New generation aircraft like the A380 and Boeing 787 Dreamliner are facilitating aviation growth at Sydney Airport with improved noise and environmental outcomes for the community. The noise footprint of the Dreamliner is 60% smaller than similarly sized aircraft and it consumes 20% less fuel.

14.0 NOISE MANAGEMENT

14.0 NOISE MANAGEMENT

Key points

- For most of the world's major airports – including Sydney – aircraft noise has been a longstanding issue. Sydney Airport acknowledges noise impacts and is committed to working with the community, governments and the aviation industry to manage and mitigate them, especially in areas close to the airport and under flight paths
- Aircraft and engine manufacturers invest billions of dollars every year into research and development of new technologies to improve the noise performance of aircraft. As a result, the International Civil Aviation Organisation has said that aircraft coming off the production line today are about 75% quieter than they were 40 years ago. The aviation industry is working to reduce aircraft noise even more
- Domestic and international aircraft in Australian skies are some of the most modern in the world, and this investment benefits the community living around Sydney Airport. With new generation quieter, cleaner and more fuel efficient aircraft continuing to replace older noisier aircraft, noise impacts from individual flights to and from Sydney Airport will continue to improve during the planning period, helping to offset the increased frequency of aircraft movements
- The Long Term Operating Plan's noise sharing modes of runway operation can continue to be used throughout the planning period. This has been demonstrated by expert noise consultants on behalf of Sydney Airport in materials submitted to Airservices Australia to support the preparation of the Australian Noise Exposure Forecast (ANEF) 2033
- New flight procedures and technologies, which are already being used at Brisbane Airport, could be used at Sydney Airport to further mitigate aircraft noise impacts. For example, smart tracking and continuous descent approaches could be used to reduce noise in areas around the airport or under flight paths
- This Master Plan assumes there will be no change to operating restrictions like the curfew, movement cap or noise sharing arrangements and no new flight paths or runways. However, modernising some of these restrictions to recognise and take advantage of the benefits of new generation quieter aircraft could increase the potential for noise sharing and create more predictable periods of respite
- The increasing use of new generation, quieter aircraft means the forecast ANEF (noise) contours for 2033 cover an area significantly less than the area in 1976, despite the increase in air traffic over that period:
  - The area of land within the 25 ANEF contour has decreased by 1,150 hectares or 36% since 1976
  - Sydney Airport recognises that aircraft noise can be an issue of concern to people living in areas outside the ANEF contours and, as such, noise management needs to occur in affected areas close to and further away from the airport

Aircraft and engine manufacturers invest billions of dollars every year into research and development of new technologies to improve the noise performance of aircraft. As a result, the International Civil Aviation Organisation has said that the new generation quieter aircraft coming off the production line today are about 75% quieter than they were 40 years ago. As the aviation industry works to reduce aircraft noise even more, the aircraft of the future will be even quieter than they are today.

Sydney Airport acknowledges the impacts of aircraft noise and continues to work with the community, governments and the aviation industry to manage and mitigate them, especially in areas close to the airport and under flight paths.

As well as Sydney Airport itself, the International Civil Aviation Organisation (ICAO), the Australian, NSW and local governments, airlines, aircraft and engine manufacturers, and regulators all play important roles. Together, they work to balance the economic and social benefits our society derives from aviation and aviation safety with the need to minimise noise impacts.

This chapter includes the plans, actions and strategies Sydney Airport and other organisations use to mitigate the impacts of aircraft noise. For Sydney Airport, these include:

- Facilitating noise sharing
- Investing in airport infrastructure to support new generation quieter aircraft
- Working closely with the Australian, NSW and local governments
- Consulting and engaging with the local community
- Consulting with the airlines that use the airport

This Master Plan assumes there will be no change to operating restrictions like the curfew, movement cap or noise sharing arrangements and no new flight paths or runways. However, modernising some of these restrictions to recognise and take advantage of the benefits of new generation quieter aircraft could increase the potential for noise sharing and create more predictable periods of respite.

Table 14.1 Sound levels of common events

	dB(A)
Threshold of pain	140+
Pneumatic drill (unsilenced at 7m distance)	95
Heavy diesel lorry (40km/h at 7m distance)	83
Modern twin-engine jet (taking off at 152m distance)	81
B737-800 jet: arriving at Sydney Airport (flying over Leichhardt) B737-800 jet: departing from Sydney Airport (flying over Croydon) [2]	75.4 70.9
Passenger car (60km/h at 7m distance)	70
Office environment	60
Ordinary conversation	50
Library reading room	40
Quiet bedroom	35
Threshold of hearing	0

The Long Term Operating Plan's noise sharing modes of runway operation can continue to be used throughout the planning period, as demonstrated by expert noise consultants on behalf of Sydney Airport in materials submitted to Airservices Australia to support the preparation of Australian Noise Exposure Forecast (ANEF) 2033

Sydney Airport's past, present and future investment in on-airport infrastructure to accommodate larger, quieter aircraft will ensure residents living close to the airport and under flight paths continue to benefit from their use.

Noise from ground-based activities at Sydney Airport is managed separately to noise from in-flight aircraft operations. Engine ground running, which is an essential part of aircraft operations and maintenance, is regulated by a comprehensive set of operational rules designed to maintain safety, comply with relevant standards and practice, and minimise noise. This Master Plan also allows for an engine run facility, in which ground running would take place.

14.1 Background

Statutory requirements

The Airports Act requires a master plan to specify the following noise-related matters:

- An ANEF for the areas surrounding Sydney Airport
- Flight paths at Sydney Airport
- Sydney Airport's plans – developed following consultation with the airlines that use the airport and local government bodies in the vicinity of the airport – for managing aircraft noise intrusion in areas forecast to be subject to exposure above the significant ANEF levels (i.e. 30 ANEF levels)

Specifying only these matters does not adequately inform the public about the strategies being implemented by Sydney Airport, governments and others to manage and mitigate aircraft noise intrusion in areas around the airport and under flight paths. As well as addressing the minimum requirements of the Airports Act, this chapter provides additional information to ensure the community is fully informed about noise management issues.

Understanding noise

Environmental or community noise includes noise in urban areas generated by transport (road, rail and air), industry, construction activity and, more generally, across neighbourhoods.

Aircraft noise is an inevitable by-product of aviation activity. While the amount of noise generated by an aircraft varies according to its type, altitude and size, it generally comes from the engines (particularly when taking off and climbing) and air moving over the body of the aircraft (particularly when landing).

Sound is measured in units called decibels, represented on a logarithmic scale. This means that a 10-decibel increase is defined as a 10-fold increase in noise energy. **Table 14.1** illustrates the sound levels of a range of common events.[1]

The effects of aircraft noise on human health and well-being have been extensively studied in Australia and around the world. Relationships between exposure to excessive aircraft noise, annoyance and, in some cases, health impacts, have been documented.[3]

1 National Airports Safeguarding Framework (Guideline A)

2 The 737-800 is one of the most common jet aircraft at Sydney Airport. These noise levels are sourced from information published by Airservices Australia.

3 For example, see: enHealth Council, The Health Effects of Environmental Noise – Other Than Hearing Loss, Australian Environmental Health Council, Canberra (2004); and Night Noise Guidelines for Europe, World Health Organisation (2009).

Table 14.2 Roles and responsibilities for managing aircraft noise

Organisation	Summary of responsibilities concerning the management of aircraft noise
International Civil Aviation Organisation (ICAO) ICAO, a United Nations specialised agency, is the global forum for civil aviation.	• Aeroplanes and helicopters built today are required to meet the ICAO's strict aircraft noise standards • As an ICAO member state, Australia has adopted laws and regulations to reflect these international standards at Australia's airports
Australian Government: Department of Infrastructure and Regional Development (DIRD) DIRD advises the Minister for Infrastructure and Regional Development on the policy and regulatory framework for airports and the aviation industry and administers the Airports Act.	• Enforces Sydney Airport's aircraft movement cap and curfew and the granting of curfew dispensations • Administers the noise insulation program • Supports the Sydney Airport Community Forum
Australian Government: Airservices Australia Airservices Australia is responsible for managing aircraft movements at Sydney Airport.	• Provides air traffic control management and related airside services to the aviation industry • Prepares and publishes jet noise abatement procedures • Determines aircraft flight paths at Sydney Airport • Implements noise sharing at Sydney through the Long Term Operating Plan (the LTOP) • Publishes information on aircraft movements, runway and track usage and noise impacts using a range of noise descriptors • Handles aircraft noise complaints and inquiries (other than ground-based noise complaints which are handled by Sydney Airport Corporation Limited) • Operates noise monitoring equipment in suburbs around Sydney Airport and publishes results • Reviews and endorses for technical accuracy the draft ANEF developed by Sydney Airport
Australian Government: Aircraft Noise Ombudsman Conducts independent administrative reviews of Airservices Australia's management of aircraft noise-related activities.	• Reviews the handling of complaints or inquiries made to Airservices Australia about aircraft noise • Reviews community consultation processes related to aircraft noise • Reviews the presentation and distribution of aircraft noise-related information
Sydney Airport Corporation Limited This company is the airport lessee and the operator of Sydney Airport.	• Manages operations at the airport and ensures the effective delivery and coordination of airport-related services and facilities • Provides and maintains on-airport infrastructure to facilitate noise sharing • Provides and maintains infrastructure to support the use of quieter new generation aircraft • Publishes an ANEF, other noise descriptors, and plans to manage noise impacts • Ensures guidelines are in place to control noise generated by engine ground running • Engages with the SACF and broader community • Handles ground-based noise complaints at Sydney Airport
Airlines and aircraft operators In 2012, there were 39 airlines flying to Sydney Airport.	• Maintain aircraft fleets and engines that meet the required ICAO and Australian Government noise-related regulations • Implement noise-abatement principles for flight operations • Develop flight schedules
NSW Government and local councils The NSW Government and local councils regulate land use planning and development in the vicinity of Sydney Airport.	• The NSW Government has issued a ministerial direction to local councils to guide land use planning and development decisions near Sydney Airport. The direction aims, in part, to ensure that development for residential purposes or human occupation, where appropriate, incorporates building features so that residents or building occupants are not adversely affected by aircraft noise
Sydney Airport Community Forum (SACF) The Australian Government established the SACF in 1996 as part of its commitment to addressing the noise impacts from Sydney Airport in consultation with affected residents.	• The role of the SACF is to act as a forum for providing advice to the Minister for Infrastructure and Regional Development, Sydney Airport and aviation authorities on the abatement of aircraft noise and related environmental issues at Sydney Airport; in particular it is the main body for consultation on the LTOP

For this reason, Sydney Airport is committed to working with the community, governments and the aviation industry to manage and mitigate noise impacts, especially in areas close to the airport and under flight paths.

