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NOISE CONTROL FOR QUALITY OF LIFE

# New method for helicopter noise mapping

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## ABSTRACT

Due to the highly discontinuous nature of helicopter traffic, noise maps based on average indicators (Lden, Lday, Levening and Lnight) defined by the European Directive 2002/49/EC or used in other regulatory documents in France are insufficient to describe appropriately the noise exposure of residents living near heliports. Consequently it is essential to focus on indicators more relevant to reflect the noise events related to helicopter overflights.

In order to provide additional elements to quantify the acoustic impact of the activity generated by the heliport of Paris - Issy-les-Moulineaux (France), Bruitparif developed in partnership with the Directorate General for Civil Aviation (DGAC/DSAC Nord), a new mapping method for the noise levels and peaks generated by helicopter overflights. The indicators mapped are the following:

- the maximum level (LAmax) on the ground for each overflight,
- the noise peaks for each overflight (difference between the LAmax and the background noise),
- the number of overflights generating an LAmax of above 62 or 65 dB(A) (NA62 and NA65) during an average day,
- the number of overflights generating a noise peak of over 10 or 15 dB(A) during an average day.

This article presents the methodology used and the maps produced.

Keywords: Aircraft Noise, Noise mapping, Noise events

## 1. INTRODUCTION

In partnership with the Directorate General for Civil Aviation (DGAC/DSAC Nord), in 2011, Bruitparif worked on the development of a method for mapping the noise levels and peaks related to helicopters flying to or from the heliport of Paris - Issy-les-Moulineaux. The new approach suggested provides additional elements for quantifying the acoustic impact of the activity generated by the heliport of Paris - Issy-les-Moulineaux, in particular concerning the event-based acoustic indicators recommended by ACNUSA (Autorité de Contrôle des Nuisances Aéroportuaires – Airport Pollution Control Authority) in its 2005 annual report[2].

It was necessary to define indicators that are representative of the sound exposure and an

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[2] In its 2005 annual report, ACNUSA recommended the use of complementary indicators (NA62 and NA65 - cf. §2) to study the possibility of allowing certain towns, or parts of towns, located outside of the noise pollution map to benefit from subsidies for insulating homes in the event that values of these indicators exceed certain thresholds (NA62 > 200 or NA65 > 100).

appropriate method of representation. As regards heliport traffic noise, the production of maps, based on average noise indicators (Lden, Lday, Levening and Lnight) in the format defined by European Directive 2002/49/EC or as used in regulatory documents such as the Noise Exposure Plan (PEB), is inadequate to suitably describe residents' exposure to noise. Indeed, the highly discontinuous nature of the traffic requires the consideration of additional indicators that better take into account the event-based nature of noise generated by helicopter overflights. It is therefore essential to look at the mapping of this type of indicator.

It also appears necessary to take account of the acoustic environment of the territories flown over. A helicopter flight will be perceived by residents with greater intensity if the background noise levels are low in that area. The utilisation of strategic environmental noise maps will enable the background noise, primarily generated by road traffic, to be assessed in the territory under consideration.

## 2. PRELIMINARY DATA

Event indicators deal with noise peaks. A noise peak corresponds to an increase, followed by a rapid decrease in noise level. This signals the emergence of a particular noise compared to the background noise. Figure 1 shows the different characteristics associated with an acoustic event. The LAmax value corresponds to the maximum intensity observed in one second while an aircraft flies overhead. The noise peak, meanwhile, is the difference between the LAmax level and the background noise level preceding the event.

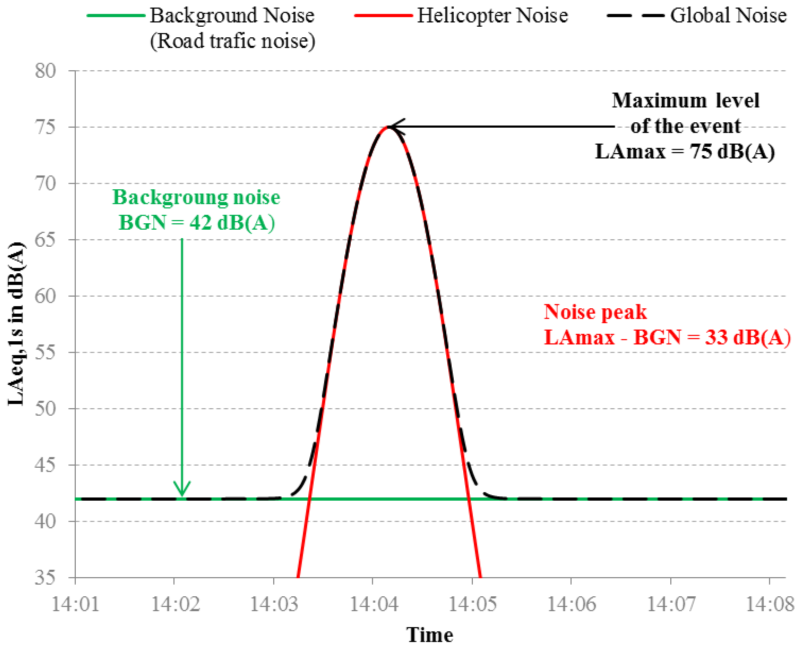



Figure 1 – Example of an "aircraft"-type noise peak

It is then possible to count the number of aircraft acoustic events over the course of a day whose maximum level over one second exceeds a certain threshold level: this is referred to as NAx (NA standing for Number Above and x for the threshold). The aggregate event indicators most frequently used for one day are NA62 and NA65, which correspond to the number of aircraft events in a day whose LAmax exceeds 62 dB(A) and 65 dB(A) respectively.

