Environmental Research and Consultancy Department

Aviation Strategy: Noise Forecast and Analyses

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Revision History

Version 2 February 2019

This version includes the correction of Luton Airport noise metric results for 2016, 2025, 2030, 2040 and 2050. These corrections present a very small variation to the overall results presented in Version 1 and do not influence the analysis undertaken in this report. A comparison of main results from both versions is presented in the table below.

Comparison of Version 1 and Version 2 main results - High forecast results with population growth

KPI type	Period	Threshold	Version 1 % change 2016-2050	Version 2 % change 2016-2050
Traffic	Average summer day 16h ATMs	-	+39.2%	+39.3%
	Average summer night 8h ATMs	-	+35.4%	+34.1%
Noise emission	Average summer day 16h QC	-	-22.2%	-22.2%
	Average summer night 8h QC	-	-30.4%	-30.7%
Area exposure	Average summer day LAeq16h	>54	-10.2%	-10.1%
	Average summer night LAeq8h	>48	-10.8%	-11.2%
	Average annual 24h Lden	>55	-8.7%	-8.8%
	Average Annual 8h Lnight	>50	-12.4%	-13.0%
Population exposure	Average summer day LAeq16h	>54	+1.7%	+1.8%
	Average summer night LAeq8h	>48	-7.8%	-7.8%
	Average annual 24h Lden	>55	+0.4%	+0.3%
	Average Annual 8h Lnight	>50	+1.5%	+1.8%
	Average summer night 8h N60	>10	+12.0%	+11.7%
	Average summer day 16h N65	>10	-0.7%	-0.5%
	Average summer day 16h N70	>10	-21.6%	-21.5%
	Average Individual Exposure (70)	At least 10 events per 16h day	+20.9%	+20.0%
	Person Events Index (70)	At least 10 events per 16h day	+16.4%	+16.5%
Noise impact	No. of people highly sleep-disturbed Average Annual 8h Lnight	>45dB Lnight	-3.2%	-3.3%
	No. of people Highly annoyed (daytime) Average annual 24h Lden	>54 dB Lden	+0.3%	+0.5%

Executive Summary

The Department for Transport is developing a new Aviation Strategy and, in support of the strategy, commissioned the CAA to undertake analyses of airport noise forecasts and consideration of how airport noise may be limited. This report presents a feasibility study of implementing airport noise limits nationally and locally, including consideration of the pros and cons that noise limits may create. To inform the consideration of noise limits, it uses DfT aviation growth forecasts to estimate the level of aircraft noise in the shorter/medium term (2025) and in 2030, 2040 and 2050. The report also includes two sensitivity analyses to understand what the effect would be if older aircraft were replaced at a faster rate and also if the rate of technology improvement was accelerated.

A review of suitable noise metrics, targets and limits relating to aircraft noise exposure and their associated effects on limiting noise emission, exposure and health impact was undertaken. The limits review considered ways to limit noise emission at source, the area exposed around an airport, the population exposed within that area, and their associated health impacts, from which a reduced set of metrics was selected for detailed analysis.

The noise around an airport varies over time, primarily depending on aviation growth rates, and the introduction of quieter aircraft. Over the last 30 years there has been a significant reduction in noise exposure around virtually all UK airports. However, after the recession of 2009, which was followed by sustained growth, noise exposure has grown over the past five years at several airports. In order to inform a consideration of noise metrics and potential targets and limits, noise analysis was undertaken for eight airports (Birmingham, Edinburgh, Glasgow, London Gatwick, London Heathrow, Luton, Manchester and Stansted), for two historical years (2006 and 2016) and the following forecast years: 2025, 2030, 2040 and 2050. The forecast analysis takes into account the adoption of the Airports National Policy Statement (NPS) and assumes a third North West Runway (NWR) at Heathrow is built by 2030.

The analysis of the 2006 and 2016 noise performance was undertaken to review the application of different limits and to understand the implications of changing noise emission (quota), contour area, population exposure, and noise impacts over the past ten years.

The forecast analysis for 2025, 2030, 2040 and 2050 was undertaken to identify the effect of different limits in relation to modelled traffic growth, in order to understand the implications and opportunities for reducing noise generation, population exposed and noise impacts. Central and high scenarios were used in the analysis based on the latest UK Aviation Forecasts. A summary of the high scenario analysis covering the total for all airports is presented in Table (a). The results presented use a population growth per CACI forecast data.

Table a: Summary of noise metric results with population growth including a third NWR runway at Heathrow, Scenario: HIGH

			Year						
Metric	**Period**	**Level**	**2006**	**2016**	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
Traffic (ATMs)	Average summer day 16h*	-	4349.5	4311.6	4513.3	5337.5	5670.1	5999.6	+39.2%
	Average summer night 8h*	-	454.3	505.7	533.9	601.1	642.1	684.9	+35.4%
Noise emission (Quota Count)	Average summer day 16h* QC	-	2696.7	2478.2	2462.9	2622.1	1970.9	1927.4	-22.2%
	Average summer night 8h* QC	-	301.3	291.8	252.1	258.6	197.7	203.1	-30.4%
Area exposure (Km^2)	Average summer day LAeq16h*	>54 dB	530.4	491.6	498.9	524.7	441.6	441.5	-10.2%
	Average summer night LAeq8h*	>48 dB	419.6	462.6	450.3	462.4	401.8	412.4	-10.8%
	Average annual 24h Lden	>55 dB	615.6	572.2	579.9	607.3	518.0	522.3	-8.7%
	Average annual 8h* Lnight	>50 dB	268.0	251.2	239.2	251.0	213.5	220.0	-12.4%
Population exposure (Numbers exposed to noise level)	Average summer day LAeq16h*	>54 dB	825,400	783,500	804,000	846,500	771,800	796,600	+1.7%
	Average summer night LAeq8h*	>48 dB	521,700	648,600	595,600	580,800	552,400	597,700	-7.8%
	Average annual 24h Lden	>55 dB	997,300	948,400	961,000	1,004,400	920,200	952,600	+0.4%
	Average annual 8h* Lnight	>50 dB	304,600	321,600	285,500	306,700	297,200	326,500	+1.5%
	Average summer night 8h* N60	>10 events	1,215,900	1,462,900	1,446,700	1,616,400	1,574,600	1,638,200	+12.0%
	Average summer day 16h* N65	>10 events	2,449,500	1,965,400	2,122,600	2,143,400	1,942,700	1,951,600	-0.7%
	Average summer day 16h* N70	>10 events	974,600	838,700	878,000	793,800	674,300	657,600	-21.6%
	Average Individual Exposure (70)	>10 events	61.8	79.6	81.3	85.0	88.9	96.2	+20.9%
	Person Events Index (70)	>10 events	64,098,100	69,591,900	75,735,500	83,538,100	75,572,000	80,995,400	+16.4%
Noise impact (Numbers exposed to noise level)	Highly sleep-disturbed average annual 8h* Lnight	>45 dB Lnight	73,800	78,300	74,000	76,000	71,600	75,800	-3.2%
	Highly annoyed (daytime) average annual 24h Lden	>54 dB Lden	180,500	173,000	173,600	182,800	168,000	173,600	+0.3%

*16h: 0700-2300 and 8h: 2300-0700

The results show that from 2006 to 2016, noise emission (QC) and noise contour areas have decreased. Population exposure has, in some cases, not followed the same trend due to the growth in population within the noise contours between the two years.

For the forecast years, the results show that noise emission and noise contour areas are expected to reduce, however the population exposure, the number of Highly annoyed people and the number of Highly sleep-disturbed people are forecast to increase, when accounting for the forecast growth in population from 2016 onwards. Some differences are seen between different noise exposure indicators, for example N70 decreases, whilst PEI(70) and AIE(70) increase, reflecting the growth in movements by quieter aircraft. Care must, however, be used when interpreting AIE results – the 20% increase in AIE reflects the decreasing population within N70 contours over time and therefore does not represent an average resident's number of events above 70dB L_{Amax}.

When a static population was considered from 2016 onwards, the population exposed decreased in line with noise contour area reductions. Impacts are also forecast to reduce, with the number of Highly annoyed people decreasing by 18.5% and the number of Highly sleep-disturbed people decreasing by 24.3%, assuming no population influx into the noise contour areas.

In order to recommend appropriate noise limits, an analysis was undertaken to determine the correlation between all metrics and their ability to limit the amount of noise emitted, the area exposure or ability to control the number of people Highly annoyed or Highly sleep-disturbed.

In order to address the Aviation Policy Framework objective to "limit and where possible reduce the number of people in the UK significantly affected by aircraft noise" and take into account the latest UK airspace policy noise objectives to "limit and, where possible reduce the number of people significantly affected by the adverse impacts from aircraft noise", the proposed limit scheme would contain the following:

1) A nationally set absolute Quota Count limit or noise contour area limit at a particular noise level for both day and night, aggregated across all major airports;
2) A locally set absolute Quota Count or noise contour area limit at a particular noise level for both day and night for each airport;
3) Local monitoring of the number of highly annoyed and highly sleep disturbed people; and
4) Reporting requirements.

A sensitivity analysis on two of the forecast noise technology assumptions was also undertaken to assess the impact of a faster substitution of quieter aircraft into the forecast fleets and of a faster rate of technology improvement.

Chapter 1

Introduction

The Department for Transport is developing a new Aviation Strategy and commissioned the CAA to undertake four analyses in support of the strategy: airport noise forecasts, a consideration of how airport noise may be limited, the effect of emerging aviation technologies on future noise exposure and to investigate the potential role that ambient (background) noise plays in attitudes to aircraft noise. This report covers the first two items and presents a feasibility study of implementing airport noise limits nationally and locally, including consideration of the pros and cons that noise limits may create. To inform the consideration of noise limits, it uses DfT aviation growth forecasts to estimate the level of aircraft noise in the shorter/medium term (2025) and in 2030, 2040 and 2050. The report also includes two sensitivity analyses to understand what the effect would be if older aircraft were replaced at a faster rate and also if the rate of technology improvement was accelerated.

Aviation noise has been a major global issue for decades and ICAO's balanced approach to noise management[1] sets four pillars for noise reduction: 1) reduction of noise at source through technological improvements to aircraft; 2) land use planning; 3) better operational practices; and 4) operating restrictions on aircraft. There is evidence that public sensitivity to noise has increased[2], and this should be considered.

Globally, there has been a shift towards implementing noise limits at airports in order to reduce noise. These limits are usually aimed at reducing either noise generation (e.g. quota count at Madrid Airport), noise exposure (e.g. contour area limits at Heathrow and Stansted; noise level in Paris; Person Event Index at Sydney Kingsford Smith Airport) or noise impacts (e.g. contour shape and Number of People Annoyed at Amsterdam Schiphol).

The UK Government has set out in the Aviation Policy Framework[3] its overall objective on noise, which is to "limit and where possible reduce the number of people in UK significantly affected by aircraft noise" and the new UK airspace policy[4] noise objective to "limit and, where possible reduce the number of people significantly affected by the adverse impacts from aircraft noise". Aircraft are getting quieter, but growth in movements can

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1 ICAO Doc. 9829, "Guidance on the Balanced Approach to Aircraft Noise Management", Second Edition, ICAO, 2008.

2 "Survey of noise attitudes 2014: Aircraft, CAP 1506, CAA, February 2017.

3 Aviation Policy Framework, Cm 8584, Department for Transport, ISBN: 978-0-10185-842-7, March 2013.

4 "Consultation Response on UK Airspace Policy: A Framework for balanced decisions on the design and use of airspace", Department for Transport, October 2017.

counterbalance these improvements in terms of the population exposed to noise and in terms of noise impacts. There is an expectation that airports make particular efforts to mitigate noise where changes are planned, as presented in the Airports Commission final report[5] and Airports National Policy Statement[6] where a consultation took place on how to address the noise impacts. The Independent Commission on Civil Aircraft Noise (ICCAN)[7] is being created and DfT encourages the use of ICAO's balanced approach to aircraft noise management.

A new Aviation Strategy to look at aviation's challenges, with the aim "to achieve a safe, secure and sustainable aviation sector that meets the needs of consumers and of a global, outward-looking Britain" is being developed by DfT and will set out the long-term direction for aviation policy making to 2050. As part of the preparation for the Aviation Strategy consultations[8], DfT has requested that CAA undertakes the noise analysis for this work.

The objective of this report is to undertake an assessment of the feasibility of implementing noise limits nationally and locally in UK.

The main tasks carried out are:

1. Review of suitable KPIs, targets and limits related to aircraft noise, including the pros and cons, risks and perverse incentives of each option (Chapter 2);
2. Selection of the three most suitable KPIs for limiting the adverse impacts of aircraft noise (Chapter 3);
3. Gathering of 2006 and 2016 information for major national airports (Chapter 4);
4. Analysis of 2006 and 2016 information for major national airports for proposed KPIs; identify historic trends in noise emission at source, noise exposure and health impacts (Chapter 5);
5. Analysis of four forecast years and two fleet growth scenarios for the proposed KPIs; identify forecast trends in noise emission at the source, noise exposure, population exposure and population health impacts (Chapter 6);
6. Draft a proposed noise limit or target methodology (Chapter 7); and
7. Undertake a sensitivity analysis using the limits selected (Chapter 8).

5 Final Report, Airports Commission, ISBN: 978-1-84864-158-7, July 2015.

6 Airports National Policy Statement: new runway capacity and infrastructure at airports in the South East of England, Department for Transport, ISBN: 978-1-5286-0441-3, June 2018.

7 Consultation Response on UK Airspace Policy: A framework for balanced decisions on the design and use of airspace, CM 9520, Department for Transport, ISBN: 978-1-5286-0087-3, October 2017.

8 "Beyond the horizon. The furure of UK aviation. Next Stepst towards an Aviation Strategy", HM Government, April 2018.

Chapter 2

Review of suitable metrics and limits

This section reviews suitable KPIs, and how they help to devise targets or limits in order to control aircraft noise emission, noise exposure and their associated health impacts, including the pros and cons of each option. In a previous CAA report[9], noise limits were presented as 'noise envelopes' and different metrics were presented. In this report, noise limits are a scheme to manage the excess noise and to avoid noise recurrence. A penalty system is used to enforce compliance and to penalise in cases where the limits are exceeded. The objective of introducing a noise limit is to consider ways to:

- Limit source noise emission;
- Limit the area exposed to certain levels of noise;
- Limit the number of people exposed to certain levels of noise; and
- Limit the health impacts associated with exposure to aircraft noise.

A noise limit scheme needs to take into account:

- The management of aviation growth: to what extent it should allow for sector growth and also factoring in forecast reductions in noise at source;
- The noise objective: identify whether the priority should be on limiting the aggregated adverse health impacts or the number of people exposed and identify the scope for a limit to reduce over time; and
- Fair competition within the UK airports: allowing for different airports to account for historical conditions and/or future developments.

The key considerations being used for this review of noise limits are:

- **National and local requirements:** assessing whether noise limits should be national or local or a combination of both given that national and local requirements may be different. National limits would allow for comparability amongst airports both in terms of competition matters, noise efficiency and can make visible the total number of people impacted by noise in the country. However, using absolute national limits may restrict aviation grown in certain areas. Local limits would allow for local authorities to balance noise issues against land use planning and economic issues. If absolute noise limits are used locally and selected appropriately, they can protect the population impacted by aircraft noise.

[9] "Noise Envelopes", CAP 1129, Civil Aviation Authority, December 2013.

- **Reducing or mitigating noise levels:** assessing if noise limit schemes should minimise noise emission, noise exposure, noise impacts or a combination of these.
- **Reduction of severity of health impact and/or on number of people exposed:** assessing if the noise limit scheme should reduce the severity of health impacts (e.g. through estimation of numbers of people highly annoyed or monetisation of the overall impacts using DfT's WebTAG).
- **Use of absolute or relative targets:** assessing which noise limit metrics can be used on an absolute basis (no links to traffic volume) and relative basis (linked to a traffic volume) and the advantages and disadvantages of each. An absolute limit at the national level (for a set number of airports) would set an absolute limit on noise emission, exposure or impact, whereas a relative limit, linked to a traffic volume, may allow for better functioning of the internal market. At a local level, an absolute limit would give more certainty to local residents, whereas a relative target would prioritise the noise efficiency of an airport.
- **How to monitor compliance:** assessing if the best way of monitoring compliance would be through analysis of performance over a defined period, continuous checking or a combination of both.
- **Who should monitor compliance and who should enforce limits:** assessing who should monitor and enforce the noise limit scheme.
- **Preliminary findings from the CAA's Noise Impacts survey:** CAA undertook a noise survey in 2017[10] exploring issues that people wanted CAA to tackle, butthe results have not been published yet. The top six issues raised were: 1) Aircraft numbers increasing without being able to have a say; 2) Aircraft flying lower than they should; 3) Flights early in the morning; 4) Flights late at night; 5) My local airport isn't doing enough to manage noise; and 6) Aircraft flying where they shouldn't be flying. Issue 1 is considered as part of this assessment whereas issues 2 to 6 are being taken into consideration in other CAA work streams.

In order to assess the noise limits that could be used in the UK, this report uses a noise limit scheme that has been previously defined[11] and consists of four aspects covered in more detail in the following sections:

- A noise metric (section 2.1);
- A method for taking into consideration traffic volume of an airport (section 2.2);
- A monitoring mechanism for noise limits compliance (section 2.3);
- Enforcement procedures for noise limits (section 2.4);

[10] https://consultations.caa.co.uk/policy-development/aviation-noise-impacts/

[11] "Sound noise limits: Options for a uniform noise limiting scheme for EU airports", CE Delft, 2005.

Noise limits is then covered in section 2.5 and a review of limits used at UK and international airports is presented in section 2.6. The selection of specific aspects to be included in this analysis is undertaken in Chapter 3.

2.1 Noise metric

Aircraft noise varies in magnitude, time, sound frequency and the number of discrete noise events that occur. A noise metric is a defined way to monitor noise that captures some of or all of the factors into a single indicator. Aircraft noise can be classified into the groups of metrics below:

- Emission metrics: covering metrics that measure the sound energy emitted by aircraft (e.g. ICAO certification noise levels and quota counts);
- Exposure metrics: covering metrics that measure noise on the ground. They include:
  - Single event metrics: used to describe the noise occurring during one noise event, such as an aircraft overflight;
  - Multi event metrics: used to provide a description of the type of noise exposure experienced over a given period that have a link to human reactions; and
  - Supplementary metrics: used in conjunction with the above, to provide a more meaningful depiction of the noise exposure.
- Impact metrics: metrics that are related to the health impact of aircraft noise on the exposed population.

Table 2.1 presents a summary of these metrics. Further information regarding each metric is provided in ERCD Report 0904[12]. The selection of noise metrics for this study is considered in section 3.1.

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[12] K. Jones, R. Cadoux; "ERCD Report 0904 Metrics for Aircraft Noise", Environmental Research and Consultancy Department, CAA, 2009.

Table 2.1 Different types of noise metrics and their advantages and disadvantages:

Metric Group	Type	Examples	Advantages	Disadvantages
Emissions metrics	Noise emissions: Energy emitted by aircraft.	Certificated noise levels, quota counts, etc.	Noise can be determined relatively easily.	It does not relate to the noise exposure experienced on the ground.
Exposure metrics	Single event metrics: Noise on the ground used to describe one noise event.	Lmax, SEL, PNL, EPNL, etc.	It is easier to measure and often much simpler for the public to understand.	It requires calculation or local noise measurements.
	Exposure over a period metrics: Noise on the ground used to describe noise exposure over a given period.	NNI, LAeq, variations of LAeq (Lnight, Ldn, Lden, hourly LAeq around shoulder hours)	It contains the same sound energy as the actual variable sound.	It requires calculation or ground measurements. Not helpful for the general public.
	Supplementary metrics: Measurements often used in conjunction with other metrics.	L90, L10, N70, PEI, AIE.	It can supplement information from other metrics.	It requires calculation or ground measurements. It treats noise at different levels in the same way.
Impact metrics	Noise annoyance: Measurements related to the impact of noise on the exposed population during the daytime	Number of highly annoyed people.	It limits noise nuisance.	It requires calculation or ground measurements. It is limited by the subjective nature of annoyance.
	Sleep Disturbance: Measurements related to the impact of noise on the exposed population at night.	Number of people sleep disturbed.	Limit sleep disturbance.	It requires calculation or ground measurements. It is limited by subjective nature of sleep disturbance.

2.2 Methods for taking into consideration traffic volume of an airport

When considering setting limits for an airport, a method for taking into consideration traffic volume is required if the performance of an airport is to be considered on a relative basis. Table 2.2 presents a summary of these methods including the advantages and disadvantages. The selection of methods to take into account the traffic volume of an airport is considered in Section 3.2.

Table 2.2 Methods for taking into consideration traffic volume of an airport:

Type	Definition	Advantages	Disadvantages
ATMs	Number of air traffic movements by airport	Enables limits at different sized airports according to the numbers of aircraft movements they handle.	It does not take into consideration freight load or distance flown.
Passenger throughput	Number of passengers transported by airport	Enables limits at different sized airports according to passenger throughput. Number of passengers can be used to calculate total weight by applying an average weight per passenger.	It does not take into consideration freight load or distance flown.
MTOW	Maximum takeoff weight (MTOW) transported by airport	Enables limits at different sized airports taking into consideration both passengers and freight flights.	It does not take into consideration distance flown.
Passenger - kilometre	Number of passengers x km travelled by airport	Enables limits at different sized airports taking into consideration total passengers and distance flown.	It does not take into consideration freight load or distance flown.
Tonnes of freight	Number of freight tonnes transported by airport	Enables limits at different sized airports taking into consideration total freight transported.	It does not take into consideration passenger load or distance flown.
Tonnes-kilometre of freight	Number of freight tonnes x km travelled by airport	Enables limits at different sized airports taking into consideration total freight travelled.	It does not take into consideration passenger load.
Revenue Tonne-Kilometres	Number of passengers by a notional weight (which includes their baggage) and adding it to the cargo traffic before making the distance calculation	Enable equitable exposure or impact-based limits to be set at different sized airports according to the different economic benefit they generate.	It does not take into consideration the weight of the aeroplane.
Passenger Unit	One passenger unit is equivalent to either one passenger or 90 kilograms of freight and mail.	Used for Eurostat[13] and considers actual loading (of passengers or freight) on aircraft.	It does not take into consideration mileage.
MTOW/50 x distance	Weight factor (MTOW/50) x distance factor	Used for Eurocontrol charges, just looks at the size of the aircraft.	Takes no account of the load factor.

2.3 Monitoring mechanisms for noise limits compliance

[13] https://ec.europa.eu/eurostat/

A noise limit scheme monitors compliance of implemented measures either continuously or over a defined period.

Monitoring compliance over a specified period of time can vary from simple checks such as annual air traffic movements to noise contours showing exposed areas and the population within. A check of compliance against the limit would be required at the end of the monitoring period and enforcement action could be taken in the event of a breach. Local authorities or other national bodies are best placed to monitor compliance over a defined period.

Continuous monitoring of compliance requires a more operational approach and would be undertaken as part of an airport's noise management strategy. If a regular review indicates that a breach may be likely, the airport can take early preventative action to avoid the breach. Certain parameters will be better suited for continuously monitoring compliance than others. Parameters such as air traffic movement numbers can be predicted in advance through the airport's standard scheduling processes, and then closely monitored (potentially daily, as is done currently for administration of the London airports' night-time Quota Count system).

Any monitoring mechanisms should anticipate the differences between monitoring performance using modelled or measured information. The use of modelled information allows for monitoring current performance but also allows for different past, present and future scenarios to be analysed. On the other hand, measured information is used for monitoring performance around airports, to validate models and to give assurance to residents of the noise levels in different locations. Local measurements may be prone to uncertainty, cost, suitability, coverage issues and adverse weather.

Table 2.3 presents a summary of the monitoring mechanisms including advantages and disadvantages. Section 3.3 covers “Selection of noise limit schemes”..

Table 2.3 Monitoring mechanisms for noise limits compliance of an airport:

Monitoring mechanism	Definition	Advantages	Disadvantages
Defined monitoring compliance	Uses an agreed monitoring period to evaluate the parameters.	Does not disturb regular operation of the airport Can use models to calculate the limits. Analysis on a wide range of locations. Analysis of future scenarios.	Can only enforce compliance after the period is complete. Depends on availability of data for that period. Depend on precision of the acquired data or modelling used.
Continuous monitoring compliance	Using continuous monitoring to evaluate compliance.	Captures information at the time it happens and at specific locations. Well perceived by local communities.	Availability of measurement points. Can potentially impact on airport operations.

2.4 Enforcement procedures

To maintain public confidence in the planning system it is important that limits are enforced effectively. Any enforcement measures should be agreed during the design of the noise limit controls.

This plan should be established with stakeholder agreement and published. This should set out how authorities will monitor the implementation, investigate alleged cases of unauthorised actions and act where it is appropriate to do so. The plan should highlight how this is to be undertaken proactively and in a manner that is appropriate to the circumstances.

This noise plan requires an organisational body to oversee enforcement procedures.

Table 2.4 presents a summary of enforcement procedures including advantages and disadvantages.

Table 2.4 Enforcement procedures for noise limits compliance of an airport:

Enforcement procedure	How	Examples	Advantages	Disadvantages
Monetary penalty for exceedance	Compliance checked at the end of the monitoring period	Schiphol Airport	Allows for improvement of relationship with community if fines invested in a community fund	Lack of ability to enforce compliance during monitoring period
Loss of future capacity in the next control period	Compliance checked at the end of the monitoring period	Luton night contours	Creates commercial incentive for compliance	Lack of ability to enforce compliance during monitoring period.
No ability to exceed limits	Regular monitoring of the parameters	Sydney noise curfew	Creates behaviour change and commercial incentive for compliance	Monitoring is costlier
Loss of right to operate	Noise levels measured per aircraft type	John Wayne Airport	Creates commercial incentive for compliance	Can have financial implications for airlines

2.5 Noise Limits Schemes

In this analysis, the noise limit schemes are considered under the following categories:

- Restricting noise emissions;
- Restricting noise exposure; and
- Restricting noise impact.

2.5.1 Restricting noise emissions

There are many factors which affect the amount of noise that is produced at an airport. Some of these have a very noticeable effect, whereas others are more subtle.

In general terms, a busy airport tends to make more noise than one which is less busy. For example, a high passenger throughput requires accordingly high numbers of aircraft movements. Even where fewer operations by large aircraft carry the same numbers of people as more movements by smaller aircraft, the larger aircraft typically produce more noise.

It is therefore possible to use relevant inputs as a proxy for the noise created. Possible input limits are described below and could be applied to define an envelope.

Aircraft movements

The number of aircraft ‘movements’ (total number of arrivals and departures) which occur at the airport over a given period can be set at an agreed amount based on an equivalent level of noise exposure that is not to be exceeded. There is, however, no precise relationship between the number of movements and amount of noise produced as larger aircraft produce more noise than smaller ones at the same technology level.

Passenger throughput

The number of passengers (total number of arrival and departure passengers) that can use an airport over a given period. Whilst passenger throughout better captures aircraft size and to a certain extent the number of movements, it does not reflect distance flown – aircraft flying longer distances generate more noise than ones flying shorter distances.

Noise quota

Each aircraft type is assigned a noise classification[14] according to its certificated noise performance: the noisier the aircraft, the greater the noise classification. The numbers of movements of each aircraft type, over a given period, are multiplied by the corresponding noise factor (classification), and these ‘noise factored movements’ are counted against an overall noise quota for an airport. Noise quota can be set separately for winter and summer seasons. They may be sub-divided between arrivals and departures, or between types of services in other ways, depending on the degree of flexibility required within the permitted limits. The noisier the aircraft used, the higher its noise factor and the greater the amount of the quota budget each movement uses up, thereby providing an incentive for airlines to use quieter aircraft types. Noise quota budget may be set to permit a limited amount of growth, i.e. to share the benefits of improving aircraft technology.

[14] “London Heathrow, London Gatwick and London Stansted Airports Noise Restrictions Notice (No.2) 2018”, AIP SUPPLEMENT 049/2018, DfT, 2018.

2.5.2 Restricting noise exposure

This section focuses on the noise exposure experienced by people on the ground and the limits, that could be used to restrict it.

Noise contour area

A clear and concise way of describing the noise exposure around airports is to calculate the area enclosed by the noise contour of a noise metric and level. Being a single numerical value, it is straightforward to set a limit on this area value to restrict aircraft noise exposure near an airport. Limits could be applied to the area of a contour of any agreed metric and at any agreed level. In some cases, it may be appropriate to use a noise metric which has a precedent for use in noise control or the assessment of noise impact.

Noise contour shape

Many of the principles of using the area of a noise contour apply to a greater or lesser degree to using the actual shape of the contour as a limit. However, this criterion goes beyond the remit of the area limit by being explicit on how much noise each neighbouring community can expect to be exposed to. In doing so, it leaves little scope for redistribution of noise geographically within a reporting period without breaching the limit.

Noise level limits

Noise level limit use noise measurement and prediction to establish noise exposure at specified locations in the geographical area near an airport. The noise levels from each noise monitor are integrated over a period and compared with an agreed limit value. A breach would occur if the measured level at any of the noise monitors exceeds the limit.

Population/dwellings exposed to noise

As well as calculating the area enclosed within a noise contour, it is also straightforward to count the population and number of dwellings enclosed. Being single numerical values, they lend themselves to use as envelope limits. However, the population within a given noise contour will change over time, as the population distribution changes, both through the addition of new housing and also due to the change of use of existing housing that may alter the population density within existing housing. Both of these factors are outside the aviation industry's control and therefore limit the value of using population-based indicators for restricting noise exposure.

