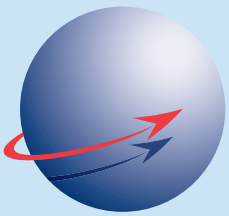
Managing the Impacts of Aviation Noise

A Guide for Airport Operators and Air Navigation Service Providers





Published September 2015

Contents

A Joint Publication of the Civil Air Navigation Services Organisation and Airports Council International

Foreword page 4
Introduction page 5
Acknowledgements page 5
Executive Summary page 6

1 Environmental context page 7
1.1 Sustainable Development page 7
1.2 Economic and Social Benefits page 7
1.3 Projected Growth page 7
1.4 Noise and Aviation Growth page 8
1.5 Environmental Impacts of Aviation page 8
2 Quantifying Noise page 10
2.1 Defining Noise page 10
2.2 Modelling Noise page 10
2.3 Aviation Noise Metrics page 11
2.3.1. Single Event Based Noise Metrics page 11
2.3.2. Time Based Noise Metrics page 12
2.3.3. Threshold Based Metrics page 13
2.3.4. Track Based Measures page 13
3 Noise Considerations for Environmental Impact Assessment page 14
3.1. Changes to Airspace Procedures page 14
3.2. Noise Assessments page 15
3.3. New Airport Infrastructure page 17
3.4. Interdependencies page 17
3.5. Social and Economic Impact Assessment page 17
4 ICAO's Balanced Approach page 18
4.1. Reduction of Noise at Source page 18
4.2. Land Use Planning Principles page 18
4.3. Noise Abatement Operational Procedures page 19
4.4. Operating Restrictions on Aircraft page 21
4.5. Community Engagement page 21
5 Land Use Planning page 22
5.1. Supporting Land Use Planning Decision Making page 22
5.2. Using Airport Noise Metrics page 22
5.3. Graduated Schemes page 23
5.4. Protecting Airport Resources page 23

© Copyright CANSO 2015

All rights reserved. No part of this publication may be reproduced, or transmitted in any form, without the prior permission of CANSO. This paper is for information purposes only. While every effort has been made to ensure the quality and accuracy of information in this publication, it is made available without any warranty of any kind.

www.canso.org

6 Noise Abatement Procedures and Technologies page 24
6.1. General Considerations page 24
6.2. Arrival Procedures page 26
6.2.1. Continuous Descent Operations page 26
6.2.2. Tailored Arrivals page 29
6.2.3. Increased Angle Approaches and Displaced Threshold page 30
6.2.4. Two-Segment (Double-Slope) Approaches page 30
6.2.5. Advanced Arrival Procedures page 31
6.3. Departure Procedures page 36
6.3.1. Continuous Climb Operations page 36
6.3.2. Precision Based Navigation Departures page 36
6.3.3. Noise Abatement Departures page 36
6.4. Other Procedures page 39
7 Airport Initiatives and Responsibilities page 42
7.1. Landing Fees page 42
7.2. Noise Monitoring and Reporting page 42
7.3. Complaint Management page 43
7.4. Other Noise Management Techniques page 43
8 Community Engagement page 45
8.1. Key Factors page 45
8.2. Recommended Actions page 45
8.2.1. Communication page 46
8.2.2. Collaboration page 46
8.2.3. Community Projects page 48
8.3. Key Principles page 48
8.3.1. Transparency page 48
8.3.2. Community Input page 50
8.3.3. Trust page 50
8.4. Other Considerations page 50
9 Conclusion page 52
10 References page 53
Acronyms page 56

Case Studies:

1. Use of noise modelling tools page 16
2. Stakeholder collaboration – Airbus, Heathrow and NATS partner for quieter flight page 20
3. Continuous descent operations campaign in the UK page 27
4. Using PBN to reduce airport to reduce noise – Greener Skies of Seattle page 34
5. "Smart Tracking" at Gold Coast Airport page 35
6. Changing a standard departure to reduce noise page 40
7. Community collaboration to reduce departure noise – Melbourne Airport early turns page 41
8. Heathrow, Gatwick, and Stansted quota count system page 44
9. WebTrak – an aircraft noise website page 47
10. Noise respite trials in the UK page 49
11. Working with a community to adjust noise – Roleystone arrival flight path trial page 51

Foreword

The aviation industry has achieved substantial and measurable reductions in noise over the last 50 years through a mixture of airframe and engine technology and operational efforts. But the problem still exists and has resulted in increasingly vocal and influential action groups, drawn from those living around airports, calling for measures to limit aircraft operations and limits to future growth on the ground and in the air.

The industry needs to address these continuing concerns if it is to maintain its licence to operate and if aviation is to maintain the support of governments and the general public. The industry must do more - work collaboratively, pool its collective ingenuity and innovative capabilities - to develop solutions that address the noise challenge.

It is against this backdrop that the Civil Air Navigation Services Organisation (CANSO) joined with Airports Council International (ACI) to develop this vital best practice guidance. The document provides information, practical advice and guidance for reducing aviation noise, especially for communities near airports. Throughout the guide the technical and operational realities of deploying noise solutions are discussed, but importantly they are also brought to life with real world examples and cases studies of successful implementation. The aim is to provide ANSPs and airports worldwide a template for action.

While the guide's primary focus is airports and ANSPs it also provides useful information to other aviation stakeholders, including aircraft operators, regulators, and the general public, highlighting the need for broad coordination on noise management to enable current operations and future growth with the establishment of trust at its core.

Noise is a local issue that can be addressed by sharing of global best practice. This document provides airport operators, ANSPs and other stakeholders with the tools to take further action on this vital issue for our industry.



Angela Gittens
Director General, ACI World



Jeff Poole
Director General, CANSO

Introduction

There are almost 1400 airlines operating worldwide flying over 25,000 commercial aircraft, large and small, that move 3.3 billion passengers annually through airspace managed by 173 air navigation service providers between 3900 airports [1]. By 2032 the industry is forecast to have over 41,000 aircraft flying 6.6 billion passengers [2].

While aviation delivers these positive global social and economic benefits, aviation noise has an impact on local communities and negatively colours public perceptions of the air transport industry. It is this environmental issue that is most likely to mobilise a local community and give rise to operational restrictions, constraints and airport project delays. These local impacts are significant and the aviation industry is committed to addressing them in a positive way.

To address the problem of noise, this guidance document sets out the noise management challenges faced by the aviation industry, offers guidance to air navigation service providers (ANSPs), airport operators and other key stakeholders to understand and reduce the impact of aircraft noise at an airport. Successful use of this guidance requires collaboration by these stakeholders. When new procedures are being contemplated at an airport, both the airline operators and the local community must be included.

Separately or preferably jointly, ANSPs and airport operators have a variety of ways to influence aviation noise levels. While ANSPs can influence aircraft flight paths and their use, the role of the airport operator is generally to coordinate and align all stakeholders to ensure implementation of the best combination of noise mitigation measures.

By outlining the ways that air navigation and airport entities can collaborate to manage aircraft noise impacts, this document seeks to guide aviation stakeholders to work together and with local communities to mitigate aircraft noise impacts. While this guide provides useful information to other aviation stakeholders, including aircraft operators, regulators, and the general public, its primary focus is on actions within the responsibility of ANSPs and airport operators. It highlights the need for wider aviation industry coordination on noise management to enable future growth.

This document is a joint publication of the Civil Air Navigation Services Organisation (CANSO) and Airports Council International (ACI). It was developed by the Environmental Workgroup (ENVWG) of the CANSO Operations Standing Committee (OSC) and international contributors from ACI based on extensive expertise and experience of several members.

Acknowledgements

The authors would like to thank the leadership of both international organisations for recognising the need for and supporting the development of this guidance document.

We also want to acknowledge the valuable contributions to this document from Paul Zissermann (Airservices Australia), Ian Jopson (NATS), Douglas Stoll (Boeing), Xavier Oh (ACI) and Mary Ellen Eagan (HMMH), as well as the valuable contributions from other ACI and CANSO Environment Workgroup members.

Executive Summary

This guidance document examines the challenge of aviation noise and describes methods that airport operators and ANSPs can use to engage effectively with key stakeholders to manage and reduce its im0pact. Interactions with communities are discussed as a means to aid decision-making. In addition, the guide describes noise mitigation measures that can be collaboratively implemented by ANSPs, airports and aircraft operators.

This document reviews and discusses the following topics:

The importance of reducing noise for affected communities, not only because it is the right thing to do, but also for maintaining the industry's licence to operate and grow. With local communities having increasing influence on planning and environmental decisions by national and local governments, the industry must address their concerns.

What is meant by aviation 'noise', the many different ways by which it can be measured, and some of the most common noise metrics now in use. The guide examines several practical tools for modelling noise around airports.

The place of noise in airport environmental impact assessments along with the issues and interdependencies associated with considering noise in the assessment. The guide stresses the importance of producing metrics that are appropriate for communication to regulators and local communities.

A review of four current approaches for managing noise: reducing noise at the source, land use planning, noise-reducing operational procedures, and operating restrictions. We also highlight why an additional approach involving community engagement is now vitally important.

An examination of land use planning to ensure that land is not developed for uses that are incompatible with current or likely future aircraft noise impacts. The guide describes ways of using noise metrics in the decision-making process.

Operational procedures and technologies that can be implemented with stakeholder collaboration to reduce community noise. These include techniques such as tailored arrivals, continuous descent operations, arrival or departure path alternation and managing thrust.

Ways in which airports can take steps to encourage less noise. These include actions such as reduced landing fees for quieter aircraft, monitoring and publishing noise impacts on local communities, complaints management system and response, and implementing quotas to limit, for example, the amount of noise at night.

The importance of engaging with local communities for balancing aviation sustainability with the needs of the community. The guide provides key principles and recommended actions for better community interactions, including effective communication, transparency and education.

Eleven case studies highlight actual experience in dealing with airport noise issues along with solutions and examples of stakeholder collaboration essential to reduce the impact of aviation noise.

1
Environmental Context

1.1 Sustainable Development

Sustainable development requires the reconciliation of environmental, social and economic demands – considered as the "three pillars" of sustainability. Sustainability is about minimising the adverse effects to the environment while maximising the social and economic benefits. For the aviation industry, economic benefits are greater than the transportation of goods and people. They include increased community job creation, along with local business and tourism activity. Social benefits include the fostering of international relations and social mobility.

Environmental stewardship includes the preservation of resources such as air, water and land quality.

This approach allows a broader view of the social and economic benefits as well as the environmental impacts of aviation and the development of an appropriate balance between the three.

1.2 Economic and Social Benefits

Transporting people and goods by air stimulates substantial economic activity and social benefits. To meet the increasing demand for air transport, the industry must continue developing infrastructure and system capacity in a sustainable manner. ANSPs and airport operators are key to enabling these changes.

Aviation is an important contributor to global economic and social development, particularly in the developing world. The aviation industry directly employs over 9 million people globally, and supports an additional 49 million jobs. It provides over $2.4 trillion in economic impact, supporting 3.4 percent of global gross domestic product (GDP). Air transport carries 0.5 percent of world trade by volume, representing 35 percent of world trade by value, valued at $6.4 trillion in 2014 [2].

Apart from the direct social benefits of employment generated by the aviation industry, air transport contributes to sustainable development by facilitating tourism, generating economic growth and improving living standards.

Increasing rates of international travel shows how closer relationships are developing between countries, particularly as expatriates and immigrants travel back to their homes to visit relatives. Increased mobility of goods and people across borders improves the development of social and economic networks with long term positive effects. This flow of people and goods benefits both the host and the originating countries, encouraging social and economic integration.

Aviation's speed and reliability are most appreciated when urgently needed assistance is required during emergencies caused by natural disasters or famine.

1.3 Projected Growth

The global aviation industry has grown rapidly over the last thirty years. In 1980, airlines carried around 1 billion passengers and by 2014, this number had tripled. This growth has not been universally welcomed, with concerns expressed about the noise and environmental impact of aviation. In recent years public opposition to airports and aviation noise has become significantly more vocal.

Aviation growth is expected to continue most notably in Asia and the Indian subcontinent. Aircraft departures will increase from 37 million in 2014 to about 60 million flights per year by 2030 [2, 3]. By 2034, the number of new aircraft

operating throughout the world is estimated to be between 32,585[1] and 38,050[2].

1.4 Noise and Aviation Growth

The aviation industry recognises that the successful management of aircraft noise is becoming increasingly critical to aviation growth in many regions of the world and is key to the context of sustainability.

For an airport operation, permission for future growth usually comes in the form of planning approval and building consents for infrastructure from local or central government. In most jurisdictions, public consultation requirements mean that expansion proposals require community support, acceptance and buy-in. This requires the airport authority, the regulatory bodies for aviation and environment – and the wider aviation industry – to demonstrate a long-term commitment to environmental protection for the community and to show that growth will not lead to unmanageable adverse environmental impacts – including noise impacts. By presenting a case for growth while considering the need to provide for future generations, the approval process should include consideration of the social and economic need and benefits of airport growth, while adequately addressing all potential environmental impacts during both construction and operational phases.

The consequences of an airport authority not demonstrating a commitment to environmental protection and the community can be significant. Community opposition to airport expansion could lead to the rejection of applications for airport growth, delays for approved projects, regulatory constraints on certain activities or operational limitations (such as aircraft movement quotas or operational curfews). Such opposition, delays and restrictions could have negative social and economic impacts, where the full growth potential of airport operations are not realised.

1.5 Environmental Impacts of Aviation

While this document focuses on aviation noise and how it can be managed from an airport and ANSP perspective, this cannot be done in isolation. Interdependencies between airport and aircraft operational choices that impact community noise and local emissions often require analysis and stakeholder coordination prior to implementing any changes.

The aviation industry has a long history of improving fuel efficiency and safety while simultaneously reducing noise. In the past 50 years, the industry has improved its fuel efficiency by over 80 percent. With demand for air transport projected to double over the next 30 years, the aviation industry has set a road map with three ambitious targets for managing the emissions from the aviation industry including:

1. An average 1.5 percent per annum fuel efficiency improvement for the global fleet, based on aircraft technology, fleet renewal and operational improvements;
2. Carbon-neutral growth from 2020, capping the net CO_2 emissions from aviation; and
3. By 2050, net aviation CO_2 emissions to be half of what they were in 2005 [4].

In a similar way, Figure 1 shows that significant improvements in airframe technology and engine innovations have led to modern jet aircraft that are 55 decibels (dB) quieter than the first models that entered service in the 1960s. In an effort to continue reducing aircraft noise, industry sets periodic noise certification standards for new production aircraft. These are documented in ICAO Annex 16 *Environmental Protection, Volume I Aircraft Noise* [5]. Each new standard is a new chapter in the Annex which is reflected in Figure 1 on the next page. Each new generation of aircraft continues this downward trend. Figure 2 on the next page depicts airport noise contours over time showing that, even with increased daily operations, the area of equal noise continues to get smaller [6].

[1] Airbus Global Market Outlook 2015-2034, www.airbus.com/company/market/forecast/

[2] Boeing Current Market Outlook 2015-2034, www.boeing.com/commercial/market/

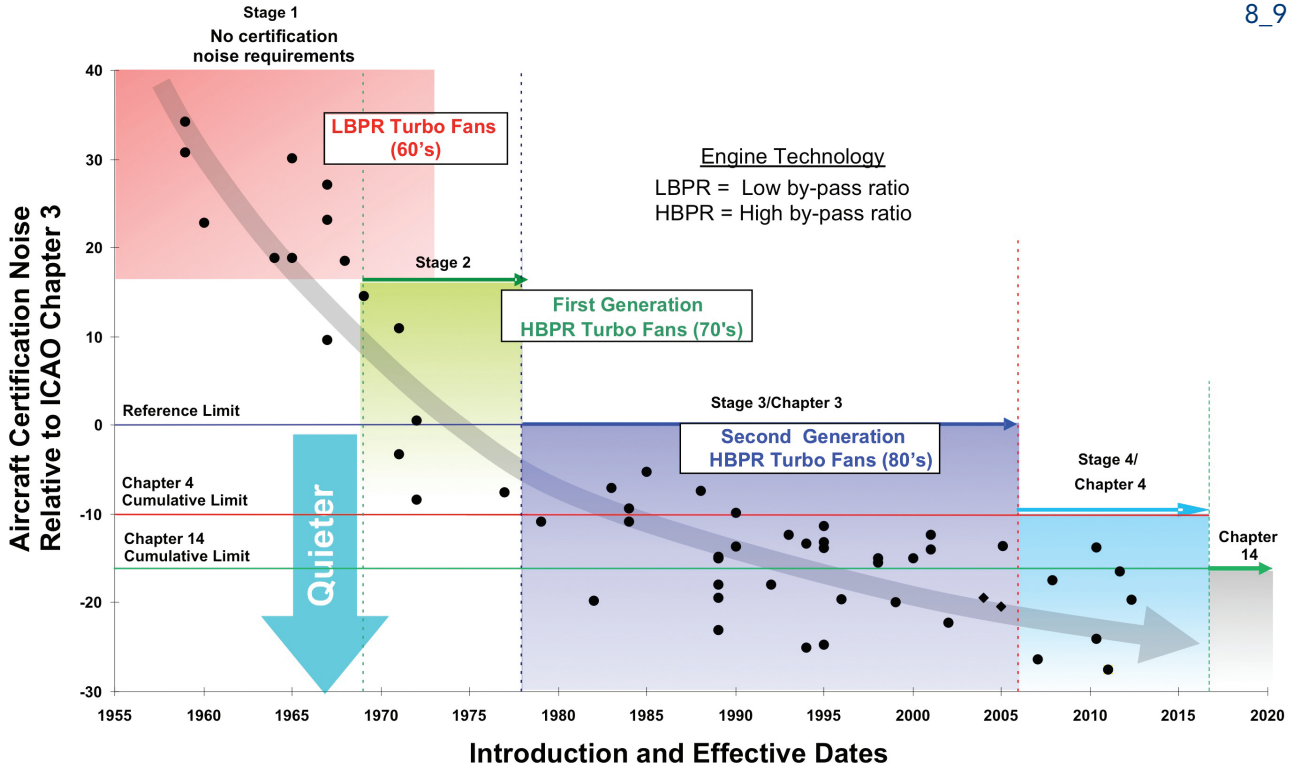


Figure 1 – Progress in commercial aircraft noise reduction, 1955-2015 (Source: Boeing)

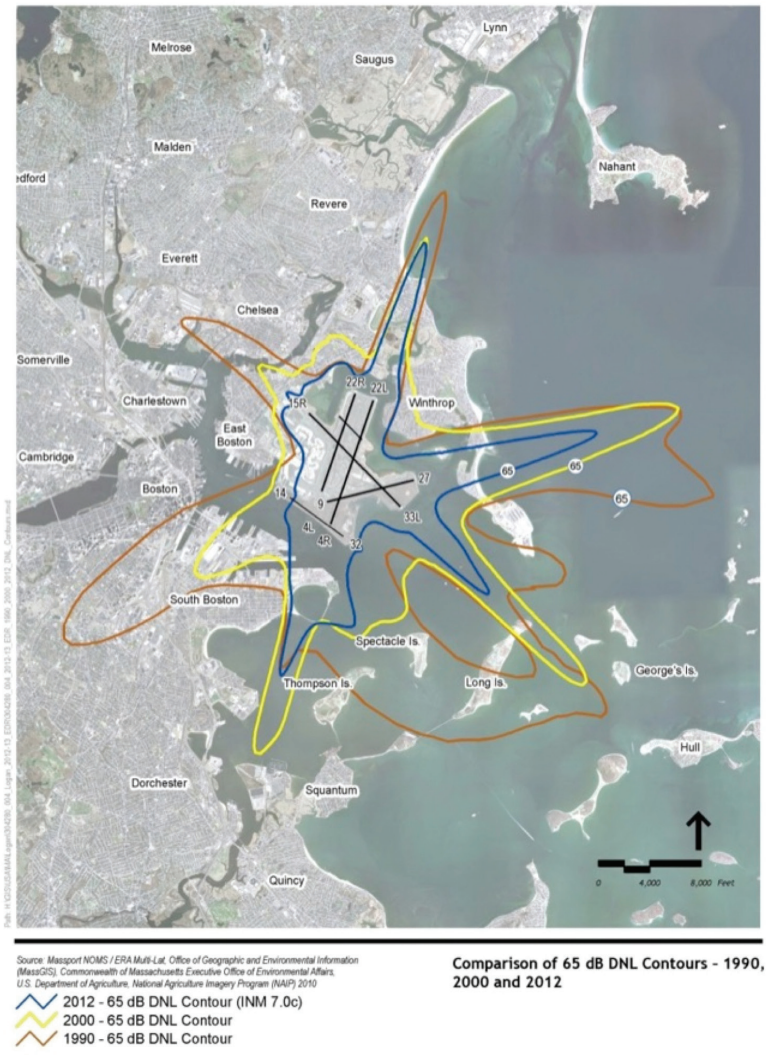


Figure 2 - Comparison of airport noise contours from 1990-2012 at Boston Logan Airport (Source: Commonwealth of Massachusetts Office of Environmental Affairs)

2
Quantifying Noise

Assessment of aircraft noise is relevant in the context of carrying out an environmental impact assessment and designing acceptable noise management policies. Measuring or quantifying aircraft noise can be done by direct measurements with calibrated noise microphones or with high-fidelity simulations. This section provides a quick review of the basics of acoustics before defining a few of the broad range of metrics available to describe aviation noise. We then provide guidance on how noise assessments should be carried out and communicated. Further definition on noise assessment can be found in ICAO Doc 10031 *Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes* (2014) [7].

