**BEFORE THE HEARINGS PANEL APPOINTED BY THE QUEENSTOWN LAKES DISTRICT COUNCIL**

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| **Under** | the Resource Management Act 1991 |
| **In the Matter** | of the urban Intensification Variation to the Proposed Queenstown Lakes District Plan |
| **Submitter** | **QUEENSTOWN AIRPORT CORPORATION LIMITED**<br>Submitter 822 and Further Submitter 1355 |

# Evidence of **Christopher William Day** (Acoustics) on behalf of Queenstown Airport Corporation Limited

Dated: 04 July 2025

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## INTRODUCTION

1 My full name is Christopher William Day.

2 I have worked in the field of acoustics, noise measurement and control for the past 50 years in England, Australia and New Zealand, specialising in transportation noise and acoustics for the performing arts. My firm is one of the largest acoustic engineering consultancies worldwide, working on major projects in over 15 countries. We employ approximately 100 professional staff throughout New Zealand, Australia, Hong Kong and France.

3 I have the qualification of Bachelor of Engineering (Mechanical) from Monash University in Melbourne, Australia. My work over the last 45 years has included noise control engineering and town planning work for various major corporations and city councils within New Zealand, and I have been engaged on numerous occasions as an expert witness before the Environment Court.

4 I have had significant involvement in matters relating to airport noise at all three major airports in New Zealand: Auckland, Wellington and Christchurch, as well as most of the regional airports, including Rotorua, Whangarei, Dunedin, Invercargill, Queenstown, Wanaka, Ardmore, Hamilton, Tauranga, Nelson, Napier, Omaka, Paraparaumu, Gisborne, Masterton and Taupo.

5 Marshall Day Acoustics has been engaged by Queenstown Airport Corporation (QAC) since 1992 to advise on various noise issues including:

5.1 preparation of the original noise contours (1995) to form the basis of the airport noise provisions in the Queenstown Lakes Operative Disrtct Plan;

5.2 preparation of the remodelled contours and associated PC35 hearings;

5.3 further remodelling of the contours and community consultation for a second plan change that ultimately did not progress.

## CODE OF CONDUCT

6 Although this is not an Environment Court hearing, I confirm that in preparing my evidence I have reviewed the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023. I have complied with it in preparing my evidence. I confirm that the matters on which I give evidence are within my area of expertise, except where relying on the opinion or evidence of other witnesses. I have not omitted to consider material facts known to me that might alter or detract from my opinions expressed.

## SCOPE OF EVIDENCE

7 In my evidence I will address whether intensification within areas affected by aircraft noise, in particular the OCB and ANB for Queenstown Airport, is appropriate in acoustic terms. In doing so I will address:

7.1 Community response to aircraft noise and health effects;

7.2 New Zealand Standard NZS 6805 (**NZS6805** or **Standard**);

7.3 Implementation of NZS 6805 at other NZ airports and at Queenstown Airport;

7.4 A comparison with general District Plan noise limits;

7.5 Why sound insulation does not resolve all the noise effects;

7.6 Examples of reverse sensitivity effects at other airports;

7.7 The EPA Decision on No.1 Hansen Road; and

7.8 Submissions on UIV

8 **Appendix 1** provides a glossary of noise terminology used in my evidence.

## EXECUTIVE SUMMARY

9 Intensification inside the airport noise boundaries for Queenstown Airport is in my opinion, inappropriate from a noise effects perspective. There are a number of key arguments to support this opinion as listed below.

10 Clause 1.1.4 of NZS 6805 recommends the Standard should not be used to downgrade existing noise controls.

11 World-wide, community annoyance from aircraft noise has approximately doubled since the land use controls in NZS 6805:1992 were first introduced, and now 26% to 46% of people exposed to 55 to 65 dB $L_{dn}$ are reported to be highly annoyed. This is a significant adverse effect that should be avoided if at all possible.

12 The World Health Organisation (**WHO**) 2018 Study[1] (section 3.3) states "aircraft noise above 45 dB $L_{den}$ [2] is associated with adverse health effects".

[1] Environmental Noise Guidelines for the European Region (WHO 2018)

[2] $L_{den}$ is a very similar measure to $L_{dn}$ with an evening penalty of 5 dB added to the $L_{Aeq}$ . In practice, the $L_{den}$ value is very close to the $L_{dn}$ value - within 1 dB or so.

13 A report by Professor Charlotte Clark (a world authority on the effects of environmental noise on health) confirms there are adverse health effects from aircraft noise at 45 dB $L_{dn}$ and above.

14 Planning controls at other New Zealand airports vary depending on the circumstances – Queenstown has determined (through PC35, adopted in the PDP) that new ASAN should be prohibited inside 55 dB $L_{dn}$ in rural areas and within the BMUZ, and limited in other existing zones inside this area.

15 Specifying sound insulation to be fitted to buildings in these noise environments will not eliminate the adverse effects of noise, due to open windows and an unsatisfactory outdoor noise environment. This approach has been confirmed in the recent High Court decision on Osterley Way.

16 Reverse sensitivity is a very real effect for airports worldwide. Costly operational constraints have been implemented at many airports.

17 For these reasons, intensification inside the airport noise contours should be avoided.

18 Each of these issues is discussed in this evidence.

**INTRODUCTION**

19 I understand that the notified Variation does not propose to intensify within the OCB and ANB for Queenstown Airport, but there are, however, several submitters who are seeking provision for intensification in these areas or removal of existing restrictions on, or upzoning of land that would enable additional noise sensitivity activities to establish within the OCB.

20 The focus of my evidence is on whether intensification inside the airport noise boundaries is appropriate in acoustic terms.

21 It is a long-established concept that aviation noise can have an adverse effect on people and communities. World-wide, the lack of appropriate land use planning around airports has historically caused significant numbers of people to be exposed to aircraft noise and subsequent community action has initiated operational constraints on airports. The adverse effects of noise include annoyance, speech interference, sleep disturbance and potentially health effects associated with annoyance.

22 In 1995 the QLDC introduced airport noise boundaries into the District Plan along with appropriate land-use controls to avoid people being exposed to the adverse effects of aircraft noise and to protect the airport from reverse sensitivity effects.

23 A number of factors confirm there are adverse effects from aircraft noise inside the 55 $L_{dn}$ Air Noise Contour and that this is not a desirable noise environment in which to locate new residential development. These are discussed shortly in my evidence.

**Nature of aircraft noise**

24 Aircraft noise by its nature involves short-duration, high-noise-level events, followed by periods of no aircraft noise, on properties beneath take-off and landing flight paths. These high levels of noise cause interruption to speech (indoors and outdoors) and disturbance to sleep, depending on the level (ie how loud the noise is). Because of the high-level (ie loud) nature of aircraft noise, it is highly noticeable above other environmental noise sources and thus residents find it more annoying.

25 This aircraft noise is difficult to mitigate, given the source of the noise is at altitude and moving. This is compared to noise from a stationary, ground-based source (such as industrial noise sources and road traffic), which may allow barriers or other shielding to be employed to minimise noise effects.

26 Aircraft noise from individual aircraft has reduced noticeably over time due to technological advances through considerable investment from the aviation industry. The graph below shows the significant reduction in aircraft noise since the 1950s.

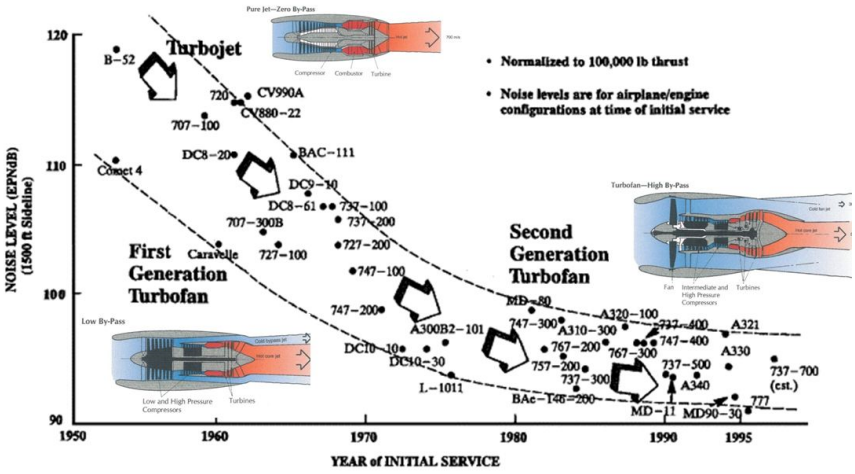


*Figure 1 – Progress in commercial aircraft noise reduction, 1950–1995 (Source: Boeing)*

27 The obvious trend from Figure 1 is that noise reductions for individual aircraft are 'bottoming out' — no further large reductions in noise look likely. This finding is confirmed by noise measurements of different aircraft types (new and old) operating at Auckland Airport.

28 There is speculation about electric aircraft solving the noise problems at airports. In my opinion, this is unlikely for several reasons. Firstly, electric aircraft are only projected to be viable for short haul regional flights, which make up a small percentage of the overall airport noise output.

29 Secondly, very little data is available on how quiet these aircraft are or will be. The proposed electric aircraft are propellor driven. In general, aircraft noise on approach is driven by 'airframe noise' — noise generated by airflow over aircraft elements such as landing gear and control flaps. Very little noise is generated by the engine on approach (low power). Thus, landing noise for electric aircraft is unlikely to be much quieter but take-off noise may be slightly quieter for short haul aircraft.

30 With only small reductions in aircraft noise output now available, the only other option to reduce the level of aircraft noise is to introduce operational constraints. Operational constraints include curfews, noise limits, noise abatement take-off procedures and noise charges. These are discussed further under reverse sensitivity in paragraphs 103 to 123.

31 In an attempt to avoid New Zealand airports becoming constrained in similar ways (and to avoid more residents being affected by aircraft noise) the New Zealand Standard was developed in 1992 to encourage sensible land use planning. I discuss the details of the New Zealand context further below from paragraph 116 of my evidence onwards.

**COMMUNITY RESPONSE TO AIRCRAFT NOISE**

32 Despite the reduction in noise achieved through technological advances and through noise abatement procedures, annoyance due to noise around airports has continued to increase. A large number of overseas studies have been carried out over time to investigate community response to environmental noise. The general approach of these studies is to question residents (verbally or in writing) as to their level of annoyance to a particular noise source. The noise level at the respondent's location is then determined by either measuring it or by using calculated noise contours.

33 'Noise levels' are normally measured / calculated as Ldn — the Day / Night Level for aircraft noise — which involves a summation of the noise energy over 24 hours with a 10 dB penalty for noise at night (due to the increased sensitivity to noise at night). Analysis of these widely varying

results allows a 'dose-response curve' (regression analysis[3]) to be prepared showing the percentage of people highly annoyed versus the level of noise they are exposed to.

34 In 1978, the Schultz curve was developed from a number of studies on general transportation noise (including air, road and rail).[4] The Schultz results were available during the preparation of New Zealand Standard NZS 6805 (discussed below at paragraph 49 onwards) and informed its development.

35 A more comprehensive amalgamation of the various transportation noise studies (including aircraft) was carried out by Miedema and Oudshoorn in 2001.[5] The dose-response curve from this study is shown in Figure 2 below.

36 In 2002, Taylor Baines & Associates and Marshall Day Acoustics conducted a noise annoyance survey in Christchurch. The study was conducted to investigate how the Christchurch community responded to environmental noise when compared to the previous overseas studies (Schultz and Miedema). The results of this study are also illustrated in Figure below.

37 There have also been a number of international studies in respect of aircraft noise that have been undertaken in recent years. Marshall Day Acoustics has completed a literature review of 45 of the latest studies.

38 Each study included analysis of a number of different airports. Of the 14 studies:

38.1 6 reported an increase in noise annoyance over time (FAA, Guski x3, WHO, Janssen and Vos);

38.2 1 reported a decrease (Vietnam);

38.3 4 reported no change (Gjestland x 2, Fidell, Gelderblom); and

38.4 3 did not report on a change (NZTA, Brink, Gjestland 2021).

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[3] Regression analysis is a statistical method that examines the relationship between two or more variables to develop a trend line from a data set.

[4] T J Schultz "Synthesis of social surveys on noise annoyance" (1978) 64(2) *Journal of the Acoustical Society of America* 377.

[5] Henk Miedema and Cartharina Oudshoorn "Annoyance from Transportation Noise: Relationships with Exposure Metrics DNL and DENL and Their Confidence Intervals" (2001) 109(4) *Environmental Health Perspectives* 409.

39 The two largest studies in this set of studies were the World Health Organisation ("WHO") study in 2018,[6] and the Federal Aviation Administration ("FAA") study in the United States in 2021.[7]

40 Both of these studies show a significantly higher level of annoyance than the Miedema 2001 dose-response curve. The dose-response curves from these studies are shown below in Figure 2 along with the Miedema and 2002 Christchurch study for comparison.

