PerthAirport | New Runway Project

New Runway Project

PRELIMINARY DRAFT
MAJOR DEVELOPMENT PLAN

VOLUME C: AIRSPACE MANAGEMENT PLAN

SECTIONS 19-26

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Arrivals

24
Health

This section provides an assessment of the impact to health from the operations of the New Runway Project (NRP).

Detail is also provided on the following areas:

- What research has been undertaken on the health impacts of aircraft noise exposure?
- How relevant is the research to the NRP?
- How will the NRP impact on the health of the surrounding communities?
- What mitigation measures will be undertaken to manage the impact to health?

24.1 Introduction

In 1948, the World Health Organization (WHO) defined health as 'a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity'. Based on this definition, it is accepted that health is a broad concept. Factors such as stress and annoyance are health concerns in their own right and not just pathways to physiological illnesses such as heart disease and hypertension.

The section describes the potential impacts on health resulting from the operation of the NRP.

A study was undertaken to examine the potential health impact from aircraft noise exposure from the operations of the NRP. The study focussed on five main health consequences:

- psychological effects,
- cognitive impairment,
- cardiovascular disease,
- sleep disturbance, and
- annoyance.

The potential health impacts associated with aircraft air emissions have also been considered.

Impacts associated with construction noise have not been assessed as construction noise is a short-term activity and the anticipated noise exposure is much lower than for that expected for aircraft operations. The construction process for the NRP is detailed in Section 6.

Information on the changes to airspace and flights paths and aircraft noise impact assessments are outlined in Section 20, 21 and 22.

24.2 Key Findings

The key findings from investigations into health include:

- Research into the health impacts of aircraft noise exposure has generally been conducted at airports much busier than Perth Airport, with no specific research completed for the Perth area.
- Generally, and not specific to the NRP, the research found that:
  - the most adverse health effect from aircraft noise exposure is considered to be sleep disturbance, due to the knock-on effects of sleep deprivation that includes an increased risk, in the long term, of obesity, diabetes and cardiovascular outcomes. Some groups, such as children and the elderly, are considered to generally be more susceptible to sleep disturbance,
  - some research has shown that aircraft noise exposure can impact on some cognitive outcomes and some areas of learning in primary age school children, with the most evidence existing for reading comprehension and some types of memory.
  - with regards to the increased risks of hypertension and the linked increased risks of ischaemic heart disease, research identifies that this risk is higher for long-term (10-15 years) exposure to aircraft noise and more prevalent in older people (over 65 years),
  - perceived and real health consequences of aircraft noise contribute to the annoyance that the noise provokes, and annoyance can result in increased stress which can lead to health consequences. The health consequences of annoyance are generally a mediator for other health issues such as stress, which is in turn linked to cardiovascular disease. Annoyance can be reduced through information, engagement to improve understanding of aircraft noise, and for those affected, manage the noise in the least intrusive way reasonably possible, and
  - the health consequences associated with air pollution include stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma, with particulate matter being the major contributor.
- With careful planning, and through engagement with affected populations, any potential health impacts resulting from NRP operations are likely to be small, or restricted to relatively few people.
- The NRP is unlikely to cause adverse psychological impacts on the surrounding communities.
- Noise induced hearing impairment is highly unlikely to result from community exposure to aircraft noise from NRP operations as hearing impairment occurs only at prolonged exposure to high levels of noise well beyond the levels from NRP flight operations.
- The operation of the NRP will impact on a small number of kindergartens, pre-schools and schools that may be sensitive to cognitive and learning impact.
- The NRP and operation of a parallel runway system will result in changes and flight paths around Perth Airport at night time. The opening of the new runway will alter the pattern of aircraft noise exposure and result in reduced aircraft noise exposure in some areas and new or higher aircraft noise exposure in other areas.
- Operation of the NRP will eventually result in a greater number of annual aircraft movements than what could operate at Perth Airport without the NRP and the increased aircraft capacity will result in small increases in pollution levels. However, increased efficiency in operations due to the parallel runway system will also have some impact in reducing emissions by reducing airborne delays for incoming aircraft and ground running for aircraft queued for departure. This, in turn, will reduce engine run times (and emissions) from arriving aircraft and aircraft with engines running and awaiting departure.
- Strategies to minimise noise impact can assist in reducing the health consequences of aircraft noise exposure. These include appropriate land planning around airports, careful route planning, noise abatement procedures, provision of clear and comprehensible information about the likely exposure to aircraft noise, as well as information to assist those affected by the noise to undertake amelioration measures that can reduce noise penetration into homes.
- Further research is required into the effect of aircraft noise and potential health impacts, with nearly every study suggesting further research is required.

24.3 Policy Context and Legislative Framework

The literature and research examining the health impacts of aircraft noise and emissions is extensive and diverse and draws on a range of Australian and international guidelines, including:

- Airports (Environment Protection) Regulations 1997 (Commonwealth),
- Guidelines for Community Noise (WHO 1999),
- Health Aspects of Air Pollution with Particulate Matter, Ozone and Nitrogen Dioxide (WHO 2003)
- The Health Effects of Environmental Noise Other Than Hearing Loss (enHealth 2004),
- Night Noise Guidelines for Europe (WHO 2009),
- Burden of Disease for Environmental Noise (WHO 2011),
- Health Effects from Particulate Matter (WHO 2013), and
- National Environment Protection Measures (NEPC 2017).

24.4 Methodology

A desk top review of relevant literature relating to the health impacts of aircraft noise, including research, reviews and guidelines was undertaken to assess health impacts.

Over the past 15 years, a number of Australian and international guidelines have been developed and large research projects undertaken in areas close to the some of the major international airports, such as Heathrow and Munich airports.

The assessment considered 168 articles that have been published between 1993 and 2017. Each article was assessed in terms of its research methodology, strength of findings, and relevance to Perth Airport operations.

24.5 Research Considerations and Limitations

24.5.1 Location and Environs

The tools and techniques for assessing the health effects of aviation vary from epidemiological population-level studies (of the patterns, causes and effects of health and disease conditions in a specific population) to detailed monitoring and assessment of the impact of specific levels of noise on individuals. The population studies vary widely in many characteristics, as does the aircraft noise to which they are exposed. The application of research findings to Perth should be considered in the context of variable social, environmental, housing, employment and geographic circumstances.

