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- Insights into Airport Noise
- Noise Enforcement at a Major Airport
- Survey of Aircraft Noise Abatement Strategies in the US

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Special Issue on Aircraft Noise

By Gijsjan van Blokland, Vice-President Outreach and Development of I-INCE.

We are happy to present this special issue of Noise News International on Aircraft Noise. With aircraft traveling around the globe and landing and taking off at airports in more or less the same way it surely is international, and it is noisy, but we must admit it is not really news. With the introduction of the first generation of very noisy jet aircraft in the sixties and the rapid expansion of affordable air travel enabled by the B747 Jumbo in the seventies, complaints skyrocketed. Even now the extent of the noise problem around airports is underestimated as the analysis by the Anima project for the airports covered by the European Noise Directive shows.

Moving the airport away from urbanized areas only worked for a limited time, since airports are not only sources of noise nuisance but also centers of economic activities that attract employees and their families. Planning their homes away from existing flight paths was not always successful as the publication on Dublin Airport learns.

Defining fixed boundaries to the noise exposed area conflicts with the desire to fully use the available space within the noise permit as can be observed in the example by Amsterdam Schiphol airport. An attempt by the authorities to reduce the number of flights to comply with the existing noise limits was found to be in violation with the EU regulation on the Balanced Approach. This ICAO guideline presents strategies on noise abatement that when fully implemented could lead to more effective noise control around airports as the paper on US airports showed.

Not all is lost though. The technology in low noise engine design is constantly improving, not in the least since it correlates highly with improving fuel efficiency. For a while it enabled aircraft to become larger without becoming noisier, but the measurements made on departing and approaching aircraft presented in this issue demonstrate the positive trend with the older A320 being noisier than the larger A321 neo. A similar trend was found for the B737 max and the twin aisle B787 both less noisy than their slightly smaller predecessors B737 NG and B757.

Furthermore, developments in air traffic control will enable less noisy continuous descent approaches even in busier times where, currently, level approaches are common.

We hope you enjoy this special issue.

Insights into Aircraft Noise: Continuous Noise Measurement around Amsterdam Schiphol Airport.

By Maarten Meeuwes, researcher at M+P Consulting engineers

Amsterdam Schiphol Airport is a major airport located in the densely inhabited western part of Netherlands and is causing noise disturbance in the large population living there (see also accompanying paper in this magazine from van Blokland). Improvement of the living quality is expected from the large-scale fleet renewal scheduled in the coming decade that is driven by the higher fuel efficiency of the newest generation of aircraft. The noise emission data available for these aircrafts in Eurocontrol's ANP database already indicate significant lower noise levels. To investigate if the expectations can be corroborated with empirical data M+P conducted an extensive study. Aircraft data and noise events of around 240.000 flyovers, both approaching and departing traffic, were recorded and analysed. Aircraft data included not only the aircraft type, but also engine type, several engine parameters and flight data made available from the Schiphol CASPER application.

How the aircraft noise measurements are conducted

Such amount of data can only be acquired by fully automated measurement systems. The flyover noise events were recorded with the unsupervised data acquisition system Yasmin developed by M+P (for more info see: Compliance of M+P software with acoustic standards). All incoming data were organized within the M+P developed LSSN sensor network. The Yasmin measurement system continuously sends 1 second of measurement data to the LSSN network. Apart from the direct noise data we also collected the flight data for each event. Only for this study the data were made available by air traffic control at Schiphol airport.

Measurements were performed at two locations around Schiphol Airport. Location 1 is positioned in Aalsmeer, directly under the approach path of the Aalsmeerbaan (runway 18L-36R) (and conveniently located at the premises of the M+P office). Location 2 is positioned near the Kaagbaan (runway 06-24). See Figure 1 for an overview. An example of the flight paths of the aircraft in relation to the measurement locations can be seen in Figure 2 and Figure 3.

Measurements of aircraft flyovers from and to the Aalsmeerbaan started in February 2023 and are ongoing. Measurements of aircraft flyovers from and to the Kaagbaan started in October 2022 and stopped in January 2024.

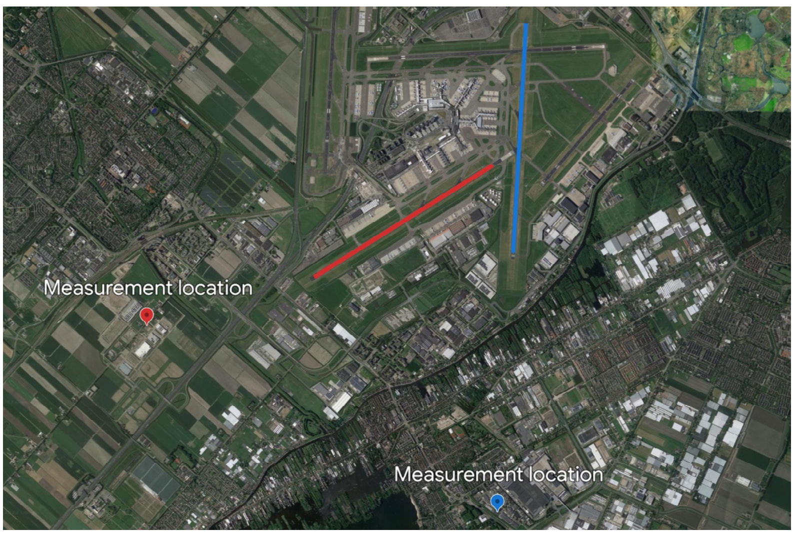

Figure 1 Overview measurement locations (Blue: Aalsmeerbaan, Red: Kaagbaan)

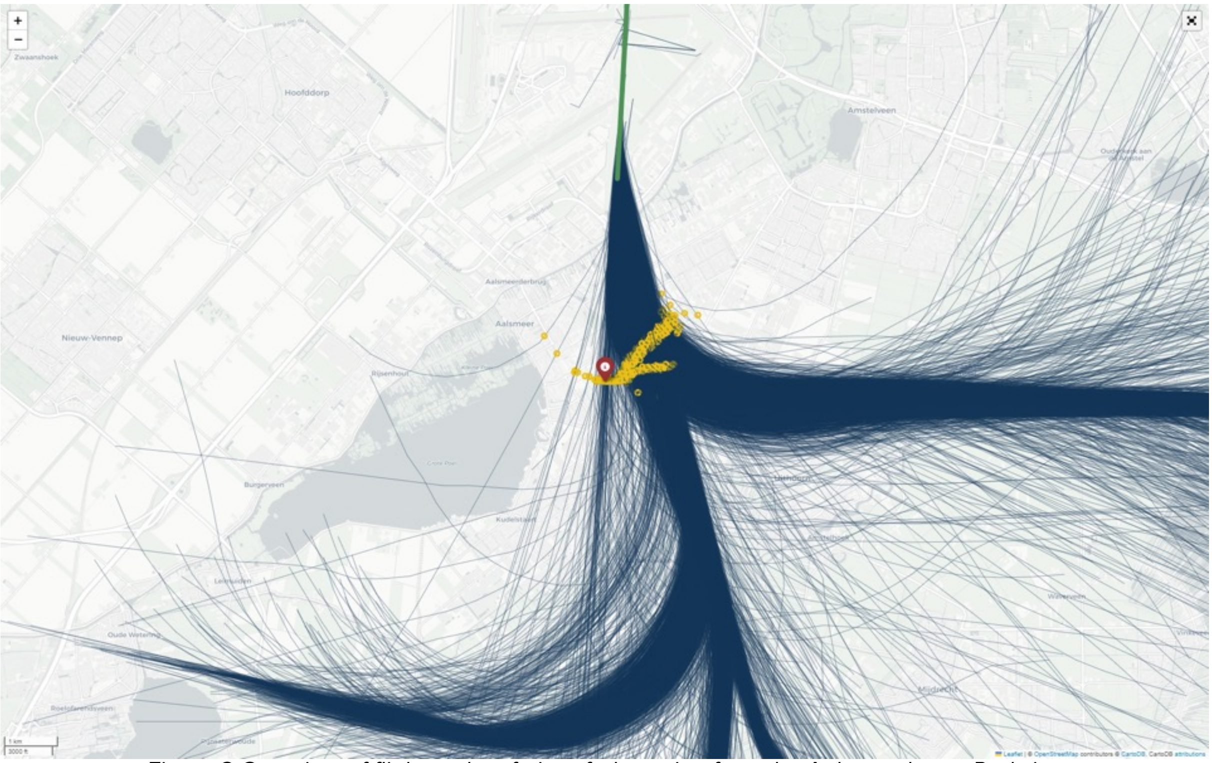

Figure 2 Overview of flight paths of aircraft departing from the Aalsmeerbaan. Red sign is location of measurement station

Figure 3 Overview of flight paths of aircraft approaching the Aalsmeerbaan. Red sign is location of measurement station

Processing (aircraft) noise measurements

In the next step for each flyover event the noise data coming from the M+P Yasmin measurement systems and collected within the M+P LSSN sensor network must be combined with the flight parameters made available by the Schiphol Air Traffic control. Figure 4 presents noise measurement data of approaching aircraft for the Aalsmeerbaan on a busy afternoon; each peak represents a flyover event.

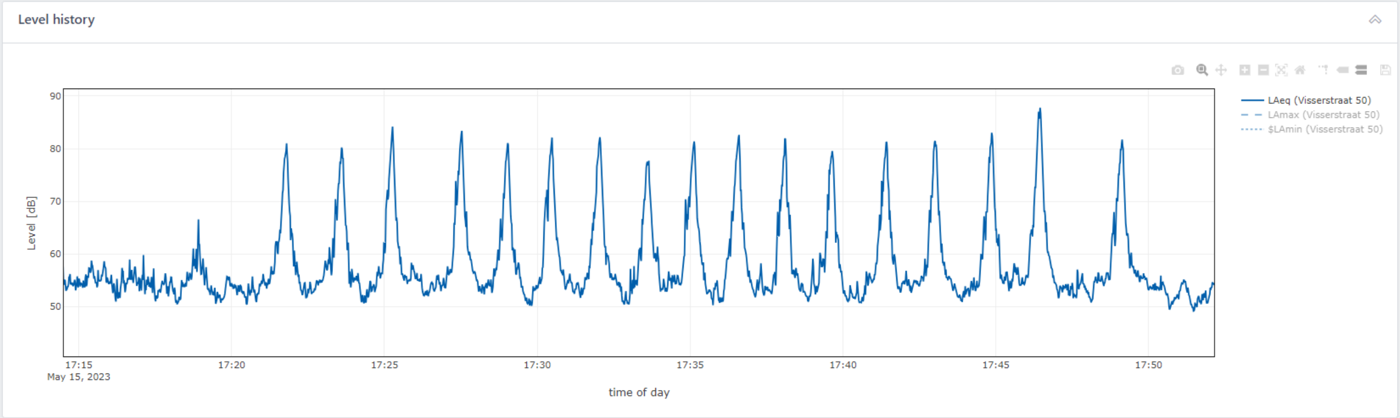

Figure 4 Example raw measurement data of approaching traffic on the Aalsmeerbaan

Of each event the SEL (Sound Exposure Level) is determined. To minimize the influence of background noise, the 10-dB down method has been employed for processing the data for each aircraft passage. This process is derived from the ISO-20906 standard. An example of this process can be seen in Figure 5.

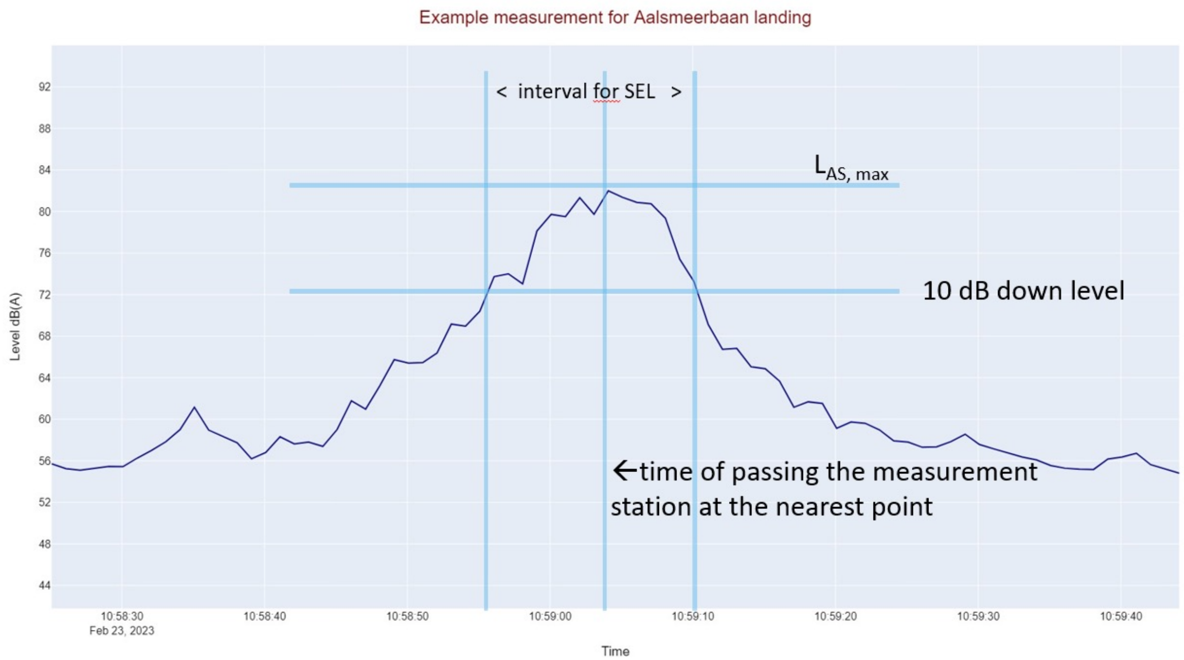

Figure 5 Example of noise data processing of a single flight event

By determining a time of passage for each flight, it is possible to correctly link the noise data to each flight parameter set. So far, it has been possible to link noise measurement data to flight parameters for approximately 240,000 events.

Develop insights based on processed aircraft noise measurements and flight parameters

SEL values as such do not provide particularly relevant insights. To generate meaningful understanding, more context must be provided alongside the SEL values. This is achieved by adding additional data about the flight. This ranges from the aircraft type, the engine type, the type of mixing to the bypass ratio of the engine. The content of four public data sources have been used for each flight:

- Aircraft Noise Performance (ANP) data base
- ICAO Aircraft Engine Emission data base
- CAPA Fleet data base
- Relevant weather data from the Netherlands Meteorological Institute KNMI

Based on the flight's geometry, parameters such as the aircraft's speed and altitude at the time of passage, the elevation angle between the measurement station and the aircraft, and based on the performance coefficients, an estimation of the thrust provided by the engine is determined.