41 In 2024 Waka Kotahi carried out a study of community response to transportation noise in New Zealand. The study included the subjective response from residents exposed to aircraft noise. The aircraft noise results are shown in Figure 2 below.

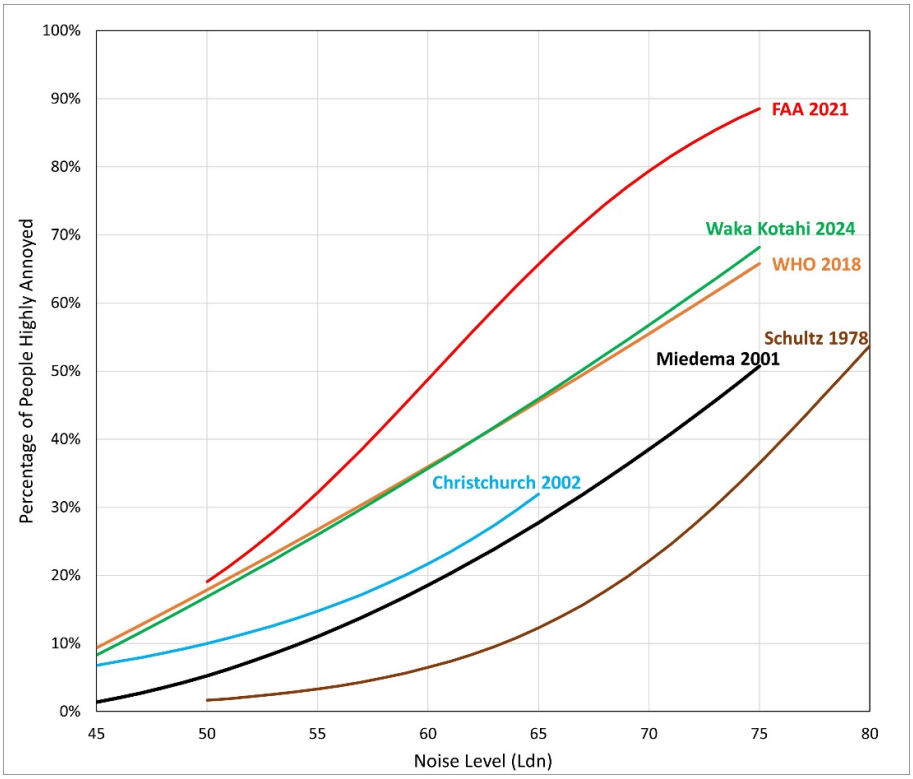


*Figure 2 – Community Response to Aircraft Noise – Comparison of Studies*

42 The clear conclusion from these recent studies (summarised in Figure 2 above), is that community annoyance from aircraft noise is significantly higher today than the results from 20

6 Rainer Guski, Dirk Schreckenberg and Rudolf Schuemer "WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Annoyance" (2017) 14(12) *International Journal of Environmental Research and Public Health* 1539.

7 US Department of Transportation, Federal Aviation Administration *Analysis of the Neighbourhood Environmental Survey* (National Technical Information Service, February 2021).

to 40 years ago. In my opinion, the recent Waka Kotahi Study shows that the WHO data in Figure is broadly applicable to the New Zealand context.

43 Figure 2 is also useful to show that at 55 to 65 dB Ldn (the noise levels within the OCB for Queenstown Airport) some 26% to 46% of people are expected to be highly annoyed (WHO). This data shows firstly that there would be a significant adverse noise effect on people if they were allowed to move into the noise boundaries and secondly, the potential for significant adverse reverse sensitivity effects for QAC.

**Health Effects**

44 At a relatively recent hearing in Christchurch (PC14), the decision makers suggested evidence was not submitted which showed a connection between 'Annoyance' and 'Health Effects'. World Health Organisation studies (including the 2018 study reported above) have investigated and reported 'annoyance' as a 'health effect' for many years. As a health focused body, WHO would not be interested in annoyance, if it were merely an amenity effect.

45 More recently, an extensive 2025 report by the European Environment Agency[8] discusses annoyance as a health effect (12 page summary attached as Appendix C). On page 70, the report states; *"The 2030 zero pollution target for noise refers to reducing the number of people who are 'chronically disturbed by noise'. This term includes a range of negative health effects such as annoyance, sleep disturbance and cardiometabolic issues amongst others. High annoyance is considered a good indicator of the adverse health impacts of noise, as it can be a harbinger of more severe health problems."*

46 The report goes on to suggest that annoyance is not just irritation - it is a chronic stress response with measurable health consequences. It triggers;

46.1 Physiological stress reactions (elevated blood pressure, heart rate, stress hormone release).

46.2 Psychological strain (irritability, anxiety, depression).

46.3 Increased risk of cardiovascular disease via sustained stress and inflammation.

47 Since the PC14 hearing, Professor Charlotte Clark has prepared a report for Christchurch Airport titled 'Airport noise exposure and health effects'[9]. Professor Clark is President of the

[8] https://www.eea.europa.eu/en/analysis/publications/environmental-noise-in-europe-2025

[9] https://www.waimakariri.govt.nz/__data/assets/pdf_file/0035/166985/STREAM-7A-and-7B-COMBINED-EVIDENCE-9-SUBMITTER-7A-254-FS-80-7B-V1-81-FS-15-CHRISTCHURCH-INTERNATIONAL-AIRPORT-PROFESSOR-C-CLARK-AIRCRAFT-NOISE-AND-HEALTH.pdf

International Commission on the Biological Effects of Noise (*ICBEN*) and she has produced influential evidence reviews on the effects of environmental noise on health, wellbeing and learning for the World Health Organization and others. Her Christchurch report aligns with my evidence and the following quote from her paragraph 54 provides a helpful summary: *"…the WHO generalised curve from the WHO ENG 2018 should be relied on, which was established from studies across a range of contexts including very small to large airports. The WHO generalised curve shows that increasing the population exposed to aircraft noise above 45 dB Lden would harm public health via annoyance effects. It follows that this would result in increased health costs or increase pressure to reduce noise through restrictions on airport operations. Acoustic insulation cannot mitigate effects in people's gardens or in other outdoor community facilities. Further, the airport's community relations are likely be negatively impacted by bringing the population nearer, which could bring challenge to further and future development of the airport and its operation, as well as require increased focus and investment in community relations".*

48 In my opinion the health effects from aircraft noise are clearly identified in the body of literature summarised above and in the Professor Clark paper and they increase from 45 dB $L_{dn}$ as reported by the WHO.

**NEW ZEALAND STANDARD NZS 6805**

49 In 1992, the Standards Association of New Zealand published New Zealand Standard NZS 6805:1992 "Airport Noise Management and Land Use Planning" with a view to providing a consistent approach to aircraft noise and land use planning around New Zealand airports. NZS 6805 is the key starting point when considering airport noise management and land use planning in New Zealand. The Queenstown Lakes District Plan uses the concepts within NZS 6805 with some modifications as discussed later in this evidence.

50 The date of this standard (1992) is important when reviewing the studies discussed above which have been carried out since 1992 and show a much high level of annoyance than was understood in 1992.

51 The Standard uses the "Noise Boundary" concept as a mechanism for local authorities to do two things:

51.1 "establish compatible land use planning" around an airport; and

51.2 "set noise limits for the management of aircraft noise at airports".

52 The Noise Boundary concept involves fixing an Outer Control Boundary (**OCB**) and a smaller, much closer Air Noise Boundary (**ANB**) around the subject airport. The location of the ANB is normally based upon the projected 65 dB Ldn contour, and the location of the OCB is generally based on the projected 55 dB Ldn contour.

53 The Standard is based on the Day / Night Sound Level ($L_{dn}$), which uses the cumulative 'noise energy' that is produced by all flights during a typical day with a 10-decibel penalty applied to night flights (see Appendix A for a list of terminology). $L_{dn}$ is used extensively overseas for airport noise assessment, and it has been found to correlate well with community response to aircraft noise.

54 Inside the ANB, the Standard recommends that new noise sensitive uses (including residential) are prohibited. Between the ANB and the OCB the Standard also recommends that "new noise sensitive uses should be prohibited unless the district plan permits such uses subject to appropriate acoustic insulation".

55 In addition to land use controls, NZS 6805 proposes maximum noise emission limits for airports. The ANB is nominated as the location for future noise monitoring of compliance with a 65 dB $L_{dn}$ noise limit.

56 The objective of the controls recommended in NZS 6805 is to limit / reduce the number of additional people exposed to high levels of aircraft noise. Some district plans also use density controls to limit the number of people exposed to noise when complete avoidance or prohibition as recommended by NZS 6805 cannot be applied.

57 In addition, NZS 6805 states that; *"This Standard shall not be used as a mechanism for downgrading existing or future noise controls designed to ensure a high standard of environmental health and amenity values"* (clause 1.1.4). In my opinion this gives additional support to not allowing downgrading of the existing noise/planning controls around Queenstown Airport.

**ICAO Airport Planning Manual**

58 The International Civil Aviation Organization (**ICAO**) Airport Planning Manual (selected pages attached as **Appendix 2**) provides further support for land use planning within aircraft noise affected areas. It is an internationally applied method for minimising noise effects and potential airport restrictions that is similar to NZS 6805.

59 The Airport Planning Manual has been prepared with the benefit of the collective experiences, and knowledge from airports worldwide. In particular, the manual identifies that governments are responsible for upholding the land use planning pillar in the Balanced Approach[10]. This involves implementing appropriate land use planning with the goal of minimising the number of people affected by aircraft noise which in turn minimises the risk of airport operational restrictions and avoids nullifying the noise reductions achieved by the aviation industry.

60 The New Zealand approach to airport noise management is in step with the manual in concept. However, I note the application of land use controls in New Zealand is at the discretion of local authorities and in practice have been applied lightly throughout most of the country.

## IMPLEMENTATION OF NZS 6805 AT NZ AIRPORTS

61 Each airport has individual historic circumstances that give rise to their particular land use planning controls. As outlined above, in many cases 'the horse had already bolted' at the time airport planning regimes were introduced. For example, when NZS 6805 was implemented at Wellington Airport in the 1990s there were already houses existing right beside the runway and over 600 houses inside the future 65 dB $L_{dn}$ Air Noise Boundary and many thousands inside 55 dB $L_{dn}$. This is discussed in more detail below.

62 The next sections of my evidence examine the three other 'main' New Zealand airports.

### Auckland International Airport

63 Auckland is an example of the less stringent approach due to the current and future shortage of residential land in the Manukau area.

64 Auckland Airport is moderately well laid out geographically for the avoidance of aircraft noise effects, in that half the noise contours (the western end) lie over the Manukau Harbour. However, the other half of the contours lie over significant areas of residential land. The size of the contours is such that a large number of residents are exposed to moderate to high levels of aircraft noise – there are 379 houses in the High Aircraft Noise Area (*HANA*) which is inside the future 65 dB $L_{dn}$.

65 There is an Aircraft Noise Notification Area (*ANNA*) between 55 dB and 60 dB $L_{dn}$ with no planning controls. The land use planning rules at Auckland commence inside 60 dB $L_{dn}$.

[10] The Balanced Approach includes Land Use Planning, noise reduction at source and operational restrictions

66 Between 60 dB and 65 dB $L_{dn}$ (an area known as the Moderate Aircraft Noise Area (*MANA*)) noise sensitive activities are a discretionary activity and there are density controls. Inside the 65 dB $L_{dn}$ (HANA) noise sensitive activities are a prohibited activity.

67 The reason for these relatively moderate land use controls is that there has been a severe shortage of residential land in Auckland and there are significant areas for new development in these moderate noise areas 55 to 65 dB $L_{dn}$ (the ANNA and MANA).

68 A community liaison group meets on a quarterly basis and provides an opportunity for the community to interact with Auckland International Airport Limited (**AIAL**) and Airways on noise issues. The majority of noise complaints at Auckland come from the relatively low aircraft noise areas – 45 to 55 dB $L_{dn}$.

69 In 2013, AIAL was involved in a high profile and very expensive exchange with disgruntled residents following the introduction of a new Required Navigation Performance (**RNP**) arrival procedure – a computer controlled shortened approach path designed to reduce fuel burn and air emissions. The residents were exposed to relatively low levels of aircraft noise (45 to 50 dB $L_{dn}$) with an imperceptible change due to the RNP procedures, but were extremely agitated by the change.

**Wellington International Airport**

70 Wellington International Airport was built in 1959 in the middle of an existing residential area. Since then, it has been compromised in terms of a curfew on airport operations and there are a significant number of people exposed to aircraft noise (660 houses inside the ANB – approximately 1,800 people).

