AVIATION WHITE PAPER

Scenario Analysis of the Future of Australian Aviation

Prepared for the Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Final Report

September 2023

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The research, analysis and stakeholder engagement for this report was conducted over the period from November 2022 through March 2023.
All information, analysis and findings are as at March 2023.

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Acronyms and definitions

A4ANZ	Airlines for Australia & New Zealand
AAM	Advanced Air Mobility
ABS	Australia Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
A-CDM	Airport Collaborative Decision Making
AFAP	Australian Federation of Air Pilots
AI	Artificial intelligence
AME	Unlicensed Aircraft Engineer
ANSP	Air Navigation Service Providers
ASK	Available seat kilometres
ATJ	Alcohol-to-Jet
ATM	Air Traffic Management
BAU	Business-as-Usual
BITRE	Bureau of Infrastructure, Transport and Regional Economics
CASA	Civil Aviation Safety Authority
CDM	Collaborative decision making
CTMS	Central Traffic Management System
EASA	European Union Aviation Safety Agency
eCTOL	Electric conventional take-off and landing
eMCO	Extended minimum crew operations
eVTOL	Electric vertical take-off and landing
FAA	Federal (United States) Aviation Administration
FIFO	Fly-in fly-out
GA	General aviation
GDP	Gross domestic product
HAPS	High Altitude Platform Systems
HEFA	Hydro-processed esters and fatty acids
HELP	Higher Education Loan Program
HSR	High-speed rail
IATA	International Air Transport Association
IFR	Instrument flight rules
LAME	Licensed aircraft engineer
MAP	Million annual passengers
MRO	Maintenance, repair, and overhaul

OEM	Original equipment manufacturer
PTP	Point-to-point
RPT	Regular public transport
RPK	Revenue passenger kilometres
SAF	Sustainable aviation fuel
SAFAANZ	Sustainable Aviation Fuel Alliance of Australia and New Zealand
STOL	Short take-off and landing
UAV	Uncrewed Aerial Vehicle
UTM	Uncrewed Air Traffic Management
VFR	Visiting friends and family
WFH	Work from home
WSI	Western Sydney Airport

1. Executive Summary

1.1 Introduction

Source: Iliya Jokic (rescue helicopter in Melbourne, Victoria)

Background

Aviation is integral to Australia's economic and social landscape. As an island nation, Australia relies entirely on international aviation as the only means for the mass transport of people and freight between Australia and the rest of the world. As the world's sixth largest country by area with a highly dispersed population, domestic and regional aviation are critical for domestic connectivity.

Aviation is an important contributor to Australia's economy. Pre-COVID, the sector directly employed over 176 thousand people, contributed more than US$16 billion in direct value to the economy per annum and indirectly generated c.US$53 billion.[1]

While commercial aviation – providing regular public transport (RPT), charter services and carrying freight – represents the largest part of the Australian aviation sector by economic activity and employment, the industry is diverse. It includes critical infrastructure such as airports and Air Traffic Management (ATM), general aviation (GA) (e.g., flight training, tourism, medi-vac and Flying Doctors services, aerial firefighting, and agriculture), security and biosecurity, and a range of associated industries, such as maintenance, ground handling services, freight logistics and manufacturing. In this report, aviation refers to both fixed and rotary wing aircraft.

Purpose of this report

This report is intended to be used by the Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA) as an input into the Aviation White Paper. The report provides perspectives on the expected key drivers of change in the aviation sector to 2050 and scenarios for the potential evolution of the industry. It is not intended to be an exhaustive survey of all possible drivers of change, nor of all areas of the sector.

This report considers the potential evolution of the drivers and scenarios over short (2030), medium (2040), and long (2050) term timeframes, and outlines the potential impacts of those scenarios on the sector.

It is important to note that the scenarios described in this report illustrate seven of the many potential versions of the future. They were designed as aids to facilitate discussion on the future of Australia's aviation sector and provide the Department and industry stakeholders with information to help inform thinking around potential policy implications during the Aviation White Paper development process. The scenarios should not be treated as forecasts or predictions and should not be interpreted as preferred or official versions of the future.

[1] IATA, The Importance of Air Transport to Australia (2018) © International Air Transport Association, 2019

1.2 Drivers – Introduction

Background to 'drivers of change'

Conceptualising the evolution of the Australian aviation industry to 2050 requires identification of the forces – trends, factors, and influences – that could determine how, when and the extent to which change occurs. While there are many potential drivers of change to 2050, this report focuses on a smaller set of drivers with the potential for significant sector impact.

Drivers refer to the forces that will influence the direction and pace of change within the aviation industry until 2050.

Drivers broadly fall into three categories:

- **Market - demand:** the forces affecting demand for commercial and GA activity (including freight), i.e., traveller preferences
- **Market - supply:** how the industry responds to and meets demand within the market to enable growth, i.e., through workforce or airport capacity
- **Exogenous - sustainability:** the ambitions of and pressures faced by the industry to become more sustainable, and the technologies and operational approaches available to achieve this

Drivers of change were evaluated over the short-term (out to 2030), medium-term (2030-2040) and long-term (2040-2050).

Driver prioritisation approach

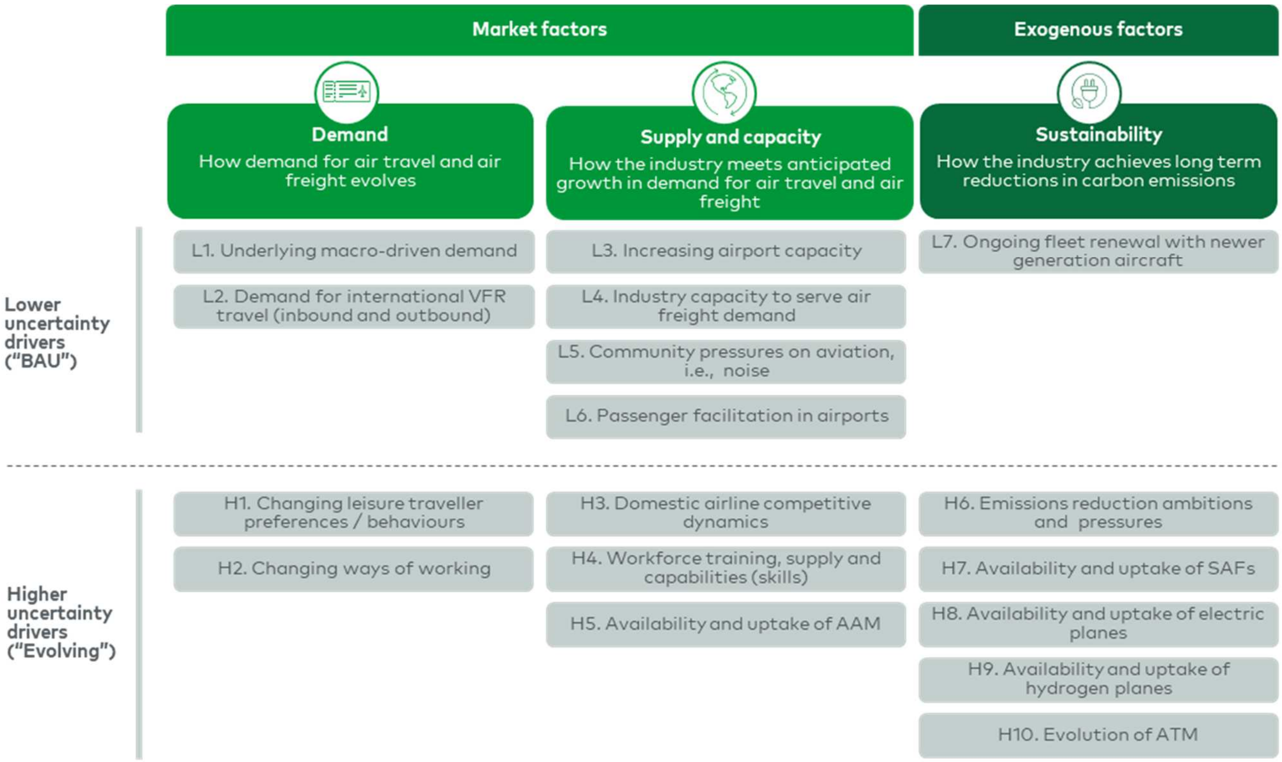
More than 30 drivers of change were initially identified, grouped into the demand, supply, and sustainability categories. Each driver was evaluated and rated using a score of 1 (low) to 3 (high) against the following criteria to create a short list:

- **Materiality of impact | T**he extent of the driver's impact on the aviation industry, including impacts on the environment and communities
- **Breadth of impact |** The breadth of aviation (and related) sectors impacted
- **Level of uncertainty |** The level of uncertainty surrounding the driver's breadth, magnitude, and timing of impact (for all plausible changes)

The short list of drivers can be seen in the graphic over the page. All drivers in the short list have the potential to materially impact the aviation sector. Drivers have been grouped into two levels of uncertainty: higher uncertainty drivers (coded with the letter "H") and lower uncertainty drivers (coded with the letter "L"). Higher uncertainty drivers reflect evolving factors such as new technologies, fuel sources and changing traveller behaviours. Lower uncertainty drivers largely represent business as usual (BAU), such as underlying macroeconomic factors, capacity and fleet.

This section summarises and provides commentary on key drivers of change.

Figure 1
Short-list of higher and lower uncertainty drivers



1.3 Drivers – Demand

Commercial aviation (passenger)

Underlying real GDP growth in Australia and inbound passenger markets will remain the key driver of aviation activity in the long-term

Underlying macroeconomic factors – particularly Australian real GDP growth, population, and demographics – will underpin the growth rate of regional, domestic, and outbound international passenger movements by Australians over the medium- to long-term. Freight demand will be driven by similar factors, notably Australian real GDP, population, and export demand for high-value goods. The long-term outlook for Australian real GDP is positive and expected to be in line with historical growth rates (c.2-3%).

Real GDP growth in Australia and other key markets will similarly underpin international aviation growth. As with domestic aviation, Australian real GDP will continue to drive outbound travel by Australians for leisure and business purposes. Positive GDP growth is forecast for key inbound markets such as New Zealand, China and USA, and emerging markets like India, Indonesia, and Vietnam. This growth will continue to drive inbound travel demand, even if the economies of some inbound markets decline.

International non-business aviation is likely to continue growing but changing passenger preferences and behaviours may affect growth

Outbound international leisure demand is strong (accounting for c.50% of all international traffic pre-pandemic) and is likely to remain strong over the short- to medium-term. However, the potential impacts of generational shifts in traveller preferences – such as greater concern for the environmental impacts of air travel or a preference for more / less frequent overseas travel – remain unclear.

Inbound international leisure traffic is similarly likely to remain strong. Leisure / holiday travel (excluding visiting friends and relatives travel) accounted for c.57% of inbound international travel in FY2019. Leisure travel grew at 5.6% per annum between 2010-2019, exceeding the growth rate of total inbound international travel (5.3% per annum).

A growing middle class in Asia and increased international point-to-point connectivity to Australia will support growth in the medium-term. Consumers in key inbound Asian markets are expected to be less sensitive to environmental concerns around air travel. European and North American travellers may reduce long-haul international travel due to sustainability concerns over the medium- to long-term.

Inbound international visiting friends and relatives (VFR) demand comprises c.20% of all international aviation activity and is expected to remain an important driver of international aviation over the long-term, underpinned by the large and growing foreign-born population in Australia.

VFR demand is likely to be more resilient to growing concern around the air travel's environmental impacts than other travel purposes. The key risks to VFR traffic are major shifts in immigration / visa policies and perceptions of Australia as an attractive country in which to live, study and work. There is little evidence that these shifts will occur.

Mix shifts are to be expected for international non-business travel. Between 1991-2019, Australia's main inbound market shifted from Japan to New Zealand (1999) and again to China (2018). These shifts historically offset declines in other markets, with total inbound traffic growing at 5.1% per annum between 1991-2019. Further shifts will continue to occur, with Southeast Asian markets (notably India and Vietnam) emerging as fast-growing sources of inbound international demand.

COVID-19 has introduced significant uncertainty into the domestic business travel market. International business travel is likely more stable

COVID-19 changed the way many people work by accelerating the use and acceptance of remote working, virtual collaboration, and videoconferencing. This has likely had a structural impact on domestic business travel demand, with market participants indicating a potential 10-25% structural reduction in demand for domestic business travel.

International business demand may prove more resilient. This travel tends to be for important, high value interpersonal interactions that are less easily replicated in a virtual environment or is combined with leisure travel given the distance being travelled (to form 'bleisure trips').