2.1 Defining Noise

For the purpose of sound level measurement, noise can be defined as unwanted sound that can cause annoyance, sleep disturbance, speech interference, distraction and at extreme levels, noise can lead to health related issues such as hearing loss.

Sound level is measured in decibels, which is a logarithmic scale (based on powers of 10) useful for expressing the vast range of sound levels humans can hear. The decibel scale encapsulates the energy of sound with reference to a specific sound level – the threshold of hearing.

The noise level perceived by the human ear is also affected by the frequency content of the sound. The human ear can hear sound from 20 to 20,000 Hertz (Hz) but is most sensitive to sound in the range of 2,000 to 5,000 Hz. Sound level metres that mimic the human frequency response measure what is called an '*A-weighted*' sound level known as dBA. This is the metric used when measuring, modelling and communicating aircraft noise levels. Normal conversation is generally at 60 dBA.

For those conducting airport noise assessments, specific noise level data by aircraft type should be obtained from an authoritative source such as the EUROCONTROL *Aircraft Noise and Performance (ANP) database*, an international online data resource detailing aircraft noise for all certified airplane types [8].

2.2 Modelling Noise

Several tools exist for modeling aircraft noise around airports. The Federal Aviation Administration (FAA) makes the Integrated Noise Model (INM) available to evaluate aircraft noise during defined operations around airports [9]. This model is based on the recommended calculation method documented in ICAO Doc 9911 Recommended Methods for Computing Noise Contours Around Airports and provides noise contours or sound level estimates at specific locations [10]. The next level of environmental analysis from the FAA replaces INM for aircraft operations with the Aviation Environment Design Tool (AEDT). Version 2.b of AEDT was released in May 2015 with improved noise tools for analysts [11].

The ANP database is maintained by EUROCONTROL and is publicly available following registration at www.aircraftnoisemodel.org. This online database provides the necessary data (noise and performance characteristics of specific aircraft types) to compute noise contours around airports. Recommended best practices for aircraft noise modeling is also found in in ICAO Doc 9911 Recommended Methods for Computing Noise Contours Around Airports and European Civil Aviation Conference (ECAC) Doc 29 Report on Standard Method of Computing Noise Contours Around Civil Airports, 3rd Edition [12]. Care must be taken to ensure that the aircraft procedures modelled agree with those in use operationally; otherwise the modelling may produce results that significantly differ from noise measurements.

Within the context of the SESAR Research and Innovation programme, EUROCONTROL has developed IMPACT, an integrated aircraft noise and emissions modelling platform that supports both aircraft noise and fuel burn/emissions assessments[3] [13]. The noise assessment part is performed using the noise calculation core engine of STAPES (SysTem for AirPort noise Exposure Studies), the multi-airport noise model developed by EUROCONTROL under contract to the European Commission[4].

Both the IMPACT input data pre-processor and the STAPES noise calculation core engine are fully compliant with the recommended calculation method documented in ICAO Doc 9911 and ECAC Doc. 29, 3rd Edition.

2.3 Aviation Noise Metrics

There are several types of noise metrics used in aviation which are useful to airport operators and regulators but may have limited use for communicating with the public (see Section 8.3). It is important to consider this when publicly reporting metrics.

Metrics can be designed to provide answers to common questions: how many aircraft noise events can be expected? How loud will they be? What will average noise levels be and what respite can be expected? The metrics described here can be used to make a quantitative assessment of a proposal to help answer these questions.

The way noise is described, or 'noise metrics', can be confusing and at times misleading to those who do not have an understanding of acoustics. Aviation related noise metrics generally fall into three broad categories:

- Single event based metrics which measure individual aircraft noise over a short period of time
- Time based metrics that tend to average over long periods of time and
- Threshold metrics which examine the number of times a noise threshold is exceeded over a period of time.

2.3.1 Single Event Based Noise Metrics

As their name suggests, these metrics measure single events such as the maximum noise level (LMax), the sound exposure level (SEL) of an event, and the effective perceived noise level (EPNL) of an event.

- L_{Max} (sometimes referred to as LAmax) is one of the most commonly used metrics to describe a single noise event, such as an aircraft fly over (see Figure 3 on the next page) and describes the maximum sound level generated during the event.
- SEL (sound exposure level). To account for the 'annoyance' of both the magnitude and duration of a noise event, the SEL metric was developed. Many people report a noise event with a longer duration as sounding 'noisier', even though it has a lower maximum LMax level (Figure 3). SEL is a one-second long steady level that contains as much energy as the varying level over the entire event duration.
- EPNL (effective perceived noise level) is similar to SEL but uses a 10 second reference instead of one second and includes weightings for tonal elements.

Noise contours can be drawn to show the physical scale (geographic area) of exposure to these metrics with the level of change that result from a new procedure.

[3] A key characteristic of this modelling platform is to allow the consistent assessment of trade-offs between noise and fuel burn / gaseous emissions thanks to a common aircraft performance model based on a combination of the Aircraft Noise and Performance (ANP) database and the latest release of EUROCONTROL's Base of Aircraft Data (BADA 4).

[4] With technical support from the European Aviation Safety Agency (EASA) and the United Kingdom's Civil Aviation Authority (UK CAA). STAPES is jointly owned by EUROCONTROL, the European Commission and EASA.

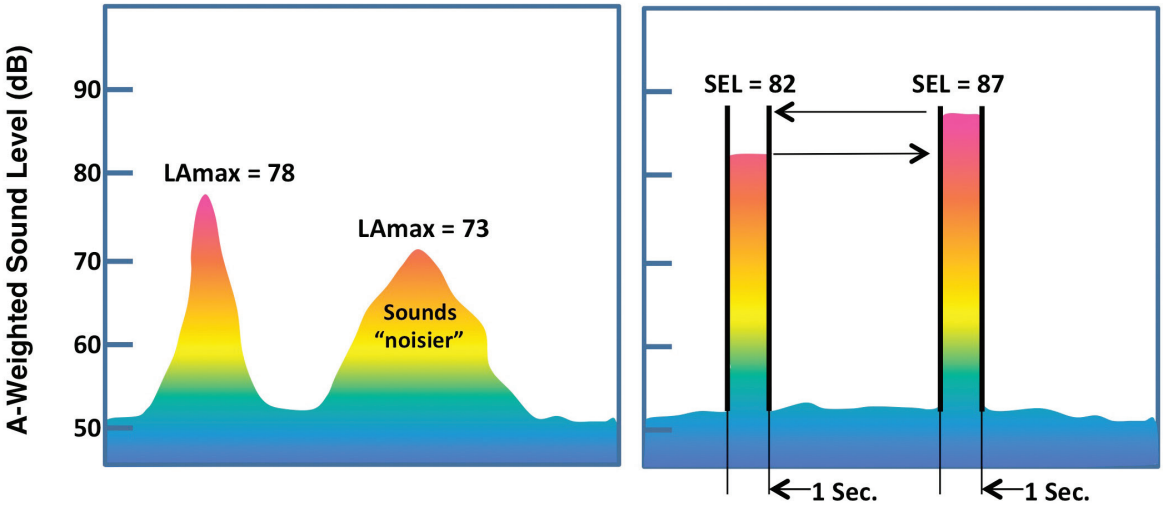


Figure 3 - L_{Max} measurements of different noise durations and the corresponding SEL measurements (Source: Boeing)

2.3.2 Time Based Noise Metrics

Time-based metrics are averaged over a period of time. These indicate the average noise level over a defined period. For aircraft noise, it might be averaged over one hour, an evening period, or even over longer periods such as three months or a year.

- **LAeq.** The A-weighted average sound level at a location over a period of time; it is the constant sound level with the equivalent energy of the actual time-varying sound over the same period. A similar LAeq level could be derived from several loud noise events with respite in between them or a lower level of continuous noise.

- **Weighted or Cumulative Noise levels.** Some noise metrics are averages with penalties (or weightings) applied to noise events that occur during night time or evening periods.

  - **DNL (or Ldn).** *Day night average sound level* is used in the U.S. The DNL is the average equivalent sound level over a 24 hour period, with a penalty added for noise during the hours of 22:00 to 07:00. During the nighttime period 10 dB is added to reflect the impact of the noise.

  - **Lden.** *Day-evening-night equivalent level* is used primarily in Europe. The A-weighted, Leq noise level measured over the 24 hour period, with a 10 dB penalty added to the levels between 23.00 and 07.00 hours and a 5 dB penalty added to the levels between 19.00 and 23.00 hours to reflect extra sensitivity to noise during the night and the evening.

  - **NEF.** *Noise Exposure Forecast* was developed to predict the degree of community annoyance from aircraft noise on the basis of various acoustical and operational data. It is applied to determine acceptable levels for various community zoning regions. NEF is based on effective perceived noise levels for various aircraft and considers all aspects of flight operations and time of day.

— **ANEF.** *Australian Noise Exposure Forecast*. The ANEF system was developed as a land use planning tool aimed at controlling encroachment on airports by noise sensitive buildings. ANEF uses a weighting for the period 19:00 - 07:00 to correlate noise exposure and community reaction.

2.3.3 Threshold Based Metrics

These metrics count the total number of times a defined noise threshold is exceeded in a specified time period such as 24 hours. Thus N60 or N70 counts the number of noise events exceeded 60 or 70 dBA over a day. In addition to a number above metric such as N70, a T70 metric measures the total amount of time during a specific period when aircraft noise exceeds 60 dBA such as from 23:00 to 7:00. Some airports are finding that these metrics are better for communicating noise impacts with local communities.

2.3.4 Track Based Measures

Track based measures indicate where aircraft flights are generally occurring.

— **Track density,** while not an indication of noise levels in itself, by showing the frequency a particular flight path is used can help communities understand the impacts of a change, as in Figure 4. If possible, the map should show the full width of a flight path, so that it is clear that aircraft can be expected anywhere within a wide corridor, not just along a tightly defined line.

— **Number of flights,** this measure counts the number air aircraft crossing over a particular geographic region over a period of time.

— **Respite periods** provide a measure of the number of hours or days per week (or month) when a specific community will not be directly overflown during certain periods. NATS and Airservices Australia have implemented a rotating block of airspace to provide a periodic respite to the inhabitants.

Each of these criteria focuses on a slightly different characteristic of noise exposure and should generally be used in combination when carrying out an assessment.

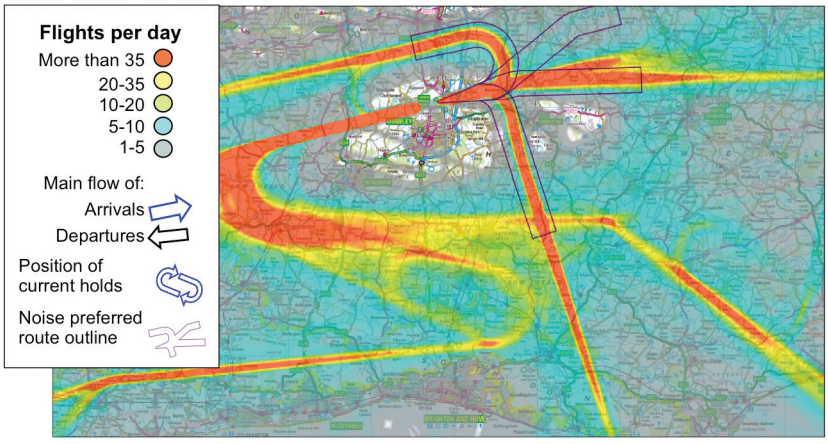


Figure 4 - Typical track density plot (Source: NATS, Gatwick Airport Runway 08 Operations)

3
Noise Considerations for Environmental Impact Assessment

This chapter focuses on the aspects of noise relevant to noise management during an environmental impact assessment (EIA). We also give guidance on how noise assessments should be carried out and communicated. Specific methodology for these assessments can be found in ICAO Doc 10031, *Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes* with Appendix B-2 describing noise assessment and metrics **[14]**.

3.1 Changes to Airspace Procedures

The introduction of more efficient flight routes and climb and descent profiles made possible by airspace changes such as performance-based navigation (PBN) can substantially reduce fuel consumption and associated air emissions. The noise impacts of PBN procedures are localised. Concentrating aircraft arrivals and departures in noise tolerant corridors has always been a staple of noise compatibility planning. Historically, the ability to keep aircraft in noise abatement corridors has been complicated by difficulties in defining the corridors so that pilots could easily stay within them.

The involvement by airports in the design of PBN procedures, and the recognition by ANSPs of the priority of PBN in its planning process, are critical components to ensure that PBN implementation addresses desired airport benefits while also minimising impacts of noise. Changes to existing airspace procedures should include appropriate noise metrics, while addressing the community's expectations for environmental benefits and review.

It should be recognised that not all communities will associate PBN with an improvement to the noise situation. Although PBN can improve safety, enhance airport capacity and reduce the environmental impact (greenhouse gas emissions) of aircraft through reducing the distance flown, PBN routes may cause some communities to be affected by a change in noise patterns or an increased concentration of noise in certain areas.

Resolution A37-11 from the 37th ICAO General Assembly in 2010 urged all States to implement routes and airport procedures in accordance with the ICAO PBN concept. Mandates for PBN implementation are being prepared for some areas of the world that will define the functionalities and procedures required for en-route and terminal airspace, including for approach and departure routes. Mandates put pressure on airports and ANSPs to accept worldwide PBN implementation and they must work together to address potential noise concerns.

Airports can capitalise on their existing community relationships and knowledge of community expectations to help ANSPs ensure that a PBN initiative addresses key factors in the design and implementation process. A strategy to address these early and proactively by the airport in coordination with the ANSP and other stakeholders may be critical components to the ANSP's success. To accomplish this, airports must understand how existing noise abatement procedures could be impacted or enhanced, and new opportunities pursued, as part of the procedure design process.

Although comprehensive community insights brought forward by airports is invaluable, equally critical to successful airspace change implementation is the ANSP's willingness to place assessment and community interactions as a high priority, and dedicate adequate time and resources to these efforts during the procedure planning and implementation process, to ensure the community expectations are met.

3.2 Noise Assessments

Any planning process for a potential change to airport physical layout or airspace procedures (unless that change is to be made urgently for safety or operational reasons) needs to include an assessment of the expected noise impacts. Airport local knowledge can be essential to the ANSP to help focus an assessment of alternatives on the most likely successful alternatives. This will allow changes in noise levels to be weighed against other environmental or economic impacts. A thorough impact assessment process can also inform procedure design and aide in determining methods and the levels of community engagement.

It is relatively simple for ANSPs to conduct noise monitoring to quantify the noise levels of aircraft. It is more difficult however, to determine the likely impact on communities of a procedure change. A noise impact assessment alone should never be used to determine the acceptability of a change to a community. This can only be gauged after community engagement, preferably with airport coordination, to allow the public to assess the range of impacts. The noise assessment process must be:

- Repeatable: different scenarios can be compared against each other; and
- Quantitative: to reduce subjectivity.

A number of noise assessment tools are available to assess procedures changes around airports (see section 2.1). These models all have detailed user guides to explain their use, but share a common need for input data for:

- The number and type of aircraft operations using the procedures under study
- A description of the local airport and surrounding area
- Position data describing the operations

It is important to produce metrics that are appropriate for communication to regulatory bodies and local communities. ANSPs and airports must consider the quantitative output in the local context. Just showing numbers does not tell the whole story. Other key factors that influence acceptance of the metrics include:

- *Sensitive locations.* Venues such as hospitals, educational establishments and places of worship, need to be located so that they are not exposed to high levels of noise for social or health reasons. Noise assessments for any changes need to take these locations into account. The World Health Organization has produced guidelines for community noise in specific environments **[15]**.
- *Scale of change.* An increase in noise levels or numbers of overhead flights, even if levels are not high, can be noticeable to communities.
- *Background noise levels.* Aircraft noise can be more noticeable in communities with low background noise levels (e.g. rural communities), than in locations such as city centres.
- *Time of day or week.* People tend to be more sensitive to noise in evenings or nights, or at weekends, when they are more likely to be at home or involved in leisure activities.
- *Time of year.* Communities can often be more sensitive to aircraft noise during warmer times of year when they may be using outdoor spaces more, or opening windows while indoors.

Once the noise impacts of a proposal have been established, they have to be weighed against other impacts. These could include fuel burn, CO_2 emissions, local air quality pollutant emissions, health, cultural and ecological impacts – as well as social and economic impacts.