71 NZS 6805 was implemented for Wellington International Airport in the 1990s but with a considerably 'watered down' version of the Standard's land use planning recommendations. The ANB is based on the 65 dB $L_{dn}$ noise contour from a projected capacity scenario.

72 New noise sensitive activities inside the ANB are not 'prohibited' as recommended by the Standard – they are permitted in residential zones and restricted discretionary in other zones. There is no OCB included in the Wellington District Plan and thus no land use controls in the moderate noise areas. The approach taken by the decision makers in Wellington was that 'the horse had already bolted' so what's a few more houses.

73 Consequently, there have been further increases in the number of people exposed to aircraft noise over the years. Wellington International Airport is an excellent example of how poor land use planning has caused a significant number of people to be exposed to the adverse effects of airport noise and for consequential restrictions on airport operations.

**Christchurch International Airport**

74 Christchurch Airport is in a unique situation where the Council and CIAL have diligently maintained a 'buffer' around the Airport through the implementation of appropriate land use planning over a significant period of time.

75 Land use controls at Christchurch commence at 50 dB $L_{dn}$ with density controls, moving through to prohibition of new ASANs inside 65 dB $L_{dn}$.

76 Christchurch has maintained very low numbers of people affected by aircraft noise due to these far-sighted planning provisions.

**Queenstown Airport**

77 The geographical layout at Queenstown Airport is well suited to the avoidance of aircraft noise except for a small pocket of historically residential land at the Frankton end of the runway.

78 The Queenstown noise boundaries are largely consistent with NZS 6805, in that an ANB based on the future 65 dB $L_{dn}$ contour, and an OCB based on the future 55 dB $L_{dn}$ contour have been adopted based on a future growth scenario. There are approximately 70 houses inside the ANB at Queenstown.

79 In Queenstown, the District Plan (through PC35) has adopted the approach of allowing new ASANs inside zones that have an historic residential expectation (eg Residential Zone, Local Shopping Centre Zone (LSCZ) - but above ground floor only) and prohibiting ASANs in other areas (Rural, BMUZ etc)

80 New residential activity is prohibited inside both the ANB (65 dB $L_{dn}$) and OCB (55 dB $L_{dn}$) for rural and commercial zones around the airport (with the exception of the LSCZ). However, new noise sensitive activities are not prohibited by the District Plan within the residentially zoned land in the ANB (because these were already enabled when the ANB was introduced), but new and altered noise sensitive activities are required to be acoustically insulated.

81 Due to the close proximity of houses to the Queenstown runway, night operations are not permitted between 10pm and 6am. Noise is further restricted at Queenstown Airport for

practical reasons as the runway and surrounding topography cannot accommodate larger wide-bodied aircraft.

82 The noise boundaries for Queenstown Airport have been based on 'projected growth' rather than 'ultimate capacity' since initial implementation in 1994. In practice, the actual growth rates have turned out to be much higher than anticipated in the projections and this has resulted in the boundaries needing to be expanded through district plan changes. Expanded noise boundaries were notified in PC35 in 2010 and implemented in the District Plan in 2013 after a protracted series of Environment Court hearings.

83 In 2018 the noise levels at Queenstown Airport were again approaching the noise boundaries in the District Plan. An updated forecast and noise study projected a 5 dB expansion of the contours was required to accommodate the anticipated growth. This was put to the community in a series of public consultation meetings and met with significant resistance from existing residents.

84 Some affected residents were of the view, "enough is enough, we don't want higher levels of airport noise" and some were of the view that existing operations should be restricted to reduce noise levels.

85 There was also a political faction that was of the opinion that 'Queenstown should not grow any further' for other reasons and they saw the airport noise contours as a tool that could be used to restrict growth in the region. There was also a business faction that was in support of the projected growth.

86 The Queenstown Airport Corporation withdrew the plan change and currently have no plans to take the plan change any further and are thus constrained to the 2013 PC35 boundaries and noise levels. The community opposition to the proposal caused this action and in my view is an example of reverse sensitivity which is discussed further in this evidence.

**GENERAL DISTRICT PLAN NOISE LIMITS**

87 The general District Plan noise limits for general noise sources received in residential areas, align with approximately 50 dB $L_{dn}$. This gives an indication of the community's view as to what is a reasonable 'receiving noise level' for the protection for residential amenity in the Queenstown context.

88 It is therefore reasonable in my view that residential uses should not be allowed to establish next to an existing noisy activity (such as an airport) at levels at least 5 dB higher – between 55dB $L_{dn}$ and 65 dB $L_{dn}$ as some submitters suggest. I address submissions later in my evidence.

**SOUND INSULATION**

89 Some advocates for residential development in areas affected by aircraft noise, and I understand some submitters on the Variation, have suggested that sound insulation fitted to proposed dwellings is sufficient on its own to avoid the adverse effects of noise and to protect the interests of the Airport. The argument is understood to be, that sound insulation provides sufficient mitigation, regardless of the population density of the land involved. In my opinion, this assertion, that sound insulation is all that is required to prevent reverse sensitivity effects, is incorrect for several reasons.

90 Firstly, the level of sound insulation required in the 55 to 65 dB $L_{dn}$ area is provided by a standard house. No additional construction techniques or materials are required in these noise levels (only ventilation/air-conditioning see next paragraph). However, 26% to 46% (WHO graph) of the population is still typically highly annoyed by aircraft noise in this environment, even though they have the opportunity to close their windows and achieve 'WHO satisfactory noise levels' inside. This is why sound insulation, on its own, is insufficient and land use controls in the form of density restrictions are the only real form of mitigation available in this case.

91 Secondly, houses exposed to aircraft noise, need to operate with their windows closed to reduce internal noise levels – this becomes particularly desirable at night. Three scenarios are then likely:

91.1 the windows are kept closed resulting in an unsatisfactory level of fresh air; or

91.2 a ventilation system or air-conditioning system is installed to improve air quality at significant cost; or

91.3 the windows are left open resulting in an unsatisfactory noise environment.

92 Each of these scenarios is likely to result in annoyance and possible complaints from the residents. It is interesting to note that residents involved in the Auckland Airport mediation forum were shocked to learn that they would have to shut their windows to achieve an acceptable internal noise environment and they did not like the concept of mechanical ventilation.

93 In this respect, sound insulation also does not solve the problem for hospitals and education facilities as they are heavily reliant on open windows.

94 The third difficulty with sound insulation is that it does not deal with the outdoor noise environment. New Zealanders in general, enjoy an 'outdoor' type of lifestyle that includes barbecues and gardening. This is particularly the case in rural and urban fringe areas where people have more outdoor space and an expectation of enjoying it. Again, an unsatisfactory external noise environment is a potential source of residential complaint with demands to reduce noise, affecting airport operations. There has been a history in New Zealand of people moving into lifestyle blocks and complaining about noise from already existing activities within the rural zone, for example, bird scarers in vineyards. Minimising the number of people affected by airport noise by restricting residential development is the most effective form of mitigation available in this case.

95 The Standard refers to sound insulation as a fallback mitigation measure. In my opinion the Standard prefers to 'avoid' the effects of airport noise, ahead of mitigation. Table 2 in the Standard states that new residential activity inside the OCB "should be prohibited unless a district plan permits such uses, subject to a requirement to incorporate appropriate acoustic insulation."

96 In my opinion, the issues set out above highlight why partial mitigation through sound insulation is a much less desirable option to avoiding the effects of airport noise through appropriate land use controls. This approach has been confirmed in the recent High Court decision on Osterley Way[11] which stated [76]; *"To the extent that the Notification Decision is based on an erroneous view that compliance with acoustic standards was the only matter to be considered to remedy or mitigate reverse sensitivity effects, that is an error of law rendering the Notification Decision invalid".*

97 The Judge found acoustic insulation is necessary but insufficient because:

97.1 It only controls noise inside buildings with closed windows.

97.2 It does not address the annoyance and effects on outdoor spaces (balconies, courtyards).

97.3 It does not remove the risk that complaints from residents will pressure the airport to reduce operations.

[11] [2024] NZHC 2058 Auckland International Airport v Auckland Council & Kainga Ora

**REVERSE SENSITIVITY EFFECTS**

98 I understand 'reverse sensitivity' is an established concept in the Resource Management framework, which will be discussed in legal submissions. At previous hearings, some parties have suggested that reverse sensitivity effects due to aircraft noise are not a real effect and do not need to be considered at New Zealand airports. I disagree with this opinion – as have virtually all the decision makers at past airport noise hearings. Reverse sensitivity is one of the two corner stones of NZS6805 and every significant airport in New Zealand has reverse sensitivity land use controls implemented by the local authority.

99 Overseas, land use planning around airports has not been successful and there are large numbers of people living within the airport noise contours. While noise from aircraft has reduced over the last 50 years, to the contrary, the number of noise restrictions on operations has increased significantly, as shown in **Figure 3** below.

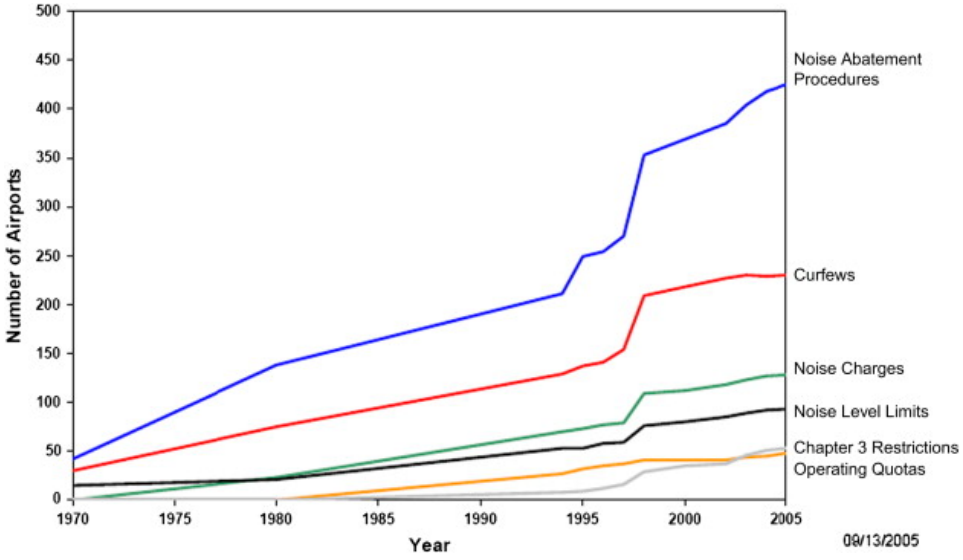


*Figure 3: Growth in Airport Noise Restrictions (Boeing)*

100 These restrictions are a direct example of reverse sensitivity at work.

101 I would now like to provide a small selection of the airports that have had their operations significantly constrained by community pressure due to aircraft noise effects.

**Amsterdam Schiphol Airport**

102 Schiphol Airport is Europe's third busiest airport on passenger numbers and has had significant noise issues for a long period of time. There are large numbers of people living inside the noise contours. This incompatibility has caused serious constraints on the airport due to noise. Four

out of the six runways at Schiphol have curfews applying and overall noise limits have been in place for a long time.

103 In 2023 a significant study was commissioned by the *Ministerie van Infrastructuur en Waterstaat*[12] in response to significant adverse community response to noise. The study included significant consultation with the Schiphol Environmental Council (a combination of various resident action groups), the government and the aviation sector. The Notification Document[13] provides a comprehensive description of the consultation process and details a set of noise objectives and subsequent actions to be implemented.

104 The Noise Objectives are a set of goals expressed in terms of percentage reductions in the number of people inside the noise contours relative to a 2024 projected baseline operation (Table 1 below). The 'Chosen Measures' are a combination of noise abatement measures that were able to be agreed upon as follows. Each of the measures is providing constraints on either the airlines or the airport operations with large cost implications. The main chosen measures are;

104.1 The use of quieter aircraft at nighttime.

104.2 A reduction in the use of secondary runways.

104.3 A cap of 28,700 annual movements at night (down from 32,000).

104.4 A cap of 452,500 annual movements (down from 500,000+).

105 The results of these chosen measures along with the objectives is shown in Table 1 below.

**Table 1 Schiphol Airport – Noise Reduction Objectives and Chosen Measures**

| Indicator | Objective (by 2024) | Chosen Measures |
|---|---|---|
| The number of houses within the 58 dB(A) $L_{den}$ contour | Reduce by 20% | 16% Reduction |
| The number of highly annoyed people within the 48 dB(A) $L_{den}$ contour | Reduce by 20% | 15% Reduction |

[12] Ministry of Infrastructure and Water Management

[13] European Commission Notification - Balanced Approach procedure for Schiphol (September 2023)

106 In summary, Schiphol is significantly constrained (including through reductions to previous operations) due to community response to noise. It is ironical that the measure of effectiveness of the posthumous restrictions at Schiphol is the 'reduction in number of people inside the noise contours'. We have the opportunity at Queenstown to avoid intensification inside the contours and avoid having to restrict operations at a later date.