Beyond the impacts of changed ways of working, demand for business travel may also be supressed over the medium- to long-term by corporate initiatives to reduce carbon emissions.

Regional aviation demand for passengers and freight is likely to continue in line with historical trends

Regional demand is likely to remain relatively consistent with historical trends, as regional aviation typically caters to travel for non-discretionary purposes, such as work and medical treatment. The key drivers are population, demographics, economic activity (i.e., resources, construction, public service). Regional demand is expected to continue to evolve in line with these drivers.

The material adoption of sustainable aviation fuel (SAF) in the medium- to long-term would help decarbonise air travel, but could disrupt a historic trend towards cheaper flying (unless a reduction in SAF prices occurs)

Real airfares are currently higher than recent historical averages (fares have not consistently exceeded current levels since before 2008) but are expected to decrease in the short-term as the industry recovers from COVID-19 and capacity returns to the market. In the medium- to long-term, there is the potential for a structural increase in airfares as airlines implement net zero plans, increase use of SAF (unless a material reduction in SAF prices occurs) and / or other emissions related cost-base changes such as carbon taxing. The impacts of such an increase on demand are uncertain, although sustained increases in real airfares may suppress demand.

General aviation

Underlying general aviation (GA) demand is likely to continue to grow with population and real GDP in the short- to medium-term

GA is diverse, with GA activity covering training, sightseeing / tourism, fly-in fly-out (FIFO), skydiving, agriculture, medical, emergency services, aerial firefighting, charter, private aviation, and recreational flying. Underlying demand for GA is expected to grow broadly in line with population and Australian real GDP growth in the short- to medium-term, underpinned by growth in tourism and charter / FIFO markets.

1.4 Drivers – Supply

Commercial aviation (passenger)

Domestic airline competition has the potential to be a material driver of change

The Australian domestic commercial airline market has historically been characterised by two major airline groups with a very high combined market share (c.90%) and several smaller airlines primarily operating regional routes.

The start of domestic jet operations by Rex in 2021 and Bonza in 2023 will test whether Australia can sustain more than two carriers in the domestic jet market.

Long-term domestic competition dynamics are difficult to predict. However, higher demand resulting from real GDP and population growth, combined with growing capacity at key airports, may enable the sustainable operation of more than two airline groups.

International capacity and connectivity are expected to continue to grow in support of increasing demand for international air travel

International airline capacity and competition is expected to continue to grow over the medium- to long-term. Although current international capacity – route network, frequency, and total number of seats – remains below 2019 levels (with the result that airfares are materially higher), this is expected to recover in coming years.

Ongoing deliveries of longer-range widebody (A350, B787) and narrowbody (A321LR/XLR) aircraft will continue to support the opening of new routes and increase Australia's international connectivity, particularly with Asia, North America, and Europe.

The need to replace portions of Australia's aging regional turboprop fleet in the medium-term may lead to changes in regional market dynamics, unless new airframes are developed

Australia's regional fleet is aging, with the Saab 340s and Q-300s that serve many regional areas now averaging over 20-30 years old. These aircraft can remain in service for years to come with adequate spares but will likely need to be replaced or substantially refurbished in the medium- to long-term.

The passenger capacity of these aircraft – with c.30-50 seats – is ideal for many regional markets, and there is no alternative aircraft of a similar size currently in production that could serve as a replacement. Unless new airframes come to market, these aircraft will eventually need to up-gauge to a larger aircraft type, such as the c.70 seat Q-400 or the c.100-120 seat A220. As a result of using a larger aircraft, airlines may decide to operate less frequently or withdraw services, depending on individual route economics.

The introduction of larger aircraft onto some regional routes may also trigger airport infrastructure upgrades, which would require funding.

Australia is likely to have sufficient airport capacity to meet its growth ambitions

The opening of new runways and terminals across capital cities from the mid-2020s (notably WSI, MEL, BNE and PER) is expected to provide substantial capacity increases at Australia's largest and most important airports. This will provide additional peak capacity and could increase airline competition.

Enduring labour shortages could constrain aviation activity in the short- to medium-term

Labour shortages are likely to be a fixture of the industry for some time to come, particularly for certain skilled jobs. This challenge is multi-faceted and there is not a simple solution. This issue could impact different areas of the industry disproportionately, with general and regional aviation most likely to be impacted.

Career attractiveness – from pilot to ground handler – has been in decline for decades and has been further damaged by COVID-19.

A "brain drain" of skilled labour to other countries, offshoring of maintenance, repair, and overhaul (MRO) work and the lack of attractiveness of other roles in the industry make it likely that Australia's skill shortage will continue, or even worsen.

General Aviation / AAM

The adoption of Advanced Air Mobility (AAM) in Australia could lead to a substantial increase in aircraft movements in the long-term

The commercialisation of AAM in Australia could substantially increase GA activity in the medium-long term. Depending on the technological advances, AAM could generate high volumes of point-to-point trips in / around both capital cities and regional centres. Range and payload (passenger / freight capacity) will be an important factor in the viable use cases for AAM. Range is expected to start at c.70-100km for initial AAM aircraft, growing to c.200km+ by 2050.

Note: The scope of this review did not include small drones with payloads of less than 50kg (i.e., delivery drones, which have payloads of c.10kg).

Freight

Freight capacity is likely to continue to meet growing air freight demand in the long-term

Both domestic and international in-belly air freight capacity is expected to grow roughly in line with domestic passenger capacity. In addition, ongoing international widebody fleet replacements are likely to lead to an increase in net international freight capacity, as newer aircraft types often have greater capacity than existing aircraft types (e.g., an A350 has a higher freight capacity than an A380).

Broadly, regional freight capacity is expected to accommodate demand (excluding seasonal surges in demand, such as for produce). Expected gradual up-gauging of regional aircraft over the long-term would serve to increase overall capacity.

1.5 Drivers – Sustainability

Sustainable aviation fuel

Sustainable aviation fuel (SAF) will be essential to the decarbonisation of the industry in the long-term

SAF is expected to play a critical role in the decarbonisation of the aviation industry to 2050. SAF will be particularly important for medium-and long-haul flights on larger aircraft, for which other clean technologies are unlikely to be suitable.

The cost premium of SAF over conventional jet fuel and limited SAF production capacity in Australia and globally are major barriers to wider use in the short- to medium-term. Australia will need a reliable supply of large quantities of SAF -- either locally produced or imported -- to decarbonise its medium to long haul (i.e., international) aviation.

The aviation sector will likely be competing with other transport sectors for a limited supply of biofuel feedstocks. However, given the feasibility of other technologies (hydrogen and electric) for other ground-based modes, aviation may be in a position to have first claim over biofuels.

Fleet

The regular fleet renewal cycle will deliver incremental sustainability gains in the short- to medium-term (these gains add up in aggregate)

Ongoing fleet renewal is expected to incrementally improve aircraft / engine efficiency, reducing fuel burn and emissions on a per passenger basis. Incremental improvements in aircraft and engine technology are likely to only deliver modest c.1-2% p.a. savings, insufficient to meet net zero goals (particularly given growing demand).

Electric and hydrogen fixed-wing aircraft may enter the fleet in the medium- to long-term. They will primarily replace regional turboprops and small jets

Electric, hydrogen-electric, and hydrogen powered fixed wing aircraft are considered the most attractive long-term solution to full industry decarbonisation. However, the technology is unlikely to be technically or commercially viable at scale in the near term.

Electric fixed wing airplanes are expected to enter service in Australia in the late 2020s or early 2030s, but with limits on range (up to c.200km) and payload (up to c.19 seats) that will restrict them to short-haul, low-passenger services (i.e., GA, charter, tourism / sightseeing, and some regional RPT services).

However, the introduction of fixed wing electric aircraft could be further delayed if aircraft manufacturers deliver on plans to produce next-generation, conventional turboprop aircraft in the short- to medium-term. Such aircraft would allow airlines to replace their existing, aging turboprop fleets without the infrastructure and operational changes required by electric aircraft.

Hydrogen-electric and hydrogen aircraft are gaining significant industry interest, including from major aircraft manufacturers. However, hydrogen-electric aircraft capable of replacing existing turboprops are not expected to enter service until 2035 at the earliest, with first deployments in 2040-2050 more likely.

A step-change in technology is required for electric, hydrogen-electric or hydrogen powered aircraft to comprise a material portion of the Australian commercial aviation fleet by 2050.

Air Traffic Management

Air Traffic Management (ATM) will likely play a small but important role in increasing aviation sustainability in the short- to medium-term

ATM improvements have the potential to deliver modest environmental benefits in the short- to medium-term (i.e., c.5-10% emissions reduction on short haul routes). This could include free route airspace, improved collaborative decision making (CDM), and AI-enabled dynamic route planning.

1.6 Scenarios overview

Source: Nico Smit (Seaplane in Hobart, Tasmania)

Approach to developing scenarios

Future industry scenarios were developed using top-down and bottom-up approaches:

- The top-down approach involved identifying potential scenarios based on major themes that emerged from stakeholder consultations and industry research.
- The bottom-up approach grouped different drivers to form potential scenarios, guided by the scenario principles.

The scenarios have been informed by consultation with industry stakeholders and the themes arising from those discussions. They are intendent to show how traditional aviation use cases could change in response to the drivers. Consequently, very small aircraft, e.g., UAS and small drones, are not captured.

Importantly, the scenarios assume 'BAU' policy settings at all levels of Australian government. Potential policies that could substantially alter market outcomes, e.g., SAF adoption mandates or subsidies for electric aircraft, are excluded from all scenarios. While not explicitly referenced, the analysis assumes that airlines and other industry stakeholders meet their obligations under the current Safeguard Mechanism policy, and the proposed changes to the policy as of March 2023.

Scenario summaries

Combining both approaches produced seven industry scenarios:

- **S1. Steady State -** The industry evolves in line with historical growth rates and trends, with some us-age of SAF and new technologies
- **S2. Destination Australia -** Australian domestic and international traffic increases substantially due to significant improvements to Australia's tourism proposition and / or a stronger propensity to visit Australia. Domestic competition increases due to Australia's increased profile as a tourism desti-nation, driving high inbound international and domestic air traffic growth
- **S3. Environmentally Conscious -** Demand is structurally reduced by the rise of virtual ways of work-ing and changed leisure traveller preferences, as consumers reduce travel due to environmental concerns
- **S4. Stifled Growth -** Airline, airport and / or labour constraints stifle industry growth, creating excess demand and putting upward pressure on real airfares
- **S5. Green Fuelled Growth** - Green technology and sustainability ambitions are

achieved and exceeded. SAF usage, electric and hydrogen powered aircraft (in the medium- to long-term), and advances in ATM help make flying more sustainable and support consumer demand growth

- **S6. Unsustainable Aviation** - Australian airlines are unable to achieve their SAF uptake targets due to insufficient domestic production capacity and competition for imported SAF. Airlines fail to substantially decarbonise, with demand suffering in the long-term
- **S7. New Mobility Paradigm** - AAM successfully commercialises for a wide range of use cases, materially increasing aircraft movements, improving passenger and freight mobility, and creating additional airspace complexity (this scenario does not quantify traditional RPT passenger movements)

1.7 Scenario analysis – passenger movements and emissions

Introduction

A high-level analysis of commercial aircraft traffic, passenger movements and emissions was developed to tease out the implications of the scenarios on the commercial aviation industry. The analysis builds upon historical real GDP-based demand elasticities to quantify total passengers, seats, aircraft movements, ASKs and CO_2 emissions out to 2050 under the scenarios.

Outputs of the analysis represent unconstrained demand, except for the S4. Stifled Growth scenario. These scenarios are not definitive forecasts; they are intended to help readers understand the relativities of different potential changes to the industry.

Overview of quantitative scenario outcomes

Domestic passenger movements grow in all scenarios, although growth is slowing in most scenarios compared to recent historical growth rates

The scenario analysis uses domestic passenger growth rates between 0.4% per annum (S4. Stifled Growth) and 3.5% per annum (S2. Destination Australia) over the period from 2023 to 2050. Within this range, most scenario growth rates are below the recent historical average of 2% per annum between 2009 and 2019.

The range of growth rates reflects the uncertainty surrounding key drivers of domestic growth, e.g., changing ways of working impacting business traveller preferences, the impact of environmental concerns on travel demand ('flight shame') and the impact on domestic travel of increased international passenger movements.

Consequently, domestic passenger movements reach a maximum of c.150 million per annum (for S2. Destination Australia) and a minimum of c.65 million per annum (for S4. Stifled Growth), compared to c.61 million in 2019.