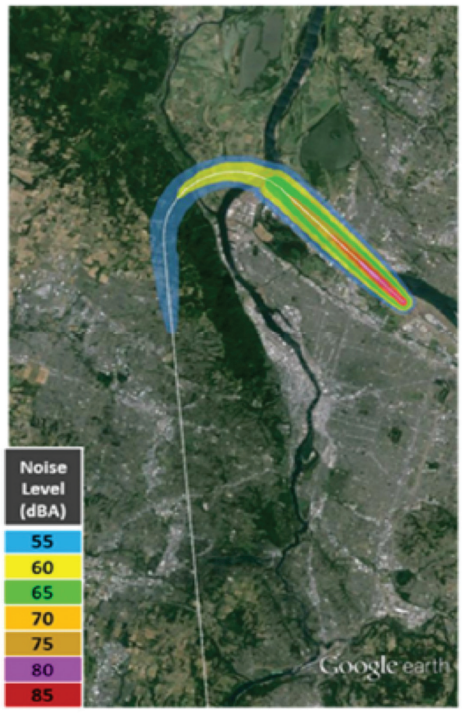
CASE STUDY 1

Use of noise modelling tools

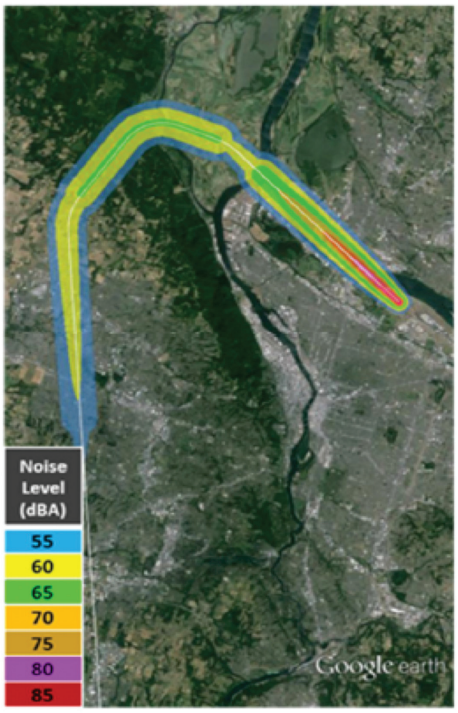
Alaska Airlines partnered with Boeing, and the Portland, Oregon air traffic control to bring new, more efficient and quieter airplane arrivals to Portland Airport using performance-based navigation procedures. Using the integrated noise model (INM) tool, required navigation performance (RNP) precision arrival procedures were evaluated considering both fuel savings and population noise exposure in order to find the right balance for all concerned.

INM indicated fuel savings between 300 to 530 pounds (136 to 240 kg) for a typical Boeing 737 aircraft and reduced noise exposure of 55 dBA or greater for 59,000 to 73,000 people as shown below for Portland arrivals.

New Arrival Path

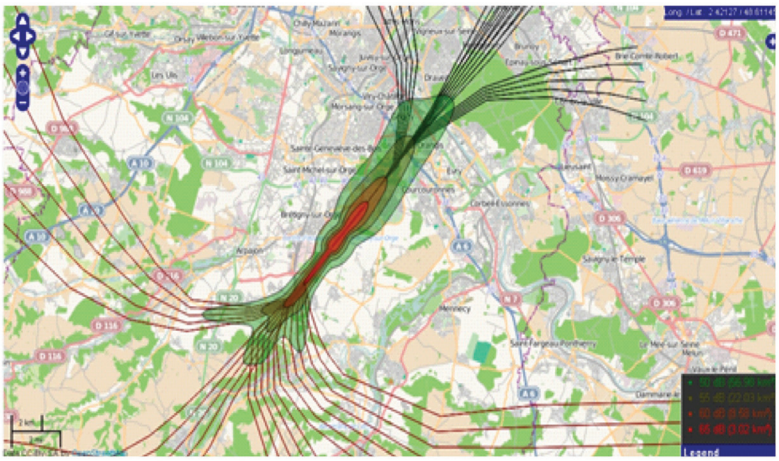


Typical Prior Arrival Path



Source: Boeing

Typical Noise Contour Outputs from IMPACT



Source: EUROCONTROL

3.3 New Airport Infrastructure

Changes to airport layout, including runway extensions and new runways, have the potential to affect the traffic patterns of the airport, and to affect the rates at which runways are used. All of these physical modifications could change noise levels in and around the airport area. These possible changes should be carefully evaluated using standard environmental assessment procedures, which are generally prescribed by national governments.

3.4 Interdependencies

When making decisions to optimise new operations, care must be taken to consider whether the proposed changes have environmental interdependencies. The term 'interdependency' is used to refer to a situation where a change in Factor A results in a change to Factor B (and vice versa), whereas the term 'trade-off' is used to describe an interdependency where an improvement in Factor A results in a detrimental change to Factor B.

The concept of interdependencies is especially important when considering noise-related operational changes, as the implementation of noise mitigation approaches (e.g. avoiding overflight of a noise sensitive area) often results in an increase in track miles, and therefore fuel burn and emissions. Decisions to optimise operational procedures should be made with full consideration of interdependencies to avoid any unintended consequences. ANSPs and government regulatory agencies can contribute by making policy for which factor takes precedence. For example, some ANSPs have declared that below a certain altitude (e.g. 2000 metres or 6500 feet) noise management takes precedence over emissions reduction for operational evaluations.

As ICAO 10031, *Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes* (Section 4.2) notes, one very common interdependency is "noise versus fuel burn and CO_2: routeings that benefit noise-sensitive areas should reduce noise impacts to local communities, but may increase fuel burn and CO_2 emissions due to the additional track-miles travelled" **[16]**. In addition, certain procedures that reduce noise close to an airport may increase noise further away.

If trade-offs are unavoidable, informed decisions to manage the interdependencies must be made on the basis of local priorities between economic objectives and environmental targets.

3.5 Social and Economic Impact Assessment

An airport operator's economic impact assessment (EIA) for an infrastructure project will usually address how environmental impacts would be managed and mitigated as well as some discussion on the social and economic benefits for infrastructure expansion. These economic and social benefits require evaluation by policy-makers against environmental impacts.

Social development is not limited to airport-related employment opportunities. Airports can conduct direct community engagement and provide social opportunities such as community projects, sponsorships and education. The community benefits not only from employment and economic stimulation, but also by having access to regional and international mobility, via the global aviation network for business and leisure travel.

4
ICAO's Balanced Approach

The importance of a broad, multi-stakeholder approach to managing aircraft noise is reflected in the ICAO Document 9829 *Guidance on the Balanced Approach to Aircraft Noise Management*, 2008 (Second edition) **[17]**. The Balanced Approach provides guidance to authorities for managing aircraft noise around airports. It supports them in addressing aircraft noise problems at individual airports in an environmentally responsive and economically responsible way. It also provides guidance on the economic analysis of noise management options and how to identify the most cost effective option. This document describes the four principal elements of the ICAO Balanced Approach:

- Reduction of noise at source
- Land use planning and management
- Noise abatement operational procedures
- Operating restrictions – to be used only after potential benefits from the previous three elements have been exhausted

The ability and responsibility for implementing each of these elements lie with different aviation stakeholders. The third element is the usual path for airports and ANSPs to work with operators, regulators and communities to implement procedures for local noise management.

4.1 Reduction of Noise at Source

In the Balanced Approach, "reduction of noise at source" specifically refers to the aircraft noise certification standards contained in ICAO Annex 16 Environmental Technical Protection Vol. 1, Procedures for the Noise Certification of Aircraft. It is the element of the Balanced Approach over which ICAO has standard-setting authority. This element underpins the global approach by airplane manufacturers to design ever-quieter aircraft.

In 2013, ICAO agreed on a new noise standard amendment to ICAO Annex 16, Chapter 14, which will come into force in two stages: in 2017 for larger aircraft and 2020 for smaller aircraft **[18]**. Although a noise standard only applies to new aircraft types certified after the applicability date, in practice, manufacturers will usually modify aircraft types that do not comply or take them out of production if a new, quieter airplane type exists to replace it in the market. Existing aircraft that do not comply can continue operating under specific conditions covered in the Annex.

Aircraft engine and airframe manufacturers continually improve low noise technology, while aircraft operators continually modernise their fleets by buying new, quieter aircraft. Since aircraft development and fleet modernisation takes time, introduction of these new, quieter airplanes can take several years to have a significant impact at an airport.

4.2 Land Use Planning Principles

Land use planning (LUP) is the process whereby noise sensitive areas such as residences, hospitals and schools, are avoided as much as possible by current and future aircraft operations.

Local or municipal governments are usually responsible for land zoning. In high noise areas new activities incompatible with aircraft noise should not be permitted (or planned to be removed from those areas). In moderate noise areas, some authorities permit such new development in conjunction with sound insulation and ventilation requirements. Sound insulation, however, is only a partial solution, as it does not address outdoor noise levels or interior noise levels when windows are open. In many jurisdictions, retrofitting of noise insulating components to buildings associated with sensitive activities (e.g. residences, schools) has been one of a suite of approaches to mitigate aircraft noise impacts (e.g. Heathrow, Sydney, Gatwick airports).

ANSPs need to take these land use considerations into account when contemplating the implementation of new airspace procedures. Sometimes a small change in a procedure design can avoid a locally sensitive area. The airport authority can help by ensuring the ANSP is aware of the local issues and the relative priority of each. ANSPs that fulfil both roles need to ensure procedure designers are aware of land use planning factors.

Local developers will often resist proposals to limit residential development even in areas affected by noise. Airports and other aviation stakeholders, especially airlines and ANSPs, must work with local governments; requesting and recommending appropriate LUP rules to protect airport operations. Some national governments recognise the impact on airports of the encroachment of residential areas and have created national policy to restrict residential growth near airports.

For some high noise areas, existing homes and schools may be retrofitted with improved sound insulation and alternative ventilation. In some cases, an airport operator may even purchase homes in very high noise areas.

LUP is a long-term strategy. Policy should not be based on a short-term or current noise contour map. LUP should take into account future levels of aircraft activity at an airport. While fleet modernisation has reduced the extent of airport noise, residential encroachment can pressure airports not to grow traffic.

4.3 Noise Abatement Operational Procedures

Despite several decades of aircraft noise reductions and LUP, noise complaints are increasing from residents further from airports, well outside traditionally recognised high noise contours. Communities are becoming more sensitive to aircraft noise and have higher expectations regarding their exposure to overflying aircraft. The management of aircraft operations is the main means for addressing these issues.

Noise abatement procedures specifically address the operation of aircraft to avoid or reduce noise over populated areas (see Section 6 for more details). These can include:

- Noise preferred routes (NPR), preferential flight track or runway use
- Concentrating flights over unpopulated areas or areas less sensitive to noise
- Dispersion of flights over populated areas or noise sharing (flying over certain areas on some days and moving the flights to other areas on other days)
- Noise abatement take-off procedures such as the management of engine power during departure
- Approach procedures such as continuous descent operations (CDO) and low power, low drag techniques
- Moving the nominal takeoff or landing points on the runway
- Restrictions on engine run-ups and/or ground equipment use

Operational procedures to reduce noise impacts should be developed in close consultation with stakeholders, including aircraft operators, pilots, the ANSP, the airport operator and community representatives.

CASE STUDY 2

Stakeholder collaboration – Airbus, Heathrow and NATS partner for quieter flight

Airbus, British Airways (BA), Heathrow Airport and NATS launched a unique partnership to develop operational procedures to reduce the number of people affected by noise around London's Heathrow airport. The effort will use British Airways' A380, recognised as one of the quietest aircraft of its size today.

In July 2014, the four cross-industry partners initiated a three-stage 'Quieter Flight' project. The project utilises the capabilities of the A380, with the aircraft manufacturer, airline, airport and ANSP looking to further reduce noise for local communities. Airbus ProSky is designing various departure and arrival procedures for the A380 based on the recommendations of NATS, Heathrow and BA.

— The first stage identified possible operational improvements such as reducing thrust on departure and optimising the height at which the aircraft is flown, which can significantly reduce noise levels shortly after take-off.

— The second stage evaluated these procedures in a British Airways flight simulator.

— Once these project stages were complete, the partners began a series of demonstration and evaluation flights, starting in early 2015. After the trial, the procedures will be shared with other operators and airports where the A380 operates.

The Quieter Flight project brings together industry expertise to manage noise, and when combined with other initiatives, will help make a difference to those people living under the flight path.



4.4 Operating Restrictions on Aircraft

An operating restriction is any noise-related action that limits or reduces an aircraft's access to an airport and must be applied as a last resort. Restrictions include limits on total movements, noise quotas, night time restrictions and curfews. Restrictions might be applied to specific runways or flight tracks, specific aircraft types, specific operations such as departures or arrivals, or to specific time periods.

In general, operating restrictions are imposed by a government (national, regional or local) or by a court decision. However, curfews and restrictions are a 'blunt instrument' and can severely impact the efficiency of operations such as the movement of freight. Noise quotas or limits on certain movements can allow some activity while placing a limit on noise impact.

Night curfews in one region may contribute to an increased need for night time movements in another region. Although time zones and passenger demand play a role, curfews may be seen as shifting night time aircraft noise from one region to other regions.

ICAO encourages its Member States to not apply operating restrictions as a first resort, but only after consideration of the benefits possible from the other three elements of the ICAO Balanced Approach.

It is thus vital that airports and ANSPs engage and collaborate with local communities to ensure all options are discussed in relation to potential operational procedures for noise mitigation so operational restrictions become only a last resort.

The development of regulatory processes should also be encouraged to provide oversight on applications on the Balanced Approach to ensure that all options have been genuinely considered before an operating restriction may be applied. If an operating restriction must be applied, it could impact the local economy and the air transport network and must be seen as the last option.

4.5 Community Engagement

Community engagement is not formally part of the Balanced Approach. Its importance was recognised in the second edition published in 2008. However, there is little information or advice on matters such as communications strategies, community outreach and complaints management. This information should be considered for a future revision.

Airports and ANSPs should both engage with the community to increase the public's awareness of the constraints and restrictions that govern safe and efficient flight, and to help find a suitable path for new operations and aviation growth based on a mutual understanding of these factors and the public's concerns.

5
Land Use Planning

Land Use Planning is one of the most important mechanisms for preventing the disturbance of residential communities by aircraft noise. However, the zoning of land and the approval of residential developments is the domain of municipal or local government authorities and is not under the control of airport operators, civil aviation authorities or government departments of transport.

5.1 Supporting Land Use Planning Decision Making

Airport operators should work with the relevant government authorities to ensure that land use that is compatible with aircraft noise is approved in areas affected by aircraft noise. Many airports have to deal with several levels of government (local or municipal versus regional, state or federal) and multiple jurisdictions (e.g., adjacent cities or counties).

ANSPs can contribute to this dialogue with information relating to local airspace operations such as track maps and frequency of flights by time of day to assist policy makers with informed land use decisions.

Even if land use has already started in areas affected by noise, it may still be beneficial for airports and ANSPs, with airline support, to take joint action that informs relevant government authorities and could prevent increases in the numbers of dwellings and residential density.

5.2 Using Airport Noise Metrics

The use of noise metrics and choosing the appropriate metrics will primarily be the responsibility of airport operators unless procedure changes are also contemplated by ANSPs, which could impact future LUP decisions. In many cases, airport noise contours based on time-averaged noise levels (such as Leq, Ldn, Lden, or NEF) are appropriate for defining the level of airport noise impact for land use planning purposes. An extended averaging period (e.g., three months or a year) could highlight daily and seasonal variations in the traffic flows.

In some cases, it may be appropriate to use the average noise level during specific periods (e.g. night time) or the noise from specific aircraft events (e.g. Lmax, SEL, EPNL) to identify the level of airport noise impact and assess land use compatibility. In the case where new residences are proposed near night flight regions, it might be appropriate to use a combination of average noise contours and single event metrics when developing land zoning boundaries.

Land use should be protected from incompatible activity based on the best available projections of future noise levels and not necessarily the current noise metrics. Policy makers should be informed and take account of the projected growth of air traffic activity, the future composition of aircraft fleets and any plans for new infrastructure such as runways, terminals and taxiways.

Encroachment of incompatible land uses should be avoided by using calculated noise metrics from an appropriate future operational scenario. Ideally, traffic projections should be based on projections of 20 to 30 or more years of future airport capacity and operations including expected fleet changes from the industry that impact individual aircraft noise and cumulative noise.

In summary, relevant Government authorities should be urged to legislate and apply, in close consultation with airport management, airlines, and ASNPs as appropriate, land use planning that avoids use that is incompatible with aircraft noise.

5.3 Graduated Schemes

Many planning approaches use graduated schemes based on projected noise contours and metrics. These schemes may define low, medium and high airport noise levels and then apply different land use restrictions in each area. In some New Zealand cities, for example, areas of 'low' aircraft noise are defined between the Ldn of 55 and 60 dBA noise contours while 'medium' falls between Ldn 60 and 65 dBA and 'high' is greater than Ldn 65 dBA. All are based on 30-year traffic projections. In high areas, new residential dwellings are prohibited and existing residential dwellings are subject to the upgrading of sound insulation and ventilation. In medium areas, new residential dwellings are subject to sound insulation and ventilation requirements. In low areas new residents must be notified of the airport noise situation.

5.4 Protecting Airport Resources

In New Zealand, government legislation (Resource Management Act 1991) recognises the importance of protecting the country's natural and physical resources **[19]**. Airports are considered to be physical resources as they are a vital component of the air transport sector and provide clear economic and social benefits.

The law also recognises 'reverse sensitivity' – an airport's ability to respond to demand can be limited by the increase or encroachment of residential (and other noise sensitive) activity in areas of high aircraft noise and the associated community pressures. Such a legal framework can help airport operators influence the zoning of land by local government and prevent or minimise new residential activity.

6
Noise Abatement Procedures and Technologies

6.1 General Considerations

CANSO and ACI Members are often directly involved with other stakeholders in the third element of the Balanced Approach - noise abatement operational procedures. These procedures (and relevant technologies) can be used to reduce or redistribute noise. Table 1 lists various methods that can be applied to current or future airport operations to reduce or redistribute noise.

These procedures help minimise noise at the airport during ground operations or during flight near the airport during arrival and departures. The ICAO document Review of Noise Abatement Procedure Research and Development and Implementation Results – Discussion of Survey Results provides more in-depth descriptions of many of the arrival/departure procedures mentioned above [20].