Who's responsible for managing aircraft noise?

As **Table 14.2** shows, managing noise impacts at Sydney Airport is shared by many organisations. As well as Sydney Airport itself, ICAO, the Australian, NSW and local governments, airlines, aircraft and engine manufacturers, and regulators all play important roles. Together, they work to balance the economic and social benefits our society derives from aviation and aviation safety with the need to minimise noise impacts.

Ground-based noise complaints are handled by Sydney Airport and noise complaints relating to aircraft in flight are handled by Airservices Australia.

14.2 Plans, actions and strategies for managing aircraft noise

For most of the world's major airports – including Sydney – aircraft noise has been a longstanding issue.

As with these other airports, Sydney Airport and the people who live around it and under flight paths have benefitted from the use of new generation quieter aircraft. The International Civil Aviation Organisation has said that the new generation quieter aircraft coming off the production line today are about 75% quieter than they were 40 years ago. As the aviation industry is working to reduce aircraft noise even more, the aircraft of the future will be even quieter than they are today.

While the Airports Act requires only Sydney Airport's plans for managing aircraft noise intrusion in areas forecast to be subject to exposure above the ANEF 30 contour levels to be specified, experience shows that noise does not stop at this or any other contour. Sydney Airport recognises that aircraft noise can be an issue of concern to people living in areas outside the ANEF contours and, as such, noise management needs to occur in affected areas close to and further away from the airport.

The following plans, actions and strategies for managing aircraft noise intrusion therefore apply to all areas – including those within the ANEF 30 contour – and are undertaken by:

- Sydney Airport (Section 14.2.1); or
- Governments, the broader aviation industry and others (see Section 14.2.2)

14.2.1 Plans, actions and strategies undertaken by Sydney Airport

Sydney Airport is committed to working with the organisations shown in **Table 14.2** to effectively manage and mitigate the impacts of aircraft noise, especially in the vicinity of the airport or under flight paths, where these impacts can be greater than in other parts of Sydney.

Facilitating noise sharing

Sydney Airport supports noise sharing, which Airservices Australia achieves by implementing the Long Term Operating Plan (LTOP)[4] for Sydney Airport. This Master Plan has been developed on the basis that the LTOP will remain in force during the planning period. To facilitate noise sharing, Sydney Airport will continue to provide and maintain the necessary on-airport infrastructure during the planning period.

The LTOP has been implemented by Airservices Australia since 1998 and was developed following extensive consultation. It describes 10 ways in which Sydney Airport's runways are used, each of which results in a different combination of flight paths affecting different parts of Sydney. These runway modes of operation (or modes) are shown in **Figure 14.1**. The LTOP takes advantage of Sydney Airport's coastal location and is implemented in a way that maximises the number of flights that occur over water.

The noise sharing modes are Modes 5, 7 and 14a. It should be noted, however, that the use of Modes 9, 12 and 13 and Sodprops can also, to varying degrees, produce noise sharing outcomes.

In 2009, Sydney Airport demonstrated its support for the LTOP by investing close to $100 million to enlarge runway end safety areas on the east-west runway. With this investment, all requirements set by the Civil Aviation Safety Authority (CASA) were fulfilled.

When deciding which mode to use and when, Airservices Australia must ensure that, subject to safety and weather conditions:

- As many flights as practical come and go using flight paths over water (i.e. Botany Bay) or non-residential areas
- The rest of the air traffic is shared over surrounding communities as fairly as possible
- Runway noise sharing modes change throughout the day so individual areas have some respite from aircraft noise on most days

The LTOP aims to achieve the following runway end movement targets:

- 55% of flights to the south of the airport (over water)
- 17% of flights to the north of the airport
- 15% of flights to the west of the airport
- 13% of flights to the east of the airport

Airservices Australia compares the actual outcomes against these targets and publishes on its website the results in monthly Sydney Airport Operational Statistics.

4 A summary of the LTOP can be found at: http://sacf.infrastructure.gov.au/LTOP/files/LTOP_general_information_fact_sheet.pdf

Figure 14.1 Runway modes of operation

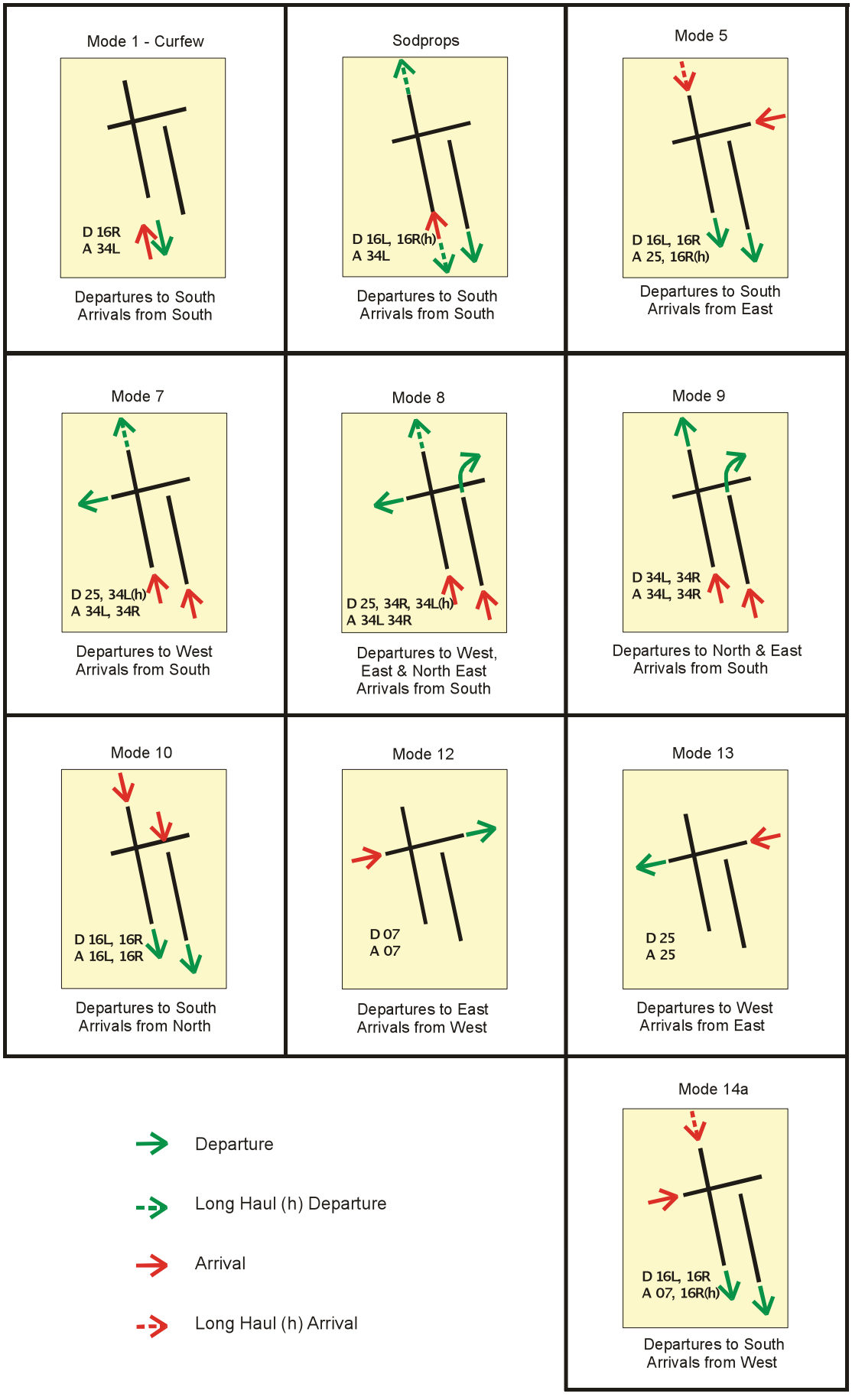


Table 14.3 Runway end impacts since 1998 compared to 2033 forecast

Year	North	South (over water)	East	West
1998 (target)	17.0%	55.0%	13.0%	15.0%
1998 (actual)	28.4%	51.8%	11.4%	8.4%
2002 (actual)	27.1%	49.4%	14.0%	9.5%
2004 (actual)	28.3%	50.0%	12.8%	8.9%
2006 (actual)	28.3%	50.3%	13.8%	7.6%
2008 (actual)	31.1%	51.0%	14.2%	3.8%
2012 (most recent full year available)	31.2%	51.8%	14.5%	2.5%
2029 (as forecast in 2009 Master Plan)	32.6%	50.6%	12.8%	5.9%
2033 (as forecast in this Master Plan)*	32.7%	49.2%	13.8%	4.3%

*The runway end impact percentages here are calculated using the same methodology used by Airservices Australia in its published monthly Sydney Airport Operational Statistics.

When these targets were originally set, the Australian Government indicated they were "… necessarily based on computer modelling of runway capacities and an analysis of historical meteorological information. The capacities of the new [LTOP] arrangements have yet to be proven in practice." Subsequent experience has proved that, while the targets are generally met in areas to the east and south of the airport, they are not in areas to the north or west of the airport.

A significant amount of work has been undertaken to understand the reasons why the LTOP runway end movement targets have not been met in areas to the north and west of the airport. Reasons are weather and demand-related. Most recently, in response to a recommendation from the Aircraft Noise Ombudsman, Airservices Australia published a fact sheet which addresses this issue in detail.[5]

A 2005 independent analysis of LTOP performance by Airways International (prepared for the Sydney Airport Community Forum) found that the implementation has been 'reasonable considering the complexity of LTOP in all its aspects'.

Table 14.3 shows the extent to which targets have been achieved historically and predictions for the future.

The Australian Government's direction to Airservices Australia to implement the LTOP states that the modes of operation should be changed throughout each day, when traffic and weather conditions permit, to provide respite from noise affecting residents in different areas. While noise sharing modes will still be used throughout the planning period, the growth in air travel means they will be used less often than occurs today.

The noise sharing modes can continue to be used throughout the planning period. This has been demonstrated by expert noise consultants on behalf of Sydney Airport in materials submitted to Airservices Australia to support preparation of the ANEF 2033. For example, the estimated times of the day during which noise sharing modes would be available in 2033 on the projected representative busy day (subject to weather) are shown in **Table 14.4**.