The scenarios suggest that the rapid historical growth of international passengers is likely to slow as inbound and outbound markets mature

The scenario analysis uses a wider range of range of growth rates for international passengers than domestic passengers. The most aggressive growth rate, of c.6.1% per annum over the period from 2025 to 2050 (S2. Destination Australia), represents an increase on recent historical international passenger growth rate of 5.8% per annum between 2009 and 2019. This increase reflects strong demand side factors that could cause passenger movements to accelerate.

The slowest growth rate in the analysis is for S4. Stifled Growth, for which international passenger movements grow at c.0.2% per annum between 2025 and 2050. This growth rate reflects a market in which supply constraints inhibit the capacity for the airline to serve customer demand.

As a result of the range of growth rates, international passenger movements grow to between c.190 million (S2. Destination Australia) and c.45 million (S4. Stifled Growth) by 2050, up from c.43 million in 2019.

Emissions could increase to 2050 unless SAF adoption occurs in line with current industry targets, or there is a material reduction in passenger movements

Emissions grow above 2025 / 2019 levels in half of the scenarios. The strongest growth occurs in S2. Destination Australia, at c.2.0% per annum, with emissions increasing by 65%

by 2050. For S1. Steady State, emissions grow at c.0.8% per annum, becoming c.25% higher than current levels by 2050.

Emissions decline most strongly in S3. Environmentally Conscious, due to slow growth in passenger movements. Emissions decline for S4. Stifled Growth for the same reason.

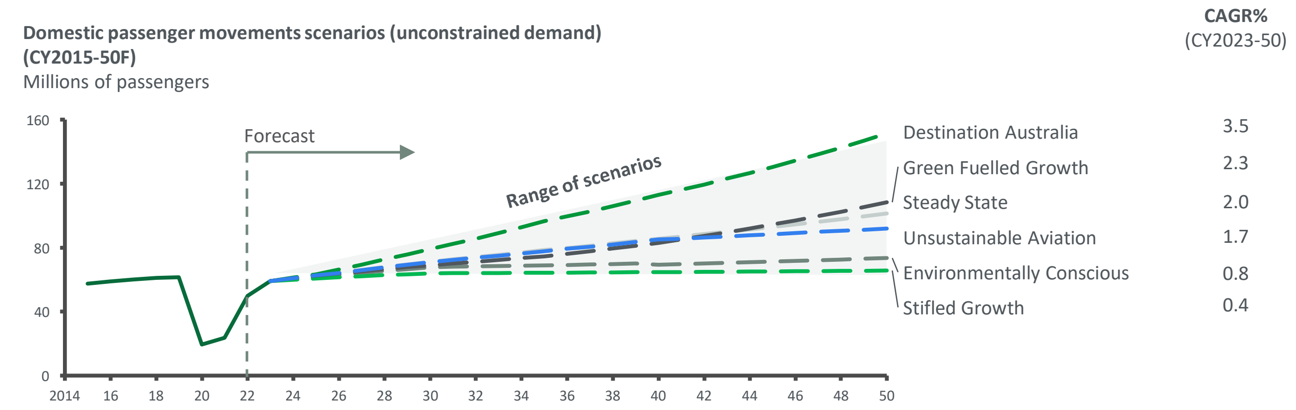
Importantly, all scenarios assume that all relevant airlines and industry participants meet their existing and proposed Safeguard Mechanism targets through a combination of technology improvements, SAF, and offsets. The scenario analysis is broadly consistent with the current, public decarbonisation plans of Qantas Group and Virgin Australia, and assumes that airlines achieve stated ambitions.

AAM could substantially increase aircraft and passenger movements

S7. New Mobility Paradigm analyses passenger and aircraft (passenger and freight) movements in the context of the rapid adoption of crewed and uncrewed AAM aircraft. In this scenario, aircraft movements increase to c.8-10 million per annum by 2050, the majority of which are trips where AAM replaces road-based modes. Total passenger movements increase to c.37 million per annum by 2050.

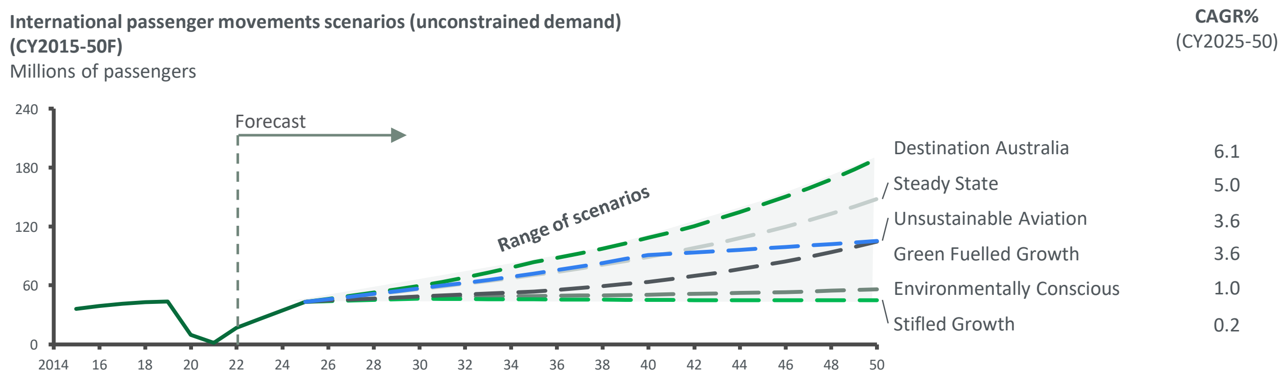
Note: There is no single solution for achieving net zero emissions in aviation by 2050. Industry decarbonisation will require a combination of SAF and emerging propulsion systems (electric, hybrid-electric or hydrogen aircraft) to substantively reduce emissions. Even with these investments and interventions, achieving net zero will likely require large purchases of high-quality carbon offsets. This poses further challenges, particularly whether there will be a sufficient supply of high-quality carbon offsets to meet global demand in coming decades – from aviation and from many other hard-to-abate industries. Solving this problem will require action from both the private and public sectors around the world.

Figure 2
Passenger movements and emissions scenario analysis outputs



Note: CY2022 data only released up until November. Year to date data was scaled to include a December; Includes data for domestic airlines performing RPT services within Australia. Data includes passengers carried between domestic airports on international flights operated by domestic carriers
Source: L.E.K. analysis

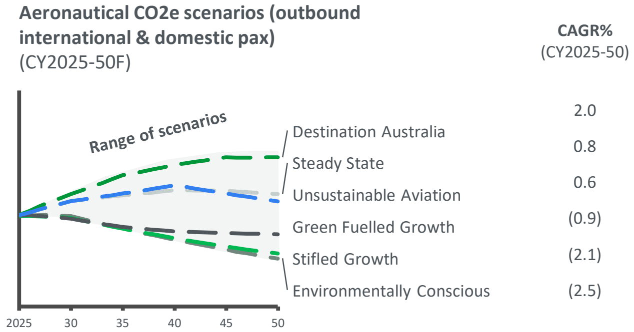
International passenger movements scenarios (unconstrained demand) (CY2015-50F)
Millions of passengers



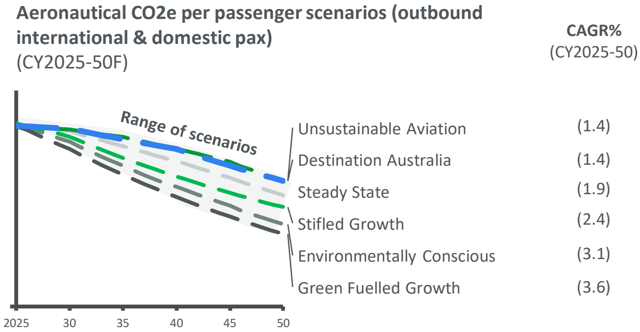
Note: CY2022 data only released up until October. Year to date data was scaled to include a November and December; Passengers include those on RPT services into or outs of Australia and includes passengers transiting Australia

Source: L.E.K. analysis

Aeronautical CO2e scenarios (outbound international & domestic pax)
(CY2025-50F)

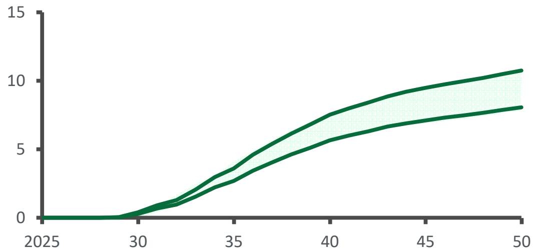


Aeronautical CO2e per passenger scenarios (outbound international & domestic pax)
(CY2025-50F)

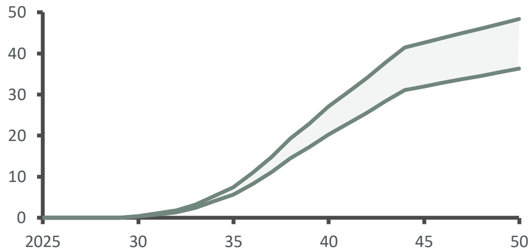


Source: L.E.K. analysis

Indicative total AAM passenger aircraft movements in Australia (CY2025-50F)
Millions of trips



Indicative total AAM passenger movements in Australia (CY2025-50F)
Millions of trips



Source: L.E.K. research and analysis

Source: L.E.K. analysis, based on BITRE passenger movements data

1.8 Scenarios narratives

Scenario 1 – Steady State

Domestic and international aviation demand returns to pre-COVID-19 levels by the mid-2020s, with growth rates broadly returning to pre-pandemic rates for domestic and international traffic. Domestic business travel takes longer to recover to pre-COVID-19 levels from its lower base (returning by 2030), but otherwise grows at pre-pandemic growth rates. Overall, domestic passenger growth averages c.2.0% to 2050. International passenger growth averages c.5.0% per annum to 2050.

Higher international growth rates lead to the balance of air traffic shifting from domestic to international travel. Domestic passenger traffic grows to c.100 million passengers per annum, up from c.61 million in 2019. International passenger movements grow to c.150 million passengers, up from c.43 million in 2019.

This shift has profound implications for the industry. Airport investment and expansion focuses on catering for larger international aircraft, including runway upgrades, Code E gates and additional terminal infrastructure for international passenger processing.

Australian airlines continue to grow, adding some new routes and frequencies. While competition remains healthy, the domestic market continues to support only a limited number of domestic carriers at significant scale. Limited peak slot availability at capital city airports along the east coast acts as a slight drag on competition.

The Australian aviation sector has mixed success recruiting and maintaining its workforce in the short to medium term. Major airlines meet their workforce needs. Some GA operators are unable to successfully meet their needs, which stymies activity in the long-term.

SAF usage gradually increases as production capacity is added, lagging demand and causing high prices. Airlines fail to meet short-term SAF targets, but some meet long-term targets.

Emissions continue to increase at a slightly lower rate than pre-pandemic in the short- to medium-term as next-generation aircraft enter the fleet. Slow SAF uptake leads to emissions being c.25% higher by 2050 than in 2025.

Regional aviation grows slowly, driven by continued demand for commercial travel to regions and regional residents seeking to access services in major cities.

AAM commercialises and scales slowly, with limited use cases in the medium term-long term.

Scenario 2 – Destination Australia

Foreign and domestic tourists, particularly younger travellers, increasingly see Australia as an attractive destination.

Continued VFR growth driven by high immigration levels, strong inbound student demand and income growth in Asia bolsters inbound and outbound international demand growth in the short-term. International business travel demand grows slightly, driven by increased 'bleisure' and conference travel.

International traffic demand grows strongly as a result, at c.6.1% per annum to 2050, or above pre-COVID-19 levels. Domestic passengers grow faster than pre-pandemic, at c.3.5% per annum to 2050.

Australian airlines respond by increasing services to leisure destinations (e.g., the Gold Coast, FNQ, Hobart) from capital cities. In the short- to medium-term, new market entrants take advantage of increased airport capacity and strong growth in domestic traffic levels to achieve material market share. Airlines invest in training and talent pathways to secure their workforces.

International airlines increase services to both Australian capital cities and some non-capital cities, e.g., Hobart, Cairns, and Newcastle, competing on price for leisure travellers. Overall competition increases and real airfares to Australia decrease, supporting sustained increases in international travel to Australia in the medium- to long-term. Regional aviation is a major beneficiary of increased demand growth, with airlines establishing additional routes and frequencies to regional airports.

Domestic and international air traffic passenger movements grow to c.150 million and c.190 million by 2050 respectively. Capital city airports are capacity constrained by 2050, despite investments in new runways and other infrastructure. Other airports near capital cities, i.e., Gold Coast, Newcastle, and Avalon, grow rapidly in later years as their catchments increase and bigger neighbours become constrained.