It is also possible to count the number of aircraft events, called NE, for which the noise peak exceeds a certain value. Noise peak values at 5, 10, 15, and 20 dB(A) - associated respectively with the indicators NE5, NE10, NE15, and NE20 - are used by default. These indicators are suggested by Bruitparif to take into account the fact that an event may be all the more annoying insofar as it significantly exceeds the background noise level.

## 3. METHODOLOGY

The work was undertaken in a research area of 3 km by 3 km centred on the heliport, as follows:

- Modelling of each flight path and profile involving the Issy-les-Moulineaux heliport;
- Calculation of simulated noise levels for each take-off and landing configuration, for all six helicopters studied, using INM 7.0c software (cf. §4.2);

- Consideration of the impact of the presence of buildings (parameter not taken into account in the INM software) on sound levels through calculations using CadnaA software in order to obtain the most realistic modelling possible of the maximum momentary levels generated on the façades of homes by different helicopter take-off and landing configuration;

- Validation of the modelling carried out and verification of the consistency of the mapping proposed;

- Production of a background noise map for the research area based on the consolidation and utilisation of road noise maps prepared by the City of Paris and GPSO[3] in application of European Directive 2002/49/EC. This study considers that background noise primarily arises from road traffic, which can be regarded as a relatively constant source of noise in the daytime. Noise from rail traffic was not taken into account since this is a highly discontinuous source of noise;

- Development of a method for mapping the noise peaks generated by different helicopter take-off and landing configurations, while taking into account the background noise in the area, using SIG "ESRI ArcView" software (production of maps for the Lden, NA, and NE indicators and estimation of the impact of the project in terms of the population's exposure to noise).

# 4. MODELLING OF THE NOISE GENERATED BY DIFFERENT HELICOPTER FLIGHTS

## 4.1 Flight paths and profiles

The Paris–Issy-les-Moulineaux heliport has two methods of operation depending on wind patterns: in an easterly wind, helicopters take off using runway heading QFU 062, whereas with a westerly wind, they take off runway heading QFU 242.

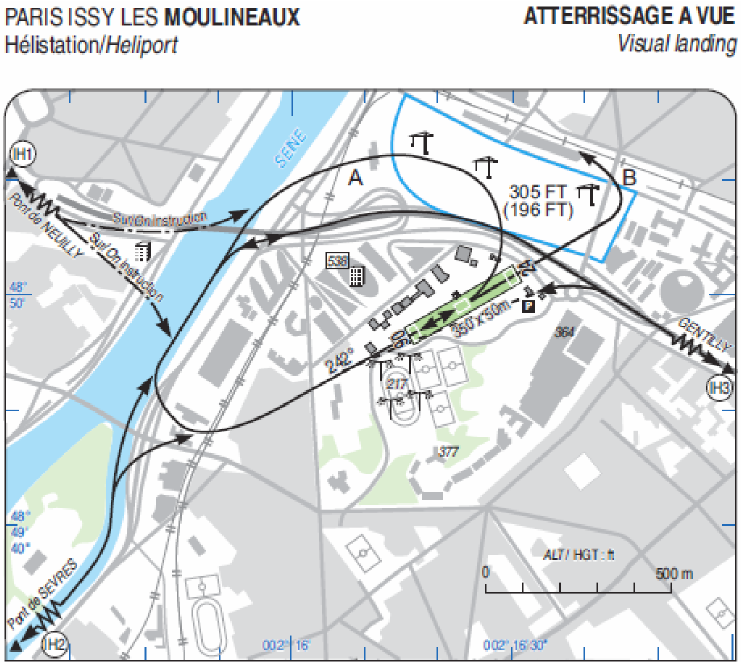



Figure 2 – Take-off and landing flight paths for the Paris–Issy-les-Moulineaux heliport

For the purposes of this study, Bruitparif exclusively modelled the movements of helicopters flying in and out of the heliport along the Issy-les-Moulineaux/Gentilly or Issy-les-Moulineaux/Pont de Sèvres paths. So four types of aircraft operations were taken into consideration for each configuration:

- Take-off towards "Gentilly",
- Take-off towards "Pont de Sèvres",
- Landings via "Gentilly",
- Landings via "Pont de Sèvres".

An aircraft operation is modelled using its ground path combined with a flight profile (altitude and speed).