Housing can have a significant impact on the intrusion of noise. In addition, physical environment and geography can affect both the propagation of aircraft noise and emissions, and the levels of background noise and emissions. Many of the studies highlight the importance of seemingly minor circumstances such as room orientation and window openings (Babisch 2006; Jones and Rhodes 2013; Miedema and Vos 2007), which can be improved through amelioration measures.

The assessment of health impacts considers evidence from both laboratory-based studies and epidemiological studies. There are inherent challenges of drawing solid and 'generalisable' conclusions from research on aircraft noise. Laboratory studies are able to objectively measure certain health effects such as sleep disturbance and cardiovascular outcomes. However, research participants in the laboratory may be more sensitive to sleep disturbance, making it difficult to extrapolate laboratory findings to 'the real world' (enHealth 2004; Ising and Kruppa 2004). Most major reviews of aircraft noise and health consider the best evidence to come from epidemiological studies i.e. research conducted in the field. Yet epidemiology carries associated risks and may not provide clear-cut answers (enHealth 2004).

Confounding happens when an association between a health effect and aircraft noise might be explained by another factor which has an independent effect on the health outcome. For example, people living in high noise areas may be more likely to have a lower socio-economic status, which in turn increases their risk for certain health impacts (Huss et al 2010). Likewise, some ethnicities have a strong association for cardiovascular disease (Hansell et al 2013). Well-designed studies take confounding factors into consideration and adjust the analysis accordingly. However, in some cases – especially population-level studies that use census data or medical records – data is not always available on individual confounding factors, like family history of cardiovascular disease, or smoking. In these cases, data is estimated. Consequently, some of the strongest evidence comes from individual-level studies because they can control more confounding factors (enHealth 2004).

In some studies, noise levels must also be estimated if not available or assessed by researchers (Miedema and Vos 2007; Ohrstrom et al 2006). This can result in misclassification if the noise levels are incorrect for some participants (Clark 2015).

Another variable that limits 'generalisability' is time. Cross-sectional studies capture a snapshot at a given time and cannot account for the possible difference between long and short-term effects (Hansell et al 2013). The most valuable evidence comes from longitudinal studies, where data is gathered for the same subjects repeatedly over a period of time. There is also a distinction between acute and chronic noise exposure, which longitudinal studies are able to delineate. The body's response to acute noise exposure might be short-term, for example a temporary increase in heart rate, which will be different from the body's response to being exposed to noise over a long period of time.

Further complications come from trying to measure subjective responses (Stansfeld and Matheson 2003). This is particularly the case for sleep disturbance and annoyance, most commonly assessed through subjective responses. Objective and subjective assessments of sleep disturbance have produced different results. This is compounded by the different methods used to assess health effects, including survey techniques (Fields et al 2001), sampling and noise exposure measurements (WHO 2011). Although other effects like cardiovascular impacts may be easier to measure objectively, determining causality from aircraft noise requires very large samples (Clark 2015).

Some of the most useful evidence comes from meta-analyses which systematically compare and summarise evidence from a range of relevant studies. While this approach has its own limits based on the comparability of disparate study designs and methodologies (Maurice et al 2009), meta-analyses provide a systematic overview of evidence including trends over time.

In some cases, research also relies on indirect evidence of the association between aircraft noise and health effects (WHO 2009). For example, there is evidence that environmental noise can cause sleep disturbance, and there is evidence that sleep deprivation has a number of adverse health effects. Therefore, the causal link between noise and those health effects is indirect (Swift 2010; WHO 2009). This is reflected in researchers' consistent calls for further research into the health effects of aircraft noise – nearly every study suggests further research is needed.

24.5.2 Pattern of Aircraft Noise

Many studies are based on aircraft traffic volume and noise levels that are very different from current operations at Perth Airport or from what is expected as a result of the NRP operations.

Perth Airport currently has just over 130,000 aircraft movements per year. This is below the peak year of 2013 that experienced 151,000 aircraft movements. The number of annual flights at Perth Airport is forecast to reach 172,000 by 2025 and 241,00 by 2045 as outlined in Section 2.

In contrast, London's Heathrow Airport had over 474,000 aircraft movements in 2017. Many of the studies undertaken have been at airports with traffic levels at the sorts of levels that occur at Heathrow Airport. This does not make the results of health studies at busier airports irrelevant, but it does require caution when translating studies undertaken at one airport to the circumstances of another.

Over the past 45 years, aircraft have become quieter but this does not mean that aircraft noise exposure has reduced. The growth in the number of aircraft flying and the average size of those aircraft has counterbalanced some of the substantial noise improvements of newer aircraft, such as the Boeing 787 and the Airbus A380.

Over time fleet renewal will see changes to the aircraft mix, replacing the noisiest, oldest aircraft flying with the newest, quietest models available. However, the growth forecasts for Perth Airport (detailed in Section 2) demonstrate that any noise improvements though increasing use of quieter aircraft types may be offset by the growth in the average size and the number of aircraft flying.

24.5.3 Aircraft Noise Metrics

In general, a particular challenge in assessing the health impact of aircraft noise exposure is how the studies rely on the measurement of aircraft noise to which a population is exposed. Various noise metrics are available and can result in varying conclusions. Section 22 provides further information on relevant aircraft noise metrics.

Measuring Noise

Noise is measured in decibels. Decibels are logarithmic scales that provide ratios of pressure, from which the power of a sound wave and its perceived loudness can be calculated. The measurement of sound for the purposes of most research on the health effects of aircraft noise exposure is based on the A-weighted scale, referred to as dBA. An increase of one dBA is considered just discernible by a person with good, undamaged hearing in isolation from background noise. A three dBA change is considered to be a level of increase just discernible for the average person in an outdoor environment. An increase of ten dBA is a perceived doubling of loudness as shown in Figure 24-1.

