*Société Française d'Études et Réalisations d'Équipements Aéronautiques*
*3, Carrefour de Weiden, 92441 Issy-les-Moulineaux Cedex ; France*
*http://www.sofreavia.com*
***BIPE***
*L'Atrium – 6 place Abel Gance, 92652 Boulogne-Billancourt Cedex, France*
*http://www.bipe.com*

EUROPEAN COMMISSION
DG TREN-F3

# Study on the different aspects of Noise Limits at Airports

## Final Report

## Version 1.0

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| Drafted by : | Olga Eglin, Maud Rotureau, Pierre-Yves Savidan, Jean-Paul Desgranges, Régis Hellot | |
| Verified by : | Jean-Paul Desgranges, Régis Hellot | Date : 05/10/04 |
| Authorised by : | Jean-Paul Desgranges | Date : 05/10/2004 |
| Addressees : | European Commission DG-TREN/F3 : Eckard Seebohm, Ronny Rohart | |

# DOCUMENT REVIEW

| Version | Date | Description of evolution | Modifications |
|---|---|---|---|
| 1.0 | 05/09/2003 | First draft version sent to the Client | |
| 2.0 | 31/10/2003 | Interim Report | |
| 1.0 | 22/12/2003 | Draft Final Report | |
| 2.0 | 22/04/2004 | Draft Final Report | |
| 1.0 | 25/06/2004 | Final Report | |
| 2.0 | 05/10/2004 | Final Report – definitive version | |

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# INTRODUCTION

## Preamble

Sofreavia and BIPE, hereafter called “the consultant”, have been contracted by European Commission DG TREN/F3, to assess the implementation of noise limits at European airports and how they impact both the populations exposed and the aircraft operators.

The consultant’s work was being conducted in accordance with the methodology proposed in its Technical Proposal of 22/10/2002 (CSS/P7107/PR02067T), following the Call for Tender N° TREN/F3/52-2002 and as amended by its Project Management Plan (PMP) version CSS/C1494 PMP Noise Limits v1.0.

## Objective of the study

The objective of this study is to analyse the current situation regarding the specification and enforcement of noise limits at airports in EU countries and how their impact on the aviation sector and on other stakeholders may be assessed.

Indeed, each country has usually developed its own system often based on political pressures, national perception of nuisance, and in the light of implementation constraints. These systems vary a lot from one country to another, from total curfews at night to mere noise abatement procedures.

Yet, although this study includes an inventory of all these measures, it then focuses on noise level limits only, i.e. on those measures which set a noise limitation with a direct effect on noise levels.

In this view, we have elaborated the following noise level limits classification:

1) **Noise level limits per flight**, (e.g. 65dB per movement), as measured at monitoring points, with a special attention paid to those measures specific to night-time;
2) **Noise volume limits over a time-period**, usually expressed in terms of *quotas* (over a day, a year, or a IATA season....), with, here also a special attention to measures specific to night-time.

Therefore, all other noise management measures, which may indeed have an indirect impact on airport generated noise levels, are excluded from this study, such as:

- Traffic limitations (such as 250 000 movements at Orly, 45 millions passengers in CDG, 440 000 movements at Schiphol, etc) are not considered as noise limits *per se*: they may have an impact on noise, but they do not ensure that, for a same activity volume, they will limit noise volumes;
- Similarly, restrictions/bans on the noisiest aircraft (such as night bans on noisiest Chapter 3 aircraft) which are instruments used to reduce noise, are not considered as noise limits *per se*.

In line with the terms of reference, and as indicated in the consultant proposal and PMP, this study has been broken down into the following two main phases (or working packages – WPs):

WP1 consisted in a review of existing mechanisms for creating, applying and checking noise limits. An interim report was produced resuming this part. It is fully reproduced in Part I of this report, including the remarks done and additional information requested in the mean-time by the Commission.

WP2 consisted in a review of the impact assessments of existing practices, based on available data/studies, representing Part II of this report.

## Report content

This report includes two main parts summarising the main findings of the two mentioned above Work packages:

***Part I: Review of existing mechanisms for creating, applying and checking noise limits***.

This part includes four main chapters:

- **Chapter 1: Inventory Methodology** provides a brief description on the way we have set-up this inventory, our data sources and the airport segmentation we have come-up to when analyzing their respective noise management policies;
- **Chapter 2: Noise management measures** lists the various measures we have identified and classified during our survey, its provides an overview of all those measures in order to set-up the framework within which we will then analyse the core subject of this study;
- **Chapter 3: Noise level limits**, with a distinction between those limits imposed per movements and those imposed over a time period; for both cases, we have made a further distinction for those limits which only concerns night-time.
- **Chapter 4: Conclusion**

***Part II: Elaboration of a methodology to assess CBA of airports noise limits***

Our proposed approach for this part was to develop the common representation template so as to structure what information is available.

Yet, our investigations led to the conclusion that no country has ever done an impact assessment restricted to noise limits. Indeed, most assessments are quite qualitative and informal, and, when a formal cost benefit analysis does exist, it addresses the whole noise limitation policy as a whole.

In an attempt to identify those principles on which the elaboration of a CBA methodology can be based, we broke down this part into three main chapters:

- **Chapter 1: Introduction**
- **Chapter 2: Case studies** presents the approaches adopted by France, the United Kingdom, and Switzerland; it is completed by a summary of the interviews led in Netherlands and Germany, provided in **Appendix IV**, noting that those approaches are not directly aimed at noise limits.
- **Chapter 3: Definition of cost and benefit indicators** aims at identifying those indicators that are suitable for supporting a CBA (e.g. the number of people exposed to aircraft noise above noise levels).
- **Chapter 4: Conclusions**

## Scope of work

Originally, in our technical proposal, and according to the terms of reference, we had proposed to collect information on the national regulatory frameworks and indicators within the 15 EU states, while limiting the initial investigation of operational implementation processes to those European countries with large airports (typically, those airports with more than 150,000 movements per year).

Yet, because, in the meantime, we have been able to appreciate how the Boeing data base on these noise management measures has significantly evolved during the last months, providing more comprehensive readily available information, we agreed during kick-off meeting to extend this review to geographical Europe airports (not limited to current EU countries) for as many airports as possible with more than 50 000 commercial movements (which more or less corresponds to the airport concerned by EC directive 2002/30 on “the Establishment of rules and procedures with regard to the introduction of noise related operating restrictions at community airports” i.e. airports with more than 50 000 movements of civil subsonic jet aeroplanes per calendar year).

The list of airports surveyed is reproduced in Attachment I.

The main issue encountered while collecting raw data to be used for populating this report is the lack of common understanding about what a noise limit is. For instance, one of our major sources, the Boeing web-site, gathers information for all European airports on a variety of topics, including ‘Noise Level Limits’; in many cases, the information filled in by the airport is not stored under the correct item. This also relates to the difficulty of isolating a maximum noise level being used as **a noise limit *per se*** from a maximum noise level being used as a **contouring parameter** for the noise management policy.

It must also be stressed that, in the currently fast changing environmental management framework, the limits mentioned in this report are those in force by the end of year 2003 when the report was elaborated, and may therefore have changed since then.

# ACRONYMS, ABBREVIATIONS AND DEFINITIONS

| | |
|---|---|
| ANMAC | Aircraft Noise Monitoring Advisory Committee. This UK Committee is chaired by the Department for Transport and comprises representatives of the airlines, Heathrow, Gatwick and Stansted airports and airport consultative committees. |
| ERCD | Environmental Research and Consultancy Department of the UK Civil Aviation Authority. |
| ICAO | International Civil Aviation Organisation. |
| NATS | National Air Traffic Services Ltd. NATS provides air traffic control services at several major UK airports, including Heathrow, Gatwick and Stansted. |
| NTK | Noise and Track Keeping monitoring system. The NTK system associates radar data from air traffic control radar with related data from both fixed (permanent) and mobile noise monitors at prescribed positions on the ground. |
| QC | Quota Count: the basis of the London airports Night Restrictions regime. |

## Noise related terminology

| | |
|---|---|
| A-weighted | A filter that is applied to the output of the microphone within a sound level meter to simulate the way the sensitivity of the human ear varies with sound frequency, broadly being more sensitive to high frequencies than low. With this filter, the meter output is A-weighted sound level. |
| Certificated Noise Levels | The ICAO aircraft noise certification procedure for subsonic aircraft over 5,700 kg requires three separate noise measurements to be made at approach, sideline and flyover locations. The three certificated noise levels (measured in EPNdB) are determined within tight tolerances and normalised to standard atmospheric conditions. |
| dB | Units describing sound level or changes of sound level. |
| dB(A) | Units of sound level on the A-weighted scale. |
| EPNdB | Units for Effective Perceived Noise Levels. |
| PNdB | Units for Tone Corrected Perceived Noise Levels. |

## Single Event Maximum Sound Level Metrics

| | |
|---|---|
| LAmax (dB(A)) | Maximum A-weighted sound level |
| PNL | Perceived Noise Level (PNL) is computed from sound pressure levels measured in octave or one-third octave frequency bands. Currently it is used in the noise certification process for all turbojets -- powered aircraft and large propeller-driven transports. An approximation is given by adding 13 dB (±3) to the measured A-weighted noise level. |
| PNLT | Tone Corrected Perceived Noise Level is basically the Perceived Noise Level adjusted to account for the presence of discrete frequency components. The method for calculating PNLT adopted by the FAA involves calculation of the PNL of a sound and the addition of a tone correction based on the tonal frequency and the amount that the tone exceeds the noise in the adjacent one-third octave bands. |

### Single Event Energy Dose metrics

EPNL Effective Perceived Noise Level is a single number measure of complex aircraft flyover noise which approximates human annoyance responses. It is derived from PNL and PNLT and includes correction terms for the duration of an aircraft flyover and the presence of audible pure tones or discrete frequencies (such as the whine of a jet aircraft) in the noise signal. The EPNL is used as the noise certification metric for large transport and turbojet aircraft and helicopters.

SEL Sound Exposure Level generated by a single aircraft at a particular point. It is a measure of the effect of duration and magnitude for a single event measured in A-weighted sound level above a specified threshold which is at least 10 dB below the maximum value.

### Airport Cumulative Metrics

Leq Equivalent continuous sound level. Energy average noise level (usually A-weighted) integrated over some specified time. The purpose of Leq is to provide a single number measure of noise averaged over a specified time period. The total acoustical energy associated with the fluctuating sound (during the prescribed time period) is equal to the total acoustical energy associated with a steady sound level of LAeq for the same period of time.

LDEN A 24-hour equivalent continuous level in dB(A) where 5 dB is added to evening noise levels from 19:00 to 23:00 and 10 dB is added to night-time noise levels from 23:00 to 07:00.

*Sources:*

*Aviation Noise Effects, Federal Aviation Authority (1985). This report summarizes the effects of aviation noise in many areas, ranging from human annoyance to impact on real estate values. It is a very informative document, with several graphs and explanatory figures.*

*Environmental Noise Measurement, Brüel & Kjaer*

# PART I:
# REVIEW OF EXISTING MECHANISMS FOR CREATING, APPLYING AND CHECKING NOISE LIMITS

# 1. INVENTORY METHODOLOGY

## 1.1. Sample characteristics

The size of the airports population to be analysed was mostly determined by the need to ensure consistency with the definition of the airports concerned by Directive 2002/30/EC. Yet, without prejudging the results of our analysis, we found interesting to segment this population into the following categories:

| Number of movements per year | Airport ranking | Corresponding airports (based on 2002 traffic) |
|---|---|---|
| > 200 000 | 1 – 16 | Paris CDG / Vienna |
| 150 – 200 000 | 17 – 28 | Manchester / Hamburg |
| 100 – 150 000 | 29 – 43 | Stuttgart / Malaga |
| 70 – 100 000 | 44 – 64 | Aberdeen, UK / Bristol |
| 55 – 70 000 | 65 – 85 | Bordeaux / Cardiff |
| 50 - 55 000 | 86 –102 | Bologna / Strasbourg or Avignon |

The first two categories of major airports usually have a complete Environment Direction or Department highly staffed, with noise control/issues specialists, and publish Environmental Reports or provide information on their general website.

The third and fourth categories have usually one or two persons in charge of all environmental issues.

In the smallest ones, the Managing Director is the contact for environmental issues.

The list of airport studied is reproduced in **Appendix I**.

## 1.2. Sources

We used six main sources:

- **Boeing Airport Noise Regulation Information** Web Site (http://www.boeing.com/commercial/noise/flash.html), up-dated in May 2003, although latest information on this database was often 2002. The type of information is reproduced in **Appendix II**.
- **Specific surveys / questionnaires** which we have sent to those seven airports which had not filled the Boeing database.
- **A previous survey conducted by Bipe** in 2001 on the busiest 25 EU airports.
- **Environmental reports** when available although the latter are not always in English language.
- **Airports websites,** as well as http://www.abm.fr/avion/gvawebapt3.html particularly to collect legal information:
- **"Miscellaneous publications"** such as the French "Rapport d'information parlementaire sur l'Avenir du transport aérien et la politique aéroportuaire, July 2003" or various Southeast and East of England Regional Air Services (SERAS) studies, or the French ACNUSA annual report (Autorité de Contrôle des Nuisances Sonores Aéroportuaires).

## 1.3. Information searched

Besides the **limits in terms of noise level** (Noise level per flight, noise level over a time period), which will form the core of this study, we have identified five other major types of noise actions to investigate:

- **Operational noise limits** (curfews, quotas in terms of movements, most noisy aircraft operating restrictions)
- **Operational measures** (preferential runways, noise abatement flight procedures)
- **Tax incentives** (through noise charges) or **Enforcement measures** (penalties in case of overrun)
- **Land use planning** or managing (such as zoning or mechanisms to finance insulation)
- **Legal or regulatory base** (imposed by national Laws).

Furthermore, in order to provide input for WP2, the following information was also collected:

- Noise index (although, in EU country, the harmonisation to $L_{den}$ and $L_{night}$ is under process)
- Noise zones and population concerned (when available).

An example of the template used as a working document to collect this data is reproduced in **Appendix III**.

# 2. NOISE MANAGEMENT MEASURES AT EUROPEAN AIRPORTS

As already indicated, noise limits (per flight or over a time period) represent only one component out of the multitude of possible noise management measures implemented by airports or national authorities.

Prior to going more in depth into noise limits analysis as developed in Chapter 3, Chapter 2 reviews briefly those various other noise management measures by specifying their respective definitions and/or scope enlightened by some examples.

Those listed measures include:

- Noise level limits per movement
- Noise volume limit over a time period
- Most noisy aircraft restrictions
- Movement quotas in terms of activity.

## 2.1. Noise index (survey item 0)

As already mentioned, this information was collected, mostly to indicate the effort of harmonisation which is still needed, independently from the obligation set-up by Directive 2002/49/EC to express limits values in terms the $L_{den}$ and $L_{night}$ by 2005. Here also, variety of indices still appears quite important when facing the 2005 EU deadline for harmonisation.

## 2.2. Noise level limits per movement (survey item 1.1 & 1.2)

Noise level limits per movement are not to be confused with noise level limits over a time period or with quotas. This kind of noise level limit is a noise value ceiling above which an aircraft may not be allowed to operate over specified areas usually linked to noise zones. They might be for all day or specific during night.

Brussels, Düsseldorf, Swiss airports, are examples among many others as further developed in Chapter 3.

## 2.3. Noise volume limit over a time period (survey item 2.1 & 2.2)

The authority may decide to limit the noise volume over a time period on the airport over a specific period:

- on a yearly basis, or
- over a IATA season
- over nightly period to be defined.

These limits are usually computed from theoretical data rather than measured from monitors. Yet, they may be combined with noise limits values measured at monitors.

Amsterdam, Brussels, Copenhagen, Madrid, Paris-CDG, and several major British airports, are examples among many others as further developed in Chapter 3.

## 2.4. Restrictions on the noisiest aircraft, partial or total (survey item 3.1 & 3.2)

European Union airports have implemented the EU 1992 Directive phasing out Chapter 2 aircraft operations on EU airports leading to total ban of Chapter 2 airplanes since 1st April 2002.

Yet, noting that the Directive banned those aircraft with a maximum take-off weight higher than 34 tons (or with a capacity exceeding 19 passenger seats), some European airports have extended their ban to all Chapter 2 aircraft at least at night.

Some other airports have also extended night ban to the noisiest Chapter 3 aircraft.

At Amsterdam Airport, Chapter 3 aircraft for which margin between the cumulative noise certification levels and the Chapter 3 noise limits is less than 5 EPNdB are not allowed to take-off between 23:00 to 06:00. At Paris-CDG Airport, noisiest chapter 3 (minus 5 dB) aircraft operations at night are being progressively banned (by 20% decreases each year until 31 December 2008).

## 2.5. Quotas in terms of activity (survey item 4)

The authority may decide to limit the number of flights on the airport on a yearly basis, or only during night-time.

At Paris/Orly, a 1994 legal act (Arrêté ministériel), adopted an annual movement quota of 250 000 movements per year.

At Amsterdam, commercial traffic was limited in 2001 to 440 000 movements. This limitation was increased in 2002 to 460 000 movements (+4.5%). Yet, from 2003, this system has been replaced by total noise volume and maximum noise levels in $L_{den}$.

At Düsseldorf, in 1992, the regional government's noise policy tried to limit the number of operations to 71 000 between May and October 1993. The airlines were opposed to this restriction. The threshold of 71 000 movements was based on the average summer noise of 1979-1983. This capping of movements was considered as a trade-off in order to obtain approval for building a second runway at the airport.

## 2.6. Curfews (survey item 5)

Curfews are usually during night hours, with sometimes, some more stringent requirements implemented on week-ends. Yet, very few airports have adopted total night curfews.

It means that some airports do not allow aircraft landing and take off during that time, except for special or exceptional reasons.

- At Paris-Orly, a total night curfew from 23:30 to 06:00 has been implemented since 1968: no arrival may be scheduled between 23h30 and 6h15, and no departure between 23:15 to 06:00 AM.
- On other airports exceptions are possible (postal or freight transport for instance).
- At Swiss airports, (Bern, Geneva, Zurich), a formal ban on flights between 00:00 and 05:00 AM has been introduced via the concession agreements between the Government and the airports. Yet, this limit has not been imposed through a legislative act. For shoulder periods, a night surcharge is being levied.

- At Frankfurt, landing between midnight and 05:00 AM is prohibited excepted for based airlines which have an extra hour to terminate their operations. Lufthansa can land its last aircraft at 01:00am while other European airlines must depart before 12 Midnight.
- At Roma, a night curfew exists but only limited to the runway which is the nearest to high density areas.

Curfews with period differences between week days and week-end have been implemented:

- at Liverpool or Aberdeen Airport, with specific Sunday extended curfews;
- at Stockholm, with specific curfews extended on Saturdays, Sundays and holidays.

## 2.7. Night hours (survey item 5b)

Night hours are usually from 23:00 to 06:00 AM. These hours serve to determine the various limits. They may also include an evening time notion. Yet, this period may vary highly from one country to another, such discrepancies being based either on national or local habits:

- 20:00 - 04:00 at Bale-Mulhouse,
- 20:00 - 06:00 at Nuremberg ,
- 18:00 - 08:00 at Rotterdam, but
- 00:00 - 06:00 at Lisbon.

It may also be based on the specificities of the based airline network. For example, Air France has an extended African network which requires early landing in Paris. Similarly, Lufthansa has an extended Asian network which requires also some adaptation. For small to medium size airports, activities very often are limited to short to medium haul operations and end around 20:00/21:00

## 2.8. Preferential runways (survey item 6)

When airports have several runways, they usually have a preferential runway policy (except for CDG). This is the most common noise management measure.

During night, when traffic is lower, a preferential runway may also be used in order to reduce noise impact without restricting traffic demand. Take off as well as landings can be modified.

Each airport reacts to its specific noise problematic and may adapt the national/regional law in order to reduce it. The history of each place determines also the current situation.

In some cases, a new runway has been built due to a noise abatement concern rather than due to physical saturation. For example, Nice airport created a new south runway in order to contain its neighbours' exposure to noise while enabling the growth of its operations. Its new south runway is indeed located nearer to the sea and consequently further away from the populated areas.

Paris-CDG, so far, has had no preferential runways in order to reduce noise exposure. In fact, as a trade-off with neighbouring population, it was agreed that the formerly planned fifth runway would be dropped in order to limit potential traffic. Yet, in the light of Amsterdam experience, this decision is being reviewed by some French air transport stakeholders on the basis that the construction of a new runway which could be declared as a preferential runway would enable noise limitation by decreasing the number of exposed population without restricting traffic.

## 2.9. Noise abatement flight procedures (survey item 7)

In order to reduce noise in housing areas, flight procedures have often been modified and adapted to noise. Usually those procedures are defined for take off and landing. Noise abatement flight procedures have been adopted by almost all important airports in Europe.

## 2.10. Noise Zones definition (survey item 8)

Noise levels (interval) define areas with specific requirements or bans and eventually areas of insulation policy. It is an administrative tool to manage land use and define insulation measures around airports. A map is then drawn from this zones definition.

Most European airports have noise zones or contours. But, the comparison from one country to another is difficult, as long as noise indices will also differ, as well as accompanying measures: construction limitations, insulations, destruction.

For example, policies can be noted at Amsterdam, Frankfurt and Paris policy, but they all differ in terms of standards to be applied.

A noise contour can also be used, like in Amsterdam, to define a noise limit policy. The noise volume of each subpart of the contour must be respected noting that an over-exposure to noise in one part of the contour cannot be compensated by an under-exposure to noise in another area.

## 2.11. Population concerned in each zone (survey item 8B)

This item is not a noise limit (except for Amsterdam which has set their noise contours on the basis of a limit to the volume of affected population). Yet, when available, it gives an order of magnitude of the problems faced when aiming at evaluating noise limits impact. It may differ highly from one airport to another depending on the local population density and on the zoning computation. Yet, it provides the declared perception by each individual state of their respective airport annoyance, and the environmental measures these states may be willing to take.

For equivalent airports, it mostly ranges from 10 000 for Nice, located by the sea or 10 000 houses for Schiphol, to 200 000 for Paris-CDG, or 300 000 to 600 000 for Heathrow (depending on the noise level adopted).

## 2.12. Penalties in case of overrun (survey item 9)

There are two ways to motivate airlines to respect noise limit: through collaborative programs or through penalties in case of overrun.

The law may provide for fines in case of infringements. When an aircraft does not respect the rules, the monitoring system may identify it and a fine bill can be sent directly to the airline concerned.

English airports, Frankfurt, Italian and French airports have created penalties in case of overrun.

## 2.13. Noise Surcharge (survey item 10)

A special noise surcharge may be created in order to reimburse noise abatement related costs. It may have an influence on airline aircraft type allocation within their route planning; it may also incite airlines to modernise their fleet. In some cases, this surcharge is used for financing insulation and it may be removed when it is not justified anymore (which is the case at Rotterdam, where the additional noise surcharge imposed by the Government at a certain time has been no longer in force as soon as the accompanying insulation programme has been achieved). It differs from one country to another, and sometimes, from one airport to another one within a same country.

At some airports, like Brussels, Frankfurt, London, landing charges are also based on noise category.

