19.861.01 • July 2019

CPRE aircraft noise study

Findings report

Aviation Consultants

to70

CPRE aircraft noise study

Findings report

Prepared for:

CPRE Sussex Branch
Ms. K. Trainor

Prepared by:

To70 B.V.
P.O. Box 85818
2508 CM The Hague, The Netherlands
tel. +31 (0)70 3922 322
Email: info@To70.nl

Author:

Ruud Ummels
Mark Verkerk

The Hague, August 2019

Table of Contents

Executive summary

CPRE has requested To70 to provide a comprehensive report which CPRE can use in the ongoing debate on airport expansion in the United Kingdom.

The UK government and airports are following the minimal reporting threshold of 55 dB(A) L_{den} as specified in the EU Environmental Noise Directive and the 54 dB(A) $L_{Aeq,16}$ as specified in the government aviation policy. Other EU countries and airports report noise contours starting at much lower thresholds. The area covered by the 45 dB(A) L_{den} contour, which is included in the World Health Organisation (WHO) Environmental Noise Guideline, could cover an area that is over five times bigger than the existing focus area. Although the percentage of people which are highly annoyed due to aircraft noise is low (<10%) at these lower noise levels, there is clearly a significant amount of people impacted by aircraft noise within these larger areas. There could even be more people highly annoyed here than there are people impacted by the higher noise levels.

Noise management policies have historically focused on the areas with high noise levels. Comparison of several aircraft noise annoyance studies throughout the years show that the L_{den} level at which 25% of respondents were highly annoyed decreased significantly over the past 50 years. In other words, nuisance has increased. In the UK, comparison of studies shows that the percentage of people who are highly annoyed is also increasing; in 1982 9% of people indicated that they were highly annoyed at 57dB $L_{aeq,16}$, the same percentage was found in 2014 at 54dB.

There are a multitude of socio-psychological factors which influence the level of annoyance caused by aircraft noise. As such, aircraft noise management requires an approach on multiple fronts in which industry, government and communities cooperate. This should provide solutions for all involved stakeholders and bring a new perspective for the future. Alongside the technical noise reduction policies, such as the L_{den} reporting threshold, non-acoustic/socio-psychological factors, such as trust or expectations, should be given a raised priority in the design of aircraft noise management strategies.

To illustrate changes in airport operations and noise over the years Gatwick Airport is used as an example. Between 2012 and 2018, passenger numbers have risen by 35% and aircraft movements by 15%. The increase in movements are mainly medium planes. Growth has primarily taken place during hours were the airport was/is not (yet) operating near maximum capacity. These hours are primarily at the beginning of the night, between 21:00 and 24:00.

Over the years, both arriving and departing traffic around Gatwick has concentrated. For departures this is due to the increasing usage of Performance Based Navigation. Arrivals have concentrated due to a trial with relocated ILS joining points, which was overturned due to an increase in the number of noise complaints made by residents. Concentration can benefit some communities which are less overflown. However, the consequence is an increased concentration of aircraft noise over a smaller area which negatively affects communities close to the route.

1 Introduction

All around the world the aviation industry is growing. Figure 1 shows the locations of the twelve largest airports in England based on 2018 passenger numbers. The figure also shows the impact of these airports on the country, with people reporting hearing low flying aircraft throughout the country.

The Campaign to Protect Rural England (CPRE) is an organisation that campaigns for a sustainable future for the English countryside. As a part of this campaign, the CPRE is using their own research to lobby the public and all levels of government. Aircraft noise disrupts the tranquillity of the countryside and air traffic contributes significantly to the UK's carbon footprint. The figure on the next page shows the Top 12 England airports and areas where people report hearing low flying aircraft. CPRE believes that the recent rapid expansion of aviation exceeds environmental limits and that the Government is failing to promote alternatives to flying. In order to better understand the noise and health impacts of aviation, CPRE commissioned independent aircraft noise research to be undertaken.

CPRE has requested To70 to provide a comprehensive report which CPRE can use in the ongoing debate on airport expansion in the United Kingdom. This report focusses on the following topics:

1. Lower noise levels
   Currently the focus in noise monitoring, reporting and management focusses on areas close to airports where noise levels are highest (eg. 54 dB(A) $L_{Aeq,16}$). This chapter provides insights into lower noise levels around based on actual operational data and describe the impact on communities.

2. Noise tolerance and expectations
   The health impacts aircraft noise has on people depends on several factors. By making use of existing scientific research papers, this chapter provides an analysis of these factors, how they differ in varying environments and how aircraft noise tolerance has changed over time.

3. Changes in operations and noise at Gatwick Airport
   Based on historical traffic and track data of Gatwick, changes in the operation are identified and the effects of these changes on the noise footprint around the airport are presented. Changes which are analysed include traffic volume and frequency, aircraft type, route usage, concentration/dispersion of traffic flows and future plans for the airport.

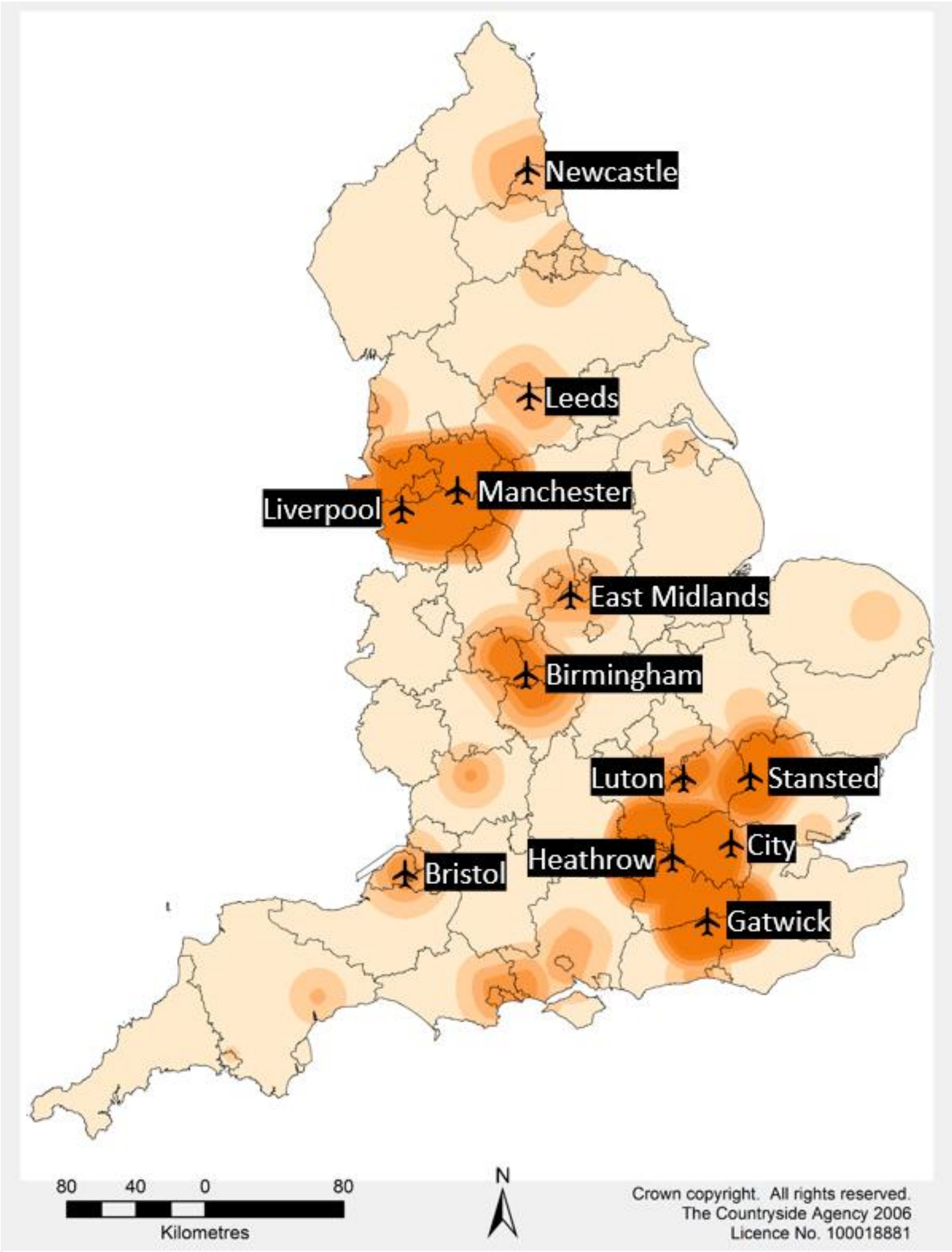


Figure 1: Top 12 England airports and areas where people report hearing low flying aircraft

2 Lower noise levels

2.1 Noise contours close to the airport

Noise contour maps provide information to the public and policy makers on the exposure to aircraft noise. The European Union's directive relating to the assessment and management of environmental noise (the Environmental Noise Directive – END) requires EU member states to produce noise contour maps for all airports registering over 50,000 movements (take-offs or landings) per year. Based on this directive, the EU requires Member States to prepare action plans containing measures that address noise issues.[1]

The END specifies a reporting threshold at 55 dB(A) L_{den} and 50 dB(A) L_{night}. L_{den} is the A-weighted equivalent continuous noise level, evaluated over an annual average 24-hour period, with a penalty added to the levels at night (23.00-07.00) and the evening (19.00-23.00) to reflect people's increased sensitivity to noise during these periods. L_{night} is the A-weighted equivalent continuous noise level assessed only over an annual average night period (23.00-07.00).[1] Long-term average noise indicators such as L_{den} provide a useful means to assess the evolution of the noise climate around an airport and are generally considered useful for supporting land-use planning. However, it is increasingly accepted that they are not intuitive to many people. Local communities are unable to relate them to their actual experience. This has materialised with the development of a range of additional indicators and metrics. It should be noted however that there is no single metric that reflects all aspects of community perception of aircraft noise exposure.

The END was transposed into UK law as The Environmental Noise (England) Regulations 2006. The regulation takes over the END threshold, requiring airports to report L_{den} contours of 55 dB(A) or greater and L_{night} contours of 50 dB(A) or greater. Supplementary noise indicators include L_{Aeq} (continuous sound level in dB(A) that, over the period 07:00 – 23:00 hours), L_{day} and $L_{evening}$. Figure 3 shows the L_{den} noise contours for Edinburgh Airport in increments of 5 dB, starting at 55 dB(A) L_{den}. Figure 2 shows the same contour map for Gatwick Airport.

The specified reporting threshold of 55 dB(A) L_{den} and 50 dB(A) L_{night} in the END are minimal requirements. Whilst the UK is keeping these minimal requirements, other EU countries report noise contours starting at lower thresholds because this better reflects people's response to aircraft noise. Figure 4 shows noise contours used on a dialog forum for the community around Vienna Airport, Austria. The reported noise contours start at a threshold of 45 dB(A) L_{day}. Consequently, the L_{night} is reported starting at a lower level of 40 dB(A) L_{night}. Figure 5 shows noise contours used to map noise in the Environmental Impact Assessment for Amsterdam Schiphol Airport in the Netherlands. For Schiphol noise levels of 48 dB(A) L_{den}, 58 dB(A) L_{den}, 40 dB(A) L_{night} and 48 dB(A) L_{night} are used for reporting. Using lower threshold levels acknowledges the health impacts experienced by aircraft noise and allows for noise reduction initiatives to be undertaken for areas further away from airports, such as flight path changes and respite.