Another source of current noise mitigation procedures can be found in Sustainable Aviation's Noise

Initiative, Procedure or Technology	Airport Noise	Departure Noise	Arrival Noise
Ground Operations	✓		
Automated airplane tug	✓		
Reduced APU use	✓		
Thrust reversal limitations at night	✓		
Taxi speed limits	✓		
Departure Operations			
Departure management collaboration		✓	
Thrust managed climb		✓	
RNAV departures		✓	
Continuous climb operations (CCO)		✓	
Departure path alternation (noise sharing)		✓	
Arrival Operations			
Arrival path alternation (noise sharing)			✓
Arrival management collaboration			✓
Low power/low drag operations			✓
'Quiet' landing gear			✓
Continuous descent operations (CDO)			✓
Optimised profile descent			✓
Two-segment (dual slope) approach			✓
RNAV/RNP approaches			✓
Tailored arrivals			✓
Displaced threshold			✓
Other Considerations			
Preferential runways		✓	✓
Noise constrained operating times		✓	✓
Longer intervals between noisy operations	✓	✓	✓

Table 1 - Potential Methods for Airport Operational Noise Mitigation

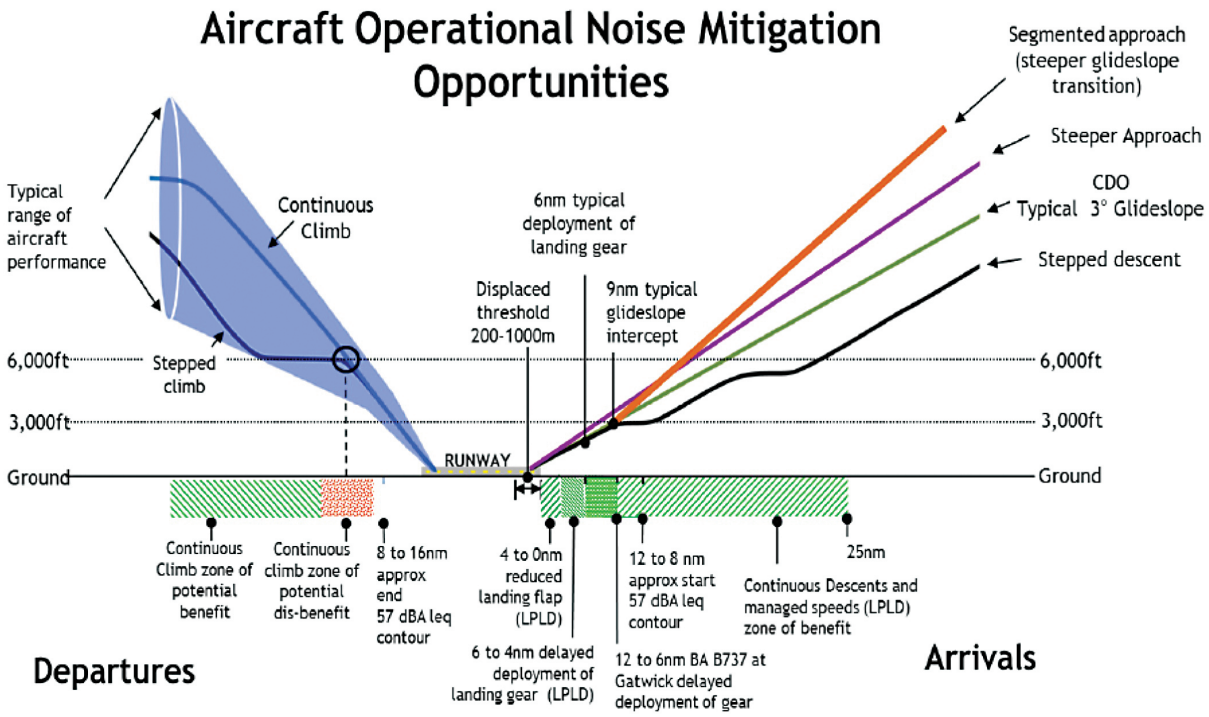


Figure 5 - Potential Noise Abatement Procedures (Source: Sustainable Aviation)

Road-Map: A Blueprint for Managing Noise from Aviation Sources to 2050 and depicted in Figure 5 above [21].

Some of the items in Table 1 can incentivise operators to minimise operations with older, noisier aircraft (e.g. noise constrained operating times).

Noise management procedures such as flight path alteration and noise sharing are effective mitigation methods. However, they have the potential to increase noise for other communities, which will likely be sensitive to it. Mitigation proposals that include an element of noise sharing or flight path alteration therefore require increased levels of community engagement.

Other potential noise improvement measures require cross-industry cooperation in operational simulation, data analysis, or even procedure development (which may involve community engagement). Some examples include:

— Automated tug – automated tugs offer new technology for no-engine towing that could reduce both emissions and noise from aircraft ground operations.

— Thrust reverse limitations – at certain times (such as weekends or nights) or when arrivals are not closely spaced, pilots may be able to avoid using thrust reversal after landing when this can be done safely.

— Departure and arrival management collaboration – incorporates the progress made in collaborative decision-making to integrate more precision and predictability in both arrivals and departures. This enhances continuous descent and continuous climb operations, which can minimise controller vectoring and local noise during arrival and departure operations.

— Arrival or departure path alternation – incorporates local rules to dictate which arrival routes or departure paths may be used on certain days. This supports the creation of respite periods, a form of noise sharing, to allow communities to know in advance which days will have restricted overhead flights.

— Thrust managed climb profiles – some common noise abatement procedures require reduced thrust after a safe altitude is reached. Further definition is provided in Section 6.3.3, noise abatement departures.

— Low power/low drag operations – are techniques for making landing approaches less noisy. These operations require coordination between ANSPs, airport operators and aircraft operators to coordinate landing gear and flaps

extension delays. While this can reduce local noise by keeping the aircraft aerodynamically 'cleaner', safety must never be compromised.

Engine ground running restrictions, quota counts, and noise charges – can impose limits on the locations or time of day when ground testing of engines may be undertaken, or the number of aircraft that can fly during a time period based on their noise classification. These are reviewed further in Section 7.

6.2 Arrival Procedures

Several procedures can reduce community noise during aircraft arrivals. Some of these procedures are in use, some are in operational trials, and a few have been demonstrated to explore feasibility.

6.2.1 Continuous Descent Operations

Continuous descent operations (CDO) are also known as optimised profile descents (OPD) or continuous descent approaches (CDA). They are designed for fuel efficiency and quieter terminal area operations by reducing the need for intermediate level-offs as shown in Figure 6 below. The definition found in ICAO Document 9931 Continuous Descent Operations Manual of a CDO is **[22]**:

"An operation, enabled by airspace design, procedure design, and ATC, in which a arriving aircraft descends without interruption, to the greatest possible extent, by employing minimum engine thrust, ideally in a low drag configuration, prior to the final approach fix/final approach point."

This document goes on to note that:
"… the generic term 'CD Operations' (CDO) embraces multiple techniques to maximize operational efficiency while addressing local airspace constraints including: Continuous Descent Arrivals, Optimized Profile Descents, Tailored Arrivals, 3-D Path Arrival Management and Continuous Descent Approaches."

Two guides on implementing continuous descents that also provide guidance to stakeholders are the EUROCONTROL brochure: Continuous Descent: A guide to implementing Continuous Descent **[23]** and Sustainable Aviation's A Guide to Continuous Descent Operations, for controllers and pilots from controllers and pilots **[24]**.

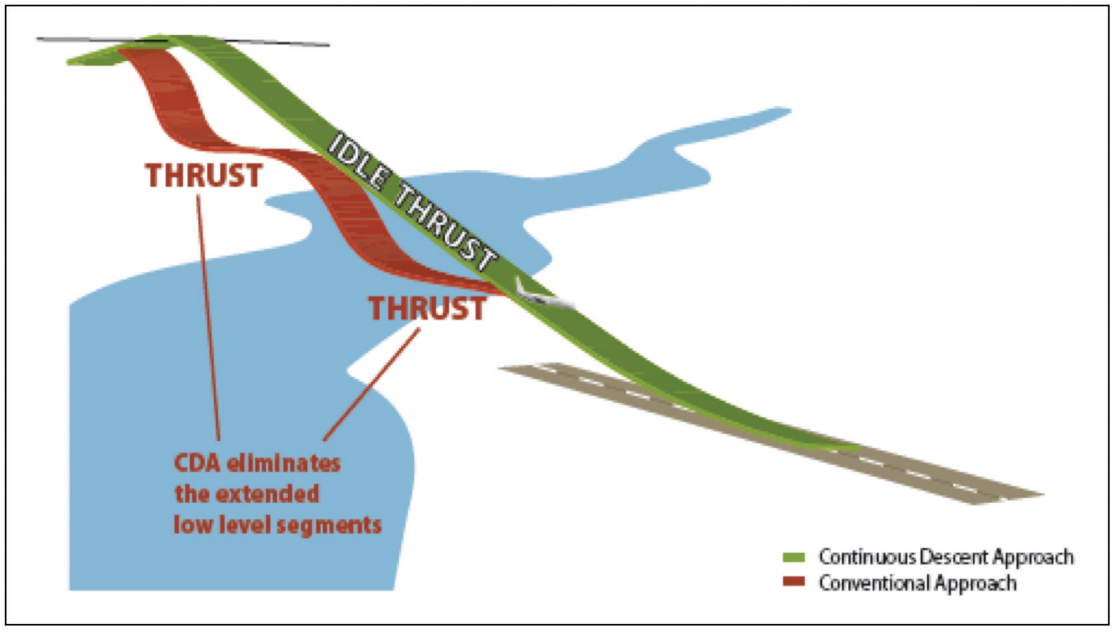


Figure 6 - Continuous Descent Operations – Quieter and Cleaner (Source: EUROCONTROL)

CASE STUDY 3

Continuous descent operations campaign in the United Kingdom

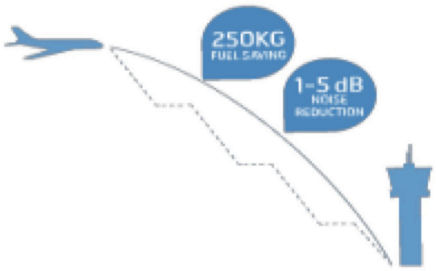
Continuous descent operations mean that an aircraft remains in a smooth descent profile instead of descending in a series of steps. The continuous descent keeps an aircraft higher above the ground and therefore is quieter. Avoiding level flight further reduces noise by not running engines, which is more fuel and environmentally efficient than a traditional stepped descent.

In 2014 and 2015, NATS led the UK coalition 'Sustainable Aviation'. This was a cross-industry collaborative continuous descent campaign representing large-scale simultaneous efforts across 15 air traffic control (ATC) units, eight airlines and 23 airports to deliver a step change in CDO performance. The campaign target is to achieve a five percent increase in CDOs across the UK, delivering over 30,000 individual quieter arrivals, and saving around 10,000 tonnes of CO_2. CDOs can reduce community noise by up to five dB compared to conventional descents. Even a one dB reduction in average noise can reduce an airport's noise contour by 30 percent.

This truly collaborative cross industry initiative saw:
- 10,000 campaign booklets distributed to pilots and controllers
- the production of a four-minute supporting campaign video watched online 2826 times in the first three weeks
- campaign posters displayed in 50 crew rooms
- over 500 NATS controllers and 7000 pilots briefed on CDO techniques



30,000 individual quieter arrivals



5% increase in UK CDO

Source: Sustainable Aviation

Fuel savings may also be achieved by undertaking CDO with the understanding that level flight fuel burn reduces as the aircraft increases altitude. Therefore, fuel can be saved by reducing intermediate level-offs.

Traditionally, implementation of CDO has been promoted as 'being the art of the possible' meaning that aircraft operators have been encouraged to fly CDO at as many airports as possible; for as many flights as possible and for the longest extent possible for each flight. A fully optimum CDO starts from the top-of-descent point at the end of cruise. However, due to constraints in the airspace structure, CDOs may only be available after initial descent has begun. Therefore ANSPs and airports often only measure CDO from lower levels. However, this may be seen as diluting the spirit of the CDO concept.

Noise reductions from CDO may be expected around airports up to 7,000 feet (ft), see Figure 7. SESAR considers that the most important environmental impact to be mitigated is noise (changing to greenhouse gases (GHG) at around 7,000 ft) [25]. Therefore, while measuring CDO from low levels should be advisable for noise reasons, CDO in terms of fuel savings should be measured as far as possible from the top of descent to provide a true picture of the fuel savings (and GHG savings) both available and achieved.

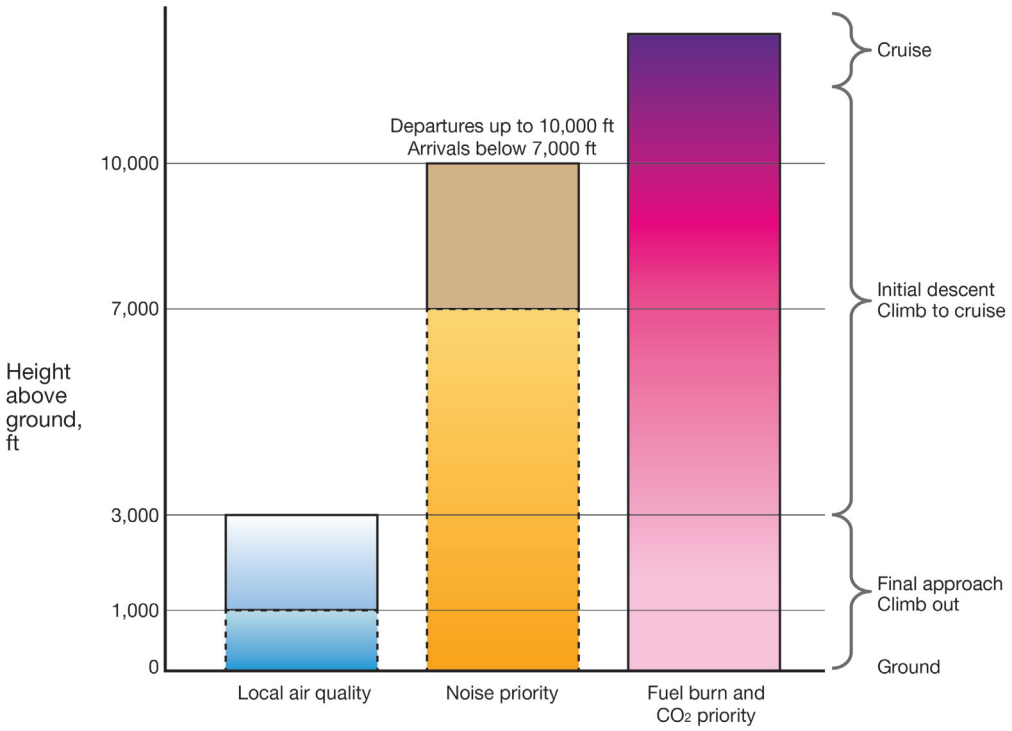


Figure 7 - Continuous Descent/Continuous Climb Operational Considerations (Source: Boeing)

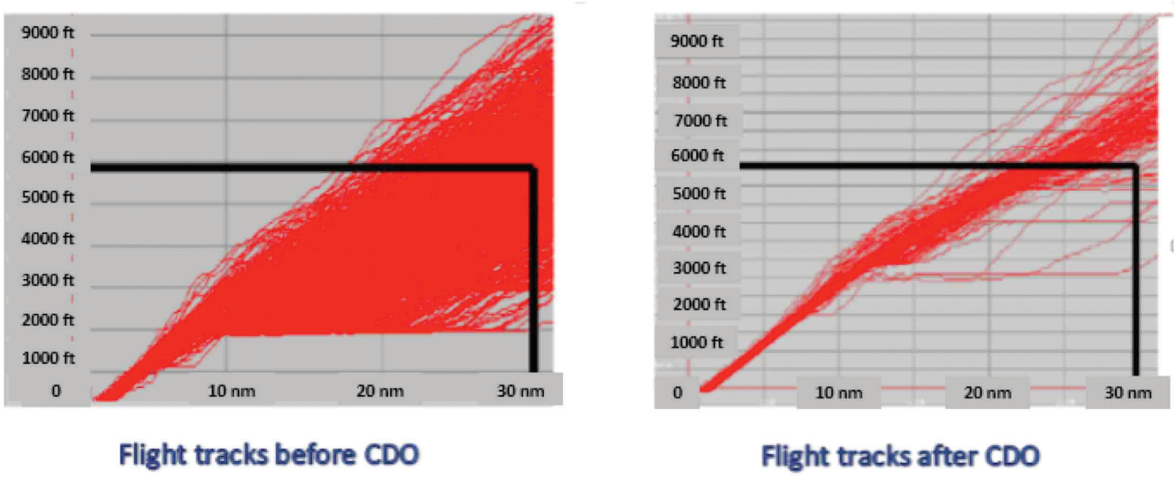


Figure 8 - Actual CDO Operations Impacts (Source: ICAO)

Care should be taken with measuring CDO as certain parameters may impact any measurement. Level flight definitions should be designed so that level flight used for deceleration prior to glide path interception is not recorded while segments of artificial descent profiles which require partial thrust (even those that appear to show a descent) should ideally be recorded as level flight in keeping with the ICAO definition of CDO. Figure 8 highlights the impact CDOs can have on the profiles of airport arrivals, demonstrating the potential reduction in noise due to fewer aircraft at low altitude **[26]**.

Noise can be reduced during descent by reducing terminal area speed so the aircrew can use flaps to slow down and maintain a continuous descent, but not so slow that they need to lower landing gear for drag as this often adds noise.

Implementing noise management procedures requires collaboration between the airport, the ANSP, the local community and the airplane operators in order to design acceptable procedures for all concerned. The EUROCONTROL CDO Implementation Program is an industry-wide collaborative effort to achieve the goals of the European Joint Industry CDA Action plan [27]. The goal is to achieve 24-hour CDO operations from top-of-descent. FAA Advisory Circular AC 120-108, Continuous Descent Final Approach, provides guidance on useful techniques during non-precision approaches **[28]**.

6.2.2 Tailored Arrivals

The tailored arrival (TA) profile is an efficient, predictable, continuous descent operation initiated from top-of-descent that takes advantage of aircraft automation to fly a specifically defined path. It is an agreement between the ANSP and the flight crew for a type of CDO where the path is 'tailored' to current traffic conditions.

The TA terminology was primarily used in the U.S. but it is now incorporated as a type of CDO. The TA is well suited to oceanic arrivals and has been demonstrated by several airlines at San Francisco, Los Angeles, Miami, Amsterdam, Sydney and Melbourne airports and are currently used at the first three.

The initial TA operational trials involved 3,500 flights from 10 airlines at San Francisco and

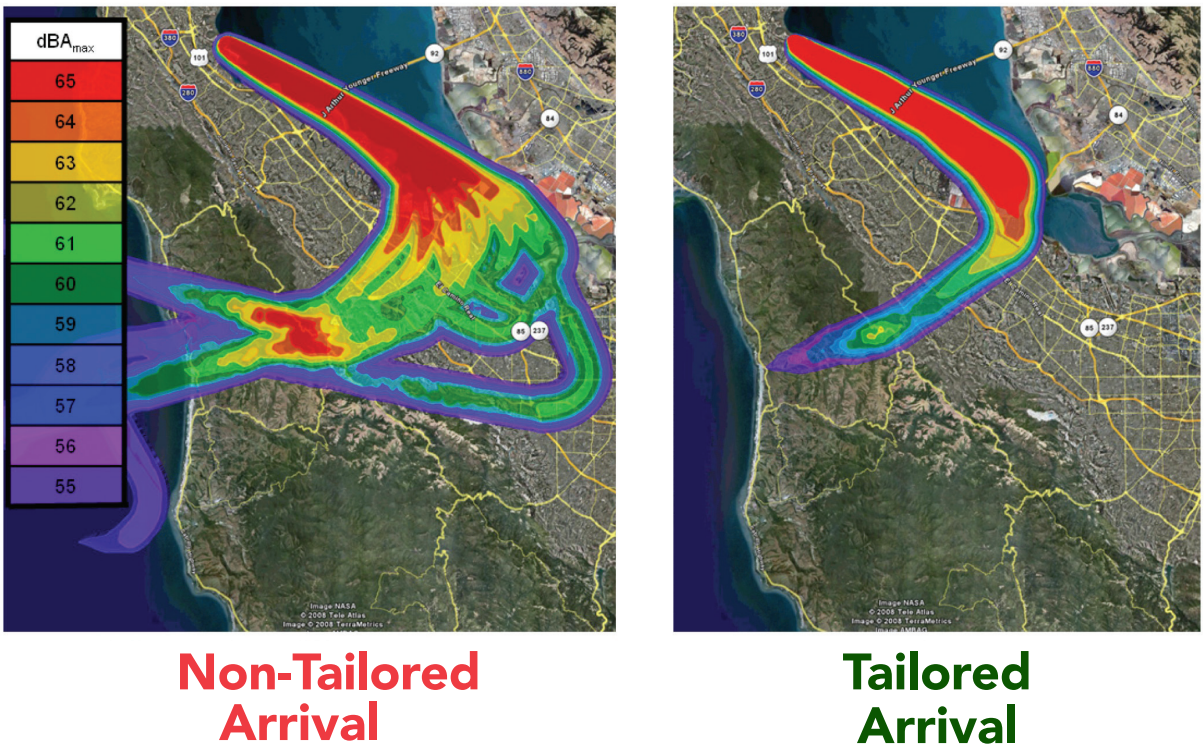


Figure 9 - Tailored Arrival noise reduction at San Francisco Airport (Source: Boeing)

reported saving 1.5 million kilograms (kg) of fuel with corresponding reduced CO_2 emissions of 4.7 million kg **[29]**. The reduction of airport noise was obtained by maintaining a continuous descent and tailoring the final paths away from specific populations as highlighted in Figure 9 above.