At French airports, the noise surcharge has been recently integrated into the general policy addressing pollution activities and is perceived by the Ministry of Environment (ADEME).

## 2.14. Insulation financing (survey item 11)

When having defined noise zones, a country may decide to insulate some housing, and in this case, finance the noise insulation expenses incurred by the people concerned. This policy may be limited on time depending on whether the airport development happened before or after housing implantation.

For example, Geneva airport has financed insulation for amount of 6 million Euros and a noise surcharge is added to the landing charge based on aircraft types.

In Nice, 3.5 million Euros have been allocated between 1996 and 2001.

Between 1995 and 1999, for Paris CDG and Orly together, 2 683 houses and 3 663 buildings have been compensated for an amount of 41.6 Million Euros.

## 2.15. Noise monitoring system and control (survey item 12)

More and more airports have been installing and gradually developing noise monitoring systems. The number of stations and their respective location may vary significantly from one airport to another.

Such a measure underlines airport implication to this policy.

As of today, almost all large European airports have installed or are currently installing a noise monitoring system, but the use and purpose of these NMS are not the same from one airport to another:

- Most of the time, these systems are used for information purposes only. The airport authority or another authority (such as ACNUSA in France) may also be in charge of disseminating information to the public.
- Yet, at Frankfurt, the data obtained from this system are used for computing landing charges (partly), forecasting noise data, testing and monitoring flight procedures, dealing with complaints from residents.

## 2.16. Legal Base of noise control (survey item 13)

Although out of the scope of this study, it was interesting, whenever available, to mention the legal basis on which the noise limits may refer to in various countries, independently from more recent EU Directives. This indicates the degree of priority given by national governments to environmental issues. It also underlines the difficulties that Member States may have when implementing harmonised measures when it may affect existing laws.

A thorough analysis of these Laws would be a lengthy exercise; yet it is interesting to note how some States refer to general environmental Laws and others refer to specific aviation laws:

- French 1985 Law on Urban Planning
- Belgium Environmental Law,
- Italian 1997 Decrees by Environment Minister,
- Switzerland 1986 Ordinance on Noise abatements for road and rail, with no mention to aircraft noise), on the one hand, and
- Netherlands 1995 Aviation Law, or Sweden CAA Environmental Code on the other hand.

# 3. NOISE LEVEL LIMITS

Because the analysis has underlined the existence of national policies with a common national approach and/or methodology and/or indicators, the following examples have been sorted by country. We have also separated the analysis of noise level limits by types (i.e. per movement or per period of time).

The noise limits that are considered in this analysis include the noise volume limitations as based on a defined Quota Count (QC) system. The Quota Count (QC) system was first introduced by the UK at its London Heathrow, Gatwick and Stansted airports, as soon as 1993 and has been gradually followed by an increasing number of other airports.

The QC system relies on a count of aircraft movements (arrivals and departures) against a noise quota, according to aircraft classifications. It is supposed to reflect the contribution of an individual aircraft to the total noise impact around an airport, e.g. a QC/2 aircraft is deemed to have twice the impact of a QC/1 aircraft.

The UK original QC system is based on aircraft certificated noise levels – referred to as Effective Perceived Noise Levels or EPNL, and is common for all UK airports. Arrival EPNLs are adjusted downwards by 9 EPNdB in order to achieve QC classifications comparable with those for departures. 3 EPNdB wide range bands have been defined to limit the number of QC categories, as follows:

| Noise Classification | Quota Count (referred to as QC or CR*)<br>*CR stands for Cuota de Ruido (Spain) |
|---|---|
| • Less than 90 EPNdB: | 0.5 |
| • 90 - 92.9 EPNdB: | 1 |
| • 93 - 95.9 EPNdB: | 2 |
| • 96 - 98.9 EPNdB: | 4 |
| • 99 - 101.9 EPNdB: | 8 |
| • Greater than 101.9 EPNdB: | 16 |

As the QC system gives a QC rating to each aircraft type according to how much noise it makes, the QC ratings can be used as noise level limits per movement. On the other hand, as discussed in section 3.5, the QC system can also used to set a global noise level limit over a time period.

## 3.1. Noise Level Limits per movement during day and night

### 3.1.1. Austria

***SALZBURG***

Noise Level Limits at Salzburg, Austria, are computed according to the following formula:

Maximum Allowed Noise Level (dB(A))* = 288 + 29.9*log(Takeoff Weight/25000) (in kilograms).

The sum of ICAO Annex 16 noise levels for Flyover, Sideline, and Approach for the Operational Takeoff weight is compared to the limit from the above formula to show compliance.

The noise limits are expressed in dB(A) $L_{A,max}$. These limits have been set to have a monthly survey of the loudest aircraft operating into Salzburg. A survey is conducted on a monthly basis, the global results of which being disseminated, and all the airlines having exceeded the limits being informed by the airport, but without any levied penalties. This survey is aimed at providing information to airlines in order to urge them to reduce noise by modifying their landing and take-off procedures.

The comparison of the sums for flyover, sideline and approach belonging to ICAO Chapter 3 Annex 16 is still in effect. The purpose of the new limits at the check points is to try to get the airlines more sensitive to noise abatement.

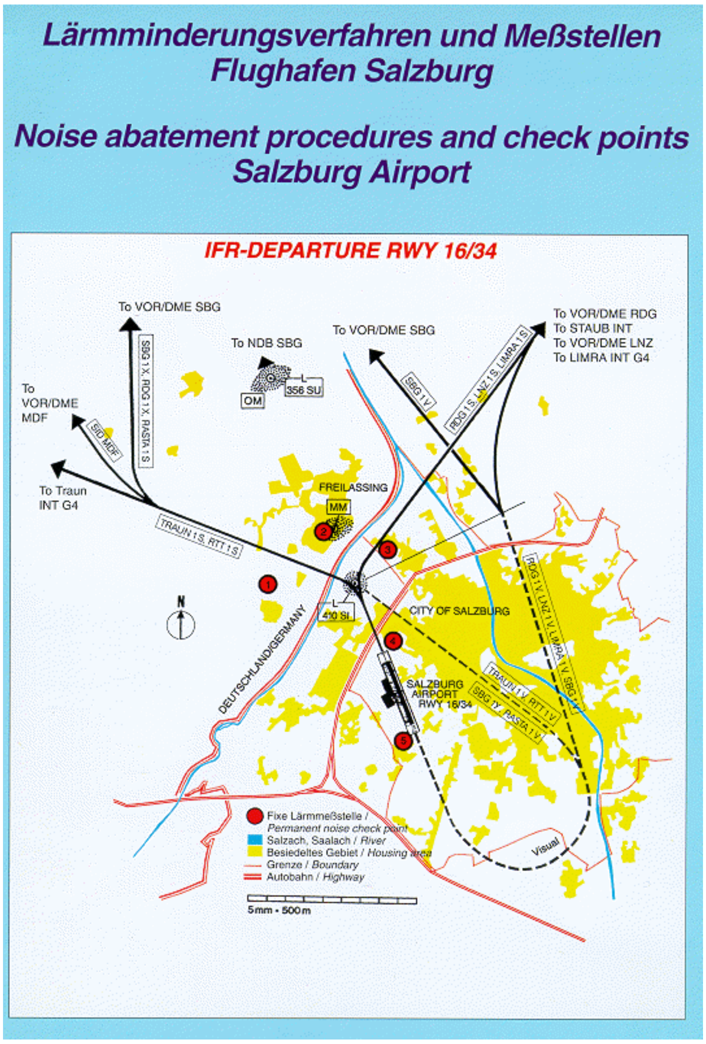
The airport has installed a noise and flight track monitoring system with five measuring points, of which two are located on German territory. The system, which is the first fixed one to be installed in Austria, is correlated by software with the airport's radar.

The following limits ($L_{amax}$) are defined for at each monitor location:

Maximum Allowed Noise Level (DBA)*

| | **Check Pt. NO. 1** | | **Check Pt. NO. 2** | | **Check Pt. NO. 3** | | **Check Pt. NO.4** | | **Check Pt. NO. 5** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Annex 16 Chapter** | **T/O** | **LDG** | **T/O** | **LDG** | **T/O** | **LDG** | **T/O** | **LDG** | **T/O** | **LDG** |
| 3 | 83 | - | 87 | 84 | 84 | - | 95 | 92 | 96 | 95 |

The map below provided by the airport indicates the locations of its five noise monitoring stations.



**At Night:**

Curfews exist:

- Between **21:00 and 22:00,** local time, **departures** are permitted only for aircraft whose noise level at departure measured at noise-measuring **station 4** is not exceeding **98 dB SEL**, but **all aircraft landings are allowed**.
- Between **22:00 and 23:00,** local time, departures are permitted only for delayed commercial flights
- Between **22:00 and 23:00,** local time, **landings** are permitted only for flights performed by aircraft whose noise level at landing measured at noise-measuring **station 4** is not exceeding **84 dB SEL**.
- Between **06:00 and 07:00,** local time, **departures** are permitted only for commercial flights performed by aircraft whose noise level at noise-measuring **station 4** is not exceeding **98 dB SEL**.
- Between **06:00 and 07:00**, local time, landings are permitted for all aircraft.

### 3.1.2. Belgium

***BRUSSELS***

In practice, **no noise limits are currently in use** at Brussels Airport, and it has been so since 19 July 2002.

Before 19 July 2002, the following noise levels limits were in use. The indicator used to define the noise level limit per *event*, referred to as **LEVT**, has been defined as the **SEL value** calculated for the *event* (**EVT**) under consideration (an event being the overflight of an aeroplane that produces more than 70 dB(A) measured in $L_{Aeq,\ 1s}$).

Regardless of weather conditions, these limit values were as follows:

- Location 0: 80 LEVT in dB(A) during day, i.e. between 0700 and 2300,
- Location 1: 90 LEVT in dB(A) during day, i.e. between 0700 and 2300
- Location 2: 100 LEVT in dB(A) during day, i.e. between 0700 and 2300.

At night, i.e. between 23:00 and 07:00, those limits are lowered by 10dB(A):

It was also planned that, at the end of an adaptation period, the Government may lower the limits per overflight.

On 19 July 2002, the Flemish Government and the Government of the Brussels Region made a common proposal for harmonised noise limits, **expressed in $L_{Aeq,\ 1sec}$** instead of SEL. As a consequence, the application of the above noise limits has been frozen since then (though legally they do still exist). These new noise levels expressed in $L_{Aeq,\ 1sec}$ were defined with respect to the existing policy of flight procedures concentration. However, as a flight dispersion plan is currently being prepared, a new common proposal by the Flemisch and Brussels Governments may possibly come.

In addition, a quota count (QC) system is effective between 23:00 and 05:59. Take-off and landing during this period is forbidden for aircraft with a QC score higher than 12.

The QC score per movement is calculated as follows (for movements with aircraft certified according to the Standards of ICAO Annex 16, Chapter 3 or 5):

QC = 10 ^ ((G-85)/10) with "G" being:

- for the purpose of *landing*: ***the certified approach noise level*** in EPNdB of the aircraft at its maximum certified landing weight, measured at the ICAO Annex 16 approach certification point, minus 9 EPNdB;

- for the purpose of *take-off*: ***half the sum of the certified flyover and the sideline noise levels*** in EPNdB as measured at the certification points specified in ICAO Annex 16 during the noise certification of the aircraft at its maximum certified take off weight.

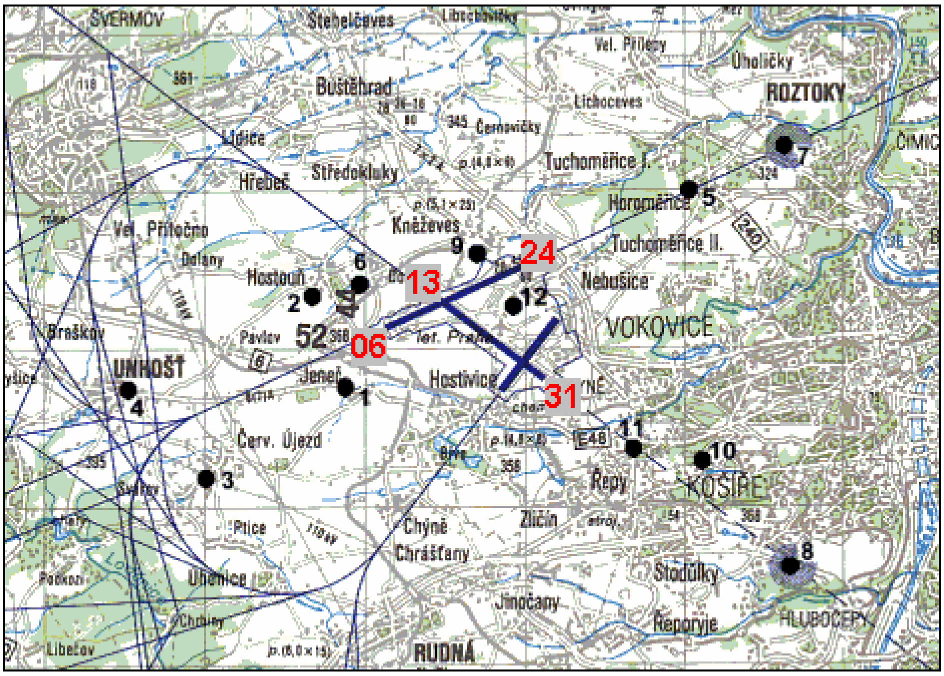
### 3.1.3. Czech republic

***PRAGUE***

Aircraft noise emissions are continuously measured, analyzed and assessed by means of twelve fixed and one mobile monitoring stations and a central evaluating station (see map below). The Maximum Noise Level LAmax and the Equivalent Noise Level LAeq are monitored on each of these stations.

The noise level limits at monitors are determined as follows:

- **85 dB(A) LAmax** from 05:00 to 21:00 (04:00-20:00);
- **75 dB(A) LAmax** from 21:00 to 05:00 (20:00-04:00).




**Ruzyne Airport runway system and location of noise monitoring stations**

### 3.1.4. Italy

***VENICE***

In the Boeing database, Venice Airport has indicated that they do have a noise limit, but without any more detail. No further explanation was provided when we surveyed directly the airport.

### 3.1.5. Sweden

***STOCKHOLM (BMA)***

The noise emission for transport category* (scheduled flights) must not exceed **86 EPNdB**.

*Transport category aircraft include:

- All jets with 10 or more seats or greater than 12 500 lb Maximum Take-Off Weight.
- All propeller driven airplanes with 19 or more seats or greater than 19 000 lbs Maximum Take-Off Weight.

The noise emission for jet aircraft (scheduled flights) with more than 60 seats and general aviation aircraft must not exceed **89 EPNdB**, being as the arithmetic mean value of the three points of measurement in accordance with Chapters 3 and 5.

### 3.1.6. United Kingdom

***GLASGOW***

All aircraft using the airport shall after take-off or interrupted landing manoeuvre, be operated in such a way that they would not generate at the relevant noise monitoring points more than

- **97 dB(A) $L_{Amax}$** (110 PNdB) by day (between 06:00 and 23:30)
- **89 dB(A) $L_{Amax}$** (102 PNdB) by night (between 23:30 and 06:00)

The measured noise reading for the event will be taken as the highest recorded at any single noise monitoring terminal. The following additional surcharges are levied on those aircraft which exceed the noise thresholds:

- by up to 3 dB(A), 250 GBP,
- by 3 dB(A) and more, 500 GBP.

***JERSEY***

Every jet aircraft using this airport must, after take-off, be operated in such a way that it does not generate more than

- **110 PNdB** by day (day is defined as 07:30-22:30 local time for this purpose), or
- **102 PNdB** by night.

From what we understood, this limit per aircraft is theoretical: calculated but not measured because there are no monitoring stations.

### *LEEDS*

The noise level policy at Leeds International Airport is named "Target Noise Levels" (TNL).

All aircraft (excluding supersonic and military jet aircraft) must be operated in such a way that, at the relevant monitoring point, they do not generate a noise level exceeding:

**By day:**

- **85 dB(A) $L_{Amax}$** after take-off from Runway 32,
- **92 dB(A) $L_{Amax}$** after take-off from Runway 14,
- **85 dB(A) $L_{Amax}$** on approach to Runway 32.

**At night:**

- **77 dB(A) $L_{Amax}$** after take-off from Runway 32,
- **84 dB(A) $L_{Amax}$** after take-off from Runway 14,
- **79 dB(A) $L_{Amax}$** on approach to Runway 32.

These noise limits are monitored: the airport installed a new noise and track keeping system in January 2000, replacing their previous Aircraft Flight Tracking and Noise System which had been installed in November 1995.

In addition, in line with UK NOTAM S3/2000:

- No departures in the night-time period (23:00 to 07:00) shall take place by aircraft with quota counts of **1, 2, 4, 8 and 16 on takeoff**.
- No landings in the night-time period shall take place by aircraft with quota counts of **2, 4, 8 and 16 on landing**.

Leeds appears as having adopted the most stringent noise restriction within the UK.

### *LONDON (HEATHROW, GATWICK AND STANSTED)*

Departure noise limits have applied since 1959 at Heathrow, 1986 at Gatwick, and 1993 at Stansted. The original limits were set in PNdB, which was superseded by the use of dB(A) $L_{A,\ max}$ in 1993, but the noise limits remained effectively unchanged until the Government's decision of 18 December 2000 following the Review which was initiated in 1993. The limits were reduced by 3 dB(A) by day and 2 dB(A) by night, and a shoulder period when the previous night limit applies was implemented in February/March 2001.

The main objectives for noise limits are

- **to deter** excessively noisy movements, by detecting and penalising those which exceed the limits, and
- **to encourage** the use of quieter aircraft and best operating practices.

The UK Department of Environment, Transportation and the Regions (DETR) have announced the decision to lower noise monitor limits around London area airports. The table below reproduces the current limits and their effective date:

| Time | Take-off limiut | Effective Date |
|---|---|---|
| **07:00 - 23:00** | **94 dB(A)** | 25 Feb 2001 |
| 23:00 - 23:30 | 89 dB(A) | 25 March 2001 |
| **23:30 - 06:00** | **87 dB(A)** | |
| 06:00 – 07:00 | 89 dB(A) | |

There are penalties associated with these limits: 500 £ for an overrun of 3 dB and 1 000 £ otherwise.

Theses values are Baseline Noise Limit and they must be compared to Noise Limit at Monitor (see table below):

*Noise Limit at the Monitor =“Calibration Allowance” + “Baseline Noise Limit” + “Limit Adjustment”*

| HEATHROW | | | | | Day | | Shoulder | | Night | |
|---|---|---|---|---|---|---|---|---|---|---|
| Rwy | NTK System Refer | Distance From Brake Release km | Limit Adjust. dBA | Calib. Allow | Baseline Noise Limit | Noise Limit at Monitor | Baseline Noise Limit | Noise Limit at Monitor | Baseline Noise Limit | Noise Limit at Monitor |
| 27L/R | 6 | 6.58 | -0.3 | 0.7 | 94.0 | 94.4 | 89.0 | 89.4 | 87.0 | 87.4 |
| | 19 | 6.25 | 2.3 | 0.7 | 94.0 | 97.0 | 89.0 | 92.0 | 87.0 | 90.0 |
| | 18 | 6.00 | 4.8 | 0.7 | 94.0 | 99.5 | 89.0 | 94.5 | 87.0 | 92.5 |
| | 17 | 6.58 | -0.3 | 0.7 | 94.0 | 94.4 | 89.0 | 89.4 | 87.0 | 87.4 |
| | 15 | 6.83 | -0.6 | 0.7 | 94.0 | 94.1 | 89.0 | 89.1 | 87.0 | 87.1 |
| | 14 | 7.20 | -1.0 | 0.7 | 94.0 | 93.7 | 89.0 | 88.7 | 87.0 | 86.7 |
| 09R | 11 | 6.40 | 0.9 | 0.7 | 94.0 | 95.6 | 89.0 | 90.6 | 87.0 | 88.6 |
| | 12 | 6.50 | -0.1 | 0.7 | 94.0 | 94.6 | 89.0 | 89.6 | 87.0 | 87.6 |
| | 10 | 6.37 | 1.2 | 0.7 | 94.0 | 95.9 | 89.0 | 90.9 | 87.0 | 88.9 |
| | 13 | 6.60 | -0.3 | 0.7 | 94.0 | 94.4 | 89.0 | 89.4 | 87.0 | 87.4 |

| GATWICK | | | | | Day | | Shoulder | | Night | |
|---|---|---|---|---|---|---|---|---|---|---|
| Rwy | Site | Distance From Brake Release km | Limit Adjust. dBA | Calib. Allow | Baseline Noise Limit | Noise Limit at Monitor | Baseline Noise Limit | Noise Limit at Monitor | Baseline Noise Limit | Noise Limit at Monitor |
| 26L | 1 | 6.22 | 5.0 | 0.7 | 94.0 | 99.7 | 89.0 | 94.7 | 87.0 | 92.7 |
| | 3 | 6.87 | 1.9 | 0.7 | 94.0 | 96.6 | 89.0 | 91.6 | 87.0 | 89.6 |
| | 5 | 6.69 | 1.9 | 0.7 | 94.0 | 96.6 | 89.0 | 91.6 | 87.0 | 89.6 |
| 08R | 4 | 6.70 | 0.0 | 0.7 | 94.0 | 94.7 | 89.0 | 89.7 | 87.0 | 87.7 |
| | 6 | 6.80 | -0.2 | 0.7 | 94.0 | 94.5 | 89.0 | 89.5 | 87.0 | 87.5 |

| STANSTED | | | | | Day | | Shoulder | | Night | |
|---|---|---|---|---|---|---|---|---|---|---|
| Rwy | Site | Distance From Brake Release km | Limit Adjust. dBA | Calib. Allow | Baseline Noise Limit | Noise Limit at Monitor | Baseline Noise Limit | Noise Limit at Monitor | Baseline Noise Limit | Noise Limit at Monitor |
| 05 | 1 | 7.12 | -0.8 | 0.7 | 94.0 | 93.9 | 89.0 | 88.9 | 87.0 | 86.9 |
| | 7 | 6.32 | 2.1 | 0.7 | 94.0 | 96.8 | 89.0 | 91.8 | 87.0 | 89.8 |
| | 8 | 6.50 | -0.6 | 0.7 | 94.0 | 94.1 | 89.0 | 89.1 | 87.0 | 87.1 |
| | 9 | 6.62 | -0.8 | 0.7 | 94.0 | 93.9 | 89.0 | 88.9 | 87.0 | 86.9 |
| 23 | 3 | 6.62 | -1.0 | 0.7 | 94.0 | 93.7 | 89.0 | 88.7 | 87.0 | 86.7 |
| | 4 | 6.50 | -1.4 | 0.7 | 94.0 | 93.3 | 89.0 | 88.3 | 87.0 | 86.3 |
| | 5 | 6.89 | -1.4 | 0.7 | 94.0 | 93.3 | 89.0 | 88.3 | 87.0 | 86.3 |
| | 6 | 6.55 | -1.1 | 0.7 | 94.0 | 93.6 | 89.0 | 88.6 | 87.0 | 86.6 |

Supplements to the United Kingdom AIP, London Heathrow, Gatwick and Stansted airports noise restrictions notice 2003 came into operation on 30 March 2003.