[3] GPSO: (Grand Paris Seine Ouest - Greater Paris and Western Seine urban community)

### 4.2 Traffic from the heliport

The DGAC provided Bruitparif with a database of traffic from the Paris - Issy-les-Moulineaux heliport in 2012, which was created using the "strips". The analysis of this database allowed the preparation of statistics on the number of daily aircraft operations to or from the Paris - Issy-les-Moulineaux heliport, as well as the types of helicopters involved. For this study, we have taken two types of day into account:

- An average day, with 35 aircraft operations,
- A so-called "busy" day, with 65 aircraft operations.

We have combined each of these two types of days with an easterly wind traffic pattern and a westerly wind traffic pattern. The final results summarise these two configurations based on DGAC's 2012 statistical database (64 % of configurations with westerly wind and 36% of configurations with easterly wind).

For each configuration, the different aircraft operations were broken down into the flight paths depending on the analyses carried out on the 2012 traffic database, summarised in table 1. Out of all the heliport's aircraft operations, we can see that 70 % of flights (take-offs and landings) go over Issy-les-Moulineaux / Pont de Sèvres, and 30 % fly over Issy-les-Moulineaux / Gentilly. There were as many take-offs as landings in 2012.

Table 1 – Breakdown of aircraft operations into the different flight paths for each configuration

| | Total | Take-offs towards Pont de Sèvres (35 %) | Landings via Pont de Sèvres (35 %) | Take-offs towards Pont de Sèvres (15 %) | Landings via Gentilly (15 %) |
|---|---|---|---|---|---|
| Average day | 35 aircraft operations | 12.25 aircraft operations | 12.25 aircraft operations | 5.25 aircraft operations | 5.25 aircraft operations |
| Busy day | 75 aircraft operations | 22.75 aircraft operations | 22.75 aircraft operations | 9.75 aircraft operations | 9.75 aircraft operations |

To obtain an overall idea of the heliport's traffic, it is necessary to model each helicopter separately for each flight it makes. Therefore, the LAmax levels generated at ground level were calculated for each helicopter and for each wind configuration in initial and future situations, taking into account the effect of the presence of buildings and the topography. There are therefore 16 different maps for each helicopter.

The study concerned 10 different types of helicopters, representing nearly 95 % of the helicopter fleet that uses the Paris - Issy-les-Moulineaux heliport. Figure 3 presents an estimation of the number of aircraft operations over the year 2012 for each type of helicopter.

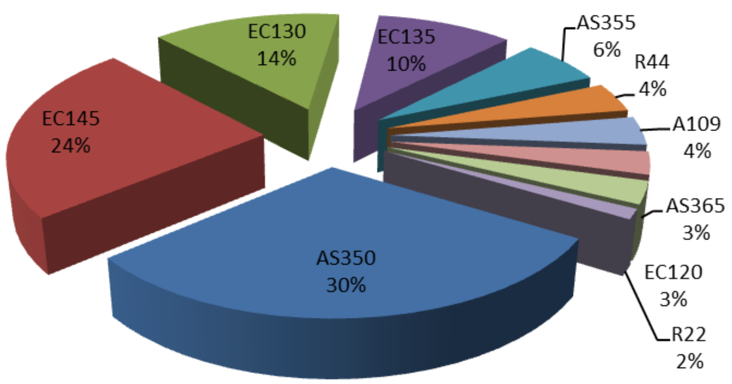



Figure 3 – Breakdown of the helicopter fleet for the year 2012

Out of the 10 most common helicopters seen at the heliport, only 7 are included in the database of the INM 7.0c software. It was not possible to model EC120, EC135, or EC145 helicopters. However, based on the recommendations of the STAC[4], the data for EC135 helicopters was replaced with that of AS 355 helicopters. Ultimately, the models were based on the following helicopters, which represent 75% of the traffic:

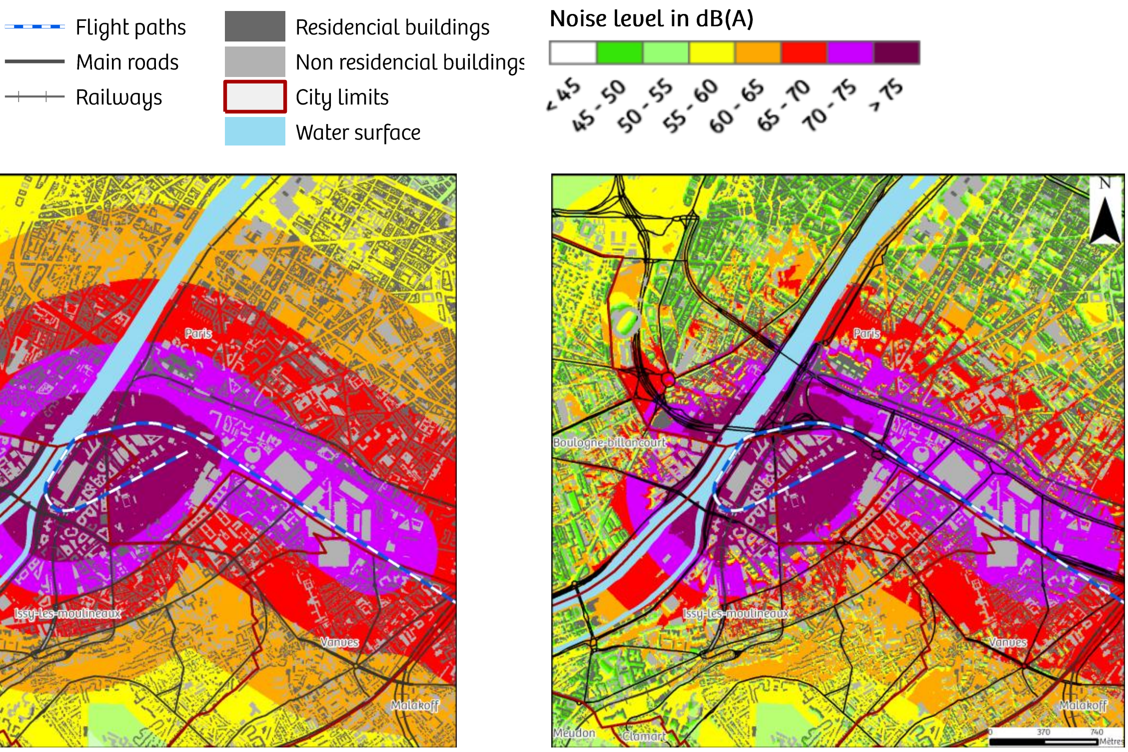
Table 2 – Helicopters available in the INM 7.0c database and proportion of the heliport's traffic

| **Type of helicopter** | **AS350** | **EC130** | **AS355** | **R44** | **A109** | **AS365** | **R22** |
|---|---|---|---|---|---|---|---|
| Proportion of the traffic | 30% | 14% | 16% | 4% | 4% | 3% | 1% |

This breakdown of the fleet was applied for each configuration. As a result, only 25.5 aircraft operations out of 35 were modelled for an average day, and 47.5 out of 65 for a "busy" day. The noise levels presented in this study are characteristic for a significant proportion of the traffic (75 %), which allows us to get a good estimation of the change in noise generated by a change in flight paths.

### 4.3 Taking into account the effect of buildings and the topography

The INM software does not take into account the effect of buildings on sound propagation. In order to more accurately represent the reality, Bruitparif modelled different scenarios using the CadnaA software: the noise generated by each helicopter movement was calculated at first without modelling the buildings, and then taking in account the buildings in the model. This method made it possible to evaluate the masking or reflection effect of buildings for each flight path and each profile. It was therefore possible to correct the LAmax noise levels estimated by the INM software for each helicopter on every flight path (cf. figures 4 and 5).




Figures 4 and 5 – LAmax noise map generated at ground level by an A109 approaching QFU06, without (figure 4) and with (figure 5) taking into account the effect of buildings

4 STAC: Service Technique de l’Aviation Civile (Civil Aviation Technical Department - REF.: LIS/STAC/ACE/PEB/73: List of helicopter substitutions, version v1 dated 26/08/11).

## 4.4 Calculation of the daytime background noise indicator: LAeq(6 am - 10 pm)

In order to evaluate background noise in the area of study, strategic road noise maps produced and provided by the City of Paris, and the GPSO urban community for the Lden and Ln indicators, were used. As there is practically no helicopter traffic at night-time (10 pm - 6 am), it was judged relevant to estimate noise peaks during the day-time period of 6 am to 10 pm. The average background noise level for this period, called LAeq (6am - 10 pm) was estimated using the Lden and Ln indicators, using the hypothesis that the road noise during the 6 pm - 10 pm period would be similar to that of the 6 am to 6 pm period, for the purposes of simplification. This is confirmed in particular by road noise measurements that have already been made in the areas concerned (a difference of less than 0.5dB(A) was observed between the 6 am - 6 pm LAeq and the 6 pm - 10 pm LAeq). The formula for calculating the estimation of this indicator using the Lden and Ln indicators is explained below.

$$Lden = 10 \times \log_{10}\left[\frac{1}{24}\left(12 \times 10^{\left(\frac{Lday}{10}\right)} + 4 \times 10^{\left(\frac{Levening+5}{10}\right)} + 8 \times 10^{\left(\frac{Lnight+10}{10}\right)}\right)\right] \quad (1)$$

<u>**With the following hypothesis**</u>**:**

$$L = Lday = Levening \cong, LAeq_{6h-22h} \quad (2)$$

We get:

$$LAeq_{6h-22h} \cong 10 \times \log_{10}\left[2 \times \frac{3 \times 10^{\left(\frac{Lden}{10}\right)} - 10^{\left(\frac{Lnight+10}{10}\right)}}{3+\sqrt{10}}\right] \quad (3)$$

Figure 6 presents a map of the 6 am - 10 pm LAeq indicator concerning road noise, which can be considered to be a good estimation of background noise over the 6 am - 10 pm period.