Table 14.4 Estimated times during which noise sharing would be available in 2033

Runway mode of operation	Time periods
Runway mode of operation	Time periods
Mode 5	2:30pm – 4:00pm
	9:00pm – 11:00pm
Mode 7	6:00am – 6:45am
	2:00pm – 3:00pm
	8:00pm – 9:00pm
	10:15pm – 11:00pm
Mode 14a	2:30pm – 4:00pm
	9:00pm – 11:00pm

On days that are less busy than the representative busy day, it would be expected that the times during which noise sharing modes could be used throughout the planning period would be greater than shown here.

Consistent with the LTOP, and as shown in **Table 14.3**, approximately half of all aircraft movements are forecast, throughout the planning period, to continue to occur over water (i.e. Botany Bay).

Sydney Airport supports the periodic review of mode selection rules used by Airservices Australia air traffic control to ensure that any increases in the use of noise sharing modes made possible by advances in technology are achieved (subject to the overriding need to maintain safety).

5 Airservices Australia, http://www.airservicesaustralia.com/aircraftnoise/airport-information/sydney

The independent steering committee which oversaw the preparation of the *Joint Study on Aviation Capacity in the Sydney Region* (2012) recommended to the Australian Government that the LTOP be reviewed with the aim of determining new, more effective measures of aircraft noise impacts and respite than the current runway end movement targets.

Sydney Airport, as a member of Sydney Airport Community Forum (SACF) and the LTOP Implementation and Monitoring Committee, will continue to support the sharing of aircraft noise in areas around Sydney Airport as equitably as possible.

Investing to support new generation quieter aircraft

Sydney Airport welcomes the introduction of the new generation of quieter aircraft like the Airbus A380, Boeing B777, B787 Dreamliner and B747-8F. It is expected that other new generation quieter aircraft like the A350XWB, B737 MAX and A320neo will be introduced within the planning period of this Master Plan.

Sydney Airport's past, present and future investment in infrastructure to accommodate these new generation aircraft is designed to ensure residents living close to the airport or under flight paths will continue to benefit from their introduction. For example, to accommodate the A380, which is both larger and much quieter than the older aircraft type it is replacing, Sydney Airport has invested significantly to upgrade infrastructure. To date, projects that have been, or are being, planned or implemented to facilitate new generation quieter aircraft include:

Airfield works:

- Widening pavement shoulders, fillets and flanks for various runways and taxiways
- Strengthening the airport tunnel over General Holmes Drive
- Relocating Taxiway G east of Taxiway D to accommodate the clearances necessary for the A380's larger wingspan. Work included demolishing two existing hangars and relocating the airport perimeter road
- Relocating airfield navigational and visual aid equipment including taxiway lighting and signage and the installation of new inset taxiway lights
- Providing additional apron capacity in the South West and South East Sectors for A380s
- Planning for new aircraft maintenance and engineering facilities, including new hangars, to accommodate new generation aircraft like the A380

Terminal works:

- Providing new contact and non-contact bays in T1 suitable for the larger A380 aircraft
- Relocating fuel points and fuel lines in the Terminal 1 (T1) precinct as necessary
- Installing new flood lighting, strengthening apron pavements in the T1 precinct to take the heavier aircraft, new pavement markings, new nose-in guidance systems and signage
- Reconfiguring adjacent bays at T1 impacted by the new larger aircraft
- Expanding Pier A at T2 to provide additional capacity for Virgin Australia's fleet of new generation A330-200 aircraft

This Master Plan indicates that other essential infrastructure upgrades to accommodate additional quieter new generation aircraft are planned to occur during the planning period. These include:

- Upgrades to taxiways and other airfield infrastructure to accommodate growth in A380 movements, as well as other new generation quieter aircraft like the B787, B777 and A350XWB
- New gates, aerobridges and other essential terminal infrastructure to be provided in the Terminal 2/ Terminal 3 (T2/T3) precinct to accommodate use by new generation quieter aircraft such as the A380 and B787
- Additional apron parking capacity for A380 aircraft
- Additional rapid exit and other taxiways to further minimise delays and facilitate use of runways more efficiently

Working closely with the NSW Government and local government

The most effective way to manage aircraft noise intrusion in areas forecast to be subject to exposure above the 30 (or any other) ANEF contour is to implement effective and appropriate land use and planning controls and acoustic standards for these areas.

Sydney Airport helps to achieve this outcome by preparing the ANEF, a process that involves engagement with the NSW and local governments (see Section 14.4). The ANEF, which is designed to create a land use planning tool to manage noise sensitive land uses around the airport, provides guidance for the NSW Department of Planning and Infrastructure (NSWDPI) and councils to make informed planning and development decisions. The system underpins Australian Standard AS2021-2000 Acoustics – Aircraft Noise Intrusion – Building Siting And Construction.[6] The standard defines areas where construction of certain building types is "acceptable", "conditionally acceptable" and "unacceptable".

Table 14.5 shows the land use planning criteria applied within Australia and building site acceptability based on ANEF zones.

6 AS2021-2000 is currently being reviewed

Table 14.5 Building site acceptability based on ANEF zones

Building type	ANEF zone site		
	Acceptable	Conditional	Unacceptable
House, home unit, flat, caravan park	Less than 20 ANEF (Note 1)	20 to 25 ANEF (Note 2)	Greater than 25 ANEF
Hotel, motel, hostel	Less than 25 ANEF	25 to 30 ANEF	Greater than 30 ANEF
Hostel, school, university	Less than 20 ANEF (Note 1)	20 to 25 ANEF (Note 2)	Greater than 25 ANEF
Hospital, nursing home	Less than 20 ANEF (Note 1)	20 to 25 ANEF	Greater than 25 ANEF
Public building	Less than 20 ANEF (Note 1)	20 to 30 ANEF	Greater than 30 ANEF
Commercial building	Less than 25 ANEF	25 to 35 ANEF	Greater than 35 ANEF
Light industrial	Less than 30 ANEF	30 to 40 ANEF	Greater than 40 ANEF
Other industrial	Acceptable in all ANEF zones		

NOTES:

1. The actual location of the 20 ANEF contour is difficult to define accurately, mainly because of variation in aircraft flight paths. Because of this, the procedure of Clause 2.3.2 of AS2021-2000 may be followed for building sites outside but near to the 20 ANEF.
2. Within 20 ANEF to 25 ANEF, some people may find that the land is not compatible with residential or educational uses. Land use authorities may consider that the incorporation of noise control features in the construction of residences or schools is appropriate.
3. There will be cases where a building of a particular type will contain spaces used for activities which would generally be found in a different type of building (e.g. an office in an industrial building). In these cases Table 2.1 of AS 2021-2000 should be used to determine site acceptability but internal design noise levels within the specific spaces should be determined by Table 3.3 of AS2021-2000.
4. This standard does not recommend development in unacceptable areas. However, where the relevant planning authority determines that any development may be necessary within existing built-up areas designated as unacceptable, it is recommended that such development should achieve the required ANR determined according to Clause 3.2 of AS2021-2000. For residences, schools, etc, the effect of aircraft noise on outdoor areas associated with the buildings should be considered.
5. In no case should new development take place in greenfield sites deemed unacceptable because such development may impact airport operations.

Source: AS2021-2000.

Sydney Airport will continue to advocate to the NSWDPI and councils in the vicinity of Sydney Airport that relevant environmental planning instruments incorporate provisions that are consistent with AS2021-2000.

At the end of May 2013, Standards Australia announced it would proceed with a review of AS2021-2000. The approved scope of the review consists of updating aircraft fleet details, reviewing the applicability of the standard to small airports and explaining the procedures to develop an ANEF.

Sydney Airport will also monitor and provide feedback on development or rezoning proposals in other areas that are affected by inappropriate levels of aircraft noise. In one development example, Sydney Airport successfully advocated that a noise disclosure clause be included in NSW planning certificates issued under Section 149 of the Environmental Planning and Assessment Act 1979 so prospective purchasers are made aware of likely noise impacts.

Consulting and engaging with the local community and airlines which use the airport

Sydney Airport engages directly with the SACF, the broader community, airlines which use the airport, and other stakeholders about relevant airport-related matters – including noise management issues – and will continue to do so during the planning period. Chapter 1 outlines the various consultation and engagement activities that are undertaken by Sydney Airport when preparing master plans, major development plans or when other development proposals are being considered.

As outlined in Chapter 13, this Master Plan includes a proposal to establish an experience centre at Sydney Airport. The centre is planned to provide the local community and visitors alike with a wealth of information about Sydney Airport's history, environmental initiatives, aircraft noise and flight path information as well as existing and planned future airport operations.

14.2.2 Plans, actions and strategies undertaken by others

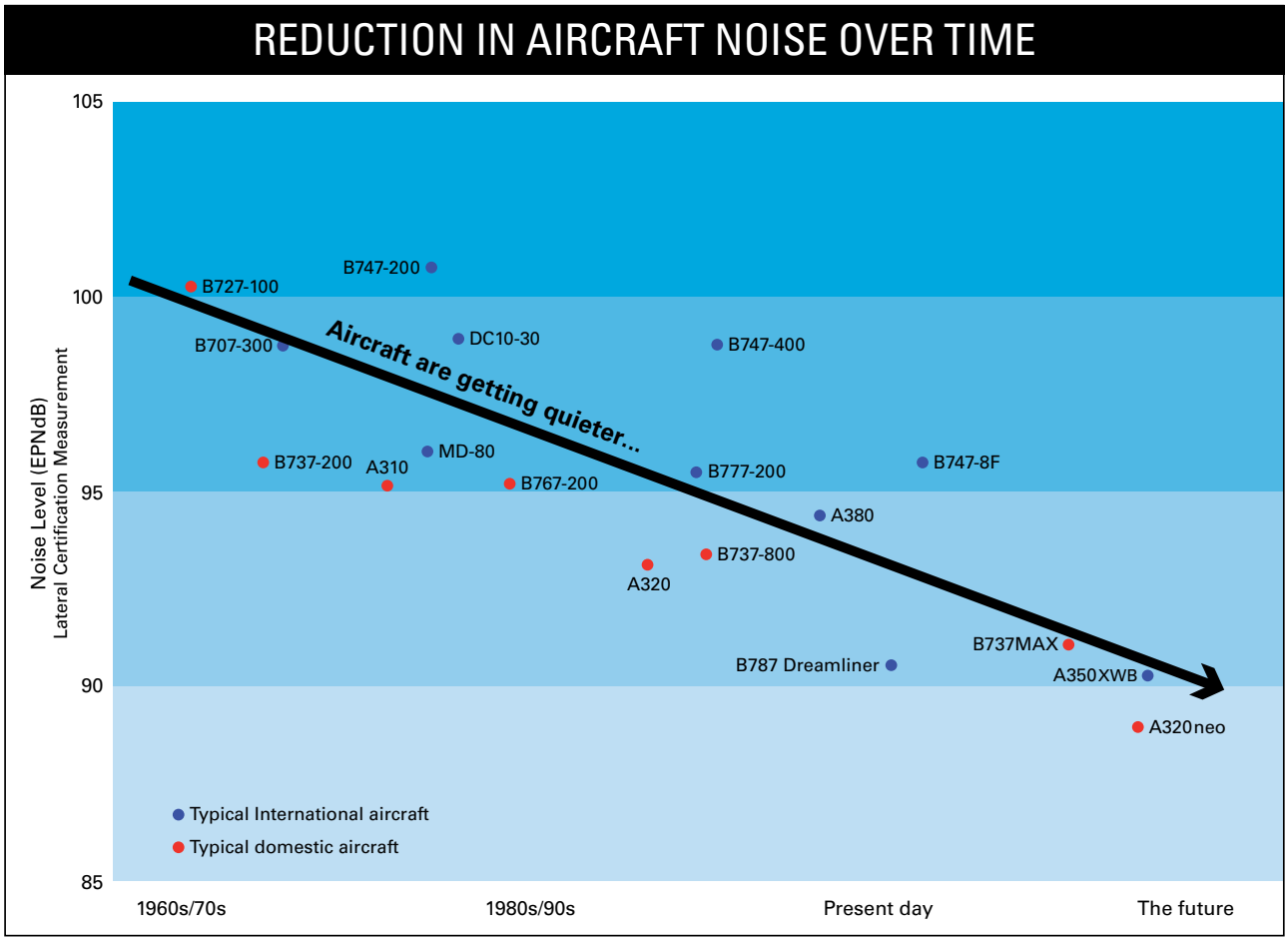
As already noted, many organisations other than Sydney Airport have responsibility for managing aircraft noise intrusion in areas forecast to be subject to exposure above the 30 or any other ANEF level. This section describes what these organisations are doing.

