Brisbane Airport

Noise Improvement Trial Report

Trial of aircraft departure settings and investigation into improved noise outcomes

JUNE 2020

This is version 1.0 of the Brisbane Airport noise improvement trial report, dated June 2020.

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1. EXECUTIVE SUMMARY

Brisbane Airport Corporation (BAC) has consistently sought to minimise the environmental impacts of Brisbane Airport operations on its community neighbours while responding to the economic and social drivers for the continued growth of Brisbane Airport.

Following Commonwealth Government approval to undertake delivery of the parallel runway system in July 2007, through the Environmental Impact Statement and Major Development Plan process, BAC has continued a comprehensive engagement process with political, industry and community stakeholders to ensure transparent and complete information on how Brisbane Airport will operate into the future.

In 2016, BAC initiated a collaboration with Airservices Australia (Airservices) to finalise the airspace design and consider the requirements of the minister in the approval of the EIS / MDP to ensure the latest safety standards, airspace and aircraft technologies, techniques and capabilities were incorporated into that finalised airspace.

Since November 2018 BAC, supported by Airservices, has been delivering an unprecedented community information program, to fully inform the community about the implications of the finalised airspace system.

1.1 Reasons for the trial

Consistent with the airspace design and Concept of Operations presented in the EIS / MDP, parallel runway operations will change flight paths, create new flight paths and introduce new areas of Brisbane to varying levels of overflight frequencies and aircraft noise exposure.

Areas of Ascot, Hamilton, Bulimba, Balmoral and New Farm in particular, will have greater exposure to operations from the new runway. In response to suggestions raised by the Bulimba / Balmoral community, and to ensure the best noise outcomes for community are achieved when Brisbane's new runway opens, BAC carried out an in depth investigation into the noise improvement potential of the two internationally and nationally accepted standard Noise Abatement Departure Procedures (NADP) for modern jet aircraft (NADP1 and NADP2).

NADP1 is a Noise Abatement Departure Procedure that requires higher initial thrust settings to gain earlier climb and altitude due to leaving the wing flaps extended until 3000ft. It is designed to provide greater noise benefits for residential areas located close to a runway. NADP2 (or ICAO B) uses slightly lower initial thrust settings than NADP1 due to earlier retraction of wing flaps at around 1000ft. It is designed to provide greater noise benefits for residential areas located further away from a runway. NADP1 and NADP2 intersect in altitude approximately 15kms from start of take-off roll. In this trial, NADP2 was assumed to be the default procedure applied by airlines flying a Noise Abatement Departure Procedure for Runway 19L departures from Brisbane Airport.

Airservices has confirmed that it is regular practice for long-haul heavy aircraft to request cancellation of the Standard Instrument Departure (SID) procedure over the city, due to an inability to meet the current published climb gradients and/or speed requirements.

Extensive noise modelling comparing the two Noise Abatement Departure Procedures was initially conducted and resulted in no perceptible difference in noise levels over communities beneath the departure flight path. BAC and Airservices presented the results at several meetings with the community representatives who are also airline pilots. They provided that, from their relevant operational experience and expertise, they believed the modelling was not representative of real-world operations. The community representatives still believed that mandating NADP1 and ensuring aircraft were consistently higher earlier would provide community benefits.

In response to this feedback, BAC and Airservices initiated a trial to compare NADP1 and NADP2 for aircraft departing from Runway 19L during October and November 2019.

While the trial did not result in a perceptible (at least 3dB(A)) reduction in average noise levels for most aircraft types over residential areas, it did confirm a significant variation in departure altitudes and speeds for similar aircraft types both between airlines as well as within the same airline. Regular pilot requests to cancel the Standard Instrument Departure (SID) procedure over the city also contributed to this variation.

The information gathered during the trial has resulted in the development of noise improvements by industry, including the airlines and Airservices' air traffic control, in the form of additional Noise Abatement Procedures (NAPs) for Brisbane Airport.

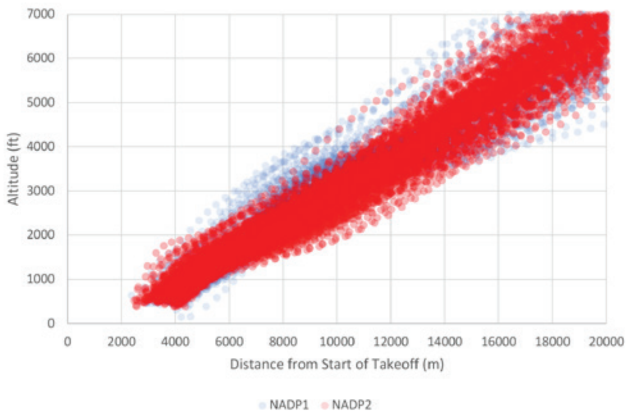
As a result of the trial, and to continue to pursue the best outcomes for the Brisbane community, BAC has also commenced work with Airservices to develop and implement the first combined Airport/Airservices Aircraft Performance and Noise Program in Australia. This system will monitor compliance with Noise Abatement Procedures (NAPs) and flight paths in order to seek continuous improvement and will provide additional information about aircraft noise to the community.

1.2 NADP1 trial results

The most common aircraft operating during the trial was the Boeing B737-800. The following figure shows the large variation in altitudes flown by departures from Runway 19L to northern destinations, both before the trial (NADP2) and during the trial (NADP1). Note that NADP2 is the standard noise abatement departure procedure flown by departures from Runway 19L at Brisbane Airport, while NADP1 was flown during the trial period.

FIGURE 1

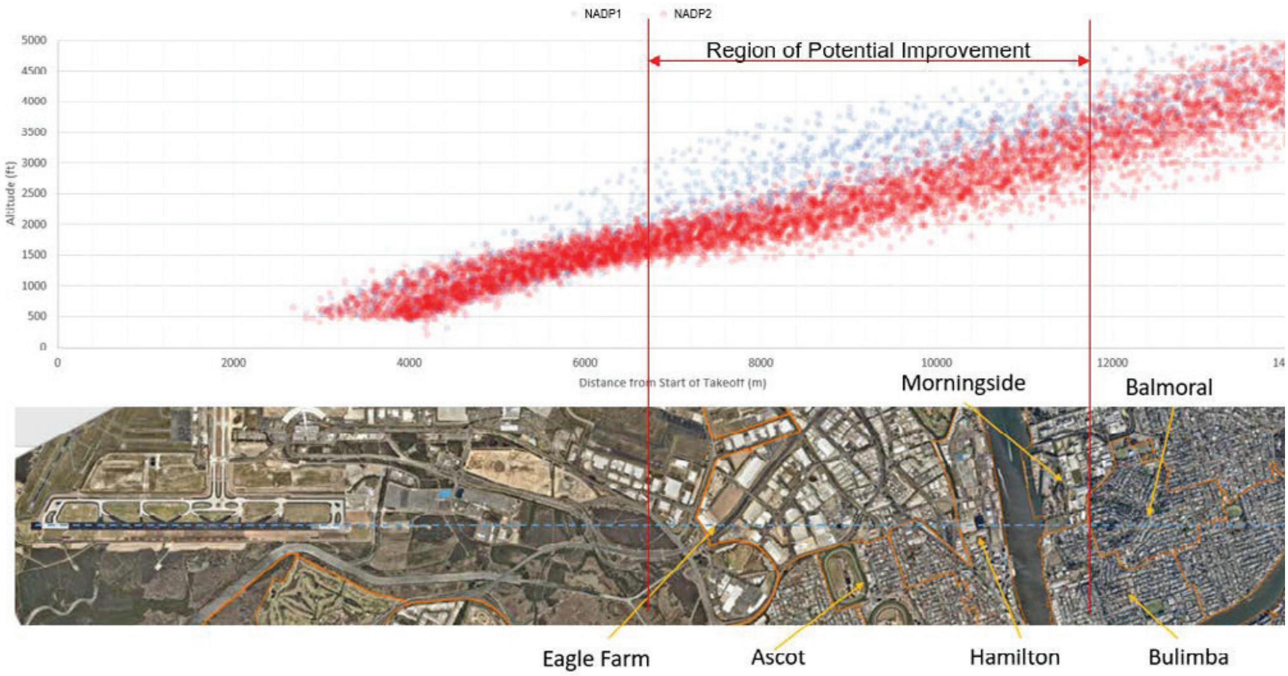
B737-800 aircraft departing using the standard NADP2 departure procedure (red dots) and the trial NADP1 departure procedure (blue dots). Altitudes are shown at distances from start of take-off roll on the runway for the B737-800 aircraft.



While the trial was conducted for departures over land off the existing runway (Runway 19L), Figure 2 transfers results of the trial to the new runway (Runway 19R), to show the likely aircraft altitudes at distances from the take-off roll over residential areas (flying NADP1 or NADP2). This figure shows the two noise abatement departure procedures and the area of potential improvement that the trial investigated.

FIGURE 2

B737-800 aircraft using NADP1 during the trial are shown as blue dots and NADP2 as red dots

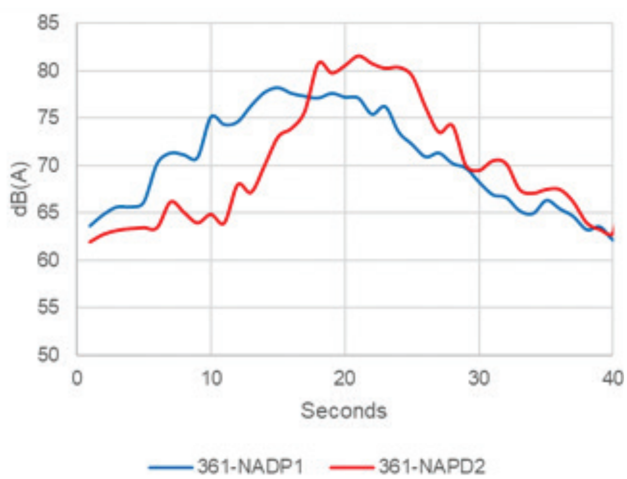


The noise difference captured during the trial included both maximum single event noise levels (LAmax) and the combined level and duration of the noise event (Sound Exposure Level – SEL).

Figure 3 below shows that, over the short-term aircraft noise monitor located at Tingalpa, NADP1 results in a lower single event noise level (LAmax), but the duration of the noise event (SEL) is longer, because NADP1 reduces the forward speed of the aircraft.

FIGURE 3

Noise level and duration comparison between NADP1 and NADP2



1.3 Emissions and fuel burn

An important part of the trial was to consider the difference in emissions and fuel burn, in addition to noise levels, between NADP1 and NADP2. The trial did not result in a perceptible reduction of average noise level and/or duration (of greater than 3dB(A)) across the aircraft fleet, but modelling using data from the trial indicated substantial increases in fuel use and emissions (CO_2). The reductions in noise and relative increases in emissions for most aircraft types are shown in Table 1.