Additionally, there are criteria that the event must meet to be included in the data set. There should not be too few or too many samples included in the SEL calculation. Measurements taken during rain are not included, nor are those taken during snow, thunderstorms, ice formation, or when the wind speed is > 10 m/s. Furthermore, the flight data must be complete and free of errors. Data from external sources may be absent, as this data may not be available for every aircraft type.

Insights into aircraft noise

The dataset includes a combination of take-offs and landings for both the Aalsmeerbaan and Kaagbaan. First in the data set the location and the type of operation was distinguished. The resulting noise data are presented in Figure 6. What is clearly noticeable is that the SELs per location and operation type vary greatly, but they roughly follow a normal distribution.

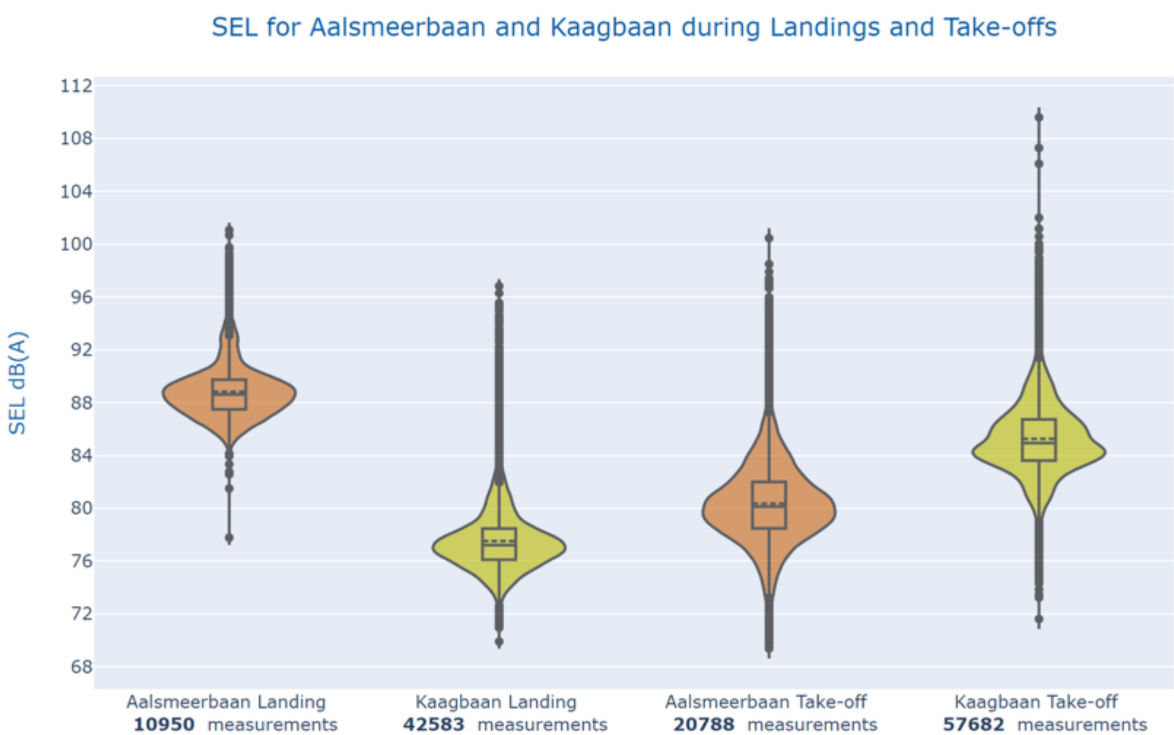

Figure 6 Violin plots with distribution of SELs per location and operation

The measuring station for the Aalsmeerbaan is positioned directly under the approach route so the lateral distances for arrivals are almost all around zero meters, and therefore the SELs are also higher. Departing flights from the Aalsmeerbaan are mainly heading eastbound, with the 'initial turn' located north-east of the measurement station (see Figure 2). This explains the lower SELs in relation to the arrivals. For the Kaagbaan the distance between the flight path and the measurement station is around the same for both approaches and take-offs.

Insights into aircraft noise per aircraft type

In Figure 7 the distribution over individual aircraft types is presented for Kaagbaan take-offs. The Boeing 747-400 (B744) is the aircraft type with the highest mean SEL, namely 93,4 dB(A). The B744 is also the noisiest for the landings and for landing and take-off from the Aalsmeerbaan. Furthermore, it can be seen that the wide-body aircraft lie in the left half of the plot and in general exhibit a higher mean SEL than the single-aisles. What further stands out in Figure 7 is that the newer generation wide-body aircraft such as Boeing 787-8/9 (B788/B789) or Airbus A350-900 (A359) have on average around the same or lower SELs than the current generation single-aisle aircraft. For the Airbus A350-900, the mean SEL is 84,5 dB(A), while for the frequently flown Boeing 737-800 (B738), it is 86,5 dB(A).

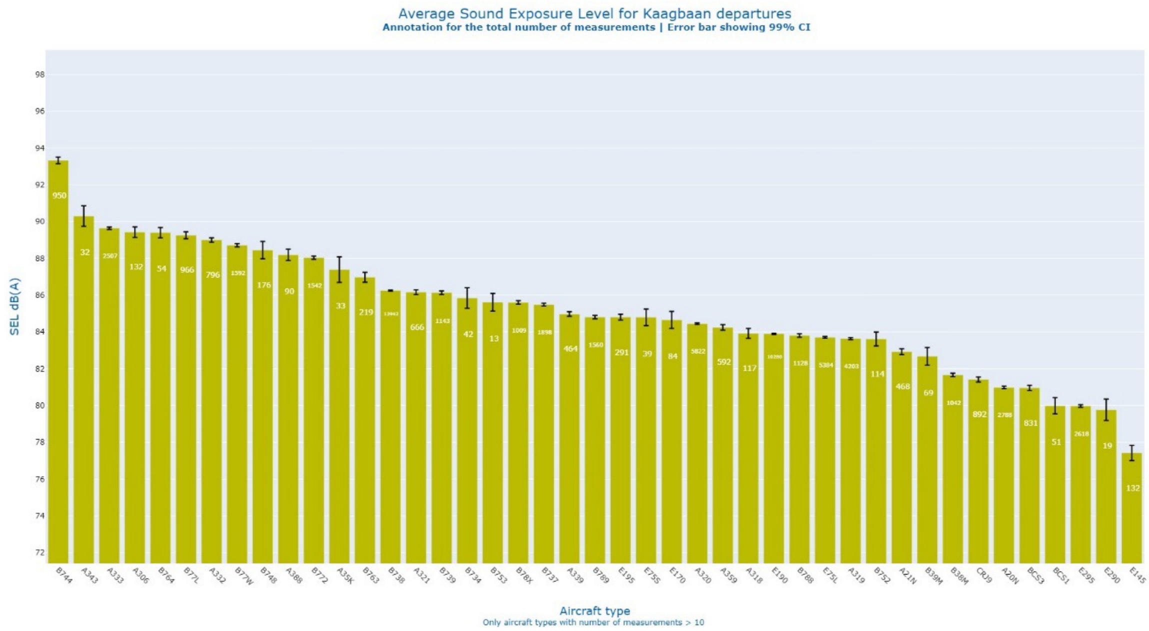

Figure 7 Average SEL values and 99% c.i around it for take-off from the Kaagbaan for different aircraft types

Fleet renewal at KLM and Transavia

KLM and Transavia, Schiphol Airport's major users, are very active with a large-scale fleet renewal with the purchase of 100 to160 A320/A321 neo and 50 Airbus A350 to replace the current fleet of Boeing 737s and Airbus A330s.

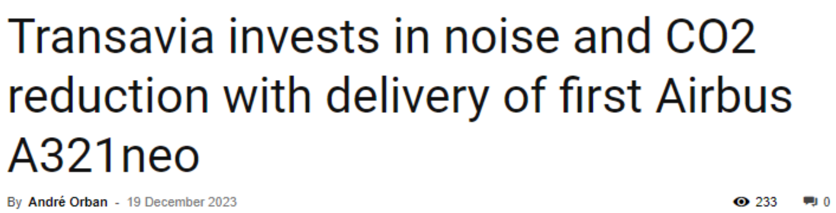

Figure 8 source: https://www.aviation24.be/airlines/air-france-klm-group/transavia/transavia-invests-in-noise-and-co2-reduction-with-airbus-a321neo/

From a noise perspective, we observe for the new A321neo aircraft type approximately 4 dB lower SEL levels during take-off compared to the current B737-800 used by Transavia. During landing, the A321neo is approximately 1.5 dB quieter. When comparing, it's important to consider that the successors of certain types are not necessarily of the same size. For instance, the A321neo is larger than the B 737-800. Reductions in SEL levels of departing aircraft of the same size of up to approximately 5 dB are realistic.

Our measurements indicate that fleet renewal can make a significant contribution to reducing noise around airports. The extent to which noise reduction benefits the environment and affects the nuisance situation around the airport depends on many other parameters, such as the number of passages, the time of day they occur, and other sources relevant to the nuisance in the area.

Detailed analysis of engine specification influencing produced noise

Up to here the basis of distinguishing aircraft with respect to noise was the manufacture and type. Since the engine is the main source of noise emission, it is interesting to investigate the effect of engine type and character on the noise production. This is done on base of a subset of the measurement data with A320 NEO and A321 NEO. These types are equipped with either CFM56-LEAP or PW1100G engines. The results of distinguishing engine type are presented in Figure 9.

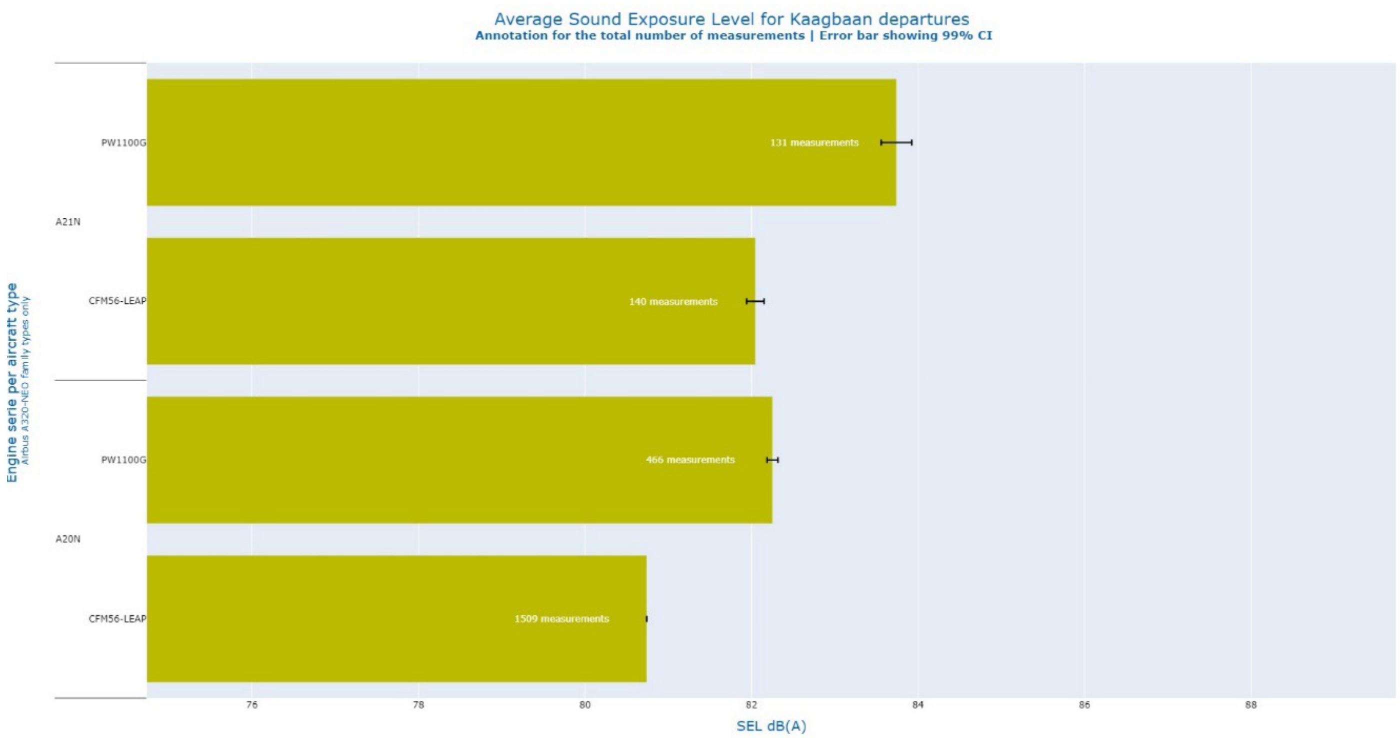

Figure 9 SEL levels for take-off from the Kaagbaan for A320 neo and A321 neo equipped with either a CFM or a PW engine.

What is clearly visible is that the type of engine does indeed influence the SELs and differences up to 2 dB are observed with the CFM56-LEAP being the less noisy one for both the A320 and A321 neo.

Within the engine types, also a difference can be made between Turbofan (TF) and Mixed Turbofan (MTF). It is assumed that MTF engines produce a lower noise level compared to TF engines, because the mixing of the two gas streams with strongly different velocities takes place within the engine and the noise emission from the resulting turbulences is shielded by the nacelle. In case of TF types the mixing takes place in the unshielded rear of the engine (for more info see: TF vs MTF). To verify this assumption, a look is taken at aircraft types that have both TF and MTF engines mounted. This is the case for the Airbus A319, A320 and A321, therefore these aircraft types are selected for further analysis.