Aircraft are getting quieter

Aircraft and engine manufacturers invest billions of dollars every year into research and development of new technologies to improve the noise performance of aircraft.

Domestic and international aircraft in Australian skies are some of the most modern in the world so this investment benefits the community living around Sydney Airport. With new generation quieter, cleaner and more fuel efficient aircraft continuing to replace

Figure 14.2 Reduction in aircraft noise over time



Source: ICAO and FAA

older noisier aircraft, noise impacts from individual flights to and from Sydney Airport will continue to improve during the planning period, helping to offset the increased frequency of aircraft movements.

In the years following 1958, when Sydney Airport's curfew was introduced, the most common jet aircraft were the noisy and polluting B707 and B727. Improved technology means today's aircraft are significantly quieter than these older models (see **Figure 14.2**). In fact, ICAO said in 2012 that aircraft coming off the production line today are about 75% quieter than they were 40 years ago. The aviation industry is working to reduce this even more.

ICAO has developed standards relating to aircraft noise. As Australia is a member of ICAO, airports in Australia and the aircraft permitted to operate at those airports are affected by these standards, which are reflected in Australian Government laws such as the Air Navigation (Aircraft Noise) Regulations 1984. Over time, these regulations have become stricter as technology (relating to jet engine, airframe and navigation technologies) has improved.

Only aircraft meeting stringent noise requirements (known as Chapter 3 aircraft) are permitted to operate at Sydney Airport. The last 'marginally compliant' Chapter 3 aircraft to operate at Sydney stopped flying in 2010. In 2001, ICAO adopted a more stringent 'Chapter 4' noise standard. In the 2009 National Aviation Policy White Paper, the Australian Government indicated its strong belief that the time has come for industry to move away from the use of aircraft which fail to meet Chapter 4 noise standards.

In February 2013, ICAO's Committee on Aviation Environmental Protection (CAEP) reached agreement on a new noise standard. The agreed noise standard will be 7dB(A) below the existing Chapter 4 standard. This new and more stringent noise standard will be presented for final review and approval by the ICAO Council later in 2013. If approved, it will be applicable to new-design aircraft entering into service from 2017 and, from 2020, for the lower weight aircraft.

Table 14.6 Noise monitoring results around Sydney Airport

Location of NMT	Aircraft type	Arriving or departing	Average LA max [dB(A)]	Reduction in decibels	Reduction in noise energy
Sydenham	A380	Departing	87.7	- 4.4	- 64%
	B747-400	Departing	92.1		
	A380	Arriving	93.9	- 2.6	- 45%
	B747-400	Arriving	96.5		
Leichhardt	A380	Departing	81.7	- 3.9	- 59%
	B747-400	Departing	85.6		
	A380	Arriving	84.4	- 2.1	- 38%
	B747-400	Arriving	86.5		
Annandale	A380	Departing	71.5	- 5.5	- 72%
	B747-400	Departing	77.0		
St Peters	A380	Departing	73.6	- 6.7	- 79%
	B747-400	Departing	80.3		
Croydon	A380	Departing	76.7	- 2.3	- 41%
	B747-400	Departing	79.0		

Source: Airservices Australia

New generation Airbus aircraft: A380, A350 XWB and A320neo

In 2008, Airservices Australia released a report showing that an Airbus A380 departing from or arriving at Sydney Airport is between 2.1 and 6.7 decibels quieter than the 747-400, the older aircraft type it typically replaces.

Airservices Australia indicates in its report that "a three decibel reduction is regarded as a halving of an aircraft's noise energy."

Table 14.6 provides results that were measured at noise monitoring terminals (NMTs) located around Sydney Airport. This shows that the A380's smaller noise footprint on take-off and landing reduces the impact of aircraft noise on airport neighbourhoods.

In August 2011, Qantas announced it would acquire up to 78 A320 neo aircraft. Airbus indicates that compared to the A320s flying today, these new generation aircraft are significantly quieter, at 15dB(A) below ICAO's strict Chapter 4 noise standard.

Emirates has on order 70 of the new generation quieter A350 aircraft, which Airbus has said emits noise levels significantly below ICAO Chapter 4 requirements.

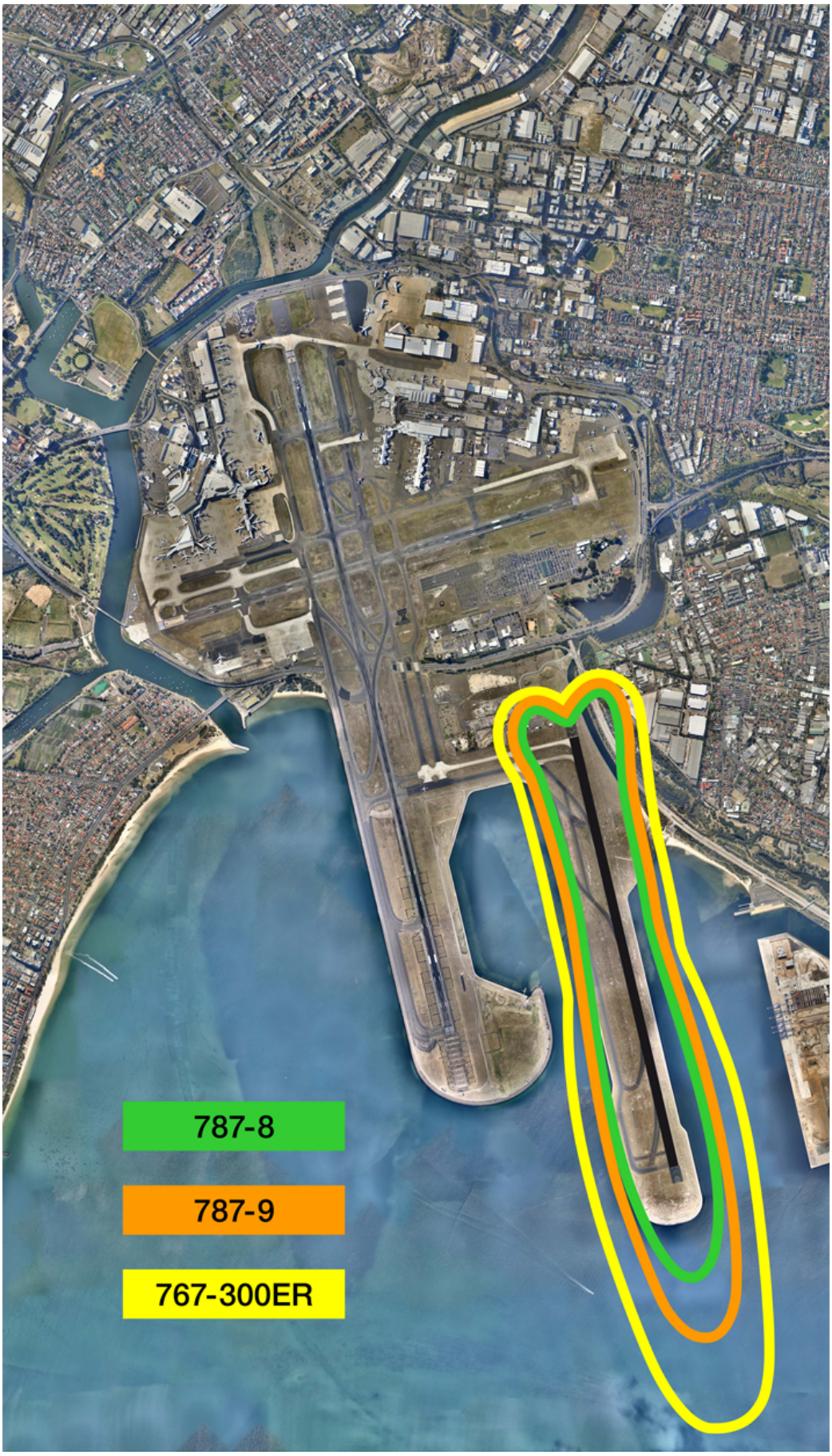
New generation Boeing aircraft: B737 MAX, B787 Dreamliner and B747-8F

In July 2012, Virgin Australia announced an agreement with Boeing to order 23 of its new generation 737 MAX aircraft, the first airline in Australia to do so. Boeing has said that the noise footprint of this aircraft is 40% smaller than today's B737s.

The B787 Dreamliner began flying to Sydney in August 2013. Qantas has selected the B787 Dreamliner as the cornerstone of its domestic and international fleet renewal program. Under the fleet plan, the Qantas Group has orders for 15 Boeing 787 aircraft, with the first aircraft having arrived in the second half of 2013. Qantas has options and purchase rights for a further 50, available for delivery from 2016. Powered by General Electric's GEnx engines, Qantas indicates that it has a 50% smaller noise footprint. The B787 will, over time, replace older aircraft like the B767-300. A comparison of the noise footprints of the B787 is shown in **Figure 14.3**.