Based on emissions modelling and information provided by industry from the trial (using 2019 movement numbers for the aircraft types listed in Table 1), the additional fuel consumed flying NADP1 over a 12 month period would be more than 1,200,000kg, with additional CO_2 emissions of almost 3,900,000kg. The trial concluded that permanently mandating NADP1 for all Runway 19L/R departures would result in a significant cost to the environment and industry, with no perceptible noise benefits for the community for most aircraft types.

TABLE 1
Noise and emissions differences by aircraft type departing Brisbane Airport Runway 19L during the NADP1 trial in October-November 2019

	Noise improvement AVE LA max (dB(A))	Noise improvement AVE SEL (dB(A))		*Fuel Increase kg (over 12 months)	*CO_2 increase kg (over 12 months)
B738 Northern destinations	1.0 (dB(A))	0.4 (dB(A))	B738 North and South	560,440 kg	1,797,406 kg
B738 Southern destinations	1.1 (dB(A))	0.5 (dB(A))			
A320 Northern destinations	3.6 (dB(A))	2.0 (dB(A))	A320 North and South	295,694 kg	937,760 kg
A320 Southern destinations	2.0 (dB(A))	1.6 (dB(A))			
A330	2.6 (dB(A))	1.5 (dB(A))	A330	178,800 kg	554,280 kg
B787	3.1 (dB(A))	2.8 (dB(A))	B787	75,600 kg	239,910 kg
B777	1.5 (dB(A))	1.4 (dB(A))	B777	52,800 kg	168,000 kg
A350	3.4 (dB(A))	2.7 (dB(A))	A350	54,180 kg	171,570 kg

Note: Industry workshops revealed that NADP2 was rarely used during the pre-trial baseline period for international operations. Baseline noise, therefore, is likely to be higher and improvements due to NADP1 are likely to be overstated for these operations.

**CO_2 and fuel burn was estimated, through modelling, for each aircraft type against profile information from the trial and multiplied by the number of aircraft departing from Runway 19 to give an estimate of emissions increases over 12 months (based on movements from 2019).*

1.4 Noise improvements

Following the NADP1 trial, industry workshops were held to review the trial outcomes and look for possible improvements to the noise abatement procedures at Brisbane Airport. These workshops included representatives from Brisbane Airport, Airservices and the airlines, including air traffic controllers and pilots.

These workshops resulted in a number of improvements and can be summarised as follows:

- Recognising that increased speed at take-off is resulting in lower altitudes and increased noise, and that maximum speeds will be more clearly defined and monitored.
- Agreement that improved compliance with existing noise abatement procedures (NAPs), and restricting indicated air speed to minimum flap speed (the minimum speed specified by manufacturers that each aircraft type must reach before retracting wing flaps), or 250kts to 10,000ft will help reduce the occurrence of lower flying aircraft.
- The current flight path for aircraft departing over the city to northern destinations is not fit for purpose, with heavy aircraft regularly cancelling the SID procedure, due to their likely inability to meet speed restrictions and height requirements. As a consequence, noise abatement departure requirements are not being met. This flight path has been redesigned by Airservices to meet all fleet requirements for Runway 19L/R departures. In addition, a specific noise abatement departure climb requirement (NADP1) will be introduced to ensure compliance if the standard instrument departure procedure is cancelled.
- An additional initiative from the airlines to use minimum flap settings on the final stages of approach prior to landing on Runway 01L/R (ie. over land), when safe to do so in order to reduce airframe noise.

The improvements included in the revised Brisbane Airport Noise Abatement Procedures published by Airservices (21 May 2020) were as follows:

- Runway 19L/R jet departures:
  - Jet noise abatement climb procedures apply as follows:
    - NADP required for all jet departures including radar departures
    - If speed restrictions are cancelled, NADP must still be flown
    - NADP1 required if SID cancelled by ATC at pilot request, except due to weather
    - All jet aircraft to comply with minimum clean speed, or max IAS 250kts below 10,000ft
- Landing on Runway 01L/R:
  - Use, as the final landing flap setting, the minimum certified landing flap setting for the applicable conditions.

1.5 Aircraft noise and performance

As a direct result of the trial findings and the analysis summarised in this report, BAC and Airservices are developing Australia's first combined Airport/Airservices Aircraft Performance and Noise Program which will operate for an initial two-year period after runway opening.

This automated system will monitor compliance with noise abatement procedures and flight paths and address the need for additional and transparent information about how aircraft are performing to minimise noise impacts. Recognising the sensitivity of residents to major changes in aircraft noise patterns, this program includes the provision of six extra noise monitoring terminals in addition to the eight permanent noise monitors already in use by Airservices (as displayed in WebTrak on Airservices website - https://www.airservicesaustralia.com/aircraftnoise/webtrak). Four temporary noise monitors will be placed in New Farm, Bardon, Carina, and Hamilton and two permanent noise monitors at the southern end of the airport.

With development of best-practice analytical tools, the information from this initiative will allow BAC and Airservices to continue to discuss ongoing opportunities with industry for potential improvements to aircraft performance and noise outcomes.

FIGURE 4A

Noise monitor terminal locations across Brisbane including the additional six new noise monitors to be installed prior to runway opening at Bardon, New Farm, Carina, Hamilton and inside the airport boundary south of each runway

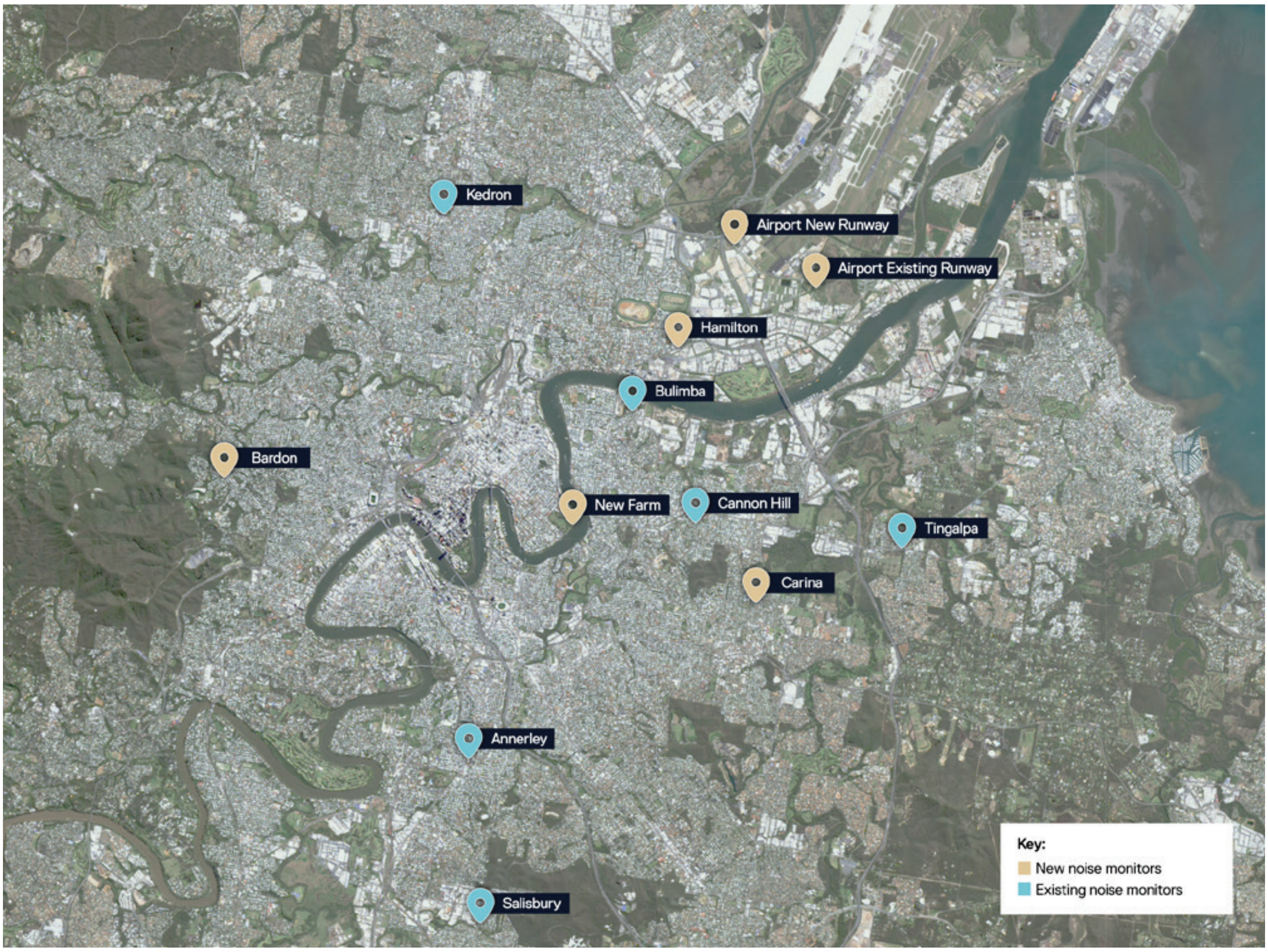


FIGURE 4B

Airservices aircraft noise monitor at Salisbury – part of Brisbane's existing aircraft noise monitoring network

2. INTRODUCTION

After more than 40 years of planning and preparation, Brisbane's new runway will commence operations on 12 July 2020. Minimisation of aircraft noise on Brisbane residents has been a core planning consideration from the time the new parallel runway project was conceived and has continued to be a priority focus throughout the delivery of the project.

This process began with the selection of the site in the early 1970s, through the new Brisbane Airport Master Planning process, and continued with the Environmental Impact Statement and Major Development Plan in 2006-07 through to the detailed physical design and construction and airspace design. The airport's new runway and airspace system has been designed to deliver both the aviation capacity needed for Brisbane Airport and to reduce noise impacts to the extent practical for the community. This has been achieved by making maximum use of modern airline fleet capabilities and over the bay procedures which are available due to the airport's proximity to Moreton Bay and the two-kilometre separation between the two parallel runways. The adjusted positioning by BAC of Brisbane's new runway as close as practical to the Moreton Bay shoreline, also maintains a six-kilometre buffer to the nearest residences consistent with the existing runway.

The detailed airspace design and flight paths were finalised and approved by the Civil Aviation Safety Authority (CASA), Australia's aviation safety regulator, in 2018. BAC and Airservices, Australia's air navigation service provider, are committed to exploring any further opportunity to manage aircraft operations in the most effective way to minimise aircraft noise and emissions, always ensuring that safety of aircraft operations is maintained.

