Environmental Research and Consultancy Department

Civil Aviation Authority

ERCD REPORT 1104

Environmental Metrics for FAS

P Havelock
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Summary

The report describes a selection of metrics that may be used to quantify and explain various environmental impacts. There are primary impacts, which can be thought of as direct environmental indicators, and also secondary measures, which are not directly related, but which may be associated with or resulting from the primary metrics. The aim of the report is to include descriptions of a selection of metrics that have been consulted upon as part of the development of the Future Airspace Strategy (FAS). It should be noted that the inclusion of such metrics in this report does not necessarily mean they are in actual use at present.

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Enquiries regarding the content of this publication should be addressed to:
Environmental Research and Consultancy Department, Directorate of Airspace Policy, Civil Aviation Authority, CAA House, 45-59 Kingsway, London, WC2B 6TE.

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Glossary of Terms

AIE Average Individual Exposure

ASK Available Seat Kilometres

CDA Continuous Descent Approach

DALY Disability Adjusted Life Years

dB Decibel units describing sound level or changes of sound level.

dBA Units of sound level on the A-weighted scale.

DEA Data Envelopment Analysis

EPNL Effective Perceived Noise Level

GTP Global Temperature Change Potential

GWP Global Warming Potential

L_{max} The maximum sound level (in dBA) measured during an aircraft fly-by.

L_{den} Equivalent sound level of aircraft noise in dBA for the 24-hour annual day, evening, and night where the evening movements are weighted by 5 dB and night movements are weighted by 10 dB.

L_{eq} Equivalent sound level of aircraft noise, often called equivalent continuous sound level. L_{eq} is most often measured on the A-weighted scale, giving the abbreviation L_{Aeq}.

PEI Person Event Index

QALY Quality Adjusted Life Years

RF Radiative Forcing

RFI Radiative Forcing Index

RPK Revenue Passenger Kilometres

SEL Sound Exposure Level

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1 Introduction

1.1 This report describes a selection of metrics that may be used to quantify and explain various environmental impacts. There are primary impacts, which can be thought of as direct environmental indicators, and also secondary measures, which are not directly related, but which may be associated with or resulting from the primary metrics. Primary impacts include:

- Noise
- Climate change
- Local Air Quality
- Tranquillity

1.2 Secondary metrics are also described, and these include health and social effects and methods of evaluating the trade-off between metrics.

1.3 Fundamental to future airspace will be the way in which the environmental impacts are considered together and in conjunction with other aspects such as efficiency and capacity. For that reason, this report begins with a discussion of three different methods that might be used in considering environmental impacts holistically. There then follows a description of a selection of metrics for use in assessing primary and secondary impacts.

2 Combining Environmental Metrics

2.1 There are a number of ways in which the environmental metrics may be combined or "traded-off". Any change in airspace may result in different environmental impacts. Those impacts may be positive or negative, large or small. Without a common standardised unit, the difficulty is how to decide whether one impact outweighs another. The following examples are ways in which trade-offs may be applied to environmental metrics.

Weighting

2.2 Weighting is the process of assigning multipliers to particular factors and then adding the weighted factors to produce an overall measure of environmental impact. Weighting is largely subjective and involves assigning larger values or emphasis to those impacts that are considered more important than others that are assigned smaller weightings. For example, a climate change metric may be assigned a weighting of 50%, with a noise metric being weighted as 30% and a local air quality metric being given a weighting of 20%. This combination of environmental metrics allows comparisons between alternative scenarios.

2.3 The weighting process is sometimes called multi-criteria analysis. A comprehensive guide on the subject originally produced by the Department of Transport is now available from the Department of Communities and Local Government (DCLG, 2009).

Monetisation

2.4 Monetisation is the use of monetary values to reflect the degree of environmental impact. The most relevant form of monetisation is hedonic pricing - a technique that identifies price factors according to the premise that price is determined both by the internal characteristics of the goods being sold and external factors affecting it. It is most commonly applied to property prices where variations between nearly identical properties reflect the value of local environmental attributes.

An example would be the value that residents are prepared to pay for a reduction of aircraft noise.