Cathay Pacific already flies the new generation B747-8F freighter to Sydney and has said that its noise footprint is 30% smaller than the older freight aircraft type it replaced.

Figure 14.3 Comparing the noise footprint of the B787 Dreamliner and the B767



Jet noise abatement

Jet noise abatement procedures enable noise during aircraft operations in the vicinity of an airport to be minimised. ICAO has identified several methods, including preferential runways and routes, and low noise procedures to be used by pilots during take-off, approach and landing. Airservices Australia has published jet noise abatement procedures to minimise noise impacts in areas around Sydney Airport or under flight paths.[7]

Aircraft noise insulation program

The aircraft noise insulation program provided a mechanism to insulate homes and public buildings (such as schools, pre-schools, churches and health care facilities) and purchase the most seriously affected properties. The program was administered by the Australian Government with funds raised from a levy applied to passenger tickets for jet aircraft operating at Sydney Airport. All eligible properties under the program have now been insulated. This involved insulating 4,083 homes and 99 public buildings. In addition, 147 residences were voluntarily acquired and the land turned into a park.

The Australian Government has indicated that it will continue to monitor the noise contours in Sydney for any changes.

Operations allowed during the curfew period

The Australian Government's rules for the operation of the curfew are in the Commonwealth's Sydney Airport Curfew Act 1995 and Sydney Airport Curfew Regulations 1995.

The curfew operates from 11pm until 6am. To mitigate noise impacts during this period, take-offs and landings at the airport are restricted to specific types of aircraft and operations. The principal categories of permitted operations are as follows:

- Small (less than 34,000kg) noise certificated propeller driven aircraft and low noise jets – mostly business and small freight jets (these are specified on a list which has been approved by the Minister) – are allowed to operate without a quota on the number of their movements
- Australian air Express, National Jet Systems and Toll Transport have specific approval to operate a limited number of freight movements per week in medium size freight aircraft

The Curfew Act and Regulations provide for international passenger aircraft movements between 11pm and midnight and between 5am and 6am (known as the curfew shoulder periods) subject to jet aircraft meeting the strictest ICAO noise standards (Chapter 3):

- While the Curfew Act would permit up to 35 aircraft movements per week (and no more than 7 on any one day), the Curfew Regulations prescribe lower limits, being no more than 24 movements per week (and no more than 5 on any one day) between 5am and 6am, which may only be landings
- While the Curfew Act would permit up to 14 aircraft movements per week (and no more than 4 on any one day), the Curfew Regulations prescribe zero movements between 11pm and midnight

During the curfew, aircraft must operate over Botany Bay, that is take-offs to the south and landings to the north:

- On Saturdays and Sundays aircraft must also operate over Botany Bay in the hour before and after the curfew, provided the weather and traffic conditions allow this to take place safely
- Aircraft are not permitted to take off over the suburbs after 10.45pm

The curfew restrictions do not apply in cases of emergency.

In exceptional circumstances, the minister may grant dispensations for aircraft to operate when they would not otherwise be allowed to do so. These must be issued in accordance with guidelines which define what exceptional circumstances are. When a dispensation is granted, a report giving the reasons for the dispensation must be tabled in both houses of the Australian Parliament. The Curfew Act provides for fines up to $550,000 for a body corporate whose aircraft breaches the curfew.

New flight procedures could further mitigate noise impacts

New flight procedures, which are being used by Airservices Australia at Brisbane Airport, could be considered for use at Sydney Airport to help to further mitigate the impacts of aircraft noise. Subject to Australian Government approval, the following text boxes describe examples of what could occur during the planning period.[8]

Aircraft manufacturer Airbus also recently unveiled its 2050 vision for Smarter Skies, which looks beyond aircraft design to how the aircraft is operated both on the ground and in the air in order to meet the expected growth in air travel in a sustainable way and in a way that reduces aircraft noise impacts.[9]

7 See http://www.airservicesaustralia.com/aip/current/dap/AeroProcChartsTOC.htm (accessed March 2013)

8 Information sourced from Brisbane Airport's and Airservices Australia's websites

9 More information can be found at http://www.airbus.com/innovation/future-by-airbus/smarter-skies/ (accessed March 2013)

Continuous descent approach

To land at an airport, traditional landing procedures involve an aircraft descending in successive steps from cruising altitudes to the runway. In a continuous descent approach (or CDA), the aircraft flies from cruise altitude all the way down to the runway in one smooth and uninterrupted descent. Under ideal circumstances, a plane can practically glide into the airport with engines idling, though its use during busier periods is limited.

Brisbane Airport claims that research shows CDA can cut noise during landing by about 4dB(A) to 6dB(A), reducing the noise energy by approximately 60–75%.

Smart tracking

A growing number of modern aircraft are fitted with navigation systems that use satellite-assisted guidance. These systems allow aircraft to use GPS information to fly with a high degree of accuracy. This technology is known as required navigation performance – meaning the aircraft can perform in accordance with a strict set of navigation parameters.

Airservices Australia refers to these routes as smart tracking. Several features of smart tracking allow for better noise management in communities around airports. For example, in certain circumstances, smart tracking flight paths can be designed to curve around obstacles (high terrain or buildings), follow existing noise corridors (highways) or to avoid noise sensitive areas in favour of overflying industrial land or other non-residential areas. This technology has already been successfully implemented at some of the busiest and most geographically challenging airports in the world.

The independent steering committee which prepared the joint study recommended that plans for the implementation of advanced technologies and air traffic management practices – including satellite based systems at Sydney Airport – should be accelerated. Sydney Airport agrees that, as noted in the joint study, new performance based navigation (PBN) technologies offer advantages over sensor-based navigation, including reduced environmental impact through more efficient use of airspace route placement, fuel efficiency and noise abatement.

14.3 Aircraft flight paths

The Airports Act requires this Master Plan to specify flight paths at Sydney Airport. The flight paths used by aircraft arriving at or departing from Sydney Airport are determined by the Australian Government.[10]

This Master Plan assumes that the existing flight paths will remain throughout the planning period. **Figures 14.4** and **14.5** show these flight paths used by jet and non-jet aircraft respectively. The flight paths shown are those used by aircraft in the very early stages of flight (immediately after take-off) or in the very late stages of flight (immediately before landing). Flight paths used by aircraft at other stages of flight – which affect areas further away from Sydney Airport – are regularly published by Airservices Australia on its website.

14.4 Measuring, mapping and communicating about aircraft noise

The Australian noise exposure forecast (ANEF) system was developed through an extensive socio-acoustic survey carried out in the vicinity of a number of Australian airports – including Sydney – in the 1980s. The ANEF chart is a computer developed aircraft noise forecast and is based on:

- Operating schedules for aircraft, including the forecast numbers, types and times that these aircraft would be operating in future years
- The selection of runway operating modes, as influenced by forecast meteorological conditions and relevant air traffic management rules and procedures (in Sydney Airport's case, the LTOP)
- Aircraft flight paths
- Aircraft noise levels which are forecast to be produced by the various types of aircraft on arrival and departure.

This Master Plan includes two types of contour maps that are recognised under this system.[11]

As noted in Section 14.2, the ANEF is primarily designed to create a land use planning tool to manage noise sensitive land uses around airports.

ANEF 2033

As noted in Section 14.1, the Airports Act requires only one noise descriptor to be included in a master plan - the ANEF. The ANEF 2033 for Sydney Airport is shown in **Figure 14.6** and is based on the air traffic forecasts shown in Chapter 3. In accordance with the Airports Act and other requirements, Sydney Airport provided the NSW DPI and the 15 councils in the vicinity of Sydney Airport with an opportunity to comment on the draft ANEF 2033 and paid due regard to all issues raised. It was endorsed by Airservices Australia for technical accuracy on 3 December 2012 before being included in this Master Plan.

10 See Air Navigation (Aerodrome Flight Corridors) Regulations 1994.

11 Adapted from Discussion Paper: Expanding ways to Describe and Assess Aircraft Noise, Australian Government, 2000.

Figure 14.4 Flight paths at Sydney Airport (jet aircraft)

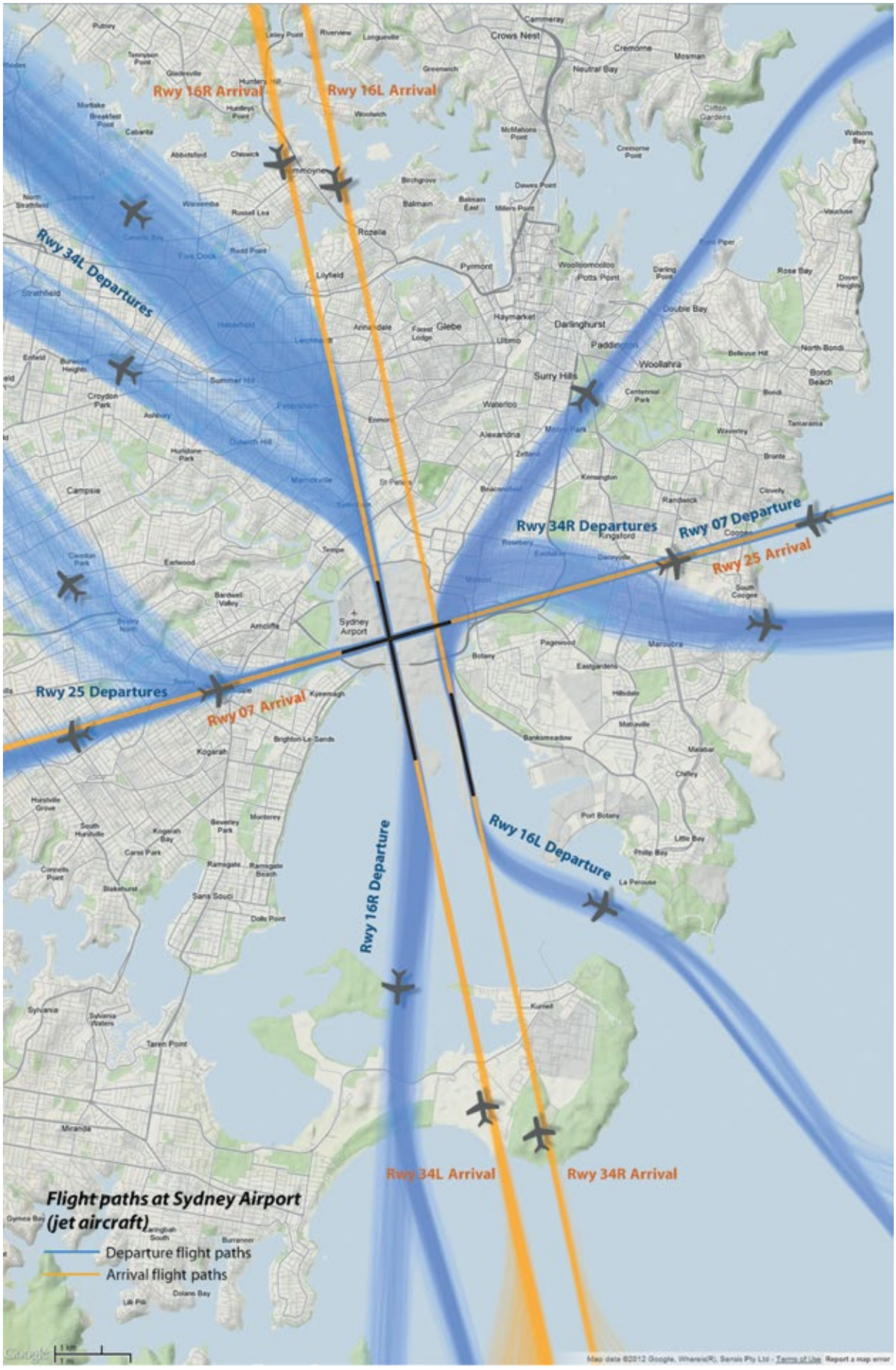


Figure 14.5 Flight paths at Sydney Airport (non-jet aircraft)