Person-Events Index (PEI)

Person-Events Index (PEI) is the number of noise events each resident is exposed to above a certain threshold level, say 70 dB LAmax, summed to give a single figure that represents the total noise load or burden the airport places on the surrounding population[15]. The more noise is concentrated on fewer people, the lower the value of PEI will be. It also assists in the interpretation of noise exposure distributions when considering different operating arrangements at an airport. The index enables a relatively quick assessment to be made of noise exposure information and reveals a somewhat different picture to initial conclusions based solely on the populations exposed.

Average Individual Exposure (AIE)

PEI gives an indication of total noise load on the surrounding population, but not how it has been distributed across the population. Dividing the PEI by the total exposed population gives the average number of noise events per person, more commonly known as the Average Individual Exposure (AIE).

2.5.3 Restricting noise impact

The two most common impacts of aircraft noise are daytime annoyance and night-time sleep disturbance.

Number of people annoyed (daytime)

Noise affects different people by different amounts. Research in the field of noise attitudes has developed exposure-annoyance relationships, including the percentage of people who might be expected to be highly annoyed during the daytime at different noise exposure levels based on average community response. This relationship can be used to estimate the total number of people who might be expected to be highly annoyed by aircraft noise at a given airport.

This limit relies on the exposure-annoyance relationships, which are subject to change reflecting advances in research. This introduces an element of uncertainty, which would need careful management. One approach might be to review existing limits whenever the dose-response relationship is revised. Like population counts, estimates of the number of people highly annoyed are also subject to changing population distributions that are outside the control of the aviation industry.

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[15] "Expanding Ways to Describe and Assess Aircraft Noise", discussion paper, Department of Transport and Regional Services, Australia, ISBN 0 642 42262 1, March 2000.

Number of people sleep-disturbed (night-time)

Whereas noise from aircraft operations during the daytime results in annoyance, noise from night operations tends to disturb people’s sleep. This metric is almost identical to the number of people annoyed, but requires a different exposure-response relationship and different noise exposure indicator as input, namely the percentage of people who are highly sleep-disturbed by night-time aircraft noise at different night LAeq8h levels. Like the number of people highly annoyed it also suffers from being affected by changing dose-response relationships for sleep disturbance and changing population distributions.

Summary

Table 2.5 presents a summary of the noise limit methods including advantages and disadvantages. The selection of noise metrics for this study is considered in Section 3.3.

Table 2.5 Noise limits scheme options for an airport

Type of Limit	Metric	Example of prior use	Advantages	Disadvantages
Limit noise emissions	Number of movements	Stansted, London City, Belfast City and Heathrow	Simple and easy to implement. Addresses people's growing sensitivity to the frequency of aircraft noise events	Does not take account of the noisiness of aircraft and therefore does not incentivise the use of quieter aircraft
	Seats for sale	Belfast City	Limits both ATMs and aircraft size	Administratively more complex and onerous. Potential enforcement challenges.
	Passenger throughput	Belfast City and Stansted	Provides more operational flexibility than a simple movement cap	Does not directly take account of the noisiness of aircraft or the number of operations
	Noise quota - night	Heathrow, Gatwick, Stansted, Manchester, East Midlands, Birmingham, Southampton, Bristol, Leeds, Amsterdam, Frankfurt, Madrid	Depending on the application places limits on the maximum noise quota for a single movement and the total nightly quota, based on the certificated noise levels for each aircraft operated. Reflects that larger aircraft tend to have higher QC values	Administratively more complex to administer so aircraft types can have differing noise quota classifications depending on variant or engine type
	Runway use restriction		Directly limits noise exposure in specific areas close to a runway. Where used a runway rotation control directly facilitates noise sharing.	

Type of Limit	Metric	Example of prior use	Advantages	Disadvantages
Limit noise exposure	Noise contour area	Heathrow, Gatwick, Stansted, Manchester, East Midlands	LAeq noise contours, by definition, represent long-term noise exposure, A contour area, expressed as a single numerical value, is easy to understand and apply as a criterion.	The LAeq indicator does not necessarily reflect all aspects of the perception of aircraft noise.
	Noise contour shape	Amsterdam Schiphol	Provides a very tight noise control and the potential to offer a comprehensive deal to residents. Maintains adherence to a noise sharing arrangement.	Significantly restricts operational flexibility. Could limit ability to alter noise sharing regime.
	Population/dwellings exposed to noise		Reflects the number of people exposed to noise. Incentivises concentration of noise in less populated areas.	Provides limited means to differentiate between people acutely or mildly exposed.
	Noise level limit	Paris Charles de Gaulle	Uses measured levels, therefore simple and transparent. Best suited to airports with simple departure route structures	Measurements are subject to extraneous noise and equipment precision. Aircraft can be operated in ways which optimise low noise over the monitors, potentially resulting in higher noise elsewhere
	Person-Events Index (PEI)	Sydney Kingsford Smith	Reflects the number of people affected by noise. Reflects the number of events each person is exposed to	Controls only take effect after the noise ‘breach’ has occurred. Population encroachment will impact on the value of PEI
	Average Individual Exposure (AIE)	Sydney Kingsford Smith Airport	Reflects the average number of noise events each person is exposed to and is a linear metric	Controls only take effect after a noise breach has occurred. Population encroachment will impact on the value

Limit noise impact	Number of people annoyed (daytime)	Amsterdam Schiphol	Considers the increased risk of being annoyed by aircraft noise at higher exposure levels	Changing understanding of exposure-annoyance relationship may introduce long-term planning uncertainty and risk
	Number of people sleep-disturbed (night-time)	Amsterdam Schiphol	Considers the increased risk of sleep disturbance at higher noise exposure levels	Complicated to calculate. Changing understanding of exposure-annoyance relationship may introduce long-term planning uncertainty and risks
	Monetised health impacts (WebTAG)		Considers the overall monetised risk of diseases associated with high noise levels	Complexity of calculation and needs to have two comparative scenarios for evaluation as set up in WebTAG.

2.6 Review of limits used at UK and international airports

2.6.1 UK Airports

A review of the implementation of noise limits at UK airports has been undertaken, to assess the extent that limits have been implemented. A summary of this assessment is presented in Table 2.6. The results show that most of the airports implement noise quota limits at night, but there is limited implementation of other noise emission restrictions during the day. In relation to limiting noise exposure, half of the airports use noise contour areas to limit noise exposure. In terms of limiting noise impact on people, most of the airports are monitoring their own impacts, but the results show that to date none of the airports have adopted limits based on noise impact on the surrounding population.

2.6.2 International Airports

The assessment of international airports is intended to highlight examples of different implementations of noise restriction limits and therefore is not a comprehensive review. Table 2.7 presents a summary of the findings, indicating that different airports focus on different ways of limiting noise. Further details will be brought to this assessment where relevant. Section 2.6.3 presents how limits are implemented at Schiphol Airport, where a wide interest on its noise control shape limits has been raised in UK in recent years.

Table 2.6: Noise limit schemes implemented in the top 10 busiest UK airports (by number of passengers)

Metric Type	Metric	Heathrow	Gatwick	Manchester	Stansted	Luton	Edinburgh	Birmingham	Glasgow	Bristol	Belfast Intl
Limit noise emission	Aircraft (per type) movement cap										
	No of movements	✓			✓					✓	
	Runway use restrictions										
	Seats for sale										
	Passenger throughput				✓						✓
	Noise quota - day					✓					
	Noise quota - night	✓	✓	✓	✓	✓		✓		✓	
Limit noise exposure	Noise contour area	✓	✓	✓	✓	✓					✓
	Noise contour shape										
	Noise level limit										
	Population exposed										
	Person-Events Index (PEI)										
	Average Individual Exposure (AIE)										
Limit noise impact	Number of people annoyed (daytime)										
	Number of people sleep-disturbed										
	WebTAG										

Table 2.7: Noise limit schemes implemented in selected international airports.

		Amsterdam	Paris CDG	Frankfurt	Sydney
Restrict noise emission	Aircraft (per type) movement cap				
	No of movements				
	Seats for sale				
	Passenger throughput				
	Noise quota - day				
	Noise quota - night			✓	
	Runway use restrictions				
Restrict noise exposure	Noise contour area				
	Noise contour shape	✓			
	Noise level limit	✓	✓		
	Population exposed				
Restrict noise impact	Number of people annoyed (daytime)	✓			
	Number of people sleep-disturbed				
	Person-Events Index (PEI)				✓
	Average Individual Exposure (AIE)				✓

2.6.3 Overview of Schiphol limits

Noise contour shape goes beyond the remit of the noise contour area by being explicit on how much noise each neighbouring community can expect to be exposed to and then placing a limit on it. This type of limiting scheme leaves little opportunity for redistribution of noise, geographically, within a reporting period without breaching the limit.

One disadvantage of a noise contour shape limit is that the airport becomes constrained to operate in a particular way despite factors that may be beyond the airport’s control. On the other hand, it has the advantage of offering clearer commitment to residents.

Schiphol airport utilises noise contour shape to limit noise exposure levels at specific locations around the airport’s perimeter and thereby controls the shape of the noise contour.

The system is rather complex, particularly in terms of calculating the limits and also in terms of planning runway operating modes to avoid breaches. Some allowance for weather variations is incorporated into the limit values, so when limits are breached, investigations are carried out to analyse whether it was due to atypical weather or other reasons. When maintenance work is undertaken that restricts access to a runway, adjustments to the limit values need to be consulted on and agreed.

The system is particularly relevant to an airport like Schiphol with five runways that may be used in a variety of different operating modes, to enforce distribution of noise and avoid concentration on a few preferred runways, and in setting clear expectations for residents.

At Amsterdam Schiphol airport a sequence of runway preferences has been defined that determines the preferred operating runways, weather permitting. To control the runway preference system, a noise budget restriction system was developed and implemented to set limits on noise exposure at specific locations and is applied through enforcement of maximum noise exposure limits at many locations near the airport. Each enforcement point has its own limiting noise exposure value, which may not be exceeded at the end of the year.

The noise contribution of an aircraft operation at each enforcement point is determined through noise calculations that consider the aircraft type, type of operation, runway, flight path and time of day. Noise load at each enforcement point is tracked on a daily and two-weekly basis.

A review of this scheme is being considered because of extensive negotiations with local and national government, the aviation sector and community representatives.

At an airport with fewer runways enforced distribution of noise would be much more dependent on distributing flights across different flight paths, which may not be possible to the same extent as that achieved using different runways, and it could lead to sub-optimal use of flight paths, additional track miles flown, leading to increased carbon emissions or even a loss of airspace capacity.

Chapter 3

Selection of suitable metrics for health impacts and noise limit schemes

To choose the noise limits that could be used in the UK, a selection of the appropriate aspects covered in Chapter 2 is considered:

- Selection of noise metric (section 3.1);
- Selection of method for taking into consideration traffic volume of an airport (section 3.2);
- Selection of noise limit schemes (section 3.3).

3.1 Selection of noise metric

Table 3.1 summarises the noise metrics selected to represent the different approaches for restricting noise, and to bring a range of options for reviewing how to limit noise impacts.

3.2 Selection of method to take into account the traffic volume of an airport

Several methods can be used to take into consideration the traffic volume at an airport and provide a relative measure for a noise limit. If a relative method is to be introduced in the UK it should be set to account for different sized airports according to the different economic benefits they generate.

A method that accounts for weight (maximum payload) and distance travelled would be recommended to enable impact-based limits as it would take into consideration both freight and passenger weight as well as distance travelled over a period.

Table 3.1: Selection of noise metrics for limiting noise

Limit Type	Metric Type	Metric Group	Recommended metrics for selection
Source Emissions	Noise emissions	Energy emitted by aircraft.	Quota count
Exposure	Single event metrics	Area or number of people exposed to specified numbers of noise events above a specified Lmax level	N65, N70 (daytime), N60 (night-time)
		The sum of the number of events above a specified Lmax level that the surrounding population is exposed to.	Person Event Index (PEI), PEI(70)
		The sum of the number of events above a specified Lmax level that the surrounding population is exposed to divided by the number of people exposed	Average Individual Exposure (AIE), AIE(70)
	Exposure metrics	Noise on the ground used to describe noise exposure over a given period. Area or number of people exposed to certain noise levels.	LAeq, Lden
Impact	Noise annoyance	Measurements related to the impact of noise on exposed population.	Number of (highly) annoyed people
	Sleep disturbance	Measurements related to the impact of noise on exposed population at night.	Number of people (highly) sleep disturbed.
	Monetised impact	Monetary estimate of the adverse health impacts associated with the noise exposure	WebTAG monetary estimate of health impact

3.3 Selection of noise limit schemes

The selection of noise limit schemes should take into consideration the direct ability to limit:

- Noise emission;
- Area exposed;
- Population exposed; and
- Health impact.

Table 3.2 presents the summary of the schemes and their ability to fulfil the objectives above. The results of this table are used to decide on which schemes to take forward for analysis.

Table 3.2: Limit schemes review

Limit Type	Metric Type	Limit scheme objective		Use of limit	
		Limit area impact	**Limit population impact**	**Absolute Limit**	**Relative limit**
Limit noise emissions	Aircraft (per type) Movement Cap	✗	✗	✓	✓
	No of movements	✗	✗	✓	✓
	Seats for sale		✗		✓
	Passenger throughput	✗	✗	✓	✓
	Noise quota - day	Y	✓	✓	✓
	Noise quota - night	✗	✗	✓	✓
Limit noise exposure	Noise contour area	✓	✓	✓	✓
	Noise contour shape	✓	✓	✓	✗
	Noise level limit (to control shape of contour)	✓	✓		✗
	Population/dwellings exposed to noise	✗	✓	✓	✓
	Runway use restrictions	P	✗	✓	✓
	Person-Events Index	✗	✗	✓	✓
	Average Individual Exposure	✗	✗	✓	✓
Limit noise impact	Number of people annoyed (daytime)	✗	✓	✓	✓
	Number of people sleep-disturbed (night-time)	✗	✗	✓	✓
	WebTAG	✗	✓	✓	✓

In respect of the other considerations covered in section 2.5, the following will be used in the analysis:

- National and local requirements: both national and local requirements will be taken into consideration in the analysis;
- Limit noise exposure or adverse health impacts: all limits that directly achieve the objective will be taken into consideration;
- Use of absolute or relative targets: it is proposed that absolute limits are set at a local level in order to limit overall noise emission, exposure or impact. At the national level, it is proposed that both absolute and relative targets are considered to take into consideration the growth forecasts for the country;
- Population or spatial limits: it is proposed that a spatial limit is considered given the limitations the aviation sector has in limiting the population within a certain area;
- Preliminary findings from CAA 2017 Noise Survey: preliminary results show that the top issues people want the CAA to tackle is “Aircraft numbers increasing without being able to have a say”, therefore this will be included in the analysis;
- How should compliance be monitored (measurements or calculations): a review of options is presented as part of the analysis;
- Who should monitor compliance and who shoud enforce limits: a review of options is presented as part of the analysis.

A summary of the analysis undertaken for the selection of the noise limit scheme is given in Table 3.3.

Table 3.3: Limit schemes selected for further investigation

Limit Type	Metric Type	Absolute Limit for population exposed	Relative Limit for population exposed	Absolute Limit for area exposed	Relative Limit for area exposed
Limit noise emissions	Noise quota - day	✓	✓	✓	✓
	Noise quota - night	✓	✓	✓	✓
Limit noise exposure	Noise contour area	✓	✓	✓	✓
	Noise contour shape	✓	✗	✓	✗
	Noise level limit (to control shape of contour)	✓	✗	✓	✗
	Population/dwellings exposed to noise	✓	✓	✗	✗
	Person-Events Index	Possibly	Possibly	Possibly	Possibly
	Average Individual Exposure	Possibly	Possibly	Possibly	Possibly
Limit noise impact	Number of people annoyed (daytime) Lden	✓	✓	✗	✗
	Number of people sleep-disturbed	✓	✓	✗	✗
	Respite	Possibly	Possibly	Possibly	Possibly
	webTAG	✓	✓	✗	✗

In summary, following from previous analysis, the approaches recommended for further consideration in the next chapters include:

For limiting noise emissions:

From the analysis presented in this chapter daytime and night-time noise quota limits were selected as the metrics to assess forecast noise and consider as noise emission limits.

For limiting noise exposure:

From the analysis presented in this chapter, the following limits were selected as the metrics to assess forecast noise and consider as noise exposure limits:

- National L_{Aeq} or L_{den} limit on the area exposed to at least 51 or 54 dB;
- National night-time limit on the area exposed (L_{Aeq8h} or L_{night}) to at least 45 or 48 dB;
- National L_{Aeq} or L_{den} limit on the area exposed to at least 51 or 54 dB normalised by transport volume (ATMs);
- National night-time limit on the area exposed (L_{Aeq8h} or L_{night}) to at least 45 or 48 dB normalised by traffic volume (ATMs);
- National N_{Ax} limit on the area exposed to at least 5 or 10 events per average summer day above 65 or 70 dB L_{Amax} or 60 dB L_{Amax} per average summer night;
- National limit based on average summer daytime total number of person-events above 70dB L_{Amax}, PEI(70) 10 events;
- National limit based on summer daytime Average individual exposure of events above 70 dB L_{Amax}, AIE(70) 10 events;
- Local daytime (L_{Aeq} or L_{den}), (54 or 51) dB contour area limit;
- Local night time (L_{Aeq8h} or L_{night}), (48 or 45) dB contour area limit;
- Local N_{Ax} limit on the area exposed to at least 5 or 10 events per average summer day above 65 or 70 dB L_{Amax} or 60 dB L_{Amax} per average summer night.

It was recommended that the number of people within the area should be a reported figure, but this should not be a limit imposed on the aviation sector as the control of the local population at a given location is outside the control of the aviation sector.

For limiting health impact

Nationally, it is recommended that limits to annoyance and sleep disturbance should be included using criteria from the WHO Europe Burden of disease report[16] or the UK Survey of Noise Attitudes 2014[3]. Whilst SoNA 2014 presented an updated dose-response function based on L_{Aeq16h}, a complementary night-time dose-response function has not been published. Thus, it was decided for consistency purposes to use the EU dose-response functions[17]. The annoyance function was limited to noise exposure above 51 dB L_{den} and 54 dB L_{den} to avoid uncertainty issues with estimating noise exposure at low noise levels[18]. Similarly, for night-time, the highly sleep-disturbed dose-response function was limited to noise above 45 dB L_{night} and 48 dB L_{night}.

Although, it was initially planned to use DfT's web-based Transport Appraisal Guidance, WebTAG, to provide a monetary value for the health impacts, this was not possible. WebTAG was conceived and implemented to assess the relative health impacts of future road, rail or aviation transport infrastructure proposals as part of an options appraisal and compare the health impacts of options against a do-nothing scenario in their opening year and over the standard 60-year life assessed for transport infrastructure. In this report, noise exposure and impacts are being compared over time and not against a do-nothing scenario, and thus WebTAG cannot be applied to such situations.

Locally, it is recommended that limits on annoyance and sleep disturbance should also be calculated using the same functions and lower thresholds.

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[16] Burden of disease from environmental noise: Quantification of healthy life years lost in Europe, WHO Europe, ISBN: 978 92 890 0229 5, 2011.

[17] Good practice guide on noise exposure and potential health effects, EEA Technical Report No. 11/2010, ISBN 978 92 9213 140 1, European Environment Agency, 2010.

[18] Measurement and Modelling of Aircraft Noise at Low Levels, ERCD Report 1006, CAA, October 2010.

Chapter 4

Modelling methodology and data acquisition

This chapter gives an overview of the methodology and data utilised as part of this work, including the modelling methodology, modelling tool and input data. Chapters 5 and 6 present the results of this analysis.

Modelling methodology and modelling tool:

The calculations presented in this study were performed using CAA ANCON version 2.4, in line with ECAC-CEAC Doc 29 4th edition. An overview of ANCON and ECAC-CEAC Doc 29 4th edition is given in Appendix B.

Airports utilised:

This study's objective is to estimate future airport noise exposure and examine the feasibility of implementing noise limits in UK with the intention of limiting and where possible reducing noise emission, noise exposure and noise impacts at UK airports. In order to capture the overall population exposure, it was decided to use the top 10 airports by size of population exposed within the 2016 55dB L_{den} contour based on data reported to Defra for the Environmental Noise Directive (END). Data to enable forecast noise calculations for London City Airport and Leeds-Bradford Airport were not available to enable their inclusions as part of this assessment. Therefore, the eight airports utilised in this analysis are: Birmingham (BHX), Edinburgh (EDI), Glasgow (GLA), London Gatwick (LGW), London Heathrow (LHR), Luton (LTN), Manchester (MAN) and Stansted (STN).

Airport expansion:

The only airport expansion included in this report is a third North West Runway at Heathrow (LHR NWR) as it is the selected expansion option in the Government's Airport National Policy Statement[19].

Historic traffic data:

19 "Airports National Policy Statement: new runway capacity and infrastructure at airports in the South East of England", Department for Transport, June 2018.

Traffic data were provided by each airport (Birmingham, Edinburgh, Glasgow, Gatwick, Heathrow, Luton, Manchester and Stansted) for 2006 and 2016. Table 4.1 presents the number of movements for the baseline years and shows that the number of movements for an average summer day 16h has decreased by 1.2%, whilst the number of movements for an average summer day 24hr has increased by 0.3%. The decreased in daytime movements is dominated by Stansted airport, which has yet to return to movement levels seen prior to the 2009-10 recession. The increase in night time movements is likely due to growth of airlines wishing to maximise revenue and therefore operating more in the shoulder hours of 23:00 to 23:30 and of 06:00 to 07:00, but further analysis would be required to confirm this.

Table 4.1 Baseline average summer day and night movements for all airports assessed:

	Scenario: Baseline No. movements		
Time Period	**2006**	**2016**	**% change 2006-2016**
Average summer day 16h	4,350	4,312	-0.9%
Average summer night 8h	454	506	+11.3%
Average summer 24h	4,804	4,817	+0.3%

Forecast traffic data:

Traffic forecasts provided by DfT for each airport were based on the 2017 UK Aviation Forecasts[20] for two scenarios: Central and High demand. The High scenario is described as having a higher passenger demand from all world regions, lower operating costs and a global emissions trading scheme. These scenarios are described in more detail in reference 17. The forecasts provided a breakdown of the annual forecast ATMs by aircraft type.

The noise indicators considered required that the data was broken down by average summer day (0700-2300) and night (2300-0700) periods, reflecting the summer seasonal peaks present at most UK airports, and for the annual L_{den} metric, broken down into annual average day (0700-1900), evening (1900-2300) and night (2300-0700) periods. Data on the proportions of movements in the different time periods from the Airports Commission, itself based on 2011 data, was found to differ from historical 2016 data and thus in the absence of better data, information from 2016 was used determine the proportions of operations in each time period by aircraft type, runway and flight path.

Table 4.2 (a) and (b) presents the number of movements for the forecast years for both High and Central scenarios. Table 4.2 (a) shows that the number of movements in the High scenario for an average summer day is forecasted to increase by 39.3% and that for

[20] DfT 2017 UK Aviation Forecasts, October 2017.

an average summer night is forecasted to increase by 34.1% between 2016 and 2050. For the Central scenario, Table 4.2 (b) shows that the number of movements for an average summer day is forecasted to increase by 37.5% and that for an average summer night it will increase by 26.8%.

Table 4.2 (a) Forecasted ATMs for all airports assessed – High Scenario

	Scenario: High		No. movements			
Time Period	**2016**	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
High - average summer day 16h	4,312	4,513	5,337	5,670	6,000	+39.2%
High - average summer night 8h	506	534	601	642	685	+35.4%
High - average summer 24h	4,817	5,047	5,939	6,312	6,685	+38.8%

Table 4.2 (b) Forecast ATMs for all airports assessed – Central Scenario

	Scenario: Central		No. movements			
Time Period	**2016**	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
Central - average summer 16h	4,312	4,411	5,245	5,616	5,920	+37.3%
Central - average summer night 8h	506	495	558	608	648	+28.1%
Central - average summer 24h	4,817	4,906	5,804	6,225	6,568	+36.3%
%Variation Central-High (24h)	-	-2.8%	-2.3%	-1.4%	-1.7%	

Aircraft noise performance:

For current aircraft types, the noise performance for 2006 and 2016 was based on radar data and noise measurements provided by Heathrow Airport, Gatwick Airport and Stansted Airport for 2006 and 2016. In all other cases, except Luton, the aircraft noise performance was based on Gatwick Airport data, except for the most dominant aircraft types operating at Birmingham and Manchester airports respectively, where local data is used. In the case of Luton airport, ERCD does not have access to the local radar data and noise measurements used for producing END noise contours. Instead, ERCD used data from Stansted airport, as it felt to better represent operation at Luton airport. For the dominant Airbus A320 and Boeing 737-800, there is little difference between noise performance as measured at Stansted and Gatwick airports. In the case of Luton, and the others where Gatwick data is used, it strikes a balance between a lack of data and/or robust data being available for some airports, and proportionality, recognising that airline standard operating procedures result in similar noise performance across different airports for the same airline operating to similar destinations – and with the exception of Heathrow airport, for the remaining seven airports assessed, noise is dominated by the same airlines and aircraft types.

For future aircraft types, the noise performance is based on noise certification data if the aircraft is already certified. For the longer term (beyond 2030) the aircraft noise performance is based on the ICAO long-term technology improvement trend of 0.1dB/year improvement[21].

Fleet retirement:

The fleet retirement rate used for 2006 to 2016 was based on actual data provided by the airports. The rate used for the forecast scenarios was given by UK Aviation Forecasts 2017[16].

Population data:

The population data used for exposure and impact assessment was provided by CACI Limited[22]. Data for 2006 was based on a CACI 2006 update of the 2001 Census and data for 2016, a 2016 update of the 2011 Census. CACI forecast data was used for 2030, 2040 and 2050. For 2025, the data was interpolated between 2016 and 2030.

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21 ICAO (2014), Report by the Second CAEP Noise Technology Independent Expert Panel, ICAO Doc. 10017, ISBN 978-92-9249-401-8, ICAO, 2014.

22 www.caci.co.uk

Chapter 5

2006 and 2016 Performance Analysis

Chapter 3 presented the selection of the most suitable metrics for limiting noise exposure and health impacts and Chapter 4 presented the methodology and data used for the calculations. This chapter presents the results of the noise metric assessment for 2006 and 2016 using the noise limit schemes selected in Chapter 3 and methodology and data presented in Chapter 4.

The purpose of the 2006 and 2016 performance analysis is to review the application of different metrics and to understand the implications on the noise contour area, population exposed and health impacts.

The metrics used for this analysis are those presented in Table 3.3 including limits for restricting noise emissions, noise exposure and noise health impacts. The results for the 2006 and 2016 analysis, presented in this chapter, are the combined results for all airports considered in Chapter 4. The results with the breakdown for each individual airport are presented in Appendix C.

For metrics that restrict noise emissions, quota count is the selected metric for evaluation and the results are presented in Table 5.1. The results show that there is a reduction in quota count for average summer day 16h. For summer night, the results show that there was a small reduction in quota count. This decrease is mainly due to a shift towards quieter aircraft, given that the ATMs increased.

Table 5.1: 2006 & 2016 Analysis - Quota Count

	Scenario: Baseline		Quota Count
Metric	**2006**	**2016**	**% change**
QC - average summer day 16h	2,697	2,478	-8.1%
QC - average summer night 8h	301	292	-3.1%
QC - average summer 24h	2,998	2,770	-7.6%

For metrics that restrict noise exposure, Table 5.2 presents a summary of the results. The results show that the noise contour area for an average summer day and an average 24 hour day have reduced at the majority of noise contour levels. On the other hand, the noise contour areas for night noise have increased both for an average summer night and for an average annual night.

In terms of the population exposed to noise, the population exposed in an average summer day and in an average annual 24 hour day have reduced at the majority of noise contour levels. On the other hand, the populations exposed to night noise have increased both in the average summer night and in the average annual 24 hour day. The increase in population exposed can be related both by the increase in aircraft movements at night and by the increase in the average population growth for the period (presented in more detail later in this chapter).

Table 5.2 also presents the results for the Number Above metric. N60 is used for indicating the number of aircraft movements above 60 dB over an average summer night, whilst N65 and N70 are used to indicate the number of movements above 65 and 70 dB respectively during an average summer day. The results from 2006 to 2016 present a reduction in Number Above for the average summer day and an increase in Number Above for average summer nights.

The analysis of PEI (70) and AIE (70) (Table 5.2) indicates an increase in PEI (70), which is in line with the increase in number of movements and increase of population in the area. The analysis also looked at AIE, showing that AIE has increased, which indicates that the population exposed to 70 dB events is being subjected to more events due to the increase in ATMs for the period.