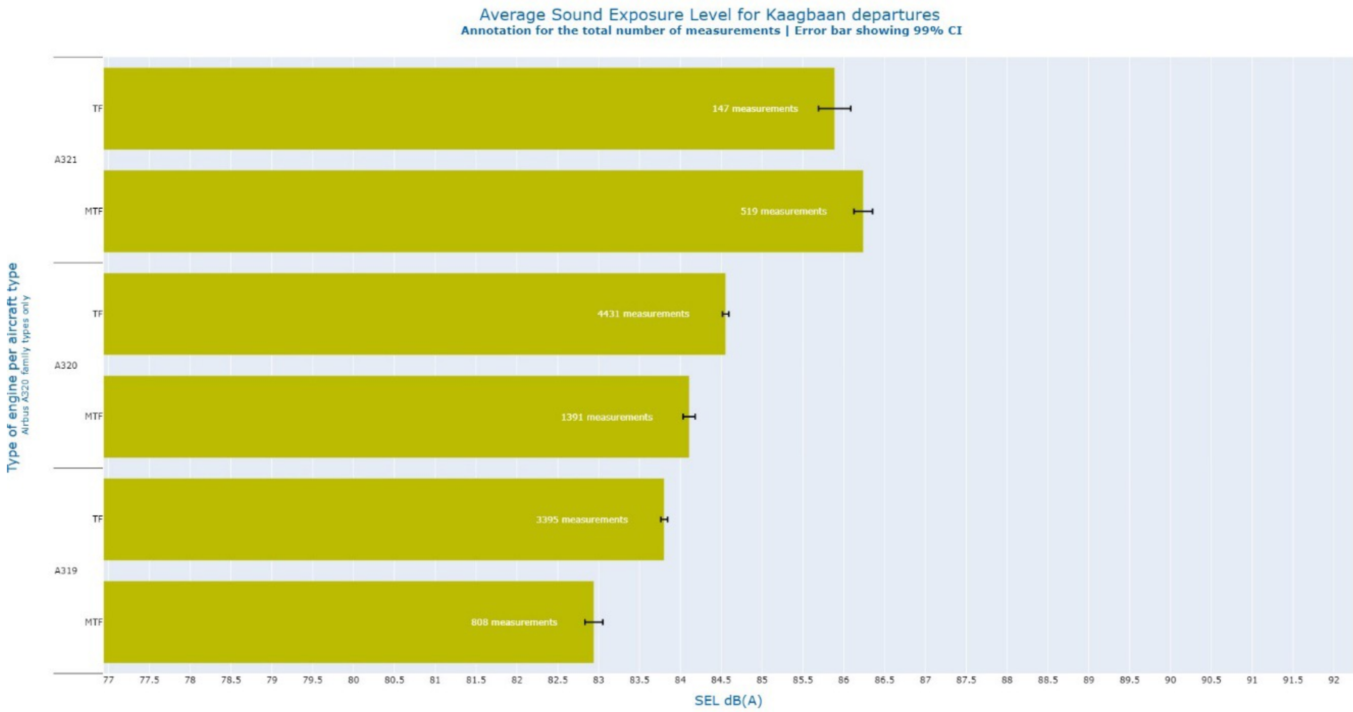

Figure 10 Average SEL for TF and MTF engines for Airbus A319, A320 and A321. Kaagbaan take-off

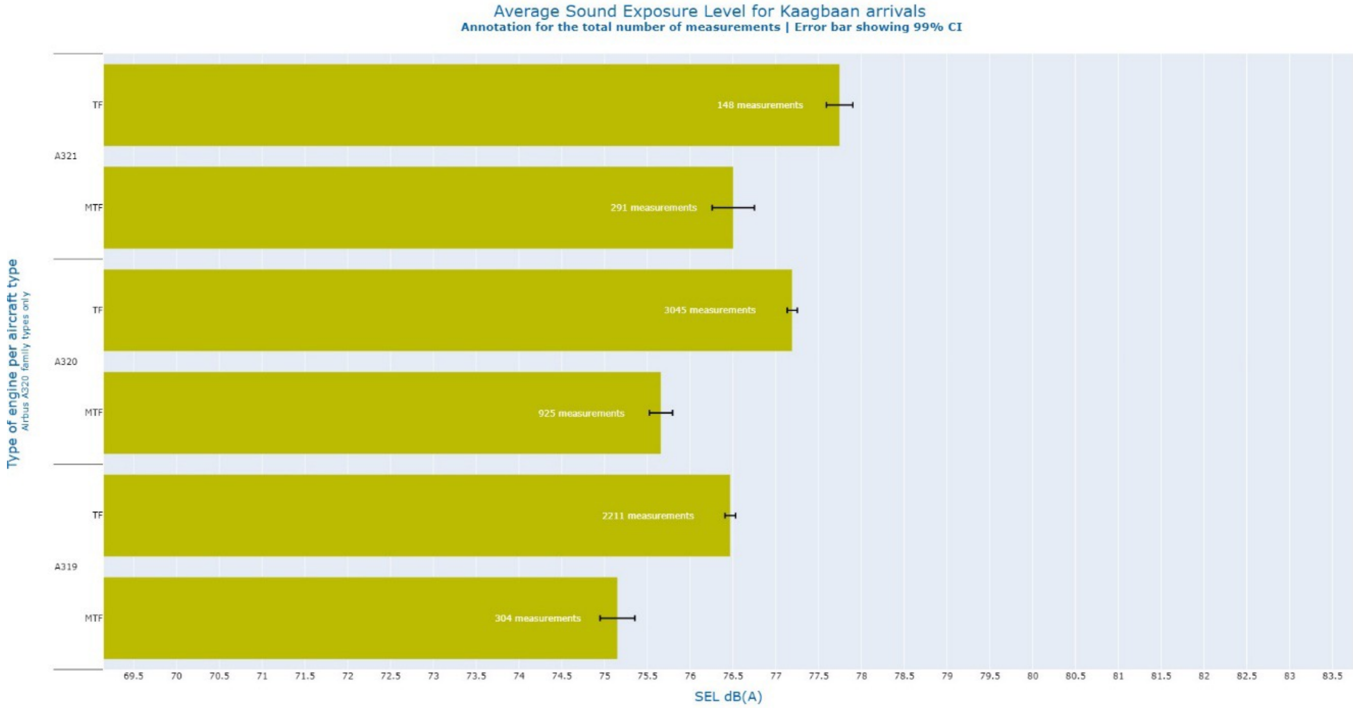

Figure 11 Average SEL for TF and MTF engines for Airbus A319, A320 and A321. Kaagbaan landing

In Figure 11 it can be seen that for Kaagbaan landings, there is indeed a difference between TF and MTF engines for all three aircraft types. This difference is less when looking at Kaagbaan take-offs in Figure 10 that shows that for the A321, there is no difference, and for the A319 and A320 the difference is smaller.

In addition, we investigated the relation between noise emission and some other aircraft and engine data. The results in Figure 12 show that there is a negative correlation between the bypass ratio and the SELs. The bypass ratio is a comparison between the mass flow rate of air drawn into the engine through the fan disk that goes around the engine core and the mass flow rate of the air that goes through the engine core (source: SKYbrary Bypass Ratio)

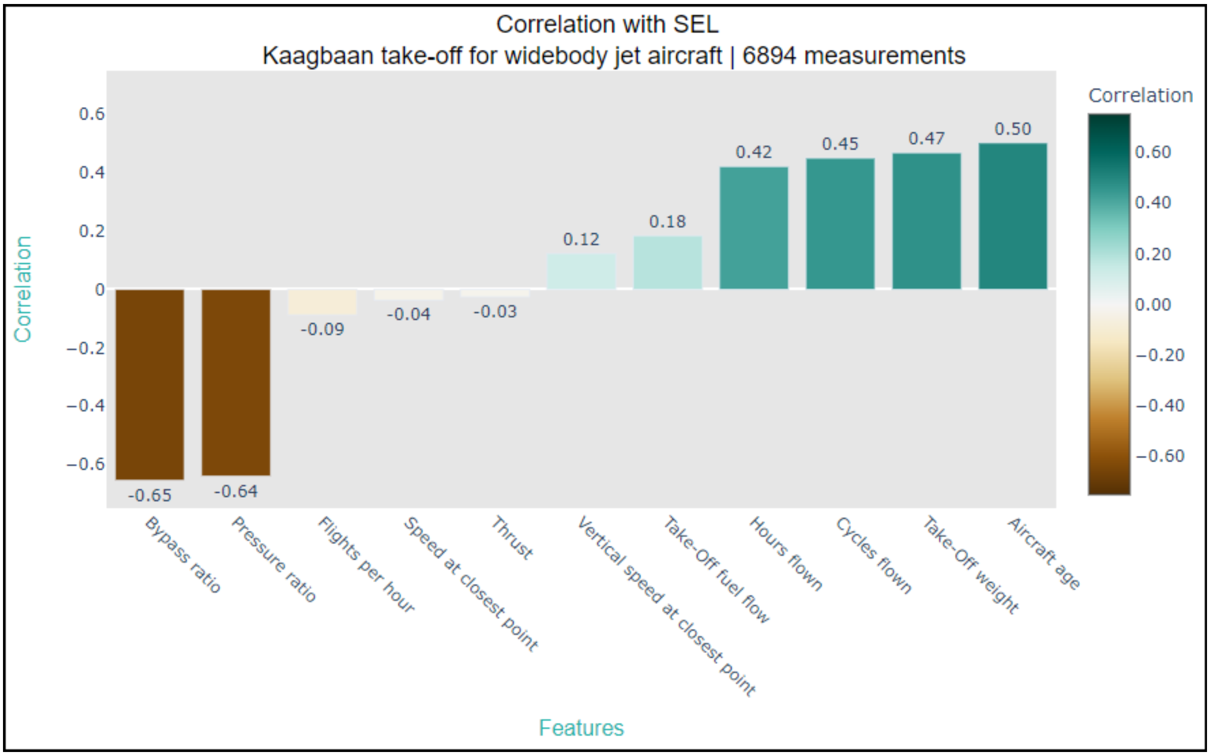

Figure 12 Correlation for Kaagbaan take-off, widebody aircraft only.

The negative correlation of -0.65 indicates a strong inverse relationship between the bypass ratio and the noise emission. As the bypass ratio of an engine rises, the SEL decreases.

Although the above results only pertain to the take-offs of wide-body aircraft on the Kaagbaan, the same negative correlation can be seen for all other combinations, i.e., take-offs, landings on both the Aalsmeerbaan and Kaagbaan, for regional, single-aisle jets and wide-body aircraft The same negative correlation applies to the pressure ratio, although this is strongly positive for landings of regional aircraft. Upon this time is it not clear why positive correlation is only present for landing regional aircraft.

The future of aircraft noise measurements at M+P

The interesting and very relevant area of aircraft noise is becoming a key topic at M+P. Currently, we are investigating whether it is possible to determine the contribution of each source within the aircraft to the produced noise using AI. Not only total A-weighted levels but also the spectral distribution of the acoustic energy is used for further understanding the nature of aircraft sound. Not only are we interested in making further steps but also to share our knowledge with the community. The possibility of an "aircraft noise view site" is being explored to share insights about aircraft noise in an accessible manner with interested parties.

Noise Enforcement of a Major Airport, a Balancing Act

By Gijsjan van Blokland, former member of the noise expert group for Amsterdam Schiphol Airport

Operating a major airport within an urban agglomeration while maintaining harmony with the people living nearby is not an easy task. The Amsterdam Schiphol Airport (AMS) has a history of almost 30 years of trying to maintain growth while at the same time improving the acoustic quality in the environment. The chart of the number of passengers and number of operations over the years, presented in Fig 1 shows that AMS was successful with the first part of the challenge.

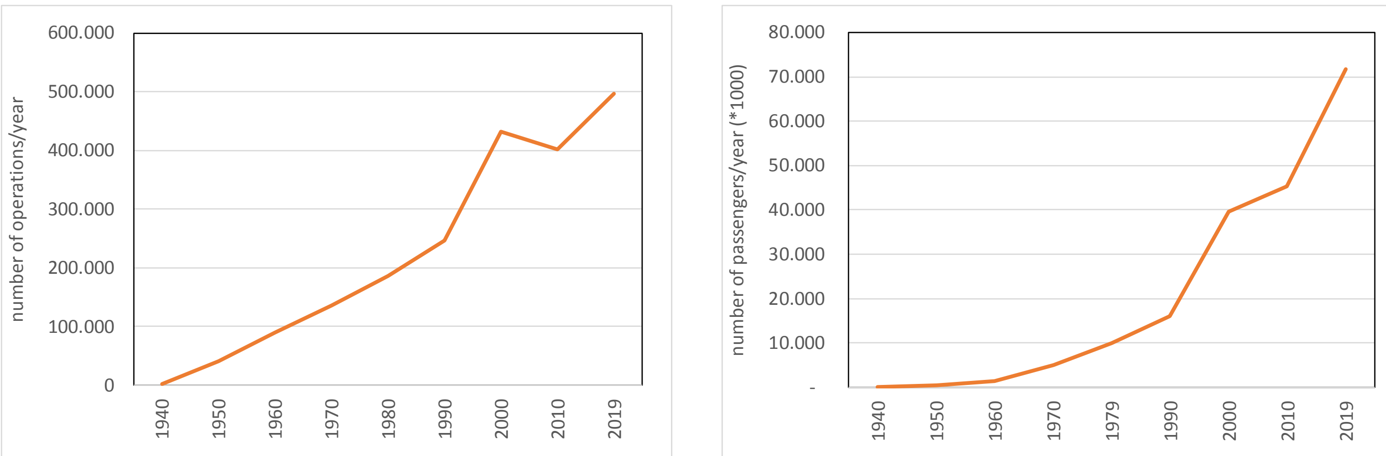

Fig 1. Development of the number of passengers and the number of operations on Amsterdam Schiphol Airport (AMS)

Maintaining the living quality for the people nearby, however, is a continuing struggle.
This paper sketches the development of procedures to limit the noise imission in the vicinity of the airport.

Fig 2. Lay-out of AMS. In 2000 runway 36L-18R was added. The smaller 04-22 runway is for general aviation only.

AMS is situated in the south-west of Amsterdam and is surrounded by several larger and smaller cities and villages. To facilitate operations under varying wind conditions it had four runways, one in E-W (09-27), two in N-S (18C-36C and 18L-36R) and one in SW-NE (06-24) orientation (see Fig 2).

Development started when in 1995 a closed not-to-exceed contour at 35 Ke noise level, comprising 15.100 houses, was defined around the four runways of the airport (Fig 3 Left). The Ke measure used is a kind of energy-based cumulation of LAmax levels over a year with a penalty for evening and night events and noisier events. For the night period a separate 26 dB LAeq (level inside bedroom) zone was drawn. In 2000 a fifth runway was added that was carefully aligned so that arriving and departing traffic could avoid urban areas in the north of the airport. Traffic in the south was not allowed. Consequently, the noise target in terms of houses within the new, not-to-exceed contour of 35 Ke could be reduced to 10.000. Comments that such a continuous contour not only limits noise exposure of inhabitants but also of cows in meadows and vehicles in parking lots were addressed by replacing the contour by a chain of enforcement points located near living areas (see Fig 3 Right). The table presents the coordinates and the not-to-exceed level without and with a 1 dB margin for extraordinary weather conditions.