---

[1] European Enviroment Agency. Enviromental noise. eea.europe.eu. [Online] 7 December 2018. [Cited: 4 June 2019.] https://www.eea.europa.eu/airs/2018/environment-and-health/environmental-noise.

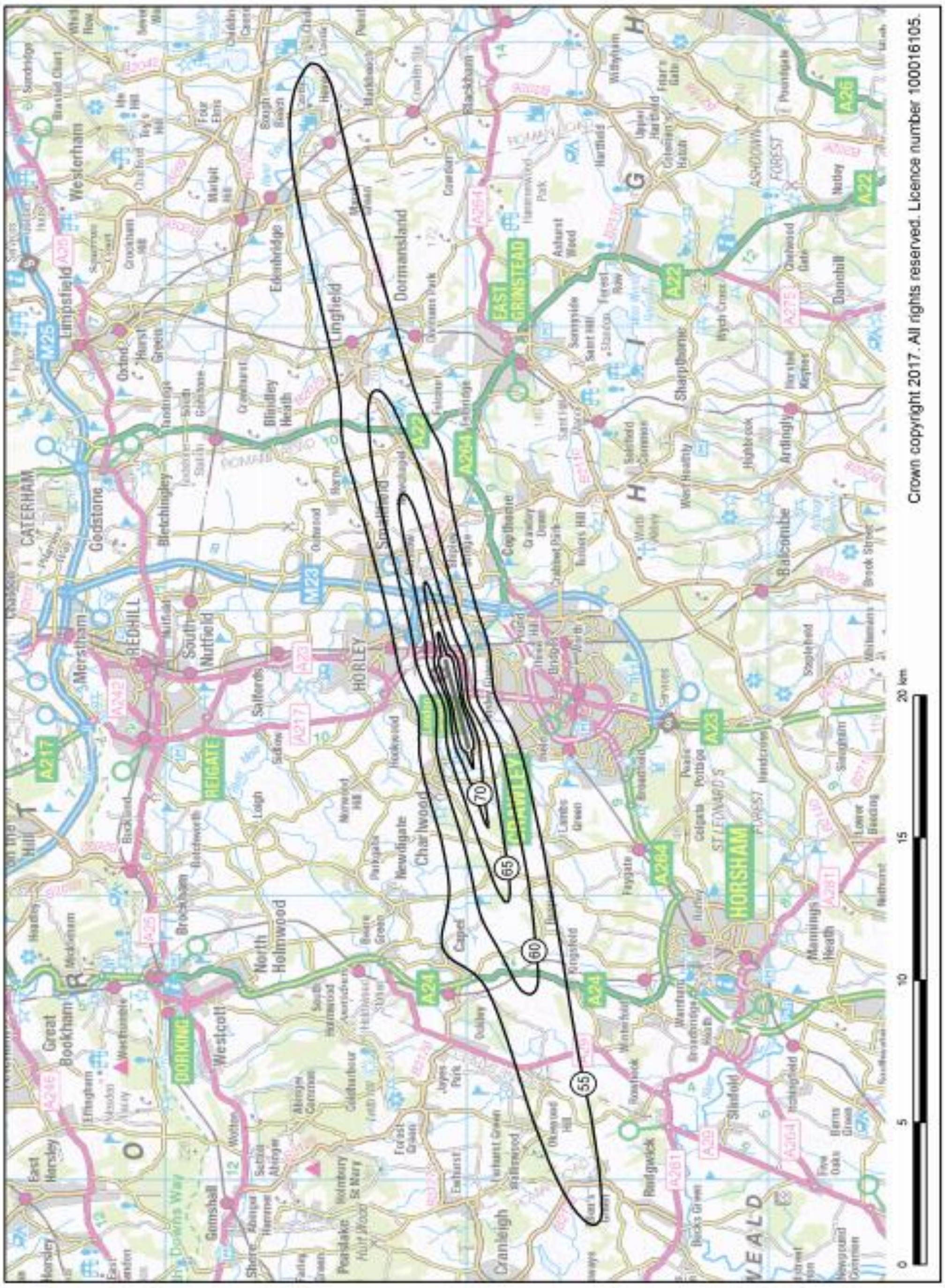


Figure 2: L_{den} noise contours Gatwick Airport

[2]

---

[2] Enviromental Research and Consultancy Department. Strategic noise maps for Gatwick Airport 2016. London : Civil Aviation Authority, 2018. ERCD Report 1705.

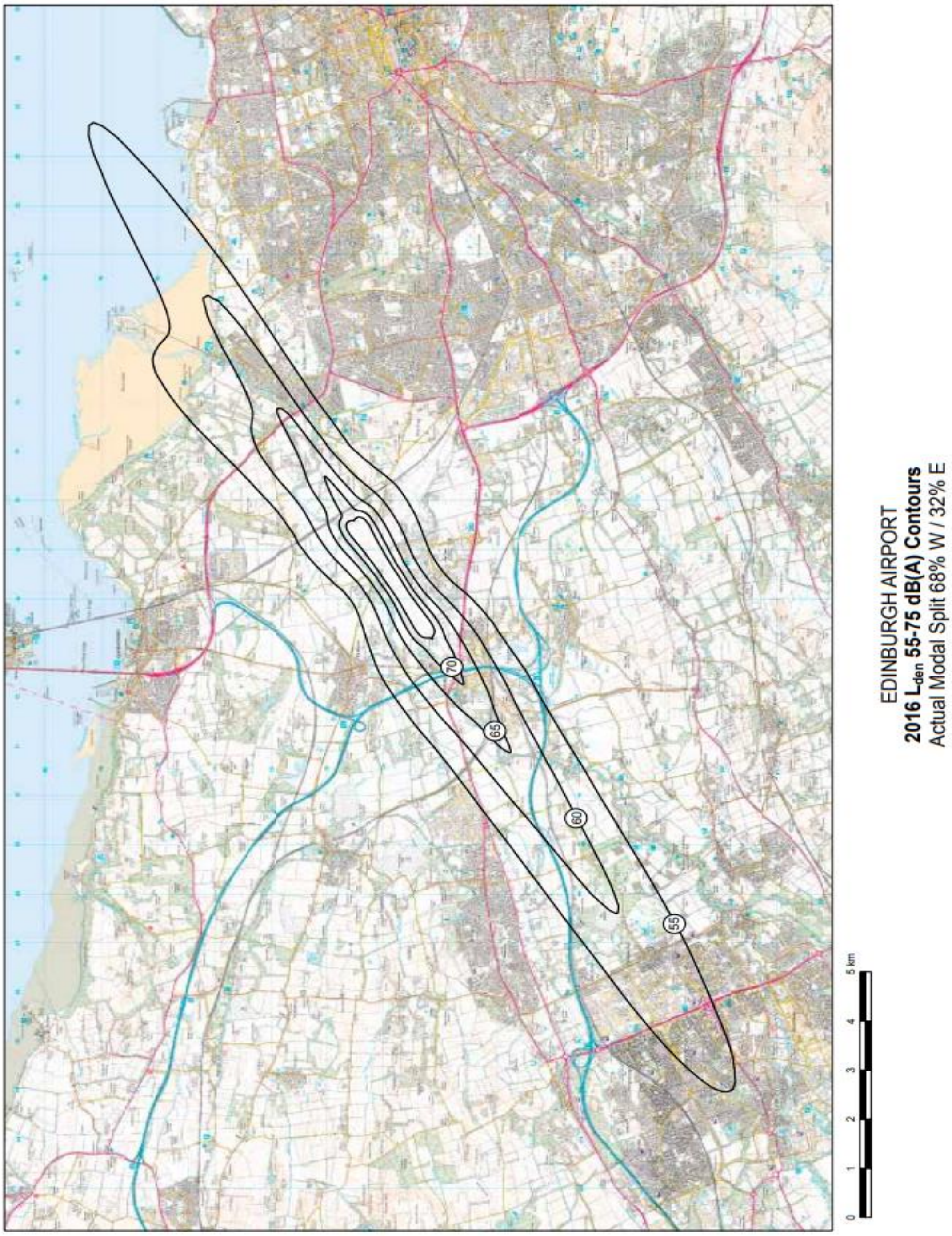


Figure 3: L_{den} noise contours Edinburgh Airport

[3]

---

[3] Edinburgh Airport. Noise action plan 2018-2023. [Online] 8 February 2018. [Cited: 4 June 2019.] https://nap.edinburghairport.com/assets/documents/NAP_Consultation_Book.pdf.

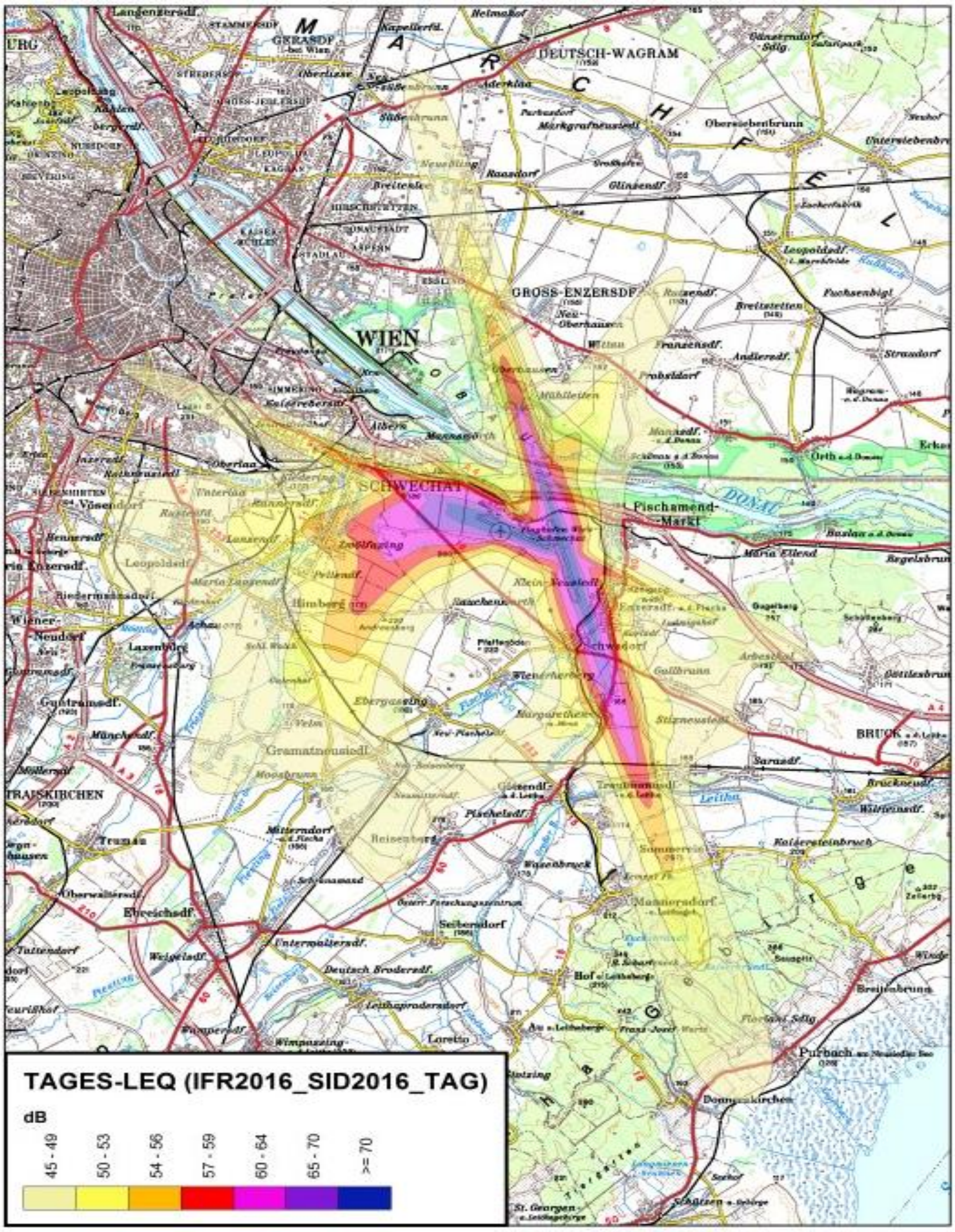


Figure 4: L_{day} noise contours Vienna airport

[4]

[4] Dialogforum. Larm & belastungen. dialogforum.at. [Online] 2016. [Cited: 10 June 2019.] https://www.dialogforum.at/themen/laerm__belastungen/fluglaerm_-_tag.