Table 5.2: 2006 & 2016 Analysis - Summary of noise exposure results for the selected metrics and contour levels

		Scenario: Baseline Noise Exposure					
		Area (km²)			Population Exposure		
Metric	**Level**	**2006**	**2016**	**% change 2006-2016**	**2006**	**2016**	**% change 2006-2016**
Average summer day LAeq16h	>51	932.3	881.3	-5.5%	1,550,500	1,562,600	+0.8%
Average summer day LAeq16h	>54	530.4	491.6	-7.3%	825,400	783,500	-5.1%
Average summer night LAeq8h	>45	716.2	800.9	+11.8%	1,016,600	1,234,100	+21.4%
Average summer night LAeq8h	>48	419.6	462.6	+10.3%	521,700	648,600	+24.3%
Average annual 24h Lden	>50	1,590.0	1,448.1	-8.9%	2,629,900	2,471,500	-6.0%
Average annual 24h Lden	>55	615.6	572.2	-7.1%	997,300	948,400	-4.9%
Average annual 8h Lnight	>45	669.3	669.2	-0.0%	1,029,100	1,109,200	+7.8%
Average annual 8h Lnight	>50	268.0	251.2	-6.3%	304,600	321,600	+5.6%
Average summer night 8h N60	>5 events	1,563.9	1,698.4	+8.6%	1,800,700	2,143,400	+19.0%
Average summer night 8h N60	>10 events	843.6	1,015.0	+20.3%	1,215,900	1,462,900	+20.3%
Average summer day 16h N65	>5 events	2,877.6	2,097.2	-27.1%	3,645,400	2,609,300	-28.4%
Average summer day 16h N65	>10 events	2,011.0	1,563.4	-22.3%	2,449,500	1,965,400	-19.8%
Average summer day 16h N70	>5 events	1,070.8	758.7	-29.2%	1,379,300	1,062,100	-23.0%
Average summer day 16h N70	>10 events	777.9	592.3	-23.9%	974,600	838,700	-13.9%
AIE (70)	>5 events	-	-	-	47.0	67.1	+42.6%
AIE (70)	>10 events	-	-	-	61.8	79.6	+28.8%
PEI (70)	>5 events	-	-	-	66,754,500	71,170,000	+6.6%
PEI (70)	>10 events	-	-	-	64,098,100	69,591,900	+8.6%

Table 5.3 presents the 2006 and 2016 analysis results for noise impact. When analysing the noise impact results for 2006 and 2016, it is observed that the number of highly annoyed people during daytime has decreased in line with the annual average day 24h metric. The number of highly sleep-disturbed people has increased in lower noise bands and increased in higher noise bands.

Table 5.3: 2006 & 2016 analysis - summary of noise impact results

	Scenario: Baseline		
	2006	2016	% change 2006-2016
No. of people highly sleep-disturbed average annual 8h Lnight >45 dB	73,800	78,300	+6.1%
No. of people highly sleep-disturbed average annual 8h Lnight >50 dB	29,600	30,800	+4.1%
No. of people highly annoyed (daytime) average annual 24h Lden >51 dB	244,000	239,800	-1.7%
No. of people Highly annoyed (daytime) average annual 24h Lden >54 dB	180,500	173,000	-4.2%

Overall, the 2006 and 2016 analysis are presented in Table 5.4.

Table 5.4: Summary of results for 2006 and 2016 analysis

Metric	% change 2006-2016
ATM, average summer day 16h	-0.9%
ATM, average summer night 8h	+11.3%
Quota count, average summer day	-8.1%
Quota count, average summer night	-3.1%
Noise contour area, average summer day, >54 dB	-7.3%
Noise contour area, average summer night, >48 dB	+10.3%
Population exposed, average summer day, >54 dB	-5.1%
Population exposed, average summer night >48 dB	+24.3%
Number Above, average summer day, N65 >10	-19.8%
Number Above, average summer night, N60 >10	+20.3%
Number Above, average summer day, N70 >10	-13.9%
Average Person Exposure, >10	+28.8%
Person Events Index, >10	+8.6%
No. of people highly annoyed, >54 dB	-4.2%
No. of people highly sleep disturbed, >45 dB	+6.1%

CHAPTER 6

Analysis forecast scenarios for 2025, 2030, 2040 and 2050

This chapter presents the results of the analysis of noise metrics calculated for 2025, 2030, 2040 and 2050.

The purpose of the forecast scenarios analysis is to identify the relationship between the trends of different metrics that track noise emission, noise exposure and noise impact in relation to forecast traffic growth, to understand the implications and opportunities of setting limits. The year 2025 was included in the analysis as there was a gap between the baseline and 2030. It may also be used as a future baseline for the major expansion proposed at Heathrow. The year 2016 is used as the baseline for the forecast analysis. Traffic forecasts were provided by DfT for each airport, based on the 2017 UK Aviation Forecasts[17].

The results represented in this chapter are the combined results for all eight airports considered in Chapter 4 and take into consideration the Heathrow third runway (LHR NWR). The results for each individual airport are presented in Appendix C. The results excluding Heathrow Airport are summarised in Appendix D.

The traffic movements used for each year and each scenario are presented in Table 4.2 (a) and Table 4.2 (b) and show that the 24h traffic for High and Central scenarios increase in relation to the 2016 baseline by approximately 39% and 36% respectively.

For noise limiting schemes that restrict emissions, quota count was the selected metric for evaluation and the results are presented in Table 6.1(a) for the High scenario and Table 6.1(b) for the Central scenario. The forecast results for the High scenario show a decrease in quota count for an average summer day and a decrease in quota count for the average summer night. Given that the number of ATMs for the High scenario are forecast to increase during the period, the decrease in quota count is expected to come from improvements in noise certification. Results for the Central scenario present similar trends as the High scenario. However, the Central scenario experiences lower quota count reductions than the high scenario for daytime and higher quota count reductions.

Table 6.1 (a): Forecast analysis - Quota Count (including LHR NWR), Scenario: HIGH

	Scenario: HIGH Quota Count					
Metric	**2016**	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
QC - average summer day 16h	2,478	2,463	2,622	1,971	1,927	-22.2%
QC - average summer night 8h	292	252	259	198	203	-30.4%
QC - average summer 24h	2,770	2,715	2,881	2,169	2,131	-23.1%

Table 6.1(b): Forecast analysis - Quota Count (including LHR NWR), Scenario: CENTRAL

	Scenario: Central Quota Count					
Metric	**2016**	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
QC - average summer day 16h	2,478	2,366	2,534	1,886	1,824	-26.8%
QC - average summer night 8h	292	239	246	188	193	-34.8%
QC - average summer 24h	2,770	2,605	2,780	2,074	2,017	-27.7%

For metrics that could limit noise exposure, Table 6.2 (a) presents a summary of the results for noise contour areas and population exposed for the High scenario. The results show that the noise contour areas for all noise exposure metrics considered are forecast to reduce by 2050, and that it consistently peaks in 2030 due to traffic growth that is subsequently offset by quieter aircraft entering the fleet in 2040 and 2050.

In terms of the population exposed to noise (Table 6.2(b)), the results show that for the average summer day, there is a small decrease within the 51 dB L_{Aeq16h} contour, but a small increase is forecast within the 54 dB L_{Aeq16h} contour. On the other hand, the average summer night contours show a small increase in population within the 45 dB L_{Aeq8h} contour and a decrease within the 48 dB L_{Aeq8h} contour. The average annual 24h population exposed to noise is forecast to increase and the average annual night time population within the 45 dB L_{night} contour will decrease whilst the population within the 50 dB L_{night} contour is forecast to increase. All of these changes are heavily influenced by forecast population growth within the noise contours.

Overall, for the noise contour levels where the population decreases, the populations have not decreased at similar rates to the noise contour area reductions. This is due to the forecasted increase in population. The forecast growth in population over time will be discussed later in this chapter.

Table 6.2 (b) also presents the results for the secondary Number Above metric. For an average N65 and N70 are used to indicate the number of movements above 65 dB and 70 dB L_{Amax} and N60 is used for indicating the number of aircraft movements above 60 dB L_{Amax} for an average summer night. The results show that the N65 and N70 are forecast to decrease. The N60 is forecast to increase, despite reductions in night time

Quota Count and contour area due to changes in fleet mix leading to noise decreases close in and noise increases further out from the airport.

The results for PEI (70) (Table 6.2) show that it is forecast to increase, mostly due to population growth. The results also show that AIE is forecast to increase, partly due to population growth, but also to increasing ATMs, which, where events are well above 70 dB L_{max} close to the airport, are not fully offset by quieter aircraft.

Table 6.2 (a): Forecast analysis - summary of noise contour area (including LHR NWR), Scenario: HIGH

		Scenario: High		Area (km²) results			
Metric	**Level**	**2016**	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
Average summer day L_{Aeq16h}	>51	881.3	898.7	942.9	809.4	806.3	-8.5%
Average summer day L_{Aeq16h}	>54	491.6	498.9	524.7	441.6	441.5	-10.2%
Average summer night L_{Aeq8h}	>45	800.9	777.4	809.2	714.6	733.7	-8.4%
Average summer night L_{Aeq8h}	>48	462.6	450.3	462.4	401.8	412.4	-10.8%
Average annual 24h L_{den}	>50	1,448.1	1,487.3	1,556.8	1,341.8	1,343.6	-7.2%
Average annual 24h L_{den}	>55	572.2	579.9	607.3	518.0	522.3	-8.7%
Average annual 8h L_{night}	>45	669.2	664.3	687.8	600.0	613.1	-8.4%
Average annual 8h L_{night}	>50	251.2	239.2	251.0	213.5	220.0	-12.4%

Table 6.2 (b): Forecast analysis - summary of population exposure (including LHR NWR), Scenario: HIGH

	Scenario: High Population Exposure						
Metric	**Level**	**2016**	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
Average summer day LAeq16h	>51	1,562,600	1,625,100	1,637,800	1,528,600	1,553,500	-0.6%
Average summer day LAeq16h	>54	783,500	804,000	846,500	771,800	796,600	+1.7%
Average summer night LAeq8h	>45	1,234,100	1,209,000	1,250,200	1,188,200	1,246,900	+1.0%
Average summer night LAeq8h	>48	648,600	595,600	580,800	552,400	597,700	-7.8%
Average annual 24h Lden	>50	2,471,500	2,581,900	2,888,700	2,662,900	2,739,700	+10.9%
Average annual 24h Lden	>55	948,400	961,000	1,004,400	920,200	952,600	+0.4%
Average annual 8h Lnight	>45	1,109,200	1,083,300	1,103,800	1,044,600	1,093,800	-1.4%
Average annual 8h Lnight	>50	321,600	285,500	306,700	297,200	326,500	+1.5%
Average summer night 8h N60	>5 events	2,143,400	2,114,800	2,301,200	2,214,500	2,321,200	+8.3%
Average summer night 8h N60	>10 events	1,462,900	1,446,700	1,616,400	1,574,600	1,638,200	+12.0%
Average summer day 16h N65	>5 events	2,609,300	2,719,500	2,659,300	2,499,900	2,354,600	-9.8%
Average summer day 16h N65	>10 events	1,965,400	2,122,600	2,143,400	1,942,700	1,951,600	-0.7%
Average summer day 16h N70	>5 events	1,062,100	1,113,200	995,200	859,500	815,600	-23.2%
Average summer day 16h N70	>10 events	838,700	878,000	793,800	674,300	657,600	-21.6%
AIE(70)	> 5 events	67.1	68.0	71.8	74.2	79.1	+17.9%
AIE(70)	> 10 events	79.6	81.3	85.0	88.9	96.2	+20.9%
PEI(70)	> 5 events	71,170,000	77,414,700	85,001,400	76,885,900	82,111,700	+15.4%
PEI(70)	> 10 events	69,591,900	75,735,500	83,538,100	75,572,000	80,995,400	+16.4%

Table 6.3 (a) shows the contour area noise exposure results for the Central scenario. The results show that all contour areas are expected to reduce and that the calculated area percentage reductions are bigger than in the High case. Table 6.3 (b) present the results for population exposed for the Central scenario. The results show that the population exposed to average summer day and average summer night noise will reduce. For the average annual 24h contour, the population exposed will increase at the lower noise contours and reduce at the higher noise contours. For the average annual night contours, the population exposed will decrease. The N-contours for the Central scenario follow the same trend presented for the High scenario, whereby N65 and N70 reduce and N60 increases with lower percentages than the Central case. PEI and AIE are also forecast to increase in the Central scenario.

Table 6.3 (a): Forecast analysis - summary of noise contour areas (including LHR NWR), Scenario: CENTRAL

		Scenario: Central AREA (km²) results					
Metric	**Level**	**2016**	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
Average summer day LAeq16h	>51	881.3	867.9	912.5	783.9	772.0	-12.4%
Average summer day LAeq16h	>54	491.6	481.2	508.7	427.4	422.3	-14.1%
Average summer night LAeq8h	>45	800.9	750.0	775.4	690.6	699.5	-12.7%
Average summer night LAeq8h	>48	462.6	434.7	445.5	389.3	394.6	-14.7%
Average annual 24h Lden	>50	1,448.1	1,435.3	1,496.1	1,299.6	1,291.2	-10.8%
Average annual 24h Lden	>55	572.2	557.6	587.9	502.3	500.2	-12.6%
Average annual 8h Lnight	>45	669.2	637.1	662.6	580.8	587.8	-12.2%
Average annual 8h Lnight	>50	251.2	228.4	242.5	207.3	210.7	-16.1%

Table 6.3 (b): Forecast analysis - summary of population exposure results (including LHR NWR), Scenario: CENTRAL

		Scenario: Central Population Exposure results					
Metric	**Level**	**2016**	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
Average summer day LAeq16h	>51	1,562,600	1,609,200	1,629,300	1,501,900	1,510,000	-3.4%
Average summer day LAeq16h	>54	783,500	792,700	835,800	743,900	757,700	-3.3%
Average summer night LAeq8h	>45	1,234,100	1,195,800	1,244,300	1,167,700	1,209,400	-2.0%
Average summer night LAeq8h	>48	648,600	587,300	572,500	536,000	569,700	-12.2%
Average annual 24h Lden	>50	2,471,500	2,568,100	2,884,500	2,617,600	2,646,600	+7.1%
Average annual 24h Lden	>55	948,400	945,700	990,000	890,400	908,800	-4.2%
Average annual 8h Lnight	>45	1,109,200	1,064,100	1,086,400	1,020,000	1,051,800	-5.2%
Average annual 8h Lnight	>50	321,600	279,700	300,400	287,600	304,000	-5.5%
Average summer night 8h N60	>5 events	2,143,400	2,084,300	2,278,000	2,181,100	2,264,500	+5.6%
Average summer night 8h N60	>10 events	1,462,900	1,436,200	1,606,600	1,549,200	1,613,300	+10.3%
Average summer day 16h N65	>5 events	2,609,300	2,691,600	2,633,000	2,459,100	2,286,100	-12.4%
Average summer day 16h N65	>10 events	1,965,400	2,092,200	2,114,100	1,911,200	1,886,200	-4.0%
Average summer day 16h N70	>5 events	1,062,100	1,089,200	956,300	835,000	754,200	-29.0%
Average summer day 16h N70	>10 events	838,700	862,700	767,900	655,100	618,200	-26.3%
AIE(70)	>5 events	67.1	66.9	72.4	72.5	81.4	+21.4%
AIE(70)	>10 events	79.6	80.7	89.2	91.8	103.2	+29.7%
PEI(70)	>5 events	71,170,000	75,859,500	84,387,400	73,964,000	77,432,500	+8.8%
PEI(70)	>10 events	69,591,900	74,212,100	82,974,600	72,673,100	76,418,300	+9.8%

Analysing the results for noise health impacts, the results show that the number of people highly annoyed is forecast to slightly increase and that the number of people highly sleep-disturbed is forecast to have a small decrease for the High scenario. For the Central scenarios, the number of people highly annoyed and highly sleep-disturbed will present a small reduction by 2050. Although the number of highly annoyed people and highly-sleep disturbed people will reduce by 2050, the forecast results show that the number of highly annoyed people and highly sleep disturbed will be at its highest in 2030.

Table 6.4 (a): Forecast analysis - summary of noise impact results (number of people highly annoyed and number of people highly sleep disturbed) (including LHR NWR), Scenario: HIGH

	Scenario: High Top 8 airports combined results					
	2016	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
No. of people highly sleep-disturbed Average annual 8h Lnight >45 dB	78,300	74,000	76,000	71,600	75,800	-3.2%
No. of people highly sleep-disturbed Average annual 8h Lnight >50 dB	30,800	26,400	28,500	27,300	30,100	-2.3%
No. of people highly annoyed (daytime) Average annual 24h Lden >51 dB	239,800	244,900	257,000	236,200	243,100	+1.4%
No. of people highly annoyed (daytime) Average annual 24h Lden >54 dB	173,000	173,600	182,800	168,000	173,600	+0.3%

Table 6.4 (b): Forecast analysis - summary of noise impact results (number of people highly annoyed and number of people highly sleep disturbed) (including LHR NWR), Scenario: CENTRAL

	Scenario: Central Top 8 airports combined results					
	2016	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
No. of people highly sleep-disturbed Average annual 8h Lnight >45 dB	78,300	72,600	74,600	69,700	72,300	-7.7%
No. of people highly sleep-disturbed Average annual 8h Lnight >50 dB	30,800	25,800	27,900	26,300	27,900	-9.4%
No. of people highly annoyed (daytime) Average annual 24h Lden >51 dB	239,800	241,700	255,300	230,500	233,400	-2.7%
No. of people highly annoyed (daytime) Average annual 24h Lden >54 dB	173,000	170,800	180,700	163,400	166,100	-4.0%

Table 6.5 presents the noise impact results assuming the population has not grown since 2016. The results show that the population exposed to noise would be reduced for all exposure metrics apart from PEI and AIE. The number of people highly annoyed and the number of people highly sleep-disturbed would reduce by at least 15% (Table 6.6).

The population exposed results from this study are slightly higher than the population exposed results provided in the NPS work (20,000-30,000 people). This is due to differences in the ANCON noise model database, allocation of DfT forecast and sensitivity to contour shape. These are explained in the next paragraphs.

ANCON noise model databases are updated year on year. Whilst the NPS work relied on the 2016 noise database, the Aviation Strategy forecasts used the 2017 database. It is a long-standing principle to use the latest available data. Normally CAA reviews the top ten noise dominant aircraft each year, but in 2017 a major review was untaken of calculated noise levels across all aircraft types, against noise measurements. Many remain the same, some are adjusted upwards, some downwards. For some aircraft newly introduced into service, e.g. A320neo and B737MAX, CAA obtained its first measurements and replaced industry certification data or estimates dating back to the time of the Airports Commission assessment.

As part of the noise modelling, there is a need to allocate the DfT aviation forecast ATMs across the day and night time periods, add a summer uplift (the core noise indicator LAeq16h, represents an average summer day) and distribute the ATMs across different airport departure routes. The NPS work relied on distributions to routes and across time periods based on third party advice to the Airports Commission work, and based on data from 2011-12. For the Aviation Strategy work, this data was updated to data from the 2016 Environmental Noise Directive noise mapping, done every 5 years. These changes subtly alter the uplift for a summer day, the split between day, evening and night periods and, most significantly, the split of ATMs across departure routes.

The third aspect that impacts population exposure is that the population within a contour is very sensitive to differences in contour shape. Contour area gives a much more reliable indicator of noise emission. Looking at LHR NWR 2050 as an example, the forecast area is 11% percent larger than for the NPS work, but the population is 9% smaller. The larger area indicates a higher noise emission. The fact the population decreases despite the area increase, is due to the contour shape changing. This is be due to the updated distribution of traffic across departure routes, reflecting the changes in markets since between 2012 and 2016, for example much higher growth on departure routes serving the Middle East for example.

It is also important to highlight that the nominal uncertainty of ANCON is ±1dB. It's extremely unlikely that a contour would be in error by +1 or -1dB in every location, and comparisons with measurements demonstrate this is not the case, but ±1dB equates to ±70,000 people at Heathrow in 2050.

Table 6.5: Forecast analysis – summary of noise exposure results (including LHR NWR), Scenario: HIGH with 2016 Population

		Scenario: High with 2016_Pop		Population Exposure results			
Metric	Level	2016	2025	2030	2040	2050	% change 2016-2050
Average summer day LAeq16h	>51	1,562,600	1,556,600	1,505,400	1,355,300	1,344,800	-13.9%
Average summer day LAeq16h	>54	783,500	770,100	779,100	684,300	690,200	-11.9%
Average summer night LAeq8h	>45	1,234,100	1,159,900	1,152,800	1,057,600	1,082,300	-12.3%
Average summer night LAeq8h	>48	648,600	570,900	535,000	489,100	515,800	-20.5%
Average annual 24h Lden	>50	2,471,500	2,463,200	2,659,600	2,358,500	2,367,200	-4.2%
Average annual 24h Lden	>55	948,400	921,900	925,100	817,300	826,800	-12.8%
Average annual 8h Lnight	>45	1,109,200	1,041,800	1,020,800	931,800	951,400	-14.2%
Average annual 8h Lnight	>50	321,600	271,500	282,200	262,400	281,200	-12.6%
Average summer night 8h N60	>5	2,143,400	2,021,800	2,120,900	1,968,000	2,017,400	-5.9%
Average summer night 8h N60	>10	1,462,900	1,384,800	1,488,900	1,399,800	1,419,700	-3.0%
Average summer day 16h N65	>5	2,609,300	2,609,200	2,459,900	2,202,500	2,057,900	-21.1%
Average summer day 16h N65	>10	1,965,400	2,033,200	1,984,400	1,698,600	1,702,900	-13.4%
Average summer day 16h N70	>5	1,062,100	1,064,400	917,100	764,000	708,900	-33.3%
Average summer day 16h N70	>10	838,700	840,700	731,300	599,000	571,500	-31.9%
AIE(70)	> 5 events	67.1	68.5	71.9	74.0	78.2	+16.6%
AIE(70)	>10 events	79.6	82.1	85.2	88.5	96.0	+20.7%
PEI(70)	> 5 events	71,170,000	73,934,100	79,235,600	69,091,300	72,081,700	+1.3%
PEI(70)	>10 events	69,591,900	72,297,400	77,897,100	67,923,400	71,096,500	+2.2%

Table 6.6: Forecast analysis - summary of noise impact results (number of people highly annoyed and number of people highly sleep disturbed) (including LHR NWR), Scenario: HIGH with 2016 Population

		Scenario: High with 2016 Pop Top 8 airports combined results					
Metric	**Level**	**2016**	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
No. of people highly sleep disturbed average annual 8h Lnight 45dB	>45	78,300	71,000	70,400	63,900	59,600	-23.9%
No. of people highly sleep disturbed average annual 8h Lnight 50 dB	>50	30,800	25,100	26,400	24,200	26,400	-14.3%
No. of people highly annoyed (daytime) average annual 24h Lden 51dB	>51	239,800	234,000	242,400	209,700	203,500	-15.1%
No. of people highly annoyed (daytime) average annual 24h Lden 54 dB	>54	173,000	166,300	174,100	149,300	140,900	-18.6%

Overall in the forecast analysis for 2025, 2030, 2040 and 2050 considering population growth around airports, the results for the High scenario is presented in Table 6.7.

Table 6.7: Summary of forecast analyses High scenario results for 2025, 2030, 2040 and 2050

Metric	% change 2016-2050
ATM, average summer day 16h	+39.2%
ATM, average summer night 8h	+35.4%
Quota count, average summer day	-22.2%
Quota count, average summer night	-30.4%
Noise contour area, average summer day, >54 dB	-10.2%
Noise contour area, average summer night, >48 dB	-10.8%
Population exposed, average summer day, >54 dB	+1.7%
Population exposed, average summer night >48 dB	-7.8%
Number Above, average summer day, N65 >10 events	-0.7%
Number Above, average summer night, N60 >10 events	+12.0%
Number Above, average summer day, N70 >10 events	-21.6%
Average Person Exposure, >10 events	+20.9%
Person Events Index, >10 events	+16.4%
No. of people highly annoyed, >54 dB	+0.3%
No. of people highly sleep disturbed, >45 dB	-3.2%

When considering a static population from 2016 onwards, the populations exposed to noise reduce for all metrics taken into consideration. The number of people highly annoyed is forecast to decrease 18.5% and the number of highly sleep disturbed people is forecast to decrease by 24.3%.

CHAPTER 7

Proposed limits

As part of this analysis, it is considered that a limit scheme for each metric type for limiting noise would be selected to be monitored and that the selection of the limiting scheme would include noise metric selection, selection of a method to take into consideration the traffic volume of an airport, selection of a monitoring mechanism for assessing noise limit compliance and selection of enforcement procedures for noise limits.

7.1 Noise metrics

The methodology utilised to select the metrics took into consideration the pros and cons from Chapter 2, the suitability to achieve the objectives, presented in Chapter 3, and how well each metric correlated with the others. The comparison between each metric was undertaken in order to reduce the overall number of metrics under consideration. For this, the correlation between each metric was calculated using the Pearson’s correlation coefficient[23]. The results for each metric pair are presented in Table 7.1 and values closer to 1 indicate a stronger correlation between the metrics; values closer to zero indicate a weaker correlation. The analysis has been undertaken using both a growing population and a static 2016 population. The results show higher levels of correlation between noise metrics when a static population is used, so a static population has been used for the metric selection analysis.

[23] https://www.spss-tutorials.com/pearson-correlation-coefficient/

Table 7.1: (a) Correlation between main metrics – High forecast scenario, 2016 static population (below 50% red, 50-70% yellow, above 70% green correlation)

	ATMs avg summer day	ATMs avg summer night	QC avg summer day	QC avg summer night	Area (km²) $L_{Aeq,16h}$ >54 dB	Area (km²) $LA_{eq,8h}$ >48 dB	Population $L_{Aeq,16h}$ >54 dB	Population $L_{Aeq,8h}$ >48 dB	Population N60 >10 events avg summer night	Population N65 >10 events avg summer day	Population N70 >10 events avg summer day	No. of HSD	No. of HA
ATMs average summer day	1.00	0.94	0.62	0.80	0.50	0.28	0.02	0.01	0.65	0.29	0.83	0.06	0.06
ATMs average summer night	0.94	1.00	0.69	0.86	0.59	0.16	0.06	0.01	0.82	0.49	0.92	0.03	0.14
QC average summer day	0.62	0.69	1.00	0.83	0.98	0.44	0.49	0.01	0.40	0.56	0.80	0.09	0.58
QC average summer night	0.80	0.86	0.83	1.00	0.74	0.35	0.20	0.00	0.57	0.44	0.82	0.20	0.35
Area 54 dB L_{Aeq16h}	0.50	0.59	0.98	0.74	1.00	0.38	0.62	0.03	0.36	0.64	0.76	0.06	0.70
Area 48 dB L_{Aeq8h}	0.28	0.16	0.44	0.35	0.38	1.00	0.17	0.38	0.00	0.00	0.17	0.49	0.19
Population Exposed >54 dB L_{Aeq16h}	0.02	0.06	0.49	0.20	0.62	0.17	1.00	0.10	0.03	0.47	0.22	0.03	0.94
Population Exposed >48 dB L_{Aeq8h}	0.01	0.01	0.01	0.00	0.03	0.38	0.10	1.00	0.17	0.42	0.04	0.62	0.07
Population Exposed to N60 >10 events	0.65	0.82	0.40	0.57	0.36	0.00	0.03	0.17	1.00	0.65	0.79	0.02	0.08
Population Exposed N65 >10 events	0.29	0.49	0.56	0.44	0.64	0.00	0.47	0.42	0.65	1.00	0.69	0.04	0.52
Population Exposed N70 >10 events	0.83	0.92	0.80	0.82	0.76	0.17	0.22	0.04	0.79	0.69	1.00	0.01	0.30
No. of people highly sleep disturbed	0.06	0.03	0.09	0.20	0.06	0.49	0.03	0.62	0.02	0.04	0.01	1.00	0.09
No. of people highly annoyed	0.06	0.14	0.58	0.35	0.70	0.19	0.94	0.07	0.08	0.52	0.30	0.09	1.00

The total number of movements has the advantage of being easily calculated and the information is available at several airports, however the number of movements does not take into consideration the noise emissions from different aircraft, neither does it account for the different payload and distances travelled, which are important. The number of movements has good correlation with day noise quota count and night noise quota count, when broken down into the number of movements per day and night respectively. It shows reasonable correlation with day noise contour area, but it gives no mechanism to limit impact within a given area. It also does not have any correlation with people exposed, so it would be not be effective in controlling population noise exposure or in driving noise reduction. Overall, the number of movements is a metric that should be monitored to understand the growth of the aviation market, but it does not provide effective controls to limit noise generation, noise exposure nor noise impacts.

The metric considered in this study for restricting noise emissions is Quota Count. It has the advantage of being easily calculated, it is already used at several airports and can be used both at national and local level, as well as in an absolute sense or be normalised by the volume of traffic. On the other hand, noise Quota Counts are not that easy to administrate and this needs to be taken into consideration if applied to smaller airports. There is good correlation between the number of daytime movements and daytime Quota Count, and a good correlation between night-time movements and night-time Quota Count. The daytime Quota Count correlates relatively well with L_{Aeq16h} contour area; however, the correlation of night-time Quota Count with L_{Aeq8h} noise contour area is not that clear. More detailed investigation highlighted that the poorer than expected correlation between night-time contour area and Quota Count is isolated to Gatwick airport and night-time fleet changes between 2006 and 2016.

The results also showed that there is some correlation between daytime Quota Count and L_{Aeq16h} population exposed, however there is no clear correlation for night-time, this being due to the large differences in population density between the airports assessed. However, at a given airport, the correlation between day or night-time population is high. The Quota Count is considered effective at ensuring that the growth in number of movements is balanced out with the introduction of new technology. However, it is not an effective control for limiting noise within a given area with population growth as it offers no mechanism to directly limit the distribution of noise around an airport. Quota Count reductions can be associated with a reduction in noise impact, but only if the noise distribution and population remain constant, as it is not effective in controlling the influx of population into areas near the airport. Quota Count offers an easy way for airports to liaise with airlines on the management of their day to day noise emission and could play a role in linking a KPI more focused in addressing noise impacts and the operational requirements from airports.