Aviation emissions increase at a faster rate than pre-pandemic in the short- to medium-term, with the industry focused on price competition rather than sustainability. SAF adoption occurs as prices decline. However, strong growth drives emissions to c.65% higher by 2050 than in 2025.

Increased tourism demand supports some growth in AAM in the medium- to long-term for tourism related GA. AAM uptake for other use cases, limited in the medium term, expands in the long term as technology matures (i.e., more extensive passenger services).

Scenario 3 – Environmentally Conscious

Domestic business travel demand is structurally reduced by c.15% on pre-COVID-19 levels out to 2030. Growth is below historical levels due to extensive work from home (WFH) and environmental concerns. International business travel demand rebounds to pre-pandemic levels in the mid-2020s and grows at pre-pandemic rates.

Lower domestic business travel levels lead to higher real airfares on domestic routes through to 2030, suppressing leisure demand. From 2030, environmental concerns among Australians further suppress short-haul demand, with a corresponding increase in airfares further reducing demand growth.

Domestic leisure travel demand is hardest hit by new environmental concerns as travellers 'save up' their emissions for long-haul travel.

The materialisation of passenger rail upgrades offering higher speeds and increased frequencies on the Sydney to Canberra corridor reduces passenger movements in the medium- to long-term, with only connecting passengers remaining.

Inbound demand growth remains strong for most markets (particularly APAC), except for Europe, where inbound demand growth slows as European travellers avoid long-haul travel and the associated emissions. The decline in inbound European passengers hurts the profitability of international carriers operating into Australia.

Overall, international passenger movements grow at only 1.0% per annum out to 2050, reaching c.56 million passengers (up from c.43 million passengers in 2019). Domestic passenger numbers grow even slower, at 0.8% per annum, reaching c.73 million passengers by 2050 (up from c.61 million in 2019).

Regional aviation activity is more resilient than inter-state and capital city flying. Demand remains mostly strong in the long-term due to the adoption of low carbon aircraft from the 2030s and lower levels of discretionary leisure and business travel.

Environmental pressures encourage investment in SAF. However, competition from overseas and from other modes for feedstocks limit uptake. Airlines fall short of consumer sustainability expectations in the 2030s due to limited adoption of first generation SAF. To counter this, airlines invest in electric and hydrogen aircraft through the 2030s (but achieve limited uptake).

Low demand growth and emissions improvements through SAF adoption result in emissions falling by c.45% on 2025 levels by 2050.

Demand for pilots and crew grows at a slower rate than pre-COVID-19, partially alleviating the skilled labour shortage, particularly for GA.

Scenario 4 – Stifled Growth

Domestic travel demand for non-business reasons returns to pre-COVID-19 levels in the mid-2020s. Business travel demand is structurally reduced post-pandemic. International travel demand returns to pre-pandemic levels.

A lack of pilot and aircraft maintenance labour in the short- to medium-term inhibits domestic supply. Existing programs to improve workforce availability (e.g., Alliance's apprenticeships) fail to improve supply. International carriers, also labour constrained, target Australian pilots.

Labour shortages lead to reduced growth across all airlines, contributing to excess demand and higher prices for domestic and international travel.

Regionally, there is no replacement for the existing turboprop fleet. 'Thinner' regional services are withdrawn in the medium term, with regional flying concentrated into major regional airports (i.e., Dubbo, Wagga Wagga) that can handle jets.

Australian airlines shift widebody aircraft from international to domestic routes to reduce pilot demand. International passenger and freight capacity suffers in the short-term, and domestic frequencies reduce.

To address the skilled labour shortage, Australian airlines increase salaries to attract / retain talent. Consumers bear these costs through elevated airfares, further depressing demand in the medium- to long-term.

Overall, high airfares, reduced services and frequencies and a poor flying experience due to frequent cancellations and longer queues depress passenger movement growth. Domestic passengers grow slightly to c.65 million by 2050. International passengers stay flat at c.45 million.

Technology is slow to mature for electric and hydrogen aircraft, leading to low adoption rates in the medium- to long-term. Airlines are more willing to pay for SAF, but production is still limited.

Uptake of electric / hydrogen aircraft is limited in the medium- to long-term. SAF uptake is faster but remains limited in the medium term. However, stagnant passenger growth leads to emissions decreasing by c.40% by 2050 on 2025 levels.

General and regional aviation activity significantly diminishes in the medium- to long-term. Major tourism and charter operators are unable to maintain their operations, at the expense of local tourism economies across Australia.

Scenario 5 – Green Fuelled Growth

Within Australia and globally, industry stakeholders invest in SAF production capacity and feedstock security in the short term. Through the 2020s, aircraft manufacturers, fuel suppliers, airlines, airports, and governments collaboratively invest in first generation SAF production. SAF availability allows airlines to rapidly increase their use of SAF, albeit at higher prices.

Australian airlines meet their SAF targets in the short term (c.10% SAF usage by 2030) and in the medium- to long-term. Airlines initially uplift SAF through international ports, but SAF is increasingly blended into domestic fuels as domestic SAF production capacity matures. In the long-term, SAF reaches pricing parity with traditional fuel, encouraging further adoption.

Airline efforts to use SAF allay consumer concerns for the environmental impacts of flying. As a result, demand growth accelerates in the medium-long term.

Overall, domestic passenger movements grow at c.2.3% per annum to c.110 million passengers by 2050. Domestically, aeronautical growth is strongest on routes between major cities. Regional growth is less affected by passenger concerns for the environmental impacts of flying. International passenger movements grow faster, at c.3.6% per annum, reaching c.105 million by 2050.

Extensive SAF use by major Australian airlines and rapidly declining SAF prices delay the introduction of electric and hydrogen powered aircraft. Smaller aircraft successfully commercialise in the late 2030s, replacing turboprops that service regional areas and are approaching end of life. Larger aircraft do not enter service before 2050. The overall impact of hydrogen and electric aircraft on emissions is limited, contributing c.0.3% to overall emissions reductions.

Hydrogen and electric aircraft also find some success in GA applications. Major use cases include AAM and flight training, as lower operating costs offer attractive economics for operators.

ATM practices also play a role in reducing emissions. In the 2020s and 2030s, Airservices Australia and other ANSPs from other jurisdictions implement a series of ATM improvements, including free route airspace, dynamic route planning and improved decision making. UTM systems also advance during this period, with UTM and ATM systems integrating in the long-term.

Overall, despite strong growth in passenger traffic, successful decarbonisation efforts result in a slight decline in emissions long-term. The industry stops emissions growth and closes the gap to net zero with offsets.

Scenario 6 – Unsustainable Aviation

SAF fails to deliver as the primary mechanism of decarbonisation for the aviation industry. Competition for feedstocks, production capacity from other biofuels (i.e., biodiesel and ethanol) and a failure to invest in second generation SAF pathways hinders SAF availability in Australia in the medium- to long-term.

Australian and international airlines fail to achieve their SAF targets in the long-term. SAF uplift at international ports is insufficient to offset SAF unavailability at domestic ports.

In the short- to medium-term, passengers are unfazed by a lack of progress for SAF. Domestic and international demand continues to grow at pre-pandemic rates in the short-term, leisure travel having rebounded to pre-pandemic levels in the mid-2020s (business travel is slower to reach pre-pandemic levels). Real airfares return to pre-pandemic levels, supporting ongoing demand growth in the short- to medium-term.

In the long-term, industry failure to decarbonise leads to slower growth for leisure and business travel, as travellers become increasingly concerned for their emissions.

Overall, domestic passenger movements grow to c.90 million passengers per annum by 2050, with growth having slowed from 2040 onwards (an average growth rate of 1.7% per annum to 2050 from 2023). International passenger movements grow faster, at c.3.6% per annum to c.105 million by 2050.

The high cost of SAF (due to production constraints) makes the use of electric / hydrogen aircraft (AAM and STOL) for short-haul regional flying more viable. Airlines primarily invest in electric and hybrid propulsion system conversions, with limited investment in new aircraft. Converted electric / hydrogen aircraft enter commercial service in a limited capacity during the late 2030s and 2040s. These aircraft inject new life into ailing regional networks as lower operating costs, and the need to operate high frequencies to offset capital costs, encourage airlines to operate new services and frequencies.

Strong air traffic growth and limited SAF and low-carbon technology uptake result in emissions growing at a faster rate than pre-pandemic to 2040. However, the slowdown in demand growth from 2040 onwards leads to emissions decreasing between 2040 to 2050. Overall, emissions grow by c.15% between 2025 and 2050.

Scenario 7 – New Mobility Paradigm

The AAM industry, both in Australia and globally, successfully trials AAM in the short-term. Government and private industry respond to successful trials by investing in urban and regional vertiports and infrastructure in the short- to medium-term. AAM leverages regional aviation infrastructure where appropriate, increasing regional airport utilisation.

The industry successfully works with Civil Aviation Safety Authority (CASA) and Airservices to develop new flight rules and ATM principles to eventually support uncrewed aircraft adoption in the medium- to long-term.

Airservices, CASA and industry introduces rudimentary UTM in the mid-2020s. This system is sufficient to support initial commercialisation of AAM aircraft. In the medium- to long-term, Airservices upgrades the UTM system with better tactical conflict detection and avoidance. In the long-term, UTM integrates into the core ATM infrastructure, supporting the scale up of AAM operations.

AAM successfully commercialises for tourism, freight and emergency services uses in the late 2020s. In the medium- to long-term, AAM usage scales as ticket prices decline, driven by increased utilisation.

The successful scale up of AAM leads to a substantial increase in GA activity in the medium- to long-term. AAM replaces some private vehicle trips (e.g., taxis, ride share) on selected journeys greater than c.20-25km.

Point-to-point (PTP) flying across urban areas and around major regional centres (i.e., Geelong, Wagga Wagga, Cairns) proliferates in the medium- to long-term, connecting areas without direct transport links.

Overall, aircraft movement increases substantially, with AAM driving an additional c.8-10 million movements per annum by 2050 (compared to c.3 million aircraft movements today).

AAM mostly supplements traditional aviation in the long-term. However, for some low volume RPT routes, e.g., Sydney to Newcastle, customers increasingly adopt AAM.

1.9 Implications

Introduction

The scenarios point to several areas with a potential need for industry and government intervention. These include enabling or ensuring:

- Sufficient SAF feedstock availability and domestic production capacity
- Net zero emissions targets
- Pilot and engineer workforce availability
- Inbound international demand growth
- Electric aircraft adoption
- Hydrogen aircraft adoption
- Commercialisation and scale up of AAM

Each of these have 'triggers' for possible intervention required. Triggers are events, milestones or developments representing inflection points where the industry may take notably different paths.

Potential interventions and timing

Potential interventions can be grouped into shorter-term vs. longer-term.