To this end, BAC has worked closely with Airservices to undertake an evaluation of possible Noise Abatement Departure Procedures (NADPs) at Brisbane Airport and "lessons learnt" workshops with the airlines to identify additional feasible options to further reduce noise impacts to the local community.

This document explains the trial and its results, and initiatives from the subsequent industry workshops resulting in improvements to the Noise Abatement Procedures. It includes how the Noise Abatement Procedures will be monitored and assessed following the opening of the new runway through establishing a new Brisbane Airport Aircraft Performance and Noise Program for Brisbane Airport. This is the first system of its type in Australia and will provide data to allow BAC and Airservices to report to the community on how industry is performing to minimise noise and to investigate further improvements.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3. BRISBANE'S NEW RUNWAY - BACKGROUND

Brisbane's new runway is the completion of long-term planning commenced in the 1970s for Brisbane Airport. Ever since planning began a wide-spaced parallel runway system in a north-south alignment has been a key feature of the ultimate development vision for Brisbane Airport.

The airport opened in its current location in 1988 with the existing main runway, the smaller cross runway, the Domestic Terminal and the new air traffic control tower in place. During this initial construction phase in the 1980s, space was reserved to the west on the new airport site for a parallel runway to be built in the future when increasing demand for air travel required the capacity it would deliver.

The parallel runway system remained the central planning feature for future expansion in the period up to BAC's purchase of the long-term lease for Brisbane Airport in July 1997. BAC retained this planning vision, with significant community outcome improvements in its first two Master Plans in 1998 and 2003 respectively, by moving the initial position of the parallel runway to as close to Moreton Bay as practical.

Consistent with the Brisbane Airport Master Plan, BAC developed a comprehensive Major Development Plan and Environmental Impact Statement (MDP/EIS) in 2006 for consideration by and approval of the Commonwealth Government. This process included extensive planning and environmental assessments and public consultation. The approvals for the parallel runway were granted in 2007, allowing time for an extended construction phase to overcome the challenges of building on low quality ground so close to Moreton Bay.

Funding also had to be negotiated with airline customers, the ultimate users of the new runway, and importantly, no taxpayers' funds were used for this project. This ensures governments can rightly focus on other public needs such as transport, health, education and defence.

Construction of the runway began in 2012 and, simultaneously, the design of the airspace for the parallel runway system was conducted by Airservices, with extensive collaboration with airspace users and regulators.

The parallel runway system will operate using six main modes of runway operations to ensure that air traffic to and from the airport operates safely and efficiently and to minimise the impact on residential areas as much as possible. These modes of operation are explained in the table below and contained in the Flight Path and Aircraft Noise Information Booklet on the BAC website:
https://bne.com.au/flightpathbooklet

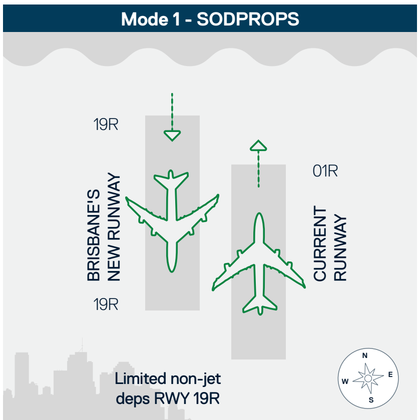
Modes of Operation for Brisbane's new runway

There are several possible modes of operation for Brisbane's new runway, with mode selection being influenced by:

- Existing air routes to and from the airport
- Optimisation of runway capacity
- Preferred runway allocation rules and Noise Abatement Procedures (NAPs) in operation at the airport
- Origin and destination of flights
- Options under varying wind conditions
- Simplicity of airspace design and flight paths to maximise safety and efficiency
- Amalgamation of existing procedures with new procedural requirements for parallel operations
- Options to minimise flights over residential areas.

About the Modes of Operation

The six main modes of operation for Brisbane's new runway are:

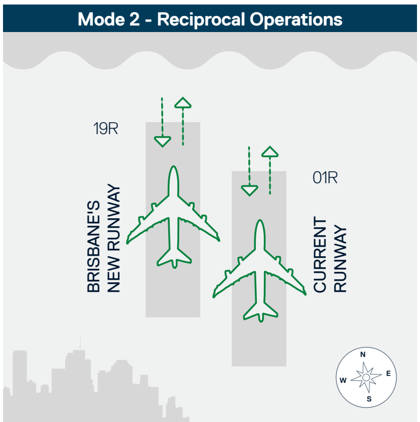


Mode 1: Simultaneous opposite direction parallel runway operations (SODPROPS)

This is a low to medium capacity mode with operations over Moreton Bay and allowing some non-jet departures from RWY 19R (5am to 10pm).

This is BAC's preferred operating mode for noise mitigation when traffic volume and weather conditions permit.

The mode can only be used when there is no more than a five knots tailwind and a dry runway, or no tailwind and a wet runway. It will most often be used at night (10pm to 6am) when demand is reduced.

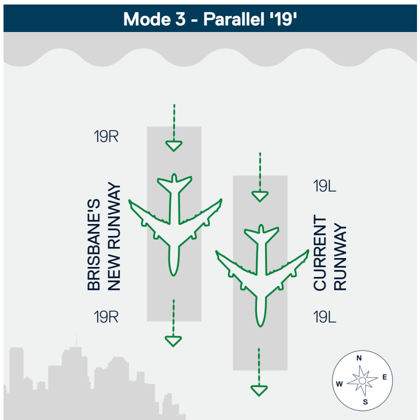


Mode 2: Reciprocal Operations

This is a low capacity night time mode (10pm to 6am) with all jets departing or landing over Moreton Bay.

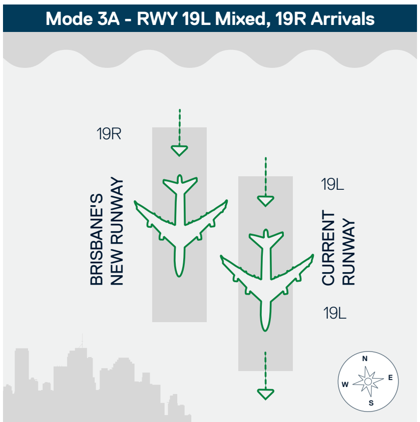
The mode can only be used at night with up to a five knots tailwind and dry runway. This mode can be used when SODPROPS can't be used due to low cloud or when visibility is less than 8km.

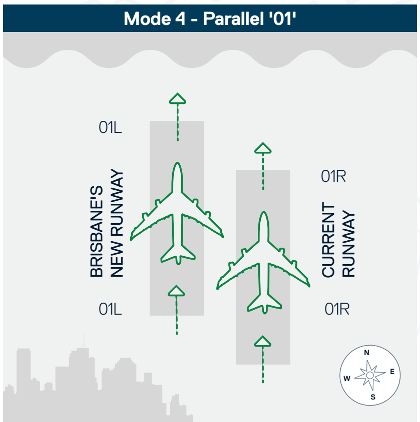
While Airservices is not able to nominate a runway direction if tailwind was to exceed 5 knots, pilots can choose to operate to a tailwind runway above 5 knots to achieve noise abatement outcomes and operational efficiencies such as reduced taxiing distances.

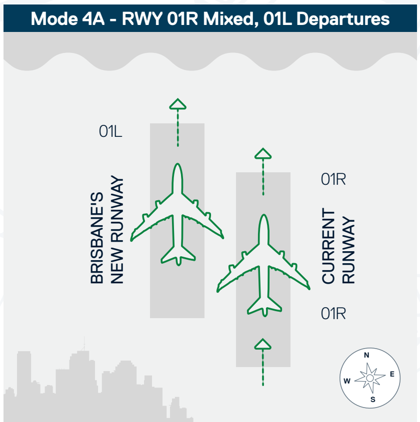


Mode 3: Mixed parallel operations on RWYs 19L and 19R

This is the most efficient mode for air traffic management for normal airport operations when weather conditions promote a southerly air traffic flow. Because arrival tracks are generally more concentrated than departure tracks, for noise abatement purposes arrivals over Moreton Bay are preferred if weather permits.







Mode 3A: RWY 19R arrivals and 19L mixed mode operations (more arrivals)

Mode 3A is a variation on Mode 3. It can be used in dry conditions with up to five knots tailwind, and in wet weather with no tailwind.
This mode is an option that may be considered during non-peak and shoulder periods with high arrival rates. This mode offers operational efficiency through reduced taxiing times from aprons.

Mode 4: Mixed parallel operations on RWYs 01L and 01R

Mode 4 is the primary mode of operation for arrivals and departures on RWY 01L and 01R. It is the most efficient mode for air traffic management for normal airport operations when weather conditions promote a northerly air traffic flow.

Mode 4A: RWY 01L departures and 01R mixed mode operations (more departures)

Mode 4A is a variation on Mode 4. It can be used in dry conditions with up to five knots tailwind, and in wet weather with no tailwind. This mode is an option that may be considered during non-peak and shoulder periods with high departure rates. This mode offers operational efficiency through reduced taxiing times from aprons.

4. AIRCRAFT NOISE CONSIDERATIONS IN THE AIRSPACE DESIGN

The positioning of Brisbane's new runway as close as possible to Moreton Bay and two kilometres west of the existing runway will maximise use of over the bay operations.

While this is the priority mode of operation in the airspace design to minimise aircraft noise for residential areas, the airspace design was developed by Airservices using the following principles:

1. Passenger safety and compliance with safety rules is paramount and must be the first consideration in design, which means the flight paths must meet the latest safety standards mandated by the aviation safety regulator and also allow aircraft to safely operate across the Brisbane airspace into Gold Coast, Sunshine Coast, Archerfield and Amberley airports. According to the latest regulatory standards, flight paths are required to be separated from each other in design either laterally or vertically. As well as determining where the flight paths can be positioned, this inbuilt safety in design reduces noise by allowing the aircraft autopilot and flight management system to control the aircraft until near the runway in constant descent or constant climb configuration, avoiding the changes to engine thrust caused by pilot's manually flying the aircraft to follow air traffic control directions.
2. Existing flight path corridors have been maintained wherever possible, reducing overflight of new residential areas.
3. Consistency with the airspace design presented in the 2007 EIS/MDP, with minor variations where required due to updates to safety standards, aircraft navigation requirements, and new flight paths introduced since 2007.
4. New flight paths or changes to existing flight paths occur over water where possible, especially when aircraft are below 5000ft.
5. Where not possible for new flight paths to be over water, flight paths are concentrated over non noise sensitive areas and establishments where possible.
6. To the extent practicable, residential areas overflown on a departure track by departing aircraft should not also be overflown by arriving aircraft on an arrival track.
7. Current and future, short-term and long-term noise exposure shall be considered when deciding on options.
8. Consideration shall be given as to whether concentration or distribution is more appropriate at the location
9. When comparing options, operations that are conducted at night or on weekends should be treated as being more sensitive than those that occur during the daytime or weekdays.
10. Options that allow for a gradual change from the current to planned procedures should be given preference.
11. Operations to target respite rather than reduced frequency.
12. No suburb, group or individual can demand or expect to be exempt from aircraft noise exposure.
13. The operational design includes maximising the number of flights taking off and landing over Moreton Bay. The noise abatement procedures require flights to operate over Moreton Bay at night (10pm to 6am) providing the wind and weather conditions allow.