In relation to metrics that restrict noise exposure, L_{Aeq16h}, L_{Aeq8h}, L_{den}, L_{night} were considered in the analysis. However, they require calculations and need to be supported with ongoing measurements. L_{Aeq16h} and $L_{Aeq,8h}$ have the advantage of already being routinely assessed and monitored at many UK airports, so limited change would be required for their use as a limit-based KPI. L_{den} is the metric specified for the environmental noise maps produced every five years under the European Noise Directive (Directive 2002/49/EC). Were it adopted as a KPI it would require assessment more frequently than is done currently, and whilst this would facilitate reporting to the EC, it would increase the assessment burden on airports. L_{den} also provides the opportunity to have a single metric to incorporate the noise levels for day, evening and night. However, when the impacts in different parts of the day are different, i.e. annoyance and sleep-disturbance, L_{den} does not address these. Given that some airports in the UK (Heathrow and Gatwick) already monitor L_{Aeq16h} at 54 dB (and above) and L_{Aeq8h} at 48 dB, it is proposed that these metrics together with their respective noise exposure areas are used as the basis for day and night noise exposure limits.

The average summer day L_{Aeq16h} contour area presents a relatively good correlation with population exposed and the average summer night L_{Aeq8h} noise contour area correlates relatively well with population exposed to night noise. The levels of correlation between the L_{Aeq16h} noise contour and the number of highly annoyed people are low due to the varying population density between different airports. At a given airport, the correlation between area and the number of people highly annoyed is high. Similar results are seen for the estimated number of highly sleep-disturbed people.

Other supplementary noise exposure metrics analysed to limit noise exposure are Number Above, PEI and AIE. These metrics can be applied to either summer or annual average time periods as well as for different periods of the day. In this report they have been analysed for the summer period. Number Above metrics are useful to understand how often a population is exposed to aircraft noise, but have the disadvantage that they treat noise at different levels in the same way, e.g. a noise event of 71 dB or 80 dB L_{Amax} is counted, but an event at 69 dB or 50 dB L_{max} is not. Nevertheless, Number Above presents a way of understanding the number of events above a certain noise level, but it does not directly relate to the level of exposure. Person Events Index (PEI) aggregates Number Above information at different quantities into a single indicator that can be considered the total noise load of an airport on the surrounding population. The Number Above metrics showed better correlation with the other metrics and therefore were selected for comparison in Table 7.1. Number Above provides a reasonable correlation with the number of ATMs and with Quota Count. Number Above has reasonable correlation with noise contour area and with population exposed during daytime. The correlation is not as clear for night-time. It shows some correlation with population exposed, but this was not strong enough to consider Number Above as an appropriate limit metric.

The analysis of noise impact took into consideration the number of highly annoyed people and the number of highly sleep-disturbed people. The advantage of these metrics is that they are directly related to the health impact associated with noise. On the other hand, they are limited by the dose-response relationships between noise exposure (L_{Aeq} or L_{den}) used to estimate the numbers of people likely to be highly annoyed or sleep disturbed, which are also subject to change over time. For this analysis, the estimates were based on L_{den} (annoyance) and L_{night} (sleep disturbance) respectively, so they are related to the annual noise exposure levels. Whilst an equivalent function is available for summer daytime, one is not available for the average summer night time, but it is recommended that similar functions are established in UK. Like for population exposure, it was found that the number of highly annoyed and highly sleep disturbed people did not correlate well with the other noise metrics when data were aggregated across airports because of the different population densities across airports, making the indicator unsuitable as a national indicator. However, it was found to correlate with noise exposure area and QC at a given airport, but like population it suffers from being affected by population growth.

Given that Number Above lacks an ability to restrict population exposure, it is not recommended as a main noise limit. However, Number Above are recognised as a useful supplementary noise metric and it is recommended as a KPI to be monitored at each airport.

Overall, Quota Count and average summer daytime and night-time noise contour area at a certain noise level are considered to represent the best correlation with other noise metrics and therefore to limit overall noise exposure.

7.2 Selection of method to take into consideration traffic volume of an airport

Several methods can be used to take into consideration the traffic volume at an airport and provide a relative measure for a noise limit. If a relative method is to be introduced in the UK it should be set to account for different sized airports according to the different economic benefit they generate.

For this study, only the number of movements for each airport was available. Figure 7.2 presents the results of normalising each metric by the number of average summer day movements. This was done by dividing each of the results by the number of average summer day movements. The results show that the normalisation does not give a consistent variation amongst most metrics and therefore may not be the most appropriate method for taking into consideration the traffic volume.

Figure 7.2: Metrics normalised by number of movements

Forecast	Metric	Level	2006	2016	2025	2030	2040	2050
High	No. Movements LAeq16h	-	1	1	1	1	1	1
High	No. Movements LAeq8h	-	0.1	0.1	0.1	0.1	0.1	0.1
High	QC - LAeq16h	-	0.6	0.6	0.5	0.5	0.3	0.3
High	QC - LAeq8h	-	0.1	0.1	0.1	0.0	0.0	0.0
High	Area (km^2) LAeq16h	>54 dB	0.1	0.1	0.1	0.1	0.1	0.1
High	Area (km^2) LAeq8h	>48 dB	0.1	0.1	0.1	0.1	0.1	0.1
High	Population exposed - LAeq16h	>54 dB	189.8	181.7	178.1	158.6	136.1	132.8
High	Population exposed - LAeq8h	>48 dB	119.9	150.4	132.0	108.8	97.4	99.6
High	Population exposed - N60	>10 events	279.5	339.3	320.5	302.8	277.7	273.1
High	Population exposed - N65	>10 events	563.2	455.8	470.3	401.6	342.6	325.3
High	Population exposed - N70	>10 events	224.1	194.5	194.5	148.7	118.9	109.6
High	No. of people highly sleep-disturbed Lnight 45dB	>45 dB	17.0	18.2	16.4	14.2	12.6	12.6
High	No. of people highly annoyed Lden 54 dB	>54 dB	41.5	40.1	38.5	34.2	29.6	28.9

Others studies[8] argue that a method that accounts for weight (maximum payload) and distance travelled would enable equitable exposure or impact-based limits as it would take into consideration both freight and passenger weight as well as distance travelled over a period. It is recommended that this method of taking into consideration traffic volume is tested and used as part of a noise limit. Eurocontrol Charges MTOW /50 uses a weight and a distance factor and therefore could be explored further as a metric to take into consideration traffic volume at an airport[24].

7.3 Selection of a monitoring mechanism for noise limits compliance

Chapter 2.3 presents the review of noise limits compliance limit. Following from section 7.1 the noise scheme derived would have metrics for noise emissions, noise exposure and noise impact and limits only for noise exposure, as it would be the best way of encouraging improvements in noise emissions and the reduction of noise impacts.

It is recommended that Quota Count and noise contour area are used to monitor noise exposure and that the number of highly annoyed people and number of highly sleep-disturbed people are monitored.

A wide range of options for compliance that could be used with these metrics is presented in Chapter 2. The selection presented here is based on keeping consistency as much as possible with what is already being used to monitor compliance.

For noise quota it is recommended that the London Airports' Quota Count system is expanded to other airports and applied to both day and night-time[25]. The monitoring of Quota Count would need to be undertaken on a continuous basis and reported annually. For noise contour area at a certain noise level, it is recommended that the selected airports would report their average summer L_{Aeq16h} and L_{Aeq8h} contour areas on an annual basis. The selection of airports could be aligned with the major airport definition in the Environmental Noise Directive, i.e. those with more than 50,000 ATMs per year or those within agglomerations, although it is recognised that this would require some airports to undertake annual assessments that do not currently.

The number of highly disturbed people and highly sleep disturbed people are currently derived from EEA functions[13] and calculated using noise exposure areas based on L_{den} and L_{night}. These metrics could be calculated as part of the Defra END five yearly reporting requirements. Alternatively, in the future, dose response functions could be derived from SoNA 2014, based on average summer day and night-time noise exposure and then be linked to the same metric for reporting noise exposure area.

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24 Central Route Charge Office, Customer Guide to Charges, Jan 16.

25 London Airports Noise Restrictions Notice (No. 2 2018)

7.4 Selection of enforcement procedures for noise limits

As presented in section 2.4, a noise limit scheme requires an enforcement procedure and an organisational body to oversee the enforcement process. Table 2.4 presents a summary of enforcement procedures including advantages and disadvantages.

Following on from the selection of noise metrics presented in section 7.1, it is recommended that Quota Count and average summer day and night noise contour areas are used to limit noise exposure and that the number of highly annoyed people and number of highly sleep-disturbed people are monitored.

If using a Quota Count based limit, it is recommended that the same approach as the London Airports Night Restrictions is used, and that any exceedance of the Quota Count results in a loss of future capacity in the next control period up to a certain proportion, beyond which a further penalty could be applied. The most appropriate control period would be the summer/winter scheduling periods, which would enable scheduling to be coordinated alongside the limit, as is done today at the London airports for the Night Quota Period.

If noise contour area at a specified contour level is used as the noise limit, a similar penalty system could be applied, but the period would need to be aligned with the noise metric, the average summer day or night.

7.5 Other factors

Unlike Quota Count, there are other factors that may alter the noise contour area for a particular airport and therefore need to be considered if an area limit is to be implemented. These factors include runway modal split, the airspace design and the distribution of flights across arrival and departure routes.

Runway modal split is dictated by wind direction and can alter contour area which could cause a breach through no fault of the airport. A change of airspace design, for instance, the introduction of different SIDs can change the contour shape and slightly alter the contour area. Where major airspace redesigns are considered, a contour area limit may need to be re-evaluated in light of the revised airspace design. Finally, a redistribution of flights between existing SIDs, e.g. due to a change in destination markets served, may also change contour shape and have a secondary effect on contour area for no increase in ATMs.

7.6 Selection of noise limit schemes

The selection of a suitable noise limit has taken into consideration the ability of the noise indicator to limit noise emission, limit area exposed to specific levels, the population exposed or health impacts. Other key considerations being used in this review, as introduced in Chapter 1, are the ability to fulfil national and local requirements, and to be related to factors within the aviation industry's control.

The analysis presented in section 7.1 to 7.5 shows that:

- Average summer day and night Quota Count represent relatively good correlations when compared with noise contour area, but little correlation with population exposed to noise when population remains constant at 2016 levels, due to differing population densities around the airports assessed. However, for a given airport, there is a good correlation between Quota Count and population exposure.
- Daytime L_{Aeq16h} contour area correlates well with population exposed to noise, when population growth is not considered. However, night-time L_{Aeq8h} contour area is not well correlated with population exposure, due to the wide range of population densities across airports, and night restrictions that result in night-time contours being similar in size across different airports, compared to daytime. $L_{Aeq,8h}$ contour area is, however, well correlated with population exposure for a given airport.
- Overall, Quota Count and noise contour area at a certain noise level present the best correlation with other noise metrics and are recommended to limit noise exposure.
- Because Quota Count and noise contour area at a certain noise level are unrelated to the population density around an airport, they are unable to control the population influx into areas exposed to noise around an airport.
- Unless the aviation industry is given much greater control over the population influx around an airport, it is not possible to recommend noise limits based on population exposure that are currently beyond the control of the aviation industry.
- Neither Quota Count nor noise contour area present very good correlations with the number of people estimated to be highly-annoyed or highly-sleep disturbed, again, due to the varying population densities across the airports assessed and therefore are not recommended as a national noise limit. There is, however, good correlation at a given airport and so there is merit in monitoring the number of people highly annoyed or highly sleep disturbed, but given that the surrounding population is allowed to grow, these metrics are outside an airport's control and no limits should be applied to them.

- The recommended methods of choice to take into consideration the traffic volume of an airport are weight (freight & passenger payload) and distance travelled. These two enable equitable exposure or impact-based. Existing airport statistics reporting Revenue Passenger Kilometres (RPK) and Revenue Tonne Kilometres (RTK) could be used as the basis of total airport productivity, however, this would add complexity and need further consideration.
- At a local level, the use of a relative limit linked to Quota Count or noise contour area would not necessarily limit noise exposure for the communities around airports. Therefore, an absolute limit is proposed to limit local noise. A locally set absolute Quota Count or noise contour area limit for each airport would allow for local authorities to balance noise limits with land use and economic issues. The local absolute limit will also ensure that airports are accountable for reducing the noise.
- At the national level, there may be wider opportunities for growth whereby a relative metric would be more suitable, however it would not necessarily limit noise exposure and would only give an indication of how efficient the airport is compared to others. A relative limit, e.g. QC per flight, would also need to be considered alongside other aviation environmental impacts such air quality and greenhouse gas emissions. The introduction of a nationally set absolute Quota Count limit or noise contour area limit would allow for comparison between airports to be made, to get a better understanding of the internal market and of the total number of people impacted by noise in the UK. If an area limit is selected, the national limit will also allow for comparison of noise contour area efficiency between airports. On the other hand, absolute national limits may restrict aviation grown in certain areas.
- In terms of noise monitoring mechanisms, it is recommended to keep in line with current reporting as much as possible in order to minimise any extra reporting burden. Therefore, for Noise Quota it is recommended that the London Airports Night Restrictions system be applied to other airports for the daytime and night-time periods across summer and winter seasons (aligned with airport scheduling changes). For noise contour area at a certain noise level, it is recommended that average summer day 54 dB L_{Aeq16h} and 45 dB L_{Aeq8h} contours are used.
- To monitor the number of people impacted, the number of highly annoyed and highly sleep-disturbed people should be used. These should be calculated using UK dose-response functions based on average summer day L_{Aeq16h} and night L_{Aeq8h} contours and thus related to noise contour area limits.

In summary, the proposed limit scheme consists of:

1) A nationally set absolute Quota Count limit or noise contour area limit at a particular noise level for both day and night, aggregated across all major airports;
2) A locally set absolute Quota Count or noise contour area limit at a particular noise level for both day and night for each airport;
3) Local monitoring of the number of highly annoyed and highly sleep-disturbed people;
4) Reporting requirements.

CHAPTER 8

Sensitivity analysis

Two sensitivity analyses were considered in order to understand what the impact would be if the older fleet was substituted at a faster rate and if the rate of technology improvement was accelerated.

In order to undertake a sensitivity analysis considering the impact of a faster rate of introduction of quieter aircraft into airport operations, this study considers that for all airports in 2025, each aircraft type is substituted with its newest equivalent type, maintaining size and range capability. The sensitivity analysis was undertaken on the average summer day L_{Aeq16h} and night L_{Aeq8h} noise contours to compare the variation between the fleet as per (DfT) forecast and a further acceleration of fleet replacement of 4% per year.

A 4% acceleration was selected by analysing the rate of change observed at the London airports in the last three summers (2015-2017) as per Figure 8.1, which shows that the average rate of fleet change per year is approximately 3%. Therefore, this sensitivity analysis considered how much the noise could be reduced if the rate of fleet change was doubled to 6% per year. The results presented in Table 8.1 show that the average summer day 54 dB L_{Aeq} contour area would reduce by a further 8% by 2025 if the rate of change towards new technology is doubled each year. The corresponding population reduction would be 6.7%. Slightly smaller improvements are seen for the night-time noise contours, due to the different fleet mix and the dominance of arrival operations.

Figure 8.1 Estimated percentages of traffic less than one year old

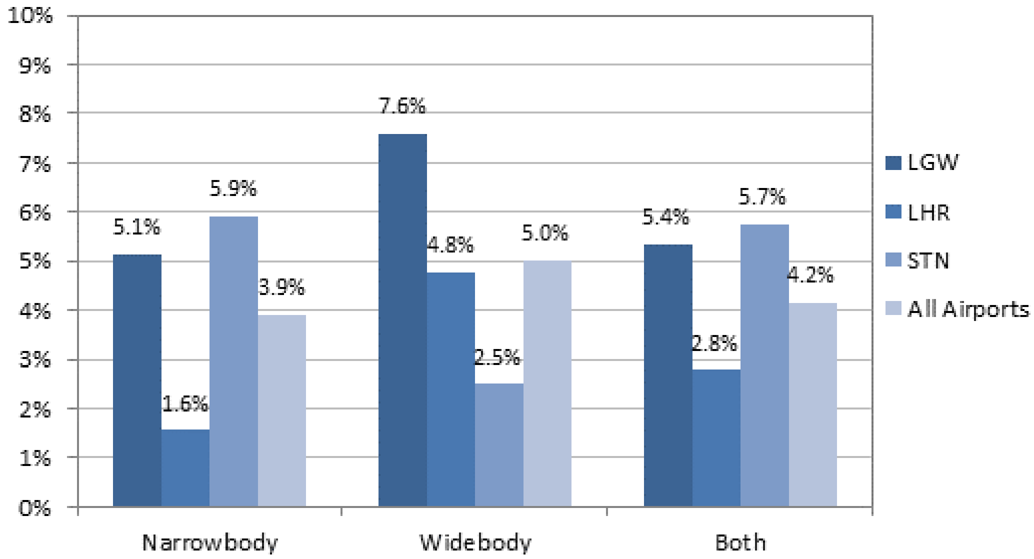


Table 8.1(a): Best in class results – 2025 noise contour area

		2025 contour area (km²)		
Metric	Level	High	High best in class	% change
Average summer day LAeq16h	>51	898.7	839.3	-6.6%
Average summer day LAeq16h	>54	498.9	461.6	-7.5%
Average summer night LAeq 8h	>45	777.4	732.4	-5.8%
Average summer night LAeq 8h	>48	450.3	423.5	-6.0%

Table 8.1(b): Best in Class results – 2025 Population Exposure

		2025 population exposed		
Metric	Level	High	High best in Class	% change
Average summer day LAeq16h	>51	1,625,100	1,560,400	-4.0%
Average summer day LAeq16h	>54	804,000	753,800	-6.2%
Average summer night LAeq 8h	>45	1,209,000	1,172,300	-3.0%
Average summer night LAeq 8h	>48	595,600	565,700	-5.0%

In order to understand the impact of different rates of technology improvement the main analysis (which used a 0.1dB/year improvement rate) was repeated using a 0.3 dB/year improvement rate and representing the upper bound of the ICAO Independent Expert Noise Technology Review[17] (0.1 dB/year being the lower bound). The analysis was undertaken for all airports in 2050 using the average summer day L_{Aeq16h} and night L_{Aeq8h} noise contours. Table 8.2 (a) presents the results, showing a further 8% reduction in average summer day L_{Aeq16h} contour area, and a further 5% reduction in average summer night L_{Aeq8h} contour area, if the rate of improvement of technology is accelerated from 0.1 dB per year to 0.3 dB per year.

Table 8.2(a): Rate of technology improvement results - noise contour area

		2050 contour area (km²)		
Metric	Level	High	High with tech. improvement	% change
Average summer day LAeq16h	>51	806.3	748.4	-7.2%
Average summer day LAeq16h	>54	441.5	407.3	-7.7%
Average summer night LAeq 8h	>45	733.7	695.6	-5.2%
Average summer night LAeq 8h	>48	412.4	390.9	-5.2%

Table 8.2(b): Rate of technology improvement results - population exposed

		2050 population exposed		
Metric	Level	High	High with Tech Improvement	% change
Average summer day LAeq16h	>51	1,553,500	1,436,000	-7.6%
Average summer day LAeq16h	>54	796,600	686,800	-13.8%
Average summer night LAeq 8h	>45	1,246,900	1,173,600	-5.9%
Average summer night LAeq 8h	>48	597,700	555,600	-7.0%

In the same manner, if there is a delay in introducing "best in class" aircraft or a delay in fleet replacement that reduces the noise improvement rate to less than 0.1 dB per year, the noise contour area and population exposure reductions estimated in the main analysis would be reduced.

CHAPTER 9

Conclusions

The Department for Transport is developing a new Aviation Strategy and commissioned the CAA to undertake four analyses in support of the strategy: airport noise forecasts, consideration of how airport noise may be limited, the effect of emerging aviation technologies on future noise exposure and to investigate the potential role that ambient (background) noise plays in attitudes to aircraft noise. This report covers the first two items and presents a feasibility study of implementing airport noise limits nationally and locally, including consideration of the pros and cons that noise limits may create. To inform the consideration of noise limits, it uses DfT aviation growth forecasts to estimate the level of aircraft noise in the shorter/medium term (2025) and in 2030, 2040 and 2050. The report also includes two sensitivity analyses to understand what the effect would be if older aircraft were replaced at a faster rate and also if the rate of technology improvement was accelerated.

A review of suitable noise metrics, targets and limits relating to aircraft noise exposure and their associated effects on noise limiting noise emission, exposure and health impact was undertaken. The limits review considered ways to limit noise emission at source, the area exposed around an airport, the population exposed within that area, and their associated health impacts, from which a reduced set of metrics was selected for detailed analysis.

The noise around an airport varies over time, primarily depending on aviation growth rates, and the introduction of quieter aircraft. Over the last 30 years there has been a significant reduction in noise exposure around virtually all UK airports. However, after the recession of 2009, which was followed by sustained growth, noise exposure has grown over the past five years at several airports. In order to inform a consideration of noise metrics and potential targets and limits, noise analysis was undertaken for eight airports (Birmingham, Edinburgh, Glasgow, London Gatwick, London Heathrow, Luton, Manchester and Stansted), for two historical years (2006 and 2016) and the following forecast years: 2025, 2030, 2040 and 2050. The forecast analysis takes into account the adoption of the Airports National Policy Statement (NPS) and assumes a third North West Runway (NWR) at Heathrow is built by 2030.

The analysis of the 2006 and 2016 noise performance was undertaken to review the application of different limits and to understand the implications of changing noise emission (quota), contour area, population exposure, and noise impacts over the past ten years.

The forecast analysis for 2025, 2030, 2040 and 2050 was undertaken to identify the effect of different limits in relation to modelled traffic growth, in order to understand the implications and opportunities for reducing noise generation, population exposed and noise impacts. Central and high scenarios were used in the analysis based on the latest

UK Aviation Forecasts. A summary of the high scenario analysis covering the total for all airports is presented in Table 9.1. The results presented use a population growth per CACI forecast data.

Table 9.1: Summary of noise metric results with population growth including a third runway (NWR) at Heathrow, Scenario: HIGH

			Year						
Metric	**Period**	**Level**	**2006**	**2016**	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
Traffic (ATMs)	Average summer day 16h*	-	4349.5	4311.6	4513.3	5337.5	5670.1	5999.6	+39.2%
	Average summer night 8h*	-	454.3	505.7	533.9	601.1	642.1	684.9	+35.4%
Noise emission (Quota Count)	Average summer day 16h* QC	-	2696.7	2478.2	2462.9	2622.1	1970.9	1927.4	-22.2%
	Average summer night 8h* QC	-	301.3	291.8	252.1	258.6	197.7	203.1	-30.4%
Area exposure (Km^2)	Average summer day LAeq16h*	>54 dB	530.4	491.6	498.9	524.7	441.6	441.5	-10.2%
	Average summer night LAeq8h*	>48 dB	419.6	462.6	450.3	462.4	401.8	412.4	-10.8%
	Average annual 24h Lden	>55 dB	615.6	572.2	579.9	607.3	518.0	522.3	-8.7%
	Average annual 8h* Lnight	>50 dB	268.0	251.2	239.2	251.0	213.5	220.0	-12.4%
Population exposure (Numbers exposed to noise level)	Average summer day LAeq16h*	>54 dB	825,400	783,500	804,000	846,500	771,800	796,600	+1.7%
	Average summer night LAeq8h*	>48 dB	521,700	648,600	595,600	580,800	552,400	597,700	-7.8%
	Average annual 24h Lden	>55 dB	997,300	948,400	961,000	1,004,400	920,200	952,600	+0.4%
	Average annual 8h* Lnight	>50 dB	304,600	321,600	285,500	306,700	297,200	326,500	+1.5%
	Average summer night 8h* N60	>10 events	1,215,900	1,462,900	1,446,700	1,616,400	1,574,600	1,638,200	+12.0%
	Average summer day 16h* N65	>10 events	2,449,500	1,965,400	2,122,600	2,143,400	1,942,700	1,951,600	-0.7%
	Average summer day 16h* N70	>10 events	974,600	838,700	878,000	793,800	674,300	657,600	-21.6%
	Average Individual Exposure (70)	>10 events	61.8	79.6	81.3	85.0	88.9	96.2	+20.9%
	Person Events Index (70)	>10 events	64,098,100	69,591,900	75,735,500	83,538,100	75,572,000	80,995,400	+16.4%
Noise impact (Numbers exposed to noise level)	Highly sleep-disturbed average annual 8h* Lnight	>45 dB Lnight	73,800	78,300	74,000	76,000	71,600	75,800	-3.2%
	Highly annoyed (daytime) average annual 24h Lden	>54 dB Lden	180,500	173,000	173,600	182,800	168,000	173,600	+0.3%

*16h: 0700-2300 and 8h: 2300-0700.

The results show that from 2006 to 2016, source noise emission (Quota Count) has decreased by 8.4% for an average summer day and by 0.6% for an average summer night. Noise contour areas have decreased by 7.6% for an average summer day at 54 dB and by 12.7% for an average summer night at 48 dB. Population decreased by 5.2% for an average summer day and increased by 25.6% for an average summer night, due to the growth in population within the noise contours between the two years.

For the forecast years, the results show that source noise emission (Quota Count) is expected to reduce by 22.2% for an average summer day and reduce 30.7% for an average summer night. The noise contour areas are expected to reduce by 10.1% for an average summer day and by 11.2% for an average summer night. However, the population exposed is expected to increase by 1.8% for an average summer day at 54 dB and to decrease by 7.8% for an average summer night at 48 dB. The number of Highly Annoyed people is expected to increase by 0.5% at 54 dB and number of Highly Sleep Disturbed people is expected to decrease by -3.3% at 45 dB, when accounting for the forecast growth in population from 2016 onwards.

When a static population was considered from 2016 onwards, the population exposed decreased by 11.8% for an average summer day at 54 dB and by 20.5% for an average summer night at 48 dB, in line with noise contour area reductions. Impacts are also forecast to reduce, with the number of Highly Annoyed people decreasing by 18.5% at 54 dB for an average annual day and the number of Highly Sleep-Disturbed People decreasing by 24.3% at 45 dB for an average annual night, assuming no population influx into the noise contour.

In order to derive the proposed noise limits, an analysis was undertaken to determine the correlation between the metrics selected, to understand how well they relate to each other and their ability to limit the amount of noise emitted, the noise exposure (contour area) and the number of people highly annoyed or highly sleep-disturbed.

In order to address the Aviation Policy Framework objective to “limit and where possible reduce the number of people in the UK significantly affected by aircraft noise” and take into account the latest UK airspace policy noise objectives to avoid significant adverse impacts and mitigate and minimise adverse impacts, the proposed limit scheme would contain the following:

1) A nationally set absolute Quota Count limit or noise contour area limit at a particular noise level, for both day and night, aggregated across all major airports;

2) A locally set absolute Quota Count or noise contour area limit at a particular noise level, for both day and night, for each airport;

3) Local monitoring of the number of highly annoyed and highly sleep disturbed people;

4) Reporting requirements.

A sensitivity analysis on two of the forecast noise technology assumptions was also undertaken to assess the impact of a faster substitution of quieter aircraft into the forecast fleets and of a faster rate of technology improvement.

If the rate of substitution of aircraft to the best in class is doubled from 2016 to 2025 a further 8% reduction in noise contour areas would be achieved for an average summer day at 54 dB and a further 6.7% reduction in noise contour area would be achieved for an average summer night. In the same way, the population exposed would decrease by 6.7% for an average summer day at 54 dB and by 5.2% for an average summer night at 48 dB.

If the rate of technology improvement was increased from 0.1 dB to 0.3 dB per year from 2016 to 2050 the noise contour area would reduce by a further 7.8% for an average summer day at 54 dB and by 5.2% for an average summer night at 48 dB. The population exposed would reduce a further 13.8% for an average summer day at 54 dB and by 7% for an average summer night at 48 dB.

APPENDIX A

Glossary

A-weighting A frequency weighting that is applied to the electrical signal within a noise-measuring instrument as a way of simulating the way the human ear responds to a range of acoustic frequencies.

AIE Average Individual Exposure is the average number of noise events per exposed person above a certain level

ATM Air Traffic Movements

BHX Birmingham Airport

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

DNL See Ldn.

DfT Department for Transport (UK Government).

Eurostat European Statistical Office

EDI Edinburgh Airport.

EPNL Effective Perceived Noise Level. Its measurement involves analyses of the frequency spectra of noise events as well as the duration of the sound.

ERCD Environmental Research and Consultancy Department of the Civil Aviation Authority.

GLA Glasgow Airport.

ICAO International Civil Aviation Organization.

HA The number of people (highly) annoyed during the day according to EU WHO [4] or SoNA [5] definitions.

HSD The number of people (highly) sleep-disturbed according to EU WHO [4] or SoNA [5] definitions.

LA The A-weighted sound level (in dBA).

LAeq8h Equivalent sound level of aircraft noise in dBA for the 8 hour annual day. For conventional historical contours for a particular year this is based on the daily average movements that take place between 0700 and 2300 local time during the 92-day period 16 June to 15 September inclusive.

LAeq16h Equivalent sound level of aircraft noise in dBA for the 16 hour annual day. For conventional historical contours for a particular year this is based on the daily average movements that take place between 0700 and 2300 local time during the 92-day period 16 June to 15 September inclusive.

LAmax The maximum A-weighted sound level (in dBA) measured during an aircraft fly-by.

Lday Equivalent sound level of aircraft noise in dBA for the 12-hour annual day (0700-1900).

Lden 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.

Ldn 24-hour Leq measure with an un-weighted 11-hour daytime period (0700-2200) and a 10 dB weighting for any noise events occurring during a 9-hour night- time period (2200-0700). This metric is commonly referred to as the Day-Night Level (DNL).

Leq Equivalent sound level of aircraft noise, often called equivalent continuous sound level. Leq is most often measured on the A-weighted scale, giving the abbreviation LAeq.

Levening Equivalent sound level of aircraft noise in dBA for the 4-hour annual evening (1900-2300).

LGW London Gatwick Airport.

LHR London Heathrow Airport.