Potential short-term interventions may include:

- Securing SAF feedstocks for Australian producers and investing in domestic SAF production capacity (as opposed to renewable diesel production)
- Ensuring a portion of domestic SAF production is reserved for domestic use rather than export
- Supporting the electrification of other transport modes to reduce competition for SAF / biofuels
- Introducing measures to improve the attractiveness of aviation careers, e.g., financial support, training pathways and training capacity
- Adjusting skilled migration programs to attract skilled aviation workers to Australia
- Investing in tourism infrastructure and marketing to grow international demand beyond current and planned commitments
- Expanding bilateral traffic rights with key markets to increase international passenger and freight capacity
- Investing in domestic hydrogen production and logistics infrastructure
- Designing airspace for drones and AAM, and implementing a first generation UTM system

In the medium- to long-term, potential interventions may include:

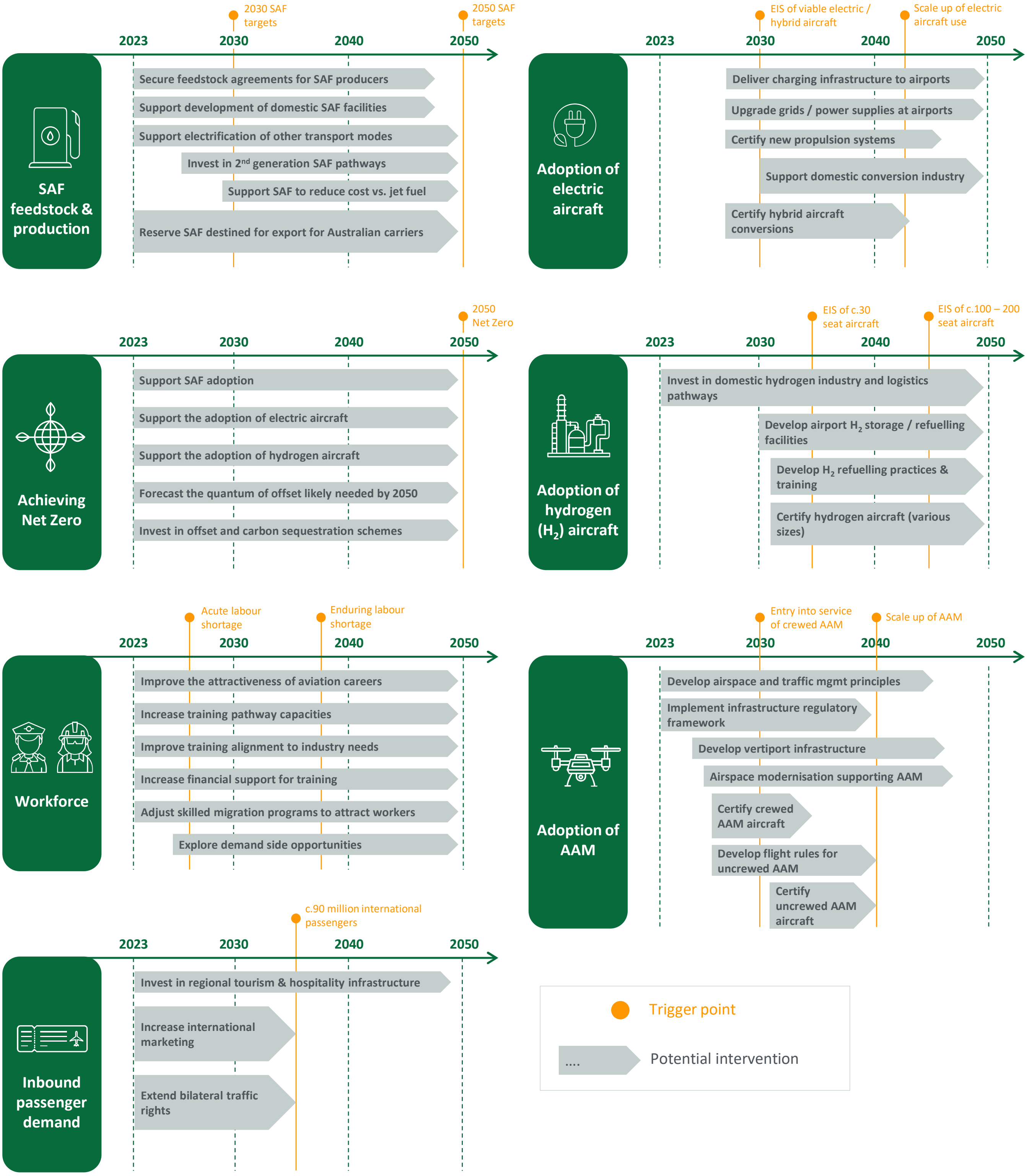
- Investing in second generation SAF pathways to increase the emissions savings potential of SAF, while reducing SAF costs
- Introducing measures to support SAF adoption by reducing the cost of SAF versus traditional jet fuel
- Exploring demand side options to alleviate potential future pilot shortages (such as reduced crew operations)
- Investing in electric and / or hydrogen refuelling infrastructure at airports, including storage facilities for hydrogen (particularly at smaller / regional airports)
- Upgrading electrical grids to support electric aircraft charging at airports (particularly at regional airports)
- Certifying new aircraft types (e.g., electric aircraft, hydrogen aircraft and crewed and uncrewed AAM aircraft)

- Supporting domestic electric and hybrid-electric propulsion system conversion programs
- Developing new flight rules for remotely piloted and autonomous aircraft (i.e., digital flight rules)
- Investing in infrastructure required to for AAM (e.g., vertiports, communications, UTM, and charging)
- Supporting the availability of high-quality carbon offsets

Potential interventions and trigger points

Figure 3

Key triggers for potential industry and government intervention



Source: L.E.K. analysis

1.10 Conclusion

This report is intended for use by the Department as an input into the Aviation White Paper. The report outlines perspectives on the expected key drivers of change in the aviation sector to 2050, and scenarios for the potential evolution of the industry. The scenarios in this report were designed to facilitate discussion on the future of Australia's aviation sector and inform thinking on policy implications during the Aviation White Paper development process.

The drivers of change, stakeholder consultations, and scenarios analysis highlighted four key findings:

1. Underlying demand is strong and enduring

- Underlying passenger (domestic, international, regional and general) and freight growth is likely to be robust to 2050, unless there is a major shift in consumer preferences and behaviours
- International demand is expected to grow the fastest, with international passenger movements overtaking domestic movements in the 2030s
- In all scenarios, passenger demand increases, despite potential environmental concerns and/or higher real airfares to pay for the cost of decarbonisation
- Growth will naturally moderate over time, but aviation will play a critical role to 2050

2. Decarbonisation will be a key driver of change

- Stakeholders consistently highlighted Decarbonisation as a strategic imperative for the industry was the most consistent theme in stakeholder consultations
- SAF is the main lever through which most industry participants are seeking to decarbonise in the period to 2050, but SAF alone cannot deliver decarbonisation
- Competition for Australian feedstocks from other jurisdictions, competition for domestic biofuel production capacity, and the high price of SAF relative to traditional jet fuel could slow SAF availability and adoption
- Even with further improvements in aircraft efficiency, emissions are likely to increase with demand growth in the long-term, leaving an 'emissions gap' to net zero of c.35-50% of total emissions by 2050
- Electric and / or hydrogen aircraft are unlikely to fill this gap by 2050, based on current OEM timelines, expected technology range and payload limitations, uncertain operating economics, and fleet replacement cycles
- Consequently, in the period to 2050 the aviation industry will likely need to rely on the significant use of offsets to reach Net Zero. Securing high-quality offsets will be critical

3. Capacity growth is unlikely to constrain demand growth

- Commercial motivations will likely ensure that the capacity growth of airlines, airports and supporting industries keeps pace with demand
- Multiple stakeholders flagged that limited availability of skilled labour - notably aircraft maintenance engineers - may impact parts of the sector, particularly GA / regional aviation
- While workforce issues are partly cyclical, prolonged shortages could structurally damage some areas of the industry
- Therefore, there may be a case for intervention to preserve critical industry capabilities and connectivity in general and regional aviation

4. Australia's skies will get busier

- Aircraft movements are highly likely to grow - in the highest growth scenario, movements will approximately triple by 2050. However, AAM could present the biggest potential change to Australia's skies
- Passenger and freight drones could lead to a huge increase in air traffic movements and air-space complexity, particularly in urban areas. If the industry successfully scales in the long-term, AAM aircraft movements could grow as high as c.8-10 million per annum (by comparison, total aircraft movements are c.3 million per annum today)
- Next generation ATM systems (including UTM) will play an increasingly important role as traffic increases. Increased aircraft movements will also likely intensify debates about the balance of community concerns (i.e., noise, safety) with the social and economic benefits of aviation growth

It will be incumbent on all stakeholders – industry, government and community – to collaborate to achieve a future where aviation is accessible and beneficial to as many people as possible

2. Introduction

2.1 Introduction

Source: Nick Sarvari (Brisbane Airport)

Since the first powered flight in Australia in 1910, aviation has been a core component of Australia's economic and social landscape. Aviation is a fundamental pillar in Australia's economy, transporting people and high-value time-sensitive goods, as well as enabling business across vast distances. It serves as Australia's primary connection to each other and the rest of the world.

The Australian aviation industry has matured and undergone a substantial transformation, evolving from a collection of fledgling operators providing postal services to rural areas into a substantial industry. In 2018, the sector directly employed 176 thousand people,[2] carried c.1.3 million tonnes and moved c.42 million passengers domestically and to and from international destinations.[3] Aviation directly contributed c.US$16 billion to the Australian economy (c.1% of GDP) and indirectly generated up to cUS$53 billion, supporting industries like tourism, mining, and higher education.[4]

The aviation industry comprises two core components: commercial aviation and general aviation (GA). Commercial aviation activity involves the scheduled transport of passengers and freight. Within the domestic aviation market, Qantas Group and Virgin Australia are the two largest operators. Regional Express (Rex) and Alliance also have substantial operations.[5]

The international market is more diverse: overseas carriers held a market share of c.67% in 2010.[6]

Commercial aviation in Australia operates out of a network of international and domestic airports. The state capital city airports hold most of the passenger share, with the top five airports (Sydney, Melbourne, Brisbane, Perth, and Adelaide) responsible for c.71% of domestic passengers and c.94% of international passengers.[7]

GA comprises all remaining non-scheduled aviation activity. Types of GA activity include charter flying, tourism / sightseeing flights, emergency services flying and recreational flying. GA typically occurs out of dedicated GA airports (Bankstown, Essendon and Archerfield being key examples) or regional

[2] Australian Government, The Future of Australia's Aviation Sector (2020) © Commonwealth of Australia 2022
[3] BITRE, Freight Performance Dashboard (2021) © Commonwealth of Australia 2020
[4] IATA, The Importance of Air Transport to Australia (2018) © International Air Transport Association, 2019
[5] ACCC, Airline Competition in Australia Report (Sep 2022) © Commonwealth of Australia 2020
[6] BITRE, International Airline Activity (Oct 2022) © Commonwealth of Australia 2020
[7] BITRE, Airport Traffic Data (Oct 2022) © Commonwealth of Australia 2020

airports, using both fixed and rotary wing aircraft.

The industry is still recovering from the effects of COVID-19. In the peak of the pandemic, passengers carried in Australia fell by c.97% and over 40 thousand aviation workers were stood down or laid off.[8] COVID-19 exacerbated the challenges that the industry already faced, including shifts in business travel patterns, labour shortages, and pressures to reduce carbon emissions. Therefore, it is important to set forth policies that ensure industry viability post-pandemic and further into the future.

[8] Parliament of Australia, The future of Australia's aviation sector, in the context of COVID-19 and conditions post pandemic (Mar 2022)

2.2 White Paper background

The Australian Government has historically played an important role in supporting the Australian aviation industry. Essential to this role has been maintaining an open dialogue with industry stakeholders to inform sector policy development.

In 2022, the Australian Government announced its commitment to delivering an Aviation White Paper ('the White Paper') to guide the next generation of growth and innovation in the aviation sector.

The new White Paper comes 13 years after the last paper and follows a period of significant global turbulence in the aviation industry, notably COVID-19. This turbulence has created operating challenges for government and industry in the short-term and could have substantial medium- to long-term implications.

The White Paper terms of reference put forward a need to explore the likely future trends in aviation over the period to 2050, focusing on:

- Aviation's role in economic development, trade, and the visitor economy - general, domestic, regional, and international aviation
- Maximising the aviation industry's contribution to achieving net zero carbon emissions, including through SAF and emerging technologies
- Changing aviation technologies and ways to position our policies, regulations, and systems to encourage uptake and manufacturing of new and more efficient transport technologies
- Airport development planning processes and consultation mechanisms that consider the impact and changing nature of aircraft noise, and related expectations on noise sharing and noise mitigation
- Ideas on how to support and regenerate Australia's GA sector
- Future industry workforce skills and training requirements
- Appropriate consumer protections and access to services
- Maintaining fit-for-purpose aviation safety, air navigation and aviation security systems and service delivery agencies
- The role of airlines and airports in supporting regional economies
- Other significant issues raised during the consultation process

2.3 Purpose of this document

To assist with this process, the Department of Infrastructure, Transport, Regional Development, Communications and the Arts ('the Department') engaged L.E.K. Consulting (L.E.K.) to:

- Identify key drivers of change in the aviation sector
- Develop and validate possible future scenarios based on a range of identified drivers
- Identify potential triggers and implications for reform and/or policy development in the medium- to long-term

This document consolidates the project's findings on the above topics.

The remit of this project was broad, covering all commercial and general aviation activities that occur in Australian airspace. However, certain areas were not considered. These include:

- Autonomous and remotely piloted drones with less than c.50kg payloads (i.e., delivery drones that can carry c.5-10kg, or video drones)
- Defence related aerospace activity
- Very high-altitude / low earth orbit aerospace activity
- Space-related activity

The research, analysis and stakeholder engagement for this report was conducted over the period from November 2022 through March 2023. **All information, analysis and findings are as at March 2023**.

2.4 Stakeholder engagement

This work surveyed a sample of volunteer industry participants to gather early input into the key drivers of sector change to 2050, to inform both this report and the Department's understanding of the key issues.