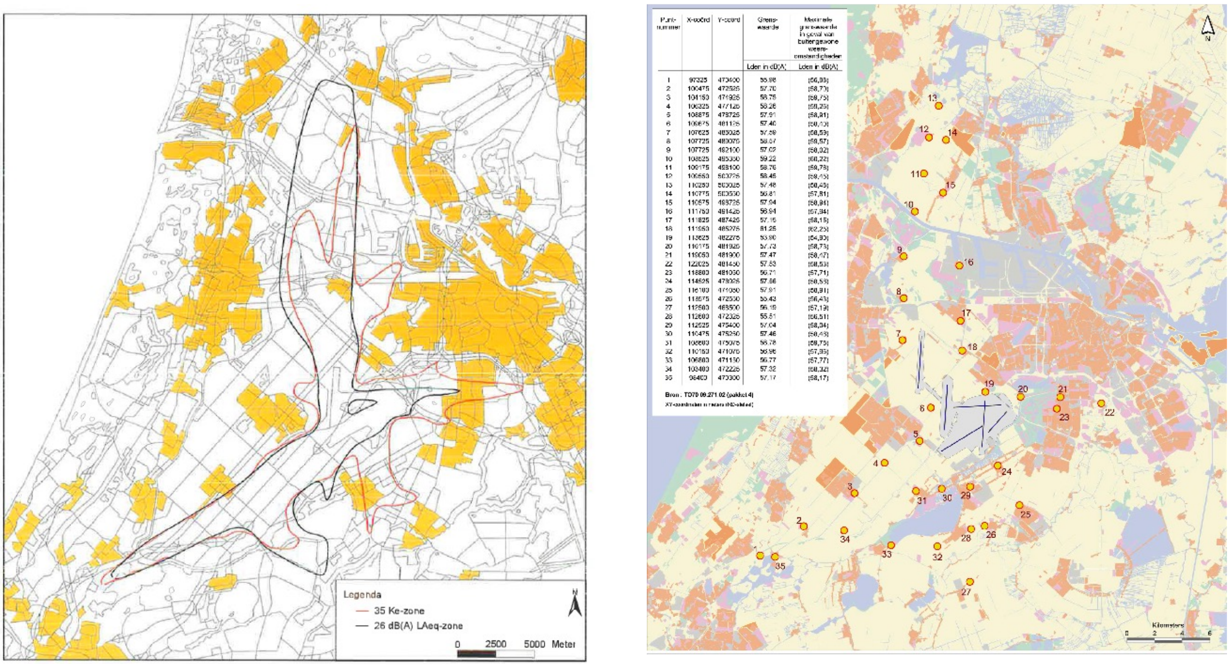

Fig 3. Enforcement geography. Left: in black the continuous not-to-exceed 35 Ke contour around the original 4 runway system (the red contour presents the additional Lnight contour). Right: the 35 enforcement points, also roughly on a 35 ke contour, but defined in dB Lden.

How to construct a not-to-exceed noise contour or series of limit values

One cannot just map all traffic within a year, including aircraft type, time of day and approach or departure protocols and put that in the noise model. This contour would fit for that specific year but will not fit next year's traffic since another wind regime or shifted origin/destinations leads to another distribution over the runways.

The construction of the contour was done by defining a typical traffic ensemble with timetable, aircraft types and origin/destinations. The distribution of this traffic over runways was modelled using flight rules such as maximal allowable tail- and side wind speeds, gusts, other safety considerations and a preference for the 18L-36R and 06-24 runway since these generate less annoyance. The wind input was based on an average of the weather over 30 years. To allow for variations in runway use due to meteorological conditions deviating from the mean, the number of operations from each runway was increased by an average of 25%.

The noise exposure in the vicinity was then determined with the typical traffic ensemble, the runway distribution including the enlargement by about 25%, the standard flight routes and standard arrival or departure procedures used in 2002.

A chain of 35 enforcement points were selected around the airport, each in the vicinity of living areas. For each point, the calculated noise level in Lden served as a not-to-exceed level. However, if one can argue that the violation of the limit was caused by extra-ordinary weather, a margin of 1 dB was tolerated. The coordinates and limit values (with 1 dB extra-ordinary weather margin in brackets) for each point are presented in Fig 3 Right. To prevent "filling-up" of the enlarged contour also the total noise production of the traffic was capped based on the original traffic without the 25% increment.

The "AMS noise constitution"

Together with implementation in 2004 of the noise permit for AMS comprising this enforcement system, a kind of constitution was formulated that stipulated that every future enforcement system shall guarantee an equal or better acoustic quality for the people living around the airport than the one implemented in 2004. The general term "acoustic quality" was specified as a maximum number of houses within 58 dB Lden contour, a maximum number of highly annoyed people within the 48 dB Lden contour and similar constraints for the 48 and 40 dB Lnight contour. Whatever you modify in the structure of the enforcement system, it shall always comply with these figures (see Table 1).

Table 1: Maximum number for houses, highly annoyed and highly sleep disturbed people within Lden and Lnight contours around Schiphol airport (note these contours include a roughly extra 25% area to account for weather variation)

Houses within 58 dB Lden contour	12.300
Highly annoyed within 48 dB Lden contour	239.500
Houses within 48 dB Lnight contour	11.700
Highly sleep disturbed with 40 dB Lnight contour	66.500

Was everybody happy? Not particularly

Soon after the introduction a most intense discussion was raised about the system of fixed enforcement locations with fixed not-to-exceed levels. It was experienced that over the years, in some locations, persistent violation of the limit values occurred while the actual levels on several other locations were far below the maximal levels. Large margins were found for enforcement points in the north, especially around the newly built fifth runway while in the south limits were often exceeded. For a well-designed system the margin should be on average about 1 dB and evenly distributed over the enforcement points. The conclusion was that the intended amount of traffic could not be handled within the designed limit values.

The systematic deviations between expected and actual values could be traced back to developments in air traffic control. Essential for the noise levels in enforcement points is the distribution of traffic over the runways. The limit values were based on runway usage steered by strict interpretation of ATC rules on allowed meteo-conditions, mainly sight, wind speed, wind direction and wind gusts. In practice, ATC operates on the safe side and in case of severe weather redirects traffic to safer but less noise preferent runways earlier. The on average 25% margin in runway usage was not enough to compensate for this effect.

Another issue was that the system of fixed levels made it hard to use the advantages of less noisy aircraft to expand operations. Limits in the capacity of the noise preferent runways, especially 18R-36L, hampered the filling up of the available acoustic room round that runway with more flights and only limited shifting to less noise preferent runways, such as 18L-36R, was possible because of the tight acoustic space available for that runway within the fixed limit values.

AMS convinced the authorities to develop a new, more flexible system.

Outline of the new enforcement system

The starting point for the new system was that it shall comply with the boundary conditions given in Table 1 and that it maintains the preferences for the "environmental friendly" runways 18L-36R and 06-24 but without a system of fixed points and fixed limits.

The easy solution would be to take the numbers from Table 1, reduce them with 20% and apply a yearly check that these reduced numbers are not exceeded. This option was studied but found to be too restrictive for the development of the airport.

A system was constructed in which the original process was followed but then on a yearly basis with a more reliable runway distribution model and a more precise modeling of the contour variations due to the variation in meteorological conditions.

The runway distribution model was developed based on a detailed correlation between 10 min. meteorological data and runway usage over a period of a few years. It considers parameters like frequency of landing or take-off (in busy times two runways for arrival or for departure will be in operation simultaneously and for short periods even two arrivals together with two departure runways) and origins/destination so that eastbound and westbound traffic on parallel runways will not cross each other.

With this improved model the runway distribution for the scheduled traffic for the coming year was to be reconstructed for each meteorological condition found in the last 40 years. That is, for every year the meteorological conditions were cut in 10 minutes interval for the whole year (52,000 intervals) and for each of these intervals the choice of runway was modelled, taking into account the listed parameters. From runway choice and origin/destination the routes can be reconstructed and after applying the existing arrival/departure procedures the noise map was calculated and from it the 58 Lden contour and the others mentioned in Table 1. To reconstruct a full equivalent of the original approach to correct for the effect of yearly meteorological variations, originally taken into account by the 25% increment in runway usage, an enveloping contour around the 40 individual yearly contours (see Fig 4) was drawn. (It was more complex since from this 40-year period 8 years were considered as having an exceptional meteorological situation and those years were not included in the construction of the enveloping contour).

The enveloping contours for 48 and 58 Lden and 40 and 48 Lnight were then subjected to the boundary conditions in Table 1.

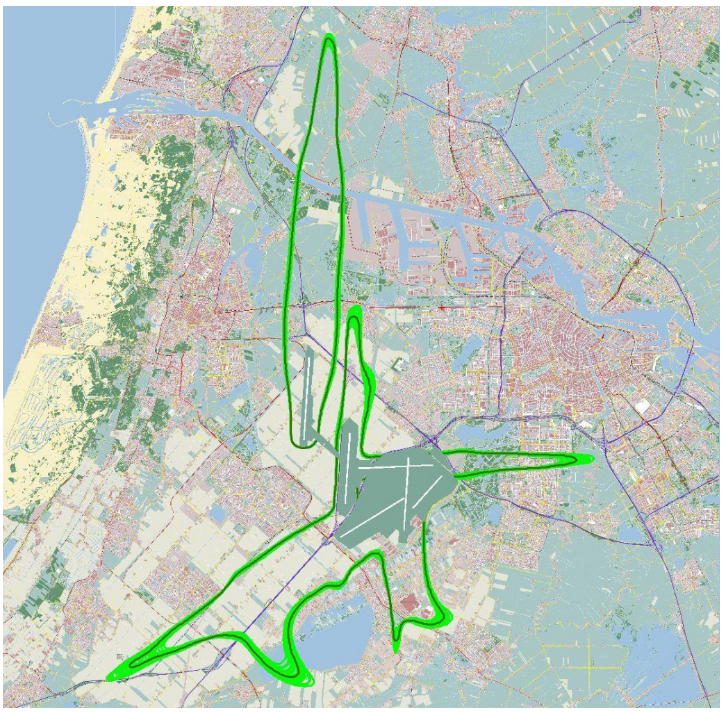

Fig 4. 58Lden contour around AMS. Traffic 2012 (434.500 operations). The dark drawn curve presents the contour in a year with average weather, the light green curves the Lden58 contours due to weather variation over 40 individual years (1971-2010) (Source to70).

Enforcement was performed as follows. The anticipated flight schedule for a coming year is subjected to the procedure sketched above, meaning runway distribution and routes are modelled and contours for 32 meteo years are calculated. Next the number of houses in the enveloping 58Lden contour are calculated (together with the appropriate figures for the 48dB Lden, and 40 and 48 Lnight enveloping contours). If the numbers comply with Table 1 then the planned flight schedule is approved. If not, the number of flights is reduced until it fits. The enforcement of the noise emission is now reduced to establishing the total sound emission that is produced by the allowed flight schedule and monitoring that this total emission is not exceeded over the operational year. Also, a check is performed to see if the runway usage did comply with the rules for noise preferences.

Difference between old and new system

There are many differences in procedure but, in the old system there was a fixed boundary. Inside the chain of enforcement points the airport could exceed the limit values, outside the chain of points the noise levels are limited.

In the new procedure such geographical fixation does not exist anymore. The contours may lie everywhere if the boundary conditions listed in Table 1 are met. This allows more flexible operations of the airport. The consequence of the improved flexibility is that the environment is less certain about what noise levels to expect in the coming years. For instance, the large acoustic margin that was available in the former system north of 36L-18R can now be used to intensify the flight operations on 36R-18L at the cost of the inhabitants of the village of Aalsmeer.

How does it work in practice, well.... Not.

The introduction of the new noise enforcement system has been delayed by several years because of another environmental issue, the deposition of NOX in nature areas around AMS. The Netherlands operates an oversized livestock industry that contributes significantly to already nature threatening levels of NOX. The permit for NOX immission by the airport was outdated and renewing implied compensation by NOX reductions elsewhere and these are hard to find.

The case now is that the former, but on paper still valid, noise enforcement system was already omitted while the new enforcement system cannot be implemented due to this NOX issue. So presently AMS operates with no valid noise enforcement system. An attempt by the authorities to reduce the number of operations as to comply with the still valid system with fixed points was found to be violating the EC regulation 2014/598 “Rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports”.

In short, noise enforcement of Amsterdam Schiphol Airport has developed from a complex project performed by acousticians and flight controllers to a legal battlefield where lawyers take over the job of regulators and judges decide on boundaries. Noise enforcement for this airport represents an interesting case.

Acknowledgement

The developments of the consecutive enforcement systems were based on work by the NLR-Netherlands Aerospace Centre and to70 Air traffic Consultants performed for the Dutch Ministry of Transport and Environment.

Evaluation of Dublin Airport's Noise Pollution

By St. Margarets The Ward/FORUM

Introduction

Dublin Airport in Ireland opened a new parallel runway, the North Runway, in August 2022. The runway opened following many decades of planning and regulatory approval. However, what became apparent to the communities of North County Dublin and neighboring County Meath was that flight paths for departures using the North Runway were in the wrong place. Thousands of homes that should never have been exposed to significant levels of aircraft noise were now severely impacted.

Quickly, resident groups in the affected areas became active. St Margarets The Ward (SMTW) and Fingal Organised Residents United Movement (FORUM) groups began to petition authorities to investigate the operations from Dublin Airport. They turned to Fingal County Council (FCC) the local authority and the Airport Noise Competent Authority (ANCA) for help and for answers.

To date, investigations into flight paths at Dublin Airport by authorities remain ongoing. However, the SMTW and FORMUM groups have taken the initiative to fund their own investigation into the noise effects. This article offers a viewpoint on the noise evaluations carried out by airport authorities, focusing on the experiences of communities directly affected by the noise. It will compare measurements to modelled scenarios, discuss how noise is averaged by airport authorities compared to the individual events that communities hear, discuss how regulations are stacked in favor of the airport operators and conclude with some suggestions that would improve the engagement of communities by airport authorities in future.

History of the North Runway

Dublin Airport is located north of Dublin City within the Fingal County administrative area. The airport first opened in 1940 with a grass runway. In 1950, a new concrete runway replaced the original grass runway, officially known as Runway 16/34. The first main runway (10/28) was opened in 1989, this is often referred to as the South Runway.

The North Runway concept has been discussed for decades; however, it wasn't until 2004 that a planning application was submitted by the airport operator to the local planning authority. After considerable debate and a full public planning hearing, the runway eventually was granted permission in 2007 with a series of conditions attached. Many of the conditions related to environmental protection including noise protection for local communities.

Due to the economic downturn in 2008, the runway construction was put on hold until 2016. At that time, some of the environmental protection conditions had to be implemented including insulation of homes and schools. The eligibility for these schemes was based on a series of noise contours which were, of course, based on a set of flight paths – ones that communities around Dublin Airport fully expected to be delivered when the runway opened.

Following construction of the runway, the first flight departed on 24 August 2022. However, the flight path for this flight and every flight since was completely different to the paths that were permitted by the planning application and that the community expected. To illustrate this, Figure 0 1 overlays the flight paths now in use at Dublin Airport in orange, on the noise insulation eligibility contours and the flight paths, in red and green, used to create them in 2016.