Consistent with the approval statement and expectations advised by the Federal Minister for Transport and Regional Services in approving the project's Environmental Impact Statement and Major Development Plan, Brisbane's new runway has provided the opportunity for Airservices to design a modern and efficient airspace system for the broader Brisbane Basin area, taking full advantage of the latest developments in navigation systems, airspace management techniques and aircraft technology.

These developments include:

- An airport location and runway system that maximises the use of overwater procedures to avoid overflying residential areas wherever possible.
- Modern, quieter aircraft engines and airframes.
- The latest aircraft technology and procedures that use constant descent and climb profiles to minimise variations in engine thrust and associated noise.
- Minimisation of aircraft vectoring by air traffic control to position aircraft; (vectoring requires disengaging of the autopilot and has the effect of forcing aircraft into fixed altitude or circling procedures which increases fuel burn and emissions and creates additional noise impacts for more residents).

5. COMMUNITY SUGGESTIONS FOR IMPROVEMENTS TO NOISE ABATEMENT PROCEDURES

The design elements of the airspace operational environment were finalised and approved in 2018 by the Civil Aviation Safety Authority (CASA), Australia's aviation safety regulator.

As the flight paths and the controlled airspace volumes required to contain those flight paths are finalised, they cannot be changed, however the noise abatement procedures (which are rules about how pilots and air traffic controllers must operate within the approved airspace to minimise noise) can be changed whenever improvements can be found.

Consistent with the airspace and Concept of Operations presented in the EIS / MDP, BAC and Airservices recognise that parallel runway operations will change flight paths, create new flight paths and introduce new areas of Brisbane to varying levels of overflight frequencies and aircraft noise exposure.

BAC, supported by Airservices, has been conducting an unprecedented level of community engagement to ensure the community is informed of how Brisbane Airport will operate when the parallel runway commences operations, where aircraft will fly and what the expected frequency of operations on the various flight paths will be. This engagement program has included the development of new information tools, made readily available on BAC's website and taken out into the residential areas and suburbs that will experience aircraft operations through a mobile information centre.

As part of this comprehensive community engagement program, feedback is considered carefully and investigated thoroughly by BAC and Airservices to ensure the best noise outcomes for community are achieved when Brisbane's new runway commences operations.

Areas of Ascot, Hamilton, Bulimba, Balmoral and New Farm will have greater exposure to operations from the new runway. In response to suggestions raised by the Bulimba / Balmoral community (with lead representation from a number of active airline pilots residing in those areas), BAC initially utilised the USA Federal Aviation Administration (FAA) Integrated Noise Model tool (INM) to model the potential for noise improvements for those communities if NADP1 was flown in preference to the default NADP2 departure procedure.

After initially comparing the two noise abatement departure procedures through this extensive noise modelling and presenting the results to the community representatives, BAC received feedback that from their relevant operational experience and expertise, the modelling was not representative of real-world operations. Analysis using a large sample of actual flight data indicated a significant variation in the height and speeds pilots were flying over residential areas.

The community representatives were adamant that mandating NADP1 for Runway 19L/R departures and ensuring aircraft were consistently higher earlier would provide community benefits.

In response to this feedback, BAC and Airservices initiated a trial to compare NADP1 and NADP2 using aircraft over noise monitors. This trial, which was conducted in October and November 2019.

6. NOISE ABATEMENT DEPARTURE PROCEDURES TRIAL

6.1 Introduction

The International Civil Aviation Organization (ICAO) is the United Nations agency responsible for standards setting for international civil aviation. Australia is a member State of ICAO and a member of the governing council.

ICAO's Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS) states that up to two noise abatement departure procedures (NADP) can be defined for a departure flight path. The first procedure (NADP1) aims to improve noise conditions for communities closer to the runway (3.5 to 7.6 km from start of take-off roll) by delaying the height at which engine thrust is reduced and wing flaps are retracted forcing the aircraft to climb more steeply initially. This comes at the cost of increased fuel consumption, emissions, and engine wear, and possible slightly increased noise levels more distant from the airport.

The second procedure (NADP2) sees thrust reduced and wing flaps retracted shortly after take-off. This reduces aircraft height initially relative to NADP1 and aims to improve noise conditions for communities further away from the runway. NADP2 is the commonly used procedure at Brisbane Airport (and at Australian major airports) as it is considered to provide the best noise outcome given the distance of six kilometres between the current runway and residential areas. NADP2 reduces fuel consumption, emissions, and engine wear relative to NADP1. It may also result in slightly lower noise levels further away from the airport.

It should be noted that altitude variations resulting from aircraft flying NADP1 and NADP2 tend to intersect at approximately 15km from start of take-off roll, which is approximately 12km from the end of the new runway.

The ICAO document Effects of PANS-OPS Noise Abatement Departure Procedures on Noise and Gaseous Emissions Cir 317 AT/136, dated 2007 provides a full analysis of NADP1 vs NADP2 in terms of noise and emissions. The ICAO document indicates that noise reductions of over 5 dB(A) may be experienced at some communities close to the runway when NADP1 is used. Given the complexity and high number of variables modelled in the ICAO document, and that the analysis and findings were based on modelling only, a one-month trial was undertaken. In the trial, noise levels from NADP1 jet departures were measured using short term noise monitors to test the results of the model in the ICAO report and assess the potential benefits of the procedure for Brisbane's new runway.

6.2 Trial description

Location

Data for the trial was obtained from five separate aircraft noise monitoring terminals located under the two existing flight paths, known in aviation terminology as Standard Instrument Departures (SIDs), for departures from Runway (RWY) 19L. These monitoring stations were located in the suburbs of Pinkenba (6.5 km from take-off roll on southern departure), Hemmant (10.5km from take-off roll on southern departure), Tingalpa (12km from take-off roll on southern departure), Eagle Farm (8km from take-off roll on northern departure) and Cannon Hill (11.5km from take-off roll on northern departure). The location of these monitors relative to the typical flight path is shown in Figure 5 and Figure 6.

The trial for noise levels associated with future operations assumes that the measurement of operations on the existing main runway can be transposed across to the new runway.

FIGURE 5
Pinkenba, Hemmant and Tingalpa noise monitors collected data for departures to southern destinations during the NADP1 trial

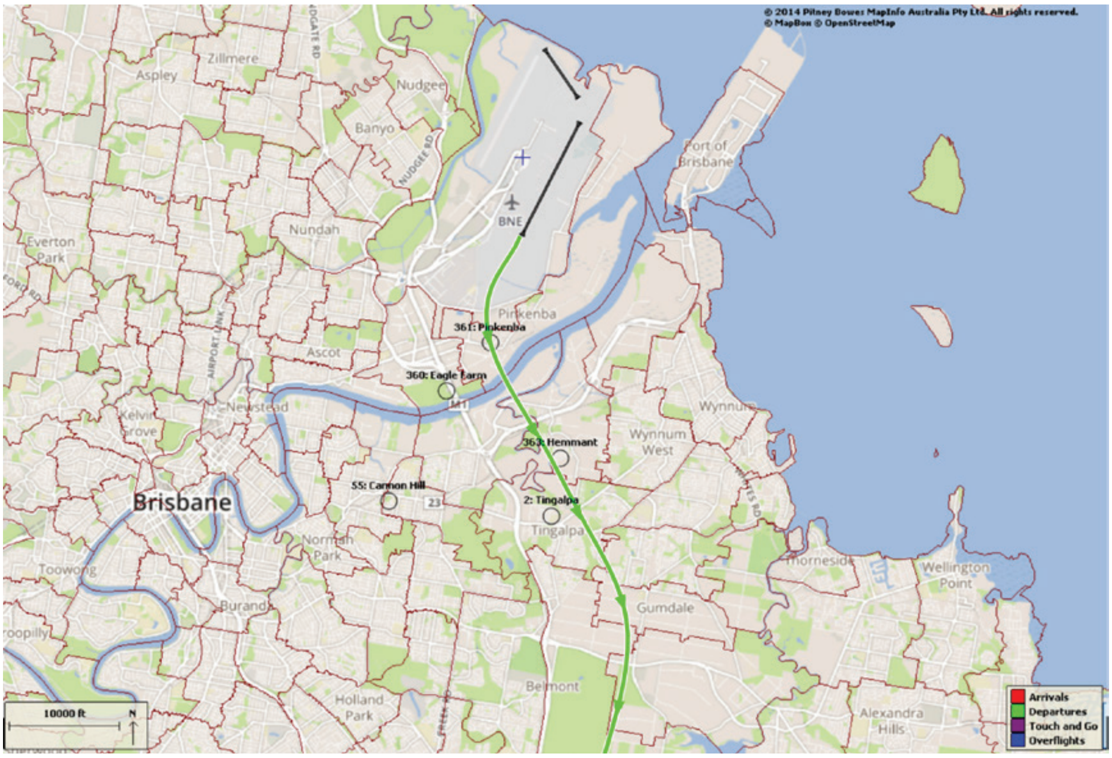
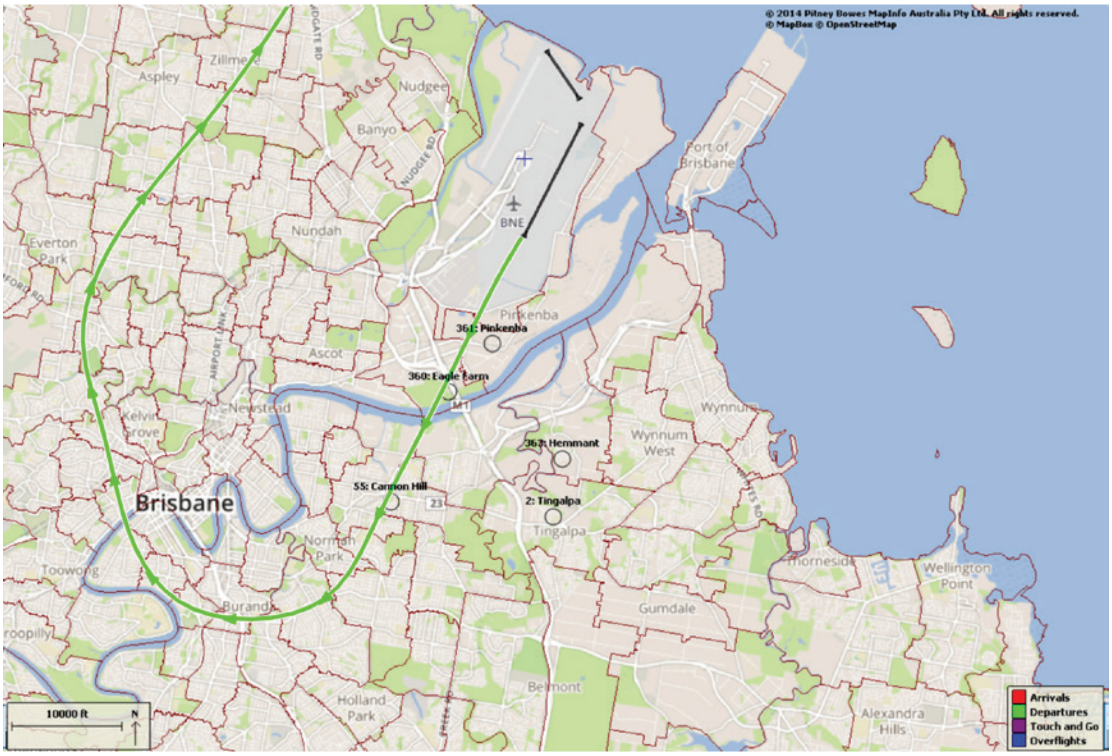