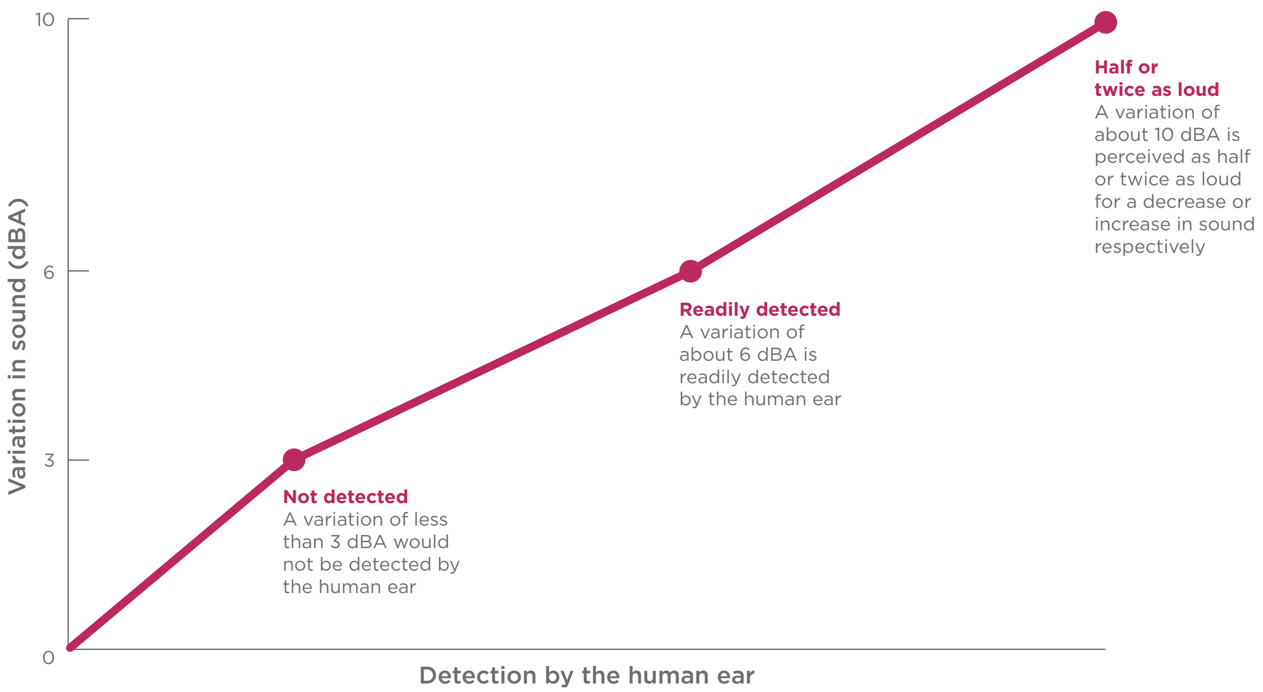

Figure 24-1 Perception of variation in sound levels
Source: Perth Airport

Composite Noise Metrics

A particular challenge in researching the health impacts of aircraft noise exposure is identifying comparable levels of noise from different sources. An aircraft passing overhead will generate noise over a relatively short duration but will exceed the level of background noise if the aircraft is loud enough, close enough and the level of background noise is low enough. There will then be no aircraft noise until the next aircraft passes. Road traffic noise tends to be less episodic (depending on the type of road). The source of the road noise is also fixed (to the road) whereas an aircraft can vary significantly in both height and lateral position, creating greater variation in noise impact.

Much analysis of aircraft noise uses metrics that seek to provide a standard, single value for noise over a given period, which might be a day, or part of a day (such as evening, day or night), and is averaged over a longer period, or calculated from composite data from a longer period. This seeks to calculate a 'continuous noise equivalent level' for the specified period of time (e.g. 24 hours, evenings, or night-time), although this continuous level is derived from episodic noises. Continuous noise equivalent measures include the Australian Noise Exposure Forecast (ANEF), the US Noise Exposure Forecast (NEF), and L_{dn}/L_{den} (day night average sound level / day evening night sound level) measures commonly used in Europe.

Formulas for calculating the continuous noise equivalent level vary, with a key difference being the weightings for day, evening and night noise. In the case of L_{dn} (day night average sound level) and ANEF formulas, evenings are not given a separate weighting but instead a widening definition of night (in the case of the ANEF 'night' is 7.00 pm to 7.00 am) which reduces the penalty for night noise, whereas L_{den} (day evening night sound level) and the NEF separate day, evening and night.

Accordingly, there are no precise conversions from one scale to another. This can complicate the comparison of different studies using different metrics. It can also inhibit the ready application of the results of a study undertaken in one location to the circumstances of another location (Correia et al 2013; Maurice et al 2009; Paunovic et al 2011; WHO 2011).

The common use of composite noise indices can also obscure important distinctions in the nature of the aircraft noise exposure. The impact of aircraft noise can be from a relatively few very loud events, a great many quieter events, or anything in between. The noise can be almost entirely during daylight hours, largely at night, in the evenings or early morning, or any of these in varying combinations.

Some continuous equivalent noise measures adjust for day, night and possibly evening, but they do not allow for varying patterns within those bands. Night noise in a burst at 10.00 pm is likely to have very different effects from noise evenly spread across the whole night. The absolute numbers of events and their loudness will further affect that variation. All of these distinctions may well have a significant effect on the impact of that noise (Stansfeld and Clark 2015).

Alternative Noise Metrics

Some health impacts of aircraft noise relate to the specific types of aircraft noise events. Aircraft noise may disturb sleep when a single event is loud enough. Disturbance not only takes the form of awakenings but also the subtler disturbance of the different sleep stages. In this context, it is important to identify the number and frequency of events above a specified level. There is limited research on the use of different metrics for measuring aircraft noise such as the number of events above a specified level (say 65 dBA) in a specified time period (such as night, perhaps defined as 10.00 pm to 6.00 am). These measures, known as the Number Above or N-contours, are not always available. Some studies have highlighted the possible benefits of using N-contours and other metrics (Maurice et al 2009; Sharp et al 2014). The N-contours for NRP operations are detailed in Section 22.