**Australia**

107 I am aware of three airports in Australia where severe public reaction to new flight paths and/or runways triggered senate inquiries and operational restrictions.

108 The approved opening of the third runway at Sydney Airport in 1994 caused a massive public reaction which led to a senate inquiry. More than 10,000 people blockaded the streets to the airport making it one of the largest environmental/civic protests in Sydney's history. Subsequently the Sydney Airport Curfew Act was passed in 1995 and the Sydney Airport Demand Management Act was passed in 1997. Under these laws, Sydney Airport has a strict curfew between 11pm and 6am and aircraft movements are capped at 80 per hour. As a result of the extreme public response, Sydney Airport now operates with a complex suite of operational restrictions that are more stringent than any other Australian Airport.

109 New flight paths at Perth Airport in 2009 triggered a public reaction which led to a senate inquiry. The inquiry was expanded to review the overall effectiveness of Airservices Australia's management of aircraft noise throughout the country. These events were instrumental in the introduction of a national Airport Noise Ombudsman to provide independent oversight and an avenue for airport noise complaints. Another outcome from the process was that the Perth flight paths were revised, and longer alternative flight paths required at night.

110 In 2020 Brisbane Airport opened a second parallel runway which had been approved in 2007 after the required public consultation and submissions. The Australian Aircraft Noise Ombudsman received complaints from thousands of residents. In response, the Ombudsman re-examined the impact of the new runway and associated flight paths and found that the initial environmental assessment by Airservices was largely compliant but nonetheless recommended the new flight paths were reviewed, including a community engagement process.

111 In 2022 the Australian Greens Party introduced the Brisbane Airport Curfew and Demand Management Bill 2022 which proposed three measures: a night-time curfew (10pm to 6am), a

cap of 45 flights per hour, and a new long-term operating plan including more flights over Moreton Bay and flight path changes to ensure a fair distribution of air traffic over Brisbane. This bill was not passed however a similar bill was lodged again by the Australian Greens Party in 2023. This bill also did not pass.

112 While restrictions such as curfews or movement caps have not been imposed yet, the issue is ongoing, and Brisbane Airport continues to assign resources to manage it. Recently, several airlines agreed to reduce their tailwind safety margins in order to enable more flights over Morton Bay.

**Wellington and Auckland Airports**

113 When Wellington Airport was originally built, there was a large number of houses very close on both sides of the runway exposed to high levels of noise. This resulted in a curfew being put in place at Wellington that prevents landings and take-offs between 11pm and 6am (there are subtle variations within this concept). The 'airport came to the residents' in this case but exactly the same happens in reverse when 'residents come to the airport' – people are annoyed by the noise and can influence restrictions.

114 In the 1980s community action groups (particularly in Wellington) were influential in Air New Zealand changing their fleet to quieter aircraft – first to the B737 Hushkit and later to the B737-300. A significant expenditure was incurred due to the real and potential effects of aircraft noise.

115 My colleague **Ms Laurel Smith** has been involved with hearings to expand the Wellington terminal building and noise due to taxiing and auxiliary power unit equipment has been of significant concern to residents close to the eastern side of the airport. This incompatibility has caused restrictions to be implemented for the expanded activities.

116 In a separate case, Wellington Airport is currently experiencing reverse sensitivity effects related to its lawfully established flight paths to the north of the airport. A residents group exposed to noise in the order of 45 – 50 dB Ldn has objected to a flight path change which was introduced for the purpose of improving safety and efficiency of airport operations. Noise from airport operations remains fully compliant with the noise rules. Despite this, the Airport Company was pressured to undertake additional infield monitoring and is currently undertaking a review of the flight path with the potential options resulting in either greater track miles or diminished safety and efficiency.

117 The resident's group has also sought a judicial review of the flight path change. In addition to the cost of the monitoring, flight path review study and legal proceedings, the reverse sensitivity effects could result in ongoing flight path restrictions, impacting efficiency.

118 Auckland Airport experienced a similar situation in 2013 relating to flight path changes that were within the airport's lawfully established activities. The most oppositional residents were exposed to noise in the order of 45 – 50 dB Ldn. Over several years the airport company received an overwhelming number of complaints, undertook additional infield noise monitoring and noise studies and eventually implemented additional alternative flight paths.

119 The Auckland and Wellington experiences demonstrate that even at lower noise exposure levels, residents who are highly annoyed can impact an airport's lawfully established operations.

120 It is important to note that airports are not static entities – they evolve with time to accommodate new technology, different flight procedures and aircraft types and noise levels may change. People who move into areas adjacent to airports do not generally understand this and end up opposing changes that involve noise effects, even where the changes are permitted.

**Summary of Reverse Sensitivity**

121 These examples highlight where residential activity inside the noise boundaries has had a significant effect on airport/aviation operations and that reverse sensitivity is a very real effect for airports. In addition, it is not just the reverse sensitivity effects on airports that need to be considered - there are undeniable adverse effects on residents from aircraft noise that should be avoided by responsible land use planning as part of a social responsibility to protect the residents.

## SUBMISSIONS ON UIV

### No. 1 Hansen Road

122 Submitter #766 (No. 1 Hansen Road) has sought rezoning of its Frankton North site from LSCZ to BMUZ and the removal of the prohibition on ASAN within the OCB that applies in the BMUZ. The removal of the prohibition on ASAN is supported by submitters #775 and #768. No. 1 Hansen Road has also sought removal of the 50 ASAN limitation that applies to the existing LDSRZ part of its site that is within the OCB.

123 For the reasons set out in my evidence, I consider that, from a noise effects and reverse sensitivity perspective, increasing residential activity inside the OCB is not supportable.

124 Previous consents have been granted for ASAN at 1 Hansen Road which is zoned LSCZ. However, these were granted for specific activities under specific conditions. In my view, the existence of these consents does not warrant enabling further development of ASAN inside the OCB at a policy or zone level.

125 The Environmental Protection Authority (EPA) granted consent through the Fast Track Consenting Act (FTCA) allowing 476 workers accommodation units at the site. The decision stated that granting consent did not set a precedent due to the unique timing, location and details of the application. In particular, the activity is not typical full time residential accommodation but rather seasonal medium term rental accommodation for workers, and the consent was granted under specific legislation that has been repealed.

126 Further to this, I consider the EPA decision was flawed as it relies on an acoustic assessment provided by Styles Group. This assessment did not in my view adequately quantify or assess the outdoor noise effects, or the greater impact that increasing residential density has on noise effects and reverse sensitivity risk. As discussed above the number of residents in aircraft noise affected areas directly increases the scale of health effects in the community which also increases the risk of future reverse sensitivity effects on the airport operations.

127 The Styles Group assessment relied on acoustic insulation to mitigate noise effects. As set out in paragraphs 89 to 97 of my evidence, acoustic insulation cannot be relied on to mitigate all the noise effects. The Osterley Way High Court decision confirms that aircraft noise effects in outdoor living areas and noise indoors with windows open are important considerations.

128 The Styles Group assessment considered the outdoor noise effects would be "*relatively low*" and the rather unusual recommendation that outdoor effects could be mitigated by designing outdoor areas "*such that the occupants will not have high expectations for outdoor amenity*".

129 I do not agree with this conclusion or recommended approach to mitigating outdoor noise. Designing outdoor living areas to be unusable or undesirable might reduce the amount of time residents spend in these areas but that leads to other adverse effects. Likewise, the reliance on mechanical ventilation and cooling to mitigate noise effects inside homes results in other effects and does not deal with outdoor effects. As discussed, acoustic insulation cannot be relied upon to mitigate all the noise effects.

130 With respect to the request to provide for ASAN inside the OCB in the BMUZ, there is an important reason for the prohibition on ASAN inside the OCB in the BMUZ. The land zoned

BMUZ was previously zoned rural and new residential activity inside the OCB was prohibited. The Environment Court found this was the appropriate planning response through PC35 to manage aircraft noise effects and safeguard Queenstown Airport.

131 Since PC35 there have been several incremental changes to land use and zoning within the OCB. There is a risk that incremental concessions to the PC35 approach are used to warrant further incremental concessions to rezone and relax controls on ASAN. Bit by bit the airport's protection will be eroded and in theory the entire area inside the OCB could be incrementally rezoned to enable high density residential activity.

132 In my opinion, any site-specific concessions to the PC35 approach, granted under specific conditions should not be used to justify further ASAN within the OCB. The relief sought to remove the prohibition of ASAN inside the OCB for the BMUZ should not be justified by existing consents or the current location of the BMUZ within the OCB. .

**General Submissions**

133 Some other submitters have sought increased density in the LDSRZ inside the OCB[14]. For the reasons set out in my evidence, I consider that from a noise effects and reverse sensitivity perspective, intensifying residential activity inside the OCB is not supportable.

134 I note that the s32 report considered upzoning the LDSRZ to MDRZ inside the OCB as part of Option 3, including an appraisal of any benefits of that option. The s32 report concluded that, taking the benefits and disbenefits into account, Option 3 was the least favourable option. I concur with this conclusion from an acoustics viewpoint.

135 Grant/Perpetual Trust (#473) has sought to rezone rural and LSCZ land within the OCB to LDSRZ or MDRZ. Other submitters[15] have sought residential intensification in the RPZ and FFBZ although the s42A report considers this relief is outside the scope of the variation. For the reasons set out in my evidence, I consider that, from a noise effects and reverse sensitivity perspective, increasing residential activity inside the OCB is not supportable.

[14] #200 Waka Kotahi, #800 HUD, #1232 NZIC, #548 Wood

[15] #44 Smith, #632 Oates, #191 Queenstown Central

**QAC Submission**

136 The QAC submission expresses a preference for Option 1 which is to retain the status quo for all zoning and provisions within the OCB. I agree that Option 1 is preferable from a noise effects and reverse sensitivity perspective for the reasons set out in my evidence.

137 The QAC submission is also supportive of Option 2 (as notified) insofar as it does not change the current zoning and it provides only minor changes to some provisions. I understand these changes may enable slightly more ASAN inside the OCB than the current provisions however this has not been quantified. Ideally, additional ASAN inside the OCB should be avoided for the reasons set out in my evidence.

138 I agree with the QAC submission that Option 1 is preferable as it does not enable increased ASAN inside the OCB.

**Christopher Day**

**4 July 2025**

## APPENDIX A GLOSSARY OF TERMINOLOGY

| Term and Abbreviation | Meaning |
|---|---|
| Air Noise Boundary (*ANB*) | Noise control boundary used to control aircraft noise and land use with a limit of 65 dB $L_{dn}$. |
| Outer Control Boundary (*OCB*) | Noise control boundary used to control aircraft noise and land use with a limit of 55 dB $L_{dn}$. |
| Decibel (*dB*) | The unit of sound level. Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of Pr=20 Pa i.e. dB = 20 x log(P/Pr) |
| A-weighting | The process by which noise levels are corrected to account for the non-linear frequency response of the human ear. |
| LAeq(t) | The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level.<br><br>The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am. |
| LAmax | The A-weighted maximum noise level. The highest noise level which occurs during the measurement period. |
| $L_{dn}$ | $L_{dn}$ is a measure of the cumulative noise exposure over time. It is defined as the A-weighted day night noise level which is calculated from the 24 hour LAeq with a 10 dB penalty applied to the night-time (2200-0700 hours) LAeq. |
| $L_{den}$ | $L_{den}$ is also a measure of the cumulative noise exposure over time. It is defined as the A-weighted day-evening-night noise level which is calculated from the 24 hour LAeq with a 10 dB penalty applied to the night-time noise (2300-0700 hours) and 5 dB during the evening (1900-2300 hours). |
| Sound Exposure Level (*SEL* or *LAE*) | The sound level of one second duration which has the same amount of sound energy as the actual noise event measured. Usually used to measure |

| Term and Abbreviation | Meaning |
|---|---|
| | the sound energy of a particular event, such as a train pass-by or an aircraft flyover. |
| NZS 6805:1992 | New Zealand Standard NZS 6805:1992 "*Airport Noise Management and Land Use Planning*" |
| Auxiliary Power Unit (*APU*) | Component of an aircraft used to generate power for essential systems when main engines are not operating. |
| Ground Power Unit (*GPU*) | Land based power supply for aircraft essential systems while parked and not running the APU. |
| Noise dose-response curve | A dose–response relationship is the magnitude of the response (in this case annoyance) of a person to a certain dose of a stimulus or stressor (in this case noise).<br><br>Dose–response relationships can be described by dose–response curves. Dose-response curves are created by graphing the magnitude of the response (level of annoyance) for each individual against the dose (noise level) and performing a statistical analysis (regression analysis or curve fit) on this data to create a single dose-response curve for the population. |

**APPENDIX B - THE INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO) AIRPORT PLANNING MANUAL (SELECTED PAGES)**

**Appendix 1 Pages from ICAO Airport Planning Manual**

ICAO

# Doc 9184

## Airport Planning Manual
## Part II — Land Use and Environmental Management

Fourth Edition, 2018

Approved by and published under the authority of the Secretary General

INTERNATIONAL CIVIL AVIATION ORGANIZATION

# FOREWORD

The purpose of this part of the manual is to provide guidance material on land-use planning in the vicinity of airports and on environmental management regarding airport development and operations. It was originally based on conclusions of the Special Meeting on Aircraft Noise in the Vicinity of Aerodromes held in 1969 and on the current practices of several States. It incorporates guidance material on airport environmental aspects as recommended by the Eighth Air Navigation Conference held in 1974.