Table 14.7 Different contour maps

Australian Noise Exposure Forecast (ANEF)	These are the official forecasts of future noise exposure patterns around an airport and they constitute the contours on which land use planning authorities (i.e. local councils) base their controls.
Australian Noise Exposure Index (ANEI)	These are contours showing historic noise exposure patterns and are used in environmental reporting and benchmarking. Before 1980, this was known as the Noise Exposure Index (NEI)

Figure 14.7 compares the endorsed ANEF 2033 with the now superseded ANEF 2029 from the 2009 Master Plan. It can be seen that the area forecast to be affected by noise contours in 2033 relative to that forecast to be affected in 2029 has generally reduced and, in some local government areas to the north-west of the airport, significantly reduced. This is because:

- In this Master Plan, the forecast number of aircraft movements in 2033 is lower than was forecast for 2029 in the 2009 Master Plan
- The version of the integrated noise model (INM) used to prepare the ANEF 2033 allows quieter A380 aircraft to be modelled, whereas the earlier INM version used to prepare the ANEF 2029 did not

While the INM version allowed A380 aircraft to be modelled, it still didn't recognise other quieter aircraft types listed in Section 14.2.2. When Sydney Airport next prepares an ANEF, the most recent version of the INM will be used.

Comparison with present day

To compare the forecast noise contours with those of the present day, **Figure 14.8** shows a comparison of the ANEI 2011 with the ANEF 2033.

Comparison with 1976

To illustrate the extent to which the area affected by noise contours around Sydney Airport has reduced over many decades, **Figure 14.9** compares the NEI 1976, the ANEI 2011 and the ANEF 2033. It can be seen that the forecast ANEF 25 contour for 2033 covers an area significantly less than the area in 1976[12], despite the more than 10-fold increase in passengers over that period and the opening of Runway 16L/34R in 1994. The area of land within the ANEF 25 contour has decreased by 1,150 hectares or 36% since 1976.

Noise and flight path monitoring system

The management of flight paths and the monitoring of aircraft noise at Sydney Airport is undertaken by Airservices Australia.

Airservices Australia operates the noise and flight path monitoring system (NFPMS), which collects Sydney Airport-related noise and flight path data 24 hours a day, seven days a week. Noise is permanently monitored at 12 noise monitoring terminals (NMTs) located at Sydney Airport (runway 34L threshold), Kurnell, Coogee, Eastlakes, Penshurst, Bexley, Sydenham, St Peters, Annandale, Croydon, Leichhardt and Hunters Hill. There are also portable NMTs that can be used in temporary locations.

NMTs record:

- The identity, flight path and altitude of each aircraft operating to and from the airport
- The noise levels produced by individual aircraft
- Weather data
- General background noise

The information collected is used to:

- Determine the contribution of aircraft to overall noise exposure
- Detect occurrences of excessive noise levels from aircraft operations
- Assess the effects of operational and administrative procedures for noise control and compliance with these procedures
- Assist in planning of airspace usage
- Validate noise forecasts and forecasting techniques
- Assist relevant authorities in land use planning for developments in areas in the vicinity of an airport
- Generate reports and provide responses to questions from government, industry organisations, community groups and individuals

The monthly NFPMS reports can be found on the Airservices Australia website.[13]

WebTrak

Airservices Australia operates WebTrak, which provides the community with detailed information about aircraft noise and flight paths.

Using information from air traffic control secondary surveillance radars, WebTrak allows anyone to get information about where and how high aircraft fly over the Sydney metropolitan area. It displays a map of surrounding suburbs within 55km of Sydney Airport. Information can be viewed about arriving and departing aircraft, from three months earlier to just 40 minutes before real time. WebTrak can also:

- Locate a particular street address so it appears on the map
- Reveal noise levels of individual aircraft
- Provide information about the aircraft including aircraft type, height, origin and destination
- Display an aircraft's flight path and point of closest approach to a particular street address

12 The NEI 1976 was prepared as part of the Major Airport Needs of Sydney Study

13 http://www.airservicesaustralia.com/publications/reports-and-statistics/noise-reports/ (accessed March 2013)