Measuring Annoyance

While annoyance is seen as a health issue in its own right, it is also implicated in other health concerns as a result of the stress related impacts it has. Accordingly, it is important to be able to measure the level of annoyance that occurs at a specified level of noise. Currently the relationship of annoyance to aircraft noise exposure is assessed by measures such as L_{den}, ANEF or the NEF. Those measures are based on 'dose/response' surveys that plot communities' responses to aircraft noise and relate these to a formula that gives a composite index for the total noise in those locations. The actual noise events in those communities can vary significantly in loudness, duration, frequency of events and distribution over time of day.

Recent commentary has questioned the validity of the dose/response relationship and the capacity of these formulas to provide an accurate representation of the noise level as perceived by those who are annoyed. This raises questions about the capacity to relate annoyance to identified levels of aircraft noise. Research shows that annoyance is frequently driven by factors other than the level of aircraft noise, such as fear of crashes, unmet expectations about the level of peace and quiet, changes in noise levels, and lack of understanding about why the aircraft have to fly where they do (Guski 1999; Civil Aviation Authority 2017; ICAO 2016; Southgate 2007). It appears that the noise level people are exposed to only plays a small part in predicting or explaining their level of annoyance.

Complaint Data

Traditionally, consumer service and supply industries draw heavily on complaint data to assess dissatisfaction. While not all people who are dissatisfied will lodge complaints, a high level of complaints, at aggregated levels, can provide important insights into consumer reactions. In the field of aircraft noise, some papers highlight the need to disaggregate complaints and annoyance (enHealth 2004; ICAO 2016) based in part on the substantial distortion of complaint data by a very few chronic complainers. Arguably, with better complaint data that does not count repeat contacts as separate complaints, aircraft noise complaints could provide at least supplementary data on the level of annoyance. They could also provide insights into levels of self-reported sleep disturbance, and some other health indicators such as self-reporting of stress in response to aircraft noise. At the non-aggregated level, complaints can provide important information about specifics of annoyance drivers, if treated with appropriate discernment.

In practice, complaint data is not used in this way (enHealth 2004; ICAO 2016) and is generally regarded as unreliable. This is a reasonable assessment in view of the poor collection and reporting of aircraft noise complaint data across the aviation industry worldwide. The standard practice of designating every contact made by a complainant as a separate complaint allows very few complainants to confound the data. Over time improved data collection and analysis, focusing on the number of distinct individuals who complain and the specific issues that provoke those complaints, may provide valuable insights beyond those currently available. Airservices has changed its approach to collection of complaints data to align with this thinking.

24.5.4 Interdependent Health Impacts

Although the various health consequences of aircraft noise exposure are generally considered under separate headings, they in fact are intricately linked, as shown in Figure 24-2. For example, sleep disturbance is linked to cardiovascular health (Basner et al 2014) and annoyance. Similarly, annoyance can affect sleep disturbance (Pirrera, De Valck and Cluydts 2010), self-reported health and cardiovascular outcomes. In reality, the health effects of noise are often intertwined and interdependent.

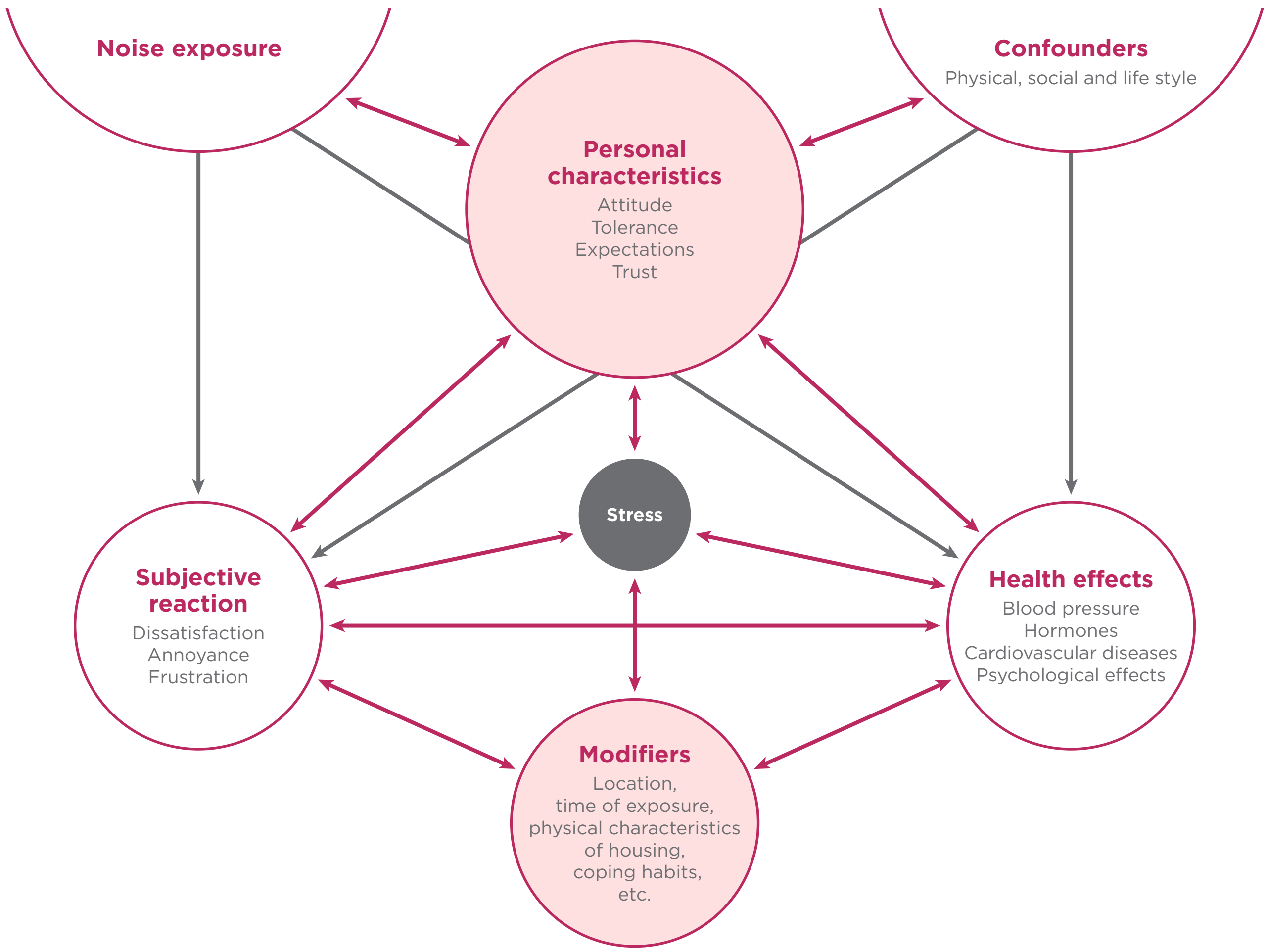

Figure 24-2 Interdependent health impacts

Source: Berry and Sanchez, The Economic and Social Value of Aircraft Noise Effects: A Critical review of the State of the Art (2014)