Guidance on the monetisation of environmental impact is available in HM Treasury's Green Book (HMT, 2003)

Data Envelopment Analysis (DEA)

2.5 Data envelopment analysis (DEA) is a performance measurement technique, which can be used for evaluating relative efficiency (Charnes *et al,* 1978).

2.6 DEA has been employed to compare banks, police stations, hospitals, tax offices, prisons, military bases, schools and university departments. It is a linear programming methodology to measure the efficiency of entities where multiple inputs and outputs are involved.

2.7 Input and output data are used to determine a feasible space in which alternatives lie. The outer boundary of this feasible space forms an efficient frontier on which alternatives are equivalent. Within the feasible space alternatives that lie closer to the efficient frontier are preferred to those that lie further from the frontier.

2.8 A simple example in two dimensions serves to illustrate the general idea. Two environmental impacts – noise and climate change – are shown on the axes of the graph in Figure 1. The exact metrics to be used do not affect the general principles being demonstrated. It is assumed that the greater the measure in both dimensions the less the environmental impact. Seven data points are plotted. It can be seen that points a, b, and c lie on the boundary of the feasible space and form the efficient frontier (red line). Under these definitions a, b and c are equally 'efficient'. It can also be deduced that m and n are equivalent because they both lie on a curve that is parallel to the efficient frontier (dashed blue line). It can further be deduced that m or n is preferable to x, which is in turn preferable to y using the same reasoning.

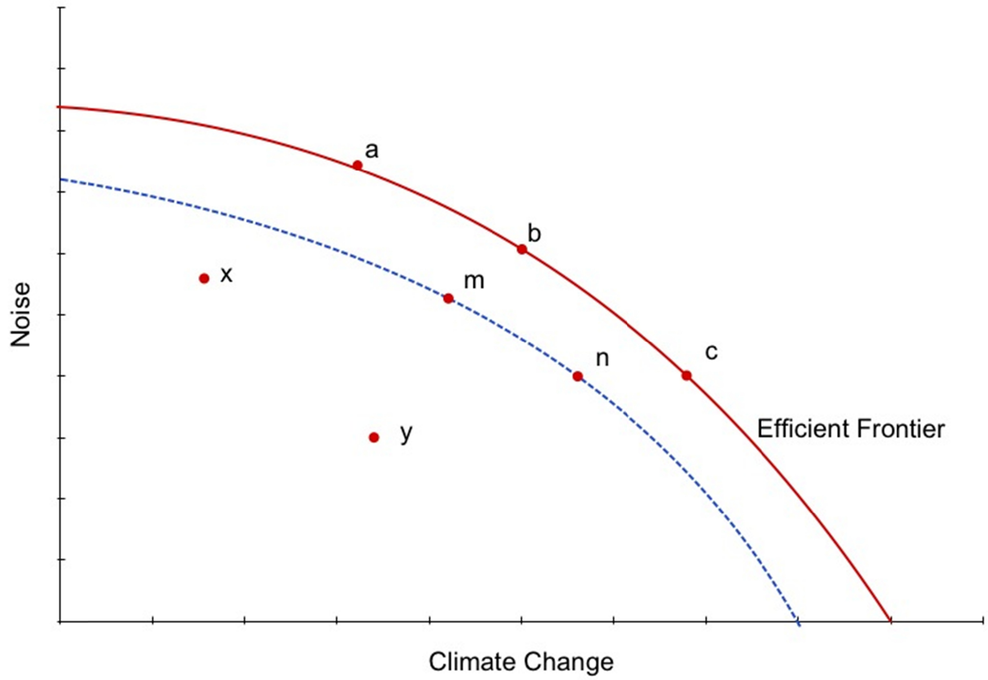

Figure 1: *An example of DEA to compare noise and climate change metrics.*

2.9 Graphical analysis of data inputs and outputs can be used to calculate efficiencies in two dimensions. Once such an analysis has been carried out it is possible to tackle, with a clearer degree of insight, issues such as:

- identification of best practice
- identification of poor practice
- target setting
- resource allocation
- monitoring efficiency changes over time

2.10 This example is limited to two dimensions considering noise and climate change but using the full mathematical linear programming technique it is possible to consider many dimensions of environmental impact.