"Land-use Planning" and "Environmental Management" are terms of relevance used by airport planners for planning the airport and its environs with a view to ensuring the safety of aircraft operations. Since these issues have evolved considerably in recent years, it was necessary to update the information included in previous editions of the manual and to reflect in the title the evolution of the environmental activities at and around airports.

This publication reflects updates from the Committee on Aviation Environmental Protection (CAEP) that were first presented to CAEP/4 in 1998. Further updates have since been added and this final version of the manual was approved at the CAEP/10 meeting in February 2016.

It is intended that the manual be kept up to date. Future editions will be improved based on the results of the work of ICAO and of comments and suggestions received from the users of this manual. Readers are therefore invited to give their views, comments and suggestions on this edition. These should be directed to the Secretary General of ICAO.

The Secretary General
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999 Robert-Bourassa Boulevard
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[...]

# Chapter 2

# ENVIRONMENTAL IMPACTS ASSOCIATED WITH AVIATION ACTIVITIES

## 2.1 GENERAL

This chapter deals with environmental issues related to airport and aircraft operations. It identifies most of the major environmental issues that may be directly associated with air transport and civil aviation in particular. However, this does not necessarily mean that all of the subjects are suitable for consideration in this manual. Excluded are issues concerning the conditions for passengers and crew (such as the effects of smoking, ozone, high altitude radiation, or noise and vibration within the cabin) and issues concerning the working conditions of airline or airport employees. These are defined as occupational health and safety issues. For each environmental issue presented, a brief description is provided, including a summary of past and present ICAO activities aimed at mitigating the issue, as well as comments on the relevant activities of other organizations, whenever pertinent.

## 2.2 AIRCRAFT NOISE

2.2.1 Since the introduction of jet aircraft, noise has been considered to be perhaps the most important local environmental impact associated with civil aviation. Noise levels in the vicinity of airports are affected by two opposing trends: the replacement of noisy aircraft by quieter ones and the increasing number of aircraft movements. As a result, the level of impact from aircraft noise may decline at some airports but increase at others. In some cases, the level of impact from noise related to aviation activities has prevented the expansion of airport capacity, thereby limiting airport growth and contributing to airport congestion. Because of this and other environmental concerns, some States limit aircraft operations at airports based on environmental considerations, rather than on airport capacity. In other words, the standard "operational airport capacity" has been replaced by capacity restrictions based on environmental parameters such as noise exposure.

2.2.2 Other noise sources that occur on and around airports may include (but not be limited to) aircraft engine testing, auxiliary power units (APUs) used during ground operations, other equipment such as ground power units (GPUs) and ground support vehicles and equipment (GSE).

2.2.4 Annex 16 — *Environmental Protection*, Volume I — *Aircraft Noise* sets the International Standards and provides Recommended Practices for noise certification of subsonic jet and large propeller-driven aircraft, small propeller-driven aircraft, helicopters and tilt-rotor aircraft. The ICAO Committee on Aviation Environmental Protection (CAEP) maintains and reviews Annex 16, Volume I, and develops new noise Standards and Recommended Practices as technology advances. Annex 16, Volume I, also includes guidelines for noise certification of auxiliary power unit (APU) installations and associated systems, as well as recommendations for noise monitoring and assessment around airports.

2.2.5 A worldwide policy has been developed, at ICAO, to define and implement operating restrictions on aircraft that are either non-noise-certificated or only meet the requirements of Annex 16, Volume I, Chapter 2. These were adopted in 1990 with Resolution A28-3[1] and nearly all States now prohibit the operation of these aircraft in their territories.

1. Superseded by Resolution A33-7.

2.2.6 In 2001, the ICAO Assembly unanimously endorsed the concept of the balanced approach to aircraft noise management and in 2007, the 36th ICAO Assembly reaffirmed the balanced approach principle in Resolution A36-22: "Consolidated statement of continuing ICAO policies and practices related to environmental protection". The balanced approach to noise management developed by ICAO consists of identifying the noise problem at an airport and then analysing the various measures available to reduce noise through the exploration of principal elements, namely reduction at source, land-use planning and management, noise abatement operational procedures and operating restrictions, with the goal of addressing the noise problem in the most cost-effective manner. The recommended practices to assist States in implementing the balanced approach are included in the *Guidance on the Balanced Approach to Aircraft Noise Management* (Doc 9829).

## 2.3 AIR QUALITY IN THE VICINITY OF AIRPORTS

2.3.1 Air quality in the vicinity of airports can vary greatly depending on local climatic conditions and can be impacted by sources such as road traffic, aircraft engine emissions, emissions from airport motor vehicles and emissions from other sources (e.g. heating/power plants incinerators and construction).

2.3.2 Air pollution refers to a condition of the air quality marked by the presence therein of one or more air contaminants that can:

— degrade the air quality from its normal state;

— endanger the health, safety or welfare of persons;

— interfere with normal enjoyment of life or property;

— endanger the health of animal life; or

— cause damage to plant life or to property.

2.3.3 Air pollution is an environmental problem in many countries, especially in urban areas, and is generally recognized to contain:

— **Carbon dioxide ($CO_2$)** which is produced by the combustion of hydrocarbon fuels;

— **Carbon monoxide (CO)** is a product originating from the incomplete combustion of hydrocarbon fuels;

— **Oxides of nitrogen (NOx)** result from high-temperature oxidation of atmospheric nitrogen and is composed of a mixture of NO and $NO_2$. This takes place in the high temperatures and pressures of aircraft engines, road vehicles and other internal combustion sources, and to a lesser extent in other combustion and natural sources (such as lightning);

— **Volatile organic compounds (VOC)** are low boiling point organic chemicals which can be both man-made and naturally occurring. Fugitive emissions and odours from aircraft fuel tanks, oil tanks and other fuel storage facilities can release VOCs into the local area with some recognized as carcinogens. Chronic exposure to some VOCs can cause health problems;

[...]

of identifying the noise problem at an airport and then analysing the various measures available to reduce noise through the exploration of four principal elements, namely reduction at source (quieter aircraft), land-use planning and management, noise abatement operational procedures and operating restrictions.

3.5.2 To reduce noise at source (quieter aircraft), States, manufacturers and research institutions have undertaken research which has led to considerable aircraft engine and airframe performance improvements and reduction of aircraft engine source noise. As a result, modern aircraft are significantly quieter than earlier generations of aircraft. With this in mind, before an aircraft is permitted to operate, it must receive noise certification to required standards granted by the State of Registry. Aircraft noise certification provisions are detailed in Annex 16 — *Environmental Protection*, Volume I — *Aircraft Noise* and the *Environmental Technical Manual on the use of Procedures in the Noise Certification of Aircraft* (Doc 9501, Volume I), which provides practical guidance to certificating authorities on the implementation of the technical procedures of Annex 16.

3.5.3 Land-use planning and management is an effective means to ensure that the activities nearby airports are compatible with aviation. Its main goal is to minimize the population affected by aircraft noise by introducing land-use zoning around airports. Compatible land-use planning and management is also a vital instrument in ensuring that the gains achieved by reduced noise of the latest generation of quiet aircraft are not offset by encroachment and further residential development closer to the airports. In addition, with a view to promoting a uniform method of assessing noise around airports, ICAO recommends the use of the methodology contained in *Recommended Method for Computing Noise Contours around Airports* (Circular 205). This is discussed in more detail in Chapters 5 to 7 of this manual.

3.5.4 Noise abatement procedures, to further reduce the population adversely affected by aircraft noise, have been employed to reduce noise levels around airports. Noise abatement procedures enable reduction of perceived noise during aircraft operations and can be achieved at comparatively low cost. There are several methods, including preferential runways and routes, as well as noise abatement procedures for take-off, approach and landing. The appropriateness of any of these measures depends on the physical layout of the airport and its surroundings, but in all cases, the procedure must give priority to safety considerations. ICAO's noise abatement procedures are contained in the *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS, Doc 8168), Volume I — *Light Procedures,* Part V. In addition to noise abatement procedures, operating restrictions are discussed in 3.2.9.

3.5.5 Acoustical barriers can only provide a benefit in a fairly limited number of situations. A wall or berm between residences and an airport will only be effective against ground-based noise sources such as aircraft taxiing and apron vehicles, and will generally not shield residences from the noise during aircraft take-off, landing and flyover. Furthermore, a wall needs to be placed very close to the residences (within about 20 m) and needs to be built sufficiently high to block the line-of-sight between the noise source and receiver.

3.5.6 If the airport has a large buffer area between it and areas affected by ground-based noise, a forested area can provide better noise mitigation than bare land. The forest buffer would need to be at least 100 m deep and care would need to be taken not to create a wildlife hazard for aviation.

3.5.7 The use of a noise barrier or enclosure to reduce the noise from aircraft engine run-ups is discussed in 4.6.2 of this manual.

3.5.8 Sound insulation can be used to improve the aircraft noise intrusion levels within buildings affected by aircraft noise. Whether retrofitted to existing buildings or required a part of a building code for new constructions, sound insulation clearly can only improve the internal noise levels of a residence, hospital or school. Furthermore, as the benefits of sound insulation are negated if a building occupant opens external windows or doors, in many climates, sound insulation will need to be accompanied by the provision of alternative ventilation for habitable spaces. Further discussion on sound insulation can be found in the land-use planning sections of this manual in Chapter 7.

[...]

# Chapter 5

# LAND USE

## 5.1 GENERAL

Land use around airports can impact the operational safety and efficiency of the airport, the safety of surrounding communities, and community exposure to the environmental effects of airport operations. Hence, activities around an airport that can affect the safe and efficient operation of aircraft and/or community exposure should be taken into consideration when planning land uses in the vicinity of airports. Similarly, land-use compatibility planning can also be utilized to minimize impacts such as aircraft noise on surrounding communities and local third'-party risk. As guidance on proper airport and land-use compatibility planning, this chapter describes a variety of possible land uses with a broad appreciation of their relative sensitivity to aircraft and airport operations, local third-party risk and aircraft noise exposure and describes their compatibility or incompatibility to aircraft noise and to airport operations.

## 5.2 NATURAL LAND USE

5.2.1 Every airport is different, as are the areas surrounding them. Natural areas, such as forests, open land, rivers, swamps, and bays are found in varying degrees in the vicinity of airports. In many cases, the presence of natural areas influences the selection of the airport site. In other cases, the selection is based on different factors, but the existence of natural areas can provide additional benefits.

5.2.2 The presence of natural features in aircraft approach and climb-out areas has done much to prevent aircraft noise problems. An example is a new airport which has been situated in the bend of a river to take advantage of the close-in water approaches under both ends of the runway. Runways located on filled land on the edge of bays also afford unobstructed approaches over water. New airports have even been located on artificial islands created specifically for the airport. Bird control measures should be used and proper reporting of bird strike problems followed in such cases.

5.2.3 Natural features have been, and can be, used to advantage not only in reducing noise impacts but also in adding natural elements and interest to the airport. Nevertheless, where rivers, lakes, bays or swamps are found in the airport area, bird hazard problems may exist. At some airports, this problem has been so serious as to cause accidents.

## 5.3 AGRICULTURAL LAND USE

Many airports provide an opportunity to establish agriculture in order to increase revenues. The agricultural use of land contributes several important factors to an airport programme, such as:

a) producing income from what might otherwise be waste or idle land;

b) providing crop cover and prevents soil erosion; and

c) eliminating the expense to the airport of mowing or taking care of the land.

5.8.2 The location of industrial sites at the airport has generally been found to be compatible with aircraft noise because of the relatively higher ambient noise level, both internal and external, associated with industrial activity. This factor, combined with the ever growing need for industrial land around airports, has contributed to the development of industrial parks in and around commercial and general aviation airports. Business has learned to take advantage of the unique benefits that air transportation can offer, and many major commercial enterprises are also located at airports.