The Department is running a broader comprehensive consultation process as part of the full development of the White Paper.

We acknowledge that views expressed were provided in the spirit of assisting the Department in understanding drivers of change in the sector, rather than in providing official statements or positions, and as such have been aggregated and deidentified.

The Department and L.E.K. would like to again thank the participants for their time and perspectives.

3. Drivers of industry change

3.1 Introduction

Background to 'drivers of change'

Conceptualising the evolution of the Australian aviation industry out to 2050 requires an understanding of the forces that could influence how, when and the extent to which change occurs. To build this understanding, historical and expected trends, factors and influences were categorised into different drivers of change, or 'drivers.'

Drivers refer to the forces that will influence the direction and pace of change within the aviation industry until 2050.

Drivers can be actions taken by non-government industry participants, major macroeconomic trends, or exogenous influences (e.g., foreign government policy, other market shocks). There are three categories of drivers:

- **Market - demand:** the forces affecting demand for commercial and GA activity (including freight), e.g., traveller preferences
- **Market - supply:** how the industry responds to and meets market demand to enable growth, i.e., through workforce or airport capacity
- **Exogenous - sustainability**: the ambitions of and pressures faced by the industry to become more sustainable, and the available technologies and operational approaches to achieve this

Drivers of change are evaluated over the short-term (out to 2030), medium-term (2030-2040) and long-term (2040-2050).

Driver prioritisation approach

More than 30 drivers of change were initially identified, grouped to the above categories.

Each driver was then rated using a score of 1 (low) to 3 (high) against the criteria of:

- **Materiality of impact |** The extent of the driver's impact on the aviation industry, including impacts on the environment and communities
- **Breadth of impact |** The breadth of aviation (and related) sectors impacted
- **Level of uncertainty |** The level of uncertainty surrounding the driver's breadth, magnitude, and timing of impact (for all plausible changes)

Further detail on the driver prioritisation approach, including the scores for each driver, is provided in the appendix.

Drivers with high levels of impact materiality and breath but low levels of uncertainty are designated as 'lower uncertainty drivers.' Lower uncertainty drivers represent the major underlying trends and influences in the industry, which would continue absent of other influences. These drivers are coded using the letter "L."

Drivers with high levels of impact and materiality and high levels of uncertainty are 'higher uncertainty drivers.' These drivers are the most likely sources of change in the industry and form the basis of the scenarios. These drivers are coded with the letter "H."

Remaining drivers with lower levels of impact and certainty are deprioritised in this document but remain important considerations for the development of the White Paper.

The full list of higher and lower uncertainty drivers is displayed on the next page.

Headwinds and tailwinds

The terms 'headwinds' and 'tailwinds' are used to describe potential driver influence.

Tailwinds are denoted by green upwards point arrows. They represent trends or influences that are likely to support industry growth, profitability, and technological progress in either the short-, medium- or long-term.

Headwinds are denoted by orange or red downwards pointing arrows. They represent trends or influences that will hinder growth and profitability or constrain technological progress in the short-, medium- or long-term.

A yellow dash denotes where the influence of the driver is neutral, or dependent on how the industry responds to other driver.

Table 1
Higher and lower uncertainty drivers

Category	Driver	Definition
Demand	Traveller preferences (domestic and international leisure travel)	The demand for leisure travel (inbound / outbound international and domestic) and how 'flight shame,' market shocks and Australia's attractiveness may impact traveller preferences
	Changing ways of working (business travel)	The impact of working from home and video conferencing technology on demand for business travel
	Underlying macro-driven demand	Underlying demand drivers including Australian real GDP and population growth
	Demand for inbound international VFR travel	How the demand for inbound and outbound flights for the purpose of visiting friends and family impacts the aviation industry
	Industry capacity to service air freight growth	The impact of express freight demands on dedicated freighter and belly freight capacity
Supply and capacity	Domestic airline competitive dynamics	The level of market competition and the resulting airfares / capacity dynamics in the Australian domestic context
	Workforce training, supply, and capabilities (skills)	How the demand for skilled aviation workers e.g., pilots and engineers, and the availability of training providers to ensure adequate supply, skill levels, and mix of skills will influence the future of aviation
	Availability and uptake of AAM	How the commercialisation and uptake of AAM (large, typically uncrewed aircraft used for passenger, freight, and other purposes) impacts the aviation industry
	Increasing airport capacity	The impact of increasing airport capacity includes new airports, runways, terminals, and gates on airlines, competition dynamics and the wider aviation industry
	Community pressures on the aviation sector (e.g., noise)	How the pressure and complaints made by the community, due to aviation operations will impact the industry
	New airport processing technology/safety	New technology such as automated security gates and the resulting impact on the aviation industry
Sustainability	Emission reductions ambitions and pressures	The ambitions, targets and external pressures faced by the industry to achieve environmental outcomes which may have impacts on growth and or profits
	Availability and uptake of SAF	The estimated uptake of SAF and the level of production capacity available to meet aviation industry demand
	Availability and uptake of electric planes	The impacts of potential commercialisation and uptake of electric aircraft on the aviation industry
	Availability and uptake of hydrogen planes	The impact potential commercialisation and uptake of hydrogen aircraft will have on the aviation industry

Category	Driver	Definition
	Evolution of ATM	The impact of ATM technology evolution, practices and priorities can affect fuel burn and emissions, airport operational efficiency, and support the adoption of new drone and AAM technology
	Ongoing fleet renewal with new generation aircraft	The replacement of current and future fleet with incrementally better aircraft technology, over time

A note on industry resilience

A resilient aviation industry is critical to Australia's wider economic and social resilience

The aviation industry is a critical enabler of the Australian economy, moving people and freight across the country. It also plays an important role in tourism, healthcare, trade, firefighting, agriculture, and emergency services, to name a few. A resilient aviation sector is therefore both essential to the success of the country, and the resilience of its people and services.

The aviation industry has shown strong resilience in the face of historical shocks and changing market conditions, even when individual market participants have not

While global passenger and freight demand growth has been remarkably resilient over time, the commercial airline industry is well known for its exposure to shocks and the commercial fragility of many individual market participants. These shocks include:

- **Demand shocks** that reduce the willingness or ability of people to travel, e.g., acts of terrorism, oil price volatility and recessions
- **Supply shocks** that reduce the industry's capacity to meet demand, e.g., airspace closures, and fuel shortages
- **Exogenous shocks** that disrupt normal industry operations, e.g., volcano eruptions, extreme weather events and pandemics

While there is high uncertainty around the timing, scope and magnitude of shocks, there is low uncertainty that they will continue to occur. The worst of these shocks have required government intervention to ensure the continued operation of the commercial aviation industry.

There are many examples of how the industry, and individual airlines, have been resilient to shocks. In 2001, the Australian aviation market was impacted by a trifecta of shocks: the 9/11 terrorist attacks, Ansett collapse and softening global economy. While this caused a dip in passenger movements, a new airline (Virgin) entered the market in 2002 to fill Ansett's gap, passenger traffic exceeded 2001 levels within c.18 months and traffic returned to a strong growth trajectory.

COVID-19 has made the industry more resilient

COVID-19 was by far the most severe shock in aviation history. Travel restrictions and border closures brought the Australian aviation industry to a near-standstill. As a result, Virgin Australia entered voluntary administration and most other industry participants – e.g., Qantas Group, airports, ground handlers – sustained substantial financial losses. Significant financial support from government was required to support continued operations and maintain essential passenger and freight connectivity.

However, the pandemic brought a silver lining: it has most likely strengthened industry resilience to shocks. Airlines, airports, and others were forced to rewrite playbooks on responding to shocks, becoming nimbler in making operational changes and diversifying revenue sources (e.g., airline expansion of dedicated freighter capacity, airport investment in non-aeronautical revenue sources). In the face of future shocks, this means the industry is likely in a better position to respond and may be less reliant on government subsidies.

The pandemic may have also led to a greater degree of industry conservativism in the short-term. For example, the return of capacity continues to lag demand. While this may not be an optimal result for consumers in terms of airfares and domestic / international network connectivity, it is an indicator of greater resilience. Over the medium- to long-term, competitive pressures will likely wear away at this conservativism, but the lessons of the pandemic may lead to a permanent shift in risk appetite.

The pandemic also accelerated the retirement of older, less fuel efficient, noisier aircraft. As airlines rebuild and grow their fleets, it will be with a higher proportion of newer, more efficient aircraft.

Long-term route consolidation in regional aviation may be an indicator of declining resilience

The number of Australian regional airports with commercial services has declined over the past 30 years, at the expense of the connectivity of regional communities. Between FY1989 and FY2019, the number of regional and remote routes declined from 458 to 291 (the number of remote routes dropped from 264 to 163).[9] This route consolidation has also led to a consolidation of airlines serving regional and remote areas. In the future, continued consolidation of regional populations in larger regional centres, slot constraints at capital city airports, and aircraft up-gauging (due to the lack of an appropriate replacement for existing c.35 seat aircraft) will likely cause further consolidation of regional routes.

Aviation plays an important role in connecting regional and remote communities for business, healthcare, education, and family and friends. Reduced air services impact passenger connectivity, as well as freight capacity growth potential of regional / remote communities.

Over the long-term, it is possible that AAM will improve regional air connectivity for passengers and freight by enabling point-to-point networks and on-demand air services on short sectors (i.e., 200-400km). Similarly, it is possible that the electrification of small fixed-wing aircraft (i.e., 9-14 seats) will materially reduce operating costs on short sectors.

This may also lead to a resurgence of air connectivity to small regional communities (subject to affordable up-front capital costs and slot capacity at larger airports).

There are other long-term risks to industry resilience – but the industry has time to prepare

Beyond "acute" shocks such as terrorism, natural disasters and pandemics, the aviation industry faces potential structural challenges to resilience.

In the medium- to long-term, climate change could result in a higher frequency of severe weather events that disrupt aviation operations, such as storms, bushfires, or flooding. Over the very long term (beyond 2050), rising sea levels could increase the risk of flooding at coastal airports.

The availability of skilled labour may be another challenge to industry growth and resilience, notably for licensed aircraft maintenance engineers and pilots.

[9] BITRE, Domestic Aviation Activity – Cities and Regions 1985-86 to 2020-21 (2021) © Commonwealth of Australia 2020

The industry is, to a significant extent, well equipped to handle these challenges. The industry is taking steps to address its current workforce issues (see H4 - Workforce training, supply, and capabilities (skills) for more detail). Similarly, the industry has many years to adjust to the potential impacts of climate change. For instance, the natural growth of Australia's airport infrastructure (i.e., runway extensions / upgrades at non-capital city airports) should increase resilience to severe weather events by expanding options for diversions.

3.2 Demand Drivers

Source: Fred Rivett (Sydney Airport)

Outlook

The underlying drivers of air travel demand, both domestic and international, are expected to remain strong in the long-term. However, changing leisure traveller behaviours and a changing and maturing corporate travel market could reduce the rate of demand growth in the medium- to long-term.