FIGURE 6
Eagle Farm and Cannon Hill noise monitors collected data for departures to northern destinations during the NADP1 trial



6.3 Measurement periods

The NADP trial was conducted from 5am, 10 October 2019 to 5am, 23 November 2019. This measurement period was split into two periods, the first of which was two weeks obtaining baseline data for NADP2 departures (as current practice for jet departures at Brisbane airport is to use the NADP2 procedure). The second phase was one month of NADP1 departures. The dates for the two periods were:

- Baseline Period (NADP2) – 5am 10 October 2019 to 5am 23 October 2019
- Trial Period (NADP1) – 5am 23 October 2019 to 5am 23 November 2019

6.4 Aircraft numbers

The most common aircraft operating on both SIDs (northern and southern destinations) are the Boeing 737-800 (B738), the predominant aircraft in the Qantas and Virgin Australia domestic fleets, followed by the Airbus A320 making up a combined 89 per cent of traffic on the southbound departure SID and 50 per cent of traffic on the northbound departure SIDs.

The Boeing B737 family of aircraft and Airbus A320/321 are narrow-body, single aisle aircraft commonly used on domestic routes. Generally, traffic on southbound routes from Brisbane is dominated by flights to Sydney and Melbourne. There is a higher proportion of larger, long-haul aircraft flying north from Brisbane Airport, as well as a higher proportion of smaller narrow-body aircraft such as the Fokker 100 and Boeing 717 servicing northern and western Queensland.

Typical traffic composition by aircraft type during the trial is shown in Table 2 and Table 3 for the two SIDs.

TABLE 2
Traffic composition by aircraft type for departures to northern destinations from RWY19L during baseline period

Aircraft	percentage of total flights
B738	70%
A320	19%
B712	3%
A321	2%
B737	1%

TABLE 3
Traffic composition by aircraft type for departures to southern destinations from RWY19L during baseline period.

Aircraft	Count
B738	37%
A320	13%
B712	9%
F100	6%
A359	5%
A332	4%
A333	4%
B77W	3%

6.5 Reported metrics

Measurement of aircraft noise is complex and can be described using several metrics.

The decibel (dB(A)) is the unit used to measure the intensity of a sound. The human ear hears sound pressures over a wide range. Decibels, which are measured on a logarithmic scale, correspond to the way our ears interpret sound pressures.

The human ear also responds to different pitches or frequencies of sound differently. We are less able to hear low frequencies like the rumble of thunder, but hear high frequencies like the cry of a baby more strongly. To account for differences in how people respond to sound, the “A-weighted” scale (dB(A)) is used. This scale most closely approximates the relative loudness of sounds in air as perceived by the human ear and provides a more useful way to evaluate the effect of noise exposure on humans by focusing on those parts of the frequency spectrum where we hear most. The A-weighted noise level has been generally accepted as the international measure to consider aircraft noise.

For noise sources in motion, like aircraft, noise levels can change over time. For example, the sound level of a plane increases as it approaches, and then as it flies away the sound level decreases. It can be useful to measure the maximum sound level, abbreviated as LAmax, of a particular noise “event”. While LAmax notes the moment of maximum sound level, it does not account for the duration of a sound event.

To account for the differences in duration and loudness of sounds, different metrics are used. These metrics are used to compare individual noise events as well as many events that take place over an extended period.

The Sound Exposure Level (SEL) metric represents all the acoustic energy (sound pressure) of an individual noise event as if that event had occurred within a one-second time period. SEL captures both the level (magnitude) and the duration of a sound event in a single numerical quantity, by “squeezing” all the noise energy from an event into one second. This provides a uniform way to make comparisons among noise events of various durations.

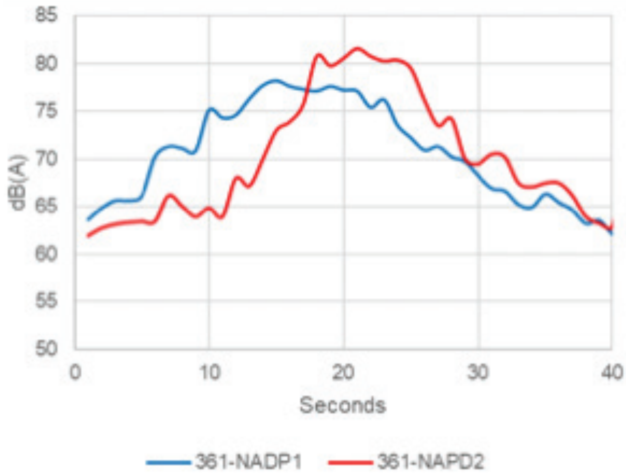
To contextualise the measures, the Transport Noise Management Code of Practice – Volume 1 Road Traffic Noise, Queensland Department of Transport and Main Roads 2013 provides guidance on the way changes in the A-Weighted Noise level is perceived by the human ear. It states that:

- Changes of up to 3dB(A) – are not likely to be perceptible.
- Changes between 3dB(A) and 5dB(A) – may be perceptible.
- Changes between 5dB(A) and 10dB(A) – are likely to be perceptible.

Aircraft ground speed under the NADP1 departure is typically slower than the speed for NADP2. So, although noise levels associated with NADP1 are expected to have a lower peak, the duration of the event will typically be longer. This may reduce any noise relief experienced by the community.

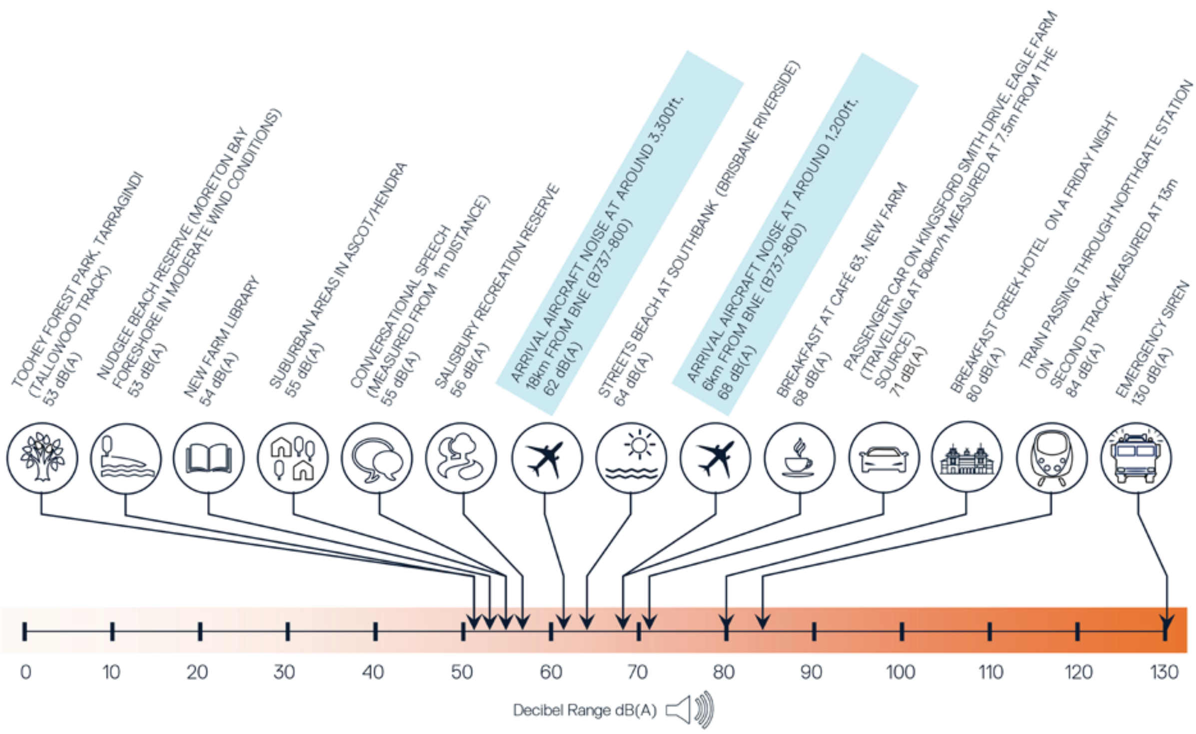
This effect is illustrated in Figure 7, showing the average noise levels over time at the Pinkenba noise monitor. It can be seen that the peak level measured on NADP1 is approximately 3dB(A) lower than what is measured on NADP2. However, the amount of time aircraft noise levels exceeded 70dB(A), the level where noise is measured as intrusive, shows this level persists for approximately 22 seconds on NADP1 and approximately 16 seconds on NADP2.

FIGURE 7
Illustration of peak vs duration of sound events at Pinkenba noise monitor



To provide an understanding of aircraft noise levels, Figure 8 shows how typical sound levels around Brisbane compare to aircraft noise levels.