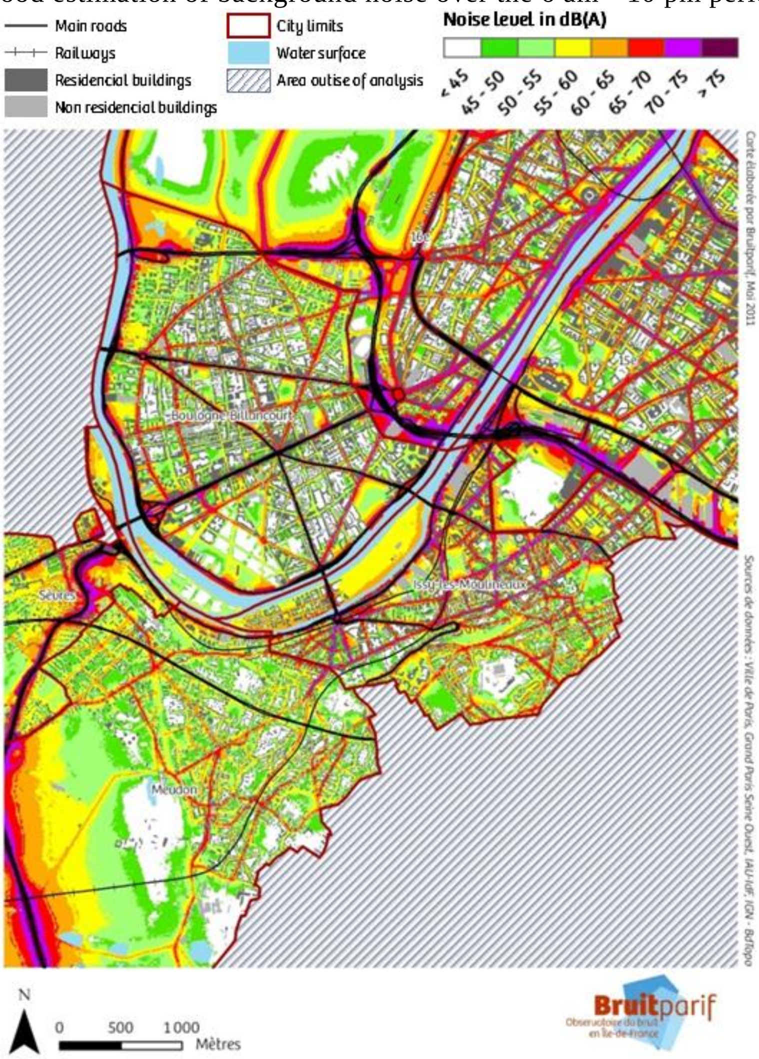



Figure 6 – Road noise map for the LAeq 6 am - 10 pm indicator – Estimation of day-time background noise

## 5. PRODUCTION OF ACOUSTIC INDICATOR MAPS

The maps of acoustic indicators concerned by the study are produced by combining the LAmax levels obtained for each helicopter in each configuration with the traffic data described in chapter 4.2.