24.6 Impact Assessment

The NRP will result in the operation of a parallel runway system that will see changes to flight paths around Perth Airport. These changes, as well as the projected future growth in air traffic, will alter the pattern of aircraft noise exposure and result in reduced aircraft noise exposure in some areas and new or higher aircraft noise exposure in other areas.

The operations of a parallel runway system will therefore alter the distribution of the potential health impacts, rather than deliver any net increase.

A health impact assessment has considered the potential health impact from aircraft noise on five main health consequences:

- psychological effects,
- cognitive impairment,
- cardiovascular disease,
- sleep disturbance, and
- annoyance.

The potential health impacts associated with aircraft air emissions has also been considered.

24.6.1 Psychological Effects

A range of health outcomes are relevant in considering the possible psychological effects of aircraft noise. At the most serious end is mental illness, defined by Australia's National Mental Health Plan (Department of Health 2003) as 'a clinically diagnosable disorder that significantly interferes with an individual's cognitive, emotional or social abilities'.

Research has also considered a range of other conditions that impact mental health, consistent with the definition of mental health as 'a state of emotional and social wellbeing in which the individual can cope with the normal stresses of life and achieve his or her potential'. Under this definition conditions such as stress and annoyance are valid mental health concerns but are not clinically defined mental illnesses.

While reliable research into mental health effects from aircraft noise exposure is limited, a consistent finding is that aircraft noise exposure has not been shown to cause psychiatric disorders (Jones 2010a; Jones and Rhodes 2013; Stansfeld and Matheson 2003; WHO 1999). It is accepted that aircraft noise exposure can result in psychological effects such as annoyance and stress (EnHealth 2004) and anxiety (Clark 2015), but it is unclear whether psychological health affects the aircraft noise response by making some people more susceptible to the mental health effects of aircraft noise exposure, or whether the aircraft noise response causes the psychological effect (Babisch 2014).

There is limited evidence of mental health concerns due to aircraft noise exposure. The data is unclear and any impact would appear to be short term. Studies identifying such impacts have generally been based on much higher levels of aircraft noise exposure than are forecast for Perth Airport. The potential impact of the new runway operations on psychological health has been assessed as negligible.

24.6.2 Cognitive Impairment

Cognitive impairment is a term generally used to refer to any form of impairment that affects the mind or the brain. In relation to aircraft noise exposure, the focus has been on the capacity of individuals to process information, most frequently in the context of learning.

A number of studies have identified links between high levels of exposure to noise and children's learning (Hygge, Evans and Bullinger 2002; Stansfeld et al 2005). The studies do not point to a clearly definable level of impact from aircraft noise and some have considered other environmental noise.

The principal impacts identified relate to reading comprehension, some types of memory, and inconsistent findings for attention (Matheson, Stansfeld and Haines 2003; Stansfeld et al 2005; Stansfeld and Matheson 2003; WHO Europe 2011). Studies have pointed to a delay in reading ability of between two and eight months (Clark et al 2006; Klatte et al 2016). Although not unanimous in their findings, some studies suggest that this effect is reversible (Hygge, Evans and Bullinger 2002; Sharp et al 2014). Two studies found that night-time noise did not have an additional cognitive effect on children over and above the effect of daytime exposure (Clark et al 2006; Stansfeld et al 2010).

Despite the uncertainties in this area of research, there is evidence to conclude that aircraft noise exposure can have a detrimental effect on some cognitive outcomes and some areas of learning in primary age school children. The most evidence exists for reading comprehension and some types of memory. The major studies that provide the primary source of data for this area of research have been undertaken in Europe and the US, often at airports with much higher levels of aircraft activity than will occur at Perth Airport.

Research on cognition effects in adults is limited but does point to there being no significant impact (WHO 2009).

The operation of the new runway will result in a number of education facilities being overflown by aircraft as outlined further in Section 25. The analysis shows a slight reduction in 2025 with the opening of the new runway, due to the spread of aircraft traffic across the parallel runways. By 2045 the number of impacted facilities will increase to pre-NRP numbers.

Research also suggests that further work is required in this area. The potential impact of the new runway operations on cognitive and learning impairment has been assessed as minor adverse as there are no schools within the significant noise effected contours as identified in the Airports Act. Perth Airport supports further research to be undertaken at an international and national level.

24.6.3 Cardiovascular Effects

The Australian Institute of Health and Welfare defines cardiovascular disease as 'all diseases and conditions involving the heart and blood vessels', of which the main types in Australia are coronary heart disease, stroke and heart failure/ cardiomyopathy.

Research in this field takes a broader view, and includes related conditions that may link to cardiovascular disease, such as hypertension (persistent long-term high blood pressure).

Studies vary significantly in the noise levels assessed and many seek to determine whether there are thresholds at which the effects are evident.

A highly-cited review of pre-2006 studies identified the threshold for evidence of ischaemic heart disease at an average sound pressure of 65 to 70 dBA (Babisch 2006). In 2009, the WHO Europe identified 55 dBA as a threshold at which there was 'limited evidence' for greater risk of myocardial infarction and hypertension, while in a 2010 publication the European Environment Agency identified 60 dBA as a threshold for higher risk of myocardial infarction. A 2014, meta-analysis suggested that earlier suggestions of a threshold were correct, but presented 55 to 60 dBA as the level at which there is a relatively small increased risk of ischaemic heart disease (Babisch 2006). Some recent studies suggest there is no threshold, but an increased risk as noise levels get higher, with the risk rising by seven to 17 per cent per ten decibel increase in noise level (Basner et al 2014).