Any aircraft which has a quota count of **8 or 16** may not:

- be scheduled to take-off or land during the night period (23:00 – 07:00);
- take-off in the night period, except in the period 23:00 to 23:30 in circumstances where :
    - o it was scheduled for take off prior to 23 hours;
    - o the take-off was delayed for reasons beyond the control of the aircraft operator; and
    - o the airport authority has not given notice to the aircraft operator precluding take-off.

## *MANCHESTER*

The noise level is monitored at 3.5 nautical miles from start of roll.

Initially these are set at:

- **92 dB(A) $L_{Amax}$**(105 PNdB) **daytime**
- **87 dB(A) $L_{Amax}$** (100 PNdB) **at night**.

Noise is measured in dB(A), adding 13 dB when expressed in PNdB.

Noise levels are listed by aircraft type in a monthly noise bulletin.

This system is reviewed annually.

A minimum penalty of 500 £, for the first dB by which the noise limits are exceeded, is applied, and 150 pounds for each full PNdB by which the limits are exceeded.

## 3.2. Noise Level Limits per movement at night only

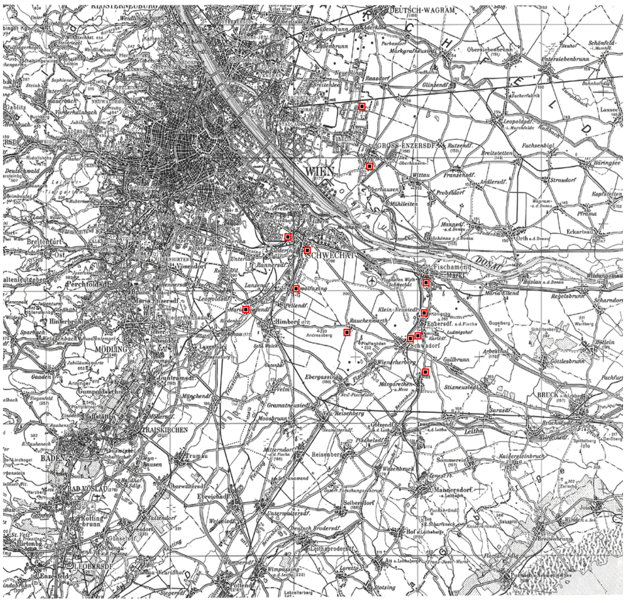
### 3.2.1. Austria

***VIENNA***

During night period, aircraft must fulfil the following requirement that the sum of the levels of the three noise certification points (approach, flyover, and sideline) must not exceed the limit calculated according to the following formula:

- LEPN = 288 for MTOW < 25,000 kg,
- LEPN = 288 +29.9*log(MTOGW/25,000) for MTOW in [25,000; 317,500] kg,
- LEPN = 321 for MTOW > 317,500 kg.

The airport has 13 installed noise monitoring terminals, complemented by two additional mobile stations.



A new federal law for noise level restrictions is being contemplated with possible adoption within the coming next two years.

### 3.2.2. Denmark

***COPENHAGEN***

At Copenhagen, noise limits only concern night period, with more and more stringent limits being progressively implemented. The last step is scheduled for **1st January 2005**.

The limits are not the same depending on whether they control **departures and arrivals** noise, or **taxiing** noise

For **departures and arrival,** the limits are based on the maximum A-weighted sound pressure level (**$L_{Amax}$**) at six measuring stations (NMT 1, 5, 6, 7, 8 and 9) located in the surrounding housing sectors in the period **23:00-06:00**. However, delayed or early arriving aircraft with departure or arrival normally scheduled in the period 06:00-23:00 are accepted (tolerated) as an exception.

Today, this limit is **85 dB(A)**. As of 2005, it will be **lowered by 5 dB(A) to 80dB(A)**.

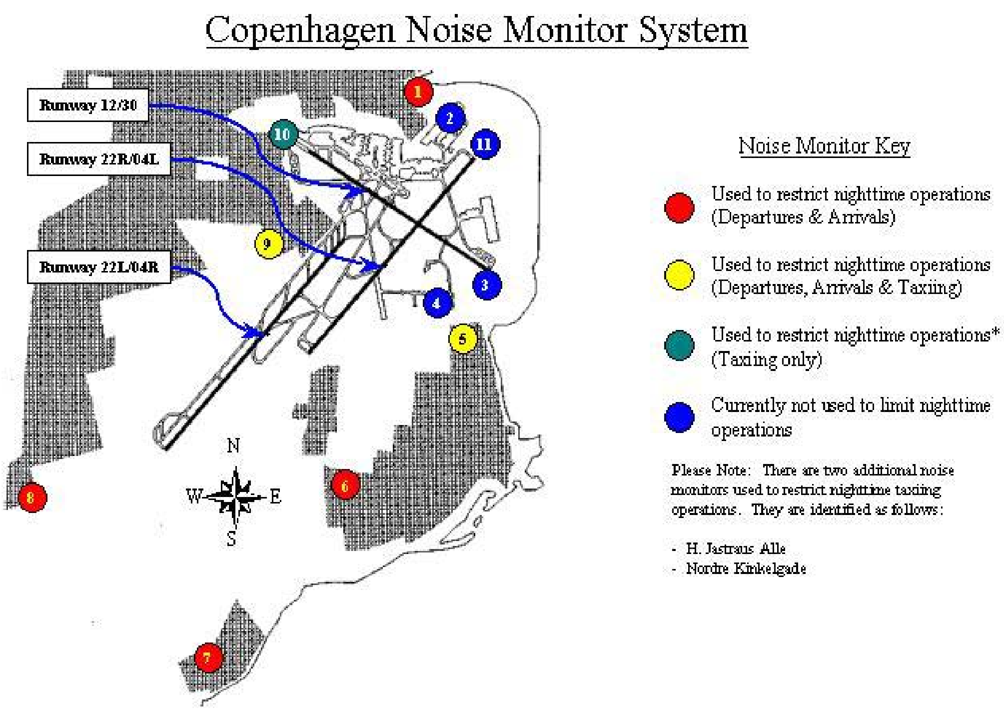
For taxiing limitations, there is a set of limitations at some of the above mentioned stations complemented by some additional stations more relevant to this noise type. It is also based on the maximum A-weighted sound pressure level applicable on the same period, **23:00-06:00.**

Those limits are the following, noting that they will be lowered by varying deltas by 2005.

| **Position** | **Noise limit at night** | |
|---|---|---|
| | **Until 2005** | **After 2005** |
| • 1-H. Jastraus Alle 4 meters over the ground, | **91dB(A)** | **79dB(A)** |
| • 2-Skyttehoj (NMT 10), 10 meters over the ground | **78dB(A)** | **74dB(A)** |
| • 3-Askov Alle(NMT 9), 5 meters over the ground | **74dB(A)** | **70dB(A)** |
| • 4-Nordre Kinkelgade, 4 meters over the ground | **86dB(A)** | **72dB(A)** |
| • 5-Raybakkeve (NMT 5), 5 meters over the ground | **70dB(A)** | **70dB(A)** |

The noise limit reduction is more important for higher levels than for lower ones, e.g. no reduction is required for monitor 5 with a 70 dB(A) current limit, while the objective is a 12-dB(A) reduction for monitor 1 with a 91 dB(A)current limit. It can also be observed than none of the future noise limit levels will be lower than 70dB(A).

The geographical distribution of these stations is reproduced on the map below.



### 3.2.3. Norway

***OSLO***

Between 23:00 and 05:00, the noise level limit at night and monitored from the airport 11 fixed stations are the following:

- **78 dB(A) Lamax** outside aircraft noise zone II
- aircraft with certificated noise levels exceeding **88 EPNdB** at departure are not permitted.

### 3.2.4. Spain

***MADRID***

As already stated, Spain has adopted a QC kind of classification and uses it as a tool for limiting the global noise volume (see section 3.4).

For information, based on scores referred to as ***CR*** (Cuota de Ruido), the following limitations are enforced:

- **An immediate ban for the two noisiest aircraft categories:** Departure and arrival operations classified as CR-8 and CR-16 are forbidden between 00:00 and 06:00.
- **A progressive ban for the following noisiest category**: Night flight permission is not given for aircraft of CR-4 category from 00:00 to 06:00, unless the operator had scheduled the flight during the last 12 months before January 25th in this hour and on a periodical way.
- From April 1, 2002, departure and arrival operations classified as CR-4 are not allowed from 00:00 to 06:00.

### 3.2.5. United Kingdom

***BIRMINGHAM***

Aircraft should not produce more then **87dB(A) $L_{A,max}$.**

As of October 1997, when the revised **Night Flying Policy** was introduced, a revised night noise violation level was applied. The violation level was reduced by 2dB from 89 dB(A) to 87dB(A).

Monitoring is reported on a quarterly basis.

There are three noise monitors located along the extended centreline of runway 15/33 in each direction; the centre monitors are at a distance of 6.5 kilometres from 'start of roll'.

A noise violation occurs when the noise level of 87 dB (A) $L_{Amax}$ (or, approximately. 102 EPNdB) is exceeded at the centre noise monitors (positioned at 6.5 km from the start of roll) during the period 23:30-06:00. In such an event, a surcharge equivalent to a runway charge is levied against the operator.

### *EAST MIDLANDS*

Aircraft departing between 23:00 and 07:00, local time, are required to operate within a maximum noise limit (measured at a distance of 6.5 km from start of roll).

The maximum noise limits are defined as follows, based on quota counts (QC) aircraft categories as defined further below:

- QC of 8 or 16 are not allowed on departure,
- QC of 4 and a MTOW greater than 100 tons (or a certified fly-over departure noise greater than 97 EPNdB) are limited to **94 dB(A)**,
- QC of 4 and a MTOW less than 100 tons are limited to **90dB(A)** on departure**,** QC of 2 and a MTOW greater than 100 tons are limited to **85dB(A)** on departure and QC of 0.5 or 1 are not limited on departure.

### *EDIMBURG*

It is combined with a curfew: aircraft non-compliant with Chapter 3 standards are not allowed to operate at night; aircraft compliant with Chapter 3 standards are allowed to operate at night without any restriction.

### *LIVERPOOL*

This airport operates and manages a Night Noise Quota System, which is based on the CAA Supplement to the UK AIP, pertaining to the Airport Noise Restrictions Notice for London Heathrow, London Gatwick and London Stansted.

The night quota period is between 23:00 and 07:00 (local time) and the operational restrictions are as follows:

- From 23:00 to 23:30, aircraft with QC of **8** and **16** must not be scheduled to take-off or land – delayed departing and arriving aircraft are allowed to take-off/land;
- From 23:30 to 06:00, aircraft with QC of **8** and **16** must not take-off or be scheduled to land – only delayed arriving aircraft are allowed to land;
- From 06:00 to 07:00, aircraft with QC of **16** must not take-off or be scheduled to land – there is no restriction anymore for aircraft with QC 8, while only non scheduled arriving aircraft with QC 16 are allowed to land.

## 3.3. Noise level limits per movement - Summary

The various noise limits detailed above are reproduced in the synthetic table below.

| | Annual | Noise Level Limits per movements | |
|---|---|---|---|
| **AIRPORT & Country** | **Movts** | **Day values** | **Night values** |
| Salzburg WA Mozart ***(Austria)*** | 57 405 | Maximum Allowed Noise Level (dBA)* :<br>**288 + 29.9*log(MTOW/25000)** (in kg).<br>**83 dB(A)**, check point 1<br>**87/84 dB(A)**,arrival/departures check point 2<br>**84 dB(A)**, check point 3,<br>**95/92 dB(A)** check point 4<br>**96/95 dB(A)** check point 5 | at noise-measuring **station 4** (also linked with curfew):<br>**98 dB(A) SEL** maxi for 21:00 to 22:00 departures<br>**84 dB(A) SEL** maxi for 22:00 to 23:00 landings<br>**98 dB(A) SEL** maxi for 06:00 to 07:00 departures |
| Vienna ***(Austria)*** | 206 279 | | Sum of the levels of the three noise certification points (approach, takeoff, sideline) formulas:<br>LEPN **= 288** for MTOW < 25,000 kg,<br>LEPN **= 288 +29.9*log(MTOGW/25,000)** for MTOW in [25,000; 317,500] kg,<br>LEPN **= 321** for MTOW > 317,500 kg. |
| Brussels National - Zaventem ***(Belgium)*** | 256 876 | **No noise limit in practise since July 2002**<br>Theoretically, it is:<br>**80 dB SEL** (Location 0)<br>**90 dB SEL** (Location 1)<br>**100 dB SEL** (Location 2) | Theoretically, it is:<br>**Day limits minus 10dB** |
| Copenhagen - Kastrup ***(Denmark)*** | 266 108 | | **85 dB(A) LAmax** during 23:00-06:00 |
| Milan - Malpensa ***(Italy)*** | 214 886 | new system to come | |
| Rome - Fiumicino ***(Italy)*** | 282 820 | new system to come | |
| Venice Marco Polo ***(Italy)*** | 65 849 | *Apparently existing but not detailed by the airport.* | |
| Oslo - Gardermoen ***(Norway)*** | 180 873 | | **78 dBA LAmax** outside aircraft noise zone II during 23:00 and 05:00. In the same period, operations with aircraft with **noise certification exceeding 88 EPNdB** at departure are not permitted. |
| Prague - Ruzynê ***(Republic Czech)*** | 103 778 | **85 dB(A) LAmax** from 0500 to 2100 (0400-2000) | ***Day limits minus 10dB*** *during 21:00-04:00* |
| Stockholm-Bromma ***(Sweden)*** | 58 328 | **86 EPNdB**. | |
| Birmingham ***(UK)*** | 115 741 | | **87 LAmax dB(A)** |
| East Midlands ***(UK)*** | 79 143 | | **85 to 94dB(A)** depending on aircraft MTOW during 23:00-06:00 |
| Glasgow ***(UK)*** | 105 197 | **97 dB(A)** *(110 EPNdB)* | **89 dB(A) LAmax, 102 PNdB** between 23:30-06:00 |
| Jersey ***(UK)*** | 79 751 | **110 PNdB** | **102 PNdB** between 22:30-07:30 |
| Leeds/Bradford International ***(UK)*** | 67 847 | Target Noise Levels(TNL)<br>**85 dB(A) LAmax** after take-off from Runway 32<br>**92 dB(A) LAmax** after take-off from Runway 14<br>**85 dB(A) LAmax** on approach to Runway 32 | Target Noise Levels(TNL)<br>**77 dB(A) LAmax** after take-off from Runway 32<br>**84 dB(A) LAmax** after take-off from Runway 14<br>**79 dB(A) LAmax** on approach to Runway 32 |
| London - Gatwick ***(UK)*** | 242 380 | | **89 dB(A) LAmax** 23:00-23:30 and 06:00-07:00 |
| London - Heathrow ***(UK)*** | 466 554 | **94 dB(A) Lamax** | **87 dB(A) LAmax** during 23:30-06:00 |
| London - Stansted ***(UK)*** | 170 774 | | |
| Manchester ***(UK)*** | 192 498 | **92 dB(A) LAmax, 105 PNdB**. | **87 dB(A) LAmax, 100 PNdB** during 23:30-07:00 |

**Noise Level Limits per movement**

## 3.4. Noise Volume Limit over a time period

Most advanced countries in this field seem to have complemented noise level limits per movement with a Noise Volume limit over a time period.

This approach is quite new or in progress (since 2003 at Paris CDG for instance), although it has been experienced by the United Kingdom since 1993.

Noise level limits specific at night are usually in use in the UK as well as quota counts.

### 3.4.1. Belgium

***BRUSSELS***

Noise limits are expressed in aircraft noise specific LAeq level (referred to as LSP aircraft) over separate day and night periods.

The limits have been set for zones and regardless of weather conditions, they are as follows:

- Location 0: **55** LSP (day), i.e. between 07:00 and 23:00,
- Location 1: **60** LSP (day), i.e. between 07:00 and 23:00,
- Location 2: **65** LSP (day), i.e. between 07:00 and 23:00.

At the end of an adaptation period, the Government may lower the limits per period.

At night, i.e. between 23:00 and 07:00, those limits are lowered by 10dB(A).

In addition, a noise quota count system is effective between 23:00 and 05:59 (refer to section 3.1 for details of QC score allocation) and the following global limitations have been defined, with a decrease planned over the years:

- **68 500** for summer 2001,
- **41 500** for winter 2001/02,
- **55 500** for summer 2002,
- **36 500** for winter 2002/03, and
- **48 000** for summer 2003.

### 3.4.2. Denmark

***COPENHAGEN***

As a consequence of an environmental approval given in April 1997, a noise quota is now in force and complements the noise level limits described above.

Until **1$^{st}$ January 2005**, the **equivalent noise exposure** ($L_{DEN}$) from aircraft operations and taxi activities may not exceed the noise exposure from 1996 with a **tolerance of 1 dB**. From 2005 onwards the noise exposure from aircraft operations and taxi activities may not exceed the noise exposure predicted for the year 2005. This measure involves a reduction of noise exposure of about **5 dB** by 2005.

### 3.4.3. France

***PARIS CDG***

For several years, the project of constructing CDG fourth runway had being contested by the neighbouring communities. A consensus was reached where the fifth runway, initially planned in the airport Master Plan, would be abandoned, and that the fourth runway would be constructed under the condition that the airport traffic would not exceed 55 million passengers.

Yet, it was recognized that the number of passengers travelling from and to an airport does obviously not reflect the noise perceived by the surrounding inhabitants. Thus, a **new indicator based on sound pressure has been elaborated** for Paris CDG and implemented through a legal act dated 28 January 2003.

**This new indicator (In) must not exceed, over a year, the limit value of 100**.

This indicator is defined for the year "n", by the value In computed as follows::

$$In = ½((w_{a,n} / w_{a,0}) + (w_{d,n} / w_{d,0})) * 100$$

Where:

- the basic indicator is « ***w*** » = $10^{(L/10)}$ ,
- « L » is a A-weighted sound pressure level measured for arrival ($w_a$) **and** departure ($w_d$) of each specific movement;

and,

- « $w_{a,n}$ » is the sum of values *w* weighted by number of ***arrivals*** for the year ***n;***
- « $w_{a,0}$ » is *wa* average value over a **three year reference period**, i.e. the third of the sum of values *w* weighted by the number of the arrivals for the years 1999, 2000 and 2001;

and similarly,

- « $w_{d,n}$ » is the sum of values *w* weighted by the number of ***departures*** for the year ***n***
- « $w_{d,0}$ » is *wd* average value over a **three year reference period**, i.e. the third of the sum of values *w* weighted by the number of departures for the years 1999, 2000 and 2001

It can be further noted that:

- the reference used or computing "L" is the most often measured noise level for the aircraft concerned ;
- If both conditions preceding are not available, the reference used is the certificated noise level for the aircraft concerned.

On the pattern adopted in $L_{den}$ computation, the individual **L value** is increased by:

- **5 dB for evening movements** (between 18:00 and 21:59);
- **10 dB for night movements** (between 22:00 and 05:59).

Although based on some measured noise levels, this indicator appears as quite theoretical and difficult to use when communicating with stakeholders.

### 3.4.4. Netherlands

***AMSTERDAM***

Until 2003, the noise volume limitation was searched through a limit on annual commercial air traffic movements. This limit was 440 000 movements per year in 2001, and 460 000 for 2002.

Until then, the noise indicators used were:

- the Kosten, referred to as Ke, for the full 24h-hour time period: it is a $L_{DEN}$ kind of indicator and,
- the $L_{Aeq}$ for the night-time period.

Between 1997 and 2003, the 35 Ke contour for the full 24-hour and the 26 dB(A) $L_{Aeq}$ contour for the night-time period were used as standards for noise nuisance, together with a maximum number of dwellings to be located within these noise contours. There were more than 250 measurement points installed for control at which (calculated) maximum annual noise levels should not be exceeded.

New noise limits have been effective since February 2003, as defined by the revised Aviation Act. Instead of a maximum number of houses within defined contours and a limited number of movements allowed per annum, there is a limit on the total volume of noise generated for an operating year. These new limits have been obtained by transposition of the preceding ones, i.e. they are equivalent to the former maximum number of houses located within the 35 Ke noise contours. On average over an operating year, this total noise volume should not exceed:

- 63,71 dB(A) $L_{den}$ for the full 24-hour period;
- 54,44 dB(A) $L_{night}$ for the 8-hour night-time period,

the $L_{den}$ and $L_{night}$ noise metrics being adopted in replacement of the Ke and $L_{Aeq}$.
Using the $L_{den}$ allows to overcome a number of disadvantages inherent to the Ke, in particular that of the 65 dB(A) capping (indeed, the Ke computation does not take into account any movements generating noise emissions lower than 65 dB(A)).

There are also noise volumes that should not be exceeded at the measurement points (these limits are averages over an operating year, expressed in dB(A) $L_{den}$ and $L_{night}$). Each monitoring point has its specific limit. They include:

- 35 monitoring points with limitations for the entire 24-hour period;
- 25 monitoring points with limitations for the night-time period.

They are all located in residential areas.

An evaluation is being currently carried out as to whether to switch to a system based on measurement instead of calculated estimates for assessing noise impact in the future.

### 3.4.5. Portugal

***LISBON***

Portuguese law establishes the following Equivalent Continuous Sound Level **(Leq)** values:

- **55 dB(A) Leq day** and **45 dB(A) Leq night** for **Sensitive areas** (land occupation by residential areas, hospitals, schools…)
- **65 dB(A) Leq day** and **55 dB(A) Leq night** for **Mixed areas** (land occupation by industry, commercial and services areas):

It can be noted that night-time (22:00 - 07:00) differs from $L_{den}$ definition. Yet, as commonly adopted, night values are 10 dB(A) lower than day values.

In order to meet the requirements of the Portuguese law, Lisbon Airport installed a Noise Monitoring system in May 2002. The system gathers noise related data captured by the monitoring stations, cross-checks it with flight and route information and enables the airport to detect the infringements to noise abatement procedures.

The system includes statistical and acoustical computation software to undertake analyses of noise or flight track information as required by the user.

At the moment, the system receives noise data from two remote stations located at critical points around the airport. Five other Noise monitoring points, located along the takeoff and approach paths, will be soon in operation. Lisbon Airport also has an additional mobile noise monitoring station.

### 3.4.6. Spain

In Spain, all airports are subject to land use planning. The noise is measured in **Leq** with the following limits:

- **65 dB at daytime** (between 07:00 and 23:00)
- **55 dB at night** (between 23:00 and 07:00)

***LAS PALMAS GRAN CANARIA***

Las Palmas is subject to the National rule.

Yet, the airport indicated in our survey that it has no monitoring station, therefore, we do not have any information on how this limit is being monitored/enforced.

***MADRID***

In our survey, Madrid has indicated that they do have day and night noise limits of respectively 65 and 55dB(A) Leq. Yet, it appears that they may more reflect a land use zoning policy than a noise limit *per se*.

Indeed, Madrid/Barajas disposes of 17 noise monitoring stations. Yet, this surveillance system is only used for land use zoning, more than for enforcement.