Figure 14.6 ANEF 2033

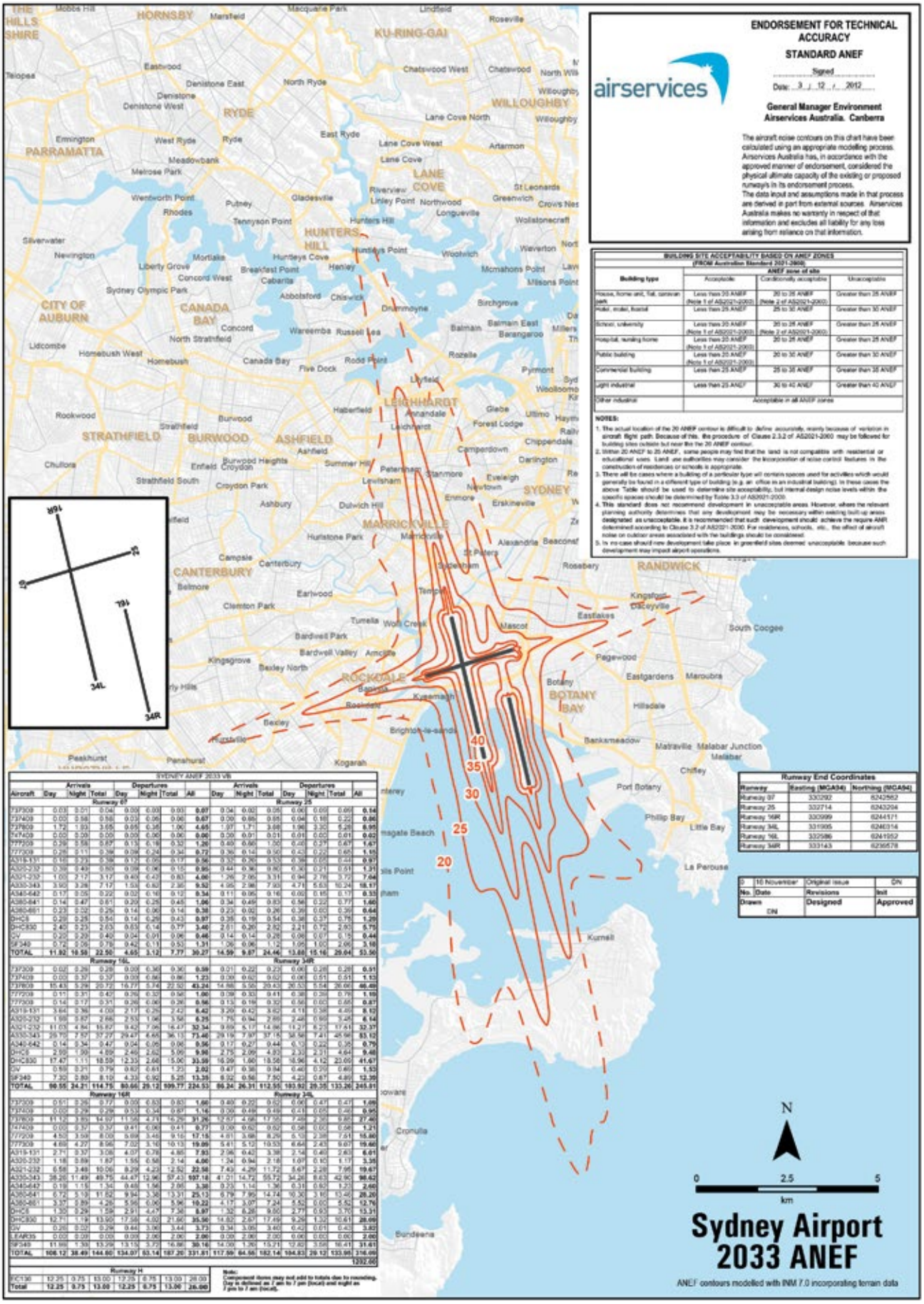


Figure 14.7 ANEF 2033 and ANEF 2029

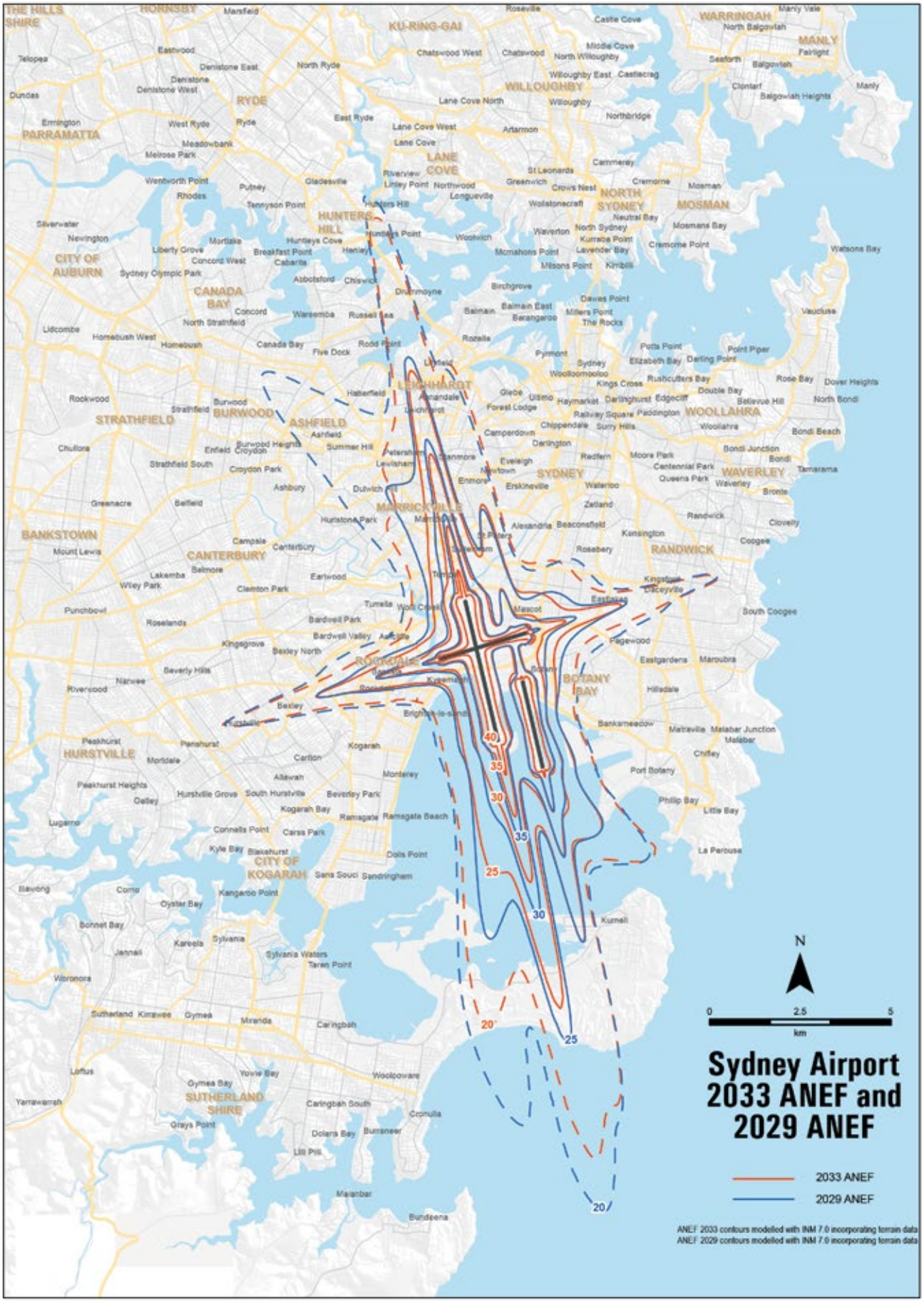


Figure 14.8 ANEF 2033 and ANEI 2011

Figure 14.9 ANEF 2033 and ANEI 2011 and NEI 1976

WebTrak can be found on the Airservices Australia website.[14]

Other ways to map noise at Sydney Airport

Sydney Airport is committed to providing the community with relevant and accurate information about noise impacts in a way that can be easily understood.

In the years since ANEFs started to be used in the 1980s, it has become apparent that, while they can be a useful noise disclosure tool, they do not describe all relevant information about aircraft noise impacts to residents.

For this reason, as well as the ANEF, noise impacts are mapped in other ways to disclose what the impact is today, and what it is forecast to be in the future, for residents living in a particular area.

Noise descriptors are the tools used to illustrate these impacts. In addition to the ANEF, other noise descriptors are provided here which clearly set out the predicted aircraft noise exposure patterns in all areas around Sydney Airport in a way that allows individuals to assess on an objective basis how they might be affected by the forecast level of aviation activity. These descriptors take into account:

- Anticipated aircraft movement numbers
- Anticipated respite hours
- Anticipated noise exposure levels (which includes whether the movement is an aircraft arrival or departure, the size of the aircraft and the level of noise it generates)
- The flight path in use

Flight path movement charts

Flight path movement charts have been in use for around 15 years and are widely accepted as a simple tool for reporting Sydney Airport's noise exposure pattern. Airservices Australia publishes these charts in Sydney Airport Operational Statistics reports.[15] In the previous 03/04 Master Plan and 2009 Master Plan, Sydney Airport published charts showing forecast movements for 2024 and 2029 respectively.

Figure 14.10 shows the predicted average daily jet flight path movements for 2033 and shows where those aircraft will fly, how many overflights are forecast (including the average daily movements and daily range), the percentage of Sydney Airport's overall movements these overflights represent and the percentage of days when there will be no aircraft movements.

Respite charts

Providing people with a break or respite from aircraft noise is an important noise sharing principle. The LTOP requires the modes of runway operation to be changed throughout each day, when traffic and weather conditions permit, to provide respite from noise affecting residents living in different areas around Sydney.

Airservices Australia publishes respite charts in Sydney Airport Operational Statistics reports.[16] In the previous 03/04 Master Plan and 2009 Master Plan, Sydney Airport published charts showing forecast respite for 2024 and 2029 respectively.

Figure 14.11 shows the predicted average daily jet aircraft respite periods in 2033 based on the number of whole clock hours (eg. 9am to 10am) when there are no aircraft movements on the particular flight path, and reporting these as a percentage of the sum of all the clock hours in the period in question. The figure shows respite during three discrete periods, morning (6am to 7am), daytime (7am to 8pm) and evening (8pm to 11pm).

Frequency-based aircraft noise charts

For the community, knowing the number of noise events that occur in an area that will exceed a particular noise level is important. For this reason, frequency-based measures of aircraft noise are used. Contour maps showing the number of events louder than 70 dB(A) have been typically used. These are known as N70 contours. This level is chosen because it is equivalent to the single event level of 60 dB(A) specified in AS 2021-2000 as the indoor design sound level for normal domestic areas in dwellings. An external single noise event will be attenuated by approximately 10 dB(A) by the fabric of a house with open windows. An internal noise level of 60 dB(A) is the sound pressure level of a noise event that is likely to interfere with conversation or with listening to radio or television. Airservices Australia publishes N70 charts for Sydney Airport in quarterly Australian Noise Exposure Index reports.[17] In the previous 03/04 Master Plan and 2009 Master Plan, Sydney Airport published charts showing forecast respite for 2024 and 2029 respectively.

Figure 14.12 shows the forecast N70 chart for Sydney Airport in 2033 and, for comparison, the equivalent contours in 2011.

From the community's perspective, it is also important to know the number of noise events that are forecast to occur during sleeping hours. AS 2021-2000 identifies 50 dB(A) as the inside noise level above which aircraft noise can be considered intrusive during sleeping hours. This inside noise level would generally be experienced by a 60 dB(A) outside noise event. A contour map showing the number of events louder than 60 dB(A) – known as N60 contours – is therefore an effective way of conveying this information to the community. Given its purpose, the noise events shown are limited to those occurring between 11pm and 6am.

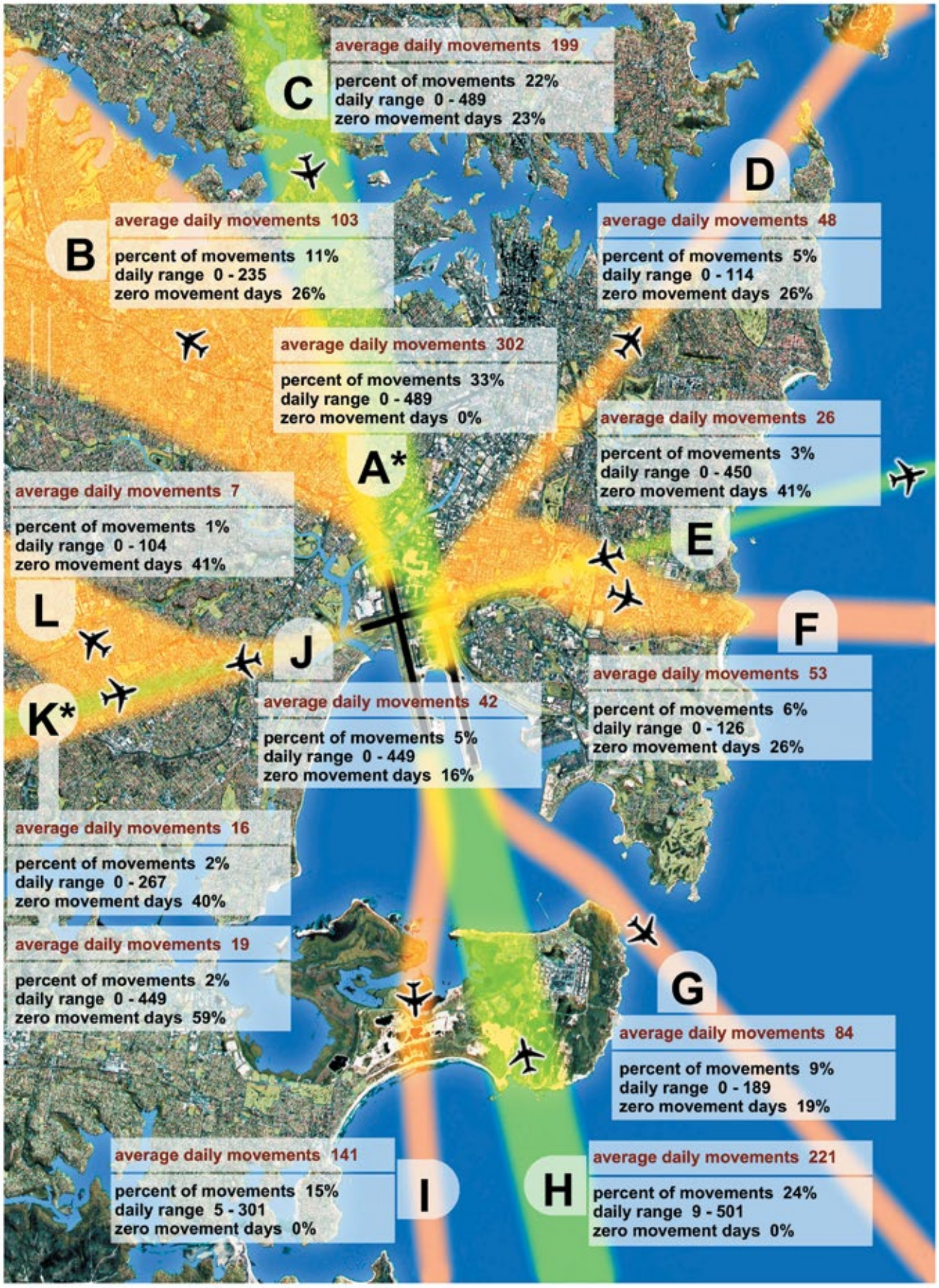
14 http://www.airservicesaustralia.com/aircraftnoise/webtrak/ (accessed March 2013)