3 Noise Metrics

3.1 Statistical

L_{90} and L_{10}

3.1.1 The levels of individual noise events are required for many purposes, including aircraft noise certification. However, in order to assess environmental noise exposure, it is necessary to consider and take account of many events over a longer term, events that may differ in magnitude and be either repetitive or isolated. Long-term aircraft noise exposure levels have been quantified in a variety of ways. These ways have been dictated partly by available instrumentation and partly by the nature of the events and their relationship to background levels, which are in turn controlled by other sources. One such measure is L_n, the sound level exceeded for n% of the measurement period. For example, in situations where the instantaneous sound level is continuously fluctuating, L_{90} and L_{10} can be used to characterise background and typical high levels respectively. Nowadays however, the most commonly used noise exposure measure for all sources is L_{eq} and, for aircraft noise, this is in widespread use around the world.

3.2 Time

Time above (TA)

3.2.1 The TA metric expresses the amount of time that aircraft noise levels are greater than a given sound level threshold. The TA is not a sound level; rather it is a time period during which noise will exceed a specified level, typically with a granularity of 0.1 minutes. The sound level threshold is expressed in decibels. The TA is a useful descriptor of the noise impact of an individual event, or for many events occurring over a certain time period.

Time Below (Respite)

3.2.2 This metric refers to the amount of time that a certain population is exposed to noise lower than a particular level deemed to result in adverse effects, for example community annoyance.

3.3 Count

N_x

3.3.1 This metric refers to ‘Number Above’ and combines information on single event noise levels with aircraft movement numbers. For example, in order to provide more meaningful information on the levels of aircraft noise exposure to the Australian public, the N_{70} metric was devised to represent ‘Number Above’ contours (Southgate et al, 2000). The N_{70} metric is easier to understand because it is an arithmetic indicator. This type of presentation can be very useful as a supplement to a L_{eq} type metric and as a communication tool.

The Person Events Index – PEI

3.3.2 The PEI allows the total noise load generated by an airport to be computed by summing, over the exposed population, the total number of instances where an individual is exposed to an aircraft noise event above a specified noise level over a given period.

The Average Individual Exposure – AIE

3.3.3 The PEI does not indicate the extent to which the noise has been distributed over the exposed population. For example, an annual PEI(70) of 2 million for an airport could mean that one person has been exposed to two million events in excess of 70 dBA (assuming this were possible), or that two million people have each received one event or it could be arrived at by any other combination of the two factors. The AIE is given by the formula:

AIE = PEI/total exposed population

3.4 Noise - *Exposure Metrics*

Equivalent continuous sound level – L_{eq}

3.4.1 L_{eq} can be defined as the hypothetical steady sound, which contains the same sound energy as the actual variable sound, over a defined measurement period, T. L_{eq} is the most commonly used noise descriptor for all types of noise source, and for aircraft noise its use is widespread across the world. L_{eq} is most often measured on the A-weighted scale (mimics the frequency response of the human ear), and usually with the averaging time indicated in the format, giving for example the abbreviation L_{Aeq}, 16 hour. For a constant level sound event, the L_{eq} remains unchanged if the duration is doubled, because the average energy is the same.

3.4.2 Aircraft noise is composed of individual noise events, therefore L_{eq} can be expressed in terms of the number of events N that occur during the measurement period T, and their logarithmic average Sound Exposure Level (SEL).

Day-Evening-Night Level – L_{den}

3.4.3 L_{den} takes account of noise throughout a 24-hour period but applies weightings for the evening and night periods to reflect the additional impact that is experienced during those two periods.

3.5 Noise - *Event Metrics*

Sound Exposure Level - SEL

3.5.1 The sound exposure level (SEL) of an aircraft noise event is the sound level, in dBA, of a one second burst of steady noise that contains the same total A-weighted sound energy as the whole event. In other words, it is the dBA value that would be measured if the entire event energy were uniformly compressed into a reference time of one second.

Quota Count – QC

3.5.2 Quota Count is a system used by Heathrow, Gatwick and Stansted Airports to limit the amount of noise generated by night-time aircraft movements.

3.5.3 In 1993 a new Quota Count system was introduced based on aircraft noise certification data. Each aircraft type is classified and awarded a quota count (QC) value depending on the amount of noise it generated under controlled certification conditions. The quieter the aircraft, the smaller the QC value is. Aircraft are classified separately for landing and take-off.

