise from a road with heavy traffic. Only air traffic noise is a partial exception to this tendency.

The design of a monitoring network is therefore difficult. It would be illusory to think that an entire city or even a small area can be comprehensively covered by a network. The alternative approach consists of identifying a selection of sites that offer a degree of representativeness of the city and address specific objectives while taking into account the city's own objectives.

The noise map produced in the context of the implementation of the EU Directive constituted an important prerequisite for defining the strategy for rolling out a measurement network. It appeared that the analysis of the noise maps produced pursuant to European Directive 2002/EC/49 was a good starting point for priorising the challenges in terms of the ways in which different sources of noise (road, rail and air traffic, industrial activities, etc.) contribute to population exposure.

We also conducted large-scale temporary measurement campaigns (more than 350 sites were documented over the Paris region) which allowed for collecting information that were used to expand and refine the analyses which were established using noise maps, in particular concerning other potential sources of noise (e.g. noise leisure activities).

At a more local level, the work carried out in coordination with local and regional elected officials, institutional representatives and citizens has been used to collect information on situations that are most in need of observation.

Having collected and analysed all this information and backed by the willingness of stakeholders as well as funding, the areas targeted for the installation of measurement devices could be selected.

The types of measurements that need to be carried out on these sites depend on the information sought:

- Long-term measurements, using fixed devices, in order to give an indication of how noise nuisances change over time.

- Medium-term measurements (over periods compatible with the phenomena to be identified; may vary from several weeks to several years) in order to assess the acoustic impact of structural modifications such as major urban projects (creations or modification of roads, creation of urban parks, eco-neighbourhoods, etc.), modifications of flight paths and flight procedures for aircraft or implementation of solutions for reducing noise (replacement of road surfaces, reduction of speed, etc.).

- Short-term measurements (from several hours to several weeks) carried out with the help of semi-mobile equipment (measurement devices, laboratory vehicles) to supplement the permanent measurement system through:

- detailed documentation (zoom approach) on the acoustic environment of an area of interest (critical noise areas, iconic sites, areas exposed to multiple noise sources, etc.);
- quantification of the impact of specific temporary events (large demonstration, construction site, street festival, car-free day, provisional arrangements, etc.);
- perform a series of measurements at a number of reference points selected to validate or ensure the consistency of noise maps.

Officially launched in 2008, the network is currently made up of 45 long-term monitoring terminals and 350 short-term noise measurements, with a specific focus on aircraft noise.

Installing and operating a measurement network requires bringing together a wide variety of crossdisciplinary skills:

- Technological skills in order to be able to keep a constant watch on new technological developments and to assess the advantages and disadvantages of measurement equipment available on the market.

- Mechanical and electrical skills in order to be able to adjust the installation of measurement equipment to the various installation configurations that may be encountered in the field (layout of pole-mounted stations, on building façades, on balconies, on terraces or in public open spaces) and to the various power supply constraints.

- IT and telecommunications skills in order to be able to transfer the data acquired by the measurement stations to a centralised server and database and to implement the hardware and software solutions required for storing, saving, processing and disseminating the collected measurement data and the information and indicators that were produced.

- Acoustic measurement skills in order to be able to verify the quality of the raw measurement data on a daily basis and to implement the necessary procedures for checking, calibrating and maintaining equipment.

- Data processing skills in order to exploit the data collected by the stations and to produce analytical reports or studies.

Managing a measurement network also requires working with multiple partners, each with its own expertise in areas that are essential to developing or operating the network, including bodies or organisations holding related data that is required for operating noise measurement devices: road, rail or air traffic counting data, weather data, land use and population data and more.

The choice of terminal depends on the noise being measured, the technical constraints related to the nature of the site and the monitoring objectives.

Around airports, we chose to have measurement systems of a high measurement quality (class 1) which have specific expert features (e.g. the automatic detection of events through the analysis of sound sources and the audio recording of sound).

For some other uses (e.g. collecting a large amount of road noise data for the purposes of calculating or recalibrating noise maps), we chose to work with a class 2 level of measurement precision.

#### 5. Types of installation

The installation choices took into account the target objectives as well as any constraints in terms of terrain. Several on-site visits, a consultation with departments from the local authority or residents' associations as well as short-term measurements were generally required in order to select a suitable location for installing the measurement equipment.

When a site is rolled out to monitor the noise emitted by a very specific noise source, the site was chosen in a way that reduces the impact of other sources as much as possible.

Terminals may be located on public or private land. However, installations on public land are best in order to ensure the long-term operability of facilities and to facilitate maintenance access. Several types of location are used:

- on a public lamp post, generally at a height of between 4 and 6 m from the ground so that it is not easily accessible and to limit the impact of noise reflection off the ground;

- on the terrace or roof of a public building (town hall, municipal buildings, schools or healthcare institutions) with the help of a securely fixed post. The microphone is generally positioned at a height of 4 to 6 m above the terrace so as to limit the impact of noise reflection off the surface of the terrace;

- on building façades. We prefer to install devices at 4 m above the ground and at a distance of 2 m from the façade to obtain measurement data that is easy to compare to the results of the noise mapping. Nevertheless, there are also sensors that can be installed directly on the façade. For these installation methods, corrective factors will need to be taken into consideration in the measurement in order to document incident noise.

- in public open spaces. This installation method is especially suitable and recommended for monitoring aircraft noise, for which the perturbations from the propagation of noise energy between the aircraft noise source and the microphone need to be minimised. Sites located on relatively flat land that is unobstructed and as far away from reflective surfaces as possible are best for these purposes.

The mechanical design and installation of the environmental noise measurement equipment must minimise any possible damage from vandalism, extreme weather conditions, etc. as well as the risks to the public, building occupants and maintenance technicians.

An agreement with the local authorities on the occupation of public space is generally made in order to specify the characteristics of the terminal layout, how power will be supplied, how data will be transmitted and the operating body's obligations in terms of insuring the equipment against breakage and outright theft as well as in terms of civil liability.

Several types of power supply are used:

- connection to the power grid

<sup>-</sup> autonomous power supply (solar panels, batteries, fuel cells)

A connection to the power grid is necessary when high-quality measurement systems are used or with the measurement of an audio recording or other advanced capabilities that require computing power. This is also the case when attempting to reduce the time to providing measurements by increasing the frequency of data transfers.

However, great progress in digital electronics has been made over the past several years in terms of minimising power consumption with the arrival of ever more efficient components that require less and less power. It has become possible to deploy permanent noise measurement stations that get their energy exclusively from a solar panel of reasonable size, as long as we can accept certain compromises on the measurement system as well as to transfer the measurement data to a central server no more than once or twice per day.

Another autonomous source of energy, the fuel cell, is used by Bruitparif in street furniture specifically designed by the association (Sonopode<sup>TM</sup>) that is compatible with the implementation of very high-quality measurement systems and real-time data transmission.



Figure 1: Terminal for aircraft noise monitoring in a Sonopode<sup>TM</sup>

#### 6. The operation of the network

#### Maintenance and operations

Bruitparif has implemented a quality assurance plan to ensure the traceability of the preventive or corrective maintenance of equipment and to track the quality of measurements.

The measurement terminals allow for performing self-calibrations (at least once a day) to check for any malfunction of the measurement system. There are different types of technology for self-checking, from simply injecting an electronic signal to incorporating an autonomous noise source inside the microphone. In addition to these autocalibration operations, on-site manual calibrations are performed on a regular basis (e.g. every three months) as well as a calibration in the laboratory LNE every 18 months to check the following minimum requirements: frequency weighting, amplitude linearity, background noise from the terminal, level range selector, background noise from octave filters and frequency response of octave filters.

#### Data transmission infrastructure

Managing a measurement network requires setting up an infrastructure for data transmission. We decided to use cellular networks because they provide wide coverage at ever-increasing transmission speeds and at steadily declining prices. In addition, it is by far the most reliable method because operators have to ensure that their mobile telephone network operates in any case. The apparent cost of data connections is largely offset by the savings in working time needed to maintain an alternative telecom infrastructure based on connecting to the WiFi or ADSL networks within private households or public buildings, for example.

We decided to set up real-time or near real-time transmission of data for the purposes of ensuring the transparency of information provided to the public.

#### Data storage

Being able to back up detailed elementary data (e.g. one-second data readings) is very valuable in order to be able to recalculate new noise indicators after the event if the regulatory indicators have research and changed or for knowledge development purposes. Given that the cost of data storage is no longer a real issue, we decided to store the elementary data in addition to the calculated indicators. Depending on the case, we stored elementary data in dB(A), dB(C) or dB(Z)or one-third octave bands. For terminals around airports, we also store digital audio recordings.

#### **Operating** tools

The network is structured in a way that allows for acquiring and using the data obtained from the measurement of multiple parameters (noise levels as well as related traffic parameters, aircraft flight paths, weather data, digital audio recordings). In this context, we implemented tools for organising and searching data (databases), viewing data (data validation procedures) and processing data in order to produce various indicators. The type of installation is also taken into account during the measurement results processing phase. Procedures for backing up and restoring data are implemented in order to ensure the long-term viability of the measurement database.

#### Dissemination and information platform

The publication of data is an essential part of operating a measurement network. All the collected data and calculated values are viewable through a web application. Bruitparif designed a unique graphical representation that gives the ability to "deep zoom" in the acoustic data. People can experience the noise fluctuations per second in fine details as well as long-term trends. Different

Figure 2: The "Rumeur" information platform (http://rumeur.bruitparif.fr)

noise indicators are published: average levels by periods as well as the precise characteristics of noise events, especially for aircrafts. Thus the data coming from RUMEUR are much closer to the nuisances perceived by local residents than the noise maps generated through modelling.

A lot of work has been done to optimize the transfer of measurement terminal data and to develop expert modules for electronically processing the database. The performance of the data consultation platform (in particular the speed at which indicator results are shown) depends on that. The quality of the information also depends on the involvement of the staff that work every day to ensure that the measurement equipment functions properly and is maintained correctly and to check the data.

The treatment and analysis of data collected allowed the observatory to produce reports for the authorities and associations concerned.

#### 7. Conclusions

The noise measurement network operated by Bruitparif pursues a triple goal: understanding phenomena, assessing actions against noise and communicating in all transparency information on the sound environment in Ile-de-France.

It brings together advanced technologies such as identification of sound events, innovative logistics solutions for long-term measurements thanks to small solar panel measurement units or original urban equipments.

As a mean to characterise the noise exposure of the population objectively, the observatory became a true decision-making tool to support public authorities in the implementation of noise policies.