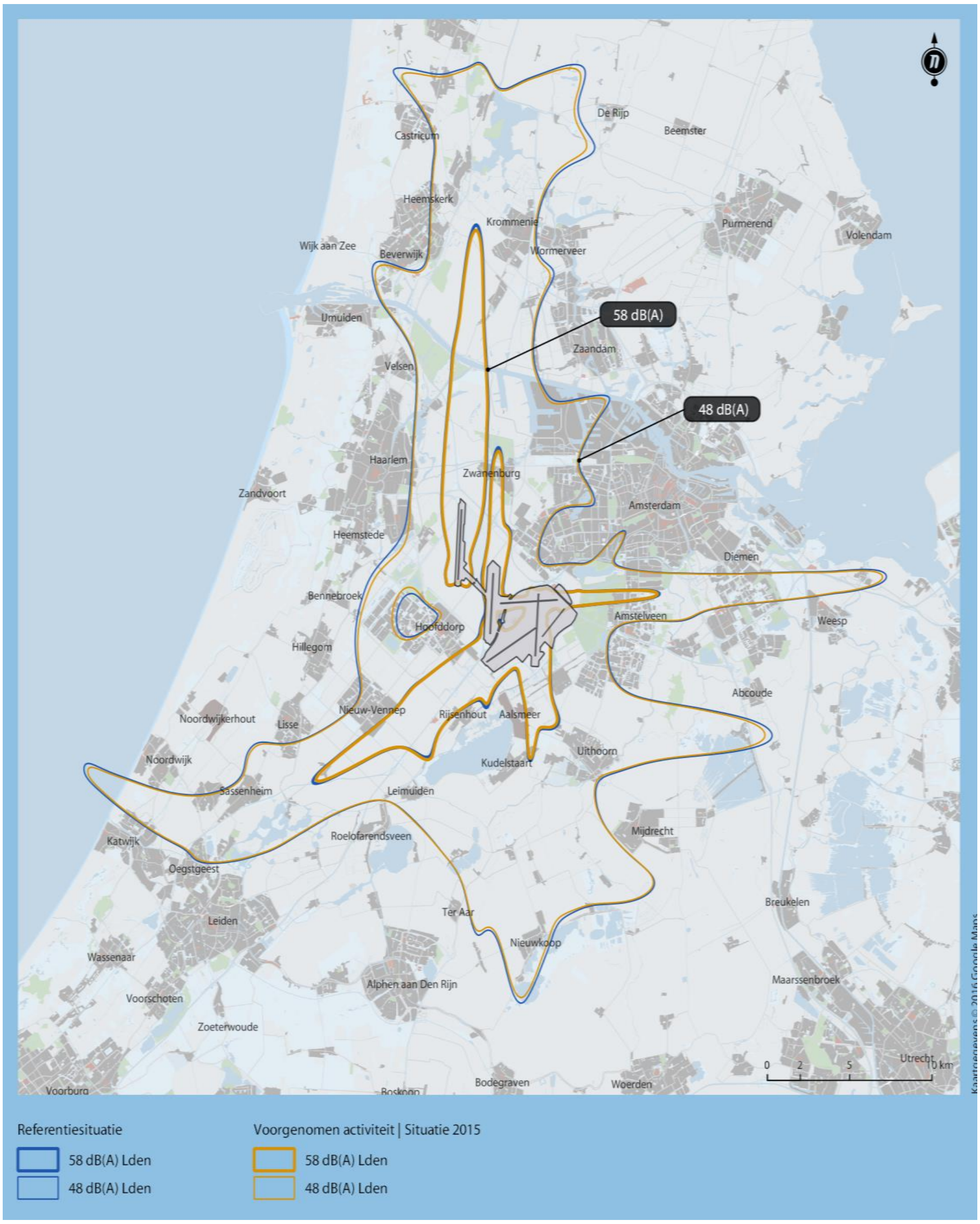


Figure 5: L$_{den}$ noise contours Schiphol Airport

[5]

---

[5] Schiphol Group. Concept MER Schiphol beschikbaar. schiphol.nl. [Online] 28 November 2018. [Cited: 10 June 2019.] https://nieuws.schiphol.nl/concept-mer-schiphol-beschikbaar/.

2.2 Lower noise levels around the airport

Using the FAA's Integrated Noise Model (INM 7.0d), To70 has conducted noise calculations for the surroundings of Gatwick Airport. The calculations are based on the 2017 flight schedules and radar data of Gatwick Airport and conducted for the main runway. The resulting L_{den} noise contours of the noise calculation are mapped from 45 dB(A) L_{den} till 75 dB(A) L_{den} in intermediate steps of 5 dB(A). The noise contours are presented in Figure 6.

Due to the differences in modelling, the result in Figure 6 cannot be directly compared with the L_{den} contours published by the ERCD in Figure 2. Figure 6 indicatively shows the increased size of the area impacted by aircraft noise levels above 45 dB(A) L_{den} compared to the area impacted by noise levels above 55 dB(A) L_{den}. Table 1 gives an overview of the area within each of the L_{den} contours. The area within the 50 dB(A) L_{den} contour in Figure 6 is more than twice the surface of the 55 dB(A) L_{den} contour. The 45 dB(A) L_{den} contour is again more than twice the surface of the 50 dB(A) L_{den} contour, making it more than 5 times larger than the 55 dB(A) L_{den} contour. An increase of 3 dB means approximately a doubling of noise in the area affected.

Table 1: Area within calculated L_{den} contours

L_{den} contour	Area (km^2)
> 45 dB(A)	408.5
> 50 dB(A)	172.7
> 55 dB(A)	75.3
> 60 dB(A)	32.2
> 65 dB(A)	12.6
> 70 dB(A)	4.9
> 75 dB(A)	1.8

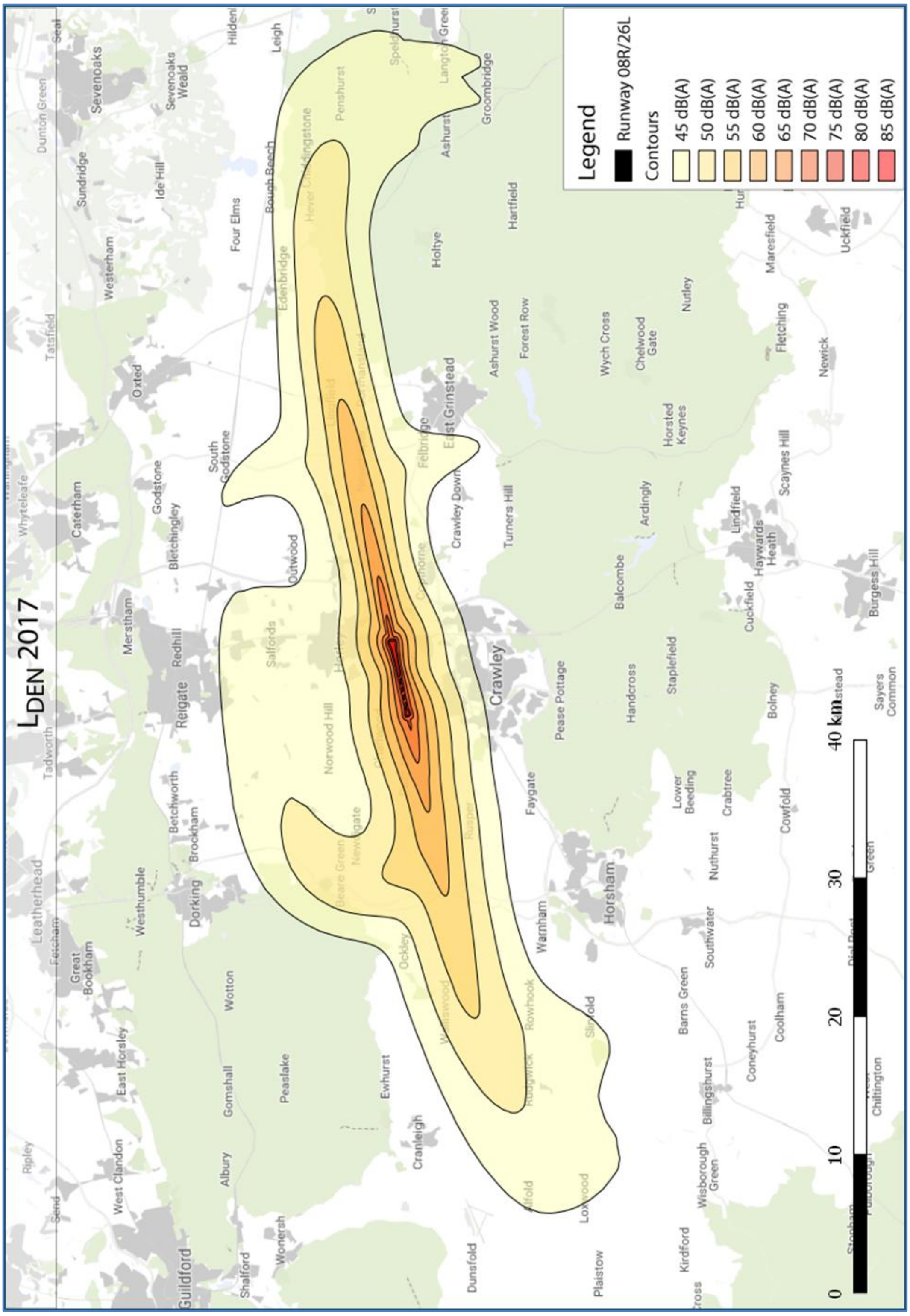


Figure 6: Noise contours around Gatwick Airport (Source: To70)

2.3 Impact of lower noise levels on communities

Annoyance is the most broadly used indicator related to the intensity of noise in communities. Some researchers believe that annoyance is an indicator of noise-induced stress and the possibility of the prevalence of diseases resulting from different stress reactions. However, most researchers consider annoyance to be an indicator of the quality of a community living environment.