3.5.4 Airports operating the system have a fixed quota for each of the summer and winter seasons. As each night-time aircraft movement takes place, an amount of this quota is used depending on the classification of the aircraft.

3.5.5 Subject to some limited carry-over provisions, when the airport's quota has been fully used up, no more night-time movements are allowed to take place. In practice, the airport spreads the quota so that it is used evenly across the season. The quotas allocated to each airport operating the system are gradually reduced year-on-year in order to achieve long-term reductions in the impact of night-time aircraft noise.

Maximum sound level - L_{max}

3.5.6 The simplest measure of a noise event such as the over-flight of an aircraft is the maximum sound level recorded. This measure is easy to understand but takes no account of the duration of the aircraft noise event.

Effective Perceived Noise Level - EPNL

3.5.7 The noise made by a passing aircraft is complicated by its motion, which causes its intensity and frequency composition to change with time. Much research into human perception of aircraft noise led to the conclusion that PNL did not adequately reflect the true noisiness of a complete aircraft event unless account was also taken of the effects of both tones and duration. Sounds that exhibit distinct whistles and whines and/or have longer durations proved to be more annoying than simple PNL measures indicate. The modified scale developed to accommodate these parameters is EPNL, which continues to be used for setting the international noise standards by which the noise performance of jet (and most other large) aircraft is assessed in the process of noise certification.

4 Climate Change

Global Warming Potential - GWP

4.1 Global warming potential (GWP) is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale, which compares the gas in question to that of the same mass of carbon dioxide (whose GWP is by convention equal to 1). A GWP is calculated over a specific time interval and the value of this must be stated whenever a GWP is quoted or else the value is meaningless.

4.2 The substances subject to restrictions in the Kyoto protocol either are rapidly increasing their concentrations in Earth's atmosphere or have a large GWP.

Radiative Forcing – RF

4.3 In climate science, radiative forcing is loosely defined as the change in net irradiance at the atmospheric boundary between the troposphere and the stratosphere (the tropopause). Net irradiance is the difference between the incoming radiation energy and the outgoing radiation energy in a given climate system and is measured in Watts per square metre ($W.m^{-2}$) A positive forcing (more incoming energy) tends to warm the system, while a negative forcing (more outgoing energy) tends to cool it.

Radiative Forcing Index – RFI

4.4 There are several forcing agents released during aircraft operations: some contributing directly to global warming and some making indirect contributions, each of which may contribute positively or negatively to warming. To account for all of them, scientists developed the radiative forcing index (RFI). The RFI is the ratio of the total radiative forcing – the sum of positive and negative contributions to warming – relative to carbon dioxide.

ΔT

4.5 This metric refers to the change in global temperature during a given time period.

Global Temperature Change Potential – GTP

4.6 Global Temperature Change Potential (GTP) goes further than GWP and integrates RF in describing the effects of emissions: it estimates the change in global mean temperature for a selected year in the future. In other words, this metric tries to answer the question:

> What will the temperature change be in year X in response to the radiative forcing of certain GHG emissions?

4.7 GTP can be used to express future climate responses to current aviation emissions. As with Global Warming Potential, the chosen time horizon greatly influences the results: short time horizons include the warming due to short-lived emissions, whereas longer time horizons exclude those effects.

5 Local Air Quality

Mass and concentration of pollutant

5.1 Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or damages the natural environment, into the atmosphere. Pollutants can be in the form of solid particles, liquid droplets, or gases. In addition, they may be natural or man-made.

5.2 Pollutants can be classified as either primary or secondary. Usually, primary pollutants are substances directly emitted from a process, such as ash from a volcanic eruption, the carbon monoxide gas from a motor vehicle exhaust or sulphur dioxide released from factories.

5.3 Secondary pollutants are not emitted directly. Rather, they form in the air when primary pollutants react or interact. An important example of a secondary pollutant is ground level ozone, one of the many secondary pollutants that make up photochemical smog. Some pollutants may be both primary and secondary: that is, they are both emitted directly and formed from other primary pollutants.