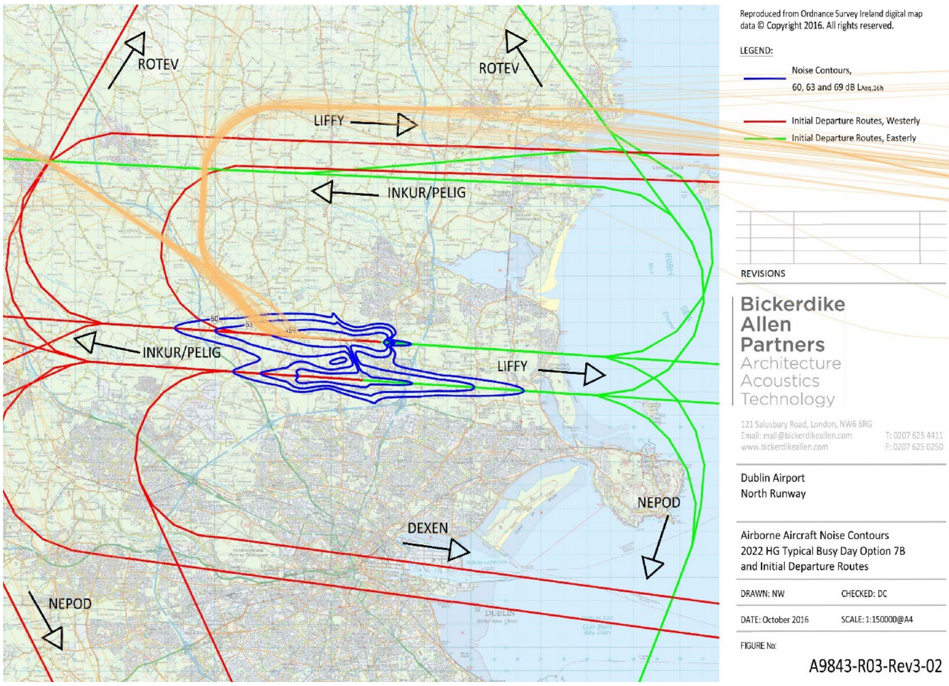

Figure 01 Actual Flight Paths Compared to Permitted Flight Paths

The flight paths being used today turn sharply at low altitude and fly over many areas that never expected to be under a flight path. This includes nursing homes, sports clubs, schools, pre-schools, villages, and towns.

No consultation was ever given to present this new flight path to communities who experienced the reality of noise from aircraft at low altitude instantly with the opening of the North Runway.

Aircraft Noise Contours – The Community Perspective

Residents living close to Dublin Airport were acutely aware of the North Runway development long before it was built. For several generations, the North Runway project and associated noise impact was studied closely by families before making decisions to settle in the area. This was done in the main by reviewing noise contour maps which graphically illustrate the expected noise level for airport operations.

We've faced several challenges comparing noise contour maps with real airport noise levels. A key issue is the averaging methodologies used by airports to create these maps, often resulting in lower noise levels depicted than what is heard from actual aircraft flyovers.

Noise contours are presented in terms of a variety of metrics, but the most common ones are LAeq,T, Lden and Lnight. Each of these metrics are average noise levels usually presented either over a specified modelling period of 92 days in the case of LAeq,T , or over a full year in the case of Lden and Lnight. Aircraft noise by its nature is an intermittent noise source which results in high noise levels when an aircraft is overhead followed by periods of lower background noise in between flights. Therefore, averaging the noise over time reduces the reported noise level significantly. In the case of computer-generated noise contours, the quiet time between flyovers is treated as having zero noise. The zero noise periods are included in the averages, having the effect of reducing the average level over a specific time period.

People don't experience noise in this manner; the irritation caused by aircraft noise occurs at the moment of maximum noise from an aircraft passing overhead. Residents might use phone applications to measure noise levels, which although not scientifically precise, do provide a relatively accurate indication of the maximum noise produced by aircraft movements. It's immensely frustrating for communities to measure maximum noise events exceeding 80dB, only to find from a contour map that the average noise level at their location is less than 60dB.

Moreover, noise contours not only average noise over time to show a lower figure but also incorporate a modal split to accommodate different wind conditions. For example, at Dublin Airport, the Dublin Airport Authority (DAA) states that 70% of the time, winds come from the west and 30% from the east. This additional averaging diminishes the noise level shown in contour maps for communities to the west and worsens the discrepancy for residents expecting the contour map's noise level to match what they actually experience.

To demonstrate this using real data, our groups carried out noise monitoring during the summer of 2023. The monitoring was done using calibrated noise monitoring equipment and the data was analyzed and reported by a competent acoustic consultant. In addition to the monitoring done by our group at two locations (Locations A and B), DAA also had a noise monitor at a third location (Location C) in a local primary school, Kilcoskan NS. Figure 0-1 presents the locations of the noise monitors with westerly departure flight paths also indicated in green. Overlaid on the image are the noise contours for the Summer 2023 period produced by DAA.

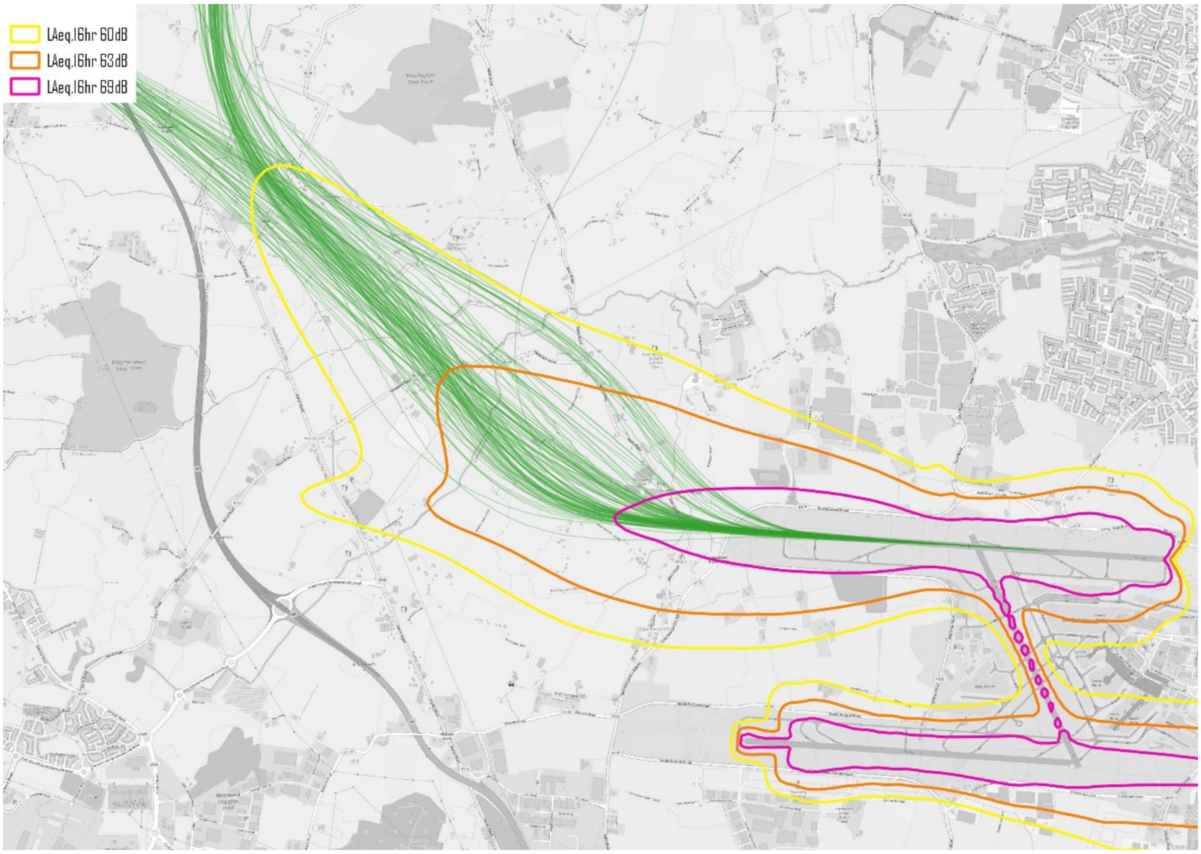

Figure 0 1 Noise Monitoring Locations

When we examine the maximum instantaneous noise level of aircraft flyovers, the contrast between the contour maps and the actual noise level experienced by our communities during an aircraft event becomes evident. Table 0 1 summarises the typical measured maximum noise level from aircraft flyovers at each location to compare to the noise contour levels for the same location.

Table 01 Comparison of Maximum Noise Level Measurements to Noise Contours

Location	Typical Measured Noise Level dB L_{ASMax}	Estimated Noise Contour Level dB $L_{Aeq,16hr}$	Difference, dB
Location A	80	~67	+13
Location B	78	~63	+15
Location C	76	~60	+16

Table 02 summarises the measured typical daytime average noise level at each location to compare to the noise contour levels for the same location.

Location	Typical Measured Noise Level dB L_{ASMax}	Estimated Noise Contour Level dB $L_{Aeq,16hr}$	Difference, dB
Location A	70	~67	3
Location B	66	~63	3
Location C	63	~60	3

The noise contour maps underestimate the noise levels for a typical day with departing flights overhead. Some of this is due to the averaging exercise that is carried out. It is also possible that the noise model which produces the contour maps is not sufficiently accurate or has not been correctly validated to account for the sharply turning flight paths.

In the case of Dublin Airport and North Runway departures, there are over 400 flights daily following the flight tracks depicted in Figure 0 1. For our communities, this means experiencing 400 or more individual maximum noise events daily, which are loud enough to disrupt outdoor conversations, necessitate an increase in TV and radio volume indoors, and require residents to keep windows closed to mitigate noise.

For communities, the noise contours commonly used by airport operators are too abstract. Instead, noise contours should be presented in terms of the maximum instantaneous noise level that a community could expect to hear. They should also be presented as single mode contours which do not apply the averaging to account for the modal split discussed earlier.

This approach would provide a transparent representation of noise around the airport, offering communities the information they need, especially when the contours forecast future operations not yet implemented.

A Case Study in Poor Community Consultation

Effective consultation with communities is essential for any organization aiming to implement projects, or initiatives that directly impact those communities. However, when consultation processes are poorly executed or neglected altogether, the consequences can be severe. Not only does poor consultation undermine trust between stakeholders and decision-makers, but it also breeds animosity and resentment within the affected communities. Unfortunately, Dublin Airport is a case study in poor community consultation.

We've detailed how flight paths from the new North Runway at Dublin Airport haven't met community expectations. Since the North Runway opened in August 2022 there have been over 53,000 individual complaints. Most noise complaints relate to departures from the North Runway using unauthorized flight paths. However, there's a significant flaw with the complaints system: complaints are directed to Dublin Airport for investigation. The authority responsible for operating the airport is also the authority specified to investigate complaints. Neither Fingal County Council nor the Airport Noise Competent Authority (ANCA) will accept noise complaints from communities.

To date, noise complaints haven't prompted any review of the actual noise level by the authority. The only outcome of making a complaint is that the flight path flown is compared to an environmental corridor specified by the airport themselves to match the unexpected flight paths. Complaints are routinely dismissed with a comment stating that the flight path is within the corridor, regardless of the noise generated.

Despite the significant anger and numerous complaints from affected communities, there has been no effort made towards transparent public consultation. Officials from DAA consistently decline to attend public townhall meetings, where local volunteer groups like ours endeavour to clarify the situation to our communities. Instead, the DAA prefer to rely on a Community Liaison Group (CLG), which, at best, appears to be a tokenistic attempt at engagement.

The CLG was set up to facilitate discussions between the DAA and community representatives regarding the impact of airport operations on nearby communities. However, since the opening of the North Runway, there has been a reluctance to address the primary concern of our communities: the North Runway flight paths. As a result, the CLG has evolved into mere token consultation, enabling the airport authority to assert that they engage with communities, when there is no sincere effort to listen to the concerns of the communities.

Inadequate consultation with communities carries extensive repercussions, ultimately resulting in the erosion of trust and the exacerbation of animosity. This is evident in the significant volume of objections from the public to any projects proposed by Dublin Airport; communities simply do not have confidence in the information contained within these plans.

The Balanced Approach – Who does the Balance Favor?

EU law mandates the adoption of the "Balanced Approach" when evaluating potential operating restrictions at European Airports. This approach aims to implement aircraft noise management while considering the needs of both the aviation industry and the communities affected by aircraft noise. In theory, this seems reasonable; however, in practice, communities often find themselves confronted with a system designed to tilt the balance in favour of maximising airport capacity.

The fundamental challenge lies in achieving aircraft noise control for communities near airports without implementing operating restrictions. However, the Balanced Approach positions operating restrictions as a last resort for noise management, prioritising other measures instead. The four principal elements of the balanced approach to aircraft noise management are:

1. Reduction of Noise at Source
2. Land-Use Planning and Management
3. Noise Abatement Operational Procedures
4. Operating Restrictions on Aircraft.

Each of these are discussed in turn.

Reduction of Noise at Source

According to airport operators, quieter aircraft are seen as the solution. It's undeniable that modern aircraft are quieter than previous generations of jets. However, any reductions in noise are overshadowed by the significant increase in the number of aircraft movements. This acknowledgment is even made by the International Civil Aviation Authority (ICAO) in their Working Paper on the Management of Noise (ICAO Document Reference A40-WP/260). They state,

> *"Aircraft technology has dramatically reduced the noise footprint of individual aircraft movements in past decades. However, in many areas, this progress in reducing aircraft noise at source has been challenged by global increases in traffic and the introduction of larger aircraft. It has also become more difficult to identify new ways of significantly improving the technical noise performance of aircraft. The result has been an increase in cumulative noise levels around some airports."*

In summary, while individual aircraft may have become marginally quieter, the rise in air traffic volumes has led to no overall reduction in noise levels for communities surrounding airports. This holds true for Dublin Airport and can be evidenced by the noise and flight track monitoring data available on the Dublin Airport website. The charts below illustrate the average night-time noise levels ($L_{Aeq,8hr}$) recorded by permanent noise monitors at the airport over time, spanning from 2017 to the present day. The noise figures are taken from regular reports issued by DAA[1].