5.8.3 Prospective sites for industrial development should still satisfy the following basic requirements:

a) desirable geographical location, considering the community in question;

b) availability of land of sufficient size to accommodate the planned industrial development;

c) access to commercial transportation facilities, in addition to air transportation, if necessary;

d) present and/or future availability of needed utilities;

e) access to nearby residential areas for the industrial employees, with reasonable commuting time; and

f) compatibility of proposed industrial development with other area land uses.

## 5.9 RESIDENTIAL AND INSTITUTIONAL LAND USE

5.9.1 In this publication, residential housing refers to single-family dwellings, multi-family dwellings, and estates. Institutional housing refers to community facilities such as schools, hospitals and churches. All these facilities should be planned and situated with thorough consideration of airport activities and the potential arrival and departure corridors with the goal to reduce the number of properties affected by aircraft noise and other environmental impacts.

5.9.2 In single-family dwellings in temperate and warm climates, families live outside during many of the daylight hours, especially in the summer months. This is also true of estates and, to a lesser extent, of multi-family dwellings, particularly where a community swimming pool exists. It is this outdoor activity that creates the real noise compatibility problem for residential property in the vicinity of the airport.

5.9.3 Institutional dwellings may require a greater degree of sound insulation than do residential structures because a lower sound level is necessary for indoor use. The requirements of patients in hospitals and of the speech level in schools and churches demand special evaluation if these facilities are located in the vicinity of the airport.

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[...]

# Chapter 6

# LAND-USE PLANNING

## 6.1 GENERAL

6.1.1 The *Guidance on the Balanced Approach to Aircraft Noise Management* (Doc 9829) provides guidance on alleviating the problem of noise in the vicinity of airports. This "Balanced Approach" recommends consideration of four noise management pillars, one of which is land-use planning.

6.1.2 Land-use planning can be an effective means to ensure that the activities nearby airports are compatible with both current and future aviation activities. Its main goal is to minimize the population affected by aircraft noise by introducing land-use planning measures, such as land-use zoning around airports. In addition, land-use planning also can have safety benefits for those people living in the vicinity of an airport.

6.1.3 There are substantial benefits to be gained from the correct application of land-use planning techniques in the development of airports. Land-use planning benefits may take time to be fully realized and should be implemented as soon as noise problems are foreseen. Efforts to correct situations detrimental to proper land-use around airports should however not be ignored simply because of the lead time for such measures to be effective. This is particularly true in the application of land-use planning to existing airports where it is recognized that the ability to make immediate land-use changes is limited, but where it is also important to prevent further expansion of incompatible land uses.

6.1.4 Compatible land-use planning and management based on appropriate "planning" noise contours, rather than "current" noise contours, can prevent encroachment of residential development at airports where future aircraft noise levels are projected to increase. Using "current" noise contours for land-use planning can allow residential encroachment, thereby nullifying the benefits the reduced noise of the latest generation of quiet aircraft.

## 6.2 ASSESSING NOISE FOR LAND-USE PLANNING

6.2.1 The intrusiveness of aircraft noise in airport communities is dependent upon many factors including the following:

- sound pressure level;
- broadband frequency distribution;
- tonal content;
- noise duration;
- flight path, including take-off and landing profiles;
- number, frequency and time of day of operations;
- operating procedures (such as engine power settings, cutback altitude);



[...]

6.2.5 In general, land-use planning should be based on a "planning" noise contour for a projected future operational scenario or based on traffic forecasts and airport capacity, taking into account future runway and infrastructure development. Three time horizons are usually studied: short-term (around five years), medium-term (around ten years) and long-term (around fifteen years).

## 6.3 NOISE ZONES AND ASSOCIATED MAXIMUM NOISE INDICES

6.3.1 In general, the planning noise contours can be used to define noise zones around the airport. The structure of noise zones should be inherently related to the particular situation where they are applied. In many jurisdictions, two zones (e.g. medium and high noise zones) are used, but in some cases more zones, either with a finer gradation or a greater noise range (e.g. medium to very high) may be used.

6.3.2 Land-use rules are then adopted and enforced based on the noise level in each zone. Some examples are provided below and in Appendix 3.

— In a high-noise zone, new noise-sensitive developments, such as residences, hospitals and schools might be prohibited. Those which already exist might be subject to sound insulation and ventilation retrofits.

— In a medium-noise zone, new developments might be allowed but subject to maximum density limits or specific sound insulation and ventilation requirements.

These zones or land-use rules may be subdivided into various noise exposure levels for appropriate land-use planning and other measures by the national or local authorities. Such measures should be strictly enforced to prevent any noise-sensitive development. Outside these noise zones, the level of aircraft noise is deemed to be compatible with residential activity and land-use restrictions are generally not required.

6.3.3 The values of the noise exposure indices, corresponding to the noise zones adopted for land-use planning, should form a logical progression. States use different noise descriptors and noise-exposure calculation methods to determine the noise levels for different land uses. An approximate comparison can be made between the values of the different methods used by States (for a description of these methods, see the *Recommended Method for Computing Noise Contours around Airports* (Doc 9911)). France, applying the European Directive 2002/49EC at the national level, uses the $L_{den}$ noise metric for noise contours around French aerodromes. For each noise exposure map, three and sometimes four noise zones are defined (PEB: Plan d'Exposition au Bruit) (see Table 6-1). The legal limit values in $L_{den}$ for these noise zones may vary depending on the type of traffic and on local situations.

6.3.4 Land-use restrictions for new constructions vary with noise zones. For example, only housing and facilities necessary for aeronautical activities, as well as public facilities which are vital to the existing population are allowed within Zone A, whereas no land-use restrictions for new constructions but obligation to insulate new housing and to inform inhabitants within Zone D.

[...]

Wherever possible, and particularly when planning the construction of new airports, the location of the airport should be considered as a part of the total planning environment, so that long-term community needs and the consequences of the airport's operation in terms of noise exposure are not in conflict (see Table 6-4).

**Table 6-4. Some typical examples of compatible land uses around airports**

| | Zones | | |
|---|---|---|---|
| | A | B | C |
| Examples of compatible land uses or development | Most land uses and development are not permitted | Some restriction on land uses and developments | Unrestricted land uses and developments |
| Agricultural:<br>Crop farming | unrestricted | unrestricted | unrestricted |
| Industrial:<br>Machine shop | unrestricted | unrestricted | unrestricted |
| Commercial:<br>Warehouse and shipping | unrestricted | unrestricted | unrestricted |
| Offices and banking | restricted | restricted | unrestricted |
| Residential:<br>Low-density housing | restricted | restricted | unrestricted |
| High-density housing | prohibited | restricted | unrestricted |
| Public facilities:<br>Schools and hospitals | restricted | restricted | unrestricted |

*Note 1.— With respect to certain uses (e.g. housing and commercial), a development might be allowed in a zone of a higher restriction when other planning considerations indicate a need, and where suitable building techniques, sound insulation, etc., can reduce the aircraft noise exposure to an acceptable level.*

*Note 2.— In special cases where activities depend on speech communication (e.g. schools) or require more stringent standards (e.g. certain hospital activities), additional restrictions may be required to take into account absolute noise levels as well as total noise exposure, unless noise reduction can be ensured in the building construction.*

*Note 3.— The zones will have to be defined against a noise exposure scale (e.g. noise contour mapping) and will have to take into account local and national needs when the zones are drawn up.*

# Chapter 7

# LAND-USE ADMINISTRATION

## 7.1 GENERAL

7.1.1 Noise exposure is not the only factor to be taken into account for the purpose of land-use management in the vicinity of airports. It is recognized that economic factors are involved in land-use choices. Ideally, land-use decisions around airports would try to find a compatible balance between the interests in the land and the aeronautical use of the airport. For this reason, the authorities, local or central, have an important part to play in ensuring that aircraft noise exposure is taken into account when planning land use in the vicinity of airports and that the ensuing plans are implemented.

7.1.2 There are many techniques for regulating development or bringing about conversion or modification of existing land uses to achieve greater compatibility between the airport and its environs. Some of these may be controls, such as zoning or building and housing codes; other methods influence development through acquisition or taxation. Experience has shown that any attempt to control land use through easements and purchases is extremely expensive and cannot be considered as a solution to the entire aircraft noise problem. A more practical approach is the adoption of proper land-use planning and zoning. Zoning, however, is limited in its ability to effect changes around existing airports located in developed areas. Land use can be managed more effectively when zoning is applied to new airports and existing airports in still undeveloped areas.

7.1.3 Unfortunately, local land development decisions are often made based on considerations which may ignore both the need to minimize the impact of aviation noise on the community and the importance of protecting the airport from encroachment by incompatible development. The most common issues are the return that the owners or developers want from their commercial properties, the local government's interest in increasing the tax base, and the interest of the owners and residents in maintaining or improving the value of their homes. For the airport environs, the cumulative total of such local decisions can seriously degrade a balanced, comprehensive planning approach and development policy. The desired goal is for effective land-use planning based on objective criteria, to minimize the amount of noise-sensitive development close to airports, while allowing for other productive uses of the land.

## 7.2 LAND-USE MANAGEMENT

### 7.2.1 Introduction

Various measures are available for managing the use of land around airports. The effectiveness of these measures for both existing and new airports should be considered on a case-by-case basis. Based on a survey of land-use measures and policies in the countries reviewed, it can be stated that no single strategy prevails over other strategies in dealing with this issue. While land-use management and noise-insulation measures are generally transferable from one place to another, the selection of a particular measure and the precise manner in which any measure is formulated, applied and financed depend to a great extent on specific national and local circumstances. Overall, land-use management measures can be categorized as:

a) planning instruments, including comprehensive planning, noise zoning, subdivision regulations, transfer of development rights, and easement acquisition;

b) mitigating instruments, including building codes, noise insulation programmes, land acquisition and relocation, transaction assistance, real estate disclosure, and noise barriers; and

c) financial instruments, including capital improvements, tax incentives and noise-related airport charges.

### 7.2.2 Planning instruments

*Comprehensive planning*

7.2.2.1 Comprehensive planning takes into account existing development and ensures that future development is compatible with various community goals. In most countries, the land-use planning and control authority rests with local governmental bodies, which may be obliged or advised to take into account aviation noise measures.

7.2.2.2 A well worked-out comprehensive plan that is used effectively to guide local land-use decisions and development (e.g. zoning, capital improvements planning, subdivision regulations, and environmental review) is among the most powerful and affordable of all compatibility strategies. This is particularly true in developing areas, but it can also be highly effective in guiding urban renewal or redevelopment. The success of such comprehensive planning depends upon its implementation through various developmental decisions and controls.

7.2.2.3 As a land-use control system in relation to airports, comprehensive planning is applied in varying degrees in all the countries surveyed. This strategy appears to be a valuable instrument that is transferable to other countries.

*Noise zoning*

7.2.2.4 Noise zoning for land use serves a two-fold purpose: the protection of the airport and the protection of the residents. It can be applied to existing airports as well as to future airport development. Zoning should take into account anticipated future airport development so that when airport development takes place, it has minimal impact. In some countries, such as France, there are noise maps that define land-use restrictions for new constructions (so-called PEB – Plan d'Exposition au Bruit) and noise insulation maps (so-called PGS – Plan de Gêne Sonore) that define those inhabitants who may benefit, under specific conditions, from home soundproofing grants.

7.2.2.5 Noise zoning enables a national or local government to define the uses for each parcel of land, depending on the level of noise exposure. It generally consists of a zoning ordinance which specifies land development and use constraints, based on certain noise exposure levels. The noise contours extending outward from the airport delineate areas affected by different ranges of noise exposure. No uses other than those specified for a particular area should be permitted.

7.2.2.6 In an ideal scenario, noise zoning regulations are established and known by all relevant authorities and stakeholders. The noise contours produced by the airport authority should be based upon on maximum airport capacity and the worst possible noise case scenarios, and provided to a single high-level government authority to administer and oversee. The government authority would then ensure that any application of noise-sensitive developments are appropriately considered to ensure that developments only occur within acceptable noise zones, as prescribed by the relevant noise zoning regulations.

7.2.2.7 In many instances where there are multiple local government authorities responsible for development approvals, these local jurisdictions with zoning power (cities, towns or larger administrative units) may often have differing or conflicting policies that have little continuity between authorities. They may also not be aligned to the noise zoning regulations and the maximum theoretical noise contours that have been produced. Having a single authority to enforce the continuity of noise zoning regulations across several local government areas within the airport noise contours can alleviate the problem of multi-jurisdictional interests.

7.2.2.8 Another issue is that the interests of the noise-affected communities near airports are not always consistent with the needs and interests of the airport operator nor with those of each other. Within local government authorities and various communities there is usually a desire for greater population growth, and rising land values. It is these drivers that are often in conflict with the need to preserve surrounding airport areas so as not to compromise the noise reduction benefits achieved from new generation aircraft, with the ultimate goal being to further reduce the total number of people affected by airport related noise.