5.4 Major primary pollutants produced by human activity include:

- Sulphur oxides (SO_x) - especially sulphur dioxide, a chemical compound with the formula SO_2. SO_2 is produced by volcanoes and in various industrial processes.
- Nitrogen oxides (NO_x) - especially nitrogen dioxide are emitted from high temperature combustion. Can be seen as the brown haze dome above or plume downwind of cities. Nitrogen dioxide is the chemical compound with the formula NO_2.
- Carbon monoxide - is a colourless, odourless, non-irritating but very poisonous gas. It is a product by incomplete combustion of fuel such as natural gas, coal or wood. Vehicular exhaust is a major source of carbon monoxide.
- Carbon dioxide (CO_2) - a greenhouse gas emitted from combustion but is also a gas vital to living organisms. It is a natural gas in the atmosphere.

- Volatile organic compounds - VOCs are an important outdoor air pollutant. In this field they are often divided into the separate categories of methane (CH_4) and non-methane (NMVOCs).
- Particulates, alternatively referred to as particulate matter (PM) or fine particles are tiny particles of solid or liquid suspended in a gas. In contrast, aerosol refers to particles and the gas together. Sources of particulate matter can be manmade or natural.
- Chlorofluorocarbons (CFCs) - harmful to the ozone layer emitted from products currently banned from use.
- Ammonia (NH_3) - emitted from agricultural processes. Ammonia is a compound with the formula NH_3.

5.5 Secondary pollutants include:

- Particulate matter formed from gaseous primary pollutants and compounds in photochemical smog.
- Ground level ozone (O_3) formed from NOx and VOCs.
- Peroxyacetyl nitrate (PAN) - similarly formed from NOx and VOCs.

5.6 DEFRA acknowledges that air pollution has a significant effect on health and has produced a simple banding index system, which is used to create a daily warning system that is issued by the BBC Weather Service to indicate air pollution levels. DEFRA has also published guidelines for people suffering from respiratory and heart diseases.

6 Tranquillity

Tranquillity Figure of Merit (FoM)

6.1 A figure of merit is a quantity used to characterize the performance of a device, system or method, relative to its alternatives. It is possible that this could be used in relation to tranquillity, by using quantifiable measures that would allow for comparisons against other areas.

Tranquillity Mapping

6.2 Tranquillity can be defined as ‘a sense of calm or quietude’ – this is the definition employed by the CAA (CAA, 2007). The Campaign to Protect Rural England (CPRE) has defined tranquillity as ‘the quality of calm experienced in places with mainly natural features and activities, free from disturbance from manmade ones’ (CPRE, 2006).

6.3 Tranquillity mapping is not a new concept. It was first developed by Simon Rendel of ASH Consulting for a Department of Transport study in 1991. The original study led to the production of a set of Tranquil Area maps covering England, produced by Rendel and ASH Consulting, and published by the (CPRE) and the former Countryside Commission (1995).

6.4 In these maps, ‘Tranquil Areas’ were defined as: ‘places which are sufficiently far away from the visual or noise intrusion of development or traffic to be considered unspoilt by urban influences’. These places were identified through specific criteria, with Tranquil Areas being found certain distances away from features such as roads, towns, airports and power stations.

6.5 Following on from this early work and critical review the concept of the naturalness of the countryside was incorporated into the measurement of tranquillity (Bell, 1999). Bell used a number of factors in assessing tranquillity:

- noise;
- visual intrusion; and
- recreational use.

6.6 Further review of this methodology, while acknowledging the benefit of simplicity, criticised this method because it neglected how individuals perceived tranquillity.

6.7 The latest method of tranquillity mapping is underpinned by research that explored what tranquillity means to people and why it is considered to be important. It uses the relatively novel technique of participatory appraisal. The results from this research were used to generate tranquillity maps for England. The maps are constructed from layers of information based on what people say adds to and detracts from tranquillity. Maps show the positive or negative impact on tranquillity of natural landscape, birds/wildlife, open spaces, transport including aircraft, light pollution, towns/cities, large numbers of people and pylons/power lines/masts/wind turbines.

Probability of Detection

6.8 This refers to the likelihood that an aircraft will be noticed in a tranquil area, either by visual intrusion, or by noise. At present, there is no standardised metric for this.