6.2.3 Increased Angle Approaches and Displaced Threshold

Increased angle final approaches keep the aircraft higher for as long as feasible to reduce the perceived noise levels on the ground. Some airports such as Frankfurt are implementing 3.2 degree approaches to reduce noise. Displacing the threshold (by 300m or 1000 ft) also keeps the arriving aircraft higher over nearby communities. This last procedure permits an aircraft to land at a point further down the runway than the normal runway touchdown threshold. The increased angle descent, including displaced threshold, is depicted in Figure 10 on the next page.

While these procedures add additional methods for managing noise, they require collaboration between stakeholders to determine if and when they could be applied. They may also require infrastructure changes at the runway to implement.

6.2.4 Two-Segment (Double-Slope) Approaches

A two-segment (double-slope), also referred to as segmented approach is a new procedure demonstrated in Germany in 2013 with several commercial aircraft **[30]**. The concept was developed first in 1973 by the National Aeronautics and Space Administration (NASA) and American Airlines **[31]**. These procedures are not yet operational. In concept (see Figure 11 on page 33) the procedure starts with a descent angle of less than 4.5 degrees flown with aircraft automation that intercepts a standard 3 degree slope by 500 m (1500 ft).

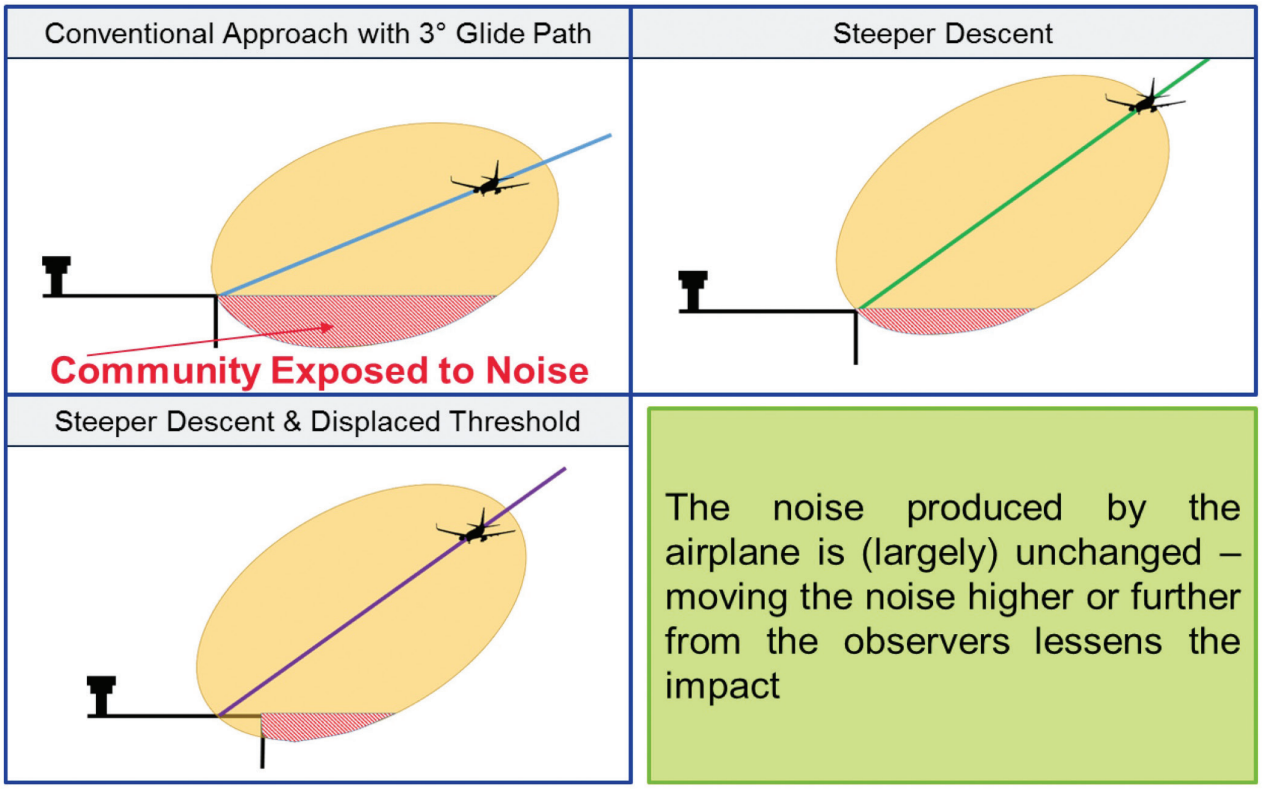


Figure 10 - Increased Angle Approaches and Displaced Threshold (Source: Boeing)

The intercept could also be to 3.2 degrees if appropriate. This keeps the arriving airplane at higher altitudes from about 30 kilometres (km) (19 nautical miles (nm)) to about 8 km (5 nm), thus further reducing noise. When this procedure can be used it may reduce noise by an additional 3-5 dB. These procedures may not be suitable as part of normal daily operations, but they may offer significant benefits for early morning or late night arrivals when traffic is lower and nose reduction more important. They also may allow continued use of existing runway infrastructure such as a 3 degree instrument landing system (ILS).

6.2.5 Advanced Arrival Procedures

The use of PBN is increasing for several reasons. PBN takes advantage of current and improving aircraft technologies to provide precise adherence to a defined flight path. PBN provides flight path predictability and more fuel efficient paths, which may be designed to reduce community noise. Arrival procedures may employ area navigation (RNAV) and required navigation performance (RNP) terminal area approaches. These approaches may be designed as RNP or RNP-AR (authorisation required) approaches as defined in FAA Advisory Circular AC 90-101A, Approval Guidance for RNP- Procedures with AR, which describes aircraft specific technologies and performance requirements necessary for these procedures **[32]**.

Well-designed RNP-AR procedures can employ curved segments that keep flight tracks away from communities by flying over water or industrial areas as shown in Figure 12 on page 33). These procedures may also connect an RNP segment to a final ILS or GLS approach.

GLS (global navigation satellite system (GNSS) landing system) represents new technology that incorporates a ground-based augmentation system (GBAS) and airplane equipment that enable new types of PBN operations at airports. One GBAS station could

economically permit the definition of multiple approaches, including different descent angles, to both ends of multiple runways at an airport. This technology is expected to be a significant help in managing airport noise in the future.

EUROCONTROL also uses the RNP-AR terminology as described in Advanced RNP (A-RNP) **[33]**. This document explains the Advanced RNP concept and specification as a successor in Europe to previous RNP definitions and defines RNP APCH (RNP Approach) along with RNP-AR APCH. As this reference explains, the main benefit of airspace procedures with Advanced RNP (or RNP-AR) is the ability to design precise flight paths that reduce noise by placing routes where they cannot be placed today.

For example, the Greener Skies over Seattle program and RNP projects managed by Airservices Australia have taken advantage of RNP and stakeholder collaboration to reduce local noise. These are described in the case studies on page 34 and 35.

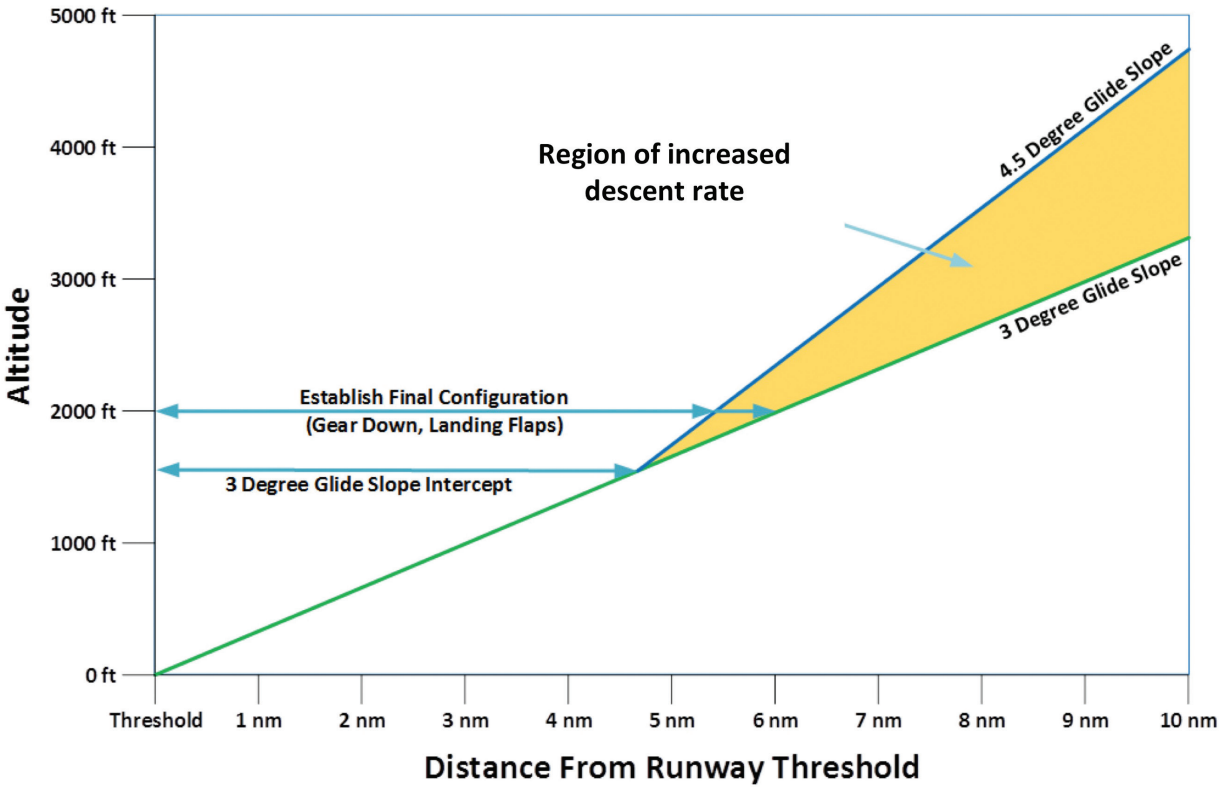


Figure 11 - Two-Segment (Double-Slope) Approach (Source: Boeing)

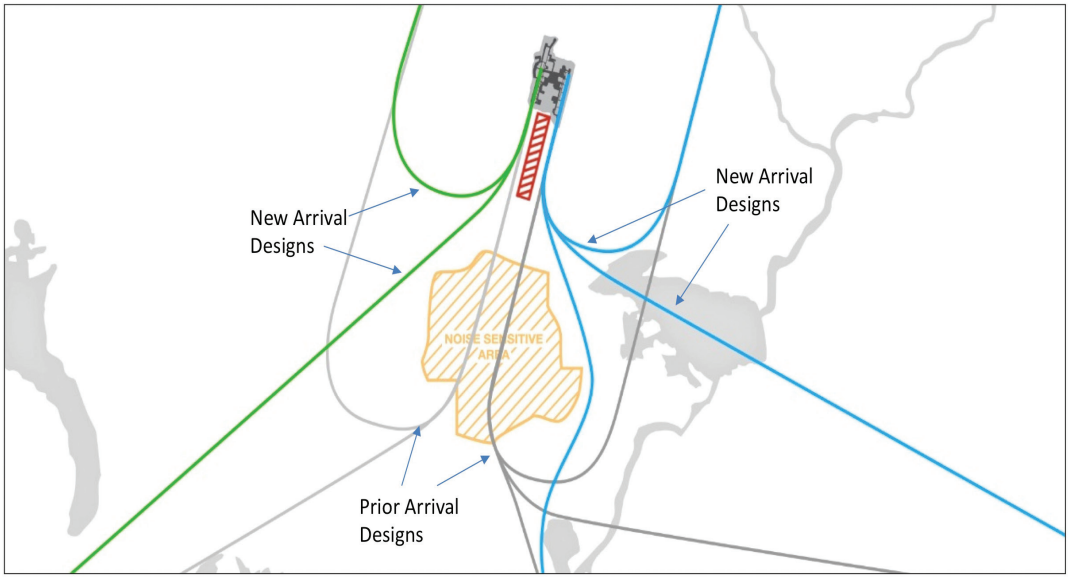


Figure 12 - Arrival Design Concepts Using RNP-AR to Minimise Noise (Source: Boeing)

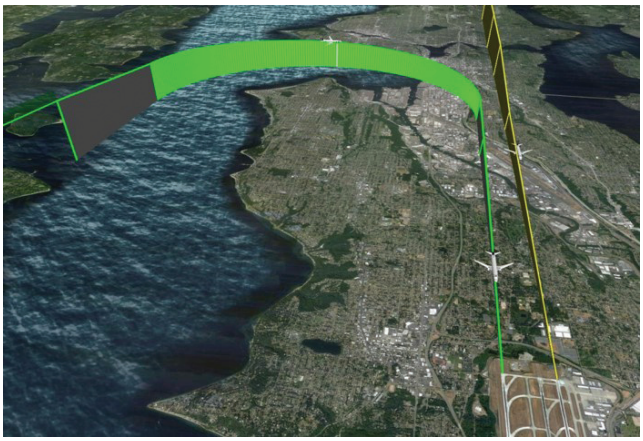
CASE STUDY 4

Using PBN to reduce noise – Greener Skies over Seattle

Flights inbound to Seattle-Tacoma International Airport are now considerably quieter due to the Greener Skies Over Seattle initiative, a collaborative project between the FAA, the airlines, the Port of Seattle and Boeing. Arriving aircraft are now flying a smooth, low-community noise approach using satellite-based RNAV routes.

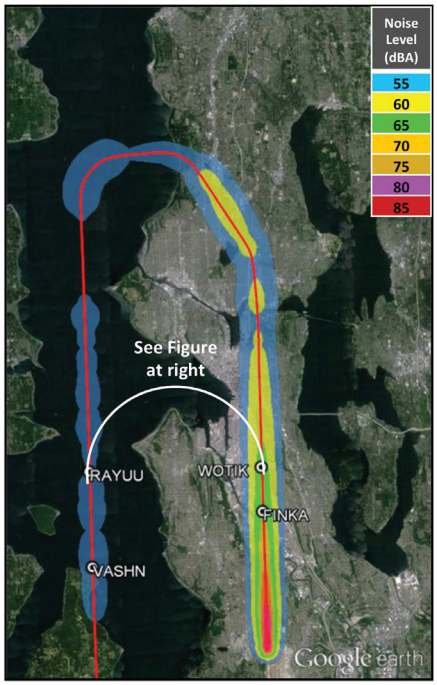
These arrival procedures at Seattle also incorporate a locally defined optimum descent.

For Seattle, the Greener Skies project defined very specific RNAV/RNP approaches designed to keep aircraft noise over water as much as possible, and not over the heart of downtown Seattle.

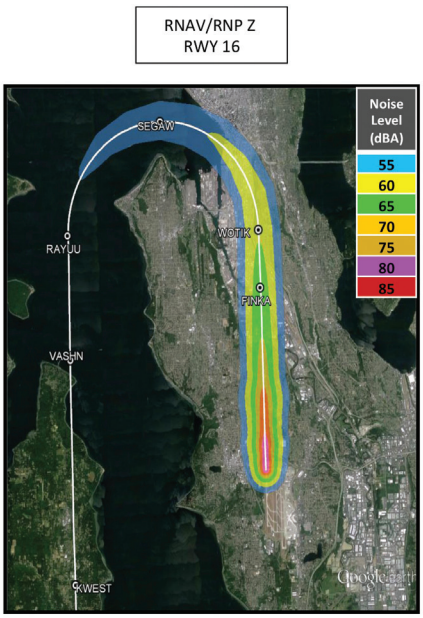


Source: Boeing

Noise Contour, Prior Procedure



Noise Contour, New Procedure



Source: Boeing

CASE STUDY 5

'Smart Tracking' at Gold Coast Airport

Satellite-assisted navigation is recognised internationally for its safety and efficiency benefits achieved through high precision navigation. Airservices refers to this PBN technology as 'Smart Tracking' and is implementing it at Australian airports to make air travel safer, cleaner and more dependable.

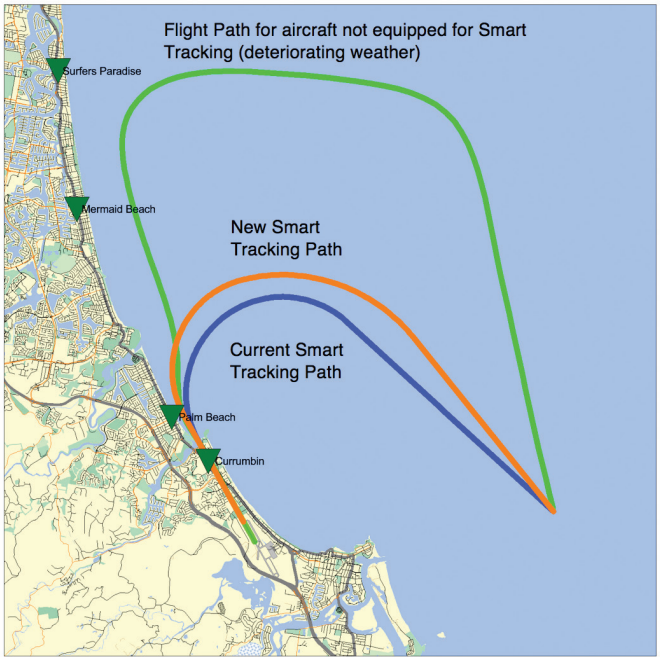
Smart Tracking uses satellite signals transmitted directly to the aircraft without using any ground-based equipment. Aircraft using satellite-assisted guidance are able to fly a flight path with greater accuracy than they could using any other form of navigation. This increases safety and capacity by providing a more stable approach during bad weather, which reduces pilot workload before landing.

Smart Tracking has been successfully trialled by some aircraft landing at Gold Coast Airport (YBGC) since 2008. To reduce noise and emissions impacts for YBGC, Airservices made Smart Tracking technology permanently available for all suitable equipped aircraft landing at the airport in December 2014.

The Smart Tracking flight path is entirely within a longstanding flight path corridor for aircraft arriving from the southeast to land from the north on Runway 14. This maximises flight over the ocean, crossing the coast a short distance from the airport. Community feedback about the trial was very positive due to the intended design of the procedure to minimise flying over land and therefore reduce community noise.

Smart Tracking also allows equipped aircraft the ability to follow flight paths with smooth curved approaches even when close to the airport in all weather conditions. This makes air travel safer, cleaner, and more dependable and can provide better noise outcomes for communities living close to the airports.