LHR London Heathrow Airport.

Lnight Equivalent sound level of aircraft noise in dBA for the 8-hour annual night (2300-0700).

LTN Luton Airport.

MAN Manchester Airport.

N_XX Number Above is the number of aircraft events louder than XX dBA

Pearson's correlation coefficient is a number between -1 and 1 that indicates the extent to which two variables are linearly related.

PEI Person Event Index is the number of noise events all residents are exposed to above a certain threshold level and gives a figure that represents the total noise load or burden the airport places on the surrounding population

PNL/PNdB Perceived Noise Level, measured in PNdB. Its measurement involves analyses of the frequency spectra of noise events as well as the maximum level.

PNLT Tone-corrected Perceived Noise Level. PNLT is a refinement of PNL that accounts for any strong tonal content in an individual spectrum.

QC Quota Count is a metric intended to reflect the contribution made by an aircraft to the total noise impact around an airport, the latter being expressed by the total Quota Count - the sum of the QC classifications of all arrivals and departures.

SEL The Sound Exposure Level generated by a single aircraft at the measurement point, measured in dBA. This accounts for the duration of the sound as well as its intensity. (SEL is referred to as LAE or LE in some texts.)

STN Stansted Airport.

APPENDIX B

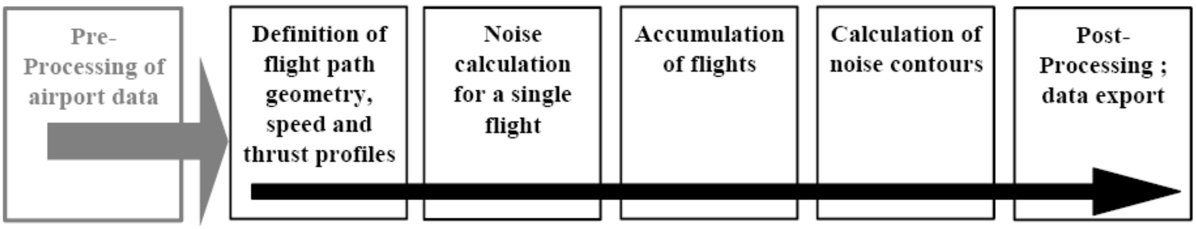
Overview of ANCON and ECAC-CEAC Doc 29 4th edition

Recommended practices for aircraft noise modelling have been published by three major aviation bodies: ICAO, ECAC and SAE. They offer guidance on how to construct a framework for modelling and how to use the manufacturer-supplied data. The level of detail varies, but there is a broad agreement on topics modellers need to consider and on areas where bodies have detailed agreement.

ECAC Doc. 29 is a standard method used for computing noise contours around civil airports, recommended for use in the 44 ECAC States, initially published in 1987 and developed by the ANCAT/AIRMOD Task Group of ECAC. Its Fourth Edition was adopted by ECAC-DGCA/147 on 7 December 2016. It allows for consistent computation of noise contours throughout ECAC States. It is also used as the reference methodology for EU noise legislation, including for the establishment of noise action plans, and contributes towards the global guidance from ICAO. The new edition of ECAC Doc. 29 includes several technical improvements to the modelling.

Figure B.1 is a description of the calculation process within ANCON. The aim is to calculate SEL and L_{Amax} at a given observer point for each specific combination of aircraft type, flight profile and flight path ("Single Event Calculation").

Figure B.1 Calculation process within ANCON



ANCON (UK Civil Aircraft Noise Contour Model) is the UK's civil aircraft noise model which is owned by the Department for Transport (DfT) and developed, maintained and operated by the CAA's Environmental Research and Consultancy Department (ERCD). It is a specialised suite of programmes, written in Fortran, and has been supported technically in-house for the last three decades and funded by the DfT through a Section 16 Letter of Agreement which is renewed annually. ANCON's mathematical model is based on ECAC Doc. 29 4th Edition (2016).

ANCON version 2.4 is the current version of the ANCON model. The model is used for the majority of ERCD's work for the DfT and its commercial clients. It predicts noise from aircraft in the vicinity of an airport and therefore provides the evidence basis which underpins noise management, policy, airspace and standards setting decisions made by the CAA, DfT, ECAC (European Civil Aviation Conference) and ICAO (International Civil Aviation Organization), amongst others.

ANCON basic principles

ANCON version 2 is the mathematical model based on ECAC-CEAC Doc 29. Its primary objective is to produce noise contours - that is, lines which enclose geographical areas where particular noise exposure levels are exceeded because of aircraft noise.

The noise exposure levels are generally expressed in terms of L_{Aeq} values. To achieve this objective the area around an airport is divided into a regular rectangular grid of observation points and the noise level from the input set of aircraft operations is calculated at each observation point. This is then converted into contours by interpolating between observation points.

The input set of aircraft operations can represent either each unique flight in terms of their flight trajectories or more commonly, a large number of flights of the same aircraft type on a given flight path can be grouped together and represented as a single flight, whilst making allowances for normal flight-to-flight variation in aircraft ground track and flight profile. The flight trajectory is broken down in a vertical (x-z) plane and the flight track over the ground in the horizontal (x-y) plane. This trajectory data provides, for each individual aircraft, a chronicle of position, height and speed. Algorithms within ANCON version 2 deduct from this data the likely engine thrust being applied at any stage of the flight. The model therefore has reliable information on the location, speed and thrust of every individual aircraft throughout its flight history within the geographical area of interest.

For specialist validation purposes, ANCON version 2 can also read flight data recorder information consisting of precise position, speed and thrust values for individual flights. This can be used with noise measurements from noise monitors deployed near the flight path to assess the effectiveness of the noise calculation algorithms.

APPENDIX C

Results by airport

Chapter 5 and 6 presented the combined results of eight airports for the baseline years and forecast years, for both High and Central scenarios. This Appendix presents the breakdown of the results presented in Chapters 5 and 6 to give visibility of the contribution from each airport to the results. The totals presented in the tables of this Appendix are for the eight airports included in the analysis carried out in Chapters 5 and 6: Birmingham Airport (Birmingham - BHX), Edinburgh Airport (Edinburgh - EDI), Glasgow Airport (Glasgow - GLA), London Gatwick Airport (Gatwick - LGW), London Heathrow Airport (Heathrow - LHR), Luton Airport (Luton - LTN), Manchester Airport (Manchester - MAN) and Stansted Airport (Stansted - STN). The scenario considered here account for Heathrow Airport expansion from 2030 onwards and is presentational only. If Heathrow Airport wasn't expanding, the forecast for the other airports (presented as Total without LHR) would be different.

Table C.1 (a): Number of average summer day movements, High Scenario

	Scenario: High			No. of average summer day movements				
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	316.4	307.6	360.8	410.6	568.9	564.8	-2.8%	+83.6%
EDI	333.3	342.1	308.7	334.6	374.5	424.2	+2.6%	+24.0%
GLA	301.2	275.4	287.2	279.8	288.0	310.4	-8.6%	+12.7%
LGW	701.7	770.6	792.5	791.6	815.2	826.6	+9.8%	+7.3%
LHR NWR	1,248.0	1,266.7	1,296.2	1,982.5	2,008.6	2,022.0	+1.5%	+59.6%
LTN	288.5	354.2	337.1	326.2	310.0	332.5	+22.8%	-6.1%
MAN	638.2	543.5	628.0	652.8	774.5	990.7	-14.8%	+82.3%
STN	522.2	451.6	502.8	559.4	530.3	528.4	-13.5%	+17.0%
Total (with LHR)	4,349.5	4,311.6	4,513.3	5,337.5	5,670.1	5,999.6	-0.9%	+39.2%
Total (without LHR)	3,101.5	3,044.9	3,217.1	3,355.0	3,661.5	3,977.6	-1.8%	+30.6%

Table C.1 (b): Number of average summer night movements, High Scenario

	Scenario: High			No. of average summer night movements				
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	31.2	40.2	47.2	53.7	74.4	73.8	+28.7%	+83.7%
EDI	27.1	37.4	33.8	36.6	41.0	46.4	+38.1%	+24.0%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	116.7	127.1	130.7	130.5	134.4	136.3	+8.9%	+7.3%
LHR NWR	70.9	84.4	86.4	132.1	133.9	134.7	+19.1%	+59.6%
LTN	52.3	53.8	51.2	49.5	47.1	50.5	+2.9%	-6.1%
MAN	76.6	80.6	93.1	96.8	114.9	146.9	+5.2%	+82.3%
STN	79.5	82.3	91.6	101.9	96.6	96.3	+3.5%	+17.0%
Total (with LHR)	454.3	505.7	533.9	601.1	642.1	684.9	+11.3%	+35.4%
Total (without LHR)	383.4	294.2	316.8	338.5	373.8	413.9	+10.3%	+40.7%

Table C.1 (c): Number of average summer day movements, Central Scenario

	Scenario: Central		No. of average summer day movements					
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	316.4	307.6	342.5	374.2	539.8	572.2	-2.8%	+86.0%
EDI	333.3	342.1	304.7	321.7	361.8	398.6	+2.6%	+16.5%
GLA	301.2	275.4	276.7	271.2	274.9	296.0	-8.6%	+7.5%
LGW	701.7	770.6	789.8	776.4	804.5	818.4	+9.8%	+6.2%
LHR NWR	1,248.0	1,266.7	1,304.3	2,014.1	2,012.3	2,023.8	+1.5%	+59.8%
LTN	288.5	354.2	335.5	321.6	311.5	311.9	+22.8%	-11.9%
MAN	638.2	543.5	608.0	623.0	729.6	915.6	-14.8%	+68.5%
STN	522.2	451.6	449.1	543.0	582.0	583.6	-13.5%	+29.2%
Total (with LHR)	4,349.5	4,311.6	4,410.7	5,245.2	5,616.4	5,920.0	-0.9%	+37.3%
Total (without LHR)	3,101.5	2,274.3	2,316.5	2,454.7	2,799.6	3,077.9	-5.2%	+35.3%

Table C.1 (d): Number of average summer night movements, Central Scenario

	Scenario: Central		No. of average summer night movements					
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	31.2	40.2	44.8	48.9	70.6	74.8	+28.7%	+86.1%
EDI	27.1	37.4	33.3	35.2	39.6	43.6	+38.1%	+16.5%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	116.7	127.1	130.2	128.0	132.6	134.9	+8.9%	+6.2%
LHR NWR	70.9	84.4	86.9	134.2	134.1	134.9	+19.1%	+59.8%
LTN	52.3	53.8	50.9	48.8	47.3	47.3	+2.9%	-11.9%
MAN	76.6	80.6	90.2	92.4	108.2	135.8	+5.2%	+68.5%
STN	79.5	82.3	58.7	71.0	76.1	76.3	+3.5%	-7.3%
Total (with LHR)	454.3	505.7	495.0	558.5	608.4	647.6	+11.3%	+28.1%
Total (without LHR)	383.4	421.3	408.1	424.3	474.3	512.7	+9.9%	+21.7%

Table C.2 (a): Average summer day Quota Count, Scenario High

	Scenario: High	QC Average summer day						
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	139.1	124.3	147.1	148.5	150.1	160.1	-10.7%	+28.8%
EDI	107.6	133.4	109.3	107.7	86.0	94.6	+23.9%	-29.1%
GLA	104.3	100.1	117.1	102.3	73.4	73.1	-4.1%	-27.0%
LGW	447.4	405.5	419.0	385.8	261.8	250.8	-9.4%	-38.1%
LHR NWR	1,130.0	979.0	933.5	1,176.3	903.9	807.0	-13.4%	-17.6%
LTN	98.8	133.3	167.4	140.8	88.2	89.0	34.9%	-33.2%
MAN	337.8	292.5	302.6	292.8	249.4	297.0	-13.4%	+1.5%
STN	331.7	310.3	266.8	267.8	158.0	155.9	-6.5%	-49.8%
Total (with LHR)	2,696.7	2,478.2	2,462.9	2,622.1	1,970.9	1,927.4	-8.1%	-22.2%
Total (without LHR)	1,566.7	1,499.2	1,529.4	1,445.8	1,067.0	1,120.4	-4.3%	-25.3%

Table C.2 (b): Average summer night Quota Count, Scenario High

	Scenario: High	QC Average summer night						
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	18.1	19.2	19.1	19.3	19.6	20.9	+5.7%	+8.7%
EDI	10.9	18.3	11.3	11.2	9.2	10.2	+68.1%	-44.4%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	62.6	56.6	61.3	56.9	40.1	39.0	-9.6%	-31.1%
LHR NWR	90.9	80.3	52.7	67.5	53.8	50.7	-11.7%	-36.8%
LTN	23.2	21.3	23.4	19.9	12.9	13.1	-8.5%	-38.3%
MAN	40.3	45.8	39.7	38.7	34.4	41.8	+13.8%	-8.6%
STN	55.3	50.4	44.7	45.2	27.7	27.4	-8.9%	-45.6%
Total (with LHR)	301.3	291.8	252.1	258.6	197.7	203.1	-3.1%	-30.4%
Total (without LHR)	210.4	211.5	199.4	191.1	143.8	152.4	0.5%	-28.0%

Table C.2 (c): Average summer day Quota Count, Scenario Central

	Scenario: Central	QC Average summer night						
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	139.1	124.3	138.2	134.2	139.1	147.8	-10.7%	+18.9%
EDI	107.6	133.4	106.0	102.6	83.4	88.6	+23.9%	-33.6%
GLA	104.3	100.1	110.2	97.1	67.4	68.6	-4.1%	-31.4%
LGW	447.4	405.5	407.9	356.7	227.4	223.0	-9.4%	-45.0%
LHR NWR	1,130.0	979.0	928.2	1,185.6	890.4	776.9	-13.4%	-20.6%
LTN	98.8	133.3	166.9	139.8	90.0	98.5	+34.9%	-26.1%
MAN	337.8	292.5	287.6	277.5	230.2	263.1	-13.4%	-10.0%
STN	331.7	310.3	220.6	240.2	157.8	157.8	-6.5%	-49.1%
Total (with LHR)	2,696.7	2,478.2	2,365.7	2,533.7	1,885.7	1,824.3	-8.1%	-26.4%
Total (without LHR)	1,566.7	1,499.2	1,437.5	1,348.1	995.3	1,047.4	-4.3%	-30.1%

Table C.2 (d): Average summer night Quota Count, Scenario Central

	Scenario: Central	QC Average summer night						
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	18.1	19.2	17.9	17.4	18.1	19.3	+5.7%	+0.5%
EDI	10.9	18.3	10.9	10.7	8.9	9.5	+68.1%	-47.9%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	62.6	56.6	59.8	53.0	35.6	35.2	-9.6%	-37.8%
LHR NWR	90.9	80.3	52.4	68.0	53.1	48.9	-11.7%	-39.1%
LTN	23.2	21.3	23.3	19.7	13.1	14.9	-8.5%	-29.7%
MAN	40.3	45.8	37.7	36.7	31.8	37.5	+13.8%	-18.1%
STN	55.3	50.4	37.0	40.5	27.7	27.8	-8.9%	-44.9%
Total (with LHR)	301.3	291.8	239.1	246.0	188.3	193.2	-3.1%	-33.8%
Total (without LHR)	210.4	211.5	186.7	178.0	135.2	144.3	+0.5%	-31.8%

Table C.3 (a): Summary of average summer day 51dB L_{Aeq16h} noise contour area (High Scenario)

	Scenario: High AREA (km²) results LAeq16h 51 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	51.1	47.9	59.9	61.1	66.6	70.1	-6.3%	+46.6%
EDI	50.4	57.4	53.7	52.9	47.9	53.2	+13.8%	-7.2%
GLA	57.8	49.3	64.4	57.6	48.9	49.7	-14.7%	+0.9%
LGW	135.8	154.5	150.6	143.8	115.1	111.7	+13.7%	-27.7%
LHR NWR	391.1	329.4	291.2	360.1	314.7	293.3	-15.8%	-11.0%
LTN	42.5	62.7	68.0	59.7	43.5	43.5	47.7%	-30.6%
MAN	108.4	97.3	108.4	105.5	100.1	113.5	-10.2%	+16.6%
STN	95.3	82.9	102.5	102.3	72.8	71.2	-13.0%	-14.1%
Total (with LHR)	932.3	881.3	898.7	942.9	809.4	806.3	-5.5%	-8.5%
Total (without LHR)	541.2	551.9	607.4	582.8	494.7	513.0	2.0%	-7.0%

Table C.3 (b): Summary of average summer day 54dB L_{Aeq16h} noise contour area (High Scenario)

	Scenario: High AREA (km²) results LAeq16h 54 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	28.7	27.4	33.1	33.5	35.2	36.9	-4.7%	+34.6%
EDI	28.3	32.2	29.6	29.1	25.5	27.6	+13.8%	-14.4%
GLA	30.1	25.2	32.8	29.4	24.0	24.0	-16.0%	-4.8%
LGW	80.1	86.5	82.4	77.9	60.8	59.4	+8.0%	-31.3%
LHR NWR	220.6	184.3	166.5	207.6	177.7	165.8	-16.4%	-10.0%
LTN	23.2	34.7	38.3	32.6	22.6	22.8	49.9%	-34.3%
MAN	64.0	55.9	62.2	60.5	58.3	68.0	-12.6%	+21.8%
STN	55.5	45.4	54.0	54.2	37.5	36.9	-18.3%	-18.6%
Total (with LHR)	530.4	491.6	498.9	524.7	441.6	441.5	-7.3%	-10.2%
Total (without LHR)	309.9	307.3	332.3	317.1	263.9	275.6	-0.8%	-10.3%

Table C.3 (c): Summary of average summer night 45dB L_{Aeq8h} noise contour area (High Scenario)

	Scenario: High AREA (km²) results LAeq8h 45 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	57.4	59.3	63.8	64.9	70.5	73.3	+3.3%	+23.6%
EDI	39.8	59.5	47.3	46.8	43.7	49.3	+49.6%	-17.2%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	151.7	189.7	179.7	172.3	149.4	147.5	+25.0%	-22.2%
LHR NWR	191.0	193.8	163.8	213.2	190.7	183.9	+1.4%	-5.1%
LTN	59.9	71.5	74.4	66.4	50.8	50.5	19.4%	-29.4%
MAN	111.4	121.5	118.3	115.1	112.5	133.8	+9.1%	+10.1%
STN	105.1	105.7	130.0	130.5	97.1	95.4	+0.6%	-9.8%
Total (with LHR)	716.2	800.9	777.4	809.2	714.6	733.7	11.8%	-8.4%
Total (without LHR)	525.2	607.2	613.6	596.0	524.0	549.8	15.6%	-9.5%

Table C.3 (d): Summary of average summer night 48dB L_{Aeq8h} noise contour area (High Scenario)

	Scenario: High AREA (km²) results LAeq8h 48 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	32.1	31.7	34.7	35.1	37.4	39.5	-1.3%	+24.7%
EDI	21.5	32.9	25.2	24.9	22.3	24.4	+53.3%	-25.8%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	91.8	107.7	103.6	99.0	83.8	83.0	+17.3%	-22.9%
LHR NWR	114.5	115.2	95.2	118.6	104.6	100.9	+0.5%	-12.4%
LTN	33.4	43.1	45.1	38.9	27.0	27.5	29.1%	-36.1%
MAN	63.6	70.2	70.7	69.3	68.8	80.2	+10.4%	+14.2%
STN	62.7	61.9	75.8	76.5	57.9	57.0	-1.2%	-8.0%
Total (with LHR)	419.6	462.6	450.3	462.4	401.8	412.4	10.3%	-10.8%
Total (without LHR)	305.1	347.5	355.1	343.8	297.2	311.6	13.9%	-10.3%

Table C.3 (e): Summary of average annual 24h 50dB L_{den} noise contour area (High Scenario)

	Scenario: High AREA (km²) results Lden 50 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	84.6	87.2	104.3	105.6	114.8	118.9	+3.1%	+36.4%
EDI	88.0	101.1	78.1	92.5	87.3	95.5	+14.9%	-5.6%
GLA	99.4	81.4	97.6	87.4	76.0	77.8	-18.1%	-4.4%
LGW	233.8	223.4	256.7	242.9	203.5	198.8	-4.4%	-11.0%
LHR NWR	636.1	498.1	437.3	537.1	473.9	446.0	-21.7%	-10.5%
LTN	82.3	125.0	112.9	99.6	75.5	74.6	51.9%	-40.4%
MAN	167.4	164.9	175.6	170.2	162.3	186.6	-1.5%	+13.1%
STN	198.5	166.9	224.8	221.7	148.5	145.4	-15.9%	-12.9%
Total (with LHR)	1,590.0	1,448.1	1,487.3	1,556.8	1,341.8	1,343.6	-8.9%	-7.2%
Total (without LHR)	953.9	950.0	1,049.9	1,019.7	867.9	897.6	-0.4%	-5.5%

Table C.3 (f): Summary of average annual 24h 55dB L_{den} noise contour area (High Scenario)

	Scenario: High AREA (km²) results Lden 55 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	30.9	31.1	38.4	38.8	41.3	43.7	+0.7%	+40.7%
EDI	34.1	37.7	32.7	32.2	28.6	31.0	+10.4%	-17.8%
GLA	36.3	27.1	32.4	29.0	24.0	24.3	-25.5%	-10.4%
LGW	94.5	104.9	102.1	96.8	80.1	78.9	+11.1%	-24.8%
LHR NWR	244.7	198.0	176.3	222.0	192.8	183.0	-19.1%	-7.6%
LTN	33.7	44.8	49.6	41.9	29.1	29.3	33.1%	-34.7%
MAN	68.2	64.1	67.7	65.8	64.3	75.8	-6.0%	+18.2%
STN	73.3	64.4	80.7	80.7	57.7	56.5	-12.1%	-12.4%
Total (with LHR)	615.6	572.2	579.9	607.3	518.0	522.3	-7.1%	-8.7%
Total (without LHR)	371.0	374.1	403.6	385.3	325.1	339.4	0.8%	-9.3%

Table C.3 (g): Summary of average annual 8h night 45dB L_{night} noise contour area (High Scenario)

	Scenario: High AREA (km²) results Lnight 45 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	39.5	43.3	47.8	48.1	50.9	53.2	+9.6%	+22.9%
EDI	37.5	48.2	38.7	38.2	34.0	36.8	+28.5%	-23.6%
GLA	49.3	29.5	30.0	26.9	22.4	22.6	-40.2%	-23.4%
LGW	118.9	132.2	128.6	122.7	105.1	103.8	+11.2%	-21.5%
LHR NWR	198.5	174.8	154.7	198.6	179.1	174.6	-11.9%	-0.1%
LTN	44.4	60.7	63.7	55.8	39.9	40.0	36.7%	-34.1%
MAN	81.6	90.6	87.3	84.0	83.5	98.5	+10.9%	+8.8%
STN	99.6	89.9	113.5	113.5	85.3	83.5	-9.7%	-7.1%
Total (with LHR)	669.3	669.2	664.3	687.8	600.0	613.1	0.0%	-8.4%
Total (without LHR)	470.8	494.4	509.6	489.2	420.9	438.5	5.0%	-11.3%

Table C.3 (h): Summary of average annual 8h night 50dB L_{night} noise contour area (High Scenario)

	Scenario: High AREA (km²) results Lnight 50 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	15.1	16.3	18.6	18.7	18.7	19.3	+8.0%	+18.7%
EDI	13.9	18.8	14.2	13.9	12.1	13.2	+35.2%	-29.6%
GLA	17.6	10.1	10.4	9.4	7.6	7.9	-43.0%	-21.9%
LGW	48.3	44.9	43.5	41.1	33.6	33.1	-7.0%	-26.3%
LHR NWR	84.4	74.0	59.1	78.6	70.4	69.3	-12.4%	-6.3%
LTN	16.4	20.6	22.0	18.7	13.2	13.6	25.5%	-34.0%
MAN	32.8	32.9	30.4	29.5	28.7	34.8	+0.4%	+5.8%
STN	39.5	33.6	41.1	41.1	29.1	28.8	-14.8%	-14.6%
Total (with LHR)	268.0	251.2	239.2	251.0	213.5	220.0	-6.3%	-12.4%
Total (without LHR)	183.6	177.1	180.2	172.5	143.0	150.6	-3.5%	-15.0%

Table C.4 (a): Summary of average summer day 51dB L_{Aeq16h} population exposure (High Scenario)

	Scenario: High		Population Exposed		LAeq16h 51 dB			
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	90,200	87,400	114,600	119,500	132,500	142,200	-3.1%	+62.7%
EDI	19,800	34,000	30,400	30,100	22,000	24,800	+71.6%	-27.0%
GLA	76,700	74,100	86,700	81,500	72,300	72,600	-3.4%	-2.0%
LGW	24,500	27,300	29,100	27,200	18,200	17,500	+11.4%	-36.0%
LHR NWR	1,167,800	1,146,000	1,131,900	1,150,400	1,065,000	1,047,800	-1.9%	-8.6%
LTN	12,300	44,100	54,000	45,200	30,300	32,000	+258.5%	-27.4%
MAN	142,800	137,000	162,000	166,500	176,500	205,100	-4.1%	+49.8%
STN	16,300	12,600	16,300	17,500	11,800	11,500	-22.7%	-9.2%
Total (with LHR)	1,550,500	1,562,600	1,625,100	1,637,800	1,528,600	1,553,500	+0.8%	-0.6%
Total (without LHR)	382,700	416,500	493,200	487,400	463,700	505,700	+8.8%	+21.4%

Table C.4 (b): Summary of average summer day 54dB L_{Aeq16h} population exposure (High Scenario)

	Scenario: High		Population Exposed		LAeq16h 54 dB			
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	45,700	48,100	59,500	60,700	62,600	66,500	+5.1%	+38.2%
EDI	7,500	9,800	8,300	8,500	7,200	7,800	+31.4%	-20.8%
GLA	46,400	39,400	53,900	47,900	36,700	36,700	-15.0%	-6.9%
LGW	10,400	11,100	12,600	12,000	8,100	8,400	+6.9%	-24.4%
LHR NWR	628,800	588,900	561,400	609,300	539,900	530,100	-6.3%	-10.0%
LTN	5,200	14,300	16,400	14,400	10,900	11,000	+175.0%	-23.1%
MAN	74,900	66,200	85,400	86,800	100,700	130,700	-11.6%	+97.4%
STN	6,600	5,700	6,500	6,900	5,500	5,500	-13.5%	-4.6%
Total (with LHR)	825,400	783,500	804,000	846,500	771,800	796,600	-5.1%	+1.7%
Total (without LHR)	196,700	194,600	242,600	237,100	231,900	266,500	-1.1%	+36.9%

Table C.4 (c): Summary of average summer night 45dB L_{Aeq8h} population exposure (High Scenario)

	Scenario: High Population Exposed LAeq8h 45 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	95,900	100,600	116,600	120,400	124,100	129,200	+4.9%	+28.4%
EDI	12,500	24,600	20,500	19,900	14,800	17,100	+96.2%	-30.4%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	26,200	34,600	34,800	33,300	25,400	24,800	+32.2%	-28.4%
LHR NWR	663,500	811,800	752,100	793,700	744,900	757,800	+22.3%	-6.7%
LTN	30,200	62,100	67,500	59,400	46,700	47,900	+105.6%	-22.9%
MAN	171,300	185,900	195,700	200,800	218,400	256,400	+8.5%	+37.9%
STN	17,000	14,600	21,800	22,600	13,900	13,600	-14.3%	-6.3%
Total (with LHR)	1,016,600	1,234,100	1,209,000	1,250,200	1,188,200	1,246,900	+21.4%	+1.0%
Total (without LHR)	353,100	422,400	456,900	456,500	443,300	489,100	+19.6%	+15.8%

Table C.4 (d): Summary of average summer night 48dB L_{Aeq8h} population exposure (High Scenario)

	Scenario: High Population Exposed LAeq8h 48 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	55,000	56,800	63,400	64,200	64,400	65,900	+3.4%	+16.0%
EDI	3,900	7,100	6,500	7,000	6,000	7,000	+82.8%	-1.5%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	10,800	14,300	15,300	14,800	11,500	11,400	+32.2%	-19.8%
LHR NWR	340,000	417,500	343,300	331,300	307,100	317,100	+22.8%	-24.1%
LTN	8,800	28,400	32,500	25,000	11,500	13,800	+222.7%	-51.4%
MAN	96,000	117,800	125,400	128,900	144,300	174,900	+22.7%	+48.4%
STN	7,300	6,800	9,100	9,600	7,600	7,500	-7.1%	+11.6%
Total (with LHR)	521,700	648,600	595,600	580,800	552,400	597,700	+24.3%	-7.8%
Total (without LHR)	181,700	231,100	252,300	249,400	245,300	280,600	+27.2%	+21.4%

Table C.4 (e): Summary of average annual 24h 50dB L_{den} population exposure (High Scenario)

	Scenario: High Population Exposed Lden 50 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	142,800	153,500	196,900	205,100	231,800	241,400	+7.5%	+57.3%
EDI	48,100	51,500	35,100	48,000	42,000	45,300	+7.1%	-12.1%
GLA	104,600	100,600	111,200	106,700	95,800	95,800	-3.8%	-4.8%
LGW	50,400	45,600	60,800	56,300	37,500	36,800	-9.4%	-19.4%
LHR NWR	1,980,500	1,761,000	1,786,900	2,086,100	1,896,200	1,909,000	-11.1%	+8.4%
LTN	45,600	90,500	96,400	88,000	68,000	70,100	+98.5%	-22.5%
MAN	222,000	234,000	249,700	251,300	262,700	312,600	+5.4%	+33.6%
STN	36,000	34,800	45,000	47,200	29,000	28,800	-3.5%	-17.1%
Total (with LHR)	2,629,900	2,471,500	2,581,900	2,888,700	2,662,900	2,739,700	-6.0%	+10.9%
Total (without LHR)	649,400	710,500	795,000	802,600	766,700	830,700	+9.4%	+16.9%