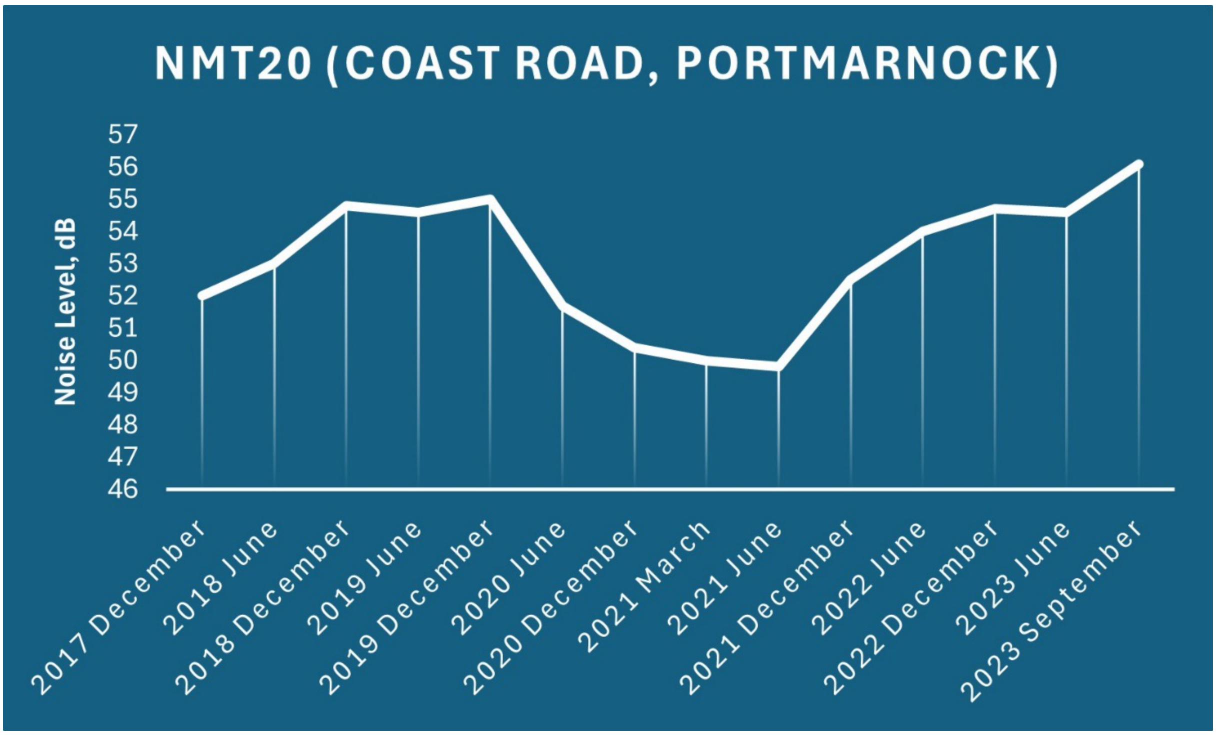

Figure 0 1 Summary of Noise Monitoring at NMT20

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1 https://www.dublinairport.com/corporate/corporate-social-responsibility/noise/airport-noise-noise-reports

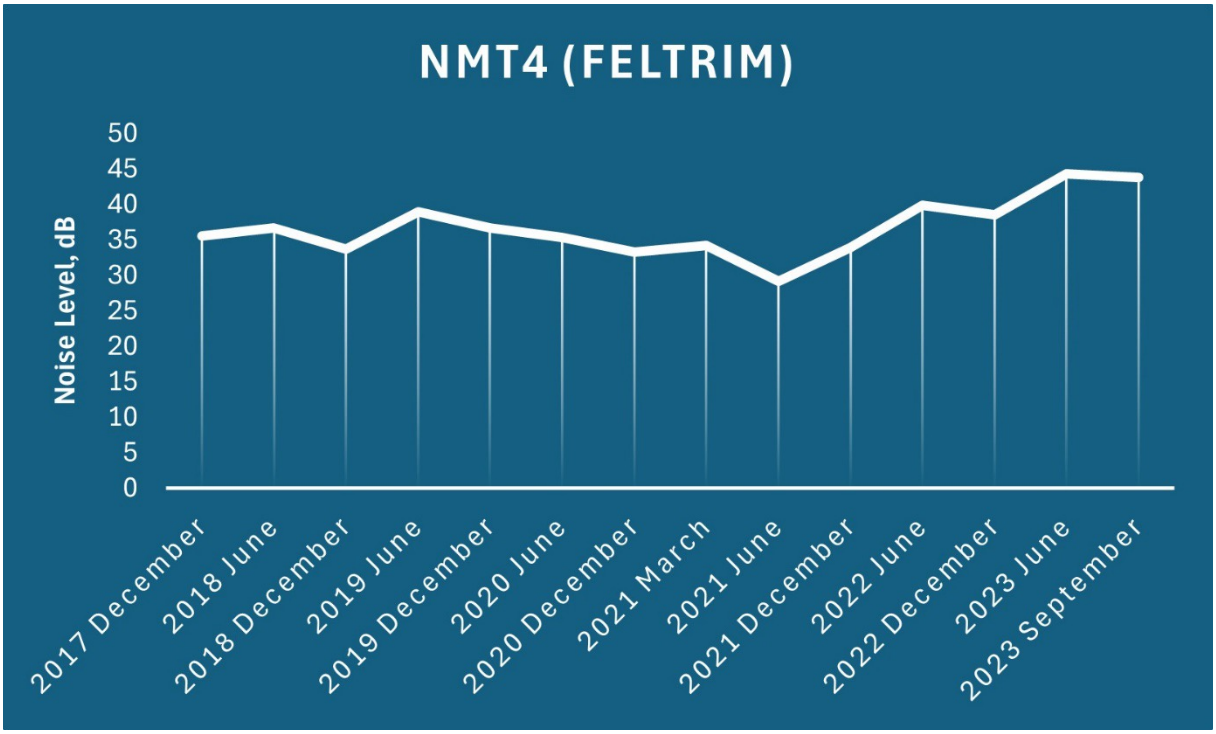


Figure 0 2 Summary of Noise Monitoring at NMT4

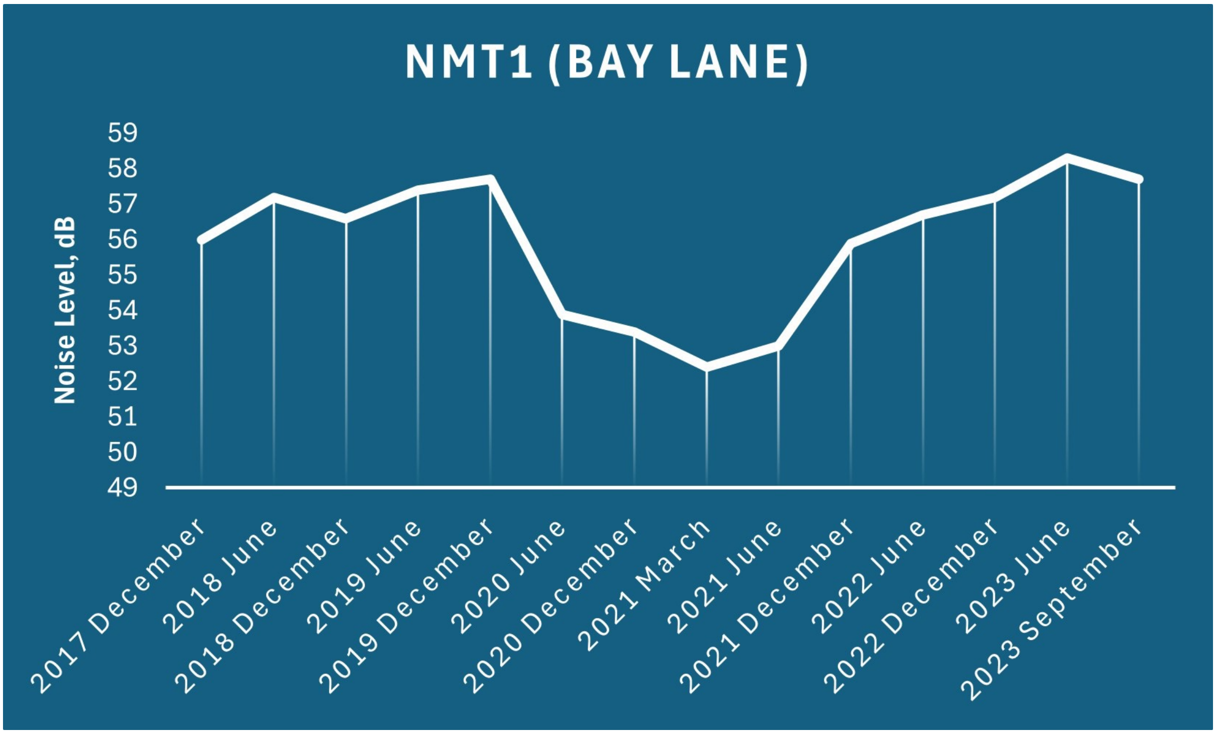


Figure 0 4 Summary of Noise Monitoring at NMT1

Each monitoring location depicts a consistent trend: noise levels measured in 2023 surpass those recorded in 2017, when monitoring commenced. The only notable reduction in noise occurred during the COVID-19 pandemic between 2020 and 2022.

The potential for future noise reductions at the source seems exceedingly limited without also constraining capacity. Nonetheless, Dublin Airport positions this strategy as central to its future plans for noise reduction, although the evidence of how this will be accomplished remains far from compelling.

Land Use Planning and Management

This category includes noise zones where new residential development may be restricted, it includes noise insulation schemes and also includes financial incentives to reduce airport charges for quieter aircraft for example.

Our community has experienced all of these management tools and they are ineffective at the very thing they are promoted to achieve, reducing aircraft noise.

Noise zones are established around Dublin Airport to restrict development, but unfortunately, they are based on hypothetical flight paths that are not currently in use. Consequently, many new homes have been constructed, and new families have settled in areas where, according to the noise zones, they had no noise concerns. However, the reality is that these areas are directly beneath flight paths. Additionally, the noise zones only apply to new developments; existing housing receives no benefit, and there is no reduction in noise by zoning the land around the airport.

Insulation is often proposed as a solution to mitigate aircraft noise. However, its effectiveness is limited to indoor spaces and relies on keeping windows and doors closed at all times. This lifestyle isn't conducive to healthy living, as it confines people indoors and compromises the outdoor environment. Moreover, insulation can only provide partial relief, and for many homes, outdoor noise levels are so high that effective insulation is impractical. Additionally, insulation does not address the root issue of reducing noise pollution outdoors.

Ultimately, while the notion of offering financial incentives to encourage quieter aircraft to utilize an airport may seem appealing, our demonstration has revealed that the slight reduction in noise from modern aircraft is eclipsed by the surge in traffic. Consequently, the net outcome is not a decrease in noise, but rather an increase, as is the case with Dublin Airport.

The community view on land use planning and management is that it is fundamentally ineffective at reducing the noise level.

Noise Abatement Operational Procedures

While there is potential for noise abatement procedures to be advantageous, in the case of Dublin Airport, the authority to implement noise-reducing procedures rests solely with the airport operator. Regrettably, this has led to the unsatisfactory situation of having no noise abatement operational procedures in place at Dublin Airport.

Without independent oversight to implement these measures communities like ours are left to hope that airport operators will voluntarily introduce them.

Operating Restrictions

For communities, implementing operating restrictions to limit overall numbers of flights appears to be the most impactful measure. However, within the framework of the balanced approach, it is considered the last resort. The balanced approach seems to serve as a methodology to enable airports to avoid implementing operating restrictions, rather than ever seriously considering their introduction.

For example, at Dublin Airport there are several operating restrictions that are in place as part of the mitigation measures which allowed the North Runway and other airport development to be granted permission. The restrictions in place at the moment are:

1. Total number of night-time flights at Dublin Airport shall be limited to 65 per night, night being defined as 23:00hrs to 07:00hrs
2. The North Runway shall not be used at night between the hours of 23:00hrs and 07:00hrs
3. The total number of passengers allowed at Dublin Airport is capped at 32 million per annum.

Although operating restrictions are intended to be enforced, in practice, they are not adhered to. In 2023, for instance, the average number of night flights stood at 115, with over 33 million passengers passing through Dublin Airport. Furthermore, the North Runway is frequently utilized at night for periods lasting 4-5 nights consecutively to facilitate maintenance work.

The DAA has pursued the removal of the 65-flight restriction and proposed its replacement with a noise quota system, which would permit unlimited night flights in the future. Additionally, they have sought to raise the passenger cap from 32 million to 40 million.

In essence, our communities are confronted with a situation where the balanced approach makes it arduous to introduce new operating restrictions, yet it provides a mechanism for existing restrictions to be lifted. This approach cannot genuinely be considered balanced, as it evidently favours airport operators and airlines.

Conclusion

SMTW and FORUM remain steadfast in advocating for our communities against the excessive noise generated by Dublin Airport. Our core objective is to hold the authorities governing Dublin Airport accountable and to campaign for compliance with all existing planning conditions and restrictions that the airport is obligated to adhere to. These include:

- Flight paths used at the airport should be those that were used to assess the environmental impacts in the Environmental Impact Assessment submitted as part of the North Runway planning permission. Any other flights paths must be considered as unauthorized until they have been assessed and approved by the planning authority.

- Night-time flights at Dublin Airport are restricted to a maximum of 65 flights per night. However, this limit is frequently exceeded, prompting the local planning authority, Fingal County Council, to issue an enforcement order demanding compliance with this condition. The airport's response has been to legally challenge the validity of the enforcement order and the condition itself. Our communities assert that the North Runway was only granted permission with the understanding that this night flight restriction would safeguard us from excessive nighttime noise. It is imperative that the night flight cap remains in place.

- Expansion of Dublin Airport beyond 32 million passengers must not be entertained until the issues surrounding flight paths and night flight conditions are resolved. Without resolution, any further expansion is untenable. When expansion is contemplated, a comprehensive independent review of noise levels and mitigation measures surrounding the airport must be conducted. For our communities, the airport has proven to be a poor neighbour, and any expansion should only proceed if noise mitigation measures are maximised for affected areas. Dublin Airport should be operated with the most effective noise mitigation measures in place, considering current understanding of the detrimental health effects of chronic exposure to aviation noise.

In conclusion, our experience with the introduction of a new runway at Dublin Airport has been disappointing. Communities have lost all trust in the airport authority's ability to uphold its promises regarding any future expansion plans for the airport. Nevertheless, we offer the following suggestions to all airport authorities on how they could improve engagement with the communities around their airports:

1. Present noise contours as maximum noise levels likely to be experienced, using single-mode representation, to accurately depict the real noise levels communities may expect.
2. Noise contour maps should undergo more rigorous validation, preferably by an independent body separate from the airport authority, responsible for creating and validating the contours.
3. The airport authority should hold public consultation events to present planned projects to the communities before any changes occur. This includes changes to flight procedures, expansion plans and physical infrastructure plans. Townhall meetings where representatives from the airport authority present this information and answer questions should be mandatory.
4. Noise mitigation contours should only be based on single mode contours and should not include potential future reductions at source until those reductions are clearly validated through measurements. Communities should not carry the risk that noise reductions at source fail to materialise or where reductions in noise from individual aircraft are offset by overall increases in traffic.
5. Noise monitoring should be conducted regularly to uphold noise contour validation and to investigate complaints effectively.
6. Complaints should not be directed to the airport authority and instead an independent body should be responsible for complaint management and investigation.
7. On going consultation regarding the operation of the airport and the impact on stakeholders, including community representation, should be mandatory.
8. Airport authorities should be mandated to continually review mitigation measures and assess their impact significance based on the most up-to-date knowledge available.