ΔANEs – Aircraft Noise Events (background)

6.9 This measure refers to the changes in background noise level, due to variations in ANEs throughout a given period of time. Changes in overall background noise can be measured, and a more accurate figure of the percentage of background noise that is attributable to aviation can be calculated.

Number of Aircraft within Set Distance

6.10 This metric refers to the number of aircraft that overfly a tranquil space, that are equal to, or above a designated altitude, to reduce noise and/or visual intrusion for those people on the ground.

7 Secondary Metrics

Productivity

7.1 In this context, productivity of the airline operator relates to local air quality or climate change effects due to fuel burn efficiency etc. Along with the number of flights, measures such as Revenue Passenger Kilometres (RPK) and Available Seat Kilometres (ASK) can also be used to provide insight to productivity.

Revenue Passenger Kilometres (RPK)

7.2 A revenue passenger-kilometre is flown when a revenue passenger is carried one kilometre. A passenger for whose transportation an air carrier receives income is called a revenue passenger.

Available Seat Kilometres (ASK)

7.3 ASK measures an airline's carrying capacity. It is: seats available × distance flown.

This number can be calculated per plane, but is usually quoted per airline. A seat-kilometre is available when a seat that is available for carrying a passenger is flown one kilometre. Seats that are not usable for various reasons are excluded.

Health and Social Effects

7.4 The health effects of aircraft noise have been extensively researched, and it is a growing area. Although not a direct environmental output, health and social effects do exist as a result of primary environmental measures such as noise and air pollution. In particular, the areas of sleep disturbance, health (cardiovascular and respiratory) and children's cognition are found to be important.

Children's Learning Deficiency (weeks)

7.5 This refers to the number of weeks, relative to children who are not exposed to aircraft noise, that children who are exposed to aircraft noise are cognitively impaired by. Studies such as the West London Schools study (Matsui et al, 2004), and the RANCH project (Stansfeld et al, 2005), have investigated the links between aircraft noise exposure, stress responses, mental health and cognitive performance in school children.

7.6 Children's learning deficiency in terms of number of weeks' impairment could provide a useful metric, especially when considering the placement of new schools or changes in flight routes that may result in aircraft flying over schools. It is not currently a standardised metric, and would probably require further research in order to produce a standard dose-response relationship.

Number of Awakenings

7.7 This metric relates the aircraft noise level at night, with the number of awakenings experienced by the sleeping population. In general, awakenings in this context are measured against Sound Exposure Level (SEL). Electroencephalogram (EEG) recordings are used to measure changes in sleep state, and awakenings, although the more inexpensive and less invasive method of actigraphy has been found to be a good predictor of awakenings also.

7.8 Some laboratory studies have associated awakenings with noise events as low as 40 dBA L_{max}, while some field studies show very few awakenings at indoor levels of 60 dBA L_{max}. These differences are believed to reflect important effects of familiarity and habituation: people sleep more soundly at home in their normal surroundings. These uncertainties mean that it is difficult to derive definitive noise exposure criteria governing sleep disturbance. Given that some effects have been measured in the laboratory at levels from about 30 dBA L_{eq}, it has been argued that to avoid any negative effects, exposure levels inside the bedroom should not exceed this threshold. It is generally agreed that, in the home, the effects of familiar events would be small when below indoor event levels of about 45 dBA L_{max}. Awakenings would be infrequent below 55 dBA L_{max}. All these levels apply to indoor conditions. If sleep effects are being related to outdoor sound levels, then about 15 dB should be added in the case of partially open windows and about 25 dB for closed windows.

Odds Ratio – Hypertension

7.9 An odds ratio is calculated by dividing the odds in the treated or exposed group by the odds in the control group. The odds is a way of presenting the probability of an event represented as a ratio of the probability of that of the event occurring to that of it not occurring. Epidemiological studies generally try to identify factors that cause harm - those with odds ratios statistically significantly greater than one.

7.10 Perhaps the most publicised study to examine the effects of aircraft noise on hypertension in recent years is the HYENA study (Hypertension and Exposure to Noise near Airports) (Larup *et al,* 2007). A total of 4861 people participated in the study, in an age range of 45-70 years old, with a minimum length of residence of five years, living near one of six major European airports (London Heathrow, Berlin Tegel, Amsterdam Schiphol, Stockholm Arlanda, Milan Malpensa and Athens Elephterios Venizelos airport). The selection process created exposure contrast to aircraft noise and road traffic noise within countries, ensuring that sufficient numbers of inhabitants in the appropriate age range had expected exposures > 60dBA and < 50dBA.