Table C.4 (f): Summary of average annual 24h 55dB L_{den} population exposure (High Scenario)

	Scenario: High Population Exposed Lden 55 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	48,400	52,700	68,800	70,000	76,200	80,800	+8.8%	+53.4%
EDI	11,800	15,500	11,900	11,600	10,200	12,000	+31.9%	-22.6%
GLA	56,800	44,000	53,200	47,600	36,800	37,500	-22.5%	-14.9%
LGW	12,600	13,800	15,800	15,200	10,800	10,600	+9.9%	-23.0%
LHR NWR	756,100	689,400	652,600	709,100	637,400	633,900	-8.8%	-8.0%
LTN	8,900	22,700	32,100	22,200	14,200	14,200	+155.1%	-37.4%
MAN	93,000	101,600	114,000	115,500	126,400	155,100	+9.3%	+52.7%
STN	9,800	8,700	12,400	13,200	8,300	8,500	-11.1%	-1.7%
Total (with LHR)	997,300	948,400	961,000	1,004,400	920,200	952,600	-4.9%	+0.4%
Total (without LHR)	241,200	259,000	308,300	295,300	282,900	318,700	+7.4%	+23.1%

Table C.4 (g): Summary of average annual 8h night 45dB L_{night} population exposure (High Scenario)

	Scenario: High Population Exposed Lnight 45 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	62,700	80,000	93,400	95,400	98,000	102,800	+27.5%	+28.6%
EDI	15,800	26,100	17,800	17,700	14,100	17,000	+65.3%	-35.0%
GLA	70,200	48,800	48,800	42,600	33,000	33,800	-30.5%	-30.7%
LGW	16,300	19,400	20,600	19,700	15,000	14,400	+18.6%	-25.5%
LHR NWR	703,600	725,800	680,400	711,100	678,400	690,700	+3.2%	-4.8%
LTN	14,900	46,900	49,700	42,300	26,800	29,000	+214.8%	-38.2%
MAN	130,300	147,900	152,000	153,400	165,200	192,200	+13.5%	+30.0%
STN	15,300	14,500	20,500	21,700	14,000	13,900	-5.7%	-4.3%
Total (with LHR)	1,029,100	1,109,200	1,083,300	1,103,800	1,044,600	1,093,800	+7.8%	-1.4%
Total (without LHR)	325,500	383,400	402,900	392,700	366,100	403,100	+17.8%	+5.1%

Table C.4 (h): Summary of average annual 8h night 50dB L_{night} population exposure (High Scenario)

	Scenario: High Population Exposed Lnight 50 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	20,700	26,300	29,800	30,600	31,100	33,600	+26.9%	+27.5%
EDI	2,900	4,600	3,900	4,100	4,100	4,300	+57.7%	-6.7%
GLA	21,100	7,700	7,800	5,900	4,200	5,200	-63.4%	-32.1%
LGW	5,000	5,200	4,700	4,800	4,500	4,700	+5.4%	-10.5%
LHR NWR	207,200	221,200	185,000	208,100	201,000	208,500	+6.7%	-5.7%
LTN	2,600	8,400	9,500	8,200	5,100	5,200	+223.1%	-38.1%
MAN	40,900	44,100	39,700	39,700	42,900	60,600	+7.9%	+37.3%
STN	4,100	4,000	5,100	5,400	4,200	4,300	-2.7%	+8.3%
Total (with LHR)	304,600	321,600	285,500	306,700	297,200	326,500	+5.6%	+1.5%
Total (without LHR)	97,400	100,500	100,500	98,700	96,200	118,000	+3.2%	+17.4%

Table C.4 (i): Summary of average summer night N60, ≥5 events population exposure (High Scenario)

	Scenario: High	Population Exposed	N60, ≥5 events					
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	166,100	229,000	245,000	259,800	281,600	294,700	+37.9%	+28.7%
EDI	58,000	71,100	63,200	64,300	59,900	61,100	+22.6%	-14.1%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	55,000	93,800	73,400	74,200	62,900	64,300	+70.7%	-31.5%
LHR NWR	1,078,700	1,325,100	1,289,300	1,456,100	1,348,400	1,331,600	+22.8%	+0.5%
LTN	97,800	115,100	117,900	111,400	98,500	100,600	+17.7%	-12.6%
MAN	299,200	269,200	280,100	288,200	324,800	430,100	-10.0%	+59.8%
STN	45,900	40,100	46,100	47,300	38,300	38,800	-12.6%	-3.4%
Total (with LHR)	1,800,700	2,143,400	2,114,800	2,301,200	2,214,500	2,321,200	+19.0%	+8.3%
Total (without LHR)	722,100	818,300	825,500	845,100	866,100	989,600	+13.3%	+20.9%

Table C.4 (j): Summary of average summer night N60, ≥10 events population exposure (High Scenario)

	Scenario: High	Population Exposed	N60, ≥10 events					
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	79,600	140,600	146,000	153,900	178,900	181,100	+76.7%	+28.7%
EDI	37,800	48,300	41,800	44,400	43,700	46,000	+28.1%	-4.8%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	27,500	38,200	45,900	40,700	34,100	36,600	+38.9%	-4.1%
LHR NWR	791,400	928,200	892,700	1,054,200	995,300	1,014,600	+17.3%	+9.3%
LTN	50,700	89,400	94,400	90,800	79,900	80,300	+76.3%	-10.2%
MAN	206,300	191,700	195,700	201,100	219,800	256,800	-7.1%	+34.0%
STN	22,700	26,400	30,200	31,400	23,000	22,800	+16.3%	-13.6%
Total (with LHR)	1,215,900	1,462,900	1,446,700	1,616,400	1,574,600	1,638,200	+20.3%	+12.0%
Total (without LHR)	79,600	534,700	554,000	562,200	579,300	623,600	+26.0%	+16.6%

Table C.4 (k): Summary of average summer night N65, ≥10 events population exposure (High Scenario)

	Scenario: High		Population Exposed		N65, ≥10 events			
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	225,600	197,400	225,100	229,700	229,200	237,200	-12.5%	+20.1%
EDI	61,000	69,800	66,400	65,100	57,100	56,700	+14.4%	-18.7%
GLA	116,200	119,000	129,600	126,000	116,200	115,000	+2.4%	-3.4%
LGW	39,300	30,200	33,300	36,700	22,600	22,600	-23.2%	-25.2%
LHR NWR	1,599,300	1,271,700	1,357,600	1,390,600	1,219,500	1,173,800	-20.5%	-7.7%
LTN	72,700	78,300	83,600	77,100	70,400	71,100	+7.7%	-9.2%
MAN	303,200	173,800	192,100	185,400	205,600	253,500	-42.7%	+45.8%
STN	32,300	25,100	34,900	32,900	22,100	21,700	-22.3%	-13.4%
Total (with LHR)	2,449,500	1,965,400	2,122,600	2,143,400	1,942,700	1,951,600	-19.8%	-0.7%
Total (without LHR)	850,300	693,700	765,000	752,800	723,200	777,800	-18.4%	+12.1%

Table C.4 (l): Summary of average summer day N70, ≥5 events population exposure (High Scenario)

	Scenario: High		Population Exposed		N70, ≥5 events			
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	146,700	114,600	109,200	106,900	96,500	103,600	-21.8%	-9.6%
EDI	32,600	35,600	36,000	34,100	28,200	26,400	+9.2%	-26.0%
GLA	87,600	88,000	96,900	93,100	81,100	79,000	+0.5%	-10.3%
LGW	20,500	10,400	13,100	13,500	10,500	10,000	-49.2%	-3.7%
LHR NWR	917,000	680,800	719,800	615,800	528,900	462,100	-25.8%	-32.1%
LTN	20,100	21,500	22,600	22,900	20,100	20,000	+7.0%	-7.0%
MAN	145,800	102,500	105,300	98,300	84,200	104,500	-29.7%	+1.9%
STN	9,100	8,600	10,400	10,600	9,900	10,000	-4.9%	+15.9%
Total (with LHR)	1,379,300	1,062,100	1,113,200	995,200	859,500	815,600	-23.0%	-23.2%
Total (without LHR)	462,300	381,300	393,400	379,400	330,600	353,500	-17.5%	-7.3%

Table C.4 (m): Summary of average summer day N70, ≥10 events population exposure (High Scenario)

	Scenario: High	Population Exposed		N70, ≥10 events				
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	104,300	94,200	87,900	86,600	76,400	72,600	-9.7%	-23.0%
EDI	26,500	27,800	28,100	25,300	19,200	19,400	+5.2%	-30.4%
GLA	72,700	72,700	82,100	78,000	68,600	67,400	+0.1%	-7.3%
LGW	14,200	7,500	10,800	11,700	9,400	9,400	-46.9%	+24.8%
LHR NWR	632,300	538,200	567,800	493,800	409,700	383,400	-14.9%	-28.8%
LTN	12,700	19,800	21,400	20,700	18,200	19,200	+55.9%	-3.0%
MAN	105,000	70,600	71,700	69,500	66,600	80,200	-32.8%	+13.6%
STN	7,000	7,800	8,200	8,300	6,200	6,100	+11.6%	-21.1%
Total (with LHR)	974,600	838,700	878,000	793,800	674,300	657,600	-13.9%	-21.6%
Total (without LHR)	342,300	300,500	310,200	300,100	264,600	274,200	-12.2%	-8.8%

Table C.5 (a): Summary of average summer day 51dB L_{Aeq16h} noise contour area (Central Scenario)

	Scenario: Central	AREA (km²) results	LAeq16h 51 dB					
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	51.1	47.9	57.5	55.8	62.3	65.9	-6.3%	+37.7%
EDI	50.4	57.4	52.5	50.8	46.3	49.7	+13.8%	-13.3%
GLA	57.8	49.3	61.3	55.3	45.8	47.4	-14.7%	-3.8%
LGW	135.8	154.5	146.4	133.0	105.6	104.0	+13.7%	-32.6%
LHR NWR	391.1	329.4	290.6	363.2	311.8	286.4	-15.8%	-13.1%
LTN	42.5	62.7	67.9	59.2	43.9	42.2	+47.7%	-32.8%
MAN	108.4	97.3	105.1	101.9	95.3	104.4	-10.2%	+7.2%
STN	95.3	82.9	86.5	93.3	72.8	72.0	-13.0%	-13.1%
Total (with LHR)	932.3	881.3	867.9	912.5	783.9	772.0	-5.5%	-12.4%
Total (without LHR)	541.2	551.9	577.3	549.3	472.0	485.6	+2.0%	-12.0%

Table C.5 (b): Summary of average summer day 54dB L_{Aeq16h} noise contour area (Central Scenario)

	Scenario: Central	AREA (km²) results	LAeq16h 54 dB					
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	28.7	27.4	31.8	30.9	33.0	34.8	-4.7%	+26.8%
EDI	28.3	32.2	29.0	28.1	24.8	26.2	+13.8%	-18.8%
GLA	30.1	25.2	31.3	28.2	22.7	23.0	-16.0%	-9.0%
LGW	80.1	86.5	79.8	71.1	54.7	54.3	+8.0%	-37.2%
LHR NWR	220.6	184.3	166.2	209.6	175.8	161.2	-16.4%	-12.6%
LTN	23.2	34.7	38.2	32.3	22.8	22.1	+49.9%	-36.4%
MAN	64.0	55.9	59.9	59.5	56.1	63.5	-12.6%	+13.6%
STN	55.5	45.4	45.1	48.8	37.5	37.4	-18.3%	-17.6%
Total (with LHR)	530.4	491.6	481.2	508.7	427.4	422.3	-7.3%	-14.1%
Total (without LHR)	309.9	307.3	315.0	299.1	251.6	261.1	-0.8%	-15.0%

Table C.5 (c): Summary of average summer night 45dB L_{Aeq8h} noise contour area (Central Scenario)

	Scenario: Central AREA (km²) results LAeq8h 45 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	57.4	59.3	61.3	59.6	66.3	69.4	+3.3%	+17.0%
EDI	39.8	59.5	46.2	44.8	42.1	45.9	+49.6%	-22.9%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	151.7	189.7	179.7	160.4	138.0	138.4	+25.0%	-27.0%
LHR NWR	191.0	193.8	163.7	215.1	189.2	180.2	+1.4%	-7.0%
LTN	59.9	71.5	74.3	65.9	51.1	49.2	+19.4%	-31.2%
MAN	111.4	121.5	114.0	110.3	106.7	120.1	+9.1%	-1.2%
STN	105.1	105.7	110.9	119.3	97.1	96.4	+0.6%	-8.8%
Total (with LHR)	716.2	800.9	750.0	775.4	690.6	699.5	+11.8%	-12.7%
Total (without LHR)	525.2	607.2	586.4	560.3	501.4	519.2	+15.6%	-14.5%

Table C.5 (d): Summary of average summer night 48dB L_{Aeq8h} noise contour area (Central Scenario)

	Scenario: Central AREA (km²) results LAeq8h 48 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	32.1	31.7	33.4	32.4	35.0	37.1	-1.3%	+17.2%
EDI	21.5	32.9	24.6	23.9	21.7	23.1	+53.3%	-29.9%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	91.8	107.7	103.6	92.9	78.1	78.2	+17.3%	-27.3%
LHR NWR	114.5	115.2	95.1	119.7	103.6	98.4	+0.5%	-14.5%
LTN	33.4	43.1	45.0	38.6	27.3	26.5	+29.1%	-38.5%
MAN	63.6	70.2	68.4	67.7	65.8	73.6	+10.4%	+4.8%
STN	62.7	61.9	64.6	70.3	57.9	57.6	-1.2%	-6.9%
Total (with LHR)	419.6	462.6	434.7	445.5	389.3	394.6	+10.3%	-14.7%
Total (without LHR)	305.1	347.5	339.6	325.8	285.7	296.1	+13.9%	-14.8%

Table C.5 (e): Summary of average annual 24h 50dB L_{den} noise contour area (Central Scenario)

	Scenario: Central AREA (km²) results Lden 50 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	84.6	87.2	100.4	97.3	108.3	112.8	+3.1%	+29.4%
EDI	88.0	101.1	91.0	88.0	84.5	90.5	+14.9%	-10.6%
GLA	99.4	81.4	92.9	83.9	71.5	74.3	-18.1%	-8.7%
LGW	233.8	223.4	249.2	225.7	188.4	186.6	-4.4%	-16.5%
LHR NWR	636.1	498.1	436.7	542.1	470.1	436.6	-21.7%	-12.3%
LTN	82.3	125.0	112.7	98.9	76.0	72.7	+51.9%	-41.8%
MAN	167.4	164.9	170.3	162.5	152.5	170.7	-1.5%	+3.5%
STN	198.5	166.9	182.2	197.6	148.5	146.9	-15.9%	-12.0%
Total (with LHR)	1,590.0	1,448.1	1,435.3	1,496.1	1,299.6	1,291.2	-8.9%	-10.8%
Total (without LHR)	953.9	950.0	998.7	953.9	829.6	854.6	-0.4%	-10.0%

Table C.5 (f): Summary of average annual 24h 55dB L_{den} noise contour area (Central Scenario)

	Scenario: Central AREA (km²) results Lden 55 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	30.9	31.1	36.9	35.8	38.7	41.0	+0.7%	+31.8%
EDI	34.1	37.7	32.0	31.1	27.9	29.4	+10.4%	-21.9%
GLA	36.3	27.1	30.8	27.9	22.6	23.2	-25.5%	-14.5%
LGW	94.5	104.9	99.6	90.3	73.9	73.6	+11.1%	-29.9%
LHR NWR	244.7	198.0	176.0	224.2	190.8	177.8	-19.1%	-10.2%
LTN	33.7	44.8	49.5	41.5	29.4	28.4	+33.1%	-36.7%
MAN	68.2	64.1	65.1	64.0	61.4	69.7	-6.0%	+8.7%
STN	73.3	64.4	67.6	73.2	57.6	57.2	-12.1%	-11.1%
Total (with LHR)	615.6	572.2	557.6	587.9	502.3	500.2	-7.1%	-12.6%
Total (without LHR)	371.0	374.1	381.7	363.8	311.4	322.5	+0.8%	-13.8%

Table C.5 (g): Summary of average annual 8h night 45dB L_{night} noise contour area (Central Scenario)

	Scenario: Central		AREA (km²) results		Lnight 45 dB			
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	39.5	43.3	45.8	44.3	47.5	49.9	+9.6%	+15.2%
EDI	37.5	48.2	38.0	36.8	33.1	34.9	+28.5%	-27.6%
GLA	49.3	29.5	28.6	25.8	21.1	21.6	-40.2%	-26.7%
LGW	118.9	132.2	125.6	115.2	97.7	97.8	+11.2%	-26.0%
LHR NWR	198.5	174.8	154.6	200.5	177.7	170.8	-11.9%	-2.3%
LTN	44.4	60.7	63.6	55.4	40.3	38.7	+36.7%	-36.3%
MAN	81.6	90.6	83.6	80.4	78.0	89.7	+10.9%	-1.0%
STN	99.6	89.9	97.3	104.2	85.2	84.5	-9.7%	-6.0%
Total (with LHR)	669.3	669.2	637.1	662.6	580.8	587.8	-0.0%	-12.2%
Total (without LHR)	470.8	494.4	482.5	462.1	403.1	417.0	+5.0%	-15.7%

Table C.5 (h): Summary of average annual 8h night 50dB L_{night} noise contour area (Central Scenario)

	Scenario: Central		AREA (km²) results		Lnight 50 dB			
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	15.1	16.3	17.8	17.2	17.6	18.3	+8.0%	+12.2%
EDI	13.9	18.8	13.9	13.4	11.7	12.5	+35.2%	-33.4%
GLA	17.6	10.1	9.9	9.0	7.2	7.5	-43.0%	-25.7%
LGW	48.3	44.9	42.4	38.3	30.6	30.6	-7.0%	-32.0%
LHR NWR	84.4	74.0	59.0	79.2	69.8	67.7	-12.4%	-8.5%
LTN	16.4	20.6	22.0	18.5	13.3	13.1	+25.5%	-36.1%
MAN	32.8	32.9	29.2	29.8	27.9	31.9	+0.4%	-3.0%
STN	39.5	33.6	34.1	37.1	29.1	29.1	-14.8%	-13.5%
Total (with LHR)	268.0	251.2	228.4	242.5	207.3	210.7	-6.3%	-16.1%
Total (without LHR)	183.6	177.1	169.4	163.3	137.4	143.0	-3.5%	-19.3%

Table C.6 (a): Summary of average summer day 51dB L_{Aeq16h} population exposure (Central Scenario)

	Scenario: Central			Population Exposed		LAeq16h 51 dB		
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	90,200	87,400	110,000	109,300	123,100	133,000	-3.1%	+52.2%
EDI	19,800	34,000	29,700	28,500	21,100	22,800	+71.7%	-32.9%
GLA	76,700	74,100	83,900	79,900	69,200	70,200	-3.4%	-5.3%
LGW	24,500	27,300	28,600	25,600	15,900	15,700	+11.4%	-42.5%
LHR NWR	1,167,800	1,146,000	1,132,800	1,164,400	1,057,800	1,027,600	-1.9%	-10.3%
LTN	12,300	44,100	53,800	44,900	30,900	30,300	+258.5%	-31.3%
MAN	142,800	137,000	157,900	161,500	172,000	198,700	-4.1%	+45.0%
STN	16,300	12,600	12,500	15,200	11,800	11,700	-22.7%	-7.1%
Total (with LHR)	1,550,500	1,562,600	1,609,200	1,629,300	1,501,900	1,510,000	+0.8%	-3.4%
Total (without LHR)	382,700	416,500	476,500	464,900	444,100	482,400	+8.8%	+15.8%

Table C.6 (b): Summary of average summer day 54dB L_{Aeq16h} population exposure (Central Scenario)

	Scenario: Central			Population Exposed		LAeq16h 54 dB		
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	45,700	48,100	57,500	56,400	59,000	62,800	+5.3%	+30.6%
EDI	7,500	9,800	8,000	7,300	7,200	7,600	+30.7%	-22.4%
GLA	46,400	39,400	51,100	45,600	33,600	34,500	-15.1%	-12.4%
LGW	10,400	11,100	11,800	10,300	7,200	7,300	+6.7%	-34.2%
LHR NWR	628,800	588,900	560,600	618,400	532,400	509,800	-6.3%	-13.4%
LTN	5,200	13,000	15,000	14,000	10,400	10,100	+150.0%	-22.3%
MAN	74,900	66,200	82,000	77,000	88,000	119,400	-11.6%	+80.4%
STN	6,600	14,300	16,000	14,400	10,900	10,800	+175.0%	-24.5%
Total (with LHR)	825,400	783,500	792,700	835,800	743,900	757,700	-5.1%	-3.3%
Total (without LHR)	196,700	194,600	232,100	217,500	211,500	247,900	-1.1%	+27.4%

Table C.6 (c): Summary of average summer night 45dB L_{Aeq8h} population exposure (Central Scenario)

	Scenario: Central	Population Exposed	LAeq8h 45 dB					
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	95,900	100,600	112,100	110,800	117,800	123,000	+4.9%	+22.3%
EDI	12,500	24,600	19,300	18,500	14,200	15,500	+96.8%	-37.0%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	26,200	34,600	34,800	30,900	22,200	22,500	+32.1%	-35.0%
LHR NWR	663,500	811,800	752,900	806,200	740,000	741,500	+22.4%	-8.7%
LTN	30,200	62,100	67,200	58,800	47,400	46,500	+105.6%	-25.1%
MAN	171,300	185,900	191,700	199,000	212,300	246,400	+8.5%	+32.5%
STN	17,000	14,600	17,800	20,000	13,900	14,000	-14.1%	-4.1%
Total (with LHR)	1,016,600	1,234,100	1,195,800	1,244,300	1,167,700	1,209,400	+21.4%	-2.0%
Total (without LHR)	353,100	422,400	442,800	438,000	427,700	467,900	+19.6%	+10.8%

Table C.6 (d): Summary of average summer night 48dB L_{Aeq8h} population exposure (Central Scenario)

	Scenario: Central	Population Exposed	LAeq8h 48 dB					
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	55,000	56,800	60,700	59,900	60,700	62,400	+3.3%	+9.9%
EDI	3,900	7,100	6,400	6,600	5,800	6,600	+82.1%	-7.0%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	10,800	14,300	15,300	13,400	10,700	10,900	+32.4%	-23.8%
LHR NWR	340,000	417,500	343,500	335,100	303,200	306,800	+22.8%	-26.5%
LTN	8,800	28,400	32,400	24,600	11,800	12,200	+222.7%	-57.0%
MAN	96,000	117,800	121,100	124,000	136,200	163,200	+22.7%	+38.5%
STN	7,300	6,800	7,800	8,900	7,600	7,500	-6.8%	+10.3%
Total (with LHR)	521,700	648,600	587,300	572,500	536,000	569,700	+24.3%	-12.2%
Total (without LHR)	181,700	231,100	243,800	237,400	232,800	262,800	+27.2%	+13.7%

Table C.6 (e): Summary of average annual 24h 50dB L_{den} population exposure (Central Scenario)

	Scenario: Central Population Exposed Lden 50 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	142,800	153,500	189,700	190,900	220,300	234,000	+7.5%	+52.4%
EDI	48,100	51,500	48,600	48,100	43,200	44,500	+7.1%	-13.6%
GLA	104,600	100,600	108,000	104,800	92,000	92,600	-3.8%	-8.0%
LGW	50,400	45,600	59,300	53,000	34,600	34,000	-9.5%	-25.4%
LHR NWR	1,980,500	1,761,000	1,787,800	2,115,200	1,876,900	1,851,400	-11.1%	+5.1%
LTN	45,600	90,500	96,400	86,200	69,100	68,200	+98.5%	-24.6%
MAN	222,000	234,000	242,500	244,200	252,500	292,800	+5.4%	+25.1%
STN	36,000	34,800	35,900	42,100	29,000	29,100	-3.3%	-16.4%
Total (with LHR)	2,629,900	2,471,500	2,568,100	2,884,500	2,617,600	2,646,600	-6.0%	+7.1%
Total (without LHR)	649,400	710,500	780,300	769,300	740,800	795,200	+9.4%	+11.9%

Table C.6 (f): Summary of average annual 24h 55dB L_{den} population exposure (Central Scenario)

	Scenario: Central Population Exposed Lden 55 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	48,400	52,700	65,800	64,100	71,000	76,800	+8.9%	+45.7%
EDI	11,800	15,500	11,300	10,900	9,700	10,900	+31.4%	-29.7%
GLA	56,800	44,000	50,400	45,400	33,800	35,000	-22.5%	-20.5%
LGW	12,600	13,800	15,100	13,600	10,200	10,200	+9.5%	-26.1%
LHR NWR	756,100	689,400	653,000	718,700	628,500	610,300	-8.8%	-11.5%
LTN	8,900	22,700	32,100	21,600	14,300	13,800	+155.1%	-39.2%
MAN	93,000	101,600	109,000	105,100	114,700	143,300	+9.2%	+41.0%
STN	9,800	8,700	9,000	10,800	8,300	8,600	-11.2%	-1.1%
Total (with LHR)	997,300	948,400	945,700	990,000	890,400	908,800	-4.9%	-4.2%
Total (without LHR)	241,200	259,000	292,700	271,300	261,900	298,500	+7.4%	+15.3%

Table C.6 (g): Summary of average annual 8h night 45dB L_{night} population exposure (Central Scenario)

	Scenario: Central Population Exposed Lnight 45 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	62,700	80,000	88,000	86,000	91,800	95,600	+27.6%	+19.5%
EDI	15,800	26,100	17,200	16,300	13,700	15,600	+65.2%	-40.2%
GLA	70,200	48,800	46,100	39,700	30,900	31,900	-30.5%	-34.6%
LGW	16,300	19,400	19,900	18,000	13,300	13,200	+19.0%	-32.0%
LHR NWR	703,600	725,800	680,700	719,300	672,600	673,800	+3.2%	-7.2%
LTN	14,900	46,900	49,700	41,700	27,400	27,300	+214.8%	-41.8%
MAN	130,300	147,900	145,900	146,500	156,300	180,300	+13.5%	+21.9%
STN	15,300	14,500	16,600	19,000	14,000	14,100	-5.2%	-2.8%
Total (with LHR)	1,029,100	1,109,200	1,064,100	1,086,400	1,020,000	1,051,800	+7.8%	-5.2%
Total (without LHR)	325,500	383,400	383,400	367,200	347,400	378,000	+17.8%	-1.4%

Table C.6 (h): Summary of average annual 8h night 50dB L_{night} population exposure (Central Scenario)

	Scenario: Central Population Exposed Lnight 50 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	20,700	26,300	27,900	26,700	28,500	30,100	+27.1%	+14.4%
EDI	2,900	4,600	3,900	4,000	4,000	4,200	+58.6%	-8.7%
GLA	21,100	7,700	7,000	4,900	3,300	4,500	-63.5%	-41.6%
LGW	5,000	5,200	4,600	3,900	3,300	3,700	+4.0%	-28.8%
LHR NWR	207,200	221,200	184,800	209,800	199,500	202,100	+6.8%	-8.6%
LTN	2,600	8,400	9,500	8,200	5,100	5,200	+223.1%	-38.1%
MAN	40,900	44,100	37,700	37,900	39,700	50,000	+7.8%	+13.4%
STN	4,100	4,000	4,400	4,900	4,200	4,300	-2.4%	+7.5%
Total (with LHR)	304,600	321,600	279,700	300,400	287,600	304,000	+5.6%	-5.5%
Total (without LHR)	97,400	100,500	94,900	90,600	88,100	101,900	+3.2%	+1.4%

Table C.6 (i): Summary of average summer night N60, ≥5 events population exposure (Central Scenario)

	Scenario: Central		Population Exposed		N60, ≥5 events			
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	166,100	229,000	241,000	244,700	273,100	289,200	+37.9%	+26.3%
EDI	58,000	71,100	62,800	62,700	59,000	60,200	+22.6%	-15.3%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	55,000	93,800	72,900	72,500	59,400	61,800	+70.5%	-34.1%
LHR NWR	1,078,700	1,325,100	1,287,100	1,463,200	1,343,000	1,318,500	+22.8%	-0.5%
LTN	97,800	115,100	117,900	110,200	98,800	99,600	+17.7%	-13.5%
MAN	299,200	269,200	263,100	282,200	309,500	396,300	-10.0%	+47.2%
STN	45,900	40,100	39,500	42,400	38,300	38,900	-12.6%	-3.0%
Total (with LHR)	1,800,700	2,143,400	2,084,300	2,278,000	2,181,100	2,264,500	+19.0%	+5.6%
Total (without LHR)	722,100	818,300	797,200	814,700	838,100	946,000	+13.3%	+15.6%

Table C.6 (j): Summary of average summer night N60, ≥10 events population exposure (Central Scenario)

	Scenario: Central		Population Exposed		N60, ≥10 events			
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	79,600	140,600	140,700	143,100	167,200	181,300	+76.6%	+28.9%
EDI	37,800	48,300	41,100	42,900	42,700	44,600	+27.8%	-7.7%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	27,500	38,200	45,400	38,100	29,500	33,600	+38.9%	-12.0%
LHR NWR	791,400	928,200	896,400	1,065,100	992,500	1,006,200	+17.3%	+8.4%
LTN	50,700	89,400	94,300	90,400	79,900	78,900	+76.3%	-11.7%
MAN	206,300	191,700	192,700	198,100	214,400	245,400	-7.1%	+28.0%
STN	22,700	26,400	25,500	28,900	23,000	23,200	+16.3%	-12.1%
Total (with LHR)	1,215,900	1,462,900	1,436,200	1,606,600	1,549,200	1,613,300	+20.3%	+10.3%
Total (without LHR)	424,500	534,700	539,700	541,500	556,700	607,000	+26.0%	+13.5%