15 http://www.airservicesaustralia.com/publications/reports-and-statistics/sydney-airport-operational-statistics/ (accessed March 2013)

16 ibid

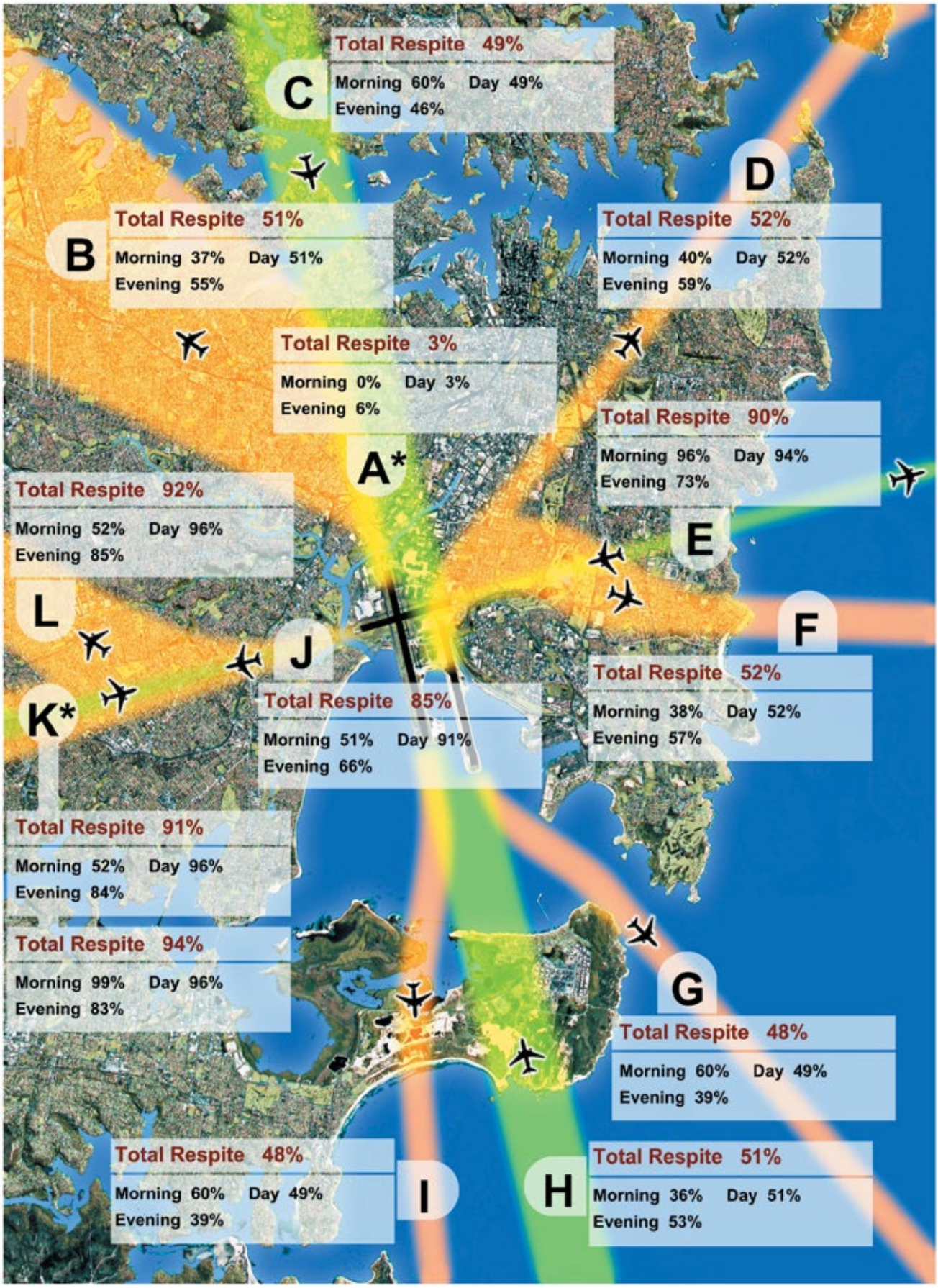
17 http://www.airservicesaustralia.com/publications/reports-and-statistics/australian-noise-exposure-index-reports/ (accessed March 2013)

Figure 14.10 Average daily jet aircraft movements 2033



Note: Track A* is Tracks B and C combined. Track L* shows departures (top box) and arrivals (bottom box).

Figure 14.11 Average daily jet aircraft respite periods 2033



Note: Track A* is Tracks B and C combined. Track L* shows departures (top box) and arrivals (bottom box).

A respite interval is a 60 minute period when there are no jet movements (R60).

Morning: 06:00 to 07:00 Day: 07:00 to 20:00 Evening: 20:00 to 23:00 Total Respite: 06:00 to 23:00

Figure 14.13 shows the forecast N60 chart for Sydney Airport in 2033 (operations between 11pm and 6am only).

14.5 Ground-based noise

Noise from ground-based activities at Sydney Airport is managed separately to noise from in-flight aircraft operations. Ground-based noise is generated from a number of sources on the airport including:

- Road traffic
- Construction and development activities
- Operation of audible alarm and warning systems
- Operation of plant and equipment
- Taxiing aircraft
- Aircraft engine ground running
- Operation of aircraft auxiliary power units (APUs)

Over the past three years, Sydney Airport has received an average of just over 14 complaints annually from the community in relation to ground-based noise. The majority of these complaints relate to aircraft engine ground running. Ground runs at the airport are carried out at the Qantas run-up bays on the northern edge of the airport and, with permission from Sydney Airport, at other designated locations by other airlines operating from the airport.

Sydney Airport has a ground based noise management strategy. Engine ground running, which is an essential part of aircraft operations and maintenance, is regulated by a policy that includes a comprehensive set of operational rules designed to maintain safety levels, comply with relevant standards and practices, and minimise noise. The Airport Environment Strategy (see attachment) provides detailed information regarding management of ground-based noise. These management practices will be maintained and improved as appropriate for the future airport operations.

The increasing number of new generation quieter aircraft flying to Sydney over the planning period is expected to reduce the need for high power engine ground runs. It is considered that this will reduce ground-based noise impacts in areas around Sydney Airport.

Noise impacts associated with construction activities are assessed during the development approval process (see Appendix E). Noise monitoring of individual projects is undertaken where necessary.

Sydney Airport is replacing APU usage (a known source of ground-based aircraft noise) with ground power and preconditioned air at all aerobridge gates at T1 as well as retrofitting any remaining gates at T2 not already fitted with ground power.

Sydney Airport is also committed to the engine ground running rules and achieving minimal complaints regarding ground-based noise. This Master Plan also allows for the planned development of an engine run facility in which ground running would take place.

Figure 14.12 N70 contours 2033 and N70 contours 2011

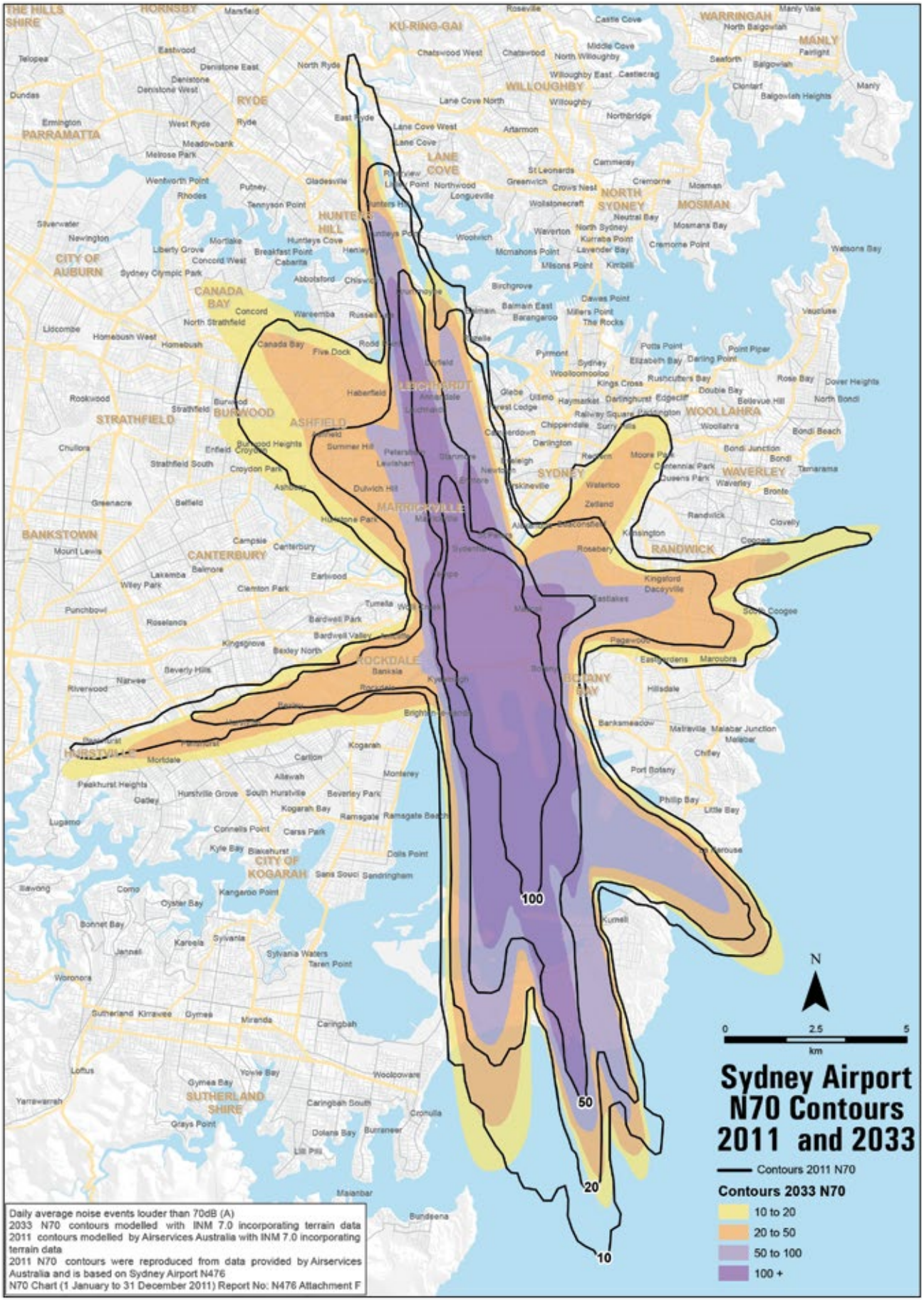


Figure 14.13 N60 contours 2033 (curfew hours only)