Surveys are used to establish relationships between L_{den} and annoyance. These relationships can then be used to estimate the prevalence of annoyance based on noise maps. Surveys have shown annoyance starts when the L_{den} noise levels of outdoor noise exceed the 35-45 dB(A).[6] Table 2 provides an overview of the % of annoyed or highly annoyed people at different L_{den} levels. It was presented in 2001 by Miedema and Oudshoorn. Miedema and Oudshoorn analysed three types of transport noise: road, air, and railway. Results showed that aircraft noise produces a stronger annoyance response than road and rail traffic.[7] The resulting dose-response relationship, or exposure-response relationship, was adopted as the European Common indicators for noise exposure for road, rail and air traffic.

Table 2 provides an overview of the relations between L_{den} noise level and the percentage of people highly annoyed found by Miedema and Oudshoorn. [3] As can be seen in Table 2, the percentage of people which are highly annoyed due to aircraft noise is low at lower noise levels and increases as noise levels rise. Over the years several aircraft annoyance studies have been conducted by different governments bodies in different countries which resulted in dose-response relations. Figure 7 shows a graph made by the CAA[8] which compares 3 dose-response relations found in UK studies (ANIS 1982, ANASE 2001 and SoNA 2014) with the EU/Miedema standard. The ANASE study is included in the graph but after review it was advised not to use the results of the study in the development of government policy. Focusing on the other curves, the curve of the more recent SoNA study is comparable to the Miedema curve.

Table 2: % op people highly annoyed at different L_{den} levels (Source: Miedema and Oudshoorn 2001)

L_{den} noise level	% Of people highly annoyed	% Of people annoyed
45	1	11
50	5	19
55	10	28
60	17	38
65	26	48
70	37	60

[6] Pesonen, Kari. Study of the effects of aircraft noise. Helsinki : Kari Pesonen Consulting Engineers - Finavia, 2018.

[7] Annoyance from transportation noise: relationships with exposure metricsLdn and Lden and their confidence intervals. Miedema and Oudshoorn. 4, s.l. : Enviromental Health Perspectives, 2001, Vol. 109.

[8] Enviromental Research and consultancy department. Aircraft noise and annoyance: recent findings. London : Civil Aviation Authority, 2018. CAP 1588

75	49	73

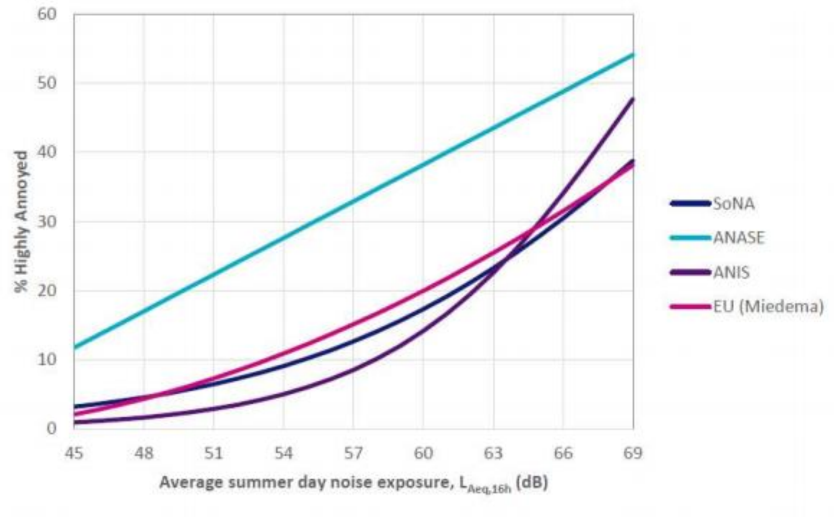


Figure 7: comparison of dose-response relations found in several UK studies (Source: CAA CAP1588)

The curves in Figure 7 show that the percentage of people which are highly annoyed due to aircraft noise is low at lower noise levels. But as can be seen in Figure 6 in the previous paragraph, the area impacted by the lower noise levels stretches out much further. Although the noise levels are lower, the number of people affected by it can be significant as such a large area also inhabits a large population. This theoretical conclusion can also be found in practice. Residents in much wider areas around airports, are reporting nuisance.

2.4 World Health Organisation guidelines

In October 2018 the World Health Organisation (WHO) published the Environmental Noise Guidelines for the European Region.[9] The WHO emphasizes that the EU (Miedema) and the several national dose-response relations are an acceptable estimate of the average percentage of people highly annoyed. However, the WHO finds there is considerable heterogeneity in effects due to differences in situation, context and culture differences around what is considered annoying. Because of this heterogeneity the WHO recommends the usage of dose–response curves derived in a local context to assess the specific relationship between noise and annoyance in a given situation.

The WHO guideline also provides source specific guidelines for long-term exposure to road traffic, railway, aircraft, wind turbine and leisure noise in order to reduce health risks related to noise exposure. Focusing on aircraft noise, the WHO recommends reducing noise levels produced by aircraft to 45 dB(A) L_{den} and 40 dB(A) L_{night} since higher levels are associated with adverse effects on health and sleep.

Currently, discussions are ongoing on how to deal with the new WHO guidelines. Critics state that the WHO's guidelines lacks strong supporting research and do not fully reflect the complexity of the way people perceive noise and the ways to mitigate noise. The WHO guideline however does put a mark on the line which is, when it comes to the L_{den} threshold, far lower than the current norms, forcing the industry and policy makers to evaluate the current practice.

---

[9] World health organization. Enviromental noise guidelines for the European Region. Copenhagen : World Health Organization, 2018.

3 Noise tolerance and expectations

3.1 Factors influencing the effect of noise on people

Figure 8 gives an overview of the general cause and effect relationships as it is included in the ECAC Doc 29[10] standard method of computing noise contours by the European Civil Aviation Conference. The figure specifies two categories of effects which noise can have on people: Physiological effects, which includes health effects caused by noise, and behavioural effects, which are caused by interference of noise with normal living.

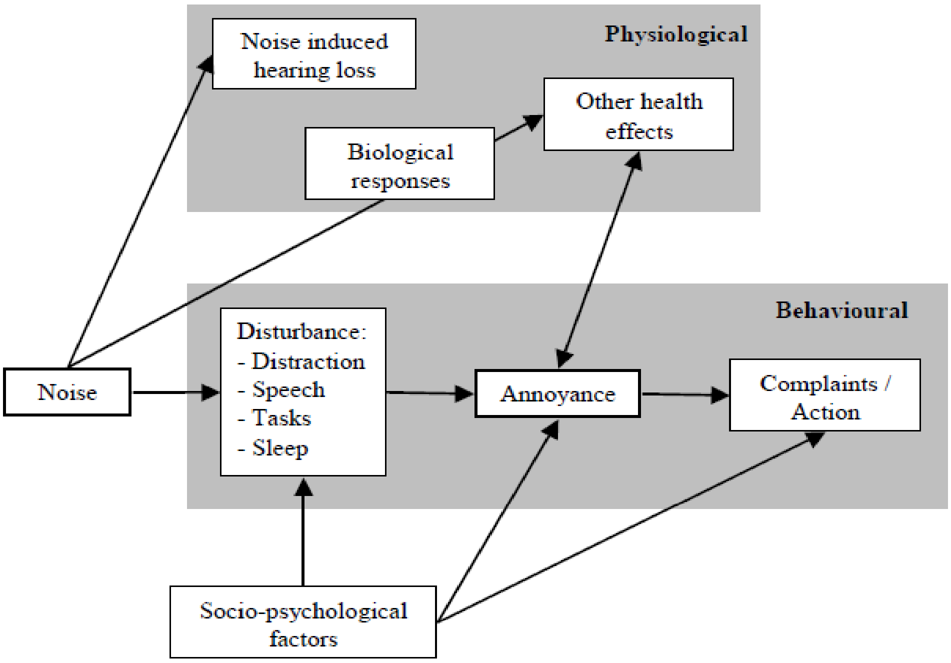


Figure 8: General cause and effect relationships Doc29 (Source: ECAC Doc 29 Applications Guide)

Within the Physiological category, noise induced hearing loss is considered to be a very local effect which is not experienced outside the airport boundary. The other physiological effect of noise can cause are biological reflexes and responses known as stress, which can increase the risk of cardiovascular disease.[6]

Focusing on the behavioural effects, the figure describes the effects in three stages. Firstly, noise disturbs an activity, for example by causing distraction, interference with speech, disruption of work or other mental activities, and sleep disturbance. This disturbance can cause annoyance, which can lead to health effects and/or complaints. The management of aircraft noise and government policy has focused strongly on those areas that are impacted by high noise levels. It is acknowledged that outside these

[10] European Civil Aviation Conference. ECAC Doc 29 - Report on Standard Method of Computing Noise Contours around Civil Airports. Neuilly-sur-Seine : European Civil Aviation Conference, 2016.

areas, there is annoyance, but little is done to decrease the noise impact for those people living further away from the airport.

However, as the diagram also shows, there is no one-on-one relation between noise and annoyance. There are a multitude of factors, which are summarised as socio-psychological factors, which influence the level of annoyance caused by aircraft noise. The relation between aircraft noise and annoyance has been researched for a long time and many reasons are found for the variation in annoyance. Figure 9 shows an example of several identified factors based on a survey conducted among residents surrounding Frankfurt Airport in 2005. As can be seen in the figure, the actual L_{den} noise level only contributes a small portion to annoyance ($0.20^2 = 4\% *0.79 = 3,1\%$). A literature study into the effects of aircraft noise by Kari Pesonen Consulting Engineers found that noise research can usually only explain between 2-40% of the variation in annoyance with the noise level.[11]

Figure 9 identifies 5 factors which influence the level of annoyance. Besides the small direct contribution of noise to annoyance, noise also contributes to annoyance through aircraft related fears and negative attitudes. These include fears for aircraft accidents and negative attitudes towards other effects than noise, such as the contribution of aviation to climate change. A third contributing factor identified by this research is the trust in the aviation industry. People who trust that the aviation industry is capable and willing to reduce aircraft noise and emissions will have lower annoyance. A last contributing factor is expectations. Both negative and positive expectations on the impact of the local airport on the quality of life contribute to the level of annoyance, with the negative expectations weighing heavier than the positive expectations. These 5 factors show how opinions, fears and believes which residents develop themselves and within their community explain more of the annoyance than aircraft noise levels itself.

[11] Pesonen, Kari. Study of the effects of aircraft noise. Helsinki : Kari Pesonen Consulting Engineers - Finavia, 2018.

The SoNA survey conducted by the UK CAA in 2014 reaches the conclusion the sensitivity to experiencing noise as annoying increased if the noise was considered to be more intense than expected after moving into the current place of residence. This again relates to the discussed socio-psychological factors. People who decide to live somewhere with a certain expectation on the quality of life will experience noise as much more annoying than people who were expecting noise.