FIGURE 8
Noise levels around Brisbane



Source: Local noise measures collected by *SoundIn*, December 2018

6.6 Noise monitor and emissions measurements

Average noise metrics recorded at the noise measurement locations during the baseline (NADP2) and trial (NADP1) periods are compared below in Table 4, to illustrate the measured noise reduction between the NADP1 and NADP2 trial periods. Fuel burn and CO_2 were also modelled across most aircraft types using the trial results to provide the relative increase in emissions resulting from NADP1.

TABLE 4
Summary of results by aircraft type for NADP1 trial period for Runway 19L departures at Brisbane Airport

	Noise improvement Average LAmax (dB(A))	Noise improvement Average SEL (dB(A))		*Fuel Increase kg (over 12 months)	*CO_2 increase kg (over 12 months)
B738 North	1.0 (dB(A))	0.4 (dB(A))	B738 South & North	560,440 kg	1,797,406 kg
B738 SOUTH	1.1 (dB(A))	0.5 (dB(A))			
A320 NORTH	3.6 (dB(A))	2.0 (dB(A))	A320 South & North	295,694 kg	937,760 kg
A320 SOUTH	2.0 (dB(A))	1.6 (dB(A))			
A330	2.6 (dB(A))	1.5 (dB(A))	A330	178,800 kg	554,280 kg
B787	3.1 (dB(A))	2.8 (dB(A))	B787	75,600 kg	239,910 kg
B777	1.5 (dB(A))	1.4 (dB(A))	B777	52,800 kg	168,000 kg
A350	3.4 (dB(A))	2.7 (dB(A))	A350	54,180 kg	171,570 kg

Note: Industry workshops revealed that NADP2 was rarely used during the pre-trial baseline period for international operations. Baseline noise, therefore, is likely to be higher and improvements due to NAD P1 vs NADP2 overstated for these operations.

**CO_2 and fuel burn was estimated, through modelling, for each aircraft type against profile information from the trial and multiplied by the number of aircraft departing from Runway 19 to give an estimate of emissions increase over 12 months (based on movements from 2019).*

It can be seen from the results in Table 4 that, while noise levels are consistently lower, there was not a perceptible (greater than 3dB(A)) average single event (LAmax) noise improvement for majority of the aircraft, and generally less than 2dB(A) difference when using SEL levels (noise level and duration).

Figure 9 illustrates the typical profile for departures to southern destinations from the start of take-off for B737-800 aircraft. It can be seen on average the NADP1 procedure will position the aircraft higher from around six kilometres from start of take-off, with the heights converging after about 15 kilometres.

FIGURE 9
Southern destinations departure profile – Boeing B737-800 (B738)

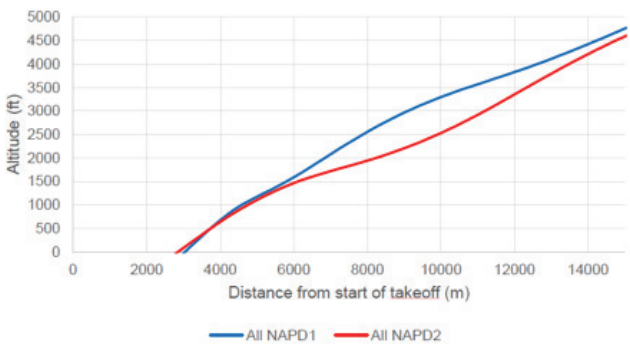
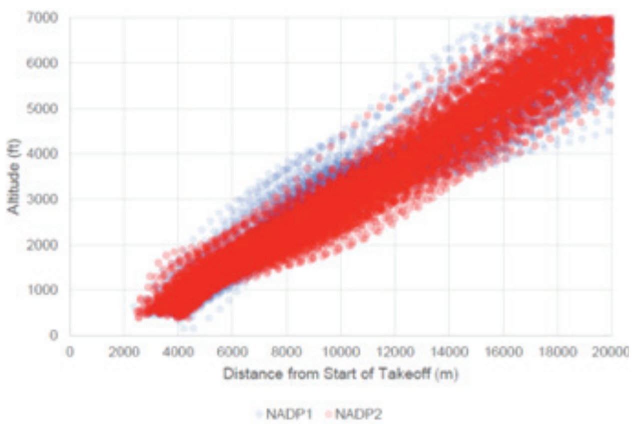


Figure 10 illustrates the measured height at various distances from the start of take-off for Boeing 737-800 aircraft departures to northern destinations during the trial. It can be seen there is significant variability in the altitude achieved. In general, NADP1 appears to result in higher average altitude from just over 4km to 16km from the start of take-off. However, in some instances NADP2 achieved greater altitudes.

FIGURE 10
Northern destinations departure variance – Boeing B737-800 (B738)



Figures 11 to 15 illustrate the height at various distances from the start of take-off for various aircraft types, extrapolated onto the departure flight path that will be used for the new runway (Runway 19R) from 12 July 2020. The variation in height achieved is evident and it could be expected that there would be further variation in actual noise dependent on factors including aircraft power and configuration, aircraft weight, air temperature, air density and wind direction and wind speed.

FIGURE 11
Trial results overlaid on northern destinations departure track for new runway (Runway 19R) for Boeing B737-800 (B738)

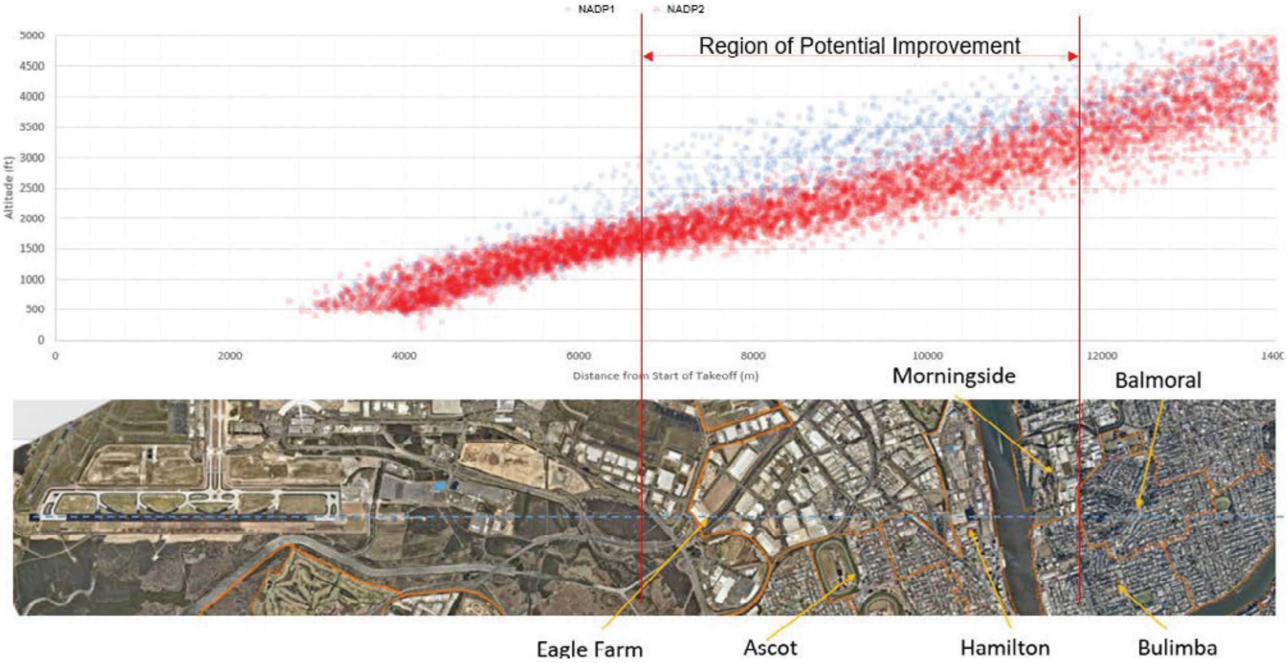


FIGURE 12
Trial results overlaid on northern destinations departure track for new runway (Runway 19R) for Airbus A320 aircraft

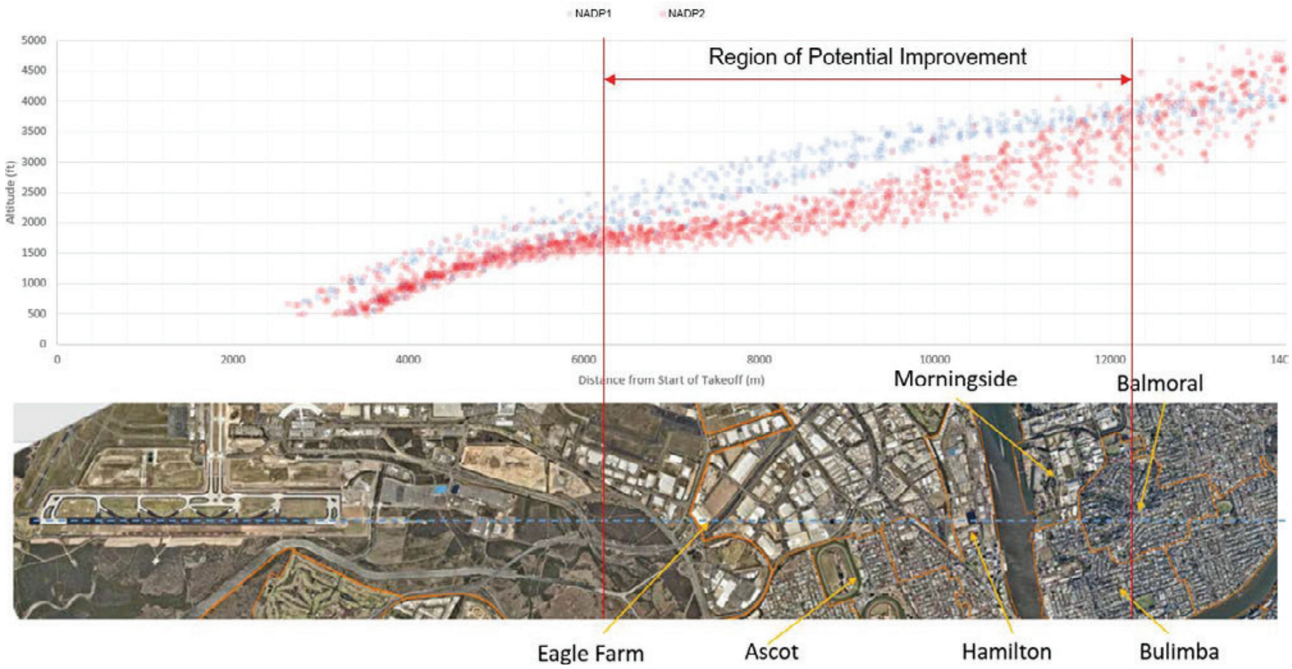


FIGURE 13

Trial results overlaid on northern destinations departure track for new runway (Runway 19R) for Airbus A330 aircraft (refer previous notes regarding low use of NADP2)