Similarly, in-door noise standard for new constructions around the airport has been limited to 40dB(A) Leq during the day a 30dB(A) Leq at night, but these limits have not been translated into operating real indicated limitation.

In addition, since June 1, 2000, a system of **total noise quota** has been established at the airport from 00:00 to 06:00.

### 3.4.7. Switzerland

In 2001, the Swiss government issued new noise limits. The restrictions apply to Zurich-Kloten, Geneva-Cointrin, Lugano and Bern. These noise limits are maximum daily averages computed for one-year time period and they are actually for land use planning and zoning. In addition, a noise surcharge system based on measured noise is enforced.

The noise limits for the daytime period from 06:00 to 22:00 are expressed in dB(A) Lr (Leq metric type). They are actually used as limit values for zoning.

| | 'Planning' value[1] | **'Limit' value[2]** | 'Emergency' value[3] |
|---|---|---|---|
| Zone I : quiet areas that need special care | 53 | 55 | 60 |
| Zone II : 'pure' residential area | 57 | **60** | 65 |
| Zone III : residential housing and small businesses | 60 | **65** | 70 |
| Zone IV : industry areas | 65 | **70** | 75 |

NB: The Lr metric is computed as follows:

Lr = Leq + K, with: K = 0 for N < 15 000, N being the number of movements,
K = l0 × log (N/15 000) for N >= 15 000.

There are noise limits for the 3-hour night-time period, 22:00-23:00, 23:00-00:00 and 05:00-06:00; they are expressed in dB(A) $L_{Aeq,\ 1h}$. They are actually used as limit values for zoning.

| | 'Planning' value[1] | **'Limit' value [2]** | 'Emergency' value[3] |
|---|---|---|---|
| Zone I : quiet areas that need special care | 43 | **45** | 55 |
| Zone II : 'pure' residential area | 47/50* | **50/55*** | 60/65* |
| Zone III : residential housing and small businesses | 50 | **55** | 65 |
| Zone IV : industry areas | 55 | **60** | 70 |

*The highest values are for the first hour of the night, i.e. 22:00-23:00.

[1] 'Planning' value: if the noise level is beyond this value, it is no longer possible to build in the area; this is to encourage housing development in quiet areas.

[2] 'Limit' value: if the noise level is beyond this value, the noise level should be reduced or it is no longer possible to build sensitive buildings in the area concerned.

[3] 'Emergency' value: if the noise level is beyond this value, appropriate measures should be immediately taken to reduce the noise (e.g. insulation).

### 3.4.8. United Kingdom

***LONDON CITY AIRPORT***

London City Airport has implemented a quite specific system, certainly due to airport location within a very populated area. This system is based on the following limitations on the number of Air Transport Movements (ATMs) allowed to land/take-off **per day of the week, and per year** (ATMs being flights by civil aircraft for the transport of passengers, cargo or mail on commercial terms including flights by aircraft engaged in sightseeing tours):

- 140 per day on Saturdays and Sundays but not exceeding 220 on any consecutive Saturday and Sunday;
- 240 on other days except holidays for which specific maxima exist;
- 73 000 per calendar year.

Besides, similar to the QC system implemented on other London airports, London City has defined “Factored movements” which are weighted on the following aircraft classification:

- **Category A** with a Noise Reference Level in **91.6 - 94.5 PNdB** counts as **1.26** ATMs
- **Category B** with a Noise Reference Level in **89.6 - 91.5 PNdB** counts as **0.63** ATMs
- **Category C** with a Noise Reference Level in **85.6 - 88.5 PNdB** counts as **0.31** ATMs
- **Category D** with a Noise Reference Level in **82.6 - 85.5 PNdB** counts as **0.16** ATMs
- **Category E** with a Noise Reference Level less than **82.6 PNdB** counts as **0.08** ATMs

In addition to the above mentioned ATMs limits, the number of **factored movements** must not exceed 15% of the permitted **number of movements** in any one week or **73 000 per calendar year.**

## 3.5. Noise Volume Limits over a time period – specific night

As introduced at the beginning of section 3, the QC system gives a QC rating to each aircraft type according to how much noise it makes, which allows to compute a global quota for the whole traffic.

So far only three countries, Belgium after Spain and the UK have chosen a QC kind of methodology to limit noise at night.

**As opposed to Spain and UK** (refer to the introduction of Section 3), **Belgium** has adopted a different way to build its QC categories, it is calculated as follows:

*QC = 10 power(10^((noise - 85)/10)*

Where,

- take-off noise = half of (take-off plus sideline certificated levels) (in EPNdB)
- landing noise = approach certificated level minus 9 (in EPNdB).

The choice of this formula indicates that **85 EPNdB** is being considered in Belgium as the average tolerable certificated noise level, aircraft with certificated noise levels higher than 85 EPNdB being penalized.

### 3.5.1. Italy

***BOLOGNA***

The airport indicates a noise level limit for night period. Yet, it seems it is more a reference to define land use planning or a noise volume limit. Moreover, the airport indicates that the metrics used (**Lva**) is similar to $L_{den}$ except, *inter alia,* it has a different night period (23:00-06:00 Local Time).

They are the following:

- **65dB** for residential area
- **65dB-75dB** for industrial areas;
- **More than 75dB** for country/airfield area

### 3.5.2. United Kingdom

The quota limit adopted by various airports varies in relation to airports specificities and environmental objectives. It only concerns night flights.

If ever a quota is being exceeded by an airline, its respective quota is lowered by 10% on the following quota period.

It must be further noted that, when a daytime noise level limit (as described in the previous chapter) is being exceeded by an operator, the corresponding flight is then integrated into its night quota computation, with the possibility that the "guilty" airline will then exceed its night quota, leading to the same 10% penalty on the following period quota.

***BIRMINGHAM***

In October 1997, complementing night noise violation level revision to **87 dB(A)** (see above in paragraph 3.2 on limitations per movements), the **Night Flying Policy** was also reviewed to incorporate a **noise quota count and an annual movement allowance**.

- A maximum number **of 4 200 movements** were assigned annually during 23:00 - 06:00; and,
- A maximum **noise quota annual allowance** of **5 500** during 23:30 - 06:00 applied.

Aircraft with a noise quota of QC8 and QC16 can not be scheduled to operate between 23:00 and 06:00. Yet, delayed departures of these aircraft are permitted up to 23:30.

Chapter 2 aircraft are not permitted to operate during the night period.

The Night Flying Policy is reviewed every 2 years and a revised policy was introduced in October 1999 introducing the balance between noise quota decreases and annual movement increases:

- **Noise quota count reduced** from 5 500 to 4 000.
- **Annual movement allowance increased** from 4 200 to 5 500.

It is also broken down into a seasonal allowance.

*As complementary information*

Under the terms of the Section 106 Obligation that the Airport entered into with Solihull Metropolitan Borough Council in July 1996, there was a provision to introduce further restrictions on **engine ground running** in the morning shoulder period, i.e. from 06:00 to 07:00. Following consultation with the Airport Consultative Committee and the Council, agreement was reached in March 2001 to establish a **ground running noise limit**, an average daily exposure, **the equivalent of 79dB LAeq***, during the period 06:00-07:00, Monday through Saturday, which should not be exceed for Taxiway E only. Only full power engine ground runs are included in the calculation for the average quarterly noise levels.

***The calculation of the average daily exposure is based upon averaging the noise levels for the morning shoulder period from engine ground runs across a quarterly period. The quarterly periods are Jan-Mar, Apr-Jun, Jul-Sep and Oct-Dec. The morning shoulder period runs from 06:00 to 07:00, Monday to Saturday and 0600 to 0800 and 1030 and 1230 on Sundays. The equivalent of 79 dB level is therefore the maximum permitted average noise level for a given quarter.

### *BRISTOL*

Bristol uses the Aircraft Noise Quota Count System.

The formula for computing QC from certificated noise levels is the following:

- For takeoffs*: (Takeoff+Sideline)/2 for Chapter 3; ((Takeoff+Sideline)/2)+1.75 for Chapter 2*
- For arrival *: Approach certificated Level minus 9*

The total Seasonal Quota is **1260** points for summer season, **900** for winter season, where

- '**quota'** means the maximum allowed total of the quota counts of all aircraft taking off from or landing at Bristol Airport during any one season **between 23:30 and 06:00**,
- **'the summer season'** means the period of British Summer Time in each year as fixed by or under the Summer Time Act 1972, and 'the winter season' means the period between the end of British Summer Time in one year and the start of British Summer Time in the year next following.

### LONDON (HEATHROW, GATWICK AND STANSTED)

In addition to using the QC system to define "noise points' budget" limitations for the night-time period, London airports also have maximum numbers of movements allowed per season, as described below:

| | Summer | Winter |
|---|---|---|
| **At Heathrow** | 3 250 | 2 250 |
| **At Gatwick** | 11 200 | 5 250 |
| **At Stansted** | 7 000 | 5 000. |

The corresponding noise points' budgets for 2003-2004 night-time period for the three airports are the following:

| | Summer | Winter |
|---|---|---|
| **At Heathrow** | 5 610 | 4 140 |
| **At Gatwick** | 9 000 | 6 640 |
| **At Stansted** | 4 950 | 3550 |

## *MANCHESTER*

The Airport Operator ensures that the night noise climate between 23:30 and 06:00 will not deteriorate over that measured in 1992/1993 levels in terms of Leq contours (average noise) and typical (average of 100 noisiest movements) dB(A) (peak noise) levels for the duration of the policy.

Noise levels are underpinned by periodic social surveys to determine local people's perception of night noise from aircraft.

The total noise points budget for arrivals and departures in the night period to summer 2005 will be:

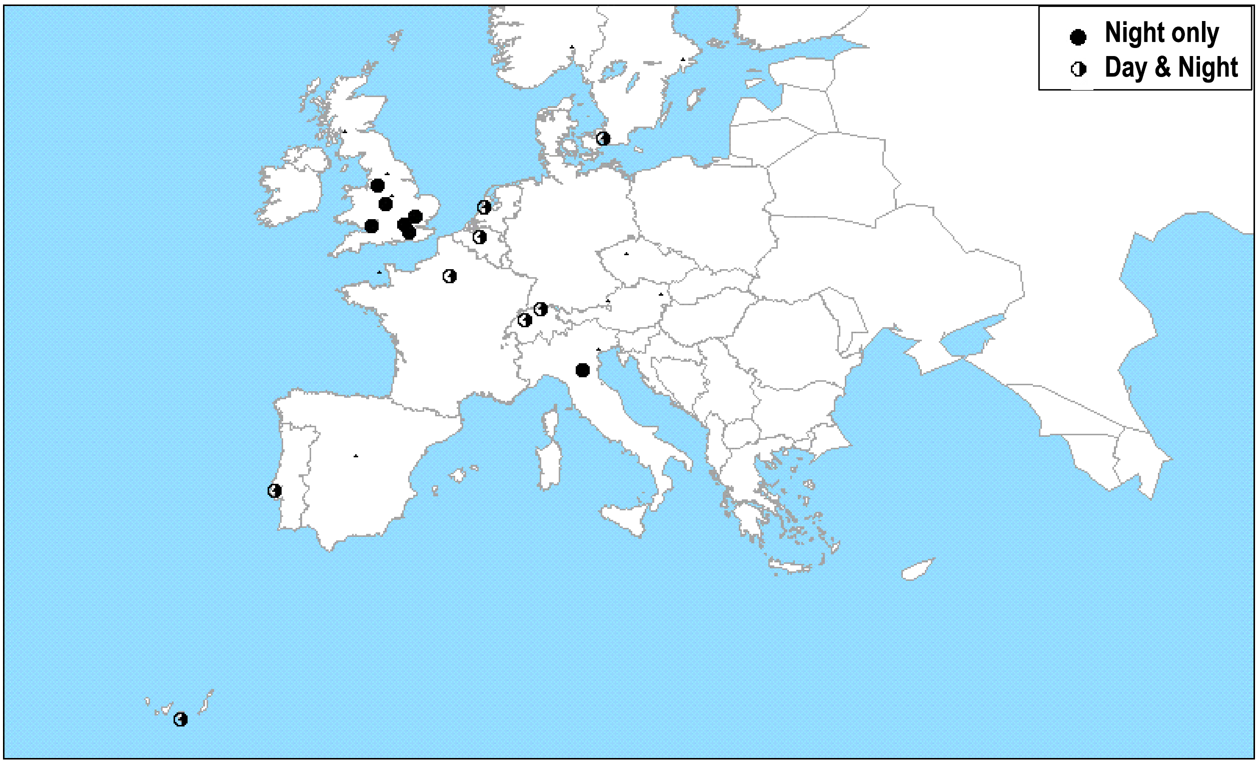
- **8 750** points, and
- **3 900** in winter.

## 3.6. Noise Volume Limit over a time period – Summary

The various noise limits detailed above are reproduced in the synthetic table and map below.

| | Annual | Noise Level Limits over a time period | |
|---|---|---|---|
| **AIRPORT & Country** | **Movts** | **Day values** | **Night values** |
| Brussels National - Zaventem ***(Belgium)*** | 256 876 | **No noise limit in practice since July 2002**<br>Theoretically, it is:<br>**55 Leq,day** (Location 0)<br>**60 Leq,day** (Location 1)<br>**65 Leq,day** (Location 2) | **Seasonal global night noise quota count system** is in effect during **23:00 - 05:59:**<br>**68 500** (summer 2001),<br>**41 500** (winter 2001/02),<br>**55 500** (summer 2002),<br>**36 500** (winter 2002/03), and<br>**48 000** (summer 2003).<br>+theoretically: Day limits minus 10dBA |
| Copenhagen - Kastrup ***(Denmark)*** | 266 108 | **Noise quota**.<br>Until the year 2005, the equivalent noise exposure (DENL) from aircraft operations and taxi activities may **not** | |
| Paris CDG ***(France)*** | 510 098 | Since 2003, **annual noise limit** (100) for a **weighted measured indicator**:<br>3-year average of noise measurements (1999-2001) | The value of L is increased by :<br>• **5 dB** for **evening** movements during 18:00-21:59 ;<br>•**10 dB** for **night** movements during 22:00-05:59. |
| Bologna Guglielmo Marconi ***(Italy)*** | 54 950 | | **65 dB LVA** Residential area<br>**75 dB LVA** Industrial area<br>**>75 dB LVA** Country/Airfield area<br>*LVA is similar to Ldn with night period 23:00-06:00 |
| Amsterdam - Schiphol ***(Netherlands)*** | 417 115 | **63,71 dB(A) Lden** and 35 monitoring points with specific limits in dB(A) Lden | **54,44 dB(A) Lnight** and 25 monitoring points with specific limits in dB(A) Lnight |
| Lisbon ***(Portugal)*** | 115 748 | **55 dB(A) Leq,day -** sensitive areas<br>**65 dB(A) Leq,day -** mixed areas | ***Day limits minus 10dB*** |
| Las Palmas, Gran Canaria ***(Spain)*** | 93 787 | **65 dB Laeq** (07:00-23:00) | **55 dB Laeq** (23:00-07:00) |
| *Bern - Belp* ***(Switzerland)*** | 62 488 | **60 dB(A) Lr** maximum in residential areas;<br>**65 dB(A) Lr** max. in small businesses areas;<br>**70 dB(A) Lr** daily average in industrial areas<br>*Lr is a Leq kind of metric | **55 dB(A) Leq,1h** during 22:00-23:00;<br>**50 dB(A) Leq,1h** during 23:00-00:00 and 05:00-06:00 in residential areas<br>A **ban** on flights by particularly loud aircraft also applies between 00:00-05:00. |
| Zurich - Kloten ***(Switzerland)*** | 278 238 | See Berne | See Berne |
| Birmingham ***(UK)*** | 115 741 | | **Noise quota count + annual movement allowance.** |
| Bristol International ***(UK)*** | 72 152 | | **Seasonal Aircraft Noise Quotas**<br>**1260** points for **summer**<br>**900** points for **winter** |
| London City ***(UK)*** | 56 102 | **240 ATMs on week days except holidays**<br>**140 ATMs** per day on weekends but not exceeding 220 over the weekend<br>**73 000** ATMs per calendar year | |
| London - Gatwick ***(UK)*** | 242 380 | | **Seasonal Aircraft Noise Quotas**<br>**9 000** for summer<br>**6 640** for winter. |
| London - Heathrow ***(UK)*** | 466 554 | | **Seasonal Aircraft Noise Quotas**<br>**5 610** for **summer**<br>**4 140** for **winter** |
| London - Stansted ***(UK)*** | 170 774 | | **Seasonal Aircraft Noise Quotas**<br>**4 950** for **summer**<br>**3 550** for **winter** |
| Manchester ***(UK)*** | 192 498 | | **Seasonal Aircraft Noise Quotas**<br>**8 750** for **summer**<br>**3 900** for **winter** |

**Noise Level Limits over a time period**



# 4. CONCLUSION

The main findings from this analysis are the following:

- Every country or airport has built its own aircraft noise management system, aiming most of the time to make it as soft as possible for its based airline; hence, the differences in the systems used are usually based on the differences in the network structures and fleet structures and characteristics of their respective differing national carriers;
- All these noise management systems have been accompanied with a land use planning policy;
- There is a large number of metrics used to define noise limits (e.g. LAmax, SEL, Leq). It is therefore difficult to compare the various noise limits that exist in Europe.
- Noise level limits are not linked to airport size, but rather to national policies and more national general environmental noise concepts; in that sense, they are more frequently used by northern European countries, although Madrid has recently implemented a QC system;
- In this framework, some countries have implemented noise limits for many years, and, in some cases for more than a decade, such as Austria, Switzerland, or the United Kingdom; these “advanced” countries have gained a high experience in analysing how these limits are being respected by airlines and are already reviewing these limits;
- Very few countries (France and UK) have implemented penalties in case of overrun, which underlines the weight given to noise limits infringement;
- Some countries have implemented limits only at night, in line with “the right for a good sleep”;
- Noise limits depend from the monitoring stations locations (which was predictable), but a correspondence may be established between measured noise, generated noise, and perceived noise at other locations (e.g. United Kingdom);
- Only one country (Denmark) seems to have adopted different limits depending on whether it is generated during flight phases (arrival and departures) or during taxiing.

Yet,

- It appears that, based on the World Health Organisation (WHO) guidelines, these limits aim at ensuring a maximum noise level close to 45dB(A) inside houses which corresponds to the acceptable noise level to ensure good sleep;
- Noting that most house insulation programs may reduce noise by 30dB(A), this corresponds to an outside noise limit of 75dB(A);
- When there is a day limit, most night limits are usually lowered by 10dB(A), which is in line with the approach adopted when constructing the $L_{den}$ indicator which maximises night noise measures by 10dB(A) compared to day noise;
- Noise level limits per movement are usually measured through monitoring stations at airports, whereas noise level limits over a time period are usually theoretically calculated with timetables and certificated level of noise per aircraft (except for the new system at Paris-CDG);
- Noise level limits or quotas which are more related to really perceived noise tend to be replacing movements limitations measures.

# PART II:
# ELABORATION OF A METHODOLOGY TO ASSESS COST BENEFIT ANALYSIS OF AIRPORTS NOISE LIMITS

# 1. INTRODUCTION

The main objective of this second part is to describe some examples of cost benefit analyses (CBA) approaches adopted by Member states when creating or lowering a noise limit.

As already stressed in the introduction, no State has gone through a formal CBA when implementing a noise limit. Yet, when questioned on the way these limits were defined, states recognise that the limits were generally not imposed from scratch but were the result of a long negotiation process with the various stakeholders concerned with noise emissions, either the affected population, or the generating industry (airlines and/or airports). Furthermore, most CBA approaches usually assess noise management policy as a whole, with not a specific attention paid to only one measure, should it be noise level limit values or any other measure.

Because national studies dedicated to this issue were not readily available, the only way to seek information was through interviews with the stakeholders or some major airports: the airports themselves, their regulators and whenever possible the affected population associations.

In addition, those interviews also provided the opportunity to validate or complete the data gathered on these airports during the study Phase I.

The airports concerned were:

- Aéroports de Paris for CDG and Orly;
- Amsterdam/Schiphol;
- BAA for London airports (mostly Heathrow, Gatwick, and Stansted);
- Frankfurt/Fraport;
- Geneva/Cointrin with an extension to Swiss airports (in particular Zurich/Unique).

The interviews were then led in order to figure out:

- Their perception of the cost benefit analysis of noise limits as a pertinent and reliable decision-making instrument;
- How the main noise limits have been elaborated;
- Why some others have not been adopted;
- Whether they were based or not on *a priori* or *a posteriori* cost benefit analysis:
- The set of technical indicators which are or could be used to evaluate the main impacts of noise limits.

The structure of this part reflects the adopted methodology:

**Chapter 2** presents three quite different case studies that are showing some attempts to conduct CBAs:

- The first section presents how the French DGAC justified *a posteriori* the new environmental objectives defined for Paris/CDG.
- The second case study consists in analysing the impact from reducing former existing noise limits at London airports.
- The last section presents the approach adopted to set noise limit values for major Swiss airports.

Finally, the conclusions and recommendation are summarised in **Chapter 3**.

The interviews led with the other two airport stakeholders were very interesting on the history and development on their noise policies. Yet, because, they were not so CBA oriented, the highlights identified from these interviews are reproduced in the **Appendix IV**, but are not integrated into this part. The contacts met during the interviews and the documentation collected are reproduced in **Appendices VI and VII.**

# 2. CASE STUDIES

## 2.1. Paris CDG airport

The following case study consists in an impact analysis conducted by the French DGAC made to justify adoption of two new measures: ban on marginally compliant Chapter 3 aircraft and creation of a maximum noise levels. Its approach was in line with ICAO balanced approach, which requires that implementation of a new measure/system/target is justified in economic terms.

On 25 July 2002, a new environmental objective was defined for CDG Airport. This objective consists in:

- **Reducing night noise**, by imposing a 5 hours period (00:00 and 05:00am) during which the noisiest emissions are forbidden:
- **Limiting noise impact during the day** through land use planning measures, by :
  - Forbidding the settlement of new populations within aircraft noise exposed area;
  - Forbidding the extension of these areas by limiting the yearly global noise volume

Since it was evaluated that the previously agreed reduction[1] of the number of slots available for the 00:00 to 05:00 night period wouldn't be sufficient to reach this objective, the French government set two ministerial Orders which altogether imposed:

- ***A progressive total ban (day AND night) on marginally compliant Chapter 3 aircraft***[2], starting 2004, and complete in 2008 (September, 8$^{th}$ 2003); the principle is to impose airlines to decrease by 20% per year the share of such aircraft within their respective fleets;
- ***A ban on non-scheduled flights take-offs*** between 00:00 and 05:00am.
- ***The creation of a maximum noise level*** for take-offs (99 EPNdB) between 00:00 and 05:00am and for landings (104.5 EPNdB) between 00:30 and 05:30am

Prior to their adoption, the French DGCA carried out an impact analysis[3], the main lines of which being described hereafter.

First, the analysis was conducted over the 10 year period 2002/2011. Three scenarios were compared for the global issue of noise volume:

- Do nothing
- Total ban on Chapter 3 noisiest aircraft
- Night curfew between 00:00 and 05:00

[1] Air France and La Poste agreed together to remove 2060 flights/year during the 00:00 to 05:00 night period and the DGCA then limited the number of slots available during that period to 22 500 for the 2003/2004 winter season and the 2004 summer season and pledged to reduce that number in the following years.