Some studies identify effects greater in older people (Rosenlund et al 2001) or have focussed on older people such as those over 64 years old (Correia et al 2013; Sorensen et al 2011). Others suggest effects require long-term exposure of up to 20 years (Huss et al 2010; Swift 2010). Certain groups are more at risk of cardiovascular illnesses including men (Australian Institute of Health and Welfare 2011) and specific ethnic backgrounds (Hansell et al 2013).

There is some evidence for an association between environmental noise and increased risks of hypertension (Babisch 2006; Jarup et al 2008; Maurice et al 2009; Rosenlund 2001), with a general view that this also links to increased risks of ischaemic heart disease. Much of the research on which this conclusion is based has considered levels of exposure above those that are forecast for Perth Airport. The potential impact of the new runway operations on cardiovascular health has been assessed as minor adverse.

24.6.4 Sleep Disturbance

From the research, the most commonly agreed health consequence of noise is sleep disturbance. It has also been cited as the most adverse health effect (WHO 2011) due to the knock-on effects of sleep deprivation. These include an increased risk, in the long term, of obesity, diabetes and cardiovascular outcomes (Swift 2010).

There are two ways of studying sleep disturbance, with different results produced from the two approaches.

Typically, laboratory-based studies assess objective sleep disturbance through polysomnography – a method of sleep study that records physiological responses during sleep such as brain waves and heart rate. Sleep disturbance can also be assessed subjectively by asking participants to fill in questionnaires.

Ultimately, knowledge about sleep disturbance and aircraft noise is incomplete. There remains disagreement over which noise measurements to use to best assess sleep disturbance and there is no single agreed dose/response relationship for sleep disturbance and aircraft noise.

Most research focuses on indoor sound levels as more accurate predictors of sleep disturbance than outside. The extent to which noise can penetrate a dwelling varies greatly, and is dependent not just on house construction and insulation, but also on factors that are difficult to isolate in research such as open windows or the orientation of bedroom windows (Jones and Rhodes 2013; Miedema and Vos 2007; Ohrstrom et al 2006).

Some groups are more susceptible to sleep disturbance, like children and the elderly, but there is little research into these specific groups. Factors other than environmental noise can cause sleep disturbance, and some studies conclude that other factors like needing the bathroom or having young children are far more likely to disturb sleep than aircraft noise (Jones and Rhodes 2013).

Research into sleep disturbance and aircraft noise exposure has sometimes produced inconsistent findings. People are generally better able to adapt to continuous noise levels like traffic (enHealth 2004) than aircraft noise, which is punctuated by events (Clark 2015; Denison 2016). However, one study using polysomnography found that road noise had the most effect on objective sleep disturbance, even though participants' self-reported sleep disturbance identified aircraft noise as more disturbing (Basner et al 2011). The uneven patterns of air traffic at night in many airports, including Perth, provide a very real confounding factor for the research and its translatability.

The noise levels at which sleep disturbance occurs varies across studies. Sleep disturbance can also occur in subtler ways than awakenings, such as altered sleep structure, cardiovascular responses and changes in the amount of time spent in different sleep stages (Basner et al 2011; enHealth 2004; Jones and Rhodes 2013).

The NRP and operation of a parallel runway system will result in changes to flight paths around Perth Airport at night time. Section 22 outlines the changes that will occur. The opening of the new runway will alter the pattern of aircraft noise exposure and result in reduced aircraft noise exposure in some areas and new or higher aircraft noise exposure in other areas.

The opening of the NRP will also impact on community facilities that may be sensitive to sleep disturbance such as child care or kindergarten facilities as outlined in further detail in Section 25.

The analysis shows a reduction in 2025 with the opening of the new runway, with 24 of the 72 facilities no longer impacted by five or more daily noise events. By 2045, the number of facilities will reach the pre-NRP counts, with an increase shown for aged care and retirement facilities.

The potential impact of the new runway operations on sleep disturbance has been assessed as moderate adverse. Perth Airport supports further research to be undertaken at international and national level.

24.6.5 Annoyance

The health effects of aircraft noise contribute to annoyance, and are contributed to by annoyance (Passchier-Vermeer and Passchier 2000). In other words, annoyance at aircraft noise is not just a response to the noise itself but also a response to what the noise represents. Perceived and real health consequences of aircraft noise contribute to the annoyance that the noise provokes, and annoyance can result in increased stress which can lead to health consequences.

At roughly similar constant equivalent noise levels, aircraft noise has been found to be more annoying than road traffic noise (Airports Commission 2013; Miedema and Vos 2007). This suggests that the pattern of the noise is a relevant factor in determining annoyance. It is likely that the episodic nature of aircraft noise makes it more annoying (ICAO 2016; Stansfeld et al 2005).

The annoyance literature also focuses on non-acoustic factors that are identified as perhaps the most important variable in explaining annoyance. Numerous sources cite non-acoustic factors as more significant than actual noise levels in predicting or explaining annoyance, and some identify acoustic factors as accounting for only a third of the cause of the annoyance (Ising and Kruppa 2004). Non-acoustic factors are described in varying ways but can be summarised as:

- unmet expectations (e.g. that there would be less, or no aircraft noise),
- change (linked to expectations that there would be no change, and a failure of communication about change),
- lack of understanding (e.g. why aircraft fly where they do),
- fear (e.g. aircraft noise prompting an associated fear of aircraft crashing),
- individual sensitivity to noise (individual responses to noise vary greatly), and
- value placed on the cause of noise (the greater the value placed on the source of the noise, i.e. aviation services and sector, the less likely an individual will be annoyed).

A change in the noise can be a driver of annoyance (ICAO 2016, enHealth 2004). However, the annoyance of the noise can also be attributed to a change in an individual's situation, such as changed hours of work or change in stress from other sources.

Another finding is that children are less annoyed by aircraft noise than adults (Stansfeld and Clark 2015). This may relate to the acoustic drivers of annoyance, such as interference with conversation, TV viewing and peace and quiet which may be more significant to adults. It is also likely to relate to the non-acoustic factors discussed previously.