Finally, we conclude by pointing out that the Balanced Approach to aircraft noise is not balanced and clearly favours the continued expansion of aviation.

Survey of Aircraft Noise Abatement Strategies in the US.

By Eoin A. King and & Paul E. Slaboch

Editor's Note: This is a summary of an article originally published in the Noise Control Engineering Journal: King E.A, Slaboch P.E, Survey of aircraft noise abatement strategies in the US, Noise Control Engr. J. 71 (1), January-February 2023, copyright INCE-USA.

Introduction

Aircraft noise is generally considered one of the worst offenders amongst all environmental noise sources. It is often cited as a reason against airport expansion and is one of the most common complaints raised by residents living in the vicinity of airports [1]. Many different types of abatement measures can be utilized by airports to reduce the noise impact, but the manner of their implementation can vary between airports. To assess how noise control strategies are implemented across the United States, a national survey of noise abatement strategies was conducted.

This article provides a summary of this survey and reports the noise control approaches at 42 different airports across the United States. The survey considered general aspects of noise control, as well as specific questions related to noise abatement procedures, noise limits and curfews. Participants were also asked their opinion on the impact of the International Civil Aviation Organization (ICAO) Balanced Approach, which is the ICAO recommended framework to address aircraft noise.

The Balanced Approach

The concept of a balanced approach to aircraft noise management was officially introduced by the ICAO in 2001 [2]. The ICAO Balanced Approach has at its core a theme of sustainable development of air travel without adversely affecting the acoustic environment. It identifies four key actions for noise control:

1. the reduction of aircraft noise at source
2. land-use planning and management
3. noise abatement operational procedures
4. operating restrictions.

Its goal is to address aircraft noise problems in the most cost-effective manner possible.

In the U.S., the Federal Aviation Administration (FAA) formally accepted the ICAO guidance document on the Balanced Approach in an advisory circular in 2004 [3]. The FAA also requires each airport complete a 14 CFR §150 Noise Study (commonly referred to as FAR Part 150), which is a study prepared by an airport to define the five-year vision of compatibility between an airport and the surrounding communities. These regulations specify that airport operators must consider the aircraft noise and community noise around their regulated airfields. These planning documents guide much of the noise abatement procedures in the U.S.

This study aimed to assess how the balanced approach has been interpreted in the U.S. to determine whether it has influenced the adoption of different noise abatement strategies. With an understanding of what noise abatement strategies have been adopted, and whether or not U.S. airports adhere to the ICAO balanced approach, regulatory authorities can determine if a better approach to noise management could be implemented. To achieve this, a noise abatement survey was distributed to airport operators in the U.S.

Survey Method

The survey was hosted on SurveyMonkey.com, a web-based survey tool, that can collate responses once received, and allows individual responses to be downloaded for further analysis. Invitations were sent between January and February 2020, prior to the start of the COVID-19 pandemic. Airport operators were contacted via email addresses on file as well as through standard questionnaire boxes offered on individual airport websites. Having distributed the survey to approximately 300 airport operators, 42 responses were received. Most responses were received in February and early March, prior to travel restrictions related to the pandemic.

Table 1 lists airports from which responses were received, along with an overview of the daily operations, the number of operational runways and the location and distance from the city the airport is serving. Of these airports, seven are identified as Commercial Large Hubs as classified by the FAA included in the National Plan of Integrated Airport Systems (NPIAS) for 2021-2025.

*Table 1: Details of Airports Surveyed (details retrieved from [4]). Note: * indicates airport is a Commercial Large Hub.*

FAA Identifier	City Serving	Nearest City (miles)	Number of Runways	Daily Operations (approx.)
ABQ	ALBUQUERQUE, NM	3	3	309
AKR	AKRON, OH	4	2	139
ANC	ANCHORAGE, AK	4	3	717
BFI	BOEING-FIELD, SEATTLE, WA	4	2	502
BHM	BIRMINGHAM, AL	4	2	287
BNA	NASHVILLE, TN	5	4	447
BRL	BURLINGTON, IA	2	2	55
BUF	BUFFALO, NY	5	2	132
BZN	BOZEMAN, MT	7	4	248
CLT*	CHARLOTTE, NC	5	4	1090
CRP	CORPUS CHRISTI, TX	5	2	230
CVG	COVINGTON, KY	8	4	322
DAL	DALLAS, TX	5	2	505
DCA	WASHINGTON, DC	3	3	816
DEN*	DENVER, CO	16	6	1212
DFW*	DALLAS-FORT WORTH, TX	12	7	1941
EFD	HOUSTON, TX	15	3	240
FAI	FAIRBANKS, AK	3	4	312
GSO	GREENSBORO, NC	7	3	181
HPN	WHITE PLAINS, NY	3	2	275
HYA	HYANNIS, MA	1	2	179
IOW	IOWA CITY, IA	2	2	53
MCI	KANSAS CITY, MO	15	3	197
MCO*	ORLANDO, FL	6	4	1003
MIA*	MIAMI, FL	8	4	1140
MKE	MILWAUKEE, WI	5	5	185

FAA Identifier	City Serving	Nearest City (miles)	Number of Runways	Daily Operations (approx.)
OAK	OAKLAND, CA	4	4	651
OKC	OKLAHOMA CITY, OK	6	4	240
PBI	WEST PALM BEACH, FL	3	3	306
PDK	ATLANTA, GA	8	3	442
PDX	PORTLAND, OR	4	3	309
PIE	ST PETERSBURG-CLEARWATER, FL	8	2	392
PIT	PITTSBURGH, PA	12	4	295
PSP	PALM SPRINGS, CA	2	2	157
SDF	LOUISVILLE, KY	4	3	414
SEA*	SEATTLE, WA	10	3	1233
SLC*	SALT LAKE CITY, UT	3	4	944
STL	ST LOUIS, MO	10	4	329
SUA	STUART, FL	1	3	330
TEB	TETERBORO, NJ	1	2	236
TTN	TRENTON, NJ	4	2	269
TVC	TRAVERSE CITY, MI	2	2	152

Survey Results

Figure 1 summarizes the types of noise abatement procedures implemented at each airport. Measures surveyed included the use of:

- preferred arrival/departure routes, which are generally used to ensure aircraft avoid flying over noise sensitive areas in the vicinity of the airport
- modified approach angles, which can reduce the time an aircraft is flying at a lower altitude over a noise sensitive area
- displaced thresholds, which involve moving the runway thresholds from the extremity of the runway surface end to a location further down the runway (away from a noise sensitive area)
- minimized use of reverse thrust (the temporary diversion of an engine's thrust), a procedure that is sometimes used to slow the aircraft on landing
- other.

The most popular procedure is the use of preferred arrival/departure routes at 74% of airports surveyed. The next most common approach is the minimized use of reverse thrust, but this is only applied at 14% of airports. The "Other" category received 22 responses, of these three reported the use of voluntary curfews during the nighttime, which varies between 22:00/23:00 and 06:00. The others included bespoke approaches including, for example, a home noise abatement program, sound attenuation construction requirements for residential development per city ordinance, and a two-minute limit on nighttime ground maintenance run-up.

Fig. 1: Survey responses indicating the types of noise abatement procedures at each airport.

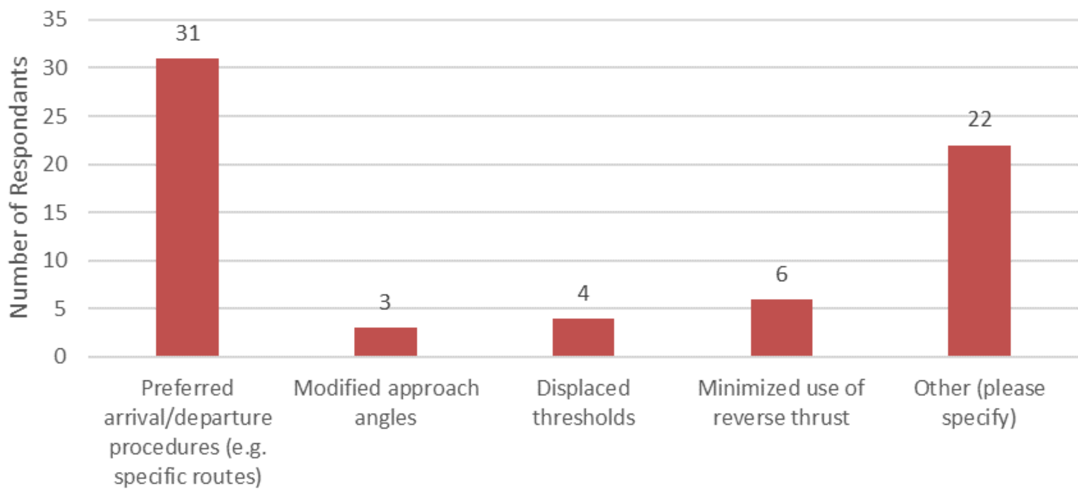


Figure 2 presents an extensive list of other noise considerations being implemented in the surveyed airports. Overall, it is quite evident that there is no single approach to noise control across the surveyed airports. The top five considerations include engine run-up restrictions (60% of airports surveyed), preferential runways (57%), avigation easements (53%), publicly available noise maps (47%), and regulations related to the development in vicinity of airports (45%). Eighteen airports considered both engine run-up restrictions, and preferential runways together. Only 1 airport surveyed imposes operating quotas, and only 2 airports impose noise charges. Two airports reported that none of the items listed in the figure are applied at their airport.

The analysis was then repeated using only the Commercial Large Hubs. With these airports a slightly higher level of consistency was observed. There were two specific actions that were implemented by 85% of these major airports; preferential runways and regulations related to development in the vicinity of the airport. Continuous descent arrivals are implemented in 3 of these major airports, and from Fig. 2, this means only 2 non-commercial hub airports surveyed implement this approach. No major airport implements noise curfews.

Fig. 2: Survey responses indicating range of noise related items in place at each airport (note for this analysis Commercial Large Hubs are identified).

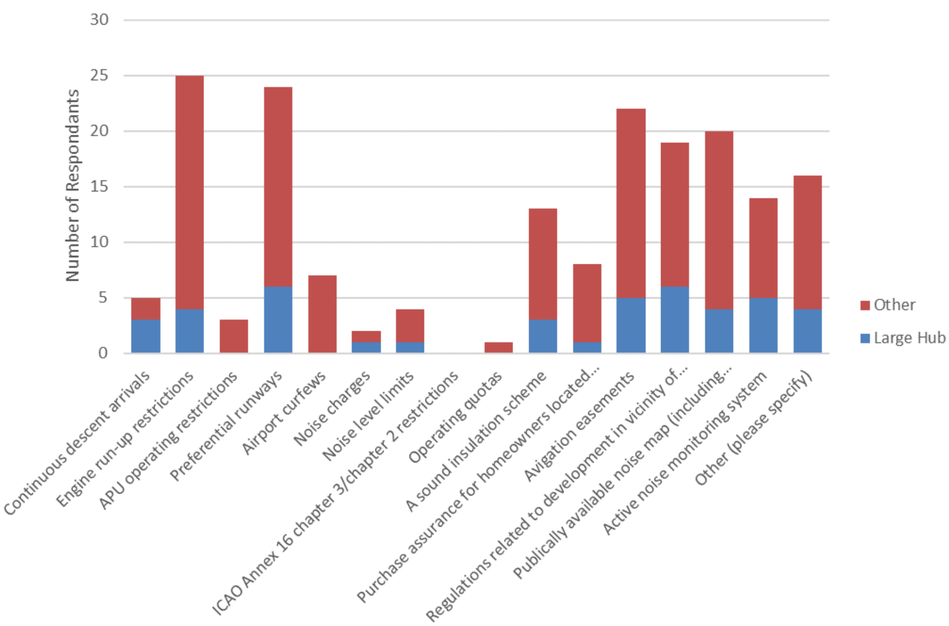
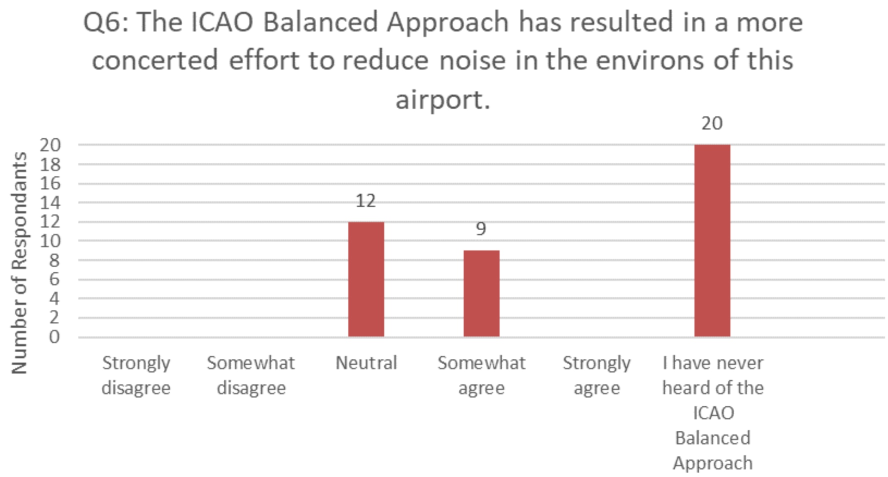


Figure 3 reports results on the general perception of the ICAO balanced approach across those surveyed. It shows that close to 50% of airport operators reported they were not familiar with the ICAO balanced approach. This could explain the lack of participation of some noise abatement procedures described above. Perhaps if airports were more aware of the ICAO balanced approach, they could be more open to mitigation tactics and implement them and reduce aircraft noise.

In the comments section of the survey, some airport operators explained that while they are familiar with the ICAO balanced approach, they follow a different noise abatement program as the "ICAO balanced approach is not standard". Further, external factors can impede the implementation of noise abatement procedures. One response noted that the approach "requires input from multiple parties", while another noted that "land-use planning and management is not always possible given local government, and operating restrictions are often impossible to implement". Intergovernmental agreements may also restrict noise abatement procedures as compliance must be maintained. One response identified that land-use planning and management is very difficult to implement given some local government policies along with operating restrictions; "Local land use controls continue to be an issue as the demand for housing continues to increase while the remaining green space is proximate to the airport. Also, the U.S. cannot restrict aircraft operations so only three legs of the four legs of the ICAO stool are available". Local land use jurisdictions seem to be unwilling to implement protective zoning against development of land near airports.