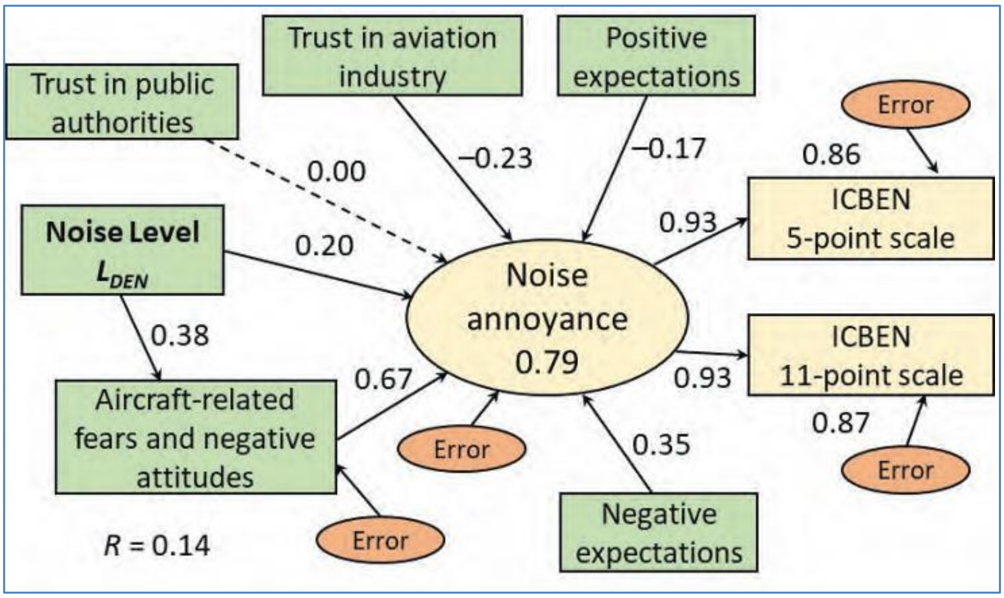


Figure 9: Factors influencing annoyance based on a survey among 2,300 residents around Frankfurt Airport

3.2 Changes in noise factors over time

The relation between aircraft noise and annoyance has been researched for a long time, mostly using noise surveys. In 2018 Kari Pesonen Consulting Engineers (commissioned by Finavia) published a study of the effects of aircraft noise.[12] As a part of this study the researchers compared the results of 38 noise surveys from different countries conducted between 1964 and 2015. The results of these surveys were converted to make a comparison over time. Figure 10 gives an overview of the L_{den} noise level at which 25% of the respondents to the noise surveys assessed aircraft noise to be highly annoying. In 1970, 25% of people were highly annoyed at an annual average noise level of approximately 67 dB L_{den}, whereas in 2010, 25% of people were highly annoyed at 51 dB L_{den}. This downward trend clearly shows that the noise level at which 25% of respondents were highly annoyed has decreased significantly over the years.

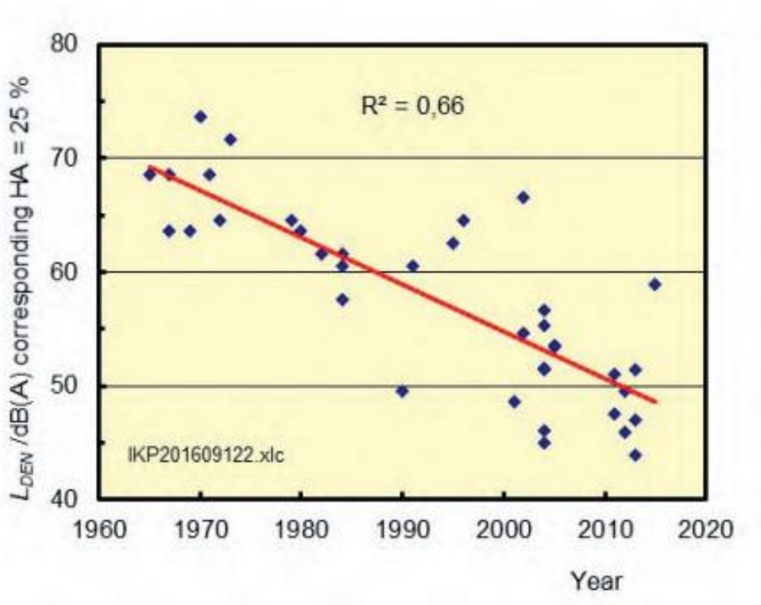
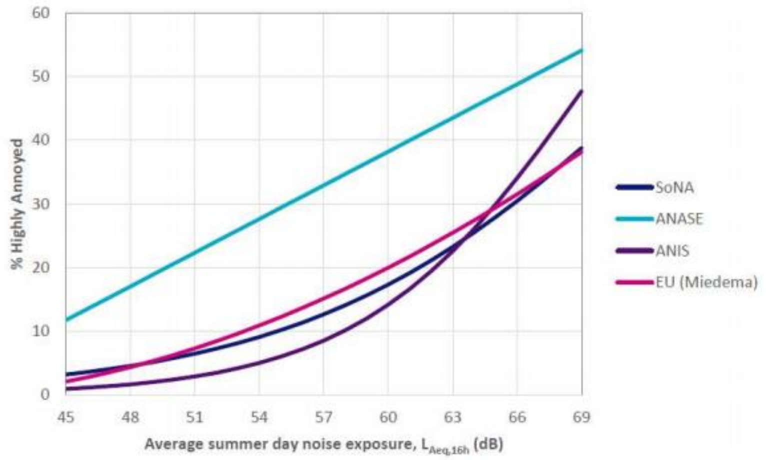


Figure 10: Changes in L_{den} levels of outdoor noise at which 25% of respondents stated they were highly annoyed, based on surveys between 1965 and 2015 (source: Kari Pesonen Consulting Engineers, 2018)

When using the same metric as in Figure 10 (dB values were %HA = 25%), studies in the UK do not identify any significant changes in sensitivity to annoyance. Figure 11 shows the results of two UK studies also discussed in chapter 2, ANIS from 1982 and SoNA from 2014. The numbers in the table and the lines in the graph show that the dose-response curve found in UK studies is also moving. At levels lower than 63 dB $L_{aeq,16h}$ the percentage of people who are highly annoyed is increasing. Where in 1982 9% of people indicated that they were highly annoyed at 57dB, the same percentage was found in 2014 at 54dB. In the higher noise levels (above 63 dB $L_{aeq,16h}$) the opposite was found. The decrease in annoyance in the higher dB levels brings the SoNA curve closer to the EU (Miedema) curve, as can be seen in the graph.

---

[12] Pesonen, Kari. Study of the effects of aircraft noise. Helsinki : Kari Pesonen Consulting Engineers - Finavia, 2018.



Average summer day noise exposure, $L_{Aeq,16h}$ (dB)	% highly annoyed	
	ANIS 1982	SoNA 2014
51	3%	7%
54	5%	9%
57	9%	13%
60	14%	17%
63	23%	23%
66	34%	31%
69	48%	39%

Figure 11: % highly annoyed at average summer day noise exposure levels $L_{aeq,16h}$[4]

Aircraft have become quieter over the past decades. This technological improvement cancels out the large growth in passenger movements which many airports have experienced. The effect of this is that the areas of noise footprints at most major airports have decreased or stabilized over time. Despite this decreasing noise exposure, the downward trend in Figure 10, the reactions of communities and resulting political opposition against airport operations all show that annoyance is increasing.

As discussed in the previous paragraph, there are many factors which drive annoyance. This increased annoyance could be an indication that the attitude towards noise itself has changed or that people are more annoyed due to the frequency of overflying aircraft. However, the numerous socio-psychological factors will also play a role. Some communities do not trust the airport operator and or airlines statements, reports and commitment. The reach of social media and the availability of information through flight tracking apps and other data sources means that information and opinion can quickly shape views based of varying degrees of information and understanding. Besides mistrust, the quality of life expectations and the quality expectations people set for the environment are increasing.

With all these factors involved, annoyance due to aircraft noise is something which requires an approach on multiple fronts where industry and government conduct effective noise management. This should provide solutions for all involved stakeholders and a new perspective for the future. Alongside the technical noise reduction policies, such as the L_{den} reporting threshold, non-acoustic/socio-psychological factors should be given a raised priority in the design of noise management strategies.

4 Changes in operations and noise at Gatwick Airport

To illustrate changes in airport operations and noise over the years Gatwick Airport is used as an example. For this chapter historical traffic and track data of Gatwick Airport available to To70 was used.

4.1 Changes in frequencies and fleet

In the past six years, Gatwick Airport has seen a continuous rise in the number of passengers travelling through the airport. As Table 3 shows, passenger numbers have risen by 35% between 2012 and 2018. Within this same time span the number of aircraft movements (arrivals or departures) has risen by 15% from 246 thousand movements in 2012 to 285 thousand movements in 2017, after which the number of aircraft movements slightly dropped in 2018.

Table 3: Gatwick Airport annual traffic[13][14]

Year	Passengers (x1000)	Movements	Average number of passengers / movement
2012	34,235	246,987	139
2013	35,444	250,520	141
2014	38,127	259,979	147
2015	40,267	267,767	150
2016	43,289	280,089	155
2017	45,561	285,969	159
2018	46,075	283,926	162

To70 analysed historical traffic data for the busy two summer months (July and August, 62 days) for the years 2012, 2015 and 2018. Figure 12 provides an overview of the number of aircraft movements (all types) per hour of day. The histogram shows that traffic has increased both during the day, evening and night. Focusing on the day, there are several hours during which the airport handles more than 50 movements/hour. The airport is naturally capped because it only has a single runway. As a result, there is limited to no capacity available for further growth during these hours and the number of movements has therefore remained stable between 2015 and 2017. Growth has primarily taken place during hours were the airport is not (yet) operating near maximum capacity. Figure 12 shows that these hours are primarily at the beginning of the night, between 21:00 and 24:00. During these, in the past relative quiet periods, the percentual growth has been 30 to 80% when comparing 2018 to 2012.

[13] Gatwick Airport Ltd. Traffic figures. gatwickairport.com. [Online] 2019. [Cited: 18 June 2019.] https://www.gatwickairport.com/business-community/about-gatwick/performance-reports/traffic-figures/.

[14] Civil Aviation Authority. UK airport data. caa.co.uk. [Online] 2019. [Cited: 20 June 2019.] https://www.caa.co.uk/Data-and-analysis/UK-aviation-market/Airports/Datasets/UK-airport-data/.