The Perth Airport Master Plan 1999 reports a telephone survey of 300 residents, within a ten kilometre radius of Perth Airport, that was undertaken by Patterson Research Group to identify perceptions of noise. This survey identified that 71 per cent of respondents considered vehicle traffic as the main cause of annoyance, compared with 17 per cent that considered aircraft as the main cause of annoyance. For those survey respondents living within the Australian Noise Exposure Forecast (ANEF) contours (current at that time), 65 per cent identified aircraft as the main cause of annoyance, however only ten per cent of the respondents within the ANEF contours said that noise had a major effect on their family. The study noted that very small proportions of respondents were worried or concerned about aircraft noise.

During the period of December 2017 to February 2018, Patterson Research Group undertook a more detailed survey of community attitudes towards infrastructure development in and around Perth. More than 2,600 people within a 30-kilometre radius from Perth Airport were randomly selected to take part in a survey about noise in their neighbourhood and their level of annoyance towards the noise sources. The survey identified:

- in terms of the extent to which aircraft noise is an irritation, four per cent of all respondents reported aircraft noise as a major irritation, five per cent as quite irritating, 25 per cent as a minor irritation and 65 per cent as hardly noticed,
- the main sources of noise issues were attributed to road traffic, barking dogs, general anti-social behaviour, and particular neighbours. Aircraft noise was reported as an issue for nine per cent of respondents, with this proportion increasing with proximity to the airport – 12 per cent of respondents within ten kilometres of the airport reported aircraft noise as an issue, nine per cent within 10-20 kilometres, and six per cent for respondents within 20-30 kilometres of the airport,
- when considering different time periods and whether aircraft noise was noticeable and an issue, the time periods that caused the most irritation were 11.00 pm to 3.00 am (5.3 per cent of all respondents), 7.00 pm to 11.00 pm (4.8 per cent), 6.00 am to 8.00 am (4.5 per cent), and 3.00 am to 6.00 am (3.7 per cent), and
- for respondents that indicated aircraft noise was a major issue or something of an issue, the main ways in which noise affected them was disturbed sleep, disruption to activities, and annoyance/irritation. The volume of noise events, as well as changes to the frequency and timing of flights, were noted as specific causes of annoyance/irritation. A few respondents also reported anxiety/stress from low flying planes.

The potential impact of the new runway operations on annoyance has been assessed as minor adverse.

24.6.6 Emissions

There is substantial literature on the health effects of emissions from road and air traffic that identifies various pollutants from the burning of fuels as responsible for adverse health effects. In 2013, the WHO undertook a major review of evidence on health aspects of air pollution and confirmed the significance of air pollution as a risk to health.

The health consequences associated with air pollution include stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma (WHO 2013), with particulate matter being the major culprit. One study identified an impact on both increased mortality and increased hospital admissions (Hanninen et al 2014). Both the WHO and the US Environmental Protection Agency have also reported on studies linking long-term exposures to a range of other adverse health outcomes such as atherosclerosis, childhood respiratory disease and adverse birth outcomes (Denison 2016).

Airport related activities that contribute to air emissions include ground service equipment used to service aircraft, auxiliary power units used to power parked aircraft, stationary aircraft engines, road traffic, energy generation (cogeneration), fuel storage, and flight operations. The assessment of emissions as a result of the NRP are detailed in Section 14 (ground-based sources) and Section 23 (airborne operations).

Operation of the new runway will eventually result in a greater number of annual aircraft movements than what could operate at Perth Airport without the new runway. The increased aircraft capacity will result in small increases in pollution levels. However, increased efficiency in operations due to the parallel runway system will also have some impact in reducing emissions by reducing airborne delays for incoming aircraft, and ground running for aircraft queued for departure. This, in turn, will reduce engine run times (and emissions) from arriving aircraft and aircraft with engines running and awaiting departure.

The potential impact of emissions from new runway operations affecting health has been assessed as minor adverse. Nitrogen oxide emissions from newer aircraft are anticipated to reduce in the future as aircraft engine technologies improve, and it is likely that the impact of the new runway operations on ambient nitrogen oxide concentrations will reduce in years to come.

24.6.7 Auditory Health

There is consistent evidence to show that hearing impairment occurs only at prolonged exposure to high levels of noise well beyond the levels from aircraft over-flights.

Studies indicate that sustained noise exposure above at least 75 dBA is necessary for auditory damage to occur (Airports Commission 2013; Basner et al 2014). Aircraft noise is by nature intermittent - albeit in extreme situations it can be intermittent at relatively high levels - and for only short periods does it exceed 75 dBA. Noise induced hearing impairment is thus highly unlikely to result from community exposure to aircraft noise (WHO 2011) and the potential impact has been assessed as negligible.

24.6.8 Impact of the New Runway Project

The NRP will not, of itself, increase the total aircraft noise load over Perth in the short term. It will allow better management of the growth in air traffic that has already occurred at the airport, and improve efficiency, customer service and effectiveness of operations. There will come a stage at which the additional runway will allow a greater total volume of air traffic than the current runway system can accommodate, which is detailed in Section 2 and Section 3.

Studies that relate health effects to total aircraft noise loads (through the use of continuous equivalent noise levels) would suggest that, as a result of the parallel runway operations, the impact of a new runway would be to alter the distribution of the health impacts, rather than to deliver any net increase in these effects. Nevertheless, a better view of the literature is that the health impact of aircraft noise is a more complex equation than a direct relationship with total noise loads.

The significance of the patterns of air traffic, the importance of non-acoustic factors, and the variability in the dose/response relationships that drive evaluations of total noise load suggest that effective, noise sensitive management of air traffic can moderate the health consequences that flow from that traffic. There is potential to use the options created by an additional runway, and subsequent parallel runway system, to reduce the negative health outcomes from air traffic though the greater flexibility in design of air traffic routes and the management of air traffic on those routes.

It is also important to consider the interrelationships between the different health concerns to understand the potential for reducing the negative health outcomes from aircraft noise exposure. Given that annoyance can lead to stress, which can cause hypertension, which can in turn lead to heart disease, there are opportunities to alter the health outcomes for heart disease through better management of the non-acoustic factors that affect annoyance due to aircraft noise.