Table C.6 (k): Summary of average summer night N65, ≥5 events population exposure (Central Scenario)

	Scenario: Central		Population Exposed		N65, ≥10 events			
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	300,500	250,600	275,400	273,000	269,400	278,400	-16.6%	+11.1%
EDI	72,800	91,100	80,100	79,600	68,700	67,600	+25.1%	-25.8%
GLA	135,400	135,100	146,100	144,900	135,300	133,500	-0.2%	-1.2%
LGW	72,300	42,600	39,100	38,400	25,300	23,900	-41.1%	-43.9%
LHR NWR	2,389,300	1,678,700	1,728,000	1,680,300	1,533,800	1,317,300	-29.7%	-21.5%
LTN	98,300	88,200	90,700	90,100	75,500	73,600	-10.3%	-16.6%
MAN	523,900	283,000	284,100	279,000	318,700	359,400	-46.0%	+27.0%
STN	52,800	39,900	48,200	47,700	32,300	32,400	-24.4%	-18.8%
Total (with LHR)	3,645,400	2,609,300	2,691,600	2,633,000	2,459,100	2,286,100	-28.4%	-12.4%
Total (without LHR)	1,256,100	930,600	963,600	952,700	925,200	968,800	-25.9%	+4.1%

Table C.6 (l): Summary of average summer night N65, ≥10 events population exposure (Central Scenario)

	Scenario: Central		Population Exposed		N65, ≥10 events			
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	225,600	197,400	224,200	220,800	222,200	231,200	-12.5%	+17.1%
EDI	61,000	69,800	66,100	63,800	56,900	56,600	+14.4%	-18.9%
GLA	116,200	119,000	127,400	125,000	114,600	113,800	+2.4%	-4.4%
LGW	39,300	30,200	25,200	24,700	20,400	20,500	-23.2%	-32.1%
LHR NWR	1,599,300	1,271,700	1,350,900	1,389,800	1,208,300	1,135,800	-20.5%	-10.7%
LTN	72,700	78,300	83,600	77,000	70,400	71,000	+7.7%	-9.3%
MAN	303,200	173,800	185,200	181,800	196,400	235,300	-42.7%	+35.4%
STN	32,300	25,100	29,700	31,100	22,100	22,000	-22.3%	-12.4%
Total (with LHR)	2,449,500	1,965,400	2,092,200	2,114,100	1,911,200	1,886,200	-19.8%	-4.0%
Total (without LHR)	850,300	693,700	741,300	724,200	702,900	750,500	-18.4%	+8.2%

Table C.6 (m): Summary of average summer day N70, ≥5 events population exposure (Central Scenario)

	Scenario: Central		Population Exposed			N70, ≥5 events		
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	146,700	114,600	109,000	103,700	93,000	92,200	-21.9%	-19.5%
EDI	32,600	35,600	35,900	34,200	28,100	26,200	+9.2%	-26.4%
GLA	87,600	88,000	95,800	92,200	80,000	78,200	+0.5%	-11.1%
LGW	20,500	10,400	12,600	12,200	9,400	7,700	-49.3%	-26.0%
LHR NWR	917,000	680,800	712,800	617,100	519,800	438,400	-25.8%	-35.6%
LTN	20,100	21,500	22,600	22,900	20,300	20,000	+7.0%	-7.0%
MAN	145,800	102,500	90,300	63,700	74,400	81,500	-29.7%	-20.5%
STN	9,100	8,600	10,200	10,500	9,900	10,000	-5.5%	+16.3%
Total (with LHR)	1,379,300	1,062,100	1,089,200	956,300	835,000	754,200	-23.0%	-29.0%
Total (without LHR)	462,300	381,300	376,400	339,200	315,200	315,800	-17.5%	-17.2%

Table C.6 (n): Summary of average summer day N70, ≥10 events population exposure (Central Scenario)

	Scenario: Central		Population Exposed			N70, ≥10 events		
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	104,300	94,200	87,300	84,700	72,100	68,600	-9.7%	-27.2%
EDI	26,500	27,800	27,400	24,700	18,500	18,800	+4.9%	-32.4%
GLA	72,700	72,700	80,000	76,900	67,400	66,800	+0.0%	-8.1%
LGW	14,200	7,500	9,200	7,300	4,900	4,900	-47.2%	-34.7%
LHR NWR	632,300	538,200	564,300	496,100	407,400	371,700	-14.9%	-30.9%
LTN	12,700	19,800	21,400	20,600	18,400	19,200	+55.9%	-3.0%
MAN	105,000	70,600	65,200	49,300	60,100	62,100	-32.8%	-12.0%
STN	7,000	7,800	7,900	8,300	6,200	6,100	+11.4%	-21.8%
Total (with LHR)	974,600	838,700	862,700	767,900	655,100	618,200	-13.9%	-26.3%
Total (without LHR)	342,300	300,500	298,400	271,800	247,700	246,500	-12.2%	-18.0%

Table C.7 (a): Average Individual Exposure (AIE), number of events above 70dB L_{Amax} for areas experiencing at least 5 events per average summer day High Scenario

	Scenario: HIGH, AIE (70) , ≥5 events							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	36.0	52.0	62.0	66.1	80.8	82.8	+44.4%	+59.1%
EDI	39.0	46.0	41.0	41.6	40.6	47.9	+17.9%	+4.1%
GLA	52.0	55.0	61.1	57.3	54.9	58.4	+5.8%	+6.3%
LGW	43.0	61.1	67.1	67.1	72.5	76.1	+42.0%	+24.6%
LHR NWR	47.5	70.1	70.8	95.3	96.3	111.7	+47.7%	+59.3%
LTN	41.5	92.3	90.9	91.0	86.2	85.9	122.4%	-6.9%
MAN	56.6	74.8	81.1	83.8	113.0	119.7	+32.1%	+60.1%
STN	60.8	85.4	69.7	72.3	49.1	50.1	+40.6%	-41.3%
Average (with LHR)	376.3	536.6	543.7	574.5	593.5	632.5	42.6%	17.9%
Average (without LHR)	328.8	466.5	472.9	479.3	497.2	520.8	41.9%	11.7%

Table C.7 (b): Average Individual Exposure (AIE), number of events above 70dB L_{Amax} for areas experiencing at least 10 events per average summer day High Scenario

	Scenario: HIGH, AIE (70) , ≥10 events							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	48.0	61.0	75.0	80.3	99.5	113.9	+27.1%	+86.7%
EDI	46.0	56.0	51.1	52.8	55.5	62.6	+21.7%	+11.8%
GLA	61.0	65.0	71.3	67.4	63.9	67.1	+6.6%	+3.2%
LGW	61.0	82.1	79.0	75.6	80.5	81.4	+34.6%	-0.9%
LHR NWR	62.7	86.6	87.8	116.9	122.7	133.7	+38.2%	+54.4%
LTN	62.7	86.4	83.2	83.2	76.9	81.3	37.9%	-6.0%
MAN	76.2	106.1	115.9	113.8	139.7	152.9	+39.2%	+44.1%
STN	76.5	93.4	87.1	89.9	72.9	76.7	+22.0%	-17.9%
Average (with LHR)	61.8	636.6	650.3	680.0	711.6	769.5	28.8%	20.9%
Average (without LHR)	61.6	550.0	562.5	563.1	588.9	635.8	27.5%	15.6%

Table C.7 (c): Persons Event Index (PEI) ≥5 events 70dB L_{Amax} High Scenario

	Scenario: High, PEI (70), ≥5 events							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	5,331,400	5,939,000	6,757,300	7,124,200	7,841,800	8,712,700	+11.4%	+46.7%
EDI	1,248,800	1,635,600	1,475,700	1,422,400	1,153,200	1,269,400	+31.0%	-22.4%
GLA	4,635,400	4,887,300	5,953,300	5,367,300	4,474,900	4,634,000	+5.4%	-5.2%
LGW	1,033,200	634,500	868,700	904,400	765,000	769,700	-38.6%	+21.3%
LHR NWR	44,814,900	47,811,900	51,134,600	58,826,800	51,067,300	52,000,300	+6.7%	+8.8%
LTN	849,100	1,835,400	1,875,000	1,876,000	1,558,500	1,644,200	+116.2%	-10.4%
MAN	8,287,300	7,689,500	8,597,900	8,724,300	9,532,900	12,570,300	-7.2%	+63.5%
STN	554,300	737,000	752,200	755,800	492,200	510,900	+33.0%	-30.7%
Total (with LHR)	66,754,500	71,170,000	77,414,700	85,001,400	76,885,900	82,111,700	+6.6%	+15.4%
Total (without LHR)	21,939,500	23,358,100	26,280,100	26,174,500	25,818,500	30,111,400	+6.5%	+28.9%

Table C.7 (d): Persons Event Index (PEI) ≥10 events 70dB L_{Amax} High Scenario

	Scenario: High, PEI (70), ≥10 events							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	5,038,200	5,795,100	6,604,100	6,973,700	7,693,900	8,499,500	+15.0%	+46.7%
EDI	1,204,600	1,579,700	1,415,500	1,364,200	1,087,400	1,218,200	+31.1%	-22.9%
GLA	4,527,700	4,775,100	5,838,100	5,251,000	4,383,500	4,554,000	+5.5%	-4.6%
LGW	978,000	614,700	885,500	892,600	756,100	764,900	-37.1%	+24.4%
LHR NWR	43,012,100	46,784,300	50,013,400	57,915,700	50,199,800	51,429,300	+8.8%	+9.9%
LTN	794,700	1,846,600	1,892,300	1,893,400	1,577,200	1,652,300	+132.4%	-10.5%
MAN	8,003,300	7,465,300	8,349,400	8,506,000	9,410,800	12,395,500	-6.7%	+66.0%
STN	539,600	731,200	737,200	741,500	463,200	481,600	+35.5%	-34.1%
Total (with LHR)	64,098,100	69,591,900	75,735,500	83,538,100	75,572,000	80,995,400	+8.6%	+16.4%
Total (without LHR)	21,086,000	22,807,600	25,722,100	25,622,400	25,372,200	29,566,100	+8.2%	+29.6%

Table C.8 (a): Average Individual Exposure (AIE), number of events above 70dB L_{Amax} for areas experiencing at least 5 events per average summer day Central Scenario

	Scenario: Central, AIE (70) , ≥5 events							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	36.0	52.0	58.9	76.5	76.5	86.7	+44.4%	+66.8%
EDI	39.0	46.0	40.2	39.9	39.6	45.3	+17.9%	-1.4%
GLA	52.0	55.0	58.9	55.8	52.4	56.2	+5.8%	+2.2%
LGW	43.0	61.1	66.9	66.8	69.8	88.2	+42.0%	+44.5%
LHR NWR	47.5	70.1	71.3	96.7	96.7	114.0	+47.7%	+62.6%
LTN	41.5	92.3	92.8	90.0	86.5	82.9	+122.4%	-10.2%
MAN	56.6	74.8	85.4	89.1	109.5	126.9	+32.1%	+69.8%
STN	60.8	85.4	60.5	64.1	49.0	50.9	+40.6%	-40.4%
Average (with LHR)	376.3	536.6	534.9	579.0	580.0	651.2	+42.6%	+21.4%
Average (without LHR)	328.8	466.5	463.6	482.2	483.3	537.2	+41.9%	+15.2%

Table C.8 (b): Average Individual Exposure (AIE), number of events above 70dB L_{Amax} for areas experiencing at least 10 events per average summer day Central Scenario

	Scenario: Central, AIE (70) , ≥10 events							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	48.0	61.0	71.8	95.7	95.7	112.9	+27.1%	+85.0%
EDI	46.0	56.0	50.1	51.4	55.2	59.5	+21.7%	+6.2%
GLA	61.0	65.0	68.9	65.5	61.2	64.6	+6.6%	-0.6%
LGW	61.0	82.1	87.0	103.6	116.6	132.3	+34.6%	+61.1%
LHR NWR	62.7	86.6	88.2	118.3	122.8	135.2	+38.2%	+56.1%
LTN	62.7	86.4	88.4	82.3	77.3	78.4	+37.9%	-9.3%
MAN	76.2	106.1	116.2	117.3	132.5	164.7	+39.2%	+55.3%
STN	76.5	93.4	75.0	79.4	72.8	78.1	+22.0%	-16.4%
Average (with LHR)	494.1	636.6	645.4	713.6	734.1	825.7	+28.8%	+29.7%
Average (without LHR)	431.4	550.0	557.2	595.3	611.4	690.5	+27.5%	+25.5%

Table C.8 (c): Persons Event Index (PEI) for areas experiencing at least ≥5 events 70dB L_{Amax} per average summer day Central Scenario

	Scenario: Central, PEI (70), ≥5 events							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	5,331,400	5,939,000	6,467,100	7,283,200	7,283,200	8,130,600	+11.4%	+36.9%
EDI	1,248,800	1,635,600	1,441,700	1,365,900	1,120,100	1,198,900	+31.0%	-26.7%
GLA	4,635,400	4,887,300	5,662,300	5,155,000	4,217,400	4,421,400	+5.4%	-9.5%
LGW	1,033,200	634,500	850,600	811,900	661,800	676,400	-38.6%	+6.6%
LHR NWR	44,814,900	47,811,900	51,075,400	59,558,200	50,524,700	50,542,000	+6.7%	+5.7%
LTN	849,100	1,835,400	1,987,000	1,855,000	1,571,200	1,586,400	+116.2%	-13.6%
MAN	8,287,300	7,689,500	7,756,100	7,681,800	8,094,000	10,357,000	-7.2%	+34.7%
STN	554,300	737,000	619,400	676,500	491,600	519,800	+33.0%	-29.5%
Total (with LHR)	66,754,500	71,170,000	75,859,500	84,387,400	73,964,000	77,432,500	+6.6%	+8.8%
Total (without LHR)	21,939,500	23,358,100	24,784,200	24,829,200	23,439,300	26,890,500	+6.5%	+15.1%

Table C.8 (c): Persons Event Index (PEI) for areas experiencing at least ≥10 events 70dB L_{Amax} per average summer day Central Scenario

	Scenario: Central, PEI (70), 10 events							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	5,038,200	5,795,100	6,313,900	7,129,700	7,129,700	7,974,800	+15.0%	+37.6%
EDI	1,204,600	1,579,700	1,381,700	1,303,700	1,050,100	1,147,900	+31.1%	-27.3%
GLA	4,527,700	4,775,100	5,546,400	5,040,200	4,124,600	4,340,900	+5.5%	-9.1%
LGW	978,000	614,700	825,200	776,700	635,200	659,400	-37.1%	+7.3%
LHR NWR	43,012,100	46,784,300	49,969,400	58,657,500	49,682,700	49,992,800	+8.8%	+6.9%
LTN	794,700	1,846,600	1,995,000	1,872,300	1,590,000	1,594,600	+132.4%	-13.6%
MAN	8,003,300	7,465,300	7,576,200	7,533,200	7,998,100	10,217,500	-6.7%	+36.9%
STN	539,600	731,200	604,400	661,400	462,600	490,400	+35.5%	-32.9%
Total (with LHR)	68,158,300	74,772,300	79,700,800	89,327,700	79,167,600	83,733,600	+9.7%	+12.0%
Total (without LHR)	25,146,100	27,988,000	29,731,400	30,670,200	29,485,000	33,740,800	+11.3%	+20.6%

Table C.9 (a): Number of people highly sleep-disturbed exposed to at least L_{night} 45dB. High Scenario

	Scenario: High			No. of people highly sleep-disturbed Lnight 45 dB				
Airports	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	4,400	5,600	6,600	6,700	6,800	7,200	+26.4%	+27.8%
EDI	1,000	1,700	1,200	1,100	900	1,100	+67.5%	-33.5%
GLA	4,800	3,100	3,100	2,700	2,100	2,200	-36.0%	-30.4%
LGW	1,100	1,300	1,400	1,400	1,000	1,000	+15.7%	-25.0%
LHR NWR	51,100	52,100	46,700	49,300	46,600	47,700	+2.1%	-8.5%
LTN	1,000	3,000	3,200	2,700	1,700	1,800	+200.0%	-40.0%
MAN	9,300	10,500	10,500	10,600	11,500	13,800	+13.0%	+32.4%
STN	1,100	1,000	1,400	1,400	900	900	-11.6%	-3.6%
Total (with LHR)	73,800	78,300	74,000	76,000	71,600	75,800	+6.1%	-3.2%
Total (without LHR)	22,700	26,100	27,300	26,600	25,000	28,100	+15.0%	+7.7%

Table C.9 (b): Number of people highly sleep-disturbed exposed to at least L_{night} 50dB. High Scenario

	Scenario: High			No. of people highly sleep-disturbed Lnight 50 dB				
Airports	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	1,900	2,400	2,700	2,800	2,800	3,000	+26.3%	+26.2%
EDI	300	400	400	400	400	400	+60.8%	-9.8%
GLA	1,800	600	600	500	300	400	-64.7%	-32.1%
LGW	500	500	400	400	400	400	+1.4%	-14.8%
LHR NWR	20,600	21,600	17,200	19,600	18,600	19,300	+4.8%	-10.5%
LTN	200	800	900	700	500	500	+300.0%	-37.5%
MAN	3,900	4,200	3,700	3,700	4,000	5,700	+6.5%	+36.2%
STN	400	400	500	500	400	400	-8.7%	+5.3%
Total (with LHR)	29,600	30,800	26,400	28,500	27,300	30,100	+4.1%	-2.3%
Total (without LHR)	9,000	9,200	9,100	8,900	8,700	10,700	+2.2%	+16.3%

Table C.9 (c): Number of people highly annoyed exposed to at least L_{den} 51dB. High Scenario

	Scenario: High			No. of people Highly annoyed Lden 51 dB				
Airports	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	13,400	14,400	18,500	19,200	21,100	22,400	+7.2%	+56.2%
EDI	3,900	4,600	4,100	4,100	3,600	3,800	+15.6%	-15.6%
GLA	11,400	9,800	11,400	10,500	9,100	9,100	-14.0%	-6.8%
LGW	3,900	4,500	4,600	4,300	3,100	3,000	+15.2%	-32.5%
LHR NWR	182,500	172,400	168,600	181,900	164,100	163,300	-5.5%	-5.3%
LTN	3,200	7,900	8,700	7,600	5,500	5,600	+146.9%	-29.1%
MAN	23,100	23,700	25,600	25,700	27,400	33,300	+3.0%	+40.4%
STN	2,700	2,500	3,500	3,700	2,400	2,500	-5.6%	-3.2%
Total (with LHR)	244,000	239,800	244,900	257,000	236,200	243,100	-1.7%	+1.4%
Total (without LHR)	61,500	67,400	76,300	75,100	72,100	79,900	+9.6%	+18.5%

Table C.9 (d): Number of people highly annoyed exposed to at least L_{den} 54dB. High Scenario

	Scenario: High			No. of people Highly annoyed Lden 54 dB				
Airports	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	9,000	9,900	12,800	13,200	14,100	15,200	+10.0%	+54.4%
EDI	2,300	3,000	2,400	2,400	2,000	2,400	+28.4%	-20.2%
GLA	9,300	7,300	8,800	7,900	6,400	6,500	-21.4%	-10.8%
LGW	2,300	2,600	2,800	2,700	2,000	1,900	+10.9%	-26.4%
LHR NWR	136,700	125,600	118,700	129,300	117,700	116,200	-8.1%	-7.5%
LTN	1,600	4,700	5,800	4,700	2,600	2,900	+193.8%	-38.3%
MAN	17,600	18,300	20,000	20,200	21,700	27,000	+3.7%	+48.1%
STN	1,700	1,600	2,200	2,300	1,400	1,400	-3.1%	-11.9%
Total (with LHR)	180,500	173,000	173,600	182,800	168,000	173,600	-4.2%	+0.3%
Total (without LHR)	43,800	47,300	54,900	53,500	50,300	57,500	+8.0%	+21.6%

Table C.10 (a): Number of people highly sleep-disturbed exposed to at least L_{night} 45dB. Central Scenario

	Scenario: Central			No. of people highly sleep-disturbed Lnight 45 dB				
Airports	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	4,400	5,600	6,200	6,000	6,400	6,600	+27.3%	+17.9%
EDI	1,000	1,700	1,100	1,100	900	1,000	+70.0%	-41.2%
GLA	4,800	3,100	2,900	2,500	1,900	2,000	-35.4%	-35.5%
LGW	1,100	1,300	1,300	1,200	900	900	+18.2%	-30.8%
LHR NWR	51,100	52,100	46,700	50,000	46,200	46,400	+2.0%	-10.9%
LTN	1,000	3,000	3,200	2,700	1,800	1,700	+200.0%	-43.3%
MAN	9,300	10,500	10,000	9,900	10,600	12,600	+12.9%	+20.0%
STN	1,100	1,000	1,100	1,300	900	1,000	-9.1%	+0.0%
Total (with LHR)	73,800	78,300	72,600	74,600	69,700	72,300	+6.1%	-7.7%
Total (without LHR)	22,700	26,100	25,900	24,700	23,500	25,900	+15.0%	-0.8%

Table C.10 (b): Number of people highly sleep-disturbed exposed to at least L_{night} 50dB. Central Scenario

	Scenario: Central			No. of people highly sleep-disturbed Lnight 50 dB				
Airports	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	1,900	2,400	2,500	2,400	2,500	2,700	+26.3%	+12.5%
EDI	300	400	400	400	400	400	+33.3%	+0.0%
GLA	1,800	600	600	400	300	400	-66.7%	-33.3%
LGW	500	500	400	400	300	300	+0.0%	-40.0%
LHR NWR	20,600	21,600	17,200	19,800	18,400	18,700	+4.9%	-13.4%
LTN	200	800	900	700	500	500	+300.0%	-37.5%
MAN	3,900	4,200	3,500	3,400	3,600	4,600	+7.7%	+9.5%
STN	400	400	400	400	400	400	+0.0%	+0.0%
Total (with LHR)	29,600	30,800	25,800	27,900	26,300	27,900	+4.1%	-9.4%
Total (without LHR)	9,000	9,200	8,600	8,100	7,900	9,200	+2.2%	+0.0%

Table C.10 (c): Number of people highly annoyed exposed to at least L_{den} 51dB. Central Scenario

	Scenario: Central No. of people Highly annoyed Lden 51 dB							
Airports	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	13,400	14,400	17,600	17,500	19,700	21,200	+7.5%	+47.2%
EDI	3,900	4,600	4,000	3,900	3,500	3,700	+17.9%	-19.6%
GLA	11,400	9,800	10,900	10,100	8,600	8,700	-14.0%	-11.2%
LGW	3,900	4,500	4,500	4,000	2,700	2,700	+15.4%	-40.0%
LHR NWR	182,500	172,400	168,600	184,600	162,400	158,600	-5.5%	-8.0%
LTN	3,200	7,900	8,700	7,500	5,500	5,500	+146.9%	-30.4%
MAN	23,100	23,700	24,600	24,600	25,700	30,500	+2.6%	+28.7%
STN	244,000	239,800	241,700	255,300	230,500	233,400	-1.7%	-2.7%
Total (with LHR)	244,000	239,800	241,700	255,300	230,500	233,400	-1.7%	-2.7%
Total (without LHR)	61,500	67,400	73,100	70,800	68,100	74,800	+9.6%	+11.0%

Table C.10 (d): Number of people highly annoyed exposed to at least L_{den} 54dB. Central Scenario

	Scenario: Central No. of people Highly annoyed Lden 54 dB							
Airports	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	9,000	9,900	12,200	11,800	12,900	14,100	+10.0%	+42.4%
EDI	2,300	3,000	2,300	2,200	1,900	2,200	+30.4%	-26.7%
GLA	9,300	7,300	8,400	7,500	6,000	6,100	-21.5%	-16.4%
LGW	2,300	2,600	2,700	2,400	1,700	1,800	+13.0%	-30.8%
LHR NWR	136,700	125,600	118,700	131,000	116,700	113,300	-8.1%	-9.8%
LTN	1,600	4,700	5,800	4,700	2,700	2,700	+193.8%	-42.6%
MAN	17,600	18,300	19,100	18,900	20,100	24,500	+4.0%	+33.9%
STN	1,700	1,600	1,700	2,100	1,400	1,500	-5.9%	-6.3%
Total (with LHR)	180,500	173,000	170,800	180,700	163,400	166,100	-4.2%	-4.0%
Total (without LHR)	43,800	47,300	52,200	49,600	46,700	52,800	+8.0%	+11.6%

Table C.11 (a) Average summer day L_{Aeq16h} 51dB population exposure using 2016 population database. High scenario

	Scenario: High with 2016_Pop		Population Exposure results			LAeq16h 51 dB		
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	90,200	87,400	110,700	111,900	118,900	124,400	-3.1%	+42.3%
EDI	19,800	34,000	29,600	28,700	20,100	22,800	+71.7%	-32.9%
GLA	76,700	74,100	86,100	80,400	71,000	71,600	-3.4%	-3.4%
LGW	24,500	27,300	27,600	25,000	16,400	15,500	+11.4%	-43.2%
LHR NWR	1,167,800	1,146,000	1,076,600	1,042,400	928,200	887,900	-1.9%	-22.5%
LTN	12,300	44,100	51,800	42,300	26,300	27,100	+258.5%	-38.5%
MAN	142,800	137,000	158,700	158,900	164,200	185,800	-4.1%	+35.6%
STN	16,300	12,600	15,500	15,800	10,200	9,700	-22.7%	-23.0%
Total (with LHR)	1,550,500	1,562,600	1,556,600	1,505,400	1,355,300	1,344,800	+0.8%	-13.9%
Total (without LHR)	382,700	416,500	480,000	463,000	427,000	456,900	+8.8%	+9.7%

Table C.11 (b) Average summer day L_{Aeq16h} 54dB population exposure using 2016 population database. High scenario

	Scenario: High with 2016_Pop		Population Exposure results			LAeq16h 54 dB		
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	45,700	48,100	57,200	57,000	56,500	58,200	+5.3%	+21.0%
EDI	7,500	9,800	8,000	7,600	6,200	6,500	+30.7%	-33.7%
GLA	46,400	39,400	54,200	47,500	36,400	36,800	-15.1%	-6.6%
LGW	10,400	11,100	12,100	11,300	7,400	7,400	+6.7%	-33.3%
LHR NWR	628,800	588,900	533,400	553,800	470,500	449,300	-6.3%	-23.7%
LTN	5,200	14,300	15,100	12,200	8,500	8,300	+175.0%	-42.0%
MAN	74,900	66,200	83,900	83,300	93,900	118,900	-11.6%	+79.6%
STN	6,600	5,700	6,200	6,300	4,800	4,700	-13.6%	-17.5%
Total (with LHR)	825,400	783,500	770,100	779,100	684,300	690,200	-5.1%	-11.9%
Total (without LHR)	196,700	194,600	236,700	225,300	213,800	240,900	-1.1%	+23.8%

Table C.11 (c) Average summer night L_{Aeq8h} 45dB population exposure using 2016 population database. High scenario

	Scenario: High with 2016_Pop			Population Exposure results			LAeq8h 45 dB	
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	95,900	100,600	112,600	112,700	111,500	113,200	+4.9%	+12.5%
EDI	12,500	24,600	19,800	18,700	13,200	15,300	+96.8%	-37.8%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	26,200	34,600	33,100	30,600	22,800	21,700	+32.1%	-37.3%
LHR NWR	663,500	811,800	716,600	722,700	653,900	647,000	+22.4%	-20.3%
LTN	30,200	62,100	65,200	56,100	41,700	41,800	+105.6%	-32.7%
MAN	171,300	185,900	191,900	191,400	202,500	231,700	+8.5%	+24.6%
STN	17,000	14,600	20,600	20,500	12,000	11,500	-14.1%	-21.2%
Total (with LHR)	1,016,600	1,234,100	1,159,900	1,152,800	1,057,600	1,082,300	+21.4%	-12.3%
Total (without LHR)	353,100	422,400	443,200	430,100	403,800	435,300	+19.6%	+3.1%

Table C.11 (c) Average summer night L_{Aeq8h} 48dB population exposure using 2016 population database. High scenario

	Scenario: High with 2016_Pop			Population Exposure results			LAeq8h 48 dB	
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	55,000	56,800	61,100	60,500	58,100	57,900	+3.3%	+1.9%
EDI	3,900	7,100	6,200	6,200	5,100	5,900	+82.1%	-16.9%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	10,800	14,300	14,800	13,800	10,500	10,200	+32.4%	-28.7%
LHR NWR	340,000	417,500	325,800	299,900	265,400	265,600	+22.8%	-36.4%
LTN	8,800	28,400	31,100	22,600	9,100	11,000	+222.7%	-61.3%
MAN	96,000	117,800	123,200	123,400	134,500	159,000	+22.7%	+35.0%
STN	7,300	6,800	8,700	8,700	6,500	6,300	-6.8%	-7.4%
Total (with LHR)	521,700	648,600	570,900	535,000	489,100	515,800	+24.3%	-20.5%
Total (without LHR)	181,700	231,100	245,100	235,200	223,800	250,200	+27.2%	+8.3%

Table C.11 (d) Average annual 24h L_{den} 50dB population exposure using 2016 population database. High scenario