7.11 The results from the HYENA study indicated that there were significant exposure response relationships between exposure to night-time aircraft noise exposure, daily average road traffic noise and risk of hypertension. The authors highlighted that the higher risk for night-time noise may be a consequence of less misclassification of exposure during the night (i.e. participants are more likely to be home during the night). They suggest that the higher night-time risks may also be explained by acute physiological responses induced by night-time noise events that might affect restoration during sleep. Overall, the conclusions from the HYENA study were that the increased risk of hypertension in relation to aircraft and road traffic noise near airports might contribute to the burden of cardiovascular disease. The authors suggested that that preventative measures should be considered to reduce road traffic noise and night-time noise from aircraft.

Quality Adjusted Life Years/Disability Adjusted Life Years (QALY/DALY)

7.12 The quality-adjusted life year (QALY) is a measure of disease burden, including both the quality and the quantity of life lived. It is used in assessing the value for money of a medical intervention. The QALY is based on the number of years of life that would be added by the intervention (e.g. by the reduction or elimination of aircraft noise). Each year in perfect health is assigned the value of 1.0 down to a value of 0.0 for death.

7.13 The disability-adjusted life year (DALY) is a measure of overall disease burden. Originally developed by the World Health Organization, it is becoming increasingly common in the field of public health and health impact assessment (HIA). It extends the concept of potential years of life lost due to premature death to include equivalent years of ‘healthy’ life lost by virtue of being in states of poor health or disability, for example with chronic exposure to aircraft noise-induced hypertension. In so doing, mortality and morbidity are combined into a single, common metric.

7.14 The DALY relies on an acceptance that the most appropriate measure of the effects of chronic illness is time, both time lost due to premature death and time spent disabled by disease. One DALY, therefore, is equal to one year of healthy life lost.

Percentage Highly Annoyed (%HA)

7.15 It is possible to calculate the numbers of people who would be 'highly annoyed' by particular levels of aircraft noise exposure by using L_{eq} contours and a well established response relationship known as the Schultz curve (Schultz, 1978). The Schultz curve is S-shaped in form and shows aircraft noise level on the horizontal axis and the percentage of highly annoyed people as described by social survey on the vertical axis. It shows that the incidence of highly annoyed people is low at low levels of aircraft noise and the curve is relatively flat at these levels. At progressively higher noise levels, the proportion of highly annoyed people grows steadily, so the slope of the curve increases. At higher levels of aircraft noise the curve begins to flatten, until at very high levels of aircraft noise the curve is nearly flat at 100% i.e. at these levels, everyone is said to be highly annoyed by aircraft noise.

Complaint Levels

7.16 The number of complaints recorded in relation to aircraft noise can be a useful indicator of the level of annoyance experienced by local residents. This is not currently a standardised environmental outcome, but may be a useful supplementary measure. It is susceptible to manipulation through orchestrated campaigns aimed at increasing complaint levels and bias.

Aircraft

Time Held on Ground

7.17 This measure refers to the time an aircraft is spent being held on the ground prior to take-off. This may be a useful means of assessing delayed flights and refers to the time between engine strike-up and take-off. Clearly the longer this period takes, the more fuel is burnt, more emissions are produced, and efficiency is compromised.

Time in Stack

7.18 The time an aircraft is spent being held in a stack may be used as an outcome measure. The longer the time spent in a stack means increased flight times, increased fuel burn and emissions etc. Time in stack may be viewed as a measure of efficiency, i.e. ideally there would be no need to be held and the aircraft would descend and land normally.

Percentage on Track

7.19 This refers to the percentage of aircraft that remain within the designated flight path. The higher the number of flights adhering to the flight path means there is less dispersal of aircraft noise.

Percentage Continuous Descent Approach (% CDA)

7.20 Continuous Descent Approach (CDA) or Optimized Profile Descent (OPD) is a method by which aircraft approach airports prior to landing. It is designed to reduce fuel consumption and noise compared with a conventional approach and involves avoiding level segments during the approach phase of flight.

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