7.2.2.9 Noise zoning can and should be used constructively to increase the value and productivity of the affected land. One of the primary advantages of zoning is that it may be used to promote land-use compatibility, while still leaving land in private ownership, on the tax rolls, and as economically productive as possible.

7.2.2.10 Zoning is not necessarily permanent and may be changed, although this may be difficult in some countries because of the local legal system. Zoning is usually not retroactive. Changing zoning primarily for the purpose of prohibiting a use which is already in effect is generally not possible. Where such zoning is allowed, an existing use may be allowed to remain as "nonconforming" until a later date when it is changed voluntarily to a conforming use. For this reason, zoning is most effective at airports that have not yet felt the impact of buildings. Furthermore, the proposed use of vacant land must be related to the market demand for the proposed activities, such as commerce or industry.

7.2.2.11 Noise zoning around airports is applied in nearly all surveyed countries as a planning measure to prevent new noise-sensitive developments near the airport. However, it is sometimes only applied to the larger or national airport(s). Ideally, noise zoning should be established for all airports.

*Subdivision regulation*

7.2.2.12 Noise zoning ordinances may include subdivision regulations. These regulations may serve as a guide to development in noise-impacted areas by reducing building exposure through orientation and density transfer and by providing open-space requirements.

7.2.2.13 Subdivision regulations on their own can be useful in minimizing noise impacts on new development. They would not affect existing development. By means of restrictive covenants, the owner is legally notified that the property is subject to noise from aircraft operations. Additionally, a covenant could require buildings to be designed and constructed in such a way as to minimize interior sound derived from exterior noise sources to the acceptable level.

*Transfer of development rights*

7.2.2.14 Under this concept, some of the development rights of a property are transferred to another property that is far from the airport where the rights may be used to intensify the level of allowable development. Land-owners could be compensated for the transferred rights by the sale of these rights at new locations or the purchase of the rights by the airport. Depending upon the market conditions and/or legal requirements, the airport could either hold or resell the rights.

7.2.2.15 The transfer of development rights must be fully coordinated with a community's planning and zoning. It may be necessary for zoning ordinances to be amended in order to permit the transfer of development rights. Such transfers are usually effected within a single jurisdiction.

*Easement acquisition*

7.2.2.16 An easement confers the right to use a land-owner's property for a limited purpose, normally in exchange for some value. In the context of airport noise-compatibility planning, two general types of easements are available:

a) those which permit airport noise over land (including right of flight); and

b) those which prevent the establishment or continuation of noise-sensitive uses on the subject property.

7.2.2.17 For maximum effectiveness, easements should restrict the use of land to that which is compatible with aircraft noise levels. Easements should also ensure the right of flight over the property, the right to create noise and the right to prohibit future height obstructions into airspace. Restrictions that may be addressed by such easements include types of buildings, types of agricultural activity that may attract birds, electromagnetic interference, and light emissions.

7.2.2.18 The first type of easement described in 7.2.2.16 a), which simply buys the right to make noise over the land, has fewer advantages. It does nothing to change the noise-sensitive character of the land or to reduce noise for people on the property. However, it does legally protect the airport operator from noise litigation, financially compensates property owners for noise, and warns potential buyers that a property is subject to aircraft noise.

7.2.2.19 The second type of easement described in 7.2.2.16 b) can be a highly effective strategy for ensuring compatible development around airports in situations where land is being developed for the first time or is being redeveloped in connection with a land acquisition and relocation strategy or general urban redevelopment programme. The easement has the advantage of being permanent. It is less costly than outright purchase of land (if the land has not otherwise been purchased) and it allows the land to remain in private ownership, in productive use, and on local tax rolls. This latter type of easement is used most frequently in combination with noise insulation. Such easements are often required by airport owners in exchange for noise insulation. Again, the use of certain easements is dependent on the legal system.

### 7.2.3 Mitigating instruments

*Building codes*

7.2.3.1 Construction techniques and material standards often determine the interior noise levels of residential or commercial structures in noise-impacted areas. Building codes are essentially a legal means of requiring the incorporation of adequate sound insulation in new construction. Any noise-insulation strategy depends upon a closed-in structure for maximum effectiveness, and this in turn usually raises the issues of adequate ventilation and air conditioning in warm weather.

*Noise insulation programmes*

7.2.3.2 Noise insulation can lower interior noise levels for structures that cannot reasonably be removed from noise-exposed areas (e.g. residential buildings). Noise insulation is particularly effective for commercial buildings, including offices and hotels. However, it is much more desirable to control insulation requirements for such buildings from the outset, if they must indeed be constructed in noise-exposed areas. While there may be difficulties in getting sound insulation requirements incorporated in building codes for new construction, these are slight compared with the problems of effective soundproofing for existing buildings, particularly housing. Even if houses in high-noise areas were made of stonework, insulation and air conditioning may cost more than the value of the additional rent or sales' prices. The degree of insulation requirements varies from country to country. In some countries, the acceptable level of interior

noise is prescribed by legislation. As an example, French legislation defines indoor–outdoor noise reduction levels for each noise zone of a noise exposure map (PEB). These requirements are applied for new constructions and depend on the type and the allocation of the buildings.

7.2.3.3 A noise-insulation programme should be preceded by a structural and acoustical survey of all homes and other buildings earmarked for noise insulation. The cost of noise insulation depends upon several variables, such as the degree of insulation required (from insulating the attic only to insulating all exterior walls and ceilings and upgrading doors and windows), size and condition of the building, and location within the noise exposure area.

7.2.3.4 For effective noise insulation, it is necessary to have a closed-window condition, which may not be desirable to homeowners in all seasons and which imposes additional ongoing costs to home-owners for climate-control systems. The major drawback to noise insulation is that it does nothing to mitigate noise outdoors. This drawback however does not apply as much to schools, hotels, commercial structures, or even large apartment buildings, because they are frequently constructed with a closed-window condition and their activities usually take place indoors.

7.2.3.5 Other insulation programmes could include sound conditioning or air conditioning. This can contribute much towards making all types of dwellings acceptable during the hours when the interior of the building is in use; this is particularly important during the night-time hours. Hence, the amount of sound reduction must be balanced against the external sound level in order to achieve an acceptable noise level for the occupants of the dwelling. Installation of sound conditioning can be relatively simple if incorporated initially in new construction but becomes more complex if incorporated as a modification of old construction.

*Land acquisition and relocation*

7.2.3.6 This strategy involves the acquisition of land through purchase by the airport operator (or planning authority in case of new developments) and the relocation from the acquired land of residences and businesses that are not compatible with airport-generated noise levels. This strategy is within the direct control of the airport operator (or planning authority) and does not require additional action by another political entity.

7.2.3.7 Land acquisition and relocation assure an airport of long-term land-use compatibility. Acquired land can be cleared, sold with easements (to control future development), and redeveloped for compatible land uses. However, this strategy is not a practical solution to the total noise problem because it is costly and socially disruptive to buy all significantly noise-impacted land.

7.2.3.8 Land acquisition and relocation have been widely used in the United States by airport operators as the ultimate solution to land-use compatibility in certain areas with significant noise exposure.

*Transaction assistance*

7.2.3.9 Transaction assistance involves some level of financial and technical assistance to a homeowner who is trying to sell a noise-impacted property. It may involve paying realtors' fees. An airport operator may even buy the property which has been on the market for an extended period of time and then resell it. In order to become compatible with noise levels, the properties are noise-insulated prior to resale and usually resold with an easement. This strategy can be useful in areas where it has been decided that existing residential neighbourhoods will be maintained. It can also be less expensive than other acquisition strategies. Homeowners are sometimes given a choice of noise insulation/easement or transaction assistance. These choices enable those people most annoyed by noise to leave the area and prevent the airport authorities or developers from having to buy out everyone.

**APPENDIX C – EUROPEAN ENVIRONMENT AGENCY -**

**ENVIRONMENTAL NOISE IN EUROPE 2025 — SUMMARY FOR POLICYMAKERS**

European Environment Agency

# Environmental noise in Europe 2025 — summary for policymakers

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# Summary for policymakers

Millions of people across Europe are exposed to harmful noise levels from transport sources, making noise one of the leading environmental health risks in Europe. Noise pollution has serious health consequences, particularly contributing to cardiovascular and metabolic diseases, among a wide range of other conditions. Furthermore, noise pollution also harms terrestrial and marine ecosystems.

The *Environmental noise in Europe — 2025* report presents the latest data and analysis on noise pollution and its effects on human health and the environment across Europe. Now in its third edition, the report draws on information submitted by European Union (EU) Member States and other EEA countries under the 2022 reporting round of the Environmental Noise Directive (END). It focuses specifically on transport-related noise from road, railway and aircraft traffic. The report was prepared in partnership with the EEA's European Topic Centre on Human Health and the Environment.

Key areas covered in the report include:

- the number of people exposed to noise levels that are harmful to health;
- the health impacts and burden of disease associated with environmental noise;
- progress towards the zero-pollution target on noise for 2030;
- impacts of noise on biodiversity and protected natural areas;
- accessibility to green and quiet areas in European cities;
- challenges and potential solutions to reduce noise impacts.

## Key messages

- According to the latest Environmental Noise Directive (END) reporting, over 20% of Europeans — more than one in five — are exposed to harmful transport noise levels. When measured against stricter World Health Organization (WHO) recommendations, this figure rises to over 30%, or nearly one in three citizens.

- Road traffic is the most widespread source of transport noise, exposing an estimated 92 million people to levels above the END threshold of 55 dB for the day-evening-night period, compared to 18 million affected by rail traffic and 2.6 million by aircraft noise.

- When compared to other environmental health threats, transport noise ranks among the top three — just behind air pollution and temperature-related factors. Chronic exposure to noise from transport contributes to 66,000 premature deaths annually in Europe, while also leading to around 50,000 new cardiovascular disease cases and 22,000 cases of type 2 diabetes.

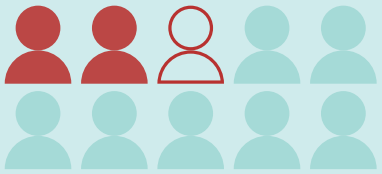
- Almost 16.9 million Europeans experience long-term annoyance due to noise from transport and approximately 4.6 million suffer from severe sleep disturbances. According to new research, noise could also contribute to thousands of cases of depression and dementia.

- It is estimated that over half a million children in Europe experience reading difficulties and about 63,000 experience behavioral issues due to transport noise. High noise levels are also linked to approximately 272,000 cases of overweight children.

- Noise pollution from transport sources results in the loss of 1.3 million healthy life years annually in Europe, equivalent to an annual economic cost of at least EUR 95.6 billion, representing around 0.6% of the region's gross domestic product (GDP) each year.

- Based on current projections, it is unlikely that the EU will meet the target set out in 2021 EU action plan 'Towards zero pollution for air, water and soil' to reduce the number of people chronically disturbed by transport noise by 30% by 2030 (compared to 2017 levels) without additional measures, including regulatory or legislative changes. The number of people highly annoyed by transport noise in the EU declined only by an estimated 3% between 2017 and 2022, falling short of the pace needed to meet the zero-pollution noise reduction objective.

## Extent of the problem



at least **20% population**
affected by unhealthy levels of noise
due to road, rail and air traffic

**30%** according to WHO recommendations

## Health impacts

almost
**17 million**
**Europeans**
experience
long-term high
**annoyance**

approximately
**4.6 million**
suffer from severe
**sleep disturbances**
due to transport
noise

**New cases in 2021**

**66,000**
premature
deaths

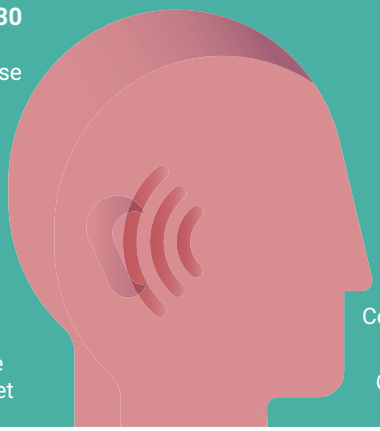
**50,000**
cardiovascular
disease cases

**22,000**
type 2 diabetes
cases

## Progress and outlook

**Zero Pollution target 2030**
-30% people chronically
disturbed by transport noise

**-3% decline in 2022**
falling short of the pace
needed to meet the target

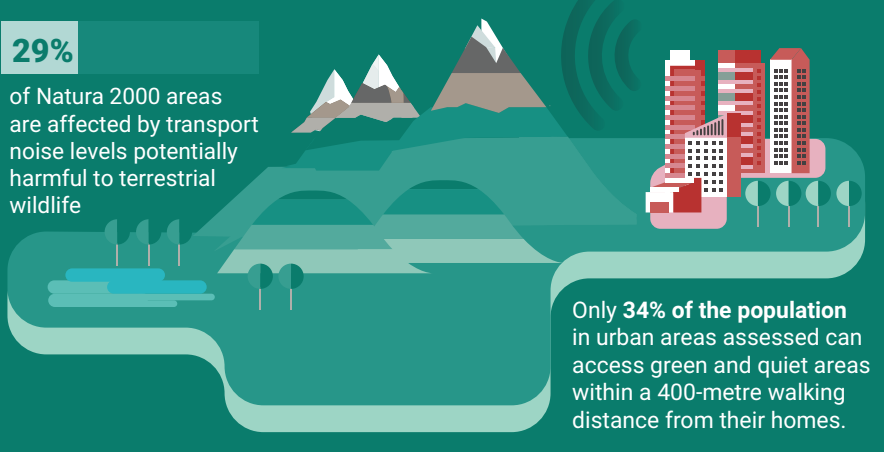


**Outlook 2030**
reduction in people
highly annoyed

**0%**
Conservative scenario
**-21%**
Optimistic scenario

## Impacts on natural areas and access to quiet-green spaces

**29%**
of Natura 2000 areas
are affected by transport
noise levels potentially
harmful to terrestrial
wildlife



Only **34% of the population**
in urban areas assessed can
access green and quiet areas
within a 400-metre walking
distance from their homes.