By 2015, about 90 per cent of aircraft landing at YGBC will use Smart Tracking with the remaining 10 percent becoming equipped over the next 5-10 years.



Source: Airservices Australia

6.3 Departure Procedures

The primary tools for mitigating departure noise include continuous climb; departure path definition, designed to avoid communities; and specific thrust management procedures, known as noise abatement departure procedures (NAPD). Continuous climbs are very efficient for reducing fuel and emissions, but if done with normal aircraft climb power, they may lead to more noise over a nearby community than a thrust managed departure that trades some climb performance for reduced noise.

6.3.1 Continuous Climb Operations

Corresponding to the continuous descent operations described above, there are continuous climb operations. CCO is similar to CDO but for departing traffic and is also a natural flight technique in the departure phase. The most fuel-efficient departure profile is to climb without any aircraft levelling off at intermediate levels. The definition from ICAO publication, Doc 9993, Continuous Climb Operations (CCO) Manual is [34]:

"An operation, enabled by airspace design, procedure design, and ATC, in which a departing aircraft climbs without interruption, to the greatest possible extent, by employing optimum engine thrust, at climb speeds until reaching the cruise flight level."

However the primary consideration in Doc 9993 is for designing standard instrument departures (SIDs) procedures for improving airspace capacity and efficiency and reducing fuel burn. This is generally not as applicable to airports with significant noise issues. Additionally, some of the procedure designs may require aircraft to have RNP capability to fly them.

Savings from CCO can be attributed to the same principle as for CDO: fuel burn in cruise is reduced by reducing level-offs at intermediate lower levels. For departing traffic, SESAR considers noise to be the most important environmental impact to mitigate, changing to GHG at around 10,000ft (Figure 8 on page 29). Therefore, while measuring CCO in lower level bands may be advisable, for noise reasons, CCO should be measured to top-of-climb to provide a true picture of the fuel and CO_2 impacts.

Procedure definition for CCOs also requires close collaboration between the ANSP, airport and aircraft operators and may require community engagement.

6.3.2 Precision Based Navigation Departure Procedures

Just as there are RNAV and RNP approaches, there are RNAV/RNP departures. When conducted with the best stakeholder collaboration, these departures can lead to safe, continuous climbs that are designed to avoid population concentrations. Atlanta Airport, one of the world's busiest, is developing RNAV departures. These departures have reduced fuel use and noise and increased departure egress routes which enhances overall airport capacity by reducing intermediate level-offs and local noise due to arrival procedure conflicts **[35]**. The FAA provides guidance on RNP-1 design in 8260.40D, Departure Procedures Design, Amendment to Appendix A **[36]**.

6.3.3 Noise Abatement Departures

Noise abatement departure procedures (NADP), provide noise relief to communities near airports from departing aircraft. These are commonly known as NADP1 and NADP2 and are employed at numerous airports such as London Heathrow, Frankfurt, Amsterdam Schiphol, Hong Kong, Tokyo Narita and Orange County California John Wayne airports. The noise abatement procedure for John Wayne Airport is depicted in Figure 13 on the next page **[37]**.

Both ICAO PANS-OPS (Procedures For Air Navigation Services – Aircraft Operations), Volume

I, Doc 8186, Section 7 [38] and FAA Advisory Circular AC 91-53A (Noise Abatement Departure Profile) [39] contain guidance for the development of two different NADPs, each designed to mitigate noise as shown in Figure 14 on the next page. NADP1 procedures are designed for airport close-in communities, while NADP2 procedures are for more distant community noise reduction. Examples of both NADP1 and NADP2 procedures can be found in ICAO Doc 8168 Aircraft Operations, Volume 1 Flight Procedures [40].

The close-in procedure (NADP 1) leverages automated engine thrust management. At a specified altitude, thrust is reduced to a lower climb power setting. The distant procedure (NADP 2) leverages flap retraction and takeoff thrust to accelerate and climb quicker, then thrust is reduced [41]. This procedure minimises aircraft noise farther from the airport by permitting the aircraft to climb higher before reducing thrust. Both noise abatement procedures are designed for maximum flexibility and can be customised for individual airports communities.

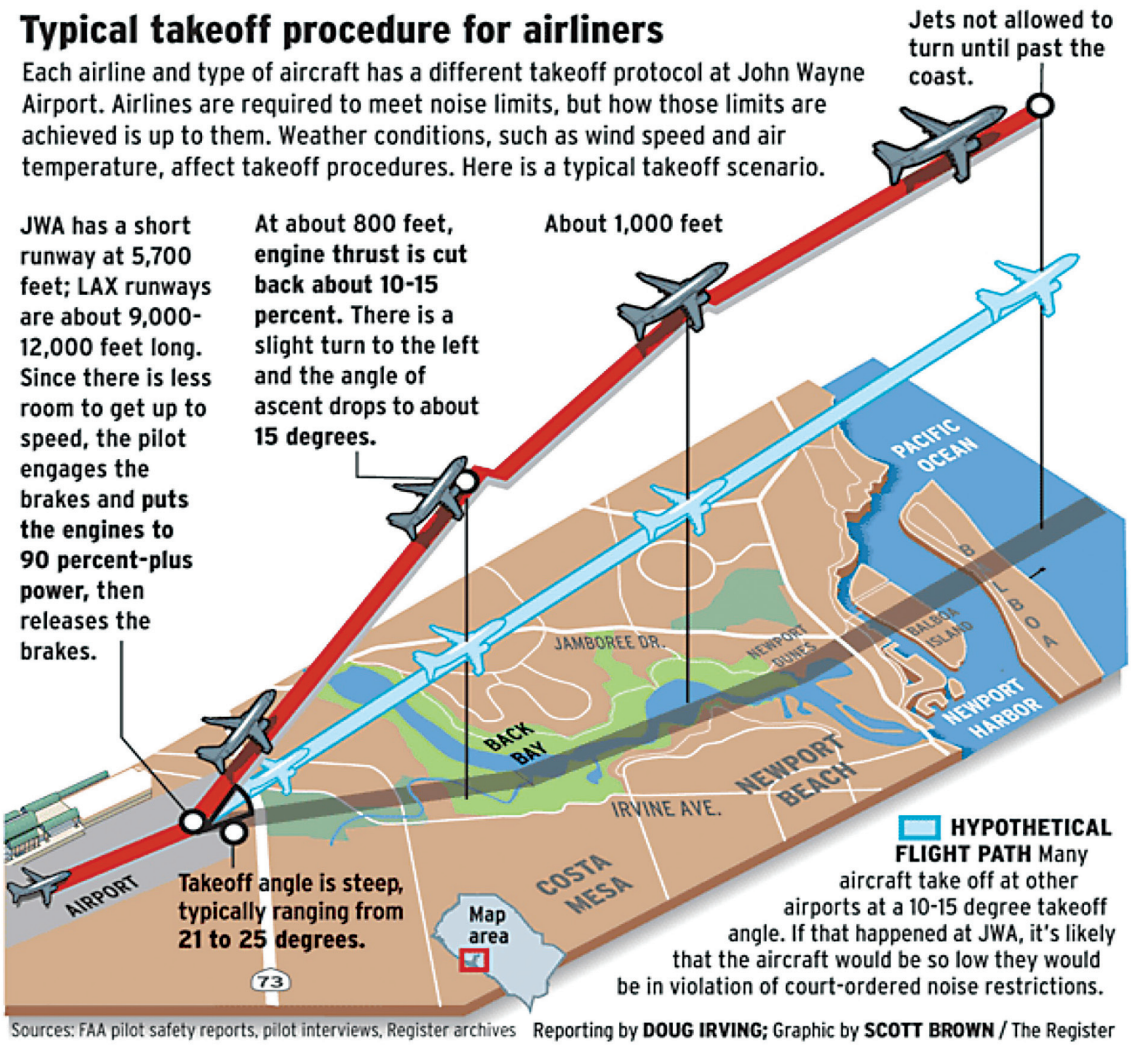


Figure 13 - John Wayne Airport Noise Abatement Procedures (Source: Orange County Register)

Although noise abatement procedures provide measurable noise reduction benefits, effective implementation requires that the procedure must be developed, tested, and evaluated for benefits and traffic impacts then approved and accepted by the ANSP and adopted by the airline operators.

Both ICAO PANS-OPS and AC 91-53A Noise Abatement Departure Profile suggest a maximum of two different noise abatement procedures be implemented by an airline. For any noise abatement operating procedure to be adopted, there must be appropriate crew training, safety review, and controller accommodation.

Figure 14 below highlights the difference these procedures have on community noise, either close-in or more distant relative to the take-off point. The noise mitigation of both NADPs takes place between 800 ft (240 m) and 3,000 ft (900 m) above ground level. This flexibility allows airlines to develop specific noise mitigation procedures that best fulfill each community's environmental needs.

The previous description used in PANS-OPS, as ICAO Procedure A, is compliant with the current definition of NADP1. Similarly, the ICAO Procedure B for distant noise mitigation procedure is compliant with the definition of NADP2 **[42]**. The flexibility currently provided in the PANS-OPS guidance provides greater implementation potential and a much broader environmental benefit – more efficient, cleaner and quieter flight.

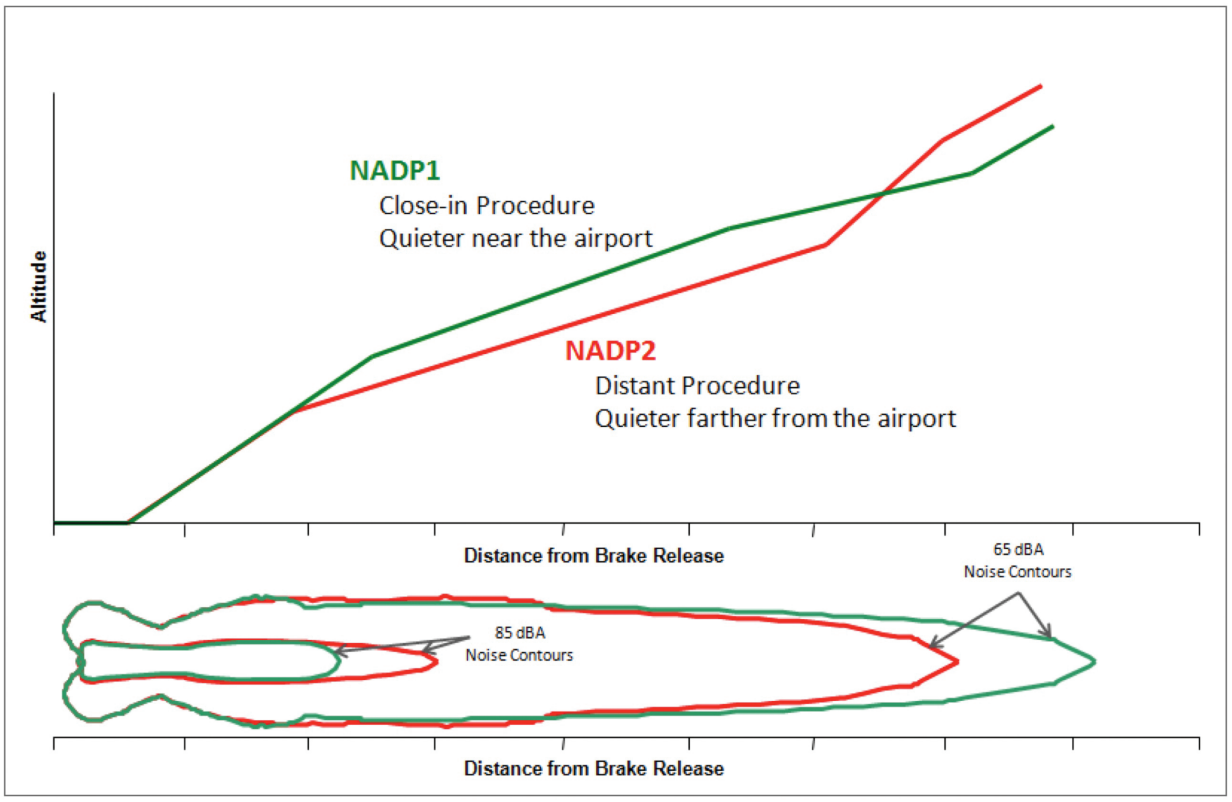


Figure 14 - Community Noise Benefits of NADP 1 and NADP 2 Procedures (Source: Boeing)

These noise abatement departure procedures, while making a measurable contribution to noise reduction near airports should be defined through a comprehensive environmental assessment.

NAPD 1 was applied to develop a thrust management procedure for an operator of older aircraft from a noise sensitive airport. The procedure used the aircraft's flight management system to reduce thrust on takeoff, climb to 1000 feet, then partially retract flaps and continue a reduced thrust climb. This procedure reduced noise by almost 2 dB out to 5 nm from brake release. Even beyond 5 nm this procedure lowered noise throughout the departure compared to the previous take-off procedure.

The environmental benefits of some departure procedures are straightforward and easy to visualise, e.g. preferential runways or flight tracks that keep away from noise sensitive communities. The selection of an appropriate departure procedure with regard to airport-specific environmental constraints requires the evaluation of available operational solutions in terms of noise and/or emissions. The impact on the community depends on the type of aircraft and the operating conditions. Assessment of noise impacts must be part of procedure development and evaluation and should include current and forecast airport fleet mix and geographical relationships of the airport runway(s) and flight paths relative to noise-sensitive areas.

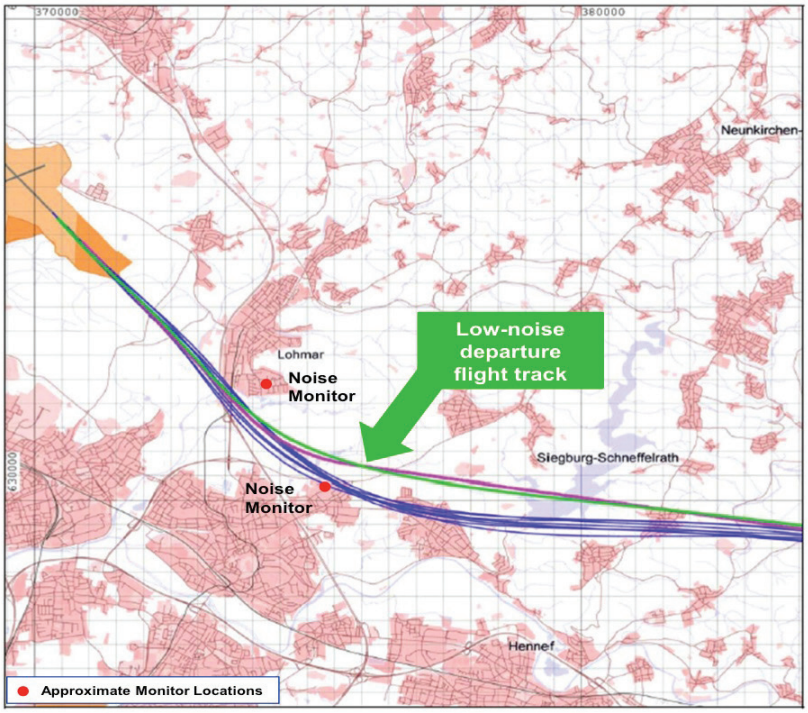
6.4 Other Procedures

There are other noise mitigation procedures that are generally under the control of the airport operator such as time constraints, noise quota counts, noise fees, engine test areas and such that are described in the next section.

CASE STUDY 6

Changing a standard departure to reduce noise

An international operator flying out of the Cologne/Bonn Airport wanted to continue to use evening departures with large aircraft but community complaints were becoming an issue. In 2012, a collaborative effort with the airline operator and a noise analysis group, worked with the airport and PBN departure designers to modify the standard departure routing for runway 14L. The INM noise tool was used to evaluate the change. This change was just enough to significantly reduce community overflights and complaints with the added benefit of slightly reducing fuel use during departure.



Source: Boeing

Cologne/Bonn Departure Runway 14L: old departures (blue), new routing (red/green)

CASE STUDY 7

Community collaboration to reduce airport departure noise – Melbourne Airport early turns

In late 2013, Airservices Australia noticed a marked increase in complaints about aircraft noise from the suburb of Keilor, south of Melbourne Airport. Airservices undertook an investigation, which showed that over the course of 2013, an increasing number of pilots were turning over the suburb rather than continuing on runway heading. For many of these aircraft, there was no obvious reason (such as traffic conditions or abnormal weather) to explain the early turns.

Early in 2014, Airservices contacted airlines, asking them to remind their pilots that that aircraft taking off from Runway 16 for destinations to the north and east should only turn to the west once they have reached a waypoint 4 nautical miles (roughly 7km) south of the airport. The number of early turns fell almost immediately and has remained low since. Airservices published this information on its website and informed the Melbourne Airport community forum (and continues to report each quarter).

Airservices also contacted as many of the complainants as possible who had alerted them to the problem to explain what action had been taken and thank them for their assistance.



Source: Airservices Australia

7
Airport Initiatives and Responsibilities

In general an airport operator has relatively little control over the noise that aircraft generate. But they can often control fees and penalties, which could directly impact the operator's business. This section examines some of the actions that airports can take to reduce noise and manage its effects on local communities. Community relations and communication will be further covered in Section 9.

7.1 Landing Fees

Many airports have a noise-related component associated with their landing fees. A reduced landing fee for the operations of quieter aircraft can provide an incentive to aircraft operators to use less noisy aircraft. Higher fees might also be charged for operations during night time periods.

Most charging schemes are based on an aircraft's certificated noise levels or on actual measured aircraft noise levels. Narita International Airport in Japan has implemented a landing charge fees structure based on the ACI Noise Rating Index.

A noise-related charging scheme can be established to be revenue neutral for the airport operator – the scheme itself generates no net income for the airport. This can be achieved if the total of the discount or reduction in landing fees for low-noise aircraft is equal to the total of the increased landing fees for higher-noise aircraft over a given period (e.g. a year). Alternatively, all residual funds raised by noise charges should be used for addressing or mitigating an airport noise issue. Examples include residential sound insulation, community funds, or other noise mitigation programmes.

ICAO's Balanced Approach document discusses landing fees in the context of generating funds for noise mitigation schemes. Consequently it is included under the section on land use planning. In general, however, airports view noise-related fees as an incentive for operators to use quieter aircraft.

7.2 Noise Monitoring and Reporting

The monitoring of aircraft noise levels in community areas is an important component of managing airport noise. Although noise monitoring has no direct noise reduction, it can be an integral component of noise management and community engagement.

Noise monitoring involves the use of specialised equipment including microphones and computerised logging devices to measure the noise levels from aircraft. An airport operator may choose to monitor noise for a variety of reasons such as:

- Determining and tracking aircraft noise levels in residential areas
- Publishing periodic noise metrics or for display in real time on an airport's website
- Compliance monitoring if individual aircraft or overall airport noise is subject to limits
- Measuring individual aircraft noise events for the purpose of charging

When locating a monitoring site, consideration should be given to background or ambient noise sources. Security and access for regular calibration and maintenance is also required. The monitoring system must be able to distinguish between aircraft events and other environmental noise events such as rain, wind and ground transport.

Automated systems should to be linked to radar or another aircraft identification system to ensure that recorded noise events are from an identifiable aircraft, and that a sufficient and representative proportion of all aircraft movements are captured.

7.3 Complaint Management

Many airports provide dedicated telephone lines for community complaints. Options include toll-free lines, facsimile (fax) lines and internet (or email) facilities.