Figure 4
Driver outlook - demand drivers

Lower uncertainty drivers

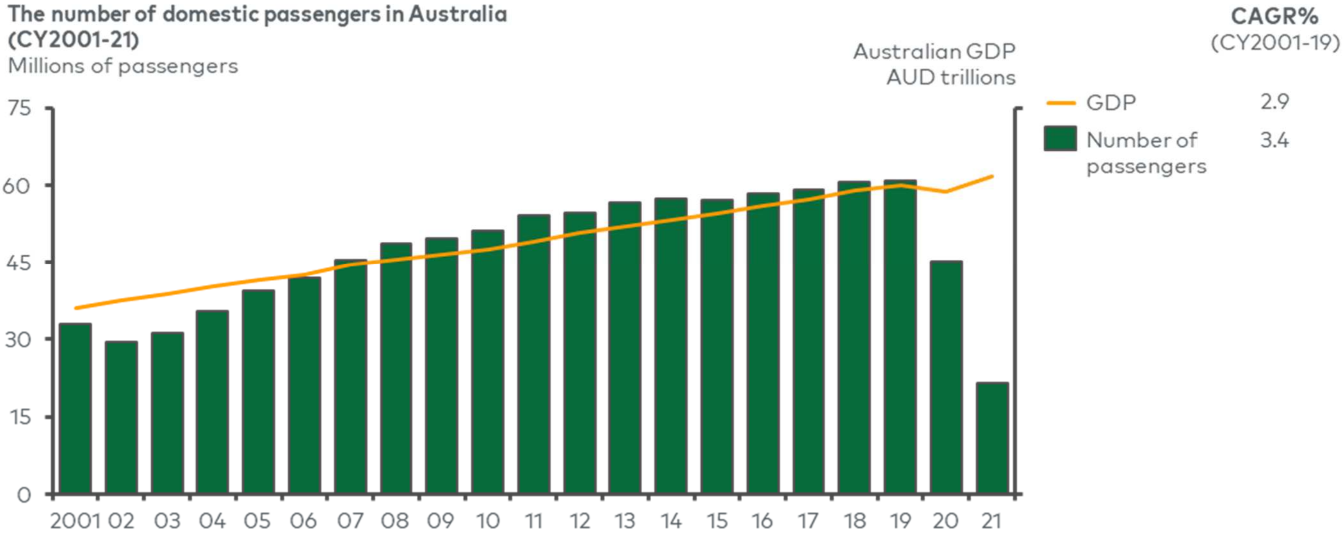
Driver	Long-term expectation
L1 Underlying macro-driven demand	↗
L2 Demand for international VFR travel (inbound and outbound)	↗

Higher uncertainty drivers

Driver	Short-term expectation	Medium-term expectation	Long-term expectation
H1 Changing leisure traveller preferences and behaviours	↗	—	—
H2 Changing ways of working	↘	↘	↘

Industry headwinds ↓ ↘ — ↗ ↑ Industry tailwinds

Figure 5
Domestic passenger volumes vs. Australian GDP (CY2001-21)



Source: BITRE

L1. Underlying macro-driven demand

Domestic aviation demand has historically followed real GDP growth

The Australian aviation market is relatively mature. Domestic aviation growth has historically followed real GDP and population growth. Over the past 20 years, Australian domestic passenger numbers grew by c.3.4% per annum between 2001-2019[10] nd real GDP grew at c.2.9% per annum.[11] Population grew at c.1% per annum over the same period.[12]

Growth in international passenger movements has exceeded domestic growth in recent history. Between 2001-2019, international travel by Australians grew at c.5.2% per annum[13], compared to real GDP growth of 2.9% per annum.[1111] The difference between passenger and real GDP growth is in part due to the greater proportion of leisure and VFR travellers travelling internationally. These travellers are typically more price sensitive, and therefore more influenced by economic changes (more elastic).

In the long-term, passenger movements are likely to grow at c.2% per annum for domestic passengers and c.3-5%+ for international passengers, absent other market forces

Given the relative maturity of Australia's aviation market, it is anticipated that Australian real GDP and population growth will continue to underpin demand growth. Absent other market changes, ongoing Australian real GDP growth of c.2-3% per annum will likely continue to drive comparable levels of domestic aviation activity growth.

International aviation activity may grow faster in the long-term. Growth is likely to moderate in the medium- to long-term as the both the inbound and outbound international markets mature.

Depending on other market factors, the differential growth rates could lead to more international passenger movements than domestic, in the long-term. This could have material implications for airport operations and infrastructure.

[10] BITRE, Australian Domestic Airline Activity (Jan 2023) © Commonwealth of Australia 2020
[11] Euromonitor, Income and Expenditure: Australia (Jul 2022)
[12] ABS, National, state and territory population (Jun 2022) © Commonwealth of Australia 2020
[13] ABS, Overseas Arrivals and Departures (Nov 2022) © Commonwealth of Australia 2020

L2. Demand for inbound international VFR travel

VFR traffic is an important driver of international aviation activity

International visiting friends and relatives (VFR) traffic is an important driver of international air traffic demand, comprising c.17% of inbound international traffic in 2019.[14] Australia's significant population of foreign-born residents and relative wealth make it a significant VFR destination.

VFR is a fast-growing international aviation segment. VFR traffic levels grew at c.6.3% per annum between 2001-2019, compared to 5.2% for all inbound international traffic.[13]

Post-COVID-19, VFR traffic has been an important driver of Australia's international aviation recovery. In FY2022, VFR traffic comprised c.56% of all international traffic, reflecting pent up demand for VFR and a willingness of VFR travellers to pay higher fares (compared to leisure travellers).[13]

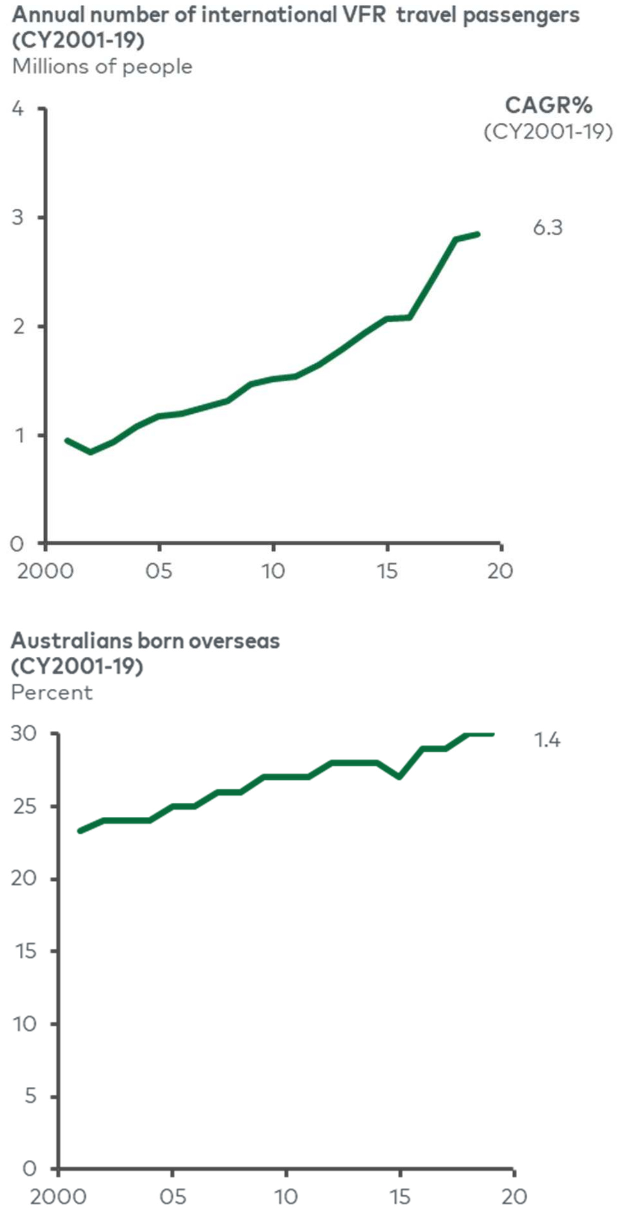
Absent any major policy change, VFR traffic is likely to continue growing at historical rates

While VFR's share of traffic is expected to reduce as leisure travel returns, strong growth is expected to continue in the short-term. The ongoing immigration of knowledge workers, a key driver of VFR traffic, is expected to grow in the long term. The Australian Government increased its immigration intake for FY2023 to 195,000, up from 160,000. International student numbers, another important driver of VFR traffic, appear likely to remain strong. International students have largely returned to Australian universities since COVID-19 restrictions lifted. Absent any substantial change in immigration policy, ongoing population growth through migration will support VFR demand in the short- to medium-term.

Growing levels of wealth in countries that are major origins for immigrants, particularly in South-East Asia, will further support inbound VFR travel demand growth. Increased wealth in these populations will support inbound VFR traffic growth, so long as Australia remains an accessible destination.

Figure 6

International VFR passengers vs Australian born overseas (CY2001-22)



Source: Tourism Research Australia

[14] Tourism Research Australia, International Visitors in Australia (Sep 2019) © Commonwealth of Australia 2020

H1. Changing leisure traveller preferences and behaviours

Leisure travel is an important driver of international aviation activity

International leisure traveller preferences, in terms of where people travel, for what reasons, and how frequently, is an important driver of future aviation activity. Australia received c.9.5 million short-term visitor arrivals in 2019, of which leisure traffic comprised c.57%. Leisure travel grew at c.5.6% per annum between 2010-2019. [11]

Asia-Pacific, New Zealand, USA, and UK are major inbound and outbound leisure markets

Australia's inbound international traffic mix skews towards major Asia-Pacific economies and countries with legacy ties to Australia. In 2019, the largest sources of inbound traffic were the major Asian economies (China, Japan, and India in particular), New Zealand, USA, and UK. Growth in Asian markets, in particular China, underpinned international traffic growth in the last ten years.

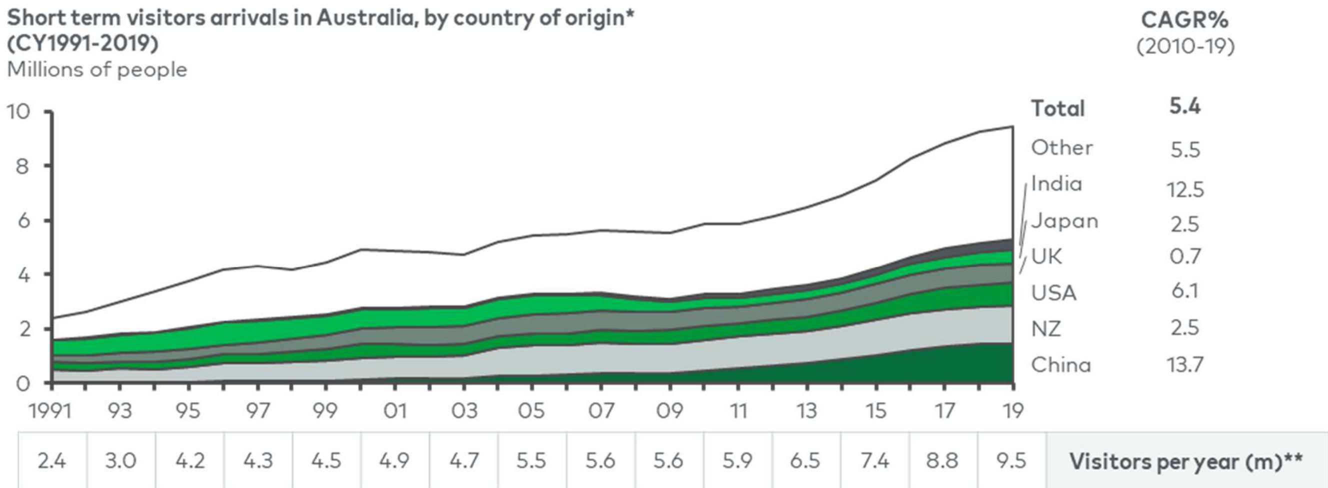
Growth in these markets is likely to remain strong in the short-term. In Australia, younger generations of travellers have an apparent preference for travelling to Asia, a region better suited to shorter, more frequent trips than Europe or North America (48% of trips in FY2019 were to Asia, up from 42% in FY2009).[15]

The introduction of the narrowbody Airbus A321LR in the mid-2020s could also increase connectivity to Asia. This aircraft will make it viable for airlines to offer direct services between Australian capitals, and major regional hubs and smaller cities in Asia.

Inbound travel is likely to be driven by emerging Asian markets. Rising income levels in Asia Pacific, and associated growth in the middle class, will support ongoing demand for travel to Australia from existing and emerging markets. By 2030, over 70% of Chinese nationals will be considered 'middle-class,' up from 25% in 2018 and 3% in 2000; similar growth is anticipated in India.[16] These markets are already significant drivers of inbound passenger traffic and are likely to remain so in the long-term.

Figure 7

Australian inbound arrivals by top 5 countries (CY1991-2019)



Note: * ABS data. Includes both leisure and VFR traffic; ** Total arrivals from all countries

Source: ABS

[15] Tourism Research Australia, Travel by Australians (Jun 2019) © Commonwealth of Australia 2020

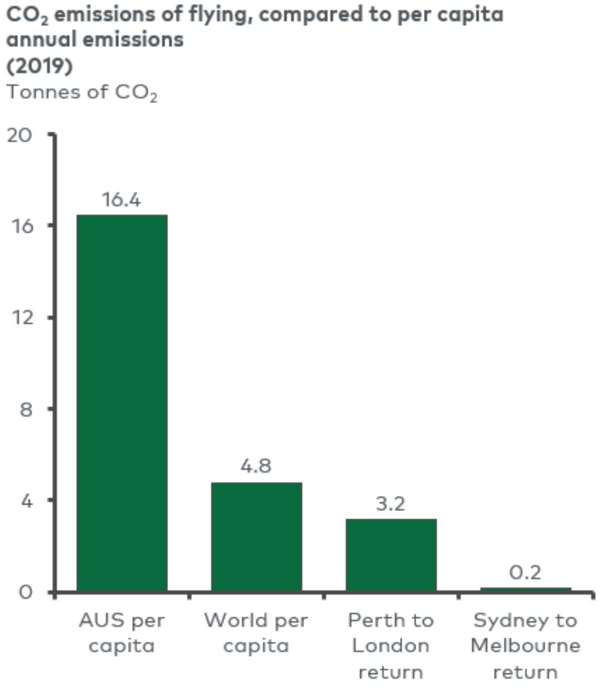
[16] World Bank, Data China (Jan 2023)

Other markets are emerging in Asia Pacific. Vietnam may become a strong source of inbound leisure passengers: total Vietnamese passenger movements grew at 14.7% per annum between 2010-2019.[17] In response, Jetstar and several Vietnamese carriers have opened direct services between Vietnam and Australia.[18]

Environmental concerns could influence Australian leisure traveller preferences

Based on historical trends, there is a high probability that Australia will remain an attractive travel destination in the short-term. However, consumer concerns for the environmental impacts of air travel, "i.e., flight shame," could act as a potential barrier to future leisure travel demand in the medium-term.