### 5.1 LAmax mapping

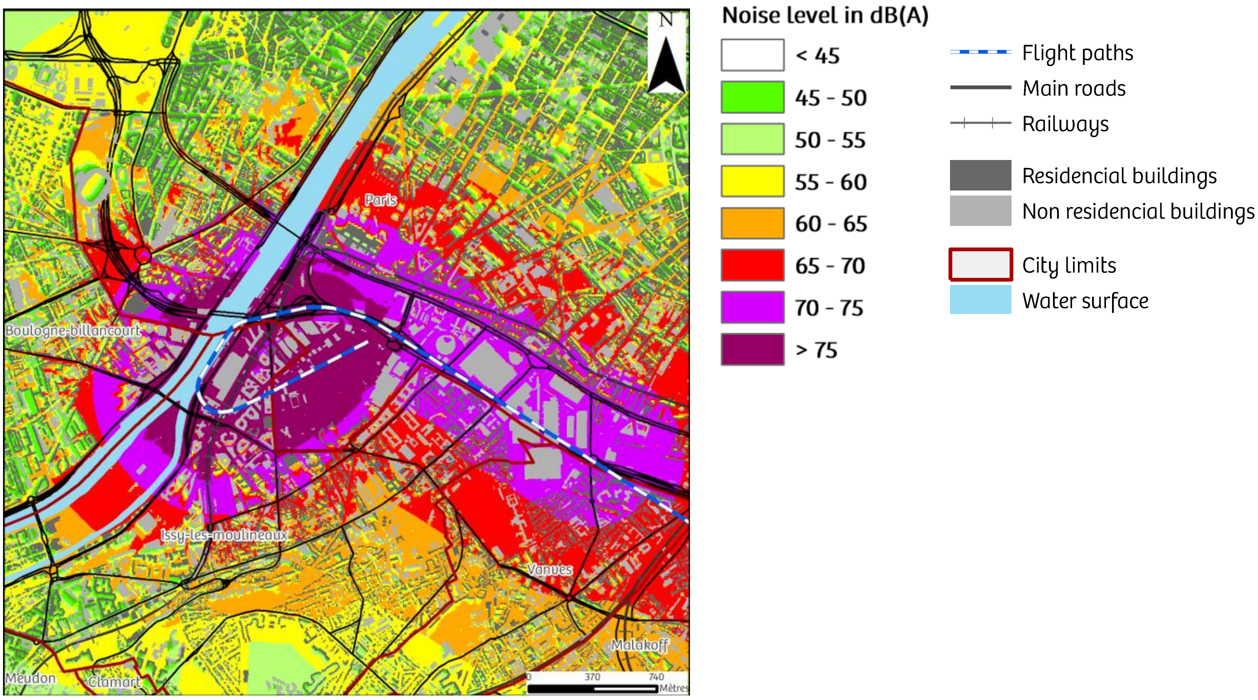



Figure 7 – LAmax noise level of the A109 taking-off from QFU06, easterly configuration

### 5.2 Mapping of noise peaks

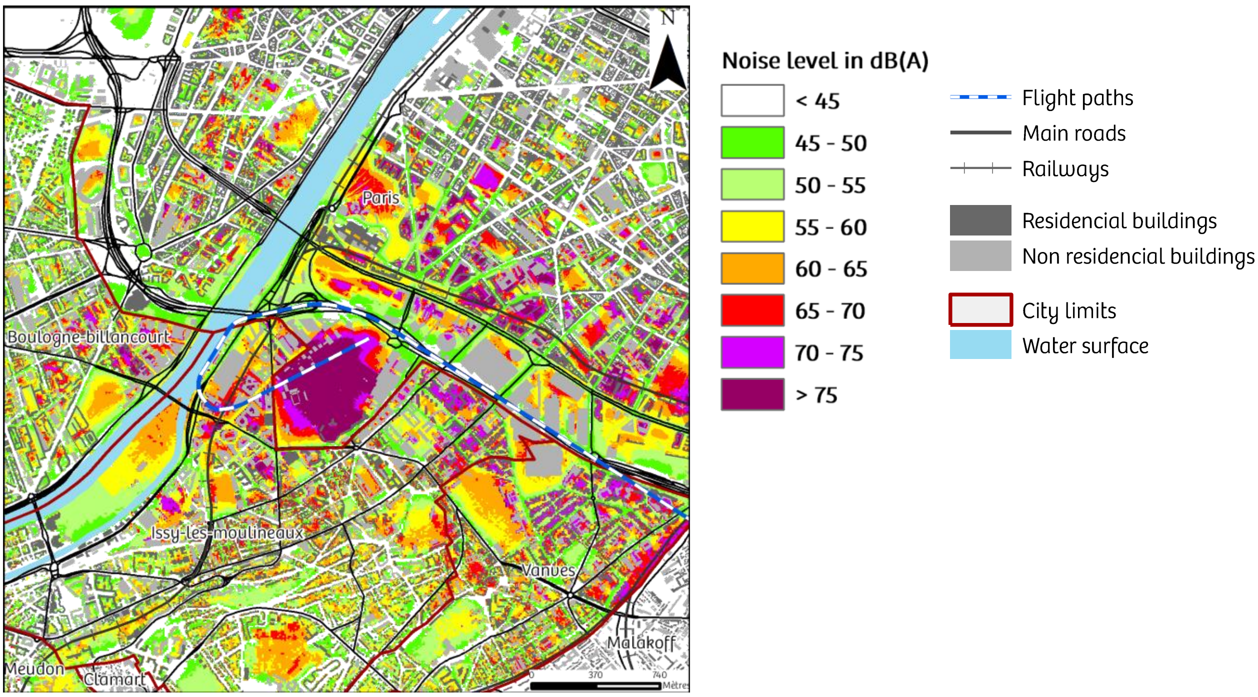



Figure 7 – Noise peaks for the A109 taking-off from QFU06, easterly configuration