A complaint processing system should include the following features:

- Well-advertised complaint services
- Simple, straight forward and easily accessible ways of lodging verbal, written and electronic complaints including access to telephone services and web sites. A systematic process for complaint handling, analysis and internal and external reporting to ensure consistency and transparency
- A guaranteed standard of response, explanation, acknowledgement, and follow-up
- Regular quality performance reviews of the complaint handling system

Complaints can provide an indication of the level of community disturbance due to airport activity, but should not be viewed in isolation. Reductions in the number of complaints may not necessarily indicate an increase in acceptance of aircraft noise levels.

Complaint management is also closely linked to community engagement (discussed in Section 8). Other methods for gauging community response should include social surveys, public consultation and analysis of media coverage. An airport should not wait for public responses to infrastructure planning applications to determine the level of community annoyance.

7.4 Other Noise Management Techniques

In some jurisdictions, operating restrictions on an airport may take the form a noise budget or quota and it is the responsibility of the airport operator to monitor and manage the noise levels. It is up to the airline operator to manage their flights to that quota.

For example, the UK has implemented a quota count (QC) system for Heathrow, Gatwick and Stansted airports to limit the amount of night time aircraft noise [43]. The QC system is based on aircraft noise certification data and each aircraft type is assigned a QC value depending on the amount of noise it generated under certification conditions. Aircraft are classified separately for landing and take-off. Quieter aircraft have smaller QC values, so a QC/2 aircraft is deemed to have twice the noise impact of a QC/1 aircraft and four times the impact of a QC/0.5 aircraft.

The UK airports operating the QC system have a fixed quota for the annual numbers of night operations which is allocated to the operating airlines. As each night aircraft movement takes place, an amount of this quota is used corresponding to the QC classification of the aircraft. When the airport's quota (or airline's allocation) has been used up, no more night movements are permitted. In practice, the airport spreads the quota so that it is used as evenly as possible.

CASE STUDY 8

Heathrow, Gatwick and Stansted Quota Count (QC) System

A quota count (QC) system was implemented in 1993 at London's Heathrow, Gatwick and Stansted airports to limit the total amount of noise generated by aircraft movements at night between 2330 and 0600.

Each aircraft type is assigned landing and take-off QC values based on noise certification data. There are seven QC bands from 0.25 to 16. The quieter the aircraft, the smaller the QC value, which permits more operations per time period. Thus a QC of 0.5 permits twice as many operations as a QC rating of 1.

Each airport has a fixed quota for the summer and winter seasons. A night time aircraft movement uses part of the airport's quota according to the aircraft's QC. If an airport's quota is fully used up, no more night-time movements are allowed in that season. Airports manage operations to ensure the quota lasts across the season. In addition to the overall movement limits, the allocated quotas at each airport can be adjusted as aircraft technology continues to improve.

At Heathrow, aircraft noisier than QC/2 may not be scheduled for night time operation. As QC/2 is more stringent than the ICAO Chapter 4 standard, QC/2 has become a de facto standard. The design of the A380 was specifically modified in order to meet QC/2, despite a small weight penalty.



8
Community Engagement

8.1 Key Factors

For airport operators and ANSPs, community engagement is a crucial link between environmental stewardship and providing the case for growth.

Community response to aviation noise is influenced by several factors, which can combine to influence both the number of people affected and the 'impression' of the noise. These factors (also noted in ICAO Doc 10031) are highlighted in Figure 15, which shows the relative degree of influence the aviation industry has on them **[44]**.

Community response against aviation activity or development may be more related to community perceptions, attitudes and expectations, than to the physical noise levels of aircraft movements. An informed and involved community will more likely respond in a measured and reasonable manner.

For an airport operator or ANSP, engagement with neighbouring communities is one action where positive and proactive initiatives can bring about positive results.

In most cases, an airport operator would take the lead role in community engagement, with the ANSP and other stakeholders involved, as outlined in the EUROCONTROL Specification for Collaborative Environmental Management (CEM) document **[45]** and the forthcoming ICAO Circular for Community Engagement **[46]**.

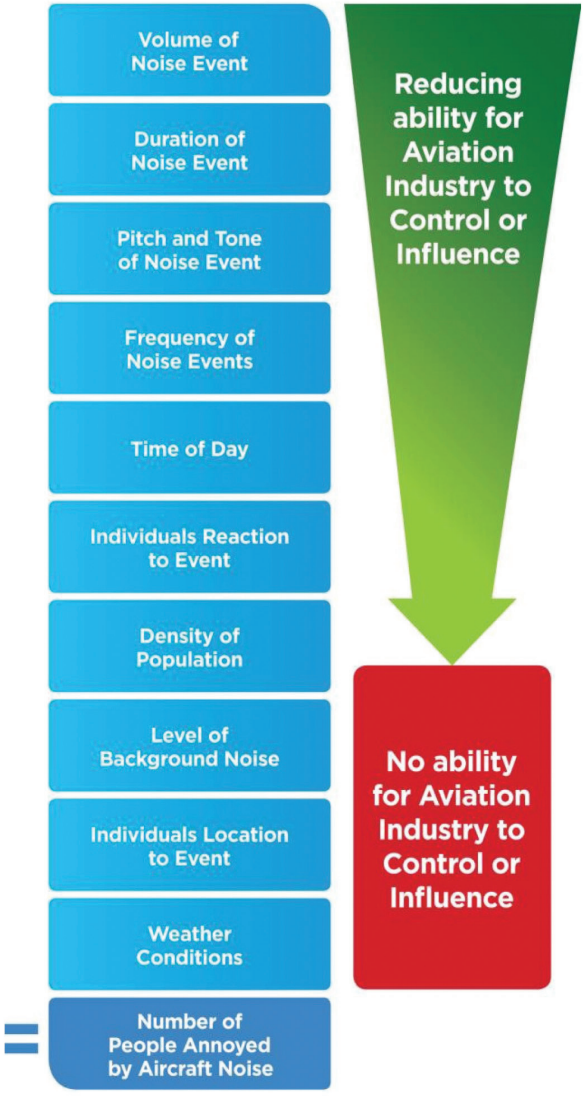


Figure 15 - The Noise Challenge (Source: Sustainable Aviation)

8.2 Recommended Actions

The EUROCONTROL CEM document provides clear guidance for ANSPs, airport operators, airline operators and other interested parties for methods to implement collaborative working relationships specifically related to environmental challenges around airports

including noise management. The core elements of CEM are based on communication and collaborative engagement to evaluate appropriate alternatives for an informed decision-making process.

The recommended actions include:

- Establishing agreed working arrangements between the stakeholders
- A method to recognise problems and issues and the contributing factors including the involvement of each collaborative party
- Recognising the underlying interdependencies
- Identifying the resources available to support the collaboration
- Reaching agreement on the outcome process and delivery method

The CEM provides additional guidance on relationships to external stakeholders such as neighbouring communities, local and national authorities, and regulators as well as steps to define working arrangements, discussion topics and communications.

8.2.1 Communication

The usual starting point for community engagement is the provision of information to affected communities. This information often includes:

- Existing operations and facilities, and the management of environmental impacts
- Identifying air traffic growth projections and options such as capacity and infrastructure expansion
- An environmental impact assessment (EIA) of the proposed projects

There are many channels of communication available to inform the general public or targeted groups including:

- Printed material such as reports, leaflets and brochures
- Websites with up-to-date information and electronic versions of documents available for download – or real-time noise monitoring and aircraft movement data (see case study on the next page)
- Social media to target messages more effectively for people interested in specific events like runway closures or night time flights
- Public meetings
- Press releases and articles in newspapers and magazines
- Radio and television spots
- Airport websites highlighting local air traffic such as WebTrak (see Case Study #11) and the Aircraft Monitoring System for the Port of Seattle and the Seattle-Tacoma International Airport **[47]**.

8.2.2 Collaboration

It is important that the views and opinions of the community are taken into consideration before implementing decisions (as the CEM stresses). This can be fostered by establishing forums or consultative groups. Such bodies, which bring together industry representatives and community members, can demonstrate a commitment to transparency, as the industry can be asked to account for any changes noticed by the community. They also provide an opportunity for the industry to report progress in noise management. Industry partners should discuss any issues that are likely to be raised ahead of the meeting, as any public disagreements will harm the credibility of the aviation industry as a whole.

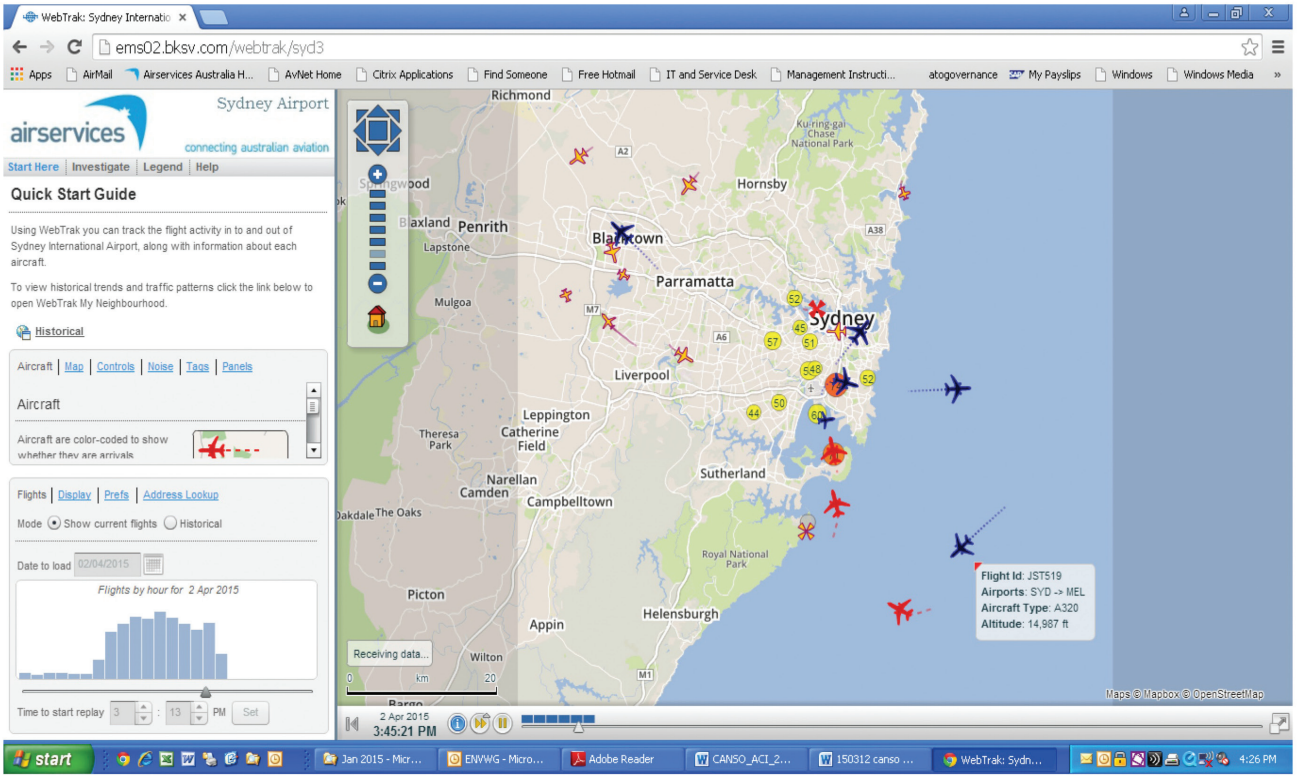
CASE STUDY 9

WebTrak - an aircraft noise website

Airservices has installed WebTrak at eight Australian city basins [48]. This is the world's largest single aircraft monitoring system, including eight major airports and eight secondary airports.

WebTrak enables the public to view aircraft movements at the relevant airport. The display provides information on type of aircraft and where it flew as it departs or approaches the airport. Noise data detected by noise monitors located around the local community is also displayed. It is possible to view the altitude at all points along the flight path along with the measured loudness as the aircraft passes a noise monitor. The user can also lodge a complaint from WebTrak. The advantage in using WebTrak for complaint lodgement is that the particular flight causing the concern is identified, making it easier to respond to the complaint.

During 2014, WebTrak was enhanced to include an overview of where aircraft typically fly, providing the user with an understanding of the operations and patterns over time. Statistics for the commonly-used flight paths as well as noise data collected for each monitoring location are provided, with users selecting the time period in which they are interested. The enhanced WebTrak features help the public address questions about the typical flight paths in their local area or area of interest. The enhanced WebTrak is considered a current best practice for online aircraft noise information. Only two other airports currently have these enhanced features.



Source: Airservices Australia

Example Webtrack display showing aircraft locations and noise values

8.2.3 Community Projects

Community engagement can move beyond communications and consultations on operations and development. Aviation stakeholders (usually airlines) are increasingly recognising their need or wish to enhance the quality of life in local communities and are implementing projects as part of a corporate social responsibility (CSR) programme. Examples can range from sponsoring local sports teams or cultural groups, supporting schools, open days, and educational events, to buying local art and targeting locally produced goods and services.

8.3 Key Principles

Aviation stakeholders need to be transparent and clear about their policies, projections and ambitions.

8.3.1 Transparency

Transparency is a key principle for community engagement. Some members of the public can be suspicious, cynical and emotional about airports and aircraft noise. Aviation stakeholders need to approach all engagements in an open and honest manner.

Information, especially on technical issues like aviation operations or noise measurement and forecasting, must be presented in a manner that is clear and understandable to a lay person. However, care must be taken not to over-simplify and to also make available additional, detailed technical information for those that have the technical capabilities or for consultants that community groups may engage.

Great care needs to be taken with noise metrics. Time-averaged (or cumulative) logarithmic noise metrics such as Lden or DNL may normally be appropriate for land use planning and zoning, but can often be confusing or unclear to those without technical background. Noise contours suggest that aircraft noise stops at a certain 'line' on a map whereas in reality it does not. Outside the contour, the noise is generally less than the specific boundary value but it is still audible. People do not relate to average noise levels and logarithmic scales can obscure potential impacts.

Noise metrics based on single events can be more useful for community engagement. Lmax (or SEL) can allow the comparison of different aircraft or flight tracks. Data on the number of over-flights in a period or N70 contours may be easier to understand. Some airports have started to provide data on respite – periods without any over-flights over a given location. These supplementary metrics can assist with better communicating the impacts of changes in airspace or infrastructure.

A combination of metrics is therefore required both for impact assessment purposes and for community information.

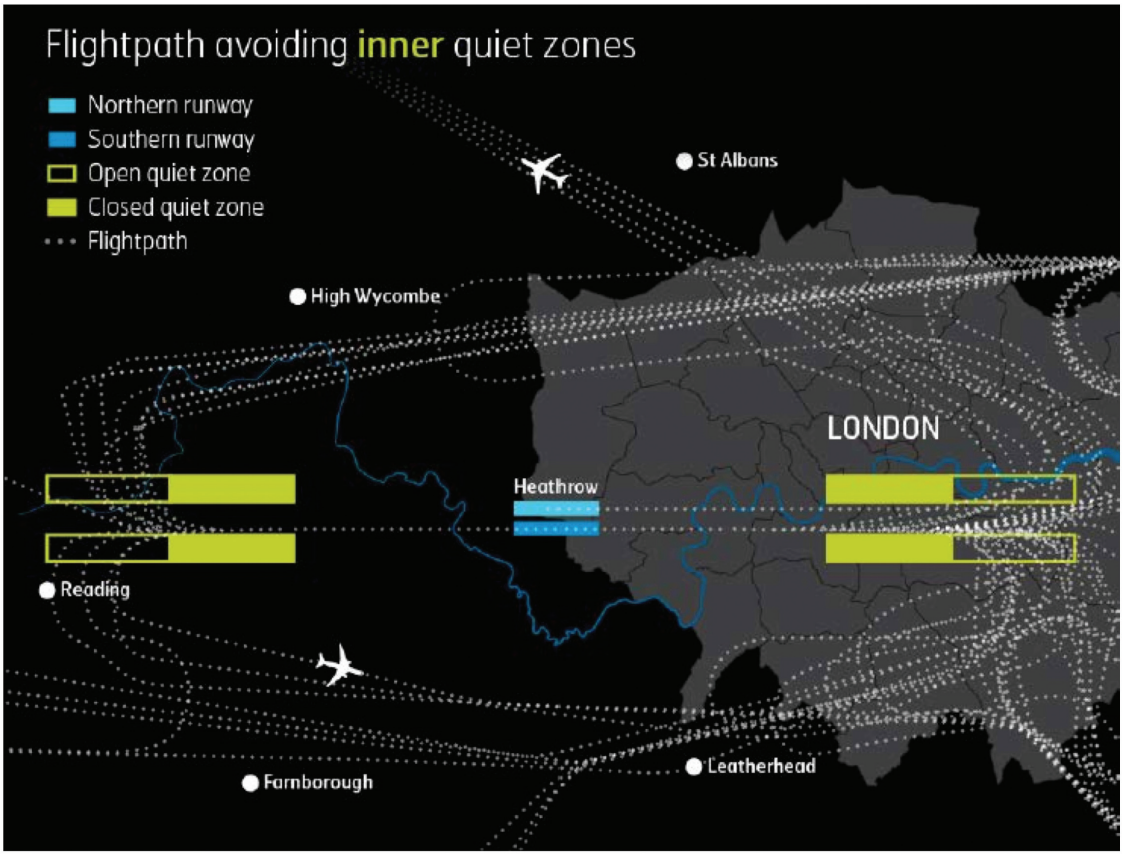
Another pitfall that can cause adverse reaction is trying to define limits of acceptability. While it may be appropriate to use noise contours to define land use planning zones, it can be counter-productive to attempt to impose acceptability criteria on residents. A resident who experiences a certain level of aircraft noise or number of events does not want to be told that his house lies outside a certain noise contour where noise impact is considered 'acceptable'. One approach is to present noise data such as the expected changes in noise due to an airspace change, without drawing conclusions on the impact of the changes.

CASE STUDY 10

Noise respite trials in the UK

In the UK, NATS worked with Heathrow Airport, British Airways and the community group HACAN on a noise respite trial for people living under the airport early morning arrival flight paths. With air traffic controllers instructing pilots to avoid flying over specific 'respite boxes' (see diagram) on alternate weeks, the trial was able to provide 100,000 people with some respite from noise. However, there were winners and losers in the trial. By providing respite for people in the southeast and east of London and the county of Berkshire, this traffic control method resulted in an increase in early morning over-flights for people in other areas of London.

This is an important example of proactive community engagement, but the findings prove that providing relief from noise is far from a straightforward proposition. Noise can be avoided for some communities, but that process can lead to an increase of noise in other areas. The team behind the trials learned from this exercise and will take this experience into further trials designed with community groups.



Source: NATS

8.3.2 Community Input

A consultation process must make provision for incorporating the views of resident communities into any decision-making process. An important component is to ensure that affected communities understand the operational and environmental issues; what can realistically be achieved; and why some measures might simply not be possible.

It needs to be understood that complete consensus or acceptance across a community might not be achievable but general preferences can be established. An example of this is the fact that some communities will tolerate longer periods of continuous low-level noise as long as they have respite from loud, individual noise events, whereas other communities prefer the opposite.

8.3.3 Trust

Communication with community members must be based on trusting the data and the people conveying the messages. Credibility and trust can only be built gradually so an airport operator and its aviation stakeholders need to make a long-term commitment to develop a strong relationship with community members. Airports need to view themselves as members of the communities that they serve.

Trust can start with transparency and honesty in communication and collaboration. Making an early start is crucial. Start working with the community, listening to their concerns and responding to their complaints as early as possible.

Community engagement requires a long-term view. Structured consultation may be a requirement for the process of obtaining planning consent for a development. However, many other voluntary initiatives such as providing information, and educating the community on the importance of the airport as a regional asset should be part of the corporate ethics of the airport operator.

8.4 Other Considerations

While aircraft noise is usually the main concern of local communities, other airport environmental impacts also include local air quality and GHG emissions, water, land, soil, habitat and waste management. Airspace management also needs to consider impacts other than noise, including fuel consumption, emissions, flight efficiency and operating costs. Some or all of these may be of concern to local communities. Airport operators need to be able to respond to these concerns and ANSPs may be called on to supply relevant information on operations.

Community engagement and consultation will also need to address issues, especially those which may have interdependencies with noise management. If new flight tracks are introduced to reduce fuel consumption and GHG emissions, residents impacted by more noise might not accept the changes. Reducing noise for many but increasing it for a few usually requires extensive engagement.

An individual's response to aviation impacts can be highly dependent on his or her attitude towards aviation. It is incumbent on the aviation industry to communicate the economic and social benefits of aviation. Understanding the importance of air transport, its regional development, job creation and economic stimulation, the value of connectivity for business, leisure and freight, can provide some mitigation of negative attitudes and annoyance. Again, with such information, open and transparent information remain paramount.

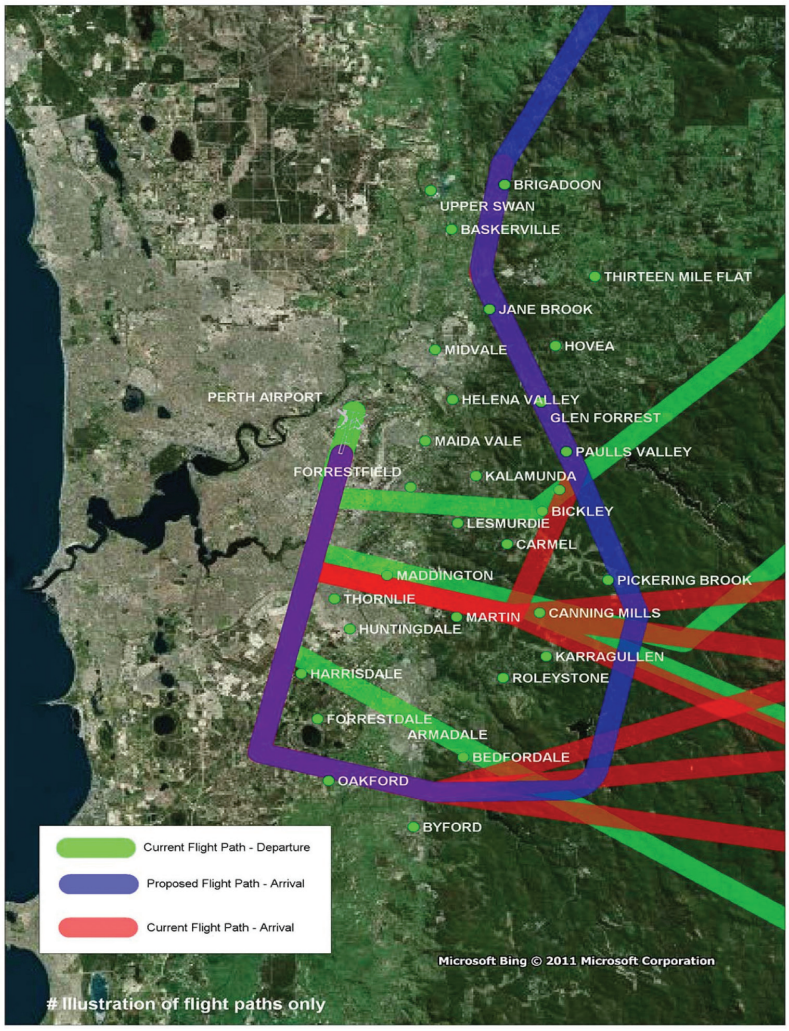
CASE STUDY 11

Working with a community to adjust noise - Roleystone arrival flight path trial

During 2010 and 2011, Airservices Australia received a consistently high number of complaints from the suburb of Roleystone, southeast of Perth Airport. An investigation by Airservices and the Aircraft Noise Ombudsman concluded that the cause of most of the complaints was an arrival flight path to the airport. Airservices designed a new flight path that would lead to fewer over-flights of Roleystone, by moving the flight path over a less populated area.

Before commencing a trial of this flight path, Airservices sought feedback from the Perth Airport Community Forum. Airservices placed extensive information about the new flight path proposal on its website; it undertook community information sessions in both Roleystone and the new area that would experience an increase in over-flight, published advertisements in local newspapers and even sent information to every affected household.

The trial commenced on 22 August 2013 and was completed in 2014. A review of the trial was conducted and a report was published for community comment. This review included analysis of complaints and comments made by community members during the trial period. Following public comments and review, the procedure was implemented in 2015.



Source: Airservices Australia

9
Conclusion

This reference document should inform and provide a variety of options for airport operators and ANSPs to assess and address the impact of aviation noise. The list of noise metrics, the ICAO Balanced Approach, possible noise reducing operations, and methods for effective community interaction, provide the tools to implement positive measures to reduce community noise around airports.

To implement these changes requires government support, both national and local; regulatory agency support; and a broad stakeholder commitment to work together to find the 'right' approach for the local situation. One solution will not fit all needs.

Figure 16, slightly modified from the Sustainable Aviation noise roadmap, encapsulates the relevant sources of noise and the methods of noise mitigation [49]. Notice that five bubbles of types of mitigation include the four fundamental elements of the ICAO Balanced Approach as well as the fifth essential element for effective community engagement and communication.

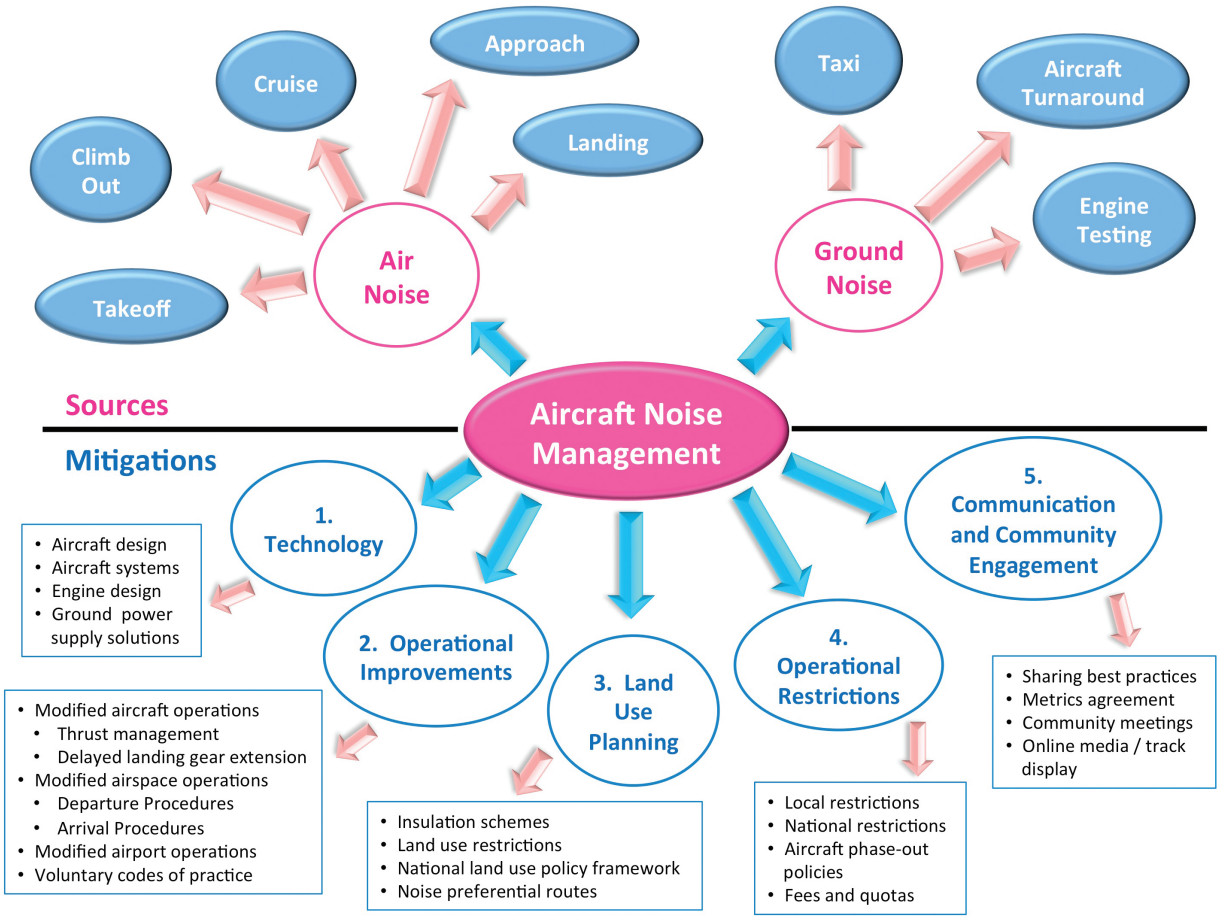


Figure 16 – Sources and Mitigations for Aircraft Noise (Source: Sustainable Aviation)

10

References

1. Air Transport Action Group (ATAG), Facts and Figures, **www.atag.org/facts-and-figures.html**
2. ATAG, *Aviation Benefits Beyond Borders*, April 2014, **http://aviationbenefits.org**
3. International Civil Aviation Organization (ICAO), **www.icao.int/TopSliderPictures/EAP-Facts-figs_598x248_rev-2013-07.png?Mobile=1**
4. ATAG, 2012 Summit Declaration, **www.atag.org**
5. ICAO, *Annex 16 Environmental Technical Protection, Volume I, Procedures for the Noise Certification of Aircraft, Doc 9501*, **www.icao.int/environmental-protection/Documents/Publications/Doc_9501_Volume_I.pdf**
6. Commonwealth of Massachusetts Office of Environmental Affairs, 2013
7. ICAO DOC 10031, *Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes* (2014), **www.icao.int/publications/pages/publication.aspx?docnum=10031**
8. *Aircraft Noise and Performance (ANP) Database Version 2.0* (Dec 28, 2012) at **www.aircraftnoisemodel.org/**
9. ICAO DOC 9911, *Recommended Method for Computing Noise Contours Around Airports* (replaces Circular 205), **www.afeonline.com/shop/icao-doc-9911.html**
10. Integrated Noise Model, FAA, now replaced by AEDT as of May, 2015.
11. Aviation Environmental Design Tool (AEDT), May 2015, **aedt.faa.gov/**
12. European Civil Aviation Conference (ECAC) Doc 29 *Report on Standard Method of Computing Noise Contours Around Civil Airports, 3rd Edition Vol 1 (User Guide) and Vol 2 (Modelling Methodology)*, **https://prod.ecac-ceac.org/ecac-docs**
13. IMPACT information can be found at **www.eurocontrol.int/services/impact**
14. Ibid 8.
15. World Health Organization, *Guidelines for Community Noise*, **www.who.int/docstore/peh/noise/guidelines2.html**
16. Ibid 8, Section 4.2, Interdependency Examples.
17. ICAO Document 9829, AN451, Guidance on the Balanced Approach to Aircraft Noise Management, 2nd Ed., **www.afeonline.com/shop/icao-doc-9829.html**
18. Ibid 6, ICAO Annex 16, Chapter 14.
19. New Zealand, Resource Management Act (1991), **www.mfe.govt.nz/rma**

20. ICAO, *Noise Abatement Procedures: Review of Research, Development and Implementation Projects – Discussion of Survey Results* 2010 (Doc 9888), **www.icao.int/environmental-protection/Pages/environment-publications.aspx**

21. *Sustainable Aviation Noise Road-Map: A Blueprint for Managing Noise from Aviation Sources to 2050* (2014), **www.sustainableaviation.co.uk/information/technical-papers/**

22. ICAO DOC 9931, *Continuous Descent Operations (CDO) Manual*, 1st Ed., 2010, **http://www.afeonline.com/shop/icao-doc-9931.html**

23. EUROCONTROL *Continuous Descent, A guide to implementing Continuous Descent* (2011), **www.eurocontrol.int/sites/default/files/publication/files/2011-cd-brochure-web.pdf**

24. Sustainable Aviation, *A Guide to Continuous Descent Operations*, 2014, **www.sustainableaviation.co.uk/wp-content/uploads/A-Guide-to-CDOs-Booklet.pdf**

25. Continuous Descent Operations, User Forum 2013, **www.eurocontrol.int/sites/default/files/rich_block/content/documents/events/Presentations/130124-uf-osdsss-cdos.pdf**

26. ICAO ASBU Workshops 2012 , presentation by Saulo Da Silva on 'Continuous Descent Operations', **www.icao.int/ESAF/Documents/meetings/2012/asbu/wp26.pptx**

27. EUROCONTROL, Continuous Descent Operations Implementation Program, **www.eurocontrol.int/articles/continuous-descent-operations-cdo**

28. FAA Advisory Circular AC-120-108, Continuous Descent Final Approach, **www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/877339**

29. "Tailored Arrivals Help Reduce Aviation's Environmental Impact", S. Meador, C. Maldonado, et.al., AIAA-2008-8868-829, 2008. **ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5655509&tag=1**

30. "Steep Segmented Approaches", Dr. Bernd Korn, Vilmar Mollwitz, DLR Institute of Flight Guidance, ICANA, 2013.

31. "Flight Evaluation of Three-Dimensional Area Navigation for Jet Aircraft for Noise Abatement", D.G. Denery, et.al. Journal Aircraft, V10 NO 4, Apr 1973.

32. FAA AC 90-101A, *Approval Guidance for RNP- Procedures with Special Aircraft and Aircrew Authorization Required*. **www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/903610**

33. EUROCONTROL, *Introducing Performance Based Navigation (PBN) and Advanced RNP (A-RNP)*. **www.eurocontrol.int/sites/default/files/publication/files/2013-introducing-pbn-a-rnp.pdf**

34. ICAO Doc 9993, *Continuous Climb Operations (CCO) Manual*, **http://cfapp.icao.int/tools/ATMiKIT/story_content/external_files/10260008117raft_en_CCO.pdf**

35. "Operational Demonstration of a Performance-Based Separation Standard at the Hartsfield-

Jackson Atlanta International Airport", R.H. Meyer, et.al., MITRE, ATM2013, **www.atmseminar.org/seminarContent/seminar9/papers/189-Mayer_0124130530-Final-Paper-4-11-13.pdf**

36. FAA, 8260.40D, Departure Procedures Design, Appendix A. **www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs400/afs420/policies_guidance/memo_TILS/media/RNP-1_DP.pdf**
37. Orange County Register, July 19, 2012, **http://www.ocregister.com/articles/john-364661-wayne-airport.html**
38. ICAO *Procedures for Air Navigation Services: Aircraft Operations, Volume I Flight Procedures*, DOC 8186, Section 7, **http://dcaa.trafikstyrelsen.dk:8000/icaodocs/Doc%208168%20-%20Aircraft%20Operations/Volume%201%20Flight%20Procedures,%205th%20ed..pdf**
39. FAA, AC 91-53A, *Noise Abatement Departure Profile* **www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/22420**
40. Ibid, Ref 38
41. Ibid, Ref 38. PANS-OPS, Volume I, Part I, Section 7, Chapter 3.
42. ICAO *Review of Noise Abatement Procedures and Implementation Results*, **www.icao.int/environmental-protection/Documents/ReviewNADRD.pdf**
43. UK CAA, *Review of the Quota Count (QC): Re-Analysis of System, Re-Analysis of the Differences Between Arrivals and Departures*, **www.caa.co.uk/docs/33/ERCD0204.pdf**
44. Sustainable Aviation – *Noise Roadmap, A Blueprint for Managing Noise from Aviation Sources to 2050* (2014), **www.sustainableaviation.co.uk/wp-content/uploads/SA-Noise-Roadmap-Publication-version1.pdf**
45. EUROCONTROL, *Specification for Collaborative Environmental Management*, **www.eurocontrol.int/articles/collaborative-environmental-management-cem-specification**
46. ICAO Circular for Community Engagement, not yet released, to be submitted for CAEP approval in February 2016.
47. Port of Seattle Aircraft Monitoring for noise abatement. **www.portseattle.org/Environmental/Noise/Noise-Abatement/Pages/Aircraft-Monitoring-System.aspx**
48. **www.airservicesaustralia.com/aircraftnoise/webtrak/**
49. Sustainable Aviation, *Aviation Noise Roadmap A Blueprint for Managing Noise from Aviation Sources to 2050* (2014) (Ref. 46, modified Fig. 6)

Acronyms

ACI	Airports Council International
AEDT	Aviation Environment Design Tool
AGL	Above ground level
ANEF	Australian noise exposure forecast
ANP	Aircraft noise and performance
ANSP	Air navigation service provider
ATAG	Air Transport Action Group
ATC	Air traffic control
ATM	Air traffic management
BADA	Base of aircraft data
CAA	Civil aviation authority
CAEP	Committee on Aviation Environmental Protection (ICAO)
CANSO	Civil Air Navigation Services Organisation
CCO	Continuous climb operations
CDA	Continuous descent approach
CDO	Continuous descent operations
CEM	Collaborative Environmental Management
dB	Decibel
dBA	A-weighted sound
DNL	Day night average sound level
EASA	European Aviation Safety Agency
ECAC	European Civil Aviation Conference
EIA	Environmental impact assessment
EPNL	Effective perceived noise level
ENVWG	Environmental Workgroup (CANSO)
FAA	Federal Aviation Administration
Ft	Feet
GBAS	Ground-based augmentation system
GDP	Gross domestic product
GHG	Greenhouse gas
GLS	GBAS landing system
GNSS	Global navigation satellite system
Hz	Hertz
HBPR	High by-pass ration
ICAO	International Civil Aviation Organization
ILS	Instrument landing system
INM	Integrated noise model
KLAX	Los Angeles International Airport

KM	Kilometres
KSFO	San Francisco International Airport
KSNA	John Wayne Airport
Lden	Day-evening-night equivalent level
Ldn	Day night average sound level
LMAX	Maximum sound level
LAeg	A-weighted equivalent sound level
LBPR	Low by-pass ratio
LUP	Land use planning
NAP	Noise abatement procedures
NADP	Noise abatement departure procedure
NASA	National Aeronautics and Space Administration
NEF	Noise exposure forecast
NM	Nautical mile
NPR	Noise preferred route
OPD	Optimised profile decent
PANS-OPS	Procedures for air navigation services – aircraft operations
PBN	Performance-based navigation
QC	Quota count
RNAV	Area navigation
RNP	Required navigation performance
RNP APCH	Required navigation performance approach
RNP AR	RNP authorisation required (approach)
RWY	Runway
SEL	Sound exposure level
SESAR	Single European Sky ATM Research
SID	Standard instrument departure
STAPES	System for Airport Noise Exposure Studies
TA	Tailored arrival
UK	United Kingdom
YBGC	Gold Coast Airport