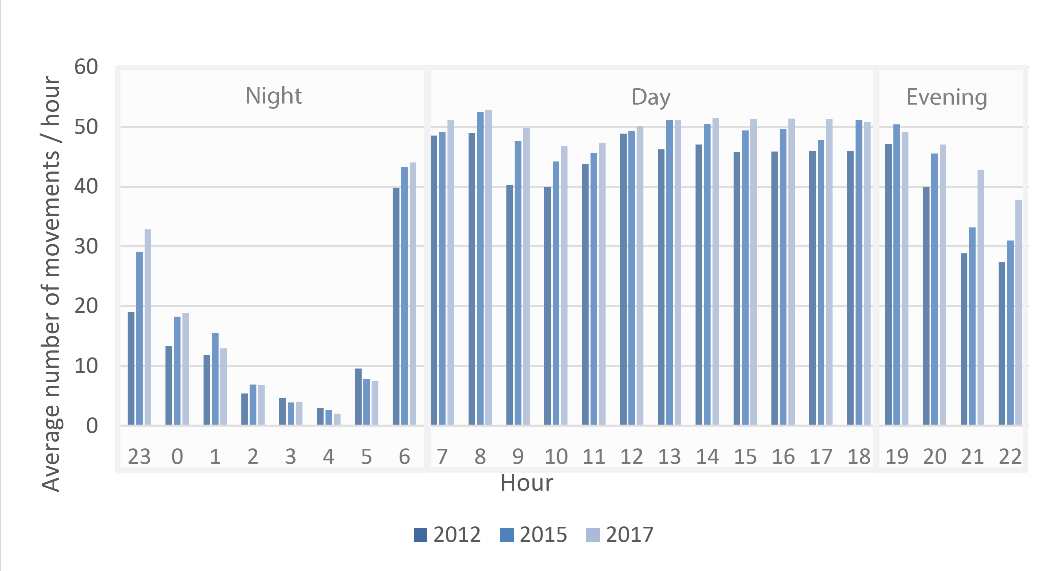


Figure 12: Average number of aircraft movements per hour

With passenger numbers growing faster than aircraft movements, the number of people per aircraft has increased over the years, as can be seen in Table 3. This increase is caused by an increase in aircraft yields and airlines flying larger aircraft. Most aircraft movements (around 90%) at Gatwick are medium aircraft such as the Airbus A320 and the Boeing 737. The number of heavy aircraft[15] movements decreased from 75 movements per day in 2012 to 66 movements per day in 2015. After 2015 the number of heavy aircraft movements has again increased, to an average of 82 movements a day in 2017.

The histogram in Figure 13 shows the average number of movements per hour of heavy aircraft in the three analysed years. The histogram shows a mixed bag of decreasing and increasing number of movements throughout the day. During the evening and night no significant growth of movements with heavy aircraft has taken place over the years. Notable is the sharp decrease in heavy aircraft movements between 5:00 and 6:00, from an average 4 movements in 2012 to only 1 movement in 2015 and 2017. Comparing 2015 and 2017, growth has taken place mainly during the day, with a notable increase in movements in the early morning between 6:00 and 7:00.

Within the heavy aircraft category there are notable shifts over the years. In 2017 there were less movements with older aircraft types such as the A340, B767, B777 and A330 than in 2012 and other aircraft type, such as the A300, has been completely removed from daily operations. This decrease in older heavy aircraft is compensated by new heavy aircraft such as the B787, which accounted for around a quarter of the heavy aircraft movements at Gatwick in 2017. When this aircraft was introduced at Heathrow Airport, the ERCD collected noise measurements and compared them to measurements of

[15] based on wake turbulence category

other heavy aircraft. The results (presented in CAP1191[16]) showed that the 787 is on average up to 7 dB quieter on departure than the B767, and up to 8 dB quieter than the A330. On arrival the B787 is up to 3 dB quieter. Besides the B787 the A350 is also gaining presence in the operation at Gatwick Airport. The ERCD also collected noise measurements of the A350 (presented in CAP1733[17]). The A350 is relatively similar to the B787, being on average up to 6 dB quieter on departure than the A330, and up to 9 dB quieter than the A340. On arrival the A350 is also up to 3 dB quieter.

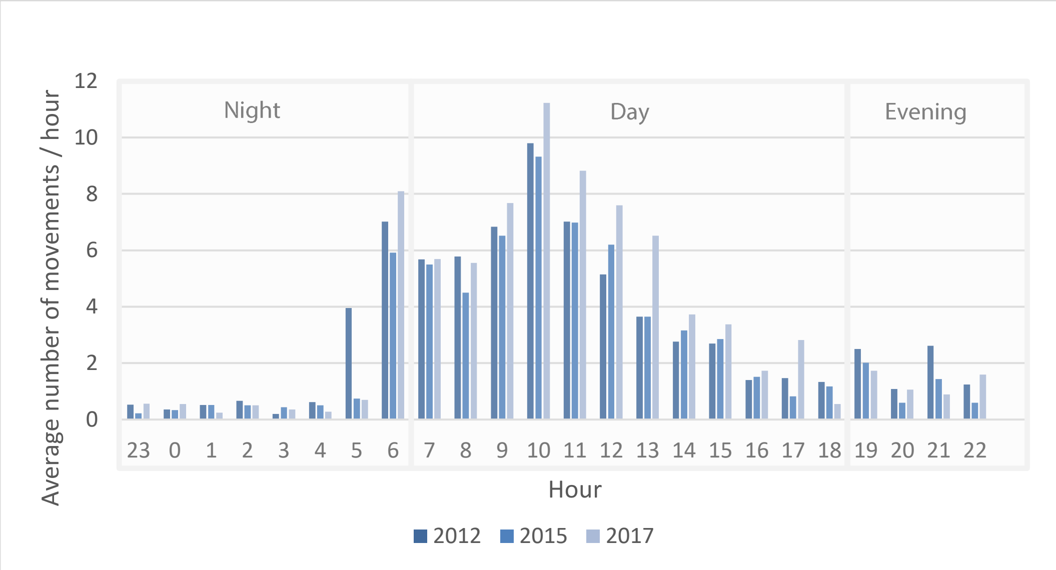


Figure 13: Average number of Heavy movements per hour

[16] Enviromental Research and Consultancy Department. Noise data for the first 17 months of Boeing 787 operations at Heathrow airport. London : Civil Aviation Authority, 2014.

[17] Noise data for the first three years of Airbus A350 operations at Heathrow Airport. London : Civil Aviaiton Authority, 2019. CAP 1733.

4.2 Changes in aircraft flight paths

Figure 14 and Figure 15 show the 48 and 56 dB(A) L_{den} noise contours of Gatwick Airport for the years 2012 and 2015. The figures also show a month of flight tracks to indicate the common flight paths for those years. The difference between the L_{den} noise contours in Figure 14 and Figure 15 are not only caused by a growth in movements (see previous paragraph) but also by changes in the flight paths. In 2013, NATS and GAL initiated the Approach Stabilisation Initiative to further stabilize the approach and therefore reduce the number of go arounds at the airport. Under the initiative the minimum ILS joining points on the final approach tracks were relocated from 8nm to 10nm from touchdown.

The effects of moving these ILS joining points can be seen in Figure 15: the points where most of the arrival tracks merge has moved further away from the airport both for easterly and westerly arrivals. The radar tracks also show how the arrival flow, especially for easterly arrivals, has narrowed in 2015 compared to 2012. This led to a strong increase in noise in the area's around the ILS joining points, as can be seen in Figure 16.

This increase in noise caused by the initiative led to a significant increase in the number of noise complaints made by residents. From analysis conducted as part of the Gatwick Airport Independent Arrivals Review[18] it can be concluded that the noise consequences of the initiative further to the east and to the west of Gatwick Airport were not adequately considered or understood by either NATS or Gatwick Airport when the initiative was implemented. The large shift of the 48 dB(A) L_{den} contour in Figure 16 shows that the changes in flight paths and concentration of flights had the largest effects in the lower noise levels. This again demonstrates the importance of modelling, reporting and acting on noise levels lower than the current threshold of 55 dB(A) L_{den}. In 2017 the minimum ILS joining points were relocated to their original location and flights were again dispersed over a wider area.

Figure 15 also shows a concentration of departing aircraft. Concentrations of departing aircraft are a consequence of Performance-based Navigation (PBN). Over the years, the number of aircraft which navigate using PBN has increased. This has led to a greater concentration of aircraft on route centrelines. Concentration through PBN can benefit communities since routes which avoid populated areas can be flown more accurately. However, the consequence of PBN is also an increased concentration of aircraft noise over a smaller area which negatively affects communities close to the route.

---

[18] Lake, Graham and Redeborn, Bo. Gatwick Airport Independent Arrivals Review. London : s.n., 2016.