	Scenario: High with 2016_Pop		Population Exposure results			Lden 50 dB		
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	142,800	153,500	189,600	191,000	207,400	211,400	+7.5%	+37.7%
EDI	48,100	51,500	34,000	45,300	38,700	41,800	+7.1%	-18.8%
GLA	104,600	100,600	110,200	104,700	93,700	93,700	-3.8%	-6.9%
LGW	50,400	45,600	58,100	51,600	33,200	31,900	-9.5%	-30.0%
LHR NWR	1,980,500	1,761,000	1,691,800	1,902,100	1,655,000	1,619,300	-11.1%	-8.0%
LTN	45,600	90,500	92,300	82,500	61,500	62,100	+98.5%	-31.4%
MAN	222,000	234,000	244,300	239,100	243,600	282,500	+5.4%	+20.7%
STN	36,000	34,800	43,000	43,300	25,400	24,500	-3.3%	-29.6%
Total (with LHR)	2,629,900	2,471,500	2,463,200	2,659,600	2,358,500	2,367,200	-6.0%	-4.2%
Total (without LHR)	649,400	710,500	771,400	757,500	703,500	747,900	+9.4%	+5.3%

Table C.11 (e) Average annual 24h L_{den} 55dB population exposure using 2016 population database. High scenario

	Scenario: High with 2016_Pop		Population Exposure results			Lden 55 dB		
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	48,400	52,700	66,300	65,800	68,700	70,900	+8.9%	+34.5%
EDI	11,800	15,500	11,300	10,600	8,800	10,500	+31.4%	-32.3%
GLA	56,800	44,000	53,200	47,400	36,500	37,000	-22.5%	-15.9%
LGW	12,600	13,800	15,200	14,200	9,800	9,400	+9.5%	-31.9%
LHR NWR	756,100	689,400	621,200	645,200	557,300	539,700	-8.8%	-21.7%
LTN	8,900	22,700	30,500	19,500	11,100	10,900	+155.1%	-52.0%
MAN	93,000	101,600	112,400	110,500	117,800	141,000	+9.2%	+38.8%
STN	9,800	8,700	11,900	12,000	7,300	7,300	-11.2%	-16.1%
Total (with LHR)	997,300	948,400	921,900	925,100	817,300	826,800	-4.9%	-12.8%
Total (without LHR)	241,200	259,000	300,800	280,000	260,000	287,100	+7.4%	+10.8%

Table C.11 (f) Average annual 8h L_{night} 45dB population exposure using 2016 population database. High scenario

	Scenario: High with 2016_Pop		Population Exposure results			Lnight 45 dB		
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	62,700	80,000	90,100	89,500	88,100	90,100	+27.6%	+12.6%
EDI	15,800	26,100	17,200	16,500	12,600	15,300	+65.2%	-41.4%
GLA	70,200	48,800	48,900	42,400	33,100	33,900	-30.5%	-30.5%
LGW	16,300	19,400	19,800	18,200	13,600	12,700	+19.0%	-34.5%
LHR NWR	703,600	725,800	649,400	648,600	595,700	589,200	+3.2%	-18.8%
LTN	14,900	46,900	48,000	39,400	22,900	24,100	+214.8%	-48.6%
MAN	130,300	147,900	149,000	146,600	153,900	174,500	+13.5%	+18.0%
STN	15,300	14,500	19,400	19,600	12,100	11,700	-5.2%	-19.3%
Total (with LHR)	1,029,100	1,109,200	1,041,800	1,020,800	931,800	951,400	+7.8%	-14.2%
Total (without LHR)	325,500	383,400	392,300	372,200	336,100	362,300	+17.8%	-5.5%

Table C.11 (g) Average annual 8h L_{night} 50dB population exposure using 2016 population database. High scenario

	Scenario: High with 2016_Pop		Population Exposure results			Lnight 50 dB		
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	20,700	26,300	28,800	28,700	28,000	29,300	+27.1%	+11.4%
EDI	2,900	4,600	3,600	3,600	3,400	3,500	+58.6%	-23.9%
GLA	21,100	7,700	8,000	6,100	4,300	5,500	-63.5%	-28.6%
LGW	5,000	5,200	4,600	4,500	4,000	4,000	+4.0%	-23.1%
LHR NWR	207,200	221,200	173,900	188,900	174,000	175,100	+6.8%	-20.8%
LTN	2,600	8,400	8,400	7,000	4,300	4,300	+223.1%	-48.8%
MAN	40,900	44,100	39,200	38,500	40,700	55,700	+7.8%	+26.3%
STN	4,100	4,000	4,900	5,000	3,700	3,700	-2.4%	-7.5%
Total (with LHR)	304,600	321,600	271,500	282,200	262,400	281,200	+5.6%	-12.6%
Total (without LHR)	97,400	100,500	97,700	93,400	88,400	106,100	+3.2%	+5.6%

Table C.11 (h) Average summer night N60, ≥5 events population exposure using 2016 population database. High scenario

	Scenario: High with 2016_Pop			Population Exposure results			N60, ≥5 events	
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	166,100	229,000	236,500	242,500	252,400	257,800	+37.9%	+12.6%
EDI	58,000	71,100	61,600	61,100	56,000	56,800	+22.6%	-20.1%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	55,000	93,800	70,500	68,500	56,900	56,700	+70.5%	-39.6%
LHR NWR	1,078,700	1,325,100	1,221,900	1,327,700	1,179,900	1,133,600	+22.8%	-14.5%
LTN	97,800	115,100	113,500	104,900	89,500	89,700	+17.7%	-22.1%
MAN	299,200	269,200	273,900	273,300	300,000	389,900	-10.0%	+44.8%
STN	45,900	40,100	43,700	43,000	33,300	32,900	-12.6%	-18.0%
Total (with LHR)	1,800,700	2,143,400	2,021,800	2,120,900	1,968,000	2,017,400	+19.0%	-5.9%
Total (without LHR)	722,100	818,300	799,900	793,200	788,200	883,800	+13.3%	+8.0%

Table C.11 (i) Average summer night N60, ≥10 events population exposure using 2016 population database. High scenario

	Scenario: High with 2016_Pop			Population Exposure results			N60, ≥10 events	
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	79,600	140,600	140,800	143,500	160,100	157,900	+76.6%	+12.3%
EDI	37,800	48,300	40,700	42,100	40,700	42,900	+27.8%	-11.2%
GLA	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LGW	27,500	38,200	43,900	37,400	31,100	32,700	+38.9%	-14.4%
LHR NWR	791,400	928,200	848,500	960,000	871,600	863,300	+17.3%	-7.0%
LTN	50,700	89,400	90,800	85,900	73,000	71,700	+76.3%	-19.8%
MAN	206,300	191,700	191,500	191,600	203,500	232,000	-7.1%	+21.0%
STN	22,700	26,400	28,600	28,400	19,900	19,200	+16.3%	-27.3%
Total (with LHR)	1,215,900	1,462,900	1,384,800	1,488,900	1,399,800	1,419,700	+20.3%	-3.0%
Total (without LHR)	424,500	534,700	536,200	528,900	528,200	556,400	+26.0%	+4.1%

Table C.11 (j) Average summer day N65, ≥5 events population exposure using 2016 population database. High scenario.

	Scenario: High with 2016_Pop		Population Exposure results				N65, ≥5 events	
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	300,500	250,600	268,800	261,500	249,200	252,900	-16.6%	+0.9%
EDI	72,800	91,100	78,800	76,400	31,100	63,300	+25.1%	-30.5%
GLA	135,400	135,100	145,800	143,800	134,500	132,100	-0.2%	-2.2%
LGW	72,300	42,600	39,600	39,500	25,700	23,400	-41.1%	-45.1%
LHR NWR	2,389,300	1,678,700	1,653,100	1,536,600	1,362,700	1,148,200	-29.7%	-31.6%
LTN	98,300	88,200	87,500	84,800	67,900	65,400	-10.3%	-25.9%
MAN	523,900	283,000	284,000	271,100	303,500	345,700	-46.0%	+22.2%
STN	52,800	39,900	51,600	46,200	28,000	27,000	-24.4%	-32.3%
Total (with LHR)	3,645,400	2,609,300	2,609,200	2,459,900	2,202,500	2,057,900	-28.4%	-21.1%
Total (without LHR)	1,256,100	930,600	956,100	923,400	839,800	909,800	-25.9%	-2.2%

Table C.11 (k) Average summer day N65, ≥10 events population exposure using 2016 population database. High scenario

	Scenario: High with 2016_Pop		Population Exposure results				N65, ≥10 events	
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	225,600	197,400	217,200	214,500	205,800	207,800	-12.5%	+5.3%
EDI	61,000	69,800	65,100	61,800	16,500	53,300	+14.4%	-23.6%
GLA	116,200	119,000	128,700	124,100	113,900	112,600	+2.4%	-5.4%
LGW	39,300	30,200	32,100	33,900	20,400	19,900	-23.2%	-34.1%
LHR NWR	1,599,300	1,271,700	1,288,900	1,271,400	1,069,300	999,700	-20.5%	-21.4%
LTN	72,700	78,300	80,400	72,500	63,800	63,000	+7.7%	-19.5%
MAN	303,200	173,800	187,600	176,500	189,900	228,300	-42.7%	+31.4%
STN	32,300	25,100	33,100	29,800	19,100	18,200	-22.3%	-27.5%
Total (with LHR)	2,449,500	1,965,400	2,033,200	1,984,400	1,698,600	1,702,900	-19.8%	-13.4%
Total (without LHR)	850,300	693,700	744,300	713,100	629,300	703,200	-18.4%	+1.4%

Table C.11 (l) Average summer day N70, ≥5 events population exposure using 2016 population database. High scenario.

	Scenario: High with 2016_Pop			Population Exposure results			N70, ≥5 events	
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	146,700	114,600	105,000	100,000	86,600	90,400	-21.9%	-21.1%
EDI	32,600	35,600	34,900	32,300	26,200	24,200	+9.2%	-32.0%
GLA	87,600	88,000	96,100	91,200	79,800	77,800	+0.5%	-11.6%
LGW	20,500	10,400	12,700	12,600	9,500	8,900	-49.3%	-14.4%
LHR NWR	917,000	680,800	681,700	557,100	458,200	388,600	-25.8%	-42.9%
LTN	20,100	21,500	21,100	20,400	16,400	15,700	+7.0%	-27.0%
MAN	145,800	102,500	103,000	94,000	78,800	95,000	-29.7%	-7.3%
STN	9,100	8,600	9,900	9,600	8,600	8,400	-5.5%	-2.3%
Total (with LHR)	1,379,300	1,062,100	1,064,400	917,100	764,000	708,900	-23.0%	-33.3%
Total (without LHR)	462,300	381,300	382,700	360,000	305,800	320,400	-17.5%	-16.0%

Table C.11 (m) Average summer day N70, ≥10 events population exposure using 2016 population database. High scenario.

	Scenario: High with 2016_Pop			Population Exposure results			N70, ≥10 events	
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	104,300	94,200	84,700	81,200	68,500	63,600	-9.7%	-32.5%
EDI	26,500	27,800	27,400	24,100	17,600	17,600	+4.9%	-36.7%
GLA	72,700	72,700	81,800	76,900	67,500	66,800	+0.0%	-8.1%
LGW	14,200	7,500	10,500	10,800	8,400	8,100	-47.2%	+8.0%
LHR NWR	632,300	538,200	537,700	446,100	354,500	322,000	-14.9%	-40.2%
LTN	12,700	19,800	20,000	17,800	14,500	14,900	+55.9%	-24.7%
MAN	105,000	70,600	70,800	66,800	62,500	73,200	-32.8%	+3.7%
STN	7,000	7,800	7,900	7,600	5,500	5,300	+11.4%	-32.1%
Total (with LHR)	974,600	838,700	840,700	731,300	599,000	571,500	-13.9%	-31.9%
Total (without LHR)	342,300	300,500	303,100	285,200	244,500	249,500	-12.2%	-17.0%

Table C.12 (a): Average Individual Exposure (AIE), number of events above 70dB L_{Amax} for areas experiencing at least 5 events per average summer day using 2016 population database. High scenario

	Scenario: High with 2016_Pop		Population Exposure results			AIE(70), ≥5 events	
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	36.0	52.0	61.8	65.9	80.1	82.1	+44.4%	+57.9%
EDI	39.0	46.0	40.7	40.7	38.2	45.0	+17.9%	-2.2%
GLA	52.0	55.0	61.9	58.3	55.8	59.5	+5.8%	+8.2%
LGW	43.0	61.1	67.0	64.8	69.0	67.0	+42.0%	+9.7%
LHR NWR	47.5	70.1	70.5	97.5	98.5	114.3	+47.7%	+63.1%
LTN	41.5	92.3	90.0	86.4	84.5	84.2	122.4%	-8.8%
MAN	56.6	74.8	81.9	89.0	114.7	121.8	+32.1%	+63.0%
STN	60.8	85.4	73.9	72.8	50.9	51.9	+40.6%	-39.3%
Average (with LHR)	376.3	536.6	547.7	575.4	591.7	625.8	42.6%	16.6%
Average (without LHR)	328.8	466.5	477.2	477.9	493.1	511.5	41.9%	9.6%

Table C.12 (b): Average Individual Exposure (AIE), number of events above 70dB L_{Amax} for areas experiencing at least 10 events per average summer day using 2016 population database. High scenario

	Scenario: High with 2016_Pop		Population Exposure results			AIE(70), ≥10 events	
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	48.0	61.0	74.9	79.7	98.6	112.7	+27.1%	+84.8%
EDI	46.0	56.0	50.3	51.3	52.5	58.8	+21.7%	+5.0%
GLA	61.0	65.0	71.7	68.1	64.8	68.3	+6.6%	+5.1%
LGW	61.0	82.1	79.3	73.7	76.9	79.3	+34.6%	-3.4%
LHR NWR	62.7	86.6	87.4	119.9	125.8	137.2	+38.2%	+58.5%
LTN	62.7	86.4	86.3	78.5	74.6	78.7	37.9%	-9.0%
MAN	76.2	106.1	116.4	123.0	141.3	155.3	+39.2%	+46.4%
STN	76.5	93.4	90.3	87.5	73.6	78.0	+22.0%	-16.5%
Average (with LHR)	494.1	636.6	656.7	681.6	708.1	768.4	+28.8%	+20.7%
Average (without LHR)	431.4	550.0	569.2	561.8	582.3	631.1	+27.5%	+14.7%

Table C.13 (a): Persons Event Index (PEI) above 70dB L_{Amax} for areas experiencing at least 5 events per average summer day. High Scenario 2016 population database

	Scenario: High with 2016_Pop		Population Exposure results				PEI(70), ≥5 events	
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	5,331,400	5,939,000	6,479,100	6,634,500	6,967,600	7,544,600	+11.4%	+27.0%
EDI	1,248,800	1,635,600	1,416,400	1,313,100	1,002,800	1,091,200	+31.0%	-33.3%
GLA	4,635,400	4,887,300	5,973,400	5,345,200	4,463,000	4,642,300	+5.4%	-5.0%
LGW	1,033,200	634,500	855,900	813,000	657,300	649,900	-38.6%	+2.4%
LHR NWR	44,814,900	47,811,900	48,187,900	54,457,000	45,289,700	44,804,100	+6.7%	-6.3%
LTN	849,100	1,835,400	1,799,700	1,577,800	1,224,600	1,263,500	+116.2%	-31.2%
MAN	8,287,300	7,689,500	8,492,100	8,397,600	9,046,800	11,642,100	-7.2%	+51.4%
STN	554,300	737,000	729,500	697,400	439,600	443,900	+33.0%	-39.8%
Total (with LHR)	66,754,500	71,170,000	73,934,100	79,235,600	69,091,300	72,081,700	+6.6%	+1.3%
Total (without LHR)	21,939,500	23,358,100	25,746,200	24,778,600	23,801,600	27,277,700	+6.5%	+16.8%

Table C.13 (b): Persons Event Index (PEI) above 70dB L_{Amax} for areas experiencing at least 10 events per average summer day. High Scenario 2016 population database

	Scenario: High with 2016_Pop		Population Exposure results				PEI(70), ≥10 events	
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	5,038,200	5,795,100	6,335,400	6,495,500	6,834,400	7,358,900	+15.0%	+27.0%
EDI	1,204,600	1,579,700	1,359,900	1,258,500	940,300	1,044,000	+31.1%	-33.9%
GLA	4,527,700	4,775,100	5,864,200	5,236,400	4,373,900	4,562,600	+5.5%	-4.4%
LGW	978,000	614,700	839,100	800,800	649,100	638,400	-37.1%	+3.9%
LHR NWR	43,012,100	46,784,300	47,124,000	53,626,000	44,534,200	44,316,300	+8.8%	-5.3%
LTN	794,700	1,846,600	1,806,300	1,594,600	1,241,300	1,271,300	+132.4%	-31.2%
MAN	8,003,300	7,465,300	8,252,400	8,200,200	8,934,300	11,484,900	-6.7%	+53.8%
STN	539,600	731,200	716,000	685,100	416,000	420,000	+35.5%	-42.6%
Total (with LHR)	64,098,100	69,591,900	72,297,400	77,897,100	67,923,400	71,096,500	+8.6%	+2.2%
Total (without LHR)	21,086,000	22,807,600	25,173,400	24,271,100	23,389,300	26,780,200	+8.2%	+17.4%

Table C.14 (a): Number of people highly sleep disturbed exposed to at least 45dB L_{night}. High Scenario 2016 population database

	Scenario: High with 2016_Pop	No. of people highly sleep-disturbed Lnight 45 dB						
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	4,400	5,600	6,300	6,300	6,100	6,300	+26.4%	+11.9%
EDI	1,000	1,700	1,100	1,100	800	1,000	+67.5%	-41.0%
GLA	4,800	3,100	3,100	2,700	2,100	2,200	-36.0%	-29.8%
LGW	1,100	1,300	1,300	1,400	900	900	+15.7%	-34.2%
LHR NWR	51,100	52,100	44,400	45,100	41,000	34,000	+2.1%	-34.8%
LTN	1,000	3,000	3,100	2,500	1,500	1,900	+200.0%	-36.7%
MAN	9,300	10,500	10,300	10,100	10,700	12,600	+13.0%	+20.5%
STN	1,100	1,000	1,300	1,300	800	800	-11.6%	-18.3%
Total (with LHR)	73,800	78,300	71,000	70,400	63,900	59,600	+6.1%	-23.9%
Total (without LHR)	22,700	26,100	26,600	25,300	23,000	25,600	+15.0%	-1.9%

Table C.14 (b): Number of people highly sleep disturbed exposed to at least 50dB L_{night}. High Scenario 2016 population database

	Scenario: High with 2016_Pop	No. of people highly sleep-disturbed Lnight 50 dB						
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	1,900	2,400	2,600	2,600	2,500	2,600	+26.3%	+9.8%
EDI	300	400	300	300	300	300	+60.8%	-26.4%
GLA	1,800	600	700	500	400	500	-64.7%	-28.5%
LGW	500	500	400	400	400	300	+1.4%	-27.4%
LHR NWR	20,600	21,600	16,200	17,900	16,200	16,600	+4.8%	-23.3%
LTN	200	800	800	600	400	600	+300.0%	-25.0%
MAN	3,900	4,200	3,600	3,600	3,800	5,200	+6.5%	+25.3%
STN	400	400	400	400	300	300	-8.7%	-8.8%
Total (with LHR)	29,600	30,800	25,100	26,400	24,200	26,400	+4.1%	-14.3%
Total (without LHR)	9,000	9,200	8,900	8,500	8,000	9,900	+2.2%	+7.6%

Table C.15 (a): Number of people highly annoyed exposed to at least 51dB L_{den}. High Scenario 2016 population database

	Scenario: High with 2016_Pop No. of people highly annoyed Lden 51 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	13,400	14,400	17,800	18,000	18,800	19,600	+7.2%	+36.3%
EDI	3,900	4,600	3,900	3,800	3,200	3,500	+15.6%	-23.5%
GLA	11,400	9,800	11,400	10,400	8,900	9,000	-14.0%	-7.9%
LGW	3,900	4,500	4,400	4,000	2,700	2,600	+15.2%	-41.1%
LHR NWR	182,500	172,400	159,900	165,700	143,500	131,200	-5.5%	-23.9%
LTN	3,200	7,900	8,300	12,600	4,800	5,200	+146.9%	-34.2%
MAN	23,100	23,700	25,100	24,600	25,500	30,300	+3.0%	+27.6%
STN	2,700	2,500	3,300	3,300	2,100	2,100	-5.6%	-18.2%
Total (with LHR)	244,000	239,800	234,000	242,400	209,700	203,500	-1.7%	-15.1%
Total (without LHR)	61,500	67,400	74,200	76,700	66,200	72,300	+9.6%	+7.3%

Table C.15 (b): Number of people highly annoyed exposed to at least 54dB L_{den}. High Scenario 2016 population database

	Scenario: High with 2016_Pop No. of people highly annoyed Lden 54 dB							
Airport	2006	2016	2025	2030	2040	2050	% change 2006-2016	% change 2016-2050
BHX	9,000	9,900	12,400	12,400	12,700	13,300	+10.0%	+35.2%
EDI	2,300	3,000	2,300	2,200	1,800	2,100	+28.4%	-29.7%
GLA	9,300	7,300	8,900	7,900	6,400	6,500	-21.4%	-11.2%
LGW	2,300	2,600	2,700	2,500	1,800	1,700	+10.9%	-35.4%
LHR NWR	136,700	125,600	112,800	117,800	102,900	88,900	-8.1%	-29.2%
LTN	1,600	4,700	5,500	9,800	2,100	2,500	+193.8%	-46.8%
MAN	17,600	18,300	19,700	19,400	20,300	24,600	+3.7%	+34.9%
STN	1,700	1,600	2,100	2,100	1,300	1,200	-3.1%	-25.1%
Total (with LHR)	180,500	173,000	166,300	174,100	149,300	140,900	-4.2%	-18.6%
Total (without LHR)	43,800	47,300	53,500	56,300	46,300	52,000	+8.0%	+9.9%

APPENDIX D

Noise forecast results excluding Heathrow

Table D.1: Summary of noise metric results (excluding LHR NWR), Scenario: HIGH

			Scenario: High	Summary excluding LHR NWR					
KPI type	**Period**	**Threshold**	**2006**	**2016**	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
Traffic	Average summer day 16h ATMs	-	3,101.5	3,044.9	3,217.1	3,355.0	3,661.5	3,977.6	+30.6%
	Average summer night 8h ATMs	-	383.4	421.3	447.5	469.0	508.3	550.2	+30.6%
Noise emission	Average summer day 16h QC	-	1,566.7	1,499.2	1,529.4	1,445.8	1,067.0	1,120.4	-25.3%
	Average summer night 8h QC	-	210.4	211.5	199.4	191.1	143.8	152.4	-28.0%
Area exposure	Average summer day LAeq16h	>54 dB	309.9	307.3	332.3	317.1	263.9	275.6	-10.3%
	Average summer night LAeq8h	>48 dB	305.1	347.5	355.1	343.8	297.2	311.6	-10.3%
	Average annual 24h Lden	>55 dB	371.0	374.1	403.6	385.3	325.1	339.4	-9.3%
	Average Annual 8h Lnight	>50 dB	183.6	177.1	180.2	172.5	143.0	150.6	-15.0%
Population exposure	Average summer day LAeq16h	>54 dB	196,700	194,600	242,600	237,100	231,900	266,500	+36.9%
	Average summer night LAeq8h	>48 dB	181,700	231,100	252,300	249,400	245,300	280,600	+21.4%
	Average annual 24h Lden	>55 dB	241,200	259,000	308,300	295,300	282,900	318,700	+23.1%
	Average Annual 8h Lnight	>50 dB	97,400	100,500	100,500	98,700	96,200	118,000	+17.4%
	Average summer night 8h N60	≥10 events	424,500	534,700	554,000	562,200	579,300	623,600	+16.6%
	Average summer day 16h N65	≥10 events	850,300	693,700	765,000	752,800	723,200	777,800	+12.1%
	Average summer day 16h N70	≥10 events	342,300	300,500	310,200	300,100	264,600	274,200	-8.8%
	Average Individual Exposure (70)	≥10 events	431.4	550.0	562.5	563.1	588.9	635.8	+15.6%
	Person Events Index (70)	≥10 events	21,086,000	22,807,600	25,722,100	25,622,400	25,372,200	29,566,100	+29.6%
Noise impact	No. of people highly sleep-disturbed Average Annual 8h Lnight	>45 dB	22,700	26,100	27,300	26,600	25,000	28,100	+7.7%
	No. of people highly annoyed Average annual 24h Lden	>54 dB	43,800	47,300	54,900	53,500	50,300	57,500	+21.6%

Table D.2: Summary of noise metric results (excluding LHR NWR), Scenario: Central

	Scenario: Central	Summary excluding LHR NWR							
KPI type	**Period**	**Threshold**	**2006**	**2016**	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
Traffic	Average summer day 16h ATMs	-	3,101.5	3,044.9	3,106.4	3,231.2	3,604.1	3,896.2	+28.0%
	Average summer night 8h ATMs	-	383.4	421.3	408.1	424.3	474.3	512.7	+21.7%
Noise emission	Average summer day 16h QC	-	1,566.7	1,499.2	1,437.5	1,348.1	995.3	1,047.4	-30.1%
	Average summer night 8h QC	-	210.4	211.5	186.7	178.0	135.2	144.3	-31.8%
Area exposure	Average summer day LAeq16h	>54	309.9	307.3	315.0	299.1	251.6	261.1	-15.0%
	Average summer night LAeq8h	>48	305.1	347.5	339.6	325.8	285.7	296.1	-14.8%
	Average annual 24h Lden	>55	371.0	374.1	381.7	363.8	311.4	322.5	-13.8%
	Average Annual 8h Lnight	>50	183.6	177.1	169.4	163.3	137.4	143.0	-19.3%
Population exposure	Average summer day LAeq16h	>54	196,700	194,600	232,100	217,500	211,500	247,900	+27.4%
	Average summer night LAeq8h	>48	181,700	231,100	243,800	237,400	232,800	262,800	+13.7%
	Average annual 24h Lden	>55	241,200	259,000	292,700	271,300	261,900	298,500	+15.3%
	Average Annual 8h Lnight	>50	97,400	100,500	94,900	90,600	88,100	101,900	+1.4%
	Average summer night 8h N60	>10 events	424,500	534,700	539,700	541,500	556,700	607,000	+13.5%
	Average summer day 16h N65	>10 events	850,300	693,700	741,300	724,200	702,900	750,500	+8.2%
	Average summer day 16h N70	>10 events	342,300	300,500	298,400	271,800	247,700	246,500	-18.0%
	Average Individual Exposure (70)	>10 events	431.4	550.0	557.2	595.3	611.4	690.5	+25.5%
	Person Events Index (70)	>10 events	25,146,100	27,988,000	29,731,400	30,670,200	29,485,000	33,740,800	+20.6%
Noise impact	No. of people highly sleep-disturbed Average Annual 8h Lnight	>45dB Lnight	22,700	26,100	25,900	24,700	23,500	25,900	-0.8%
	No. of people Highly annoyed Average annual 24h Lden	>54 dB Lden	43,800	47,300	52,200	49,600	46,700	52,800	+11.6%

Table D.3: Summary of noise metric results (excluding LHR NWR), Scenario: High with no population growth

	Scenario: High with no population growth	Summary excluding LHR NWR							
KPI type	**Period**	**Threshold**	**2006**	**2016**	**2025**	**2030**	**2040**	**2050**	**% change 2016-2050**
Traffic	Average summer day 16h ATMs	-	3,101.5	3,044.9	3,217.1	3,355.0	3,661.5	3,977.6	+30.6%
	Average summer night 8h ATMs	-	383.4	421.3	447.5	469.0	508.3	550.2	+30.6%
Noise emission	Average summer day 16h QC	-	1,566.7	1,499.2	1,529.4	1,445.8	1,067.0	1,120.4	-25.3%
	Average summer night 8h QC	-	210.4	211.5	199.4	191.1	143.8	152.4	-28.0%
Area exposure	Average summer day LAeq16h	>54	309.9	307.3	332.3	317.1	263.9	275.6	-10.3%
	Average summer night LAeq8h	>48	305.1	347.5	355.1	343.8	297.2	311.6	-10.3%
	Average annual 24h Lden	>55	371.0	374.1	403.6	385.3	325.1	339.4	-9.3%
	Average Annual 8h Lnight	>50	183.6	177.1	180.2	172.5	143.0	150.6	-15.0%
Population exposure	Average summer day LAeq16h	>54	196,700	194,600	236,700	225,300	213,800	240,900	+23.8%
	Average summer night LAeq8h	>48	181,700	231,100	245,100	235,200	223,800	250,200	+8.3%
	Average annual 24h Lden	>55	241,200	259,000	300,800	280,000	260,000	287,100	+10.8%
	Average Annual 8h Lnight	>50	97,400	100,500	97,700	93,400	88,400	106,100	+5.6%
	Average summer night 8h N60	>10 events	424,500	534,700	536,200	528,900	528,200	556,400	+4.1%
	Average summer day 16h N65	>10 events	850,300	693,700	744,300	713,100	629,300	703,200	+1.4%
	Average summer day 16h N70	>10 events	342,300	300,500	303,100	285,200	244,500	249,500	-17.0%
	Average Individual Exposure (70)	>10 events	431.4	550.0	569.2	561.8	582.3	631.1	+14.7%
	Person Events Index (70)	>10 events	21,086,000	22,807,600	25,173,400	24,271,100	23,389,300	26,780,200	+17.4%
Noise impact	No. of people highly sleep-disturbed Average Annual 8h Lnight	>45dB Lnight	22,700	26,100	26,600	25,300	23,000	25,600	-1.9%
	No. of people Highly annoyed (daytime) Average annual 24h Lden	>54 dB Lden	43,800	47,300	53,500	56,300	46,300	52,000	+9.9%