## 5.3 Mapping of NA62

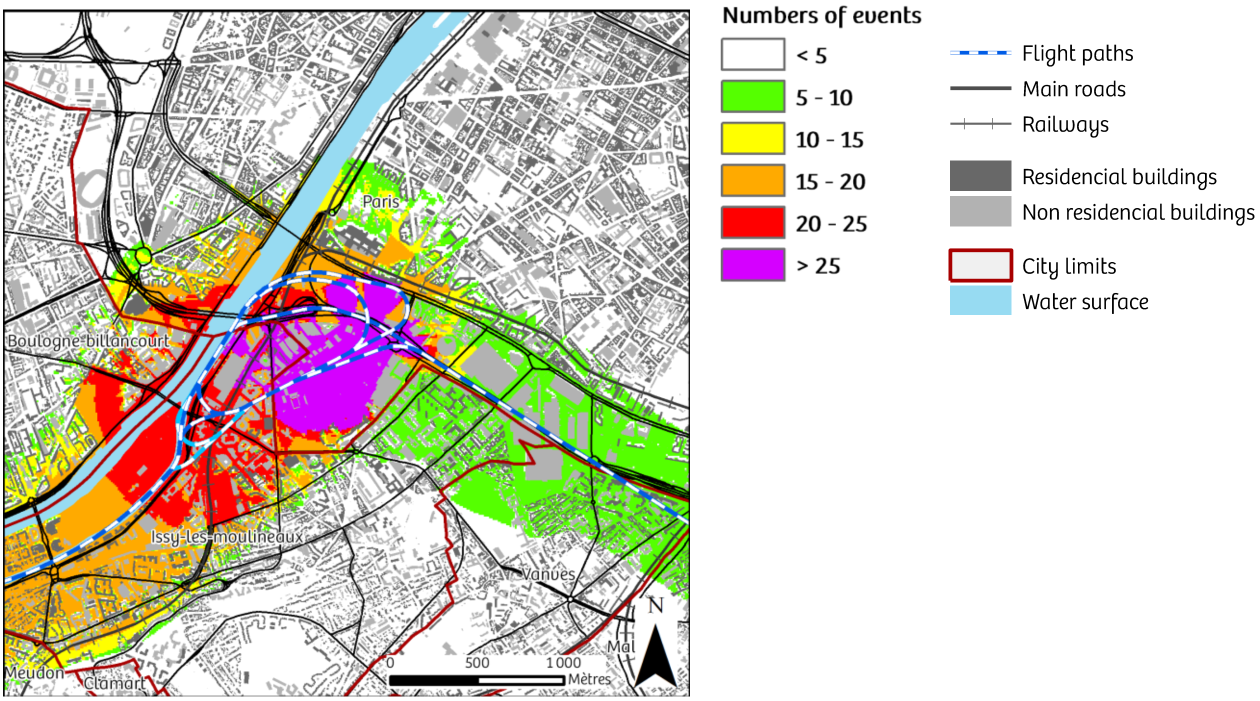



Figure 9 – Map of NA62s for an average day (35 aircraft operations)

## 5.4 Mapping of NA65

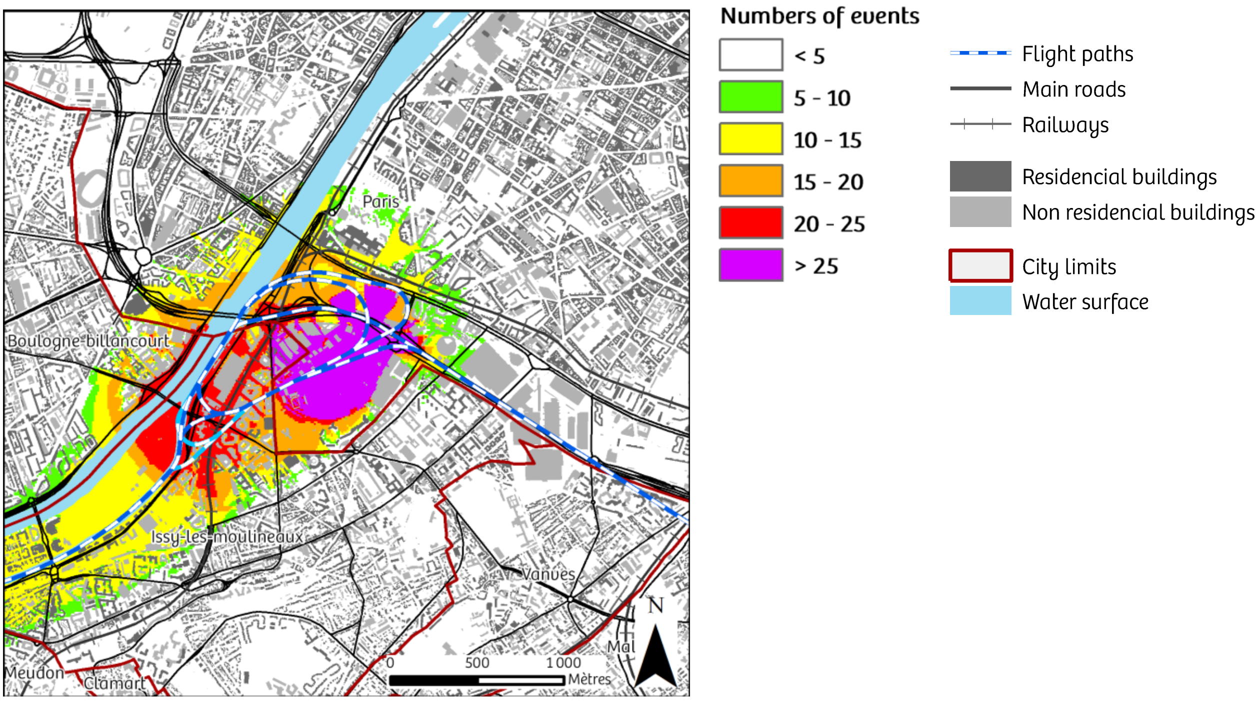



Figure 10 – Map of NA65s for an average day (35 aircraft operations)