Fig. 3: Survey responses indicating attitudes to the ICAO balanced approach and its effectiveness.



Conclusions

Although just a snapshot of activities across the U.S. are presented, results indicate a wide array of noise abatement procedures are being implemented. Results also suggest that the ICAO Balanced Approach has yet to be fully embraced in the U.S., with a large proportion of respondents reporting that they are not familiar with this approach.

Further the study demonstrates that aircraft noise abatement is very much a local issue, with different approaches applied across the U.S. Additionally, there appears to be little consistency in the way noise limits and curfews are implemented. Finally, while it may be that a uniform approach to noise control across U.S airports is not appropriate due to varying local circumstances, and that such measures appear to be discouraged by the ICAO balanced approach, it seems that there is a need for uniform guidance on available measures.

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The Importance of LOw Lden Levels in the Number of People Highly Annoyed by Aviation Noise

By Nico van Oosten, Anotec Engineering, S.L., 18600 Motril (Granada), Spain, nico@anotecengineering.com

One of the main deliverables of the H2020 ANIMA project (2017-2020) was the definition and update of a common strategic research roadmap for aviation noise reduction, involving all key aspects related to mitigation solutions, assessment of noise effects on populations, and community engagement. To support this work, a toolchain was developed with which a variety of noise reduction scenarios could be assessed to provide a complete overview of the effect of the planned research and its possibilities of achieving the goals set by ACARE from the standpoint of environmental constraints [Ref. 1]

This toolchain was also used in the PHENOMENA study, performed in 2021 for DG-ENV, with the aim to assess the potential health benefits of noise mitigation measures in Europe [Ref. 2].

The toolchain used is built around SONDEO, an ECAC Doc29 compliant airport noise model, developed by ANOTEC for research and policy support studies [Ref.3]. The main characteristics of the toolchain are:

- Definition of two baseline aircraft platforms, representative for the short-medium range single aisle and long-range twin aircraft representative for the year 2000 technology (i.e., A320/A330 classic classes respectively). A spectral noise source database was developed for both platforms to be able to introduce noise reduction measures to various noise sources (jet, fan, airframe).

- Replacement of the actual fleet operating at 10 airports in Europe by an equivalent fleet, consisting of the above two baseline platforms. To this end the number of operations of the two baseline platforms were adjusted such that the total noise contours of both actual and equivalent fleets match as good as possible.

- Determination of the noise impact for a range of indicators, from total contour area to number of people exposed to a range of Lden and Lnight levels and calculation of the corresponding number of people Highly Annoyed (HA) and Highly Sleep Disturbed (HSD). The range of levels was extended downwards to 45 and 40 dB(A) for Lden and Lnight, respectively.

- Scaling up of the results for 10 airports to all 60+ EU27 airports covered by the Environmental Noise Directive (END) [Ref.4]. In this scaling process the results of the 2017 round of END strategic noise mapping have been used for validation.

The above-mentioned projects were directed towards calculating the effect of noise mitigation measures introduced in the aircraft, engines, and their operations. The benefits of such measures were expressed as a percentage of change with respect to a baseline case.

The first step in the process was therefore to establish the noise impact for the baseline case, for which the traffic for the year 2017 was used, as for this year the number of operations at all airports was known from the END results and the validation of the methodology was performed. Whereas for the mentioned studies this was just the starting point of further work, some of the results, however, already reveal an interesting situation, worth analyzing in some more detail.

[1] Amsterdam, Frankfurt, Copenhagen, Vienna, Dublin, Palma de Mallorca, Lisbon, Cologne, Budapest, Gothenburg

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The following table gives the resulting population distribution for the baseline case, for the various Lden level classes (see table 1).

Table 1: distribution of noise exposure levels for population within 45 dB Lden END contours around European Airports

Lden						
45-49	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**≥75**
53.3%	30.0%	12.5%	3.5%	0.6%	0.1%	0.0%

[1] Amsterdam, Frankfurt, Copenhagen, Vienna, Dublin, Palma de Mallorca, Lisbon, Cologne, Budapest, Gothenburg

The END requires the determination of the number of people exposed to Lden levels above 55 dB(A). When dividing the population exposed into "non-END covered" (i.e., lower than this threshold) and "END covered" the following results are obtained (see figure 1).

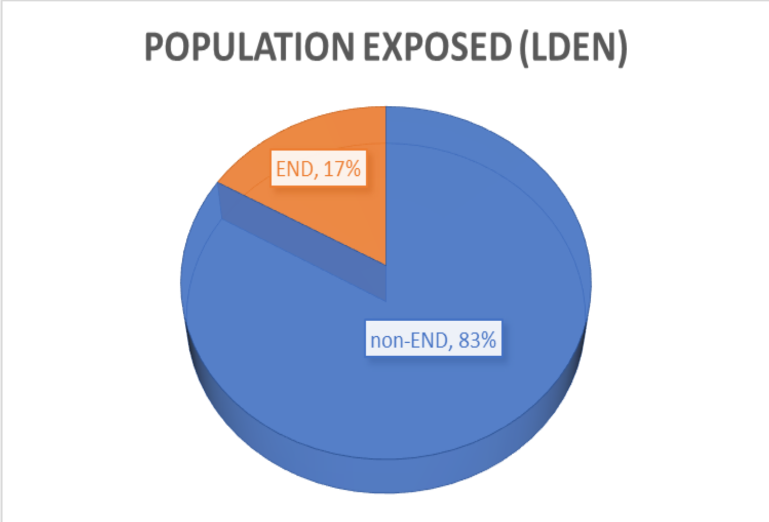

Figure 1: fraction of population within 45 dB Lden END contours around European Airports that is included (END) and is not included in END reporting (non-END)

It can clearly be seen that only a relatively small part of the population exposed to aviation noise (<20%) is covered by the END. In simple terms, this means that relatively few people are exposed to higher noise levels, and many people to lower noise levels. Obviously, the exposure to higher noise levels results in more harmful effects, but as fewer people are exposed, how does the combinations look like?

The formulas for the harmful effects of aviation noise, mentioned in Annex III to the END, provide the percentage of people Highly Annoyed (HA) as a function of Lden:

$$AR_{HA,air} = \left(-50.9693 + 1.0168 * L_{den} + 0.0072 * L_{den}{}^{2}\right) / 100$$

When considering a hypothetical population of four million people exposed to noise levels above Lden 45 dB(A), the following results are obtained (see Table 2).

Table 2: Number of people exposed and highly annoyed (HA) in corresponding Lden classes for European airports covered by the END

	Lden						
	45-49	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**≥75**
No people	2,133,333	1,200,000	500,288	139,778	22,464	4,015	121
AR	13.6%	22.3%	31.3%	40.7%	50.5%	60.6%	71.1%
HA	289,572	267,092	156,599	56,898	11,338	2,433	86
% pop	36.9%	34.1%	20.0%	7.3%	1.4%	0.3%	0.0%

Where:

- Nº people, absolute number of people in the corresponding Lden class
- AR, the % of people HA for the Lden class, based on the formula of Annex III
- HA, the absolute number of people Highly Annoyed (=Nº of people x AR)
- %pop, the relative contribution of the Lden class to the total number of people Highly Annoyed

When we again group according to "non-END" and "END," we obtain the following result (see figure 2).

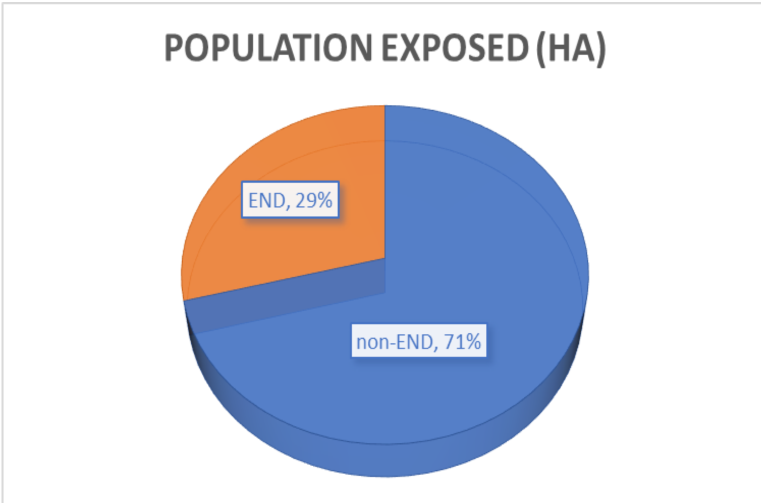

Figure 2: fraction of Highly Annoyed population within 45 dB Lden END contours around European Airports that is included (END) and is not included in END reporting (non-END).

From this, it can be concluded that considering the harmful effect (Highly Annoyed), the large amount of population exposed to lower noise levels "wins" from the small amount of people exposed to higher noise levels.

It is recognized that the prediction of the number of people exposed to lower noise levels comes with challenges with respect to its accuracy for various reasons (a.o. noise predictions less accurate due to e.g. long propagation distances, exact position of aircraft unknown at large distances from airport (direct routing above certain altitudes), etc.). Nevertheless, the difference between both groups "non-END" and "END" is so big, that even this inaccuracy is unlikely to change the general trend observed.

Until now, most efforts to reduce the noise exposure to aviation noise has been directed towards the reduction of the number of people exposed to high noise levels. If, however, the main goal of the noise policy shifts towards noise impact, i.e., minimizing the number of people Highly Annoyed and Highly Sleep Disturbed, it is recommended to broaden the geographical scope, by considering the areas where lower noise levels are expected.

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NOISE/NOTES

By Eoin A. King, NNI Editor

NNI is on Facebook and Twitter - we try to keep our readers informed with noise news from across the globe by highlighting interesting research and projects. Here is a roundup of some of the stories that have been making headlines. Follow @NNIEditor to stay up to date with all noise related news.

Reducing aircraft noise – one decibel at a time

A recent article in Horizon, the EU Research and Innovation magazine highlighted several research projects ongoing across Europe aimed at reducing aircraft noise. It notes that in Europe, 22 million people have "chronic high annoyance" because of environmental noise including from planes. But it points to the work of an EU-funded project called INVENTOR that is aiming to make landings in particular less intrusive for the inhabitants below. The focus is on the landing gear, the flaps at the back of the wings and the slats at the wing fronts. Separately, a now completed project, called DJINN, worked towards improving the simulation methods used by aircraft manufacturers to predict how loud their planes will be. It used advanced numerical methods and high-performance computing to predict fluid flows and improve the aerodynamic and acoustic performance of aircraft.

Unsafe Noise Exposure for the American Public

A recent POMA article calls on the FFA in the USA to take steps to reduce aviation noise exposure to prevent unnecessary illness and death in those people living close to airports and in overflight communities. It notes that, in response to the 1976 Aviation Noise Abatement Policy, the FAA adopted 65 dBA as the threshold of significant noise exposure, below which residential land uses are compatible. The Environmental Protection Agency, however, calculated that the safe noise levels for the public are DNL ≤55dB to prevent outdoor activity interference and annoyance and ≤45 dB to prevent indoor activity interference and annoyance.

Schipol Airport & Noise in the Courts

Euronews is reporting that a Dutch court has ordered the government to do more to cut noise pollution at Amsterdam's Schiphol airport. The Hague District Court has said that the government has systematically put the interests of the aviation sector above those of people who live near Schiphol Airport one of Europe's busiest aviation hubs, and that the treatment of residents amounts to a breach of Europe's human rights convention.

The Noise/News Podcast – Aircraft Noise

An old one but a good one: This podcast was first broadcast back in 2021 where we sat down with Dr. Graeme Heyes where the topic of the podcast was aircraft noise. The podcast can be listened to on INCE-USA's website here.

Some Background on Dublin Airport

In this special issue we heard from the resident groups around Dublin airport. The controversy around noise from Dublin airport has been in the Irish national news quite a bit recently. For those of you who are interested to learn more, our NNI Managing Editor recently wrote an explainer for Ireland National Broadcaster (RTE), which gives a broad summary of the issues surrounding the airport. You can read more here.

Noise Reductions from Blended-Wing Aircraft

To finish on a positive note – new research from the Swiss laboratory Empa, suggests that new blended-wing body (BWB) aircraft could significantly reduce noise pollution at airports. The study, which was published in Aerospace Science and Technology, evaluated the noise impact of the new type of blended wing aircraft, and people to rate their impressions of different "noise scenarios" played at the laboratory's AuraLab. It reports that "the perception-based evaluation of the BWB revealed that, while the BWB aircraft may initially be perceived as somewhat more unfamiliar, they are substantially less annoying than current tube-and-wing long-range aircraft of similar range and mission for take-offs as well as for landings". Further, for the best BWB variant, noise annoyance was reduced by 4.3 units for departures and by 3.5 units for approaches. The main reason for these findings seems to be the acoustic shielding by the body of the extended fuselage, which was found to be an important factor in reducing sound levels in the order of 10–20 dB.

See What's Inside NCEJ


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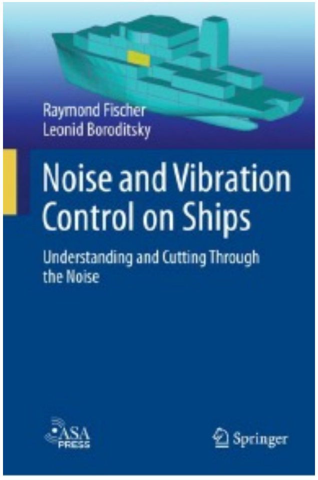
Book Review



Noise and Vibration Control on Ships Understanding and Cutting Through the Noise

Authors:
Raymond Fischer - Retired, Billerica, MA
Leonid Boroditsky - Retired, Canton, MA

- Reflects the authors' experience of consulting on hundreds of vessels
- Represents the first book devoted to controlling noise and vibration in ship environments
- Provides a complete guide from acoustics fundamentals to design principles and compliance testing

This book provides a guide for the marine community to understand and address the noise and vibration environment associated with ships. Controlling noise and vibration in an effective and optimal manner requires a comprehensive understanding of all the ship systems that are involved in achieving a quiet vessel. While there are numerous published articles addressing various components of shipboard noise and vibration, this represents the first comprehensive book on the subject.

Beginning from the basic acoustics of noise and vibration, it builds to more complex considerations in undersea sound, ship design, and compliance. The book provides an understanding of the 'source-path-receiver' modelling of shipboard noise and vibration. It delivers an overview of how to select and optimize both noise and vibration control treatments along with design guidance and methods to demonstrate compliance with acoustic regulations. It reflects the knowledge gained by the authors consulting over 40 years each on hundreds of vessels, and represents an invaluable resource for ship builders and marine engineers.

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- **AUGUST 25-29, 2024**
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