[2] Noisiest chapter 3 aircraft: aircraft certificated with a margin lower than 5 dB(A)

[3] Analysis driven by the French CAA, DGAC: 'L'approche équilibrée de la gestion du bruit sur l'aéroport de Paris CDG'.

### 2.1.1. Daytime

The scenario of progressive total ban of marginally compliant Chapter 3 aircraft was chosen over the total night curfew for two reasons:

- both economic impacts were similar
- but, keeping the airport open at night enables both freight and passengers activities development while a curfew has direct, indirect and induced effects on a wide number of actors because it means a stop on major part of freight (especially express freight) activities.

The main principles supporting the impact analysis approach for the extension to the day period of Chapter 3 noisiest aircraft are the following:

1. The measure is almost at zero cost for airlines since the accelerated replacement of only some part of their fleet is gradual over 5 years and fully balanced over a ten year period by the profit raised from using more efficient aircraft (better productivity, lower operating maintenance and fuel consumption costs);

2. The only cost is then supported by the consumers when such measures could lead to that decrease in the supply and then not fully satisfy the demand;

3. The study does not address the benefits gained in terms of residents comfort improvement.

**Indicators and hypotheses used in the assessment of the extension to the full day of the Chapter 3 –5dB(A) ban**

| ***Stakeholders*** | ***Indicators used to quantify impacts*** |
|---|---|
| ***Society/Environment*** | None |
| ***Air Transport Users*** | Economic cost of unsatisfied demand:<br>*Only 94% of demand would be satisfied in 2004 and 86% in 2008* |
| ***Economic impact***<br>• ***Airlines*** | ***Cost***: Fleet accelerated renewal cost (bought or leased)<br><br>*B747-200/300s replaced by B747-400s*<br>*B737-200 replaced by B737-500*<br>*B727-200 replaced by A320*<br>*DC9 replaced by A 319*<br>*DC10 replaced by MD11* |
| | ***Benefits:*** costs saving due to more efficient fleet |
| • ***Others stakeholders*** | **Costs:**<br><br>Passenger and airport taxes (*A segmentation is made by freight type, and between scheduled or non-scheduled flights)*<br><br>Subcontractors' revenue losses |
| • ***Indirect impacts*** | Second level subcontractors' revenues (hotels, firms, …) based on the passengers expected expenditure (per passenger):<br>• *45 euros on scheduled flights*<br>• *20 euros on non-scheduled flights* |

### 2.1.2. Night-time

The main principles used for assessing the measure imposing night noise levels above which take-offs or landings are forbidden, are the following:

- The environmental benefits are quantified:
  - The ban of take-off for B747-200 should preserve 60,000 people from 450 noise emissions exceeding 80 dB LAmax and 13,000 people from 166 emissions for B747-400;
  - The ban of landings should preserve 1,500 people from a hundred emission exceeding 80 dB LAmax.
- The cost supported by airlines is based on the loss of revenues generated by the reduction in embarked payload in order to reduce the take-off weight and resulting take-off noise: it leads to an aggregated 54 millions loss for the industry.

  *NB: Yet, it is acknowledged that this loss is certainly overestimated, because airlines can adapt their network strategy but scheduling banned aircraft during the unconstrained period, or changing their network strategy*.
- The cost incurred by B747-200 removal is not taken into account in this "independent" CBA, assuming it is already taken into account as the result of the measure described above.

**Indicators and hypotheses used in the assessment of noise level limit for take-offs and landings during the night period**

| ***Stakeholders*** | ***Indicators used to quantify impacts*** |
|---|---|
| ***Society/Environmental*** | number of flights affected by the noise limit for each type of aircraft<br>*B747-200 (454 flights for takeoff and 103 for landings)*<br>*B747-400 (166 for takeoff)*<br>number of people concerned by emissions exceeding 80dB(A)<br>*takeoff: more than 73,000 people*<br>*landings: 1,500 people* |
| ***Economic impacts***<br>• ***Airlines*** | Cost of imposing noisiest aircraft to be operated only during the unconstrained time period (*B747-200 300 and 400)*<br><br>Losses due to the max payload reduction *(passenger and freight revenue)* |
| • ***Other stakeholders*** | **Costs/ Revenue losses:**<br><br>Passenger and airport taxes (*A segmentation is made by freight type, and between scheduled or non-scheduled flights)*<br><br>Shops' revenue losses (*Estimated to 2.6 millions euros between 00:00 and 05:00am)*<br><br>Subcontractors' revenue losses |
| • **Indirect impacts** | Second level subcontractors' revenue (hotels, firms, …) based on the passengers expected expenditure (per passenger):<br>• *45 euros on scheduled flights*<br>• *20 euros on non-scheduled flights* |

### 2.1.3. Aborted attempt to impose a noise limit per movement

In the light of other measures undertaken by ACNUSA (the French Authority in charge of controlling noise nuisances at airports), some indicators or qualitative CBA approaches/principles can be identified.

Indeed, in 2000, ACNUSA proposed to introduce a unified noise limit for each aircraft flying during night-time on major French airports (Paris,-CDG, Paris-Orly, Nice, Lyon, Marseilles, Toulouse, Strasbourg). The proposed limit was 85 dB(A) $L_{Aeq,\ 1s}$ on the borders of B and C areas of noise exposure plans (the limit where residential dwellings are allowed under insulation conditions). As already developed in Part I, the 85 dB(A) value was chosen because it takes into account:

- The 45 dB(A) health tolerance recommended by WHO (World Health Organisation) as maximum sound level inside houses,
- The coming soon isolation technique progress which, according to ACNUSA experts, should enable noise reduction in houses by 40 dB(A) (Currently, reductions by 35dB(A) are commonly achieved).

Yet, imposing such a limit on the B/C contours turned out to be difficult to implement and control. It was then decided that a more pragmatic approach would consist in imposing this limit to be measured at 4.5 km from the runways' threshold, for each landing and take-off.

On the other hand, under the pressure of the industry, this proposal was dropped on the basis that a sole "harmonised" limit is not applicable to seven airports as a whole because it cannot be implemented due to the high discrepancies that exist from one airport to another noise zoning. The ICAO recommended **"balanced approach"** was used as an argument by the industry to support the principle that such drastic limits should be implemented only at those airports where noise nuisance were deemed problematic.

Finally, a new metrics based on $L_{den}$ computation was adopted for assessing a noise volume at Paris-CDG. This metric further described in Part I sets a **maximum value of 100**, which represents the noise volume average over the last **three years** (years 1999, 2000 and 2001), which implies that future noise volume must be limited to its recent average levels.

Yet, this indicator remains quite theoretical and is difficult to support communication with other stake-holders. Some opponents even consider that this indicator does not reflect the actually perceived noise since it does not take into account the nuisance induced by noise occurrence frequency.

This may explain why a working group is being created, in order to identify/elaborate a pertinent indicator which could take into account aircraft movement frequency in order to compare, for a same $L_{den}$ or equivalent integrating metrics, the nuisance generated by many aircraft during a short period of time with the nuisance generated by the same number of aircraft over a longer period.

### 2.1.4. Conclusion

The main findings from the impact analysis made by the DGAC raise a few issues:

- What should be the period over which an analysis should be led?
- If noise limitations measures lead to some unsatisfied demand, should not it be considered as a cost (or a profit loss in term of yield) for the airlines?
- What is the impact on residents' comfort? (i.e. quality of life, health, real estate value, etc. Here, the environmental benefits were not quantified)
- Is it possible to monetarize such impacts?
- It seems impossible to define aircraft specific noise limits with respect to an airport cumulative noise indicator in use for land use planning/zoning.

- The final decision to restrict Chapter 3 noisiest aircraft was actually the second best option since imposing one limit for all airports seemed unrealistic.
- Prior to its adoption, a system needs lengthy discussions, negotiations, communication, and validation from the major stakeholders, a process which is fully supported by the ICAO balanced approach recommendations. Those discussions remain political rather than based on complete CBA which on the other hand seem difficult to elaborate.
- Do the metrics used for noise contouring, such as Leq, reflect the annoyance perceived?

## 2.2. London Airports

The United Kingdom has gained the longest experience is this field since it has aimed at limiting noise impact at Heathrow since 1959. The most recent UK studies have stressed that the current global noise limits have reached their maximum degree of efficiency and that further progress in noise limits can be achieved only through measures aimed at specific aircraft types.

The following section presents the impact on airlines caused when reducing the existing limits by 3 dB(A) during daytime and by 2 dB(A) at night.

### 2.2.1. Reduction of a noise limit: impact on airlines

The Environmental Research and Consultancy Department (ECRD) of the UK Civil Aviation Authority paid a specific attention on the impact that such a more stringent noise limitation would have on some of the noisiest aircraft types (but also the most efficient), i.e. ,747/400 and Chapter 3 747/200 .

For these two aircraft types, the following table classifies the number of movements depending on their respective noise levels. The reference period was September 2000/August 2001. The percentage indicated can therefore be also considered as the infringement rate that would create a more stringent noise limit.

It also reproduces the infringement rate estimate by the study referred to as Review of the Departure Noise Limits at Heathrow, Gatwick and Stansted Airports, conducted in 1995[1] (where 747/400s and Chapter 3 747/200 were combined).

| | | 2000-2001 | | | | | 1995 |
|---|---|---|---|---|---|---|---|
| Reference level dB(A) (+0,7dB(A) tolerance) | | Percentage of 747/400 movements exceeding the reference noise level | | | Percentage of Chapter 3 747/200 movements exceeding the reference noise level | | Percentage of Chapter 3 B747 movements exceeding the reference noise level |
| | | LHR | LGW | STN | LHR | LGW | |
| Day | 94 | 0,4% | 0,0% | 0,0% | 3,5% | 1,9% | 10,0% |
| | 93 | 1,1% | 0,0% | 0,0% | 7,6% | 4,5% | 14,0% |
| | 92 | 3,0% | 0,0% | 0,2% | 16,0% | 8,9% | 20,0% |
| | 91 | 7,2% | 0,0% | 0,5% | 29,0% | 17,0% | 28,0% |
| | 90 | 15,0% | 0,4% | 0,8% | 44,0% | 26,0% | 37,0% |
| Shoulder | 89 | 28,0% | 1,7% | 1,0% | 58,0% | 37,0% | 46,0% |
| | 88 | 43,0% | 7,9% | 2,1% | 70,0% | 46,0% | 57,0% |
| Night | 87 | 58,0% | 21,0% | 5,0% | 79,0% | 57,0% | 66,0% |
| | 86 | 72,0% | 43,0% | 8,3% | 86,0% | 66,0% | 74,0% |
| | 85 | 82,0% | 64,0% | 14,0% | 91,0% | 75,0% | 81,0% |

*Source: ERCD Report 0207, March 2003*

The main findings are the followings:

- at Heathrow, only a small percentage (. 0,4%) of departures exceeded the current daytime limit of 94 dBA;
- at Gatwick and Stansted, there was no one infringement due to the fact that those 747s operating at those airports were less noisy because their typical shorter stage lengths induce lighter take-of weights and resulting take-off operating noise. Therefore the possible economic impact on an aircraft also depends on its operating/network characteristics.
- 747/400s and Chapter 3 747/200s would not be affected similarly by lower noise limit levels. Indeed, an overall limit that would be reasonable for 747/400s would be excessively restrictive for Chapter 3 747/200s; vice-versa, an overall limit that would be reasonable for the

[1] Cadoux R E & Ollerhead J B: Review of the Departure Noise Limits at Heathrow, Gatwick and Stansted Airports: CS Report 9539, CAA, December 1995.

Chapter 3 747/200s, (such as the present daytime limit), would have almost no impact on the 747/400s. Thus noise limits that are specific to aircraft types, as a complement to an overall limit may be more appropriate and realistic.

- Compared to the 1995 study[1] data, 2001 infringement rates for the highest noise levels have significantly decreased, indicating an important progress.

- The relatively low percentage of flights affected by a limit of **92 dB(A)** for the daytime suggests that a 2-dB(A) reduction in the current noise limit level would have a low impact.

- On the opposite side, a decrease by 2 dB of the current **89 dB(A)** night-time noise limit would have a noticeable impact (58% of night flights would be affected). However it must be kept in mind that this high percentage concerns a far lower traffic level (only 17 scheduled flights at night against 1915 at day time). Indeed, the average number of departures per month for these aircraft types was as follows:

| Period | Number of 747/400 scheduled movements | | | Number of Chapter 3 747/200 scheduled movements | |
|---|---|---|---|---|---|
| | LHR | LGW | STN | LHR | LGW |
| Day | 1915 | 156 | 49 | 68 | 14 |
| Shoulder | 48 | 0 | 2 | 12 | 0 |
| Night | 17 | 0 | 4 | 0 | 0 |

*Source: ERCD Report 0207, March 2003*

Based on these data, the expected number of infringements for the 747/400s and Chapter 3 747/200s can be derived as shown below:

| Reference level dB(A) (+0,7dB(A) tolerance) | | Number of 747/400 movements exceeding the reference noise level | | | Number of Chapter 3 747/200 movements exceeding the reference noise level | |
|---|---|---|---|---|---|---|
| | | LHR | LGW | STN | LHR | LGW |
| Day | 94 | 8 | 0 | 0 | 2 | 0 |
| | 93 | 21 | 0 | 0 | 5 | 1 |
| | 92 | 57 | 0 | 0 | 11 | 1 |
| | 91 | 138 | 0 | 0 | 20 | 2 |
| | 90 | 287 | 1 | 0 | 30 | 4 |
| Shoulder | 89 | 13 | 0 | 0 | 7 | 0 |
| | 88 | 21 | 0 | 0 | 8 | 0 |
| | 87 | 28 | 0 | 0 | 9 | 0 |
| Night | 87 | 10 | 0 | 0 | 0 | 0 |
| | 86 | 12 | 0 | 0 | 0 | 0 |
| | 85 | 14 | 0 | 1 | 0 | 0 |

*Source: ERCD Report 0207, March 2003*

The British air carriers were asked to produce their own cost evaluation to validate the impact and feasibility of such a measure. The results were not made publicly available, and, could not be directly extended to third countries airlines.

Yet, this example indicates that, although it does not provide a full CBA, such an analysis enables to broadly evaluate the impact that a new measure could have on the industry, in line with “balanced approach”.

Indeed, this last table indicates that

- **At day time, reducing noise limits levels by 1 or 2 dB(A) might be envisaged**: it would affect a quite limited number of flights/aircraft and would therefore be probably "manageable" by airlines.
- Nevertheless, **due to economic consideration, mostly with regard to third countries air carriers, this reduction should not exceed 1 dB(A) for the moment**: indeed, a closer analysis indicates that, while British air carriers might be in a position to cope with 2 dB(A) reduction at day-time in the framework of their more general respective fleet planning, many third countries air carriers, the fleet development plans of which being usually less advanced, might not be in a position to cope on the short term with a more than 1dB(A) noise limit reduction.
- Finally, **none of the current night-time or shoulder limits of 87 and 89 dB(A) could be reduced,** given the aircraft types operating during these periods, and noting that they are already limited to very few ("necessary") movements (17 at night).

### 2.2.2. Conclusion

The main findings from this analysis are the following:

- As underlined by the percentage of flights affected by a noise limit reduction in 1995, implementation of the QC system has allowed improvement in the environmental quality/performance of operating aircraft.
- A single noise limit for all operating aircraft can affect only a few particular aircraft types; a more satisfactory system would be based on "**aircraft type specific noise limits"** to encourage quieter departures by all aircraft types.
- Once a limitation system is already in force, when an additional system is to be implemented, it seems difficult to evaluate the real economic impact caused by introduction of the new system.
- The QC system is used as baseline to structure the UK noise management system while noise limits are as tools for validation of the results derived from QC based measures.

## 2.3. Swiss airports

Following enforcement of the Environmental Protection Law and the Noise Protection Regulation in April 1987, the Federal Council was required to set up noise limit values for the airports of Zurich-Kloten, Geneva-Cointroin and Bâle-Mulhouse.

Thus the federal Commission for evaluating noise exposure limit values' was responsible for making proposals complaint with the law, considering the latest findings that related to the impact of noise on sleep disturbance.

A working group was appointed in 1987 to support the preparatory activities which included:

- Investigating noise issues in the vicinity of major airports;
- Comparing various proposals of noise limit values against relevant criteria (such as the level of protection for population living in sensitive areas) and analysing the related consequences in terms of land-use and mitigation costs.

In the light of the conclusions of the working group, the Commission reported its recommendations in 1997.

### 2.3.1. Presentation of the proposals studied by the Working Group

The working group studied four sets of noise limit values. The choice of these values was influenced, among other things, by the following facts, which were derived from interviews with people exposed to air traffic noise in the vicinity of major airports:

- Generally and more exactly for noise levels up to 58-60 dB(A) Leq, the nuisance caused by air traffic is **equivalent to the nuisance caused by road traffic**.
- For housing areas (i.e. Zones II and III), **the 'limit' values for the daytime are within the 60-65 dB(A) Leq interval**. Indeed, more than 25% of the population exposed is severely disturbed when the daily average noise level is beyond the threshold of 59-62 dB(A) Leq while there is not much additional nuisance caused between 62 and 65 dB(A) Leq.
- For housing areas (i.e. Zones II and III) **the 'limit' values for the night-time are within the 50-55 dB(A) $L_{Aeq,1\ hour}$ interval**. Indeed, sleep disturbance is caused by a level of noise that is higher than 55dB(A) LAmax inside houses, and awakening is caused by a level of noise that is higher than 60 dB(A) LAmax inside houses. 60 dB(A) LAmax inside houses is equivalent to 75 dB(A) LAmax outside and depending on the number of events, it is also equivalent to a maximum level of 50-55 dB(A) $L_{Aeq,1\ hour}$ .

NB: The limit values are expressed in dB(A) $L_{Aeq,16h}$ for the 16-hour daytime period and in dB(A) $L_{Aeq,1h}$ for the night-time period. Use of the $L_{Aeq,1h}$ metric enables to control for the loudness of the noisiest event at night. Peak values, being the most disturbing, are still noticeable if combined in 1-hour averages while 16-hour averages do not allow to capture important variations.

The proposals were assessed and compared against relevant criteria such as:

1. equivalence with the nuisance caused by road traffic (evaluated for the daytime only)
2. level of protection for 'pure' and 'mixed[1]' housing areas
3. extent of the insulation programs
4. restrictions on built areas (delimitation and equipment) for 'pure' and 'mixed[1]' housing areas
5. restrictions on buildings permits for 'pure' and 'mixed[1]' housing areas
6. level of compensation in case of expropriation compared to the existing practice

[1] 'Mixed' areas as opposed to 'pure' housing areas, refer to areas with both residential housing and small businesses.

According to the above criteria, the main characteristics of Proposal A are the following:

- The proposed limit values are such that the disturbance caused by noise from air traffic is similar to the disturbance caused by noise from road traffic.
- For 'pure' residential areas, the level of protection is high, insulation measures are important, new installations on built areas are limited, building permits are restricted and in case of expropriation, the compensation is similar to the existing one.

With respect to the same criteria, Proposal D can be described as follows:

- The proposed limit values are such that the disturbance caused by noise from air traffic is not perceived as the disturbance caused by noise from road traffic.
- For 'pure' residential areas, the level of protection is low, insulation measures are poor, new installation on built areas are hardly limited, building permits are hardly restricted and in case of expropriation, the compensation is significantly lower than the existing one.

Proposals B and C are in-between options.

The following table summarises the above description of the various options:

| | Proposal A | Proposal B | Proposal C | Proposal D |
|---|---|---|---|---|
| Equivalence with the nuisance caused by road traffic (evaluated for the daytime only) | Good | Medium-bad | Medium | Bad |
| Level of protection for:<br>– 'pure' residential areas<br>– 'mixed[1]' areas | <br>High<br>Medium | <br>Medium<br>High | <br>Medium<br>Medium | <br>Low<br>Medium |
| Extent of the insulation programs for:<br>– 'pure' residential areas<br>– 'mixed[1]' areas | <br>High<br>Low | <br>Medium<br>Medium | <br>Medium<br>Low | <br>Low<br>Low |
| Restrictions on built areas (delimitation and equipment) for:<br>– 'pure' residential areas<br>– 'mixed[1]' areas | <br>High<br>Low | <br>Medium<br>Medium | <br>Medium<br>Low | <br>Low<br>Low |
| Restrictions on buildings permits for:<br>– 'pure' residential areas<br>– 'mixed[1]' areas | <br>High<br>Low | <br>Medium<br>Medium | <br>Medium<br>Low | <br>Low<br>Low |
| Level of compensation in case of expropriation compared to the existing practise | Same level compared to existing practice | -Lower for 'pure' residential areas<br>-Higher for 'mixed[1]' area | -Lower for 'pure' residential areas<br>-Similar for 'mixed[1]' area | -Largely lower for 'pure' residential areas<br>-Similar for 'mixed[1]' area |

More details about the selection of these proposals are in the reference report[1].

[1] 'Mixed' areas as opposed to 'pure' residential areas, refer to areas with both housing and small businesses.

The noise level limit values for the four proposals are presented in the table below.

| Exposure limits values in dB(A) Lr | | | | | | | |
|---|---|---|---|---|---|---|---|
| Proposal | Zones | 'Planning' value | | 'Limit' value | | 'Emergency' value | |
| | | Day | Night | Day | Night | Day | Night |
| A | Zone I | 50 | 40 | 55 | 45 | 60 | 55 |
| | Zone II | 55 | 45 | 60 | 50 | 65 | 60 |
| | Zone III | 60 | 50 | 65 | 55 | 70 | 65 |
| | Zone IV | 65 | 55 | 70 | 60 | 75 | 70 |
| B | Zone I | 50 | 40 | 55 | 45 | 60 | 55 |
| | Zone II | 57 | 47 | 62 | 52 | 67 | 62 |
| | Zone III | 57 | 47 | 62 | 52 | 67 | 62 |
| | Zone IV | 65 | 55 | 70 | 60 | 75 | 70 |
| C | Zone I | 50 | 40 | 55 | 45 | 60 | 55 |
| | Zone II | 57 | 47 | 62 | 52 | 67 | 62 |
| | Zone III | 60 | 50 | 65 | 55 | 70 | 65 |
| | Zone IV | 65 | 55 | 70 | 60 | 75 | 70 |
| D | Zone I | 50 | 40 | 55 | 45 | 60 | 55 |
| | Zone II | 60 | 50 | 65 | 55 | 70 | 65 |
| | Zone III | 60 | 50 | 65 | 55 | 70 | 65 |
| | Zone IV | 65 | 55 | 70 | 60 | 75 | 70 |

As a reminder, the four zones are defined as follows:

- Zone I: quiet areas that need special care
- Zone II: 'pure' residential area
- Zone III: 'mixed' area, including both housing and small businesses
- Zone IV: industry areas

The noise limit values finally retained and proposed by the Swiss Federal Commission are close to those proposed in the first scenario (proposal A) and are as follows:

- The proposed values are such that the noise caused by air traffic is as annoying as the noise caused by road traffic.
- They allow low nuisance at night thanks to:
  - Limit values for the time period 22:00-00:00 and 05:00-06:00 that are such that they prevent from severe sleep disturbance, and
  - The ban on commercial flights from 00:00 to 05:00.
- They take into account financial and land use constraints.