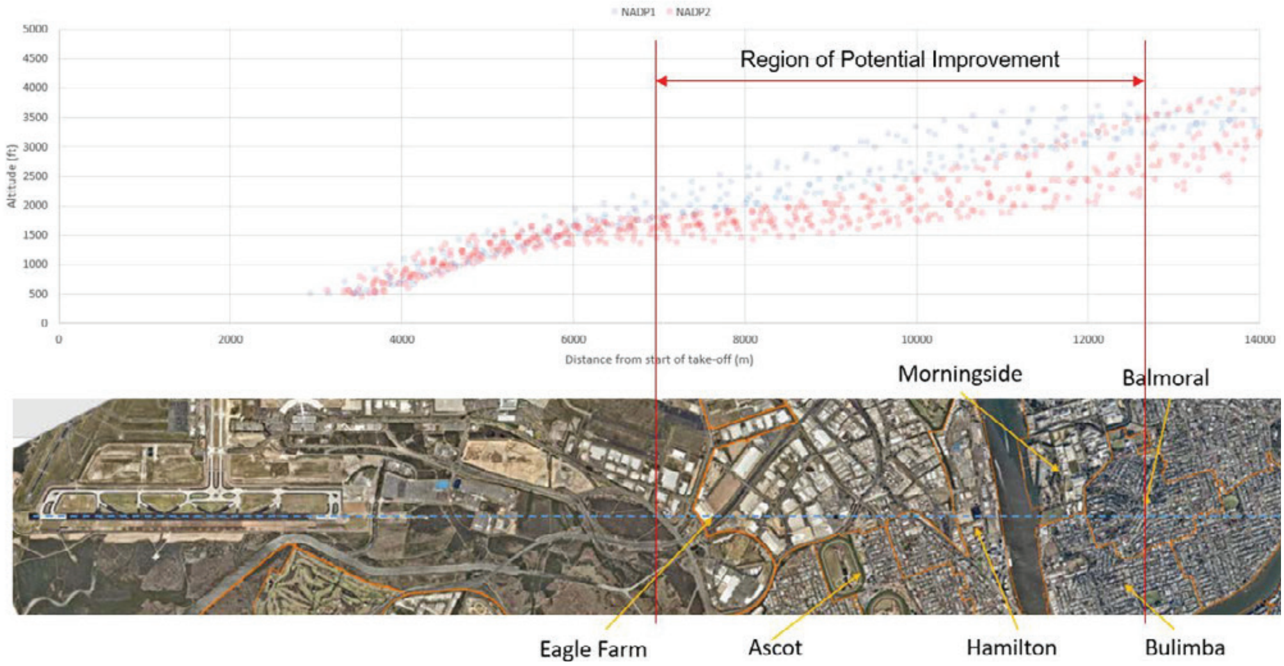


FIGURE 14

Trial results overlaid on northern destinations departure track for new runway (Runway 19R) for Boeing 777 aircraft (refer previous notes regarding low use of NADP2)

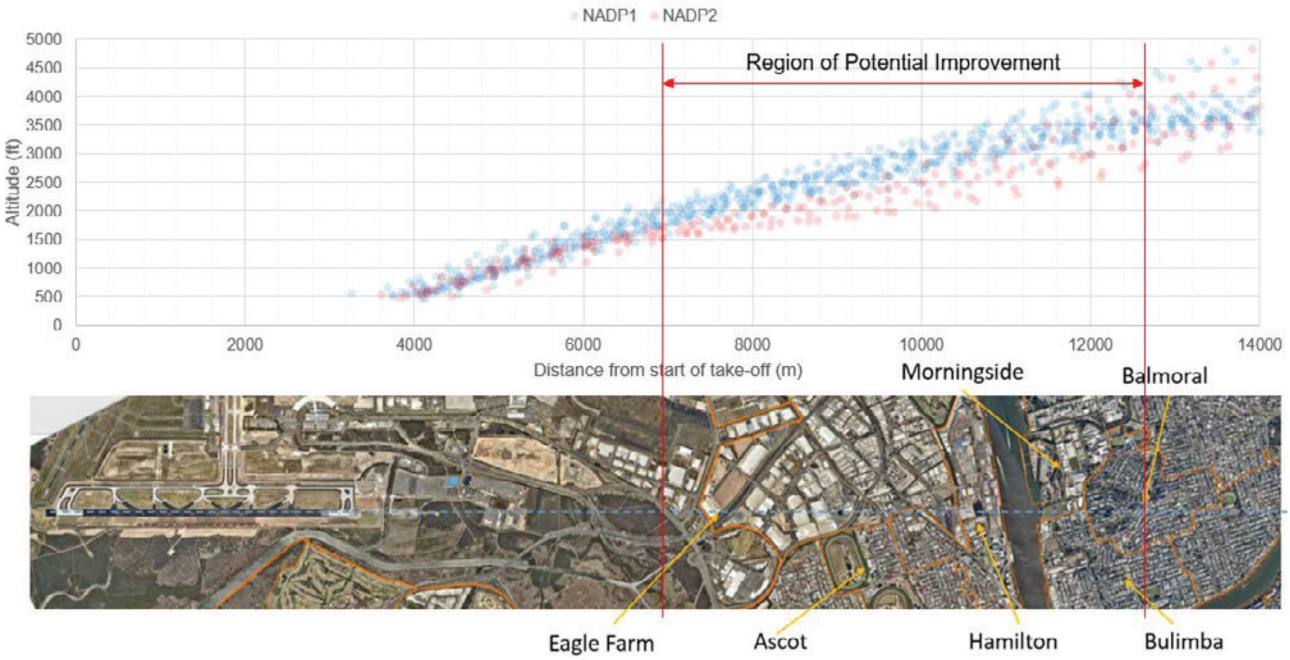
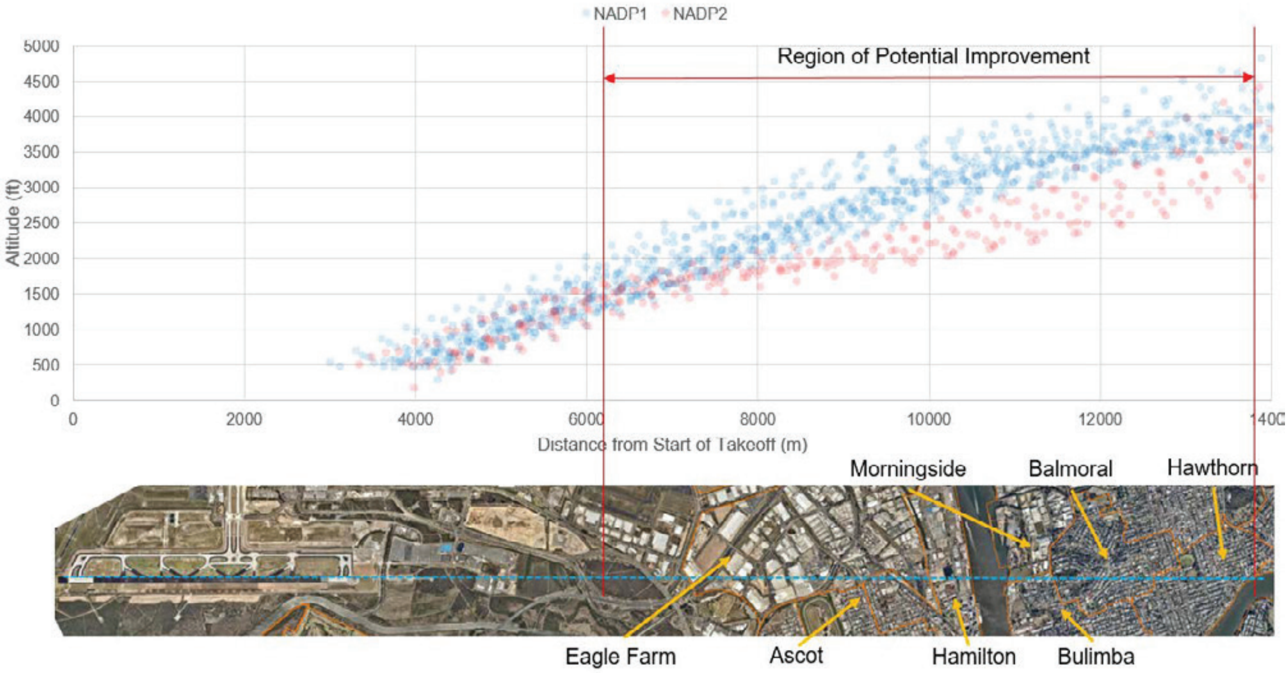


FIGURE 15

Trial results overlaid on northern destinations departure track for new runway (Runway 19R) for Boeing 787 aircraft (refer previous notes regarding low use of NADP2)



7. INDUSTRY WORKSHOPS

The data gathered from the trial indicated that while the use of NADP1 resulted in increased altitudes over some areas, the noise difference between NADP1 and NADP2 would not be perceptible to residents beneath the flight paths (with an average noise reduction of less than 3dB(A)) across most aircraft operations.

There also appeared to be significant variation in aircraft altitudes for both departure procedures, with 20 per cent of participating pilots not complying with the NADP1 requirements during the trial period.

Using the information from the trial, BAC and Airservices facilitated several workshops and discussions with airlines including Qantas, Virgin, Jetstar, Air New Zealand and the Board of Australian Airline Representatives (BARA).

The workshops were invaluable in enabling airlines to identify clear operating parameters that can be reliably implemented by pilots. They have also been helpful in identifying which operational modifications offer the best noise outcomes, and not simply higher aircraft altitudes, which do not always translate into lower noise levels.

The issues considered at the workshops were:

- Non-compliance with the NADP requirements during the trial.
  - Reasons provided:

    It is an important element in the management of aviation safety that the captain of an aircraft maintains responsibility for the safe operations of the aircraft. For that reason, many standardised procedures that provide guidance for pilots can be overrode by the pilot when he or she decides safety might be compromised.

    The existing standard instrument departure procedure (SID) for aircraft departing in southerly winds to northern destinations (over the city) requires a low air speed and steep climb gradient which many heavier aircraft are unable to accept due to the operating requirements of the aircraft.

    This results in pilots asking Airservices air traffic control to cancel the SID prior to take-off and results in some aircraft not flying the NADP as the aircraft is being flown manually according to air traffic control directions.
  - Improved outcomes:

    The new runway SID for these operations has been updated to ensure the air speed and climb gradient meet all fleet performance requirements.