Figure 8
CO_2 emissions of flying vs per capita annual emissions



Source: Our World in Data and The Guardian

Travellers have indicated they are increasingly concerned by the environmental impacts of air travel, in particular the associated carbon emissions.[19] In the medium-term, travellers could increasingly factor the emissions produced into their travel habit decisions, either in response to public pressure or personal carbon accounting.[20]

The impacts of carbon accounting on traveller behaviour are unclear. Research suggests that travellers will continue to travel internationally on long-haul flights for leisure purposes but will reduce their domestic travel to 'save up' their emissions for overseas trips.[21] However, the substantial emissions incurred on a long-haul trip could also encourage some travellers to take fewer, shorter trips.

Concerns for emissions could reduce international and domestic leisure travel in the medium-term. This reduction would likely be from Australian travellers taking fewer domestic and long-haul international flights. Travel to medium-haul Asian destinations, e.g., Vietnam and Indonesia, is less likely to be affected than travel to Europe and North America.

Inbound travel is less likely to be affected by environmental travel concerns. Travellers from Asian markets appear to be less concerned about the environmental emissions associated with air travel and are located within proximity to Australia.[22] A substantial change in inbound travel due to environmental emissions is therefore unlikely in the medium- to long-term.

European travellers appear more likely to avoid travelling to Australia. Some European travellers have already demonstrated how travel habits could change in response to environmental concerns, e.g., through a ban on short-haul flights in France that connect cities less than 2.5 hours apart by train.[23] Such a reduction is unlikely to substantially change air traffic levels into Australia given the absence of close substitutes to air travel for

[17] ABS, Overseas Arrivals and Departures, Australia (Nov 2022) © Commonwealth of Australia 2020
[18] Airline websites (Jetstar, Vietnam Airlines, Vietjet)
[19] L.E.K., Consumer Sustainability Survey (2022)
[20] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[21] L.E.K., Consumer Sustainability Survey (2022)
[22] Yang, S., Qiang, H., Wang, Y., Zhang, C., Impact of the Participation of the Tourism Sector on Carbon Emission Reduction in the Tourism Industry, Sustainability (Aug 2022)
[23] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)

most journeys (with the exception of some regional travel under c.4-5 hours driving).

The quality and competitiveness of Australia's tourism assets could influence inbound travel demand

Australia's competitiveness as a tourism destination could be a determinant of future leisure travel activity. Its natural and hospitality assets both play an important role in ensuring Australia's competitiveness.

Australia's tourism reputation is one built upon natural tourism assets, e.g., the Great Barrier Reef, beaches, and wildlife. Depending on the impact of climate change, these regions could see their natural value eroded (such as through mass coral bleaching or drought).[24] Such changes present downside risk to Australia's international and domestic tourism competitiveness.

Australia's hospitality assets could enhance or reduce its international attractiveness. At present, there is a perception that these assets need to be refreshed, particularly in areas like Far North Queensland.[25] Without ongoing refurbishment and regeneration, Australia may lose its appeal to wealthy tourists, particularly from South East Asia.

Market shocks are likely to occur, although frequency and timing are unknown. The market will likely be resilient in the long-term

COVID-19 demonstrated the significance of major market shocks on leisure travel demand. The pandemic disproportionately affected leisure travel, which is yet to return to pre-COVID-19 levels (leisure travel accounted for c.20% of short visits to Australia in 2022, compared to c.57% in 2019).[13] While leisure travel is expected to normalise, the COVID-19 experience highlights the significance of market shocks as a driver of change.

In the long-term, it is almost guaranteed that other market shocks such as terrorism events and future pandemics will occur. These market shocks are expected to cause temporary depressions in leisure travel volumes but are unlikely to materially alter leisure travel demand. For example, travel volumes after the 9/11 terrorist event returned to pre-9/11 levels within c.2-3 years.[26]

One potential shock that could have substantial implications for Australian inbound leisure traffic volumes is a protracted 'trade war' with a major source of leisure travellers. There are recent examples of travel being used as a means for achieving foreign policy aims. For example, in 2017, the Chinese Government banned Chinese organised group tours to South Korea.[27] If a similar ban were placed on Australian tours, inbound international air traffic volumes could decline by c.10-20%.

However, history suggests that the Australian international aviation market is resilient to such shocks. Japan was a major source of inbound traffic in the 1990s and early 2000s before experiencing a substantial decline in the late 2000s. Overall Australian traffic was unaffected by this decline, with growth in Chinese travellers offsetting the decline.[28] In the medium- to long-term, similar market substitutions could ensure the resilience of Australian traffic growth.

[24] The Australia Institute, Great Barrier Bleached: Coral bleaching the Great Barrier Reef and potential impacts on tourism (Jun 2018)
[25] L.E.K. Stakeholder consultations (Dec 2022 – Feb 2023)
[26] BITRE, Aviation Statistics (Jan 2023) © Commonwealth of Australia 2020
[27] L.E.K. research
[28] ABS, Overseas Arrivals and Departures, Australia (Nov 2022) © Commonwealth of Australia 2020

H2. Changing ways of working

Domestic business travel has historically been an important driver of domestic air travel activity

Business travel is an important revenue and profit driver for most airlines. Business travellers are typically less price sensitive than leisure travellers and are willing to pay for expensive, fully flexible business and economy class airfares.[29]

COVID-19 appears to have structurally reduced domestic business travel demand

COVID-19 appears to have materially changed the Australian domestic business travel market by accelerating the adoption of new ways of working. Virtual working has become normalised and increased levels of 'work from home' appear to have reduced the need for business travel.

"... Business travel will return, but as a share of the market it will be less. That's an enduring trend. The work proposition has changed permanently on a global basis. There isn't a great appetite to go back to previous patterns. The work life balance isn't going to change ..."

- Independent aviation expert, Dec. 2022

Domestic business travel is likely to remain structurally reduced post-COVID-19. Virtual meeting platforms have reduced the need for short business trips, e.g., single day journeys between Sydney and Melbourne. Similarly, companies seeking to reduce travel budgets may maintain travel prohibitions in the medium term for internal meetings and training.

New ways of working have not affected all types of domestic business travel. Travel for 'relationship' purposes, i.e., conferences, business events or sales meetings, may be less easily replaced by virtual working.[30] This travel type could continue at levels comparable to pre-pandemic in the medium- to long-term.

Similarly, fly-in, fly-out (FIFO) travel, a significant portion of the Australian business travel market, remained largely unchanged through the pandemic. FIFO travel demand is expected to remain strong in the medium- to long-term due to ongoing mining activity and the development of other regional industries, i.e., the proposed clean energy and hydrogen sector.[31]

Overall, most market participants interviewed expect a reduction of c.10-25% in domestic business travel on pre-pandemic levels in the short-term.[32] Business travel is not expected to recover to pre-pandemic levels until the mid-2020s.[33]

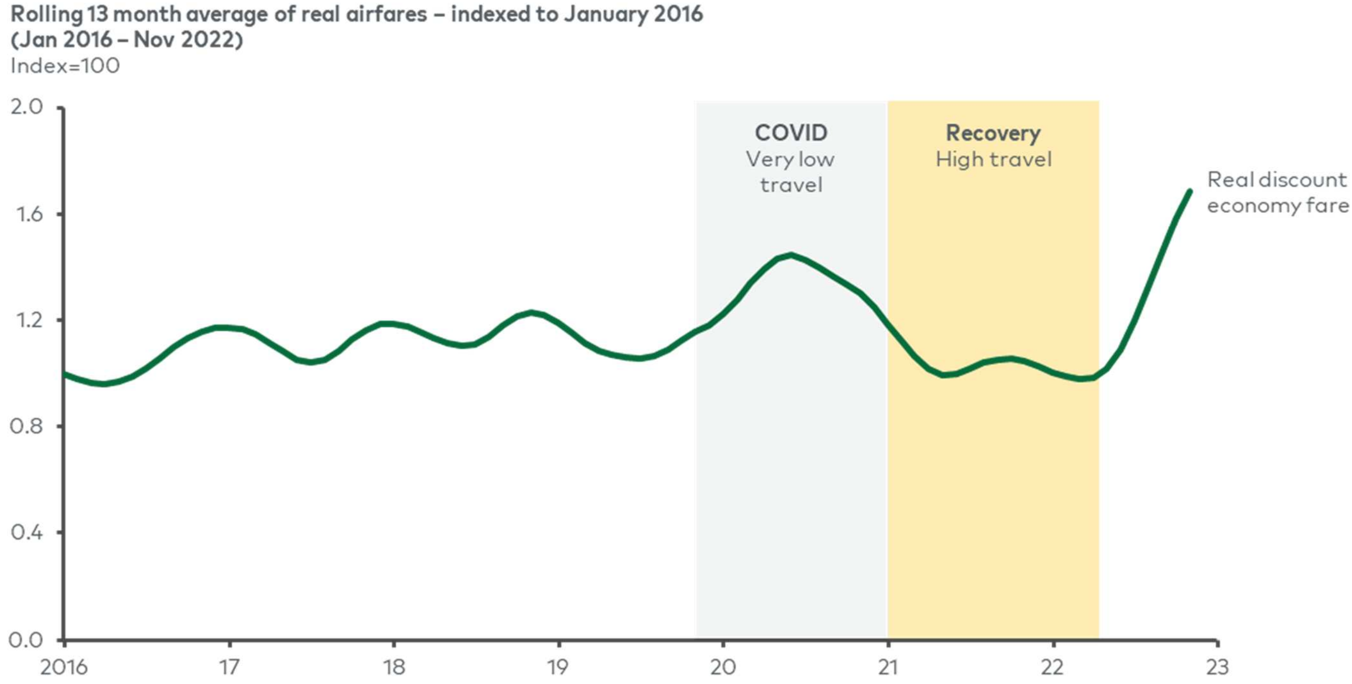
The business travel market has likely matured, with ongoing growth likely to be low in the medium- to long-term

Even before COVID-19, the Australian business travel market was relatively mature. The number of passengers travelling on the business heavy 'golden triangle' routes of Sydney to Melbourne, Sydney to Brisbane and Brisbane to Melbourne grew at c.2% per annum between 2015 and 2019, broadly in line with GDP growth over the same period.[34] Further penetration, i.e., businesses travelling more frequently, is unlikely.

In the short-term, growth may return to pre-pandemic rates. However, changes to how companies prioritise business travel could create further headwinds to business travel growth in the medium- to long-term.

[29] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[30] L.E.K., The Great Reopening and Priority Reset: Consumer Insights (Dec 2021)
[31] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[32] Ibid
[33] Ibid
[34] BITRE, Domestic Totals & Top Routes Jul 2014-November 2022 data download (2022) © Commonwealth of Australia 2020

Figure 9
Real airfares (CY2016-22)



Source: BITRE

Post-pandemic, some companies appear to be focusing on a "triple bottom line" that prioritises profit, sustainability, and the employee welfare.

- **Profit:** the adoption of "zero cost budgeting," where businesses do not allocate a specific business travel budget and instead require budget requests for every business trip
- **Sustainability:** companies are limiting travel, particularly air travel, to achieve corporate sustainability targets, although the extent of these reductions varies[35]
- **Employee welfare:** COVID-19 has increased companies' focus on employee health and wellbeing, including the impacts of business travel

This 'triple bottom line' could become entrenched in the medium- to long-term as the next-generation of business leaders that have matured in this environment gain seniority.

In the short-term, as airlines recover from COVID-19, elevated real airfares could further entrench company policies of reduced business travel. Fewer business travellers on full-fare flexible tickets and reduced services have put upwards pressure on