The following table summarizes these noise limit values.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Proposed Limit Values | Zone I | 50 | 40 | 55 | 45 | 60 | 55 |
| | Zone II | 55 | 50/45* | 60 | 55/50* | 65 | 65/60* |
| | Zone III | 60 | 50 | 65 | 55 | 70 | 65 |
| | Zone IV | 65 | 55 | 70 | 60 | 75 | 70 |

** The highest value is for the first hour of the night, i.e. 22:00-23:00.*

[1] 6ème rapport partiel de la Commission fédérale pour l'évaluation des valeurs limites d'immissions pour le bruit, September 1997, published by the federal Commission in charge of Environment, Forestry and Landscaping (OFEFP)

### 2.3.2. Comparison in economic terms of the various proposals

From an economic perspective, only two aspects were considered to compare the proposals:

- Insulation cost for both existing and new installations
- Financial compensation in case of expropriation

#### 2.3.2.1. Evaluation of the insulation costs for both existing and new installations

The cost of installing soundproof windows in the vicinity of Zurich-Kloten and Geneve-Cointroin airports was computed from the following data:

- **The number of people exposed** to noise levels that are higher than the 'limit' values for new installation and the 'emergency' values for existing installation. These figures were computed based on 1994's air traffic
- **The insulation cost per person exposed**: given that the number of windows to be installed per person is assumed to be three, the insulation cost is estimated at 2 872 Euros per person exposed. This cost was derived from 1997's building price indexes.

The results were as follows:

| Number of people exposed to noise levels that are higher than: | A | | B | | C | | D | |
|---|---|---|---|---|---|---|---|---|
| | Zurich | Geneva | Zurich | Geneva | Zurich | Geneva | Zurich | Geneva |
| the **'limit'** values | 58 600 | 21 100 | 48 500 | 21 000 | 40 200 | 16 200 | 22 200 | 10 600 |
| the **'emergency'** values | 16 400 | 7 400 | 12 200 | 5 000 | 8 700 | 4 500 | 3 600 | 600 |

| Cost (in Million Euros) of installating soundproof windows for: | A | | B | | C | | D | |
|---|---|---|---|---|---|---|---|---|
| | Zurich | Geneva | Zurich | Geneva | Zurich | Geneva | Zurich | Geneva |
| for new construction | 168 | 61 | 139 | 60 | 115 | 47 | 64 | 30 |
| existing construction | 47 | 21 | 35 | 14 | 25 | 13 | 10 | 2 |
| **Total** | **297** | | **249** | | **200** | | **106** | |

The total insulation cost associated with the noise limit values eventually retained was estimated at 238Million Euros.

#### 2.3.2.2. Evaluation of the compensation cost in case of expropriation

The compensation cost was computed from the following data:

- **The area (in hectares) with the potential for compensation**: this figure was computed based on the 'amount' of installation if any, the land's suitability for development and the probability of transfer. The uncertainty on this data varies from ±10% to ±30%.
- **The land value per hectare**. This figure was computed based on 1996's land values. The uncertainty on this data varies from ±35% to ±50%.

The results were as follows:

| in Hectares | | **A** | **B** | **C** | **D** |
|---|---|---|---|---|---|
| Land with buildings | Zurich | 205 | 220 | 150 | 90 |
| | Geneva | 65 | 60 | 55 | 40 |
| | Both | 270 | 280 | 205 | 130 |
| Land without buildings | Zurich | 270 | 265 | 185 | 135 |
| | Geneva | 165 | 135 | 120 | 75 |
| | Both | 435 | 400 | 305 | 210 |
| **Total** | | **705** | **680** | **510** | **340** |

| in Million Euros | | **A** | **B** | **C** | **D** |
|---|---|---|---|---|---|
| Land with buildings | Zurich | 724 | 779 | 514 | 290 |
| | Geneva | 198 | 176 | 160 | 109 |
| | Both | 922 | 954 | 673 | 399 |
| Land without buildings | Zurich | 294 | 287 | 214 | 172 |
| | Geneva | 172 | 137 | 124 | 89 |
| | Both | 466 | 424 | 338 | 262 |
| **Total** | | **1 388** | **1 379** | **1 012** | **661** |

NB: these results are based on the assumption that compensation would be awarded in any case.

The total potential compensation cost associated with the noise limit values eventually retained was estimated at **1 309 Million Euros**.

### 2.3.3. Conclusion

The evaluation and comparison of the four set of values as potential noise limit values is **community** (health) oriented.

The proposals were **assessed qualitatively against community related criteria** (e.g. impact on the quality of life) and quantitatively only in terms of **compensation** and **insulation** costs.

As opposed to the previous case studies, the approach is not based on ‘reducing noise at source’ but on ‘managing noise nuisance’.

# 3. DEFINITION OF COST AND BENEFIT INDICATORS

This part aims at defining the main points to be considered to evaluate the efficiency of a noise limit.

The section is organised as follows:

- Section 3.1 presents the **assumptions** that should be made prior to any evaluation.
- In Section 3.2 the **variables** to be used in the evaluation are identified, together with the **indicators** that could be used to describe / quantify the variables.
- **Monetarisation** issues are addressed in Section 3.3.

The results presented here are in the light of the three case studies presented above and the findings emerging from the other interviews conducted at Amsterdam and Frankfurt (see summary in **Appendix IV)**.

Yet, it must be kept in mind that noise limits values represent only one measure of a noise management policy. Therefore it is not possible to completely isolate the impact of such a measure from the impact of other measures taken as a whole.

## 3.1. Assumptions

Then, prior to any harmonization effort, some essential hypotheses must be defined:

- **The period of time** over which the CBA must be performed: for the Paris case, one scenario evaluated the impact over 10 years; for London airports, the impact was more assessed in terms of share of affected population than in terms of fleet evolution modifications (the fleet mix being presented as a fix input).
- **The reference situation** is also very important: should a noise limit be imposed as an absolute value to be reached at certain point or should it represent a relative improvement when compared to a reference situation?
- **The purpose** should be defined before initiating the analysis: benchmarking vs. historical analysis for a given airport.

## 3.2. Variables and indicators

Three main parties can be identified:

- The airport operator;
- The aircraft operator;
- The community (including welfare and neighbourhood).

Airlines and airports are “naturally” considered as the stakeholders that have to support the direct costs (fleet renewal, new runway, partial curfews, neighbouring dwellings noise insulation financing…).

For **airports**, in addition to implementation costs (e.g. monitoring equipment, upstream studies, etc), a more stringent noise limit may cause a decrease in operational capacity; yet, when it replaces former traffic volume restrictions (cf Paris case), such a cost may be balanced by an increased environmental capacity.

For **airlines**, fleet renewal costs are generally partly offset by lower operational costs (a new generation fleet being more efficient). The Paris case considered that demand non-satisfaction due to capacity restriction could be viewed as a cost, although its valuation may be difficult.

For the **community**, two major benefits can be identified: health and real estate, which can be quantified by the number of people affected, and the real estate value. On the other hand, the costs lie in the impacts of a limited airport capacity growth on the local/regional/national economy. For instance, the Paris/CDG case study took into account as impact the indirect turnover loss for shops or industries based at the airport.

The following tables summarize the various variables that have been identified as key points and the indicators that could be suitable to assess their contribution – the first and second tables are for costs and benefits respectively:

| COSTS | Variables | Indicators |
|---|---|---|
| **Airport Operator** | - Implementation<br><br>- Traffic decrease | Implementation costs:<br>- number of employees,<br>- monitoring equipment,<br>- upstream studies,<br>- maintenance<br>Number of passengers / movements |
| **Aircraft Operator** | - Fleet renewal<br>- Demand not satisfied | = Acquisition costs - sales costs<br>Revenue loss |
| **Welfare / Society** | Impacts due to limited airport capacity growth (long-term) | Δ (indirect + induced costs) |

| BENEFITS | Variables | Indicators |
|---|---|---|
| **Airport Operator** | Environmental capacity (short-term) | Number of movements |
| **Aircraft Operator** | Fleet renewal (efficiency) | Δ (operating costs) |
| **Welfare / Society** | - Health<br>- Real estate | Δ (number of people exposed)<br>Real estate value |

Regarding insulation and compensation costs, the financing party can be the airport authority, the Government, etc.

## 3.3. Monetarisation

From the previous case studies, the main findings are the following:

- It is common that **the benefits are assessed qualitatively only:** the evaluation of such variables as health, quality of life or real estate could be complex, questionable, and to another extent, lead to surprising results (e.g. no impact on the real estate value).
- Attempts were made to assess the monetary value of a few types of costs.

In the light of these results which emphasize the difficulty of making a formal CBA, it may be pertinent to follow a more simple approach.

An interesting alternative approach is to develop "***Noise performance indicators***", following the approach adopted by the UK for its London airports

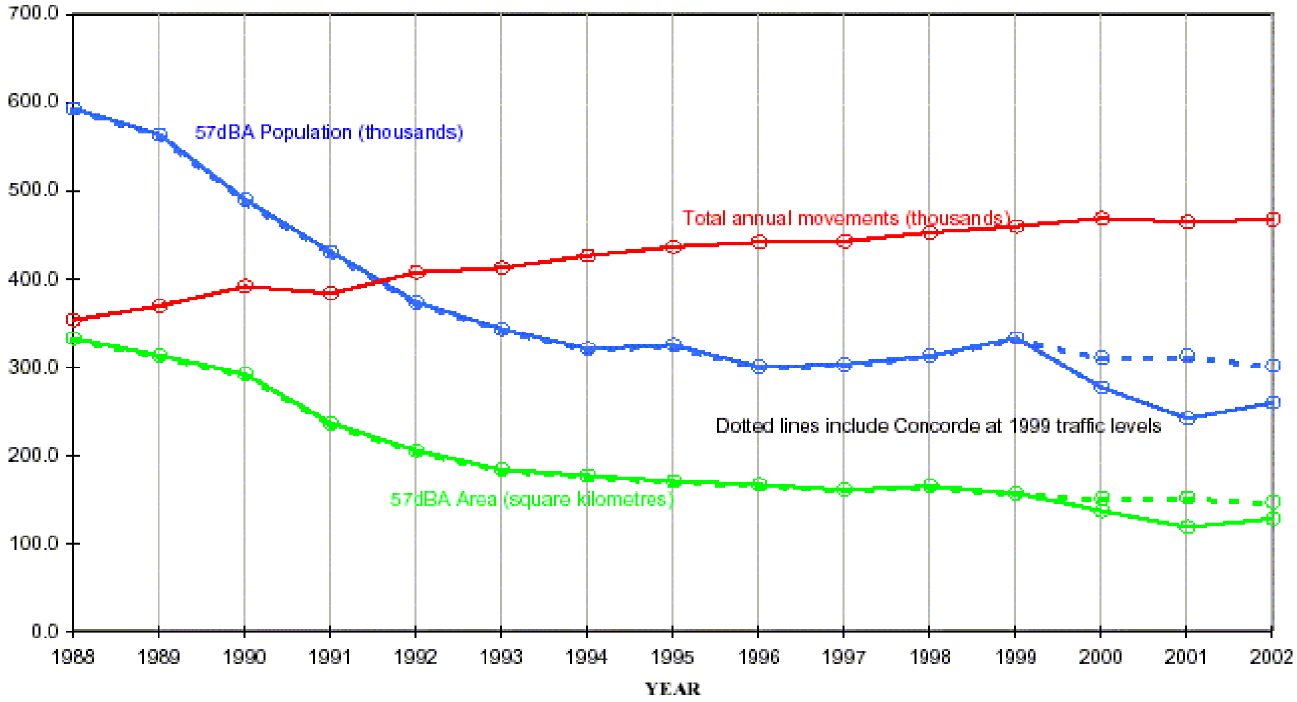
## 3.4. Alternative approach: London Heathrow

For London, the UK adopted the following three performance indicators:

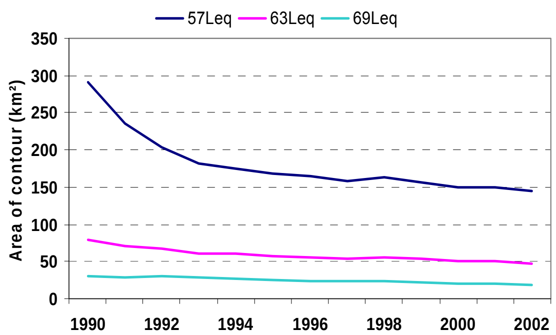
- Total annual movements growth;
- The area (in km²) of the 57 dBA Leq Noise exposure contour ;
- The population within this 57 dBA Leq contour.

When analysing the evolution of these performance indicators between 1982 and 2002 at Heathrow airport, the main findings are the following:

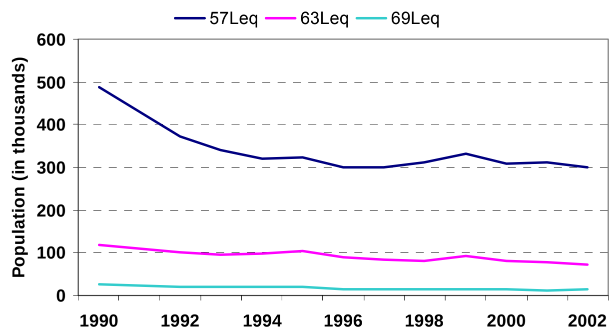
- At Heathrow, where the growth of movements is very weak, the 57 dBA Leq noise exposure area and the population within this contour have decreased significantly between 1990 and 1994. But, since 1994, very little improvement has been made, indicating that a ceiling is being reached.
- On the other hand, progress in the other areas (63 and 69 dBA Leq) remained quite limited indicating that the ceiling was reached quite early, that such an indicator may not be very relevant, and that land use planning and mitigation measures should then be the major instrument to ensure noise effects limitations on population.




**Noise Contour Area 1990-2002:**




**Population within contours 1990-2002:**

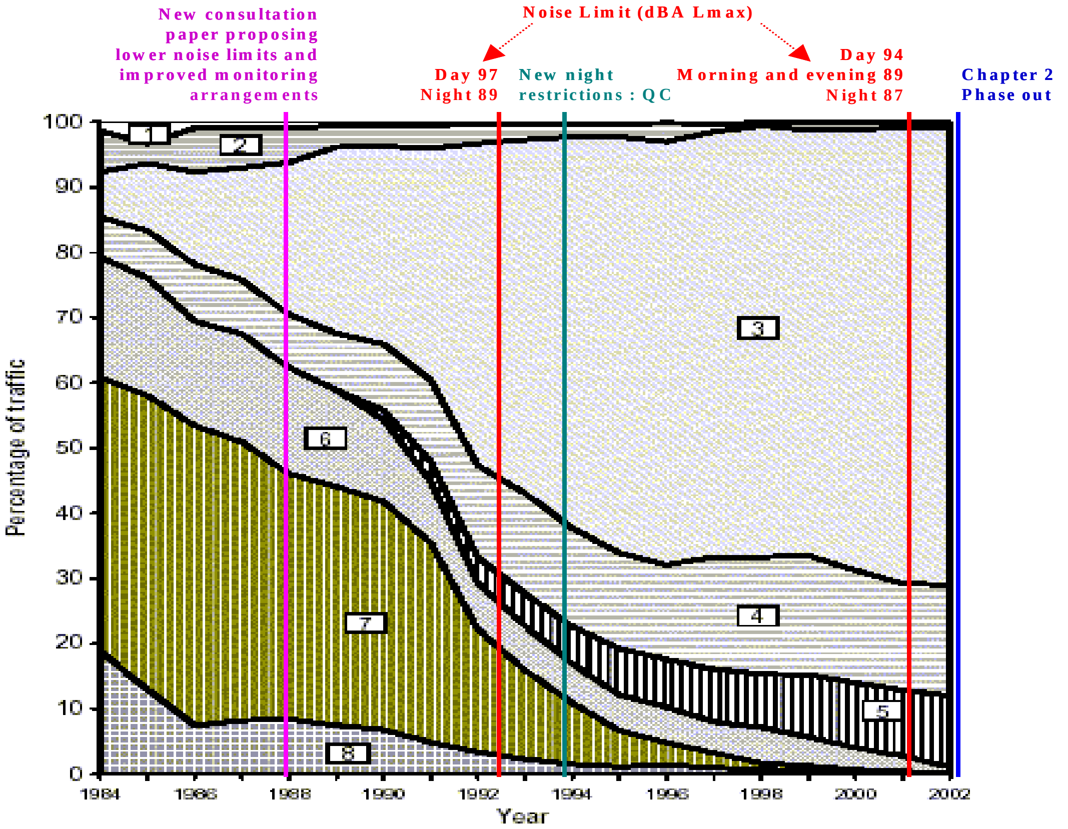


The remaining question is how the environmental capacity at Heathrow has been achieved.

- Is it the result of limitation measures such as new consultation paper or noise constraints (QC and / or Noise Limits) implementation? What kind of measures are they, and how efficient have they been?
- Reversely, did the limits come after the airlines' decision to operate quieter aircraft?
- More than implementation, it would be interesting to know when the different decisions (noise limit implementation and decision for airlines to remove their noisiest aircraft) have been exactly set. Additionally, it could be very useful to obtain information about the evolution of the fleet mix operating at an airport during the day and the night.

The following diagram presents the various measures taken regarding noise at Heathrow since 1994, together with the evolution of the fleet mix.

**Noise class of aircraft using Heathrow 1984-2002[1]**




It would be very useful in order to perform a cost benefit analysis to obtain such information from the main European airports (more than 200 000 movements per year, for example).

[1] Source : Noise exposure contours for Heathrow airport 2002, DfT. Definition of aircraft are the following :

- 1 – small props Single and twin pistons and turboprop light, business and commuter aircraft;
- 2 – large props : 2 & 4 propeller transports; e.g. 8F343, Bae, ATR42, F50, H5748, Saab 2000, Electre, Hercules, Viscount, Vanguard;
- 3 – short-haul, A320, Bae 146, B717, B737-300, B757, F100, MD-80, re-engined narrow-bodies, some business jets;
- 4 – Wide-body twins : A300, A310, A330, B767 et 777;
- 5 – 2nd gen wide-body (3 – 4 engined aircraft) : A340, MD11, B747-400;
- 6 – Large chapter 2/3 jets :1st gen wide body multis (Chapter 2 & 3) Classic 747, Trisler, DC-10, IL76, IL96;
- 7 – Narrow body twins (including huskitted versions) : F28, BAC 1-11, DC-9, B737-200 other business jets;
- 8 – 1st generation jets & concorde : eg Trident, 707, DC-8, B727, IL 62, TU154.

# 4. CONCLUSIONS

From this attempt to sketch a methodology with a view to evaluating the economic impacts caused by the implementation of noise limits, the main findings are the following:

- No formal cost benefit analysis of noise limits have been carried out for the major European airports;
- Once a limitation system is already in force, it seems difficult to evaluate the economic impacts caused by a single component of this system.
- No system can be imposed, discussions and negotiations are needed in order to gain the agreement from all air transport stakeholders;
- Most approaches until now have been based on the 'reduction at source' principle.
- Progress remains to be made for improving communication with the people living around airports as the nuisance perceived is not obviously captured by a metric value; a community oriented point of view based on 'managing noise nuisance' could be an interesting and promising approach;
- Definition of limit values for a whole set of airports is difficult to achieve;
- As the implementation of a single limit value for all aircraft operating has a significant impact on few particular aircraft types, a system based on "aircraft type specific noise limits" may be preferable;

**The main conclusion arising from this study is that, formal noise limit CBA approaches seems quite unrealistic and it would be preferable to use a set of relevant performance indicators and to monitor their evolution against the policy enforced. This would imply that a first step would consist in gathering information on these indicators for a selection of relevant airports in the light of their environmental impact (fleet mix evolution vs. noise policy history) over the longest possible reference period (10 years at least)**