The evidence on the health impacts of aircraft noise is sometimes unclear and often contradictory, but there is evidence to show a range of health issues exist. This is applicable to the NRP even though many of the studies undertaken have considered noise levels significantly higher than will occur at Perth Airport. Importantly, the evidence not only points to the potential negative impact of increased noise but also the benefits of reduced noise. In the case of the NRP, there will be reductions in aircraft noise for some populations under existing air routes, and increased or new noise events for others.

24.7 Mitigation

24.7.1 Standard Mitigation

Strategies to minimise aircraft noise impact can assist in reducing the health impacts of aircraft noise. These strategies are detailed in Section 22 and include:

- appropriate land planning around airports through State and Local government policy and decision making to ensure that future noise-sensitive uses are not located in noise impacted areas,
- operational procedures that include noise abatement procedures,
- direct engagement with populations and community facilities under flight corridors,
- provision of clear and comprehensible information about the likely aircraft noise exposure, including published Number-above contours and the Interactive Aircraft Noise Information Portal,
- provision of clear information to assist those affected by the noise to undertake amelioration measures that can reduce noise penetration into homes, such as the 'Reducing noise in existing homes brochure',
- comprehensive Perth Airport Aircraft Noise Management Plan, and
- the Perth Airport Aircraft Noise Technical Working Group, which enables the aviation industry to initiate and evaluate operational changes while ensuring that the noise impact of those changes is considered and opportunities to improve noise outcomes are explored.

24.7.2 Additional Mitigation

Additional mitigation measures to be applied throughout the design of the airspace and operations of the new runway, include:

- careful route planning and incorporating existing arrival and departure routes into the airspace design wherever possible,
- improved use of new navigation technology,
- review of noise abatement procedures for NRP and parallel runway operations,
- provision of timely information, and
- direct engagement with newly impacted education facilities.

24.8 Summary of Impacts

Table 24-1 presents a summary of the impacts assessed as part of health assessment as well as standard and additional mitigation measures and associated risk rankings.

<table>
<tr><th rowspan="2">Impacting Process</th><th rowspan="2">Impact Detail</th><th rowspan="2">Project Phase</th><th colspan="4">Initial Assessment</th><th colspan="4">Residual Assessment</th></tr>
<tr><th>Standard Mitigation</th><th>Significance/ Consequence</th><th>Likelihood</th><th>Initial Risk</th><th>Additional Mitigation</th><th>Significance</th><th>Likelihood</th><th>Residual Risk</th></tr>
<tr><td rowspan="6">Aircraft noise exposure</td><td>Increased risk of mental health</td><td>Operation</td><td rowspan="6">Appropriate land use planning, State Planning Policy 5.1 and inclusion of new runway in Perth Airport ANEF since 1983
Published-Above noise contours
Aircraft Noise Management Framework
Published noise abatement procedures
Perth Airport Aircraft Noise Technical Working Group
Engagement with populations and community facilities under flight corridors
Interactive Aircraft Noise Information Portal
Reducing noise in existing homes brochure</td><td>Negligible</td><td>Highly Unlikely</td><td>Very Low</td><td rowspan="6">Careful route planning during final airspace design
Noise abatement procedures reviewed for NRP/ parallel runway operations
Improved use of new navigation technology
Provision of timely information
Engagement with newly impacted education facilities</td><td>Negligible</td><td>Highly Unlikely</td><td>Very Low</td></tr>
<tr><td>Cognitive and learning impairment</td><td>Operation</td><td>Minor Adverse</td><td>Possible</td><td>Low</td><td>Minor Adverse</td><td>Unlikely</td><td>Low</td></tr>
<tr><td>Increased risk of cardiovascular disease</td><td>Operation</td><td>Minor Adverse</td><td>Possible</td><td>Low</td><td>Minor Adverse</td><td>Unlikely</td><td>Low</td></tr>
<tr><td>Annoyance</td><td>Operation</td><td>Minor Adverse</td><td>Possible</td><td>Low</td><td>Minor Adverse</td><td>Unlikely</td><td>Low</td></tr>
<tr><td>Hearing impairment</td><td>Operation</td><td>Negligible</td><td>Highly Unlikely</td><td>Very Low</td><td>Negligible</td><td>Highly Unlikely</td><td>Very Low</td></tr>
<tr><td>Sleep disturbance</td><td>Operation</td><td>Moderate Adverse</td><td>Possible</td><td>Medium</td><td>Minor Adverse</td><td>Possible</td><td>Low</td></tr>
<tr><td>Emissions</td><td>Increased pollutants</td><td>Operation</td><td>Decreased airborne holding and associated fuel burn</td><td>Minor Adverse</td><td>Possible</td><td>Low</td><td>No additional mitigation measures identified</td><td>Minor Adverse</td><td>Possible</td><td>Low</td></tr>
</table>

Table 24-1 Summary of impacts, risks and mitigation measures
Source: Perth Airport, 2017

24.9 Conclusion

There have been many studies dating back decades on the health impacts of environmental noise and specifically aircraft noise exposure.

Most of these health impact studies have relied on research undertaken in environments very different from Perth Airport. Some have been premised on noise and traffic levels that far exceed those that are expected at Perth Airport in the foreseeable future. Others have relied on peak noise levels that will not be generated by the traffic using the new runway. However, the research does provide conclusions that can be applied more widely and considered for the NRP.

The key conclusions that can be drawn about the impact of the NRP are:

- the noise levels associated with the new runway are well below those in many of the major studies on health impacts of aviation,
- the key health issues are likely to be:
  - cognition in learning for schools overflown,
  - sleep disturbance, and
  - annoyance,
- depending on the usage of the new runway, the noise levels generated might be below key levels for identifiable cardiovascular health impacts, and
- the key health concerns are amenable to a range of measures to ameliorate their impact.

Some individuals will find impacts, in the form of sleep disturbance and annoyance, from the new runway as significant. Through careful and sensible long-term planning and engagement with affected populations and schools, these impacts are likely to be small, or restricted to relatively few people.

PerthAirport | New Runway Project

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