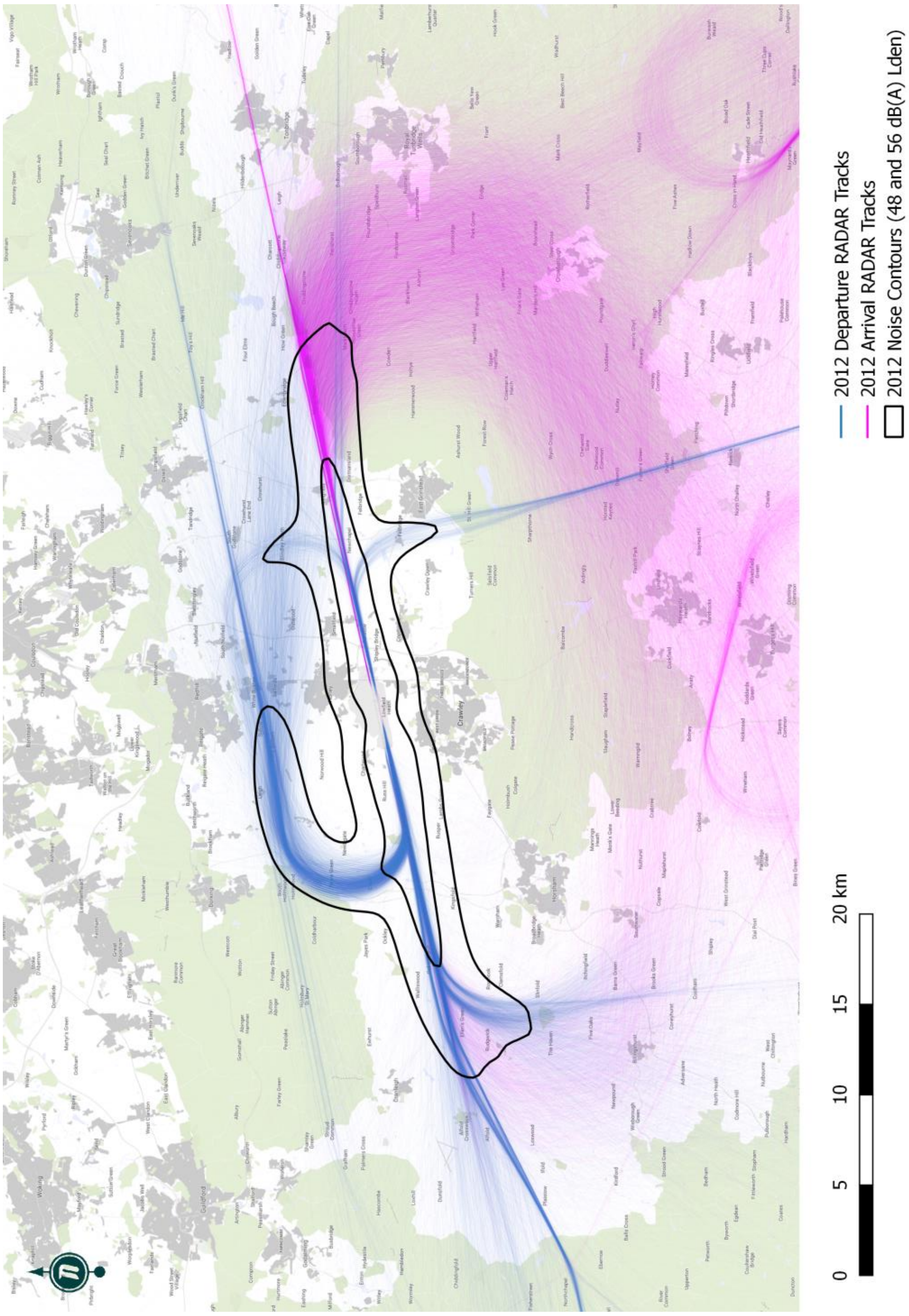


Figure 14: 2012 L_{den} noise contours and radar tracks

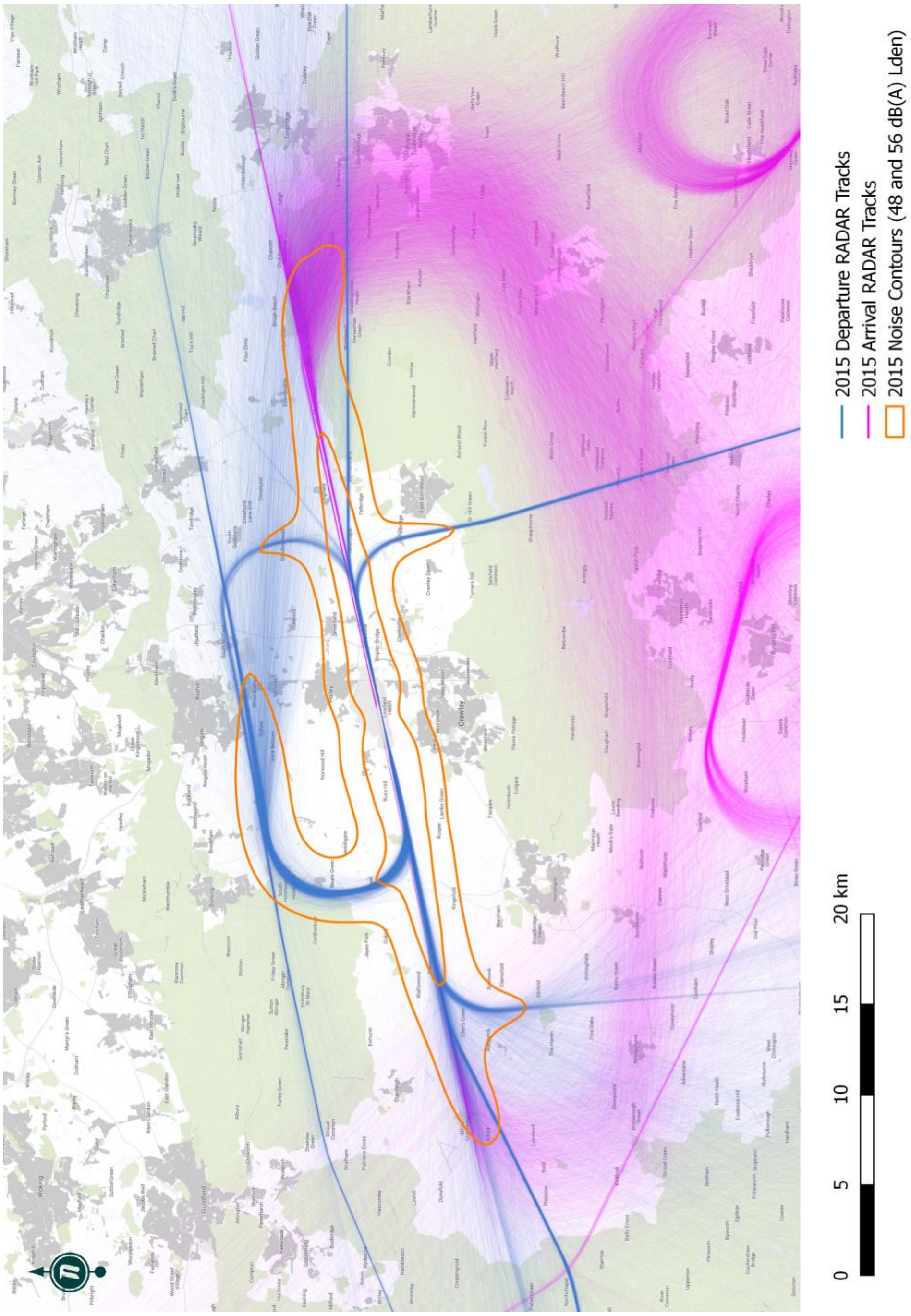


Figure 15: 2015 L_{den} noise contours and radar tracks

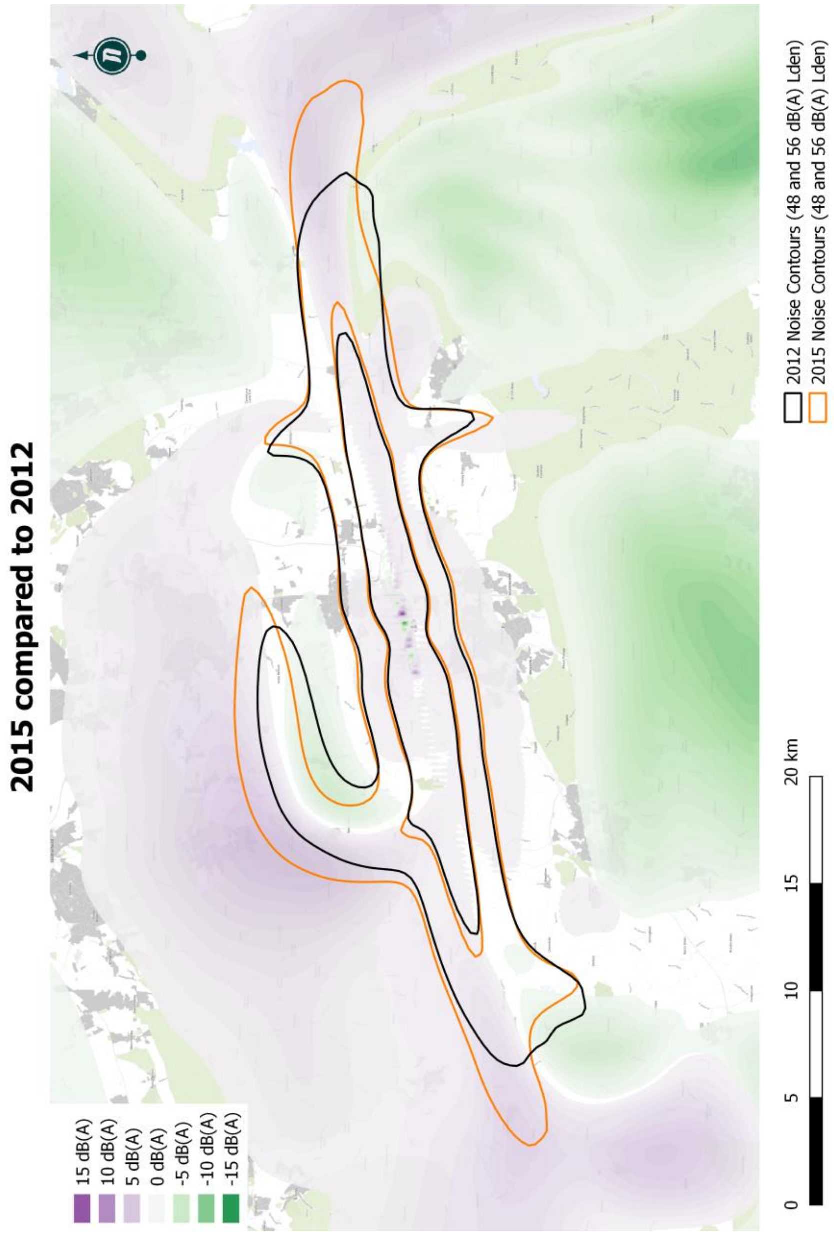


Figure 16: Difference between L_{den} noise contours for 2012 and 2015

4.3 Effects of changes in operation

The previous two paragraphs analysed different factors which are combined into the L_{den} noise contours. When combining these factors into the L_{den} contours, different operations (lower volume/noisier aircraft and higher volume/quieter aircraft) can create quite similar sized noise contours. When comparing the 2012 and 2017 L_{den} noise contours, shown in Figure 17 and Figure 18 , this is exemplified. There are some shifts in the (lower) noise levels but the contours generally remain the same, even though there has been a 15% growth in aircraft movements over the years. This shows that, since the contours combine a wide range of factors into one metric, the actual situation on the ground can be difficult to extract from just this metric. And other factors, such as non-acoustic factors, should also be taken into account.