# Appendix I: List of airports sheets classified by size

(***Number of movements in 2002)***

| Rank | CITY | Country | AIRPORT | Commercial Movements 2002 |
|---|---|---|---|---|
| 1 | Paris Charles de Gaulle | France | CDG | 510 098 |
| 2 | London Heathrow | UK | LHR | 466 554 |
| 3 | Frankfort | Germany | FRA | 458 359 |
| 4 | Amsterdam | NL | AMS | 417 115 |
| 5 | Madrid Barajas | Spain | MAD | 368 060 |
| 6 | Munich International, MUC | Germany | MUC | 344 405 |
| 7 | Rome Fiumicino | Italy | FCO | 282 820 |
| 8 | Zurich Kloten (Unique) | Swz | ZHR | 278 238 |
| 9 | Barcelona | Spain | BCN | 270 971 |
| 10 | Copenhagen | Denmark | CPH | 266 108 |
| 11 | Bruxels | Belgium | BRU | 256 876 |
| 12 | Stockholm Arlanda | Sweden | ARN | 245 694 |
| 13 | London Gatwick | UK | LGW | 242 380 |
| 14 | Milan Malpensa | Italy | MXP | 214 886 |
| 15 | Paris Orly | France | ORY | 211 080 |
| 16 | Vienna | Austria | VIE | 206 279 |
| 17 | Manchester | UK | MAN | 192 498 |
| 18 | Düsseldorf | Germany | DUS | 190 254 |
| 19 | Nice | France | NCE | 188 020 |
| 20 | Dublin | Ireland | DUB | 181 886 |
| 21 | Oslo Gardermoen | Norway | OSL | 180 873 |
| 22 | London Stansted | UK | STN | 170 774 |
| 23 | Geneva International | Swz | GVA | 163 839 |
| 24 | Istanbul / Atatürk International | Turkey | IST | 160 364 |
| 25 | Palma de Majorca - Son San Juan Airport | Spain | PMI | 160 312 |
| 26 | Athens - Eleftherios Venizelos | Greece | ATH | 159 463 |
| 27 | Helsinki | Finland | HEL | 156 614 |
| 28 | Hamburg | Germany | HAM | 150 271 |
| 29 | Stuttgart | Germany | STR | 149 240 |
| 30 | Cologne - Köln-Bonn | Germany | CGN | 138 902 |
| 31 | Berlin Tegel | Germany | TXL | 127 470 |
| 32 | Moscow Sheremetyevo | Russia | SVO | 124 630 |
| 33 | Marseille | France | MRS | 119 672 |
| 34 | Lyon | France | LYS | 118 569 |
| 35 | Edinburgh | UK | EDI | 118 419 |
| 36 | Lisbon | Portugal | LIS | 115 748 |
| 37 | Birmingham | UK | BHX | 115 741 |
| 38 | Milan Linate | Italy | LIN | 110 496 |
| 39 | Bâle/Mulhouse | Fr / Swz | BSL | 109 103 |
| 40 | Varsovie - Warsow Okecie | Poland | WAW | 108 885 |
| 41 | Glasgow | UK | GLA | 105 197 |
| 42 | Prague – Ruzynê | Tchequie | PRG | 103 778 |
| 43 | Malaga | Spain | AGP | 101 517 |
| 44 | Aberdeen, UK | UK | ABZ | 100 207 |
| 45 | Toulouse | France | TLS | 99 744 |
| 46 | Las Palmas | Spain | LPA | 93 787 |
| 47 | Bergen, Flesland (Norway) | Norway | BGO | 90 185 |
| 48 | Rotterdam | NL | RTM | 86 987 |
| 49 | Hanover | Germany | HAJ | 85 640 |
| 50 | Montpellier Méditerranée | France | MPL | 85 298 |

| Rank | CITY | Country | AIRPORT | Commercial Movements 2002 |
|---|---|---|---|---|
| 51 | Domodedovo International | Russia | DME | 84 102 |
| 52 | Luxembourg | Lux | LUX | 82 513 |
| 53 | London LUTON | UK | LTN | 80 927 |
| 54 | Belfast, UK | UK | BFS | 79 375 |
| 55 | East Midlands | UK | EMA | 79 143 |
| 56 | Newcastle International | UK | NCL | 78 884 |
| 57 | Budapest-Ferihegy | Hungary | BUD | 77 941 |
| 58 | Brussels South Charleroi | Belgium | CRL | 77 931 |
| 59 | Nuremberg | Germany | NUE | 77 858 |
| 60 | Liverpool John Lennon Airport | UK | LPL | 75 111 |
| 61 | Munich Augsburg (2001 traffic) | Germany | AGB | 75 000 |
| 62 | Clermont-Ferrand Auvergne | France | CFE | 73 952 |
| 63 | Jersey | UK | JER | 72 873 |
| 64 | Bristol International | UK | BRS | 72 152 |
| 65 | Bordeaux - Mérignac | France | BOD | 69 786 |
| 66 | Antalya International | Turkey | AYT | 69 225 |
| 67 | Stavanger (Norway) | Norway | SVG | 68 724 |
| 68 | Göteburg-Landvetter International | Sweden | GOT | 68 230 |
| 69 | Leeds/Bradford International | UK | LBA | 67 847 |
| 70 | Antwerp International (Belgium) | Belgium | ANR | 67 433 |
| 71 | Valencia, Spain | Spain | VLC | 67 210 |
| 72 | Venice Marco Polo | Italy | VCE | 65 849 |
| 73 | Moscow - Vnukovo | Russia | VKO | 65 759 |
| 74 | Nantes - Atlantique | France | NTE | 64 285 |
| 75 | Napoli - Capodichino | Italy | NAP | 63 682 |
| 76 | Tenerife Sur | Spain | TFS | 63 527 |
| 77 | Reykjavik - Keflavik International | Iceland | REK | 63 023 |
| 78 | Berne - Belp | Swz | BRN | 62 488 |
| 79 | Graz | Austria | GRZ | 62 465 |
| 80 | Turino International | Italy | TRN | 59 931 |
| 81 | Alicante | Spain | ALC | 59 210 |
| 82 | Stockholm-Bromma | Sweden | BMA | 58 328 |
| 83 | Salzburg W.A. Mozart | Austria | SZG | 57 405 |
| 84 | London City | UK | LCY | 56 102 |
| 85 | Bologna | Italy | BLQ | 54 950 |
| 86 | Cardiff International | UK | CWL | 49 115 |

International airports outside Europe

| | | | Movements in 2002 | Passengers (M) |
|---|---|---|---|---|
| | **Chicago O'Hare** | **USA** | 908 325 | 66,565 952 |
| | **Hong Kong International Airport HKG** | **HKG** | 218 005 | 33,873 921 |
| | **Los Angeles International Airport LAX** | **USA** | 643 309 | 56,223 843 |
| | **Minneapolis St Paul** | **USA** | 490 885 | 32,629 690 |
| | **Montreal-Dorval International Airport, YU** | **Canada** | 192 304 | 7,816 053 |
| | **Narita Airport, NRT, Tokyo, Japan** | **Japan** | 163 131 | 29,103 771 |
| | **John F. Kennedy International Airport, JF** | **USA** | 287 696 | 29,947 152 |
| | **Perth Airport, Australia, PER** | **Australia** | 73 746 | 5,143 858 |
| | **Rio de Janeiro, RIO (3 airports)** | **Brazil** | 239 238 | 11,506 957 |
| | **Sydney Kingsford Smith SYD** | **Australia** | 227 668 | 23,159 550 |

# Appendix II: Boeing database information

CODE, CITY, COUNTRY

AIRPORT CONTACT

ELEVATION

RUNWAY INFORMATION

NOISE ABATEMENT PROCEDURES (Noise Abatement Prescriptions and Procedures)

AIRPORT CURFEWS

PREFERENTIAL RUNWAYS

OPERATING QUOTA

ENGINE RUN-UP RESTRICTIONS

APU OPERATING RESTRICTIONS

NOISE BUDGET RESTRICTIONS

NOISE SURCHARGE / EMISSIONS SURCHARGE

NOISE MONITORING SYSTEM

NOISE LEVEL LIMITS

NOISE COMPATIBILITY PROGRAM

STAGE 2 RESTRICTIONS

STAGE 2 PHASE OUT

STAGE 3 RESTRICTIONS

STAGE 3 PHASE OUT

# Appendix III:
# Airport File template

| Airport identification<br>Annual commercial movements<br>Contact (environmental control) | Airport Name (Country)<br>number of ATM (in 2002) |
|---|---|
| 0. **Noise Index** | *Lmax (dB) ? LAeq ? Leq ?dBA ?* |
| **Limits in terms of noise level** | |
| 1.1 **Noise Level Limits per movement during day** | *Ex : dB at 6,5 km on runways : 94 dB between 7-23 h, theoric or measured…* |
| 1.2 **NLL per mov. on night** | *If any in use? Ex: 89 dB between 23-7h00…*<br>*monitoring way, calculation…* |
| 2.1 **Noise volume limit over a time period** | *maximum volume limit in terms of noise level (Specify if per day, season, or annual)* |
| 2.2 **Noise volume limit over a time period - specific night** | *maximum volume limit in terms of noise level during night only (specify period, ex. London Quota Count)* |
| **Limits in terms of activity, financing, operations, with consequence on noise** | |
| 3.1 **Most noisy airplanes restrictions chap 2** | *Restriction chapter 2? (EU members, was it before obligation ?)* |
| 3.2 **Chap 3 restrictions** | *Chapter 3? (delays) Which aircraft and when?* |
| 4. **Quota in terms of activity** | *Limitation in terms of Number of flights, possibly weighted by noise aircraft type characteristics* |
| 5. **Curfew (total?)** | *Yes? No? Hours? Type of aircraft?* |
| 5b. **Night Hours** | *Hours concerned by curfew or by noise tax; indicate if different depending on aircraft type* |
| 6. **Preferential runways** | *If any (in order to reduce noise) ? Yes/No, n° of runways…* |
| 7. **Noise Abatement Flight procedures** | *If special flight procedure to reduce noise* |
| 8. **Noise Zones** | *Ex : <57 dBALeq3: no restriction, 57-66: control in housing… level at a monitoring station or limit of noise production ; per movement.* |
| 8b. **Population concerned in each zone** | *(if countable for each zones)* |
| 9. **Penalties in case of overrun** | *…in € per … or else ; what is planned* |
| 10. **Noise Surtax (conditions)** | *Any? Reference and ways of calculation (% of extra / landing fee, other…)* |
| 11. **Financing of insulation** | *planned? done?* |
| 12. **Measurement system / noise monitoring systems** | *How many monitoring stations, eventually systems, where it is located…* |
| 13. **Legal base of noise control** | *Texts, references…* |
| 14. **Remarks** | *Particular case (hub or fret or …) ; quota when existing?* |

*Source: Abstracts from Boeing data base completed Sofreavia/Bipe survey*

# Appendix IV: Interviews

## REPORT OF THE INTERVIEW WITH FRAPORT AG

Mr Marx, Vice-President Environment, 10/11/03

### Noise policy and limits at Frankfurt Airport

No noise limit per single movement

No noise limit per period except during night time:

- Legal definition of night-time: 22.00 – 06.00; for the quota count system 23.00 to 05.00.
- Type of quota count system during night time based on 7 different categories of aircraft according to their MTOW (see further Table 2, page 69). A valuation of night noise is performed per season and per year based on a quota count system in relation to the above mentioned aircraft categories.
- Curfew in place: a) from 24.00 to 05.00 local time for landing of non based carriers;
  b) from 01.00 to 04.00 local time for home base carriers.

Fraport publishes:

- The Noise Report (monthly) with type levels, fleet levels and excesses for the airline companies and authorities (not for the public);
- Fluglärmreport (report on a/c noise) for the public with measuring results and many different topics in relation to aircraft noise

There is also a Noise Abatement Commissioner of the Hessian Ministry of Transport. His task is to eliminate avoidable aircraft noise by corresponding with the chief pilots of the airline companies about flight procedures, landing and take-off procedures, flap setting and other aircraft configurations.

Additionally to the landing fees, environmental protection charges are based on actual measured noise according to the following charging system:

**Table 1: Surcharge Noise Component per Aircraft Movement (in €)**

| | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Category 6 | Category 7 |
|---|---|---|---|---|---|---|---|
| Throughout the day | 0.00 | 20.00 | 44.00 | 137.00 | 292.50 | 3,000.00 | 6,000.00 |
| Night-time, Annex 16/3, 22.00 to 05.59 hrs. local time | 32.00 | 78.50 | 137.00 | 255.00 | 820.00 | 8,000.00 | 16,000.00 |
| Restriction hours, Annex 16/2* Day 1 to 7: 00.00 to23.59 hrs. local time | 32.00 | 78.50 | 137.00 | 255.00 | 820.00 | 8,000.00 | 16,000.00 |

* Only flights with special authorization and military flights

*Source: Fraport*

In addition to this noise charge per movement there is a noise protection surcharge destined for the noise insulation of houses around the airport: 0,50 € per departing passenger and 0,25 € per 100 kg of cargo.

### Night Noise Insulation Programme

The contours of the noise insulation program are defined by a combination of LAeq 55 dB and a maximum noise level of 6 x 75 dB. The target is to avoid noise events which exceed regularly 6 x 52 dB(A) "at the ear of a sleeping person".

The number of affected housing units is about 17.500, the economic volume of the program is 76 million €. On average each housing unit is supported with € 5000.00.

### Expansion Program:

The preparatory work for the building of a new north western runway is in its final stage. The final application for obtaining a building permission (10 000 pages) is about to be filed at the end of November 2003. Then starts a new period during which anybody (private individual or public entity) can submit objections to the project. The final decision lies in the hand of the State of Hesse and perhaps the Court of Justice if somebody likes to file a suit.

With the opening of the new runway a new noise policy strategy will be set in force. The details of this new policy are not available yet, but it will definitely integrate the new Lden indicator (which will extend the noise contours probably like in other airports in Europe) and a program to financially compensate the costs of insulation for new housings affected.

Impacts of the noise surcharge at night on the types of aircrafts used between 11/09/2001 and 31/12/2001:

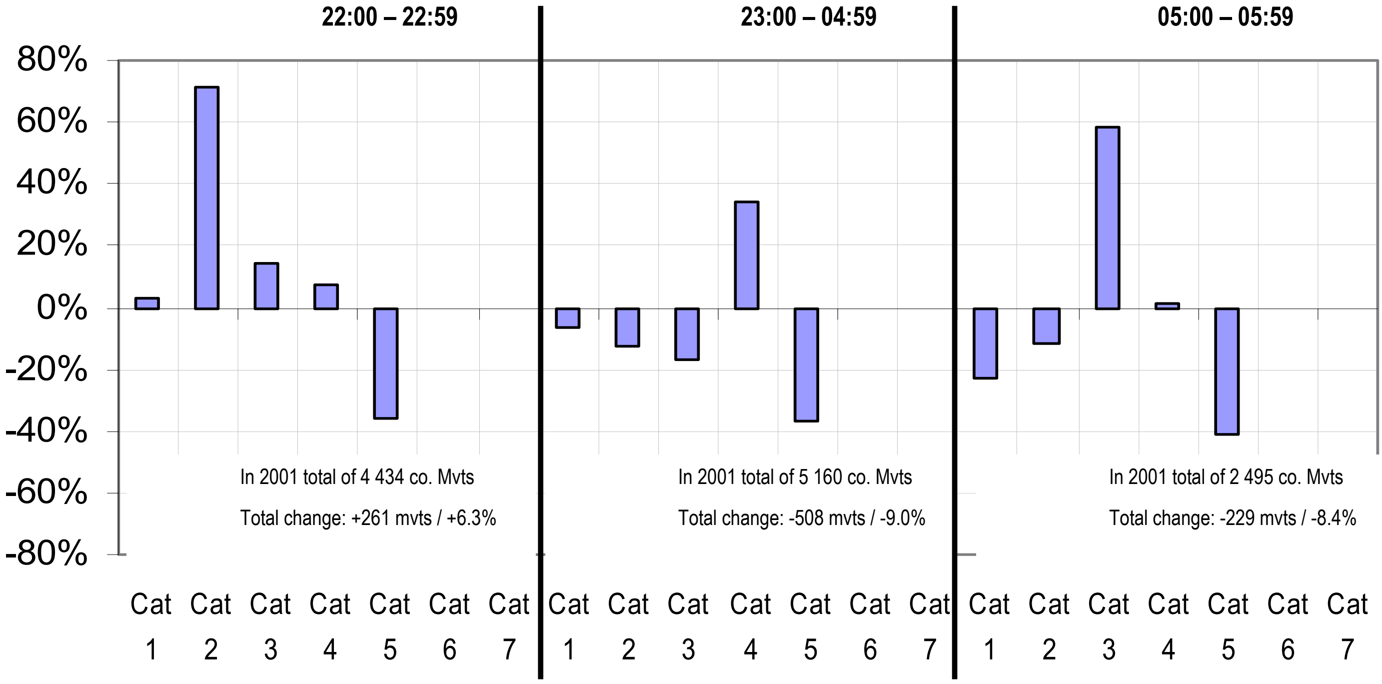


**Table 2: Classification of Turbo Jet Aircraft Licensed According to ICAO Annex 16.3, Propeller Driven Aircraft and Helicopters for the purpose of noise surcharge at Frankfurt:**

| **Category 1 : LAZ to 69.9 dB (A)** | **Category 2 : LAZ 70.0 to 73.9 dB (A)** |
|---|---|
| All chap. 3 – jets with MTOW < 34 t<br>All propeller-driven aircraft with MTOW < 34 t<br>All helicopters<br>A 319, A 320, A 321<br>AN 72/74<br>B 717<br>B 737 – 300 to – 900<br>B 757<br>Bae 146/Avro Rj.<br>C 160/ND 16 (Transall) in 2002 Category 2<br>Fokker 70/Fokker 100<br>Gulfstream IV/V<br>L 188<br>MD 90 | A 300<br>A 310<br>B 727-100 Reengined<br>B 767<br>B 777<br>C 130 (Hercules)<br>DC 6<br>IL 18<br>TU 204 in 2002 Category 1<br>YK 42/142 in 2002 Category 3 |
| **Category 3 : LAZ 74.0 to 76.9 dB (A)** | **Category 4 : LAZ 77.0 to 79.9 dB (A)** |
| A 330 in 2002 Category 2<br>A 340<br>AN 12<br>B 737-200 Hushkit in 2002 Category 2<br>DC 8-70 Serie<br>DC 9<br>IL 96<br>L 1011 (Tristar) in 2002 Category 4<br>MD 80 to MD 88<br>MD 11<br>SC 5 (Shorts Belfast) | AN 22<br>BAC 111 Hushkit in 2002 Category 5<br>B 707<br>B 727 Hushkit in 2002 Category 5<br>B 707<br>B 747-400<br>DC 10<br>TU 154 in 2002 Category 3 |
| **Category 5 : LAZ 80.0 to 82.9 dB (A)** | **Category 6 : LAZ 83.0 to 85.9 dB (A)** |
| B 747-100 to – 300<br>IL 62 | |
| **Category 7 : LAZ 86.6 dB (A) and higher** | |

*Source: Fraport AG*

**Actual and planned curfew at Frankfurt**

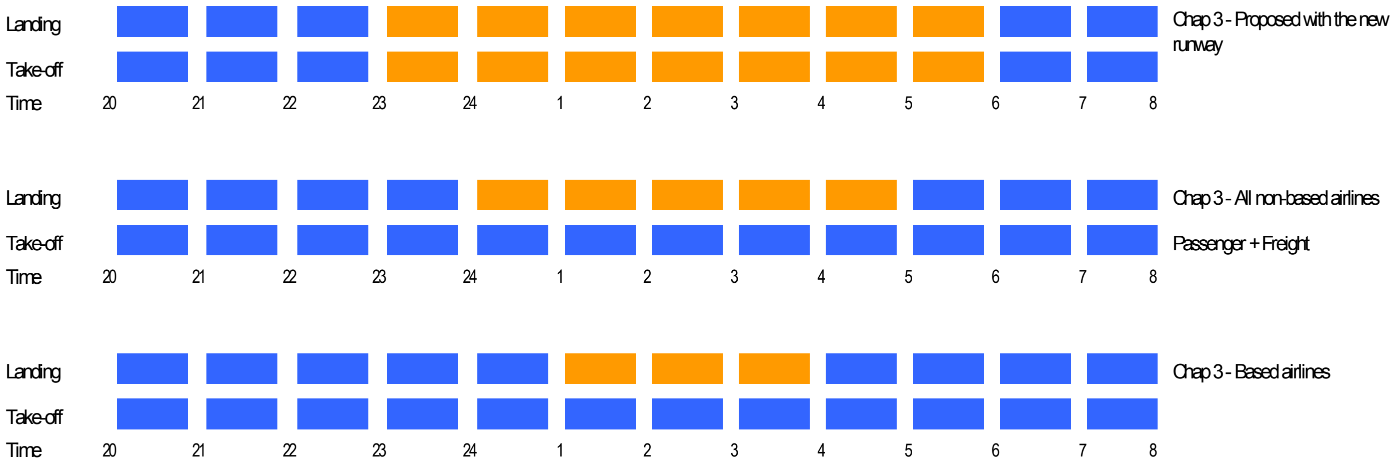
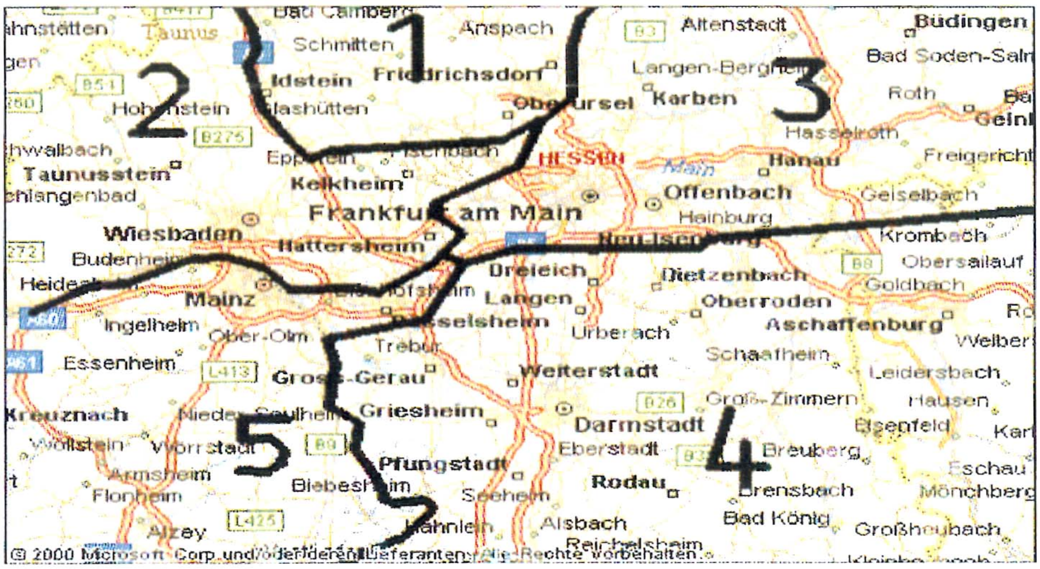



**Table 3: Complaints at Frankfurt in 2002**

| Areas | # of urban areas/cities | Population | # of complaints | # of people complaining | Av. # of complaints per person complaining | Av. Percent of people complaining over the total population |
|---|---|---|---|---|---|---|
| Hoch Taunus (1) | 12 | 114 915 | 267 415 | 411 | 651 | 0,358% |
| Taunus (2) | 29 | 753 359 | 396 120 | 1 270 | 312 | 0,169% |
| Nord – Ost (3) | 42 | 1 406 162 | 54 859 | 1 314 | 42 | 0,093% |
| Süd – Ost (4) | 47 | 897 914 | 123 467 | 1 527 | 81 | 0,170% |
| Süd – West (5) | 41 | 585 485 | 105 313 | 1 146 | 92 | 0,196% |
| **Total** | **171** | **3 757 835** | **947 174** | **5 668** | **167** | **0,151 %** |

40% of all complaints are made by 26 people!



## REPORT OF THE INTERVIEW WITH SCHIPHOL

Mr. Etienne van Zuijlen (Schiphol Goup)

Mrs. Jannie van der Pluijm (CROS – Regional Dialogue Platform)

In line with ICAO balanced approach, the Dutch Civil Aviation outlines, in its policy adopted in 1998, its dual objective of:

- Improving the quality of life around the airport: as a mean to achieve, strict environmental and safety limits leading to less nuisance to the environment of airports are defined and enforced;
- Supporting the sustainable development of airports, i.e. enabling airports to grow within the limitations.

In 2000 Schiphol airport, with a view to safeguarding its position as a main European hub, is granted the permission to grow after its proposal of building the 5th runway is proven compliant with the Government's environmental objectives. Indeed, the new runway system could permit that less aircraft are routed over densely populated areas and hence that more aircraft can operate at Schiphol.