    Noise abatement procedures will be updated to ensure that pilots know they must fly NADP even when the SID is cancelled.

    If the SID is cancelled for any reason other than operational requirements, NADP1 must be flown.
- Variation in departure altitudes and how to address the lower flying aircraft altitudes.
  - Reasons provided:

    Air traffic control requires jet aircraft to limit their speed to 250 knots (kts) indicated air speed until 10,000 feet (ft) to allow them to ensure they do not lose separation between aircraft due to faster following slower aircraft on climb. Pilots often ask air traffic control to cancel the speed restriction when there is no operational need, and this results in the aircraft flying faster and lower.
  - Improved Outcome:

    All airlines agree that enforcing either minimum flap speed (which is initially less than 250kts for most aircraft) or 250kts below 10,000ft as a noise requirement will result in less aircraft at lower altitudes over the residential areas south of the airport.

- Benefit of NADP1 vs other potential operational modifications.
  - By having air traffic controllers, pilots and BAC in the workshop, the best operational modifications could be determined to meet aircraft and air traffic control requirements and constraints, while meeting the airport's expectations to find the best noise outcomes for the community. These are identified in the summary of improvements to noise abatement procedures located in the 'Conclusions and Next Steps' section of this report.
- Costs of increased aircraft power requirement for NADP1 in terms of fuel burn and emissions.
  - The airlines provided approximate fuel burn estimates to demonstrate that NADP1 results in significant increases in fuel burn and CO_2 emissions relative to the minor improvements in noise levels.
  - BAC outsourced the modelling of fuel and emissions difference between NADP1 and NADP2 to include in the public report.
- Extent to which higher altitudes reflected lower aircraft noise levels.
  - NADP1 requires additional engine thrust and later retraction of flaps – this results in higher altitudes, but may also result in increased engine and airframe noise.
  - It was agreed that better noise outcomes will be achieved by limiting aircraft speeds and ensuring compliance with NADP requirements (eliminating the non-compliance).
- Potential for newer aircraft to offer noise improvements as airline fleets are renewed.
  - Airlines are continually upgrading their fleets with newer generation aircraft which are noticeably quieter including Qantas B787, Singapore, Cathay and China Air A350.
- For arrivals - airlines agreed that the use of minimum certified landing flap settings on approach provides incremental noise reductions without increasing fuel burn and emissions.

8. FUEL BURN AND EMISSIONS ANALYSIS

In response to airline advice that the use of NADP1 during the trial period resulted in additional fuel burn and CO_2 emissions, BAC engaged an aviation planning specialist to further analyse and quantify the potential impacts on additional fuel use and the increased emissions resulting from NADP1. The USA Federal Aviation Administration - Aviation Environmental Design Tool (AEDT) was utilised to generate the data included in Table 5 and Table 6.

For NADP1 departures to northern and southern destinations, AEDT modelling showed slightly higher fuel burn and emissions across all aircraft types.

For a short stage length Boeing B738 departure to a northern destination, AEDT modelling showed that the NADP1 departure used 24.33kg more fuel and produced 76.77kg of additional CO_2 than the NADP2 departure. By comparison, using the Australian Government Green Vehicle Guide CO_2, an average family car would travel 422km to produce the same amount of CO_2.

The modelling results also showed that the longer the stage length and the heavier the aircraft, the greater the difference in fuel burn and emissions between NADP1 and NADP2. In comparison to the narrow body B738 above, a long stage length wide body B777 departure using NADP1 to northern destinations would use 88.27kg more fuel and produce an additional 278.49kg of CO_2. This is representative of an average family car travelling 1530km to produce the same amount of CO_2.

TABLE 5
Modelled increase in fuel burn and CO_2 emissions (kg) for each aircraft type using NADP1 to northern destinations (compared to NADP2).

Increase in fuel burn and CO_2 emissions (kg)							
	B712	**B738**	**B777**	**B789**	**A320/1**	**A330**	**A350**
Fuel/Short stage length	33.96	24.33		69.93	46.41		
Fuel/Medium stage length		32.20		47.32	100.62	60.17	
Fuel/Long stage length			88.27	80.39			
Emissions/Short stage length	107.14	76.77		220.62	146.42		
Emissions/Medium stage length		101.60		149.31	317.46	189.82	
Emissions/Long stage length			278.49	253.63			

TABLE 6

Modelled increase in fuel burn and CO_2 emissions (kg) for each aircraft type using NADP1 to southern destinations (compared to NADP2).

Increase in fuel burn and CO_2 emissions (kg)							
	B712	**B738**	**B777**	**B789**	**A320/1**	**A330**	**A350**
Fuel/Short stage length	33.50	24.89		71.10	46.35		
Fuel/Medium stage length		33.25		49.01	102.16	63.74	
Fuel/Long stage length			92.24	84.28			
Emissions/Short stage length	105.69	78.53		224.33	146.23		
Emissions/Medium stage length		104.89		154.64	322.31	201.09	
Emissions/Long stage length			291.03	265.91			

Table 4 presented earlier in this report extrapolates the above individual aircraft operational data and applies the results across the entire year, using 2019 movements for the aircraft types listed in the tables and typically comprising majority of Brisbane Airport operations. The extrapolated results in Table 5 and Table 6 identify the annual impacts on fuel burn and CO_2 emissions for the listed aircraft, if NADP1 was mandated for Runway 19L departures:

- Additional annual fuel burn – 1,217,514kg (1,218 tonnes fuel)
- Additional annual emissions – 3,868,926kg (3, 869 tonnes CO_2)

This analysis combined with the noise analysis from the trial does not support mandating NADP1 for all Runway 19L/R departures due to the significant cost to the environment and industry, and no perceptible noise benefits for the community for most aircraft types.

9. CONCLUSIONS AND NEXT STEPS

With Brisbane's new runway airspace and flight paths finalised, Brisbane Airport is committed to investigating any possible improvements to the Brisbane Airport Noise Abatement Procedures that will further reduce aircraft noise impacts on residents.

As part of this commitment, and based on community feedback and investigations, a trial of the ICAO noise abatement departure procedure, NADP1, was conducted during October and November 2019 for take-offs in a southerly direction from Brisbane Airport's current runway. An analysis was undertaken by BAC and Airservices to attempt to investigate the potential benefits of applying this procedure to the new runway once it opens in July 2020.

The NADP1 trial and the analysis of actual flight data undertaken during the initial modelling phase has provided data and further insight into how departing aircraft operate at Brisbane Airport. The results did not indicate NADP1 provides a perceptible noise benefit over residential areas, but did demonstrate a significant variation in how the noise abatement procedures are currently applied. Additionally, the results showed that mandating the use of NADP1 would result in significantly increased fuel burn and CO_2 emissions.

Importantly, the trial facilitated a dialogue with industry including air traffic control and pilots which resulted in further suggestions for improvements and additions to noise abatement procedures at Brisbane Airport. These are summarised as follows:

- Recognising that increased speed at take-off is resulting in lower altitudes and increased noise, and that maximum speeds will be more clearly defined and monitored.
- Agreement that improved compliance with existing noise abatement procedures (NAPs), and restricting indicated air speed to minimum flap speed (minimum speed specified by manufacturers that each aircraft type must reach before retracting wing flaps), or 250kts to 10,000ft will help to eliminate lower flying aircraft, resulting in consistently higher altitudes.
- The current flight path for aircraft departing over the city to the north is not fit for purpose, with heavy aircraft regularly cancelling the standard instrument departure procedure due to the inability to meet speed restrictions and height requirements and, as a consequence, noise abatement departure requirements are not being met. This flight path has been redesigned to meet all fleet requirements for Runway 19L/R departures. In addition, a specific noise abatement departure climb requirement (NADP1) will be introduced to ensure compliance if the standard instrument departure procedure is cancelled.
- An additional initiative from the airlines to use minimum flap settings on the final stages of approach prior to landing on Runway 01L/R when safe to do so in order to reduce airframe noise.

The improvements included in the revised Brisbane Airport Noise Abatement Procedures published by Airservices (21 May 2020) were as follows:

- Runway 19L/R Jet Departures:
  - Jet noise abatement climb procedures apply as follows:
    - NADP required for all jet departures including radar departures
    - If speed restrictions are cancelled, NADP must still be flown
    - NADP1 required if SID cancelled by ATC at pilot request, except due to weather
    - All jet aircraft to comply with minimum clean speed, or max IAS 250kts below 10,000ft
- Landing runway 01L/R:
  - Use, as the final landing flap setting, the minimum certified landing flap setting for the applicable conditions.

10. BRISBANE AIRPORT AIRCRAFT PERFORMANCE AND NOISE PROGRAM

BAC, Airservices and airlines recognise the importance of continuing to monitor and progress initiatives to minimise the impact of aircraft operations on Brisbane communities. BAC has been open and transparent with the community as planning, construction and airspace finalisation for the new runway has progressed and will continue this approach following the airspace change milestone of 21 May 2020 and the actual parallel runway opening of 12 July 2020.

As a direct result of this trial, and in response to the significant variation in aircraft performance and flight characteristics identified, BAC is working with Airservices to develop and implement a comprehensive Brisbane Airport Aircraft Performance and Noise Program at Brisbane Airport as part of the commissioning of the new runway.

In a continued demonstration of collaboration and focus on community outcomes, the expanded system will be funded by BAC and delivered by Airservices prior to operations commencing on Brisbane's new runway.

This monitoring system will not only complement Airservices' existing Noise and Flight Path Monitoring System (NFPMS) which includes the Webtrak online tool, it will also measure effectiveness of the significant suite of Noise Abatement Procedures (NAPs) at Brisbane Airport including the additional procedures resulting from the NADP1 trial and industry workshops.

Recognising the sensitivity of residents to major changes in aircraft noise patterns, this program includes the provision of six extra noise monitoring terminals in addition to the eight permanent noise monitors already in use by Airservices (as displayed in WebTrak on Airservices website - https://www.airservicesaustralia.com/aircraftnoise/webtrak). Four temporary noise monitors will be placed in New Farm, Bardon, Carina, and Hamilton and two permanent noise monitors at the southern end of the airport.

The additional noise monitoring resources recognise the sensitivity of residents to major changes in aircraft noise patterns and the need for additional information at such sensitive times. The extra monitoring resources will provide the community access to this expanded information through regular reporting by BAC of the data collected by the system, and will provide ongoing opportunities for discussions with industry to monitor performance and assess potential further improvements.

Airservices aircraft noise monitors at Brisbane Airport - additional new noise monitors.

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