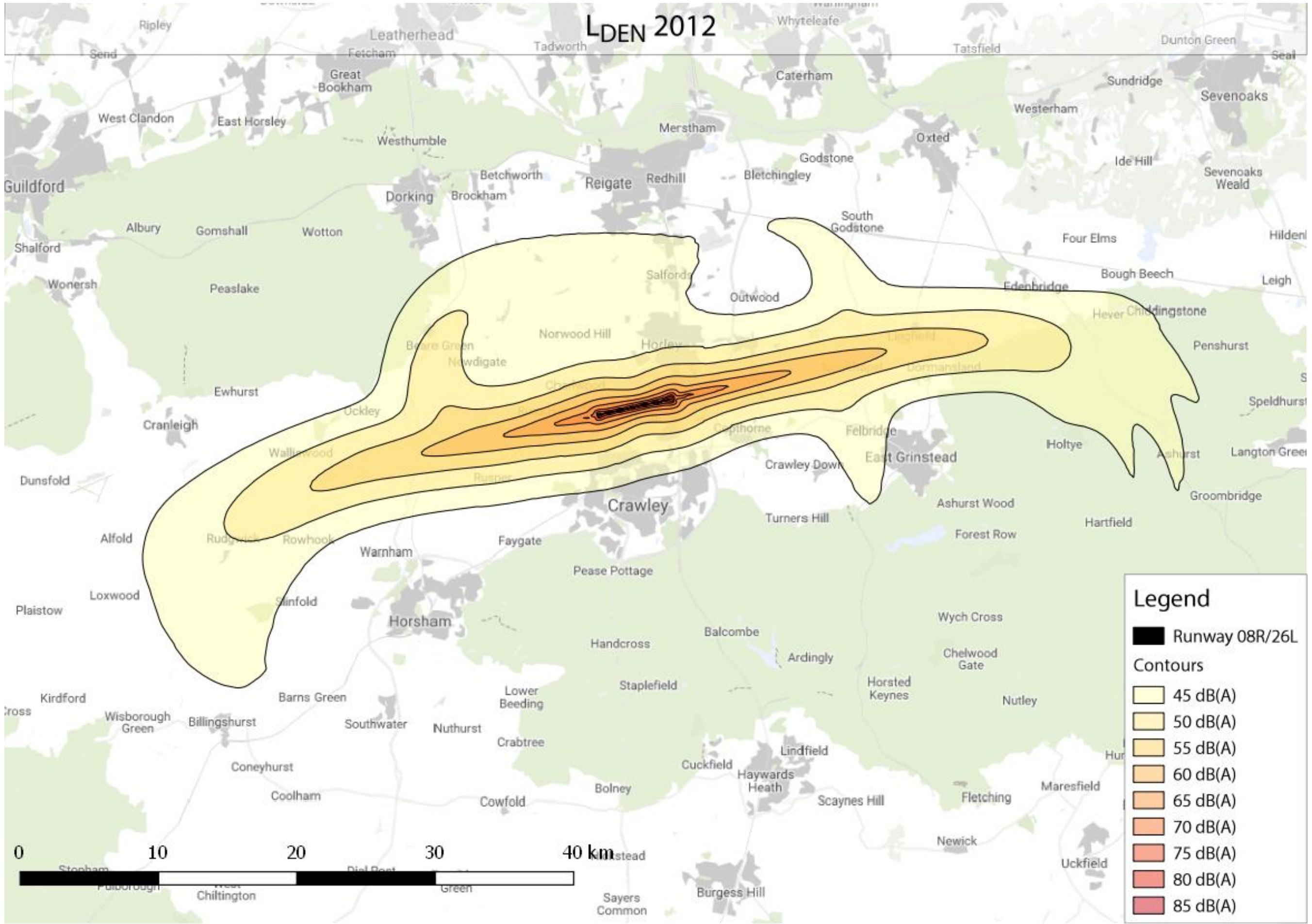


Figure 17: Calculated L_{den} contours for 2012

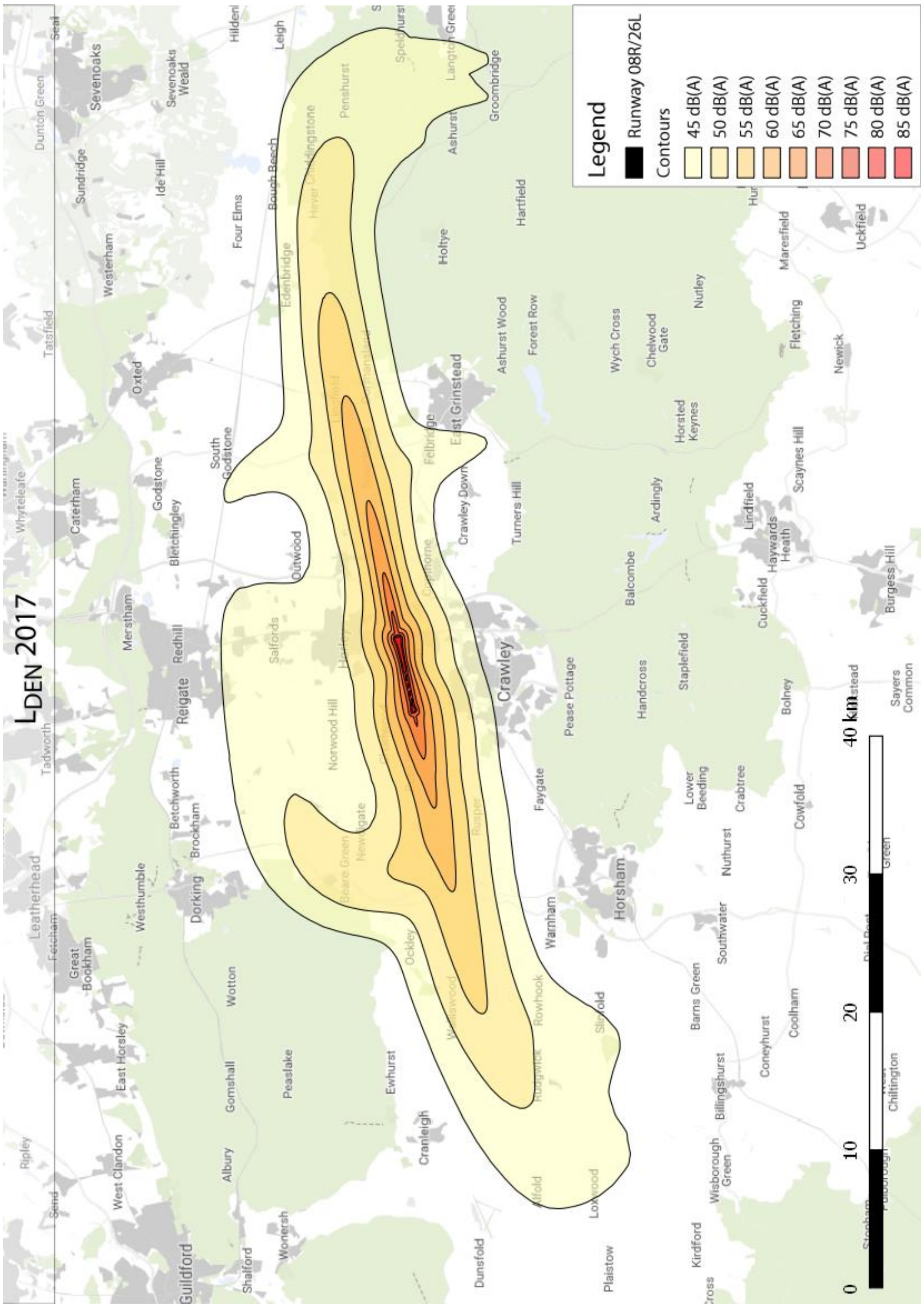


Figure 18: Calculated L_{den} contours for 2017

4.4 Future developments

Gatwick Airport has been growing fast over the last couple of years. Since 2009 Gatwick's passenger numbers have grown from 31 million passengers to more than 45 million a year (47% increase). Over the same period the number of aircraft movements has increased from 240,000 to 280,000 (18% increase). The runway capacity increased from 50 movements per hour to 55.

Gatwick Airport intends to continue to develop and grow. As part of the reviews of airport capacity in south-eastern England it proposed the construction of a second runway to the south of the existing runway and double the number of aircraft movements. This option was also shortlisted by the Airports Commission in 2013. However, in 2015, the Airports Commission recommended the expansion of Heathrow Airport as opposed to Gatwick.

In its master plan (2018), the airport presented three scenarios for Gatwick's future operations and growth and asked for views on each of the different scenarios:

1) Remaining a single runway operation using the existing main runway
2) Routinely using the existing standby runway (for departing flights only) together with the main runway
3) Continue to safeguard land for an additional runway

Gatwick indicated that these three scenarios could be used either separately, or in combination, and were not mutually exclusive choices. The airport expects that, by operating both runways simultaneously, they would be able to add between 10 and 15 additional hourly aircraft movements in the peak hours, which could deliver up to 70 million passengers by 2032.

The next step is for Gatwick Airport to undertake further detailed design and development work to bring the existing standby runway into routine use and thereafter to seek consent via the planning process through what is known as a Development Consent Order (DCO). Gatwick predicts that, despite increased movements, aircraft noise generated by this scheme would be broadly similar to today's level. The change in fleet mix is assumed to outweigh the effects of increasing flight numbers. The use of the standby runway would increase the 2028 and 2032 contour populations, compared to a single runway scenario in the same year, as shown in the figure on the next page. Without the use of the standby runway, the population within the 54 Leq summer day contour reduces from 10,950 in 2017 to 9,000 in 2028 and 8,000 in 2032. Whereas with the use of the standby runway the population within the 54 Leq summer day contour would be 10,800 in 2028 and 10,000 in 2032.

	POPULATION				
YEAR	2017	2028		2032	
NOISE METRIC	Existing main runway	Existing main runway	Main and standby runway	Existing main runway	Main and standby runway
Leq summer day 54dB	10,950	9,000	10,800	8,000	10,000
Leq summer day 57dB	3,400	2,400	3,900	2,600	4,100
Leq summer day 60dB	1,500	1,200	1,400	900	1,300
Leq summer day 63dB	550	500	600	400	500
Leq summer day 66dB	350	200	300	200	300
Leq summer day 69dB	150	100	200	100	100
Leq summer day 72dB	150	0	0	0	0

Figure 19: Summer day noise exposure change (Gatwick Airport Master Plan)

If a DCO application for the standby runway scheme is brought forward then, as part of this, Gatwick would prepare a full Environmental Impact Assessment (EIA). The airport believes that preparing for and completing this consent process would take up to five years and, allowing for the necessary construction activity, the standby runway could be brought into use alongside the main runway in the mid-2020s.

5 References

1. **European Enviroment Agency.** Enviromental noise. *eea.europe.eu.* [Online] 7 December 2018. [Cited: 4 June 2019.] https://www.eea.europa.eu/airs/2018/environment-and-health/environmental-noise.

2. **Pesonen, Kari.** *Study of the effects of aircraft noise.* Helsinki : Kari Pesonen Consulting Engineers - Finavia, 2018.

3. *Annoyance from transportation noise: relationships with exposure metricsLdn and Lden and their confidence intervals.* **Miedema and Oudshoorn.** 4, s.l. : Enviromental Health Perspectives, 2001, Vol. 109.

4. **Enviromental Research and consultancy department.** *Aircraft noise and annoyance: recent findings.* London : Civil Aviation Authority, 2018. CAP 1588.

5. **World health organization.** *Enviromental noise guidelines for the European Region.* Copenhagen : World Health Organization, 2018.

6. **European Civil Aviation Conference.** *ECAC Doc 29 - Report on Standard Method of Computing Noise Contours around Civil Airports.* Neuilly-sur-Seine : European Civil Aviation Conference, 2016.

7. **Gatwick Airport Ltd.** Traffic figures. *gatwickairport.com.* [Online] 2019. [Cited: 18 June 2019.] https://www.gatwickairport.com/business-community/about-gatwick/performance-reports/traffic-figures/.

8. **Civil Aviation Authority.** UK airport data. *caa.co.uk.* [Online] 2019. [Cited: 20 June 2019.] https://www.caa.co.uk/Data-and-analysis/UK-aviation-market/Airports/Datasets/UK-airport-data/.

9. **Enviromental Research and Consultancy Department.** *Noise data for the first 17 months of Boeing 787 operations at Heathrow airport.* London : Civil Aviation Authority, 2014.

10. —. *Noise data for the first three years of Airbus A350 operations at Heathrow Airport.* London : Civil Aviaiton Authority, 2019. CAP 1733.

11. **Lake, Graham and Redeborn, Bo.** *Gatwick Airport Independent Arrivals Review.* London : s.n., 2016.

12. **Enviromental Research and Consultancy Department.** *Strategic noise maps for Gatwick Airport 2016.* London : Civil Aviation Authority, 2018. ERCD Report 1705.

13. **Edinburgh Airport.** Noise action plan 2018-2023. [Online] 8 February 2018. [Cited: 4 June 2019.] https://nap.edinburghairport.com/assets/documents/NAP_Consultation_Book.pdf.

14. **Dialogforum.** Larm & belastungen. *dialogforum.at.* [Online] 2016. [Cited: 10 June 2019.] https://www.dialogforum.at/themen/laerm__belastungen/fluglaerm_-_tag.

15. **Schiphol Group.** Concept MER Schiphol beschikbaar. *schiphol.nl.* [Online] 28 November 2018. [Cited: 10 June 2019.] https://nieuws.schiphol.nl/concept-mer-schiphol-beschikbaar/.