As defined by the revised Aviation Act, a new regulatory system for controlling noise nuisance at Schiphol came into force in February 2003 and it consists of three elements:

- A limit on the total noise volume, it is an average over an operating year:

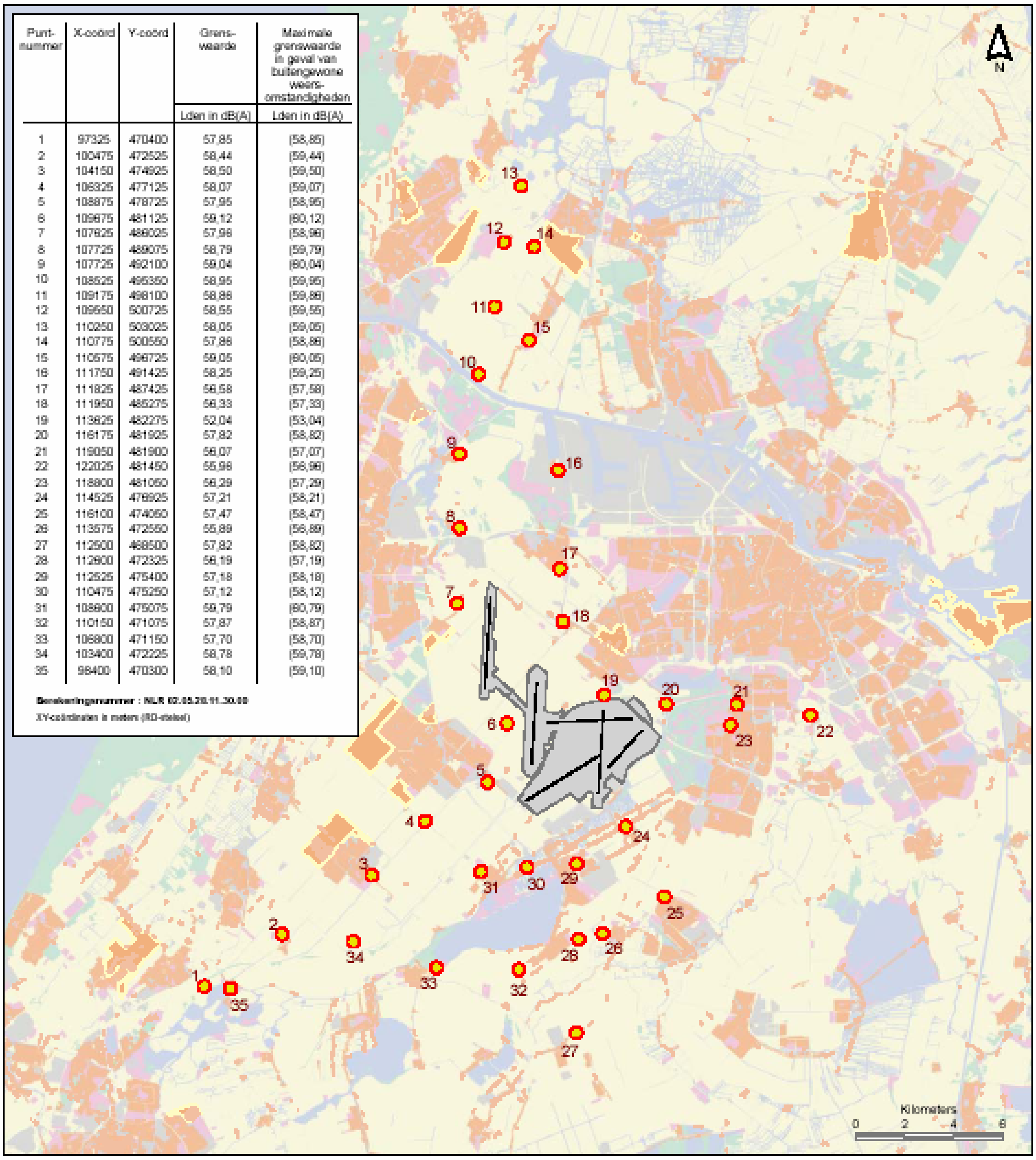
  The 63,71 dB(A) Lden and 54,44 dB(A) Lnight limits (respectively for the full 24-hour period and the 8-hour night-time period) are equivalent to those adopted by the former system, i.e. they are compliant with the former maximum numbers of dwellings to be located within the 35Ke and 26 dB(A) LAeq noise contours.

- Flight rules and regulations for the use of Schiphol airport, its runway system and surrounding airspace.
- Limits on the noise levels at certain tests points located in residential areas around the airport:

  The specific limitations for the 35/25 monitoring points (respectively for the entire 24-hour and the night-time period) have been defined in compliance to the former maximum numbers of dwellings to be located within the 35Ke and 26 dB(A) LAeq noise contours.

**Maintenance points** (Netherlands Civil Aviation Authority) **24h period**

**Luchthavenverkeerbesluit Schiphol**
Bijlage 2




| Punt-nummer | X-coörd | Y-coörd | Grens-waarde | Maximale grenswaarde in geval van buitengewone weers-omstandigheden |
|---|---|---|---|---|
| | | | Lden in dB(A) | Lden in dB(A) |
| 1 | 97325 | 470400 | 57,85 | (58,85) |
| 2 | 100475 | 472525 | 58,44 | (59,44) |
| 3 | 104150 | 474925 | 58,50 | (59,50) |
| 4 | 106325 | 477125 | 58,07 | (59,07) |
| 5 | 108875 | 478725 | 57,95 | (58,95) |
| 6 | 109675 | 481125 | 59,12 | (60,12) |
| 7 | 107625 | 486025 | 57,98 | (58,98) |
| 8 | 107725 | 489075 | 58,79 | (59,79) |
| 9 | 107725 | 492100 | 59,04 | (60,04) |
| 10 | 108525 | 496350 | 58,95 | (59,95) |
| 11 | 109175 | 498100 | 58,86 | (59,86) |
| 12 | 109650 | 500725 | 58,55 | (59,55) |
| 13 | 110250 | 503025 | 58,05 | (59,05) |
| 14 | 110775 | 500550 | 57,86 | (58,86) |
| 15 | 110575 | 496725 | 59,05 | (60,05) |
| 16 | 111750 | 491425 | 58,25 | (59,25) |
| 17 | 111825 | 487425 | 56,58 | (57,58) |
| 18 | 111950 | 485275 | 56,33 | (57,33) |
| 19 | 113625 | 482275 | 52,04 | (53,04) |
| 20 | 116175 | 481925 | 57,82 | (58,82) |
| 21 | 119050 | 481900 | 56,07 | (57,07) |
| 22 | 122025 | 481450 | 55,98 | (56,98) |
| 23 | 118800 | 481050 | 56,29 | (57,29) |
| 24 | 114525 | 478925 | 57,21 | (58,21) |
| 25 | 116100 | 474050 | 57,47 | (58,47) |
| 26 | 113575 | 472550 | 55,89 | (56,89) |
| 27 | 112500 | 468500 | 57,82 | (58,82) |
| 28 | 112600 | 472325 | 56,19 | (57,19) |
| 29 | 112525 | 475400 | 57,18 | (58,18) |
| 30 | 110475 | 475250 | 57,12 | (58,12) |
| 31 | 108600 | 475075 | 59,79 | (60,79) |
| 32 | 110150 | 471075 | 57,87 | (58,87) |
| 33 | 106800 | 471150 | 57,70 | (58,70) |
| 34 | 103400 | 472225 | 58,78 | (59,78) |
| 35 | 98400 | 470300 | 58,10 | (59,10) |

**Berekeningsnummer : NLR 02.05.20.11.30.00**

XY-coördinaten in meters (RD-stelsel)

This new system as opposed to the former one has many advantages.

It is more readily enforceable: as the new system is based on three elements which can be easily related to the responsible 'source', a clear system of control and penalty has been defined:

- The airport is responsible for ensuring that noise limits are not exceeded, both for the total noise volume and at measuring points. When a noise limit is exceeded, a penalty is imposed to the airport but the responsible party (aircraft operator) eventually pays.
- A penalty can be imposed to the Air Traffic Control (LVNL) and/or airlines when a pilot breaches the flight rules and regulations.

Using the Lden metric allows to overcome a number of disadvantages inherent to the Ke unit, in particular that of the 65 dB(A) capping (indeed, the Ke computation excludes all movements generating less than 65 dB(A)). Together with noise limits enforced in residential areas, this could enable to more accurately measure the noise nuisance actually perceived.

An evaluation is currently carried out as to whether to switch to a system based on measurement instead of calculated estimates or both for assessing noise impact in the future. Being more transparent, this system could allow an improved relationship with the community.

The new limits have been computed to be equivalent to the former existing noise constraints. Moreover, the new noise limits are based on simulated traffic scenarios, it could thus be argued that their definition is highly correlated with the decision of building the 5$^{th}$ runway. This could confirm that enforcement of noise limits does have an economic impact. Yet, an accurate quantification of the dedicated costs and benefits is unlikely.

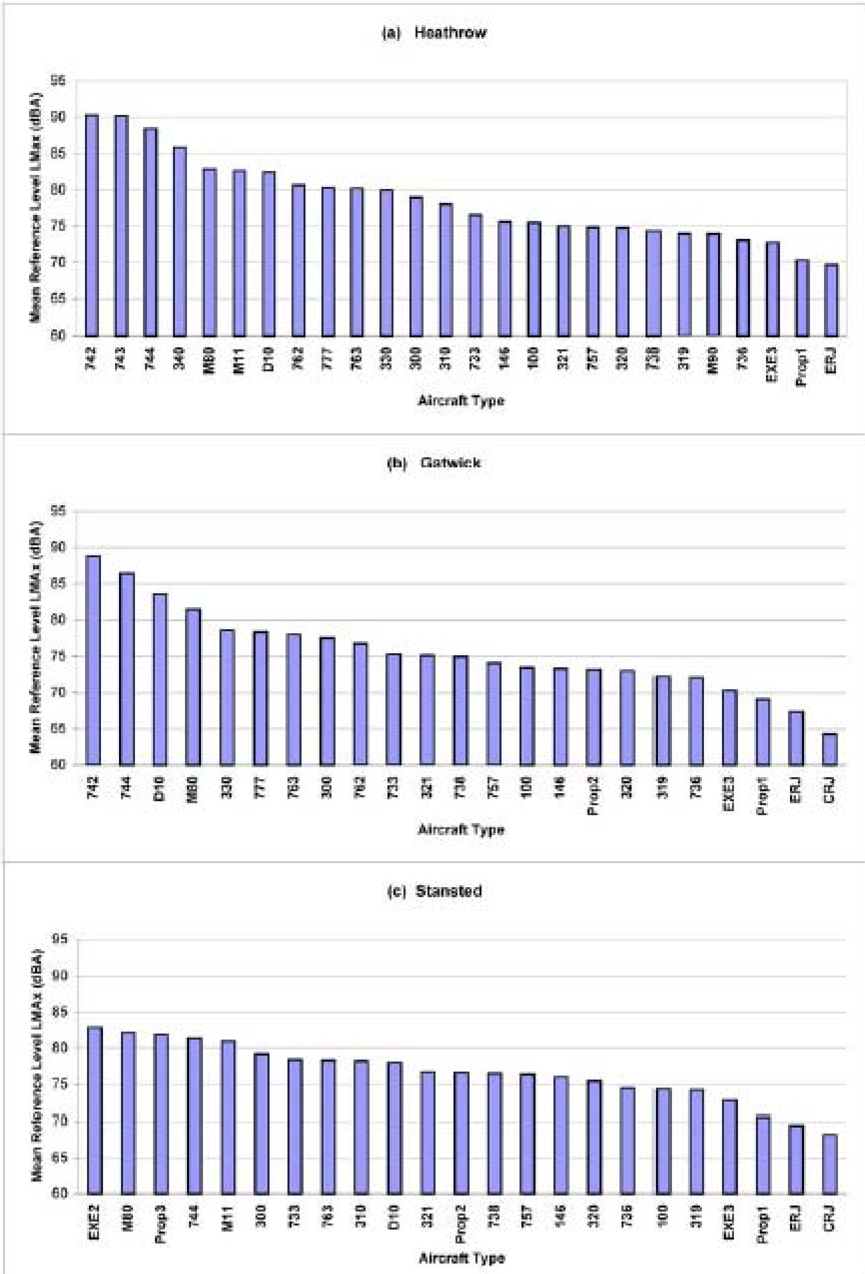
For information, due to a mistake in the initial computation, the limits do not actually reflect the real traffic schemes at Schiphol. As the implementation tool of noise limits in the Netherlands is the law, the system is not highly flexible and as a result, Schiphol airport is expected to breach the law before the end of this year if it is not changed.

# Appendix V: UK case study - additional information

## AIRCRAFT TYPE SPECIFIC NOISE LIMITS

Application of ***aircraft type specific noise limits*** requires a manageable number of homogenous clearly identified groups:

**Average Reference levels**[1]




The figure above stresses how the separation between the average reference levels of the various individual aircraft types flying at each airport remains very small.

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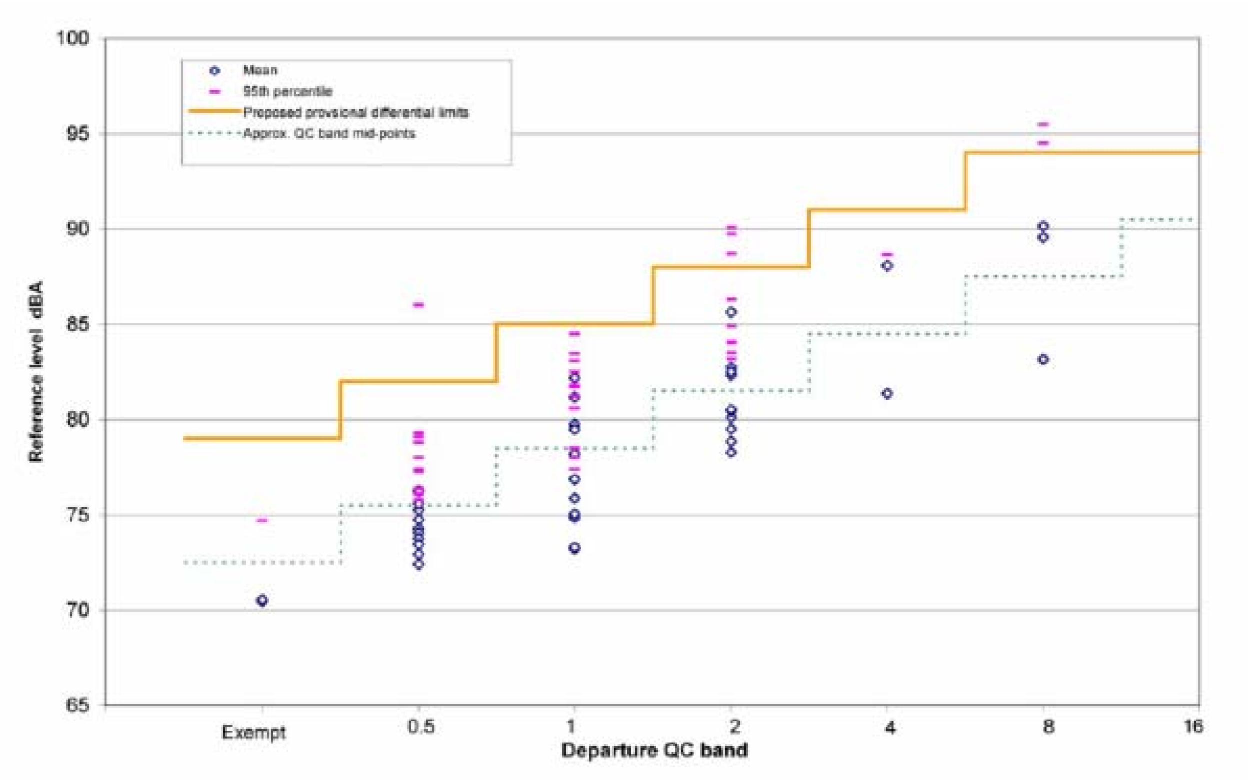
[1] Source: ERCD Report 0207: Departure Noise Limits and Monitoring Arrangements at Heathrow, Gatwick and Stansted Airports, CAA.

Then, a method of grouping aircraft, based simply on their departure QC ratings provides a suitable alternative:

- This would have the major advantage of determining the appropriate specific limit from the certificated noise levels for each aircraft;
- The QC bands being split by 3-dB wide groups, provide up to seven groups to effectively cover the range of aircraft types operating at London airports.

The figure below depicts the measured Reference levels for each aircraft type within each QC band, by showing the mean values for each type and the 95th percentile values:

**Example of aircraft type specific limits based on QC ratings: Heathrow**




This presentation underlines the possible correspondence between QC-based classification and corresponding aircraft type specific limits: a limit equal to the current daytime limit (94 dBA) applicable to QC/8 and QC/16 types, would reduced by 3 dBA in each of the lower bands down to 79 dBA for exempt aircraft.

This example shows that:

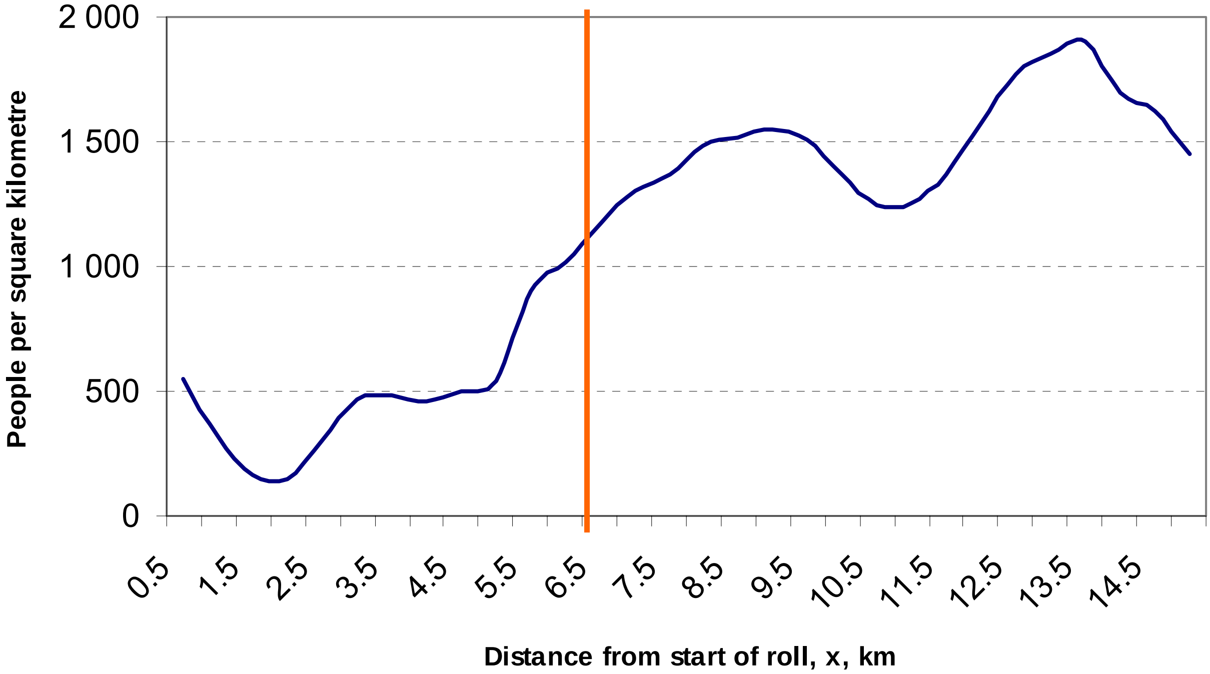
- Grouping aircraft on the basis of average measured noise levels is not realistic, because the separation between different groups is too low;
- Using departure QC bands would be more feasible to monitor, although it might generate administrative difficulties.

In line with these findings, the UK Government is contemplating the possibility to develop a Code of Practices for departure. It is also suggested that a similar working group could be set up, for instance under the auspices of ECAC/ANMAC, in order to minimise the noise impact of all departing aircraft[1].

[1] The arrivals noise Code of Practice which was a joint effort by BAA, NATS, CAA, DTLR and two representative airlines (British Airways and Airtours) has conduct to beneficial changes in the way ATC and pilots operate approaches.

Yet, the Department for Transport of UK although acknowledges that every airport world-wide may have its own approach and problems related to departure noise, so that the single focus adopted at London airports such as minimising noise at 6.5 km from Start of Roll is not appropriate everywhere: indeed, at Heathrow, this 6.5 km distance reflects the particularity of the population distribution around the airport.

**Population density (running average within corridors) at Heathrow**[1]




[1] Source: DETR, News Release, 18 December 2000.

# COST OF IMPLEMENTING THE MEASURES

| Sustainability expenditure* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Communications PR or marketing** | **Staff** | **Revenue consultancy research** | **Management & maintenance** | **Charges for consents & permits** | **Capital projects & infrastructure** | **Monitoring** | **Total spend** |
| **Noise** | **£5,600** | **£333,000** | **£28,200** | **£57,000** | **£0** | **£1,500,000** | **£5,900** | **£1,929,700** |
| Vortex | £0 | £37,000 | £0 | £0 | £0 | £2,000,000 | £0 | **£2,037,000** |
| Water quality | £0 | £0 | £43,000 | £117,000 | £55,000 | £1,600,000 | £3,000 | **£1,818,000** |
| Energy and water | £0 | £0 | £0 | £0 | £0 | £1,400,000 | £0 | **£1,400,000** |
| Air quality | £68,900 | £17,600 | £50,300 | £0 | £0 | £5,800 | £42,000 | **£184,600** |
| Landscaping and biodiversity | £9,500 | £81,000 | £0 | £313,000 | £0 | £0 | £45,000 | **£448,500** |
| Transport fund | £365,200 | £86,400 | £523,900 | £0 | £0 | £142,000 | £0 | **£1,117,500** |
| Transport (BAA Heathrow expenditure) | £169,600 | £257,000 | £190,200 | £0 | £0 | £3,000 | £0 | **£619,800** |
| Waste | £5,000 | £80,000 | £3,000 | £1,600,000 | £2,500 | £1,500 | £0 | **£1,692,000** |
| Sustainability management | £71,000 | £322,100 | £17,100 | £0 | £0 | £0 | £0 | **£410,200** |
| Social | £0 | £0 | £9,300 | £0 | £0 | £0 | £0 | **£9,300** |
| Community projects and donations | £414,500 | £172,500 | £0 | £0 | £0 | £0 | £0 | **£587,000** |
| Economic regeneration | £10,400 | £77,000 | £383,800 | £0 | £0 | £0 | £0 | **£471,200** |
| **Grand total** | **£1,119,700** | **£1,463,600** | **£1,248,000** | **£2,087,000** | **£57,500** | **£6,652,300** | **£95,000** | **£12,724,800** |

** Staff welfare and employment costs are not included.*

*Source : BAA, Creating benchmarks in sustainability 2002/2003*

# Appendix VI: Contacts

## FRANCE

**DGAC (Direction Générale de l'Aviation Civile)**
Jacques GAURAN, Airport planning and Environment Manager

**ACNUSA (Autorité de Contrôle des NUisances Sonores Aéroportuaires)**
Janine LE FLOCH FOURNIER, General Secretary
Philippe LEPOUTRE, Technical expert

**ADP (Aéroports de Paris)**
Didier HAMON, Environment Director
Thierry LAMAIRE, MSC

**Air France**
Jean-Baptiste RIGAUDIAS, General Inspection /Environmental Affairs

## GERMANY

**Fraport**
Dr Peter Marx, Vice-President Environment

## THE NETHERLANDS

**Schiphol Group**
Etienne Van Zuijlen, Manager Noise & Environmental Capacity

**CROS (Regional Dialogue Platform - Commissie Regional Overleg Schiphol Luchthaven)**
Jannie van der Pluijm

## SWITZERLAND

**Geneva International Airport**
Umbert Pocecco, Noise Management and Deputy Head of Division

**Zurich Airport Unique**
Martin Bisseger, Head of Noise Management

## UNITED KINGDOM

**DfT (Department for Transport)**
Roberta MAC WATT, Head of Branch AED2 Aircraft Noise, Aviation Environmental Division
Paul REARDON, Policy Advisor, Aviation Environmental Division;

**BAA**
Brendan CREAVIN, Noise Policy Group Manager.

# Appendix VII: Bibliography
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*** end of document ***