## 5.5 Mapping of NE10

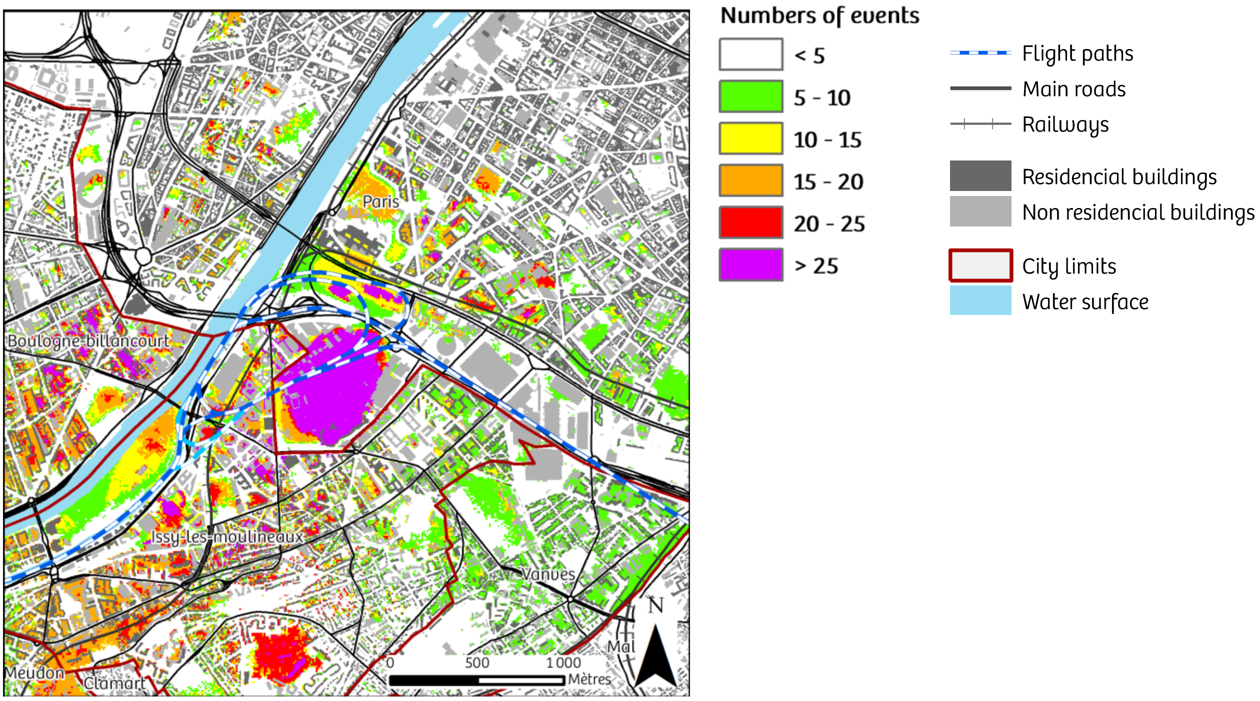



Figure 10 – Map of NA65s for an average day (35 aircraft operations)

# 6. ESTIMATION OF EXPOSED POPULATIONS

All the maps produced allow an estimation of the impact of helicopter traffic on the exposure to noise of populations in the territories covered by the area of study ($15^{th}$ and $16^{th}$ arrondissement of Paris, Boulogne-Billancourt, Issy-les-Moulineaux, and Meudon). The number of the people per building is based on the use of IAU-IdF's DENSIBATI database.[5]. Each building is attributed:

- a Lden indicator level (road and air),
- the number of NA62s,
- the number of NA65s,
- the number of NE10s,

The database thereby obtained allows an estimation of the impact of helicopter traffic on the population for these indicators (283,501 people in the area of study).

Table 3 – Exposure of the population to noise for NA62, NA65, and NE10 indicators on an average day

| Class of | 0 – 5 | | 5 – 10 | | 10 – 15 | | 15 – 20 | | 20 – 25 | | 25 – 30 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| dB(A) | Nb | % | Nb | % | Nb | % | Nb | % | Nb | % | Nb | % |
| NA62 | 74533 | 26% | 30250 | 11% | 13118 | 5% | 18485 | 7% | 3909 | (1) | 993 | 0% |
| NA65 | 80114 | 28% | 9769 | 3% | 13349 | 5% | 3531 | (1) | 453 | 0% | 83 | 0% |
| NE10 | 49577 | 17% | 46280 | 16% | 16292 | 6% | 27787 | 10% | 16331 | 6% | 10260 | 4% |

# 7. CONCLUSION

The method suggested by Bruitparif allows the production of event-based acoustic indicator maps

[5] IAU-IdF: Instutit d'Aménagement et d'Urbanisme d'Ile-de-France (Institute for Town Planning in Ile-de-France)

related to the air traffic of a heliport. These maps present the maximum level generated by each helicopter as well as the noise peaks of each overflight compared to the road noise, which is considered here to be a constant background noise. Contrary to the energy indicator maps produced up to now, this method takes into account the effect of buildings and the topography on sound propagation. Certain types of helicopters present in the fleet of the Paris - Issy-les-Moulineaux heliport could not be modelled in this study. They will be modelled soon.


## ACKNOWLEDGEMENTS

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