## Main findings

The latest data provided by countries under the END reveal the extent of noise pollution in Europe. The findings of the *Environmental noise in Europe — 2025* report highlight the urgent need for additional efforts to reduce environmental noise and its effects on human health, the environment and the economy.

### *Noise exposure — a widespread problem affecting over 100 million people in Europe*

A significant proportion of Europe's population is exposed to transport noise levels that are harmful to health. The latest estimates show that approximately 112 million people — more than 20% of the population in Europe — are exposed to long-term noise levels from road, rail and aircraft sources that exceed the thresholds set by the END.

However, the latest scientific evidence indicates that health impacts already occur at noise levels below the thresholds at which countries are obliged to report under the END. For instance, the WHO environmental noise guidelines for the European region recommend substantially stricter noise levels, meaning that in reality many more individuals are exposed to transport-related noise that pose a risk to health. When considering these lower recommended levels, it is estimated that approximately 150 million people — more than 30% of the population — are exposed to long-term unhealthy noise levels from transport sources.

The problem of noise pollution is widespread. Unhealthy levels of noise pollution are experienced across all European countries. Road traffic is identified as the dominant source of environmental noise, especially in densely populated urban areas, where the highest numbers of people are affected. Based on END thresholds, road transport accounts for around 92 million people exposed to harmful day-evening-night noise levels and 58 million exposed during nighttime. In comparison, railway noise affects 18 million people during the day-evening-night period and 13 million at night, while aircraft noise impacts around 2.6 million (day-evening-night) and fewer than 1 million during the night. While rail and aircraft noise affect fewer people overall, they remain significant sources of local noise pollution, particularly near major rail transport corridors and airports.

### *Noise pollution is not only an annoyance, it can cause extensive health impacts*

Whereas noise has typically been associated with impacts such as annoyance and sleep disturbance, its effects are much broader. Exposure to noise affects health through interconnected pathways, primarily stress and sleep disturbance. These factors can lead to inflammation and oxidative stress, which in turn contribute to a wide range of negative health outcomes, including cardiovascular and metabolic diseases, mental health disorders and even premature deaths.

In 2021, at least 66,000 premature deaths were linked to long-term exposure to transport noise, as well as 50,000 new cases of cardiovascular diseases and 22,000 new cases of type 2 diabetes. This corresponds to 0.7% of all new cardiovascular disease cases, 1.3% of all type 2 diabetes cases and 1.1% of all premature deaths in that year being attributable to noise from transport sources. Additionally, according to new research, noise from transport could contribute to thousands of cases of depression and dementia.

Noise pollution from transport sources in Europe leads to the loss of approximately 1.3 million healthy life years annually, as measured using disability-adjusted life years (DALYs). DALYs combine the years of life lost due to premature death with years lived in poor health, thus presenting a comprehensive measure of the full burden of disease from noise pollution. This also allows meaningful comparisons between different environmental risks. When compared to other environmental health threats, transport noise ranks among the top three — just behind air pollution and temperature-related (climatic) factors. Furthermore, it has a greater health impact than better-known risks such as second-hand smoke or lead exposure.

### *Noise pollution also poses risks to children's health*

Chronic exposure to transport noise can also negatively affect children, especially as they are in an important learning and developmental phase. The effects of noise on children include delayed learning and cognitive impairment but also impacts such as an increased risk of being overweight. There are approximately 15 million children living in areas affected by harmful noise levels in Europe.

Based on new research, it is estimated that transport noise contributes to over 560,000 cases of reading difficulties, 63,000 behavioural issues and an estimated 272,000 cases of overweight children in Europe.

### *Transport noise is a threat to Natura 2000 natural areas*

Noise pollution can impact both terrestrial and marine wildlife, influencing their behaviour, physiology, communication and sensory perception, while also altering predator-prey dynamics. Noise can also disrupt ecosystem functions, including pollination by insects, affecting overall ecosystem productivity and health.

At least 29% of Europe's natural areas protected under Natura 2000 are affected by transport noise levels that could pose risks to terrestrial wildlife.

Underwater noise pollution from shipping, offshore construction and marine exploration disrupts marine life, causing stress and behavioural changes, particularly in species in Europe’s waters that rely on sound for survival such as whales and dolphins. Areas with the highest underwater noise exposure in Europe include parts of the English Channel, the Strait of Gibraltar, parts of the Adriatic Sea, the Dardanelles Strait and some regions in the Baltic Sea.

While EU legislation addresses noise pollution in the marine environment, it does not currently cover noise impacts on terrestrial ecosystems and species.

### *Accessibility to quiet and green spaces in European cities could be improved*

Access to quiet and green spaces provides health benefits including stress and annoyance reduction, particularly for individuals living in noisy environments. The END and the 2018 WHO environmental noise guidelines emphasise the need to preserve and increase quiet spaces. These areas have a role in promoting well-being and can also support climate adaptation and nature restoration.

A geo-spatial analysis of 233 cities reveals that only 34% of the population can access green and quiet areas within a 400-metre walking distance from their homes, which is a common metric for acceptable accessibility. While northern European urban areas typically provide better access to such spaces, there remains a significant disparity in availability across other regions.

### *Limited progress made towards noise pollution target*

Progress in decreasing the number of people exposed to harmful levels of noise has been slow. The 2021 EU action plan 'Towards zero pollution for air, water and soil' set out an indicative target to reduce by 30% the number of people chronically disturbed by transport noise by 2030 (compared to 2017 levels). It is estimated that between 2017 and 2022, the number of people annoyed by transport noise in the EU declined by only 3%. This reduction falls short of the pace needed to meet the zero pollution noise reduction objective.

Based on current projections to 2030, it is unlikely that the EU will meet the zero pollution target without additional measures. A business-as-usual scenario (that assumes the current rate of implementation of measures) modelled in the report predicts that if no additional measures are taken, the situation by 2030 will remain unchanged. Under an optimistic scenario, where substantial additional measures are implemented, the number of people chronically disturbed by transport noise could decline by about 21%. However, this number is still short of the EU zero pollution ambition. Therefore, more substantial action at EU and national levels would likely be necessary to meet the target.

### *Increasing calls for action*

Different stakeholders have raised significant concerns regarding ongoing noise pollution in Europe. The European Court of Auditors (ECA) has highlighted that, despite longstanding regulations, actions taken by the European Commission (EC) and selected Member States have been insufficiently effective at protecting citizens from noise pollution. The ECA considers that the absence of EU noise reduction targets disincentivises Member States from prioritising actions to reduce noise pollution effectively. Furthermore, the ECA points out that the current noise reporting thresholds cover only a portion of the population exposed to harmful levels. In its report, the ECA recommends that the European Commission assesses the feasibility of introducing EU noise-reduction targets in the END and of aligning the noise exposure reporting thresholds as closely as possible with those recommended by the WHO ([1]).

In 2023, the WHO's *Declaration from the seventh Ministerial Conference on Environment and Health: Budapest Declaration*, focusing on the European region, reinforced the urgent need for action against various pollutants, including noise. The declaration emphasises the importance of collaboratively developing and implementing policies to reduce environmental noise while exploring the health benefits of interventions aimed at improving both air quality and noise pollution.

([1]) The noise thresholds of the END are set at 55 dB for the day-evening-night period ($L_{den}$) and 50 dB for the night period ($L_{night}$), while the WHO thresholds are source specific and are set at levels below the END.

In its most recent implementation report from 2023, the European Commission has committed to strengthening ongoing short-term actions on source legislation and improving the implementation of the END. The report also states that the European Commission will assess possible improvements to the directive, including the feasibility and benefit of establishing noise reduction targets at the EU level.

The scientific community has found adverse health effects at traffic noise levels even below the WHO recommendations, starting from as low as 45 decibel (dB) day-evening-night noise level for various cardiovascular diagnoses and diabetes. Given the significant role of noise as a risk factor for cardiovascular disease and other adverse health effects, the scientific community has highlighted the necessity of raising awareness about noise among health professionals as a critical environmental risk, alongside air pollution and chemical exposure. It has been suggested that incorporating noise pollution into medical education and prevention guidelines is essential for developing more comprehensive and effective disease prevention strategies.

### *Solutions to reduce noise exist*

While noise pollution poses significant challenges, there are effective solutions already available to mitigate its impact. Key solutions outlined in the report include:

**Upstream measures that reduce noise at source, including regulatory and legislative actions**

In general, these measures are found to benefit a larger segment of the population because they address all noise levels compared to localised interventions, which are only effective at hotspots. Measures at source that are backed up by regulation/legislation help to ensure consistent and effective application. Examples of such solutions could include:

- regulating noise emissions from road vehicles, such as reducing vehicle speed limits in urban areas, increasing the use of low noise tyres, and reducing noise from high emitters;
- regular rail grinding and maintenance to smooth tracks;
- optimising aircraft landing/take-off patterns to avoid populated areas and promoting the use of quieter aircraft.

Source measures are especially important to tackle road traffic noise, which is a prevalent source, but also for railway activity, which is expected to grow in the coming years.

**Long-term strategies incorporating urban and transport planning**

Long-term strategies incorporating urban and transport planning can provide a clear, iterative and achievable pathway for the delivery of tangible reductions in noise exposure, allowing for the prioritisation of preventive rather than reactive measures. This includes measures such as buffer zones between transport corridors and residential areas and sensitive locations (e.g. schools and hospitals); designing building orientation to minimise exposure; noise-sensitive indoor layouts; promoting sustainable mobility options (e.g. public transport, walking and cycling); and the creation of green and quiet spaces — all of which can also support better air quality, climate resilience and ecosystem restoration.

### *Other actions on climate, environment and health can contribute to noise reduction*

On the one hand, reducing noise pollution can contribute to the objectives in other policy areas. On the other hand, noise reduction can also be achieved as an important co-benefit of actions taken in other policy domains. These include air quality and climate policies, nature restoration and preventive health initiatives related to cardiovascular and respiratory diseases and mental health.

For instance, efforts to decarbonise cities and reduce pollution — through active mobility and investments in walking, cycling and public transport — can also deliver significant reductions in urban noise, especially in densely populated areas. The EU's biodiversity strategy and the Nature Restoration Regulation also present opportunities to reduce noise exposure. Creating and restoring green and blue spaces — such as urban forests, wetlands, parks and green corridors — not only improves ecological resilience but also increases the potential availability of quiet areas for recreation and restoration.

Additionally, various EU initiatives focused on preventive health, particularly concerning mental health and cardiovascular diseases, can be leveraged. Given that noise pollution is a significant risk factor for these conditions, integrating noise reduction into health strategies can yield beneficial outcomes for public well-being and resilience.

### *Reducing noise pollution can bring important benefits to the European economy and society*

Noise pollution should also be considered in economic terms, as it causes a large burden of disease in Europe. In terms of economic (social) costs, years of health and life lost prematurely due to illness or death significantly reduce the human resource potential of an economy and they are a source of lost productivity. The report shows that noise pollution from transport sources results in annual economic costs of at least EUR 95.6 billion in Europe. This represents 0.6% of the total gross domestic product (GDP) each year. The latest European Commission implementation report outlines that implementing the noise measures proposed in some local and national action plans would be highly cost-efficient. A study commissioned by the European Commission found that for every euro spent on specific noise measures, there is a return of EUR 10 in social benefits. This indicates that when authorities in Member States adopt these specific noise measures, they not only address health concerns but also create long-term benefits for society. Noise mitigation can therefore provide economic opportunities and help establish EU manufacturers and industries as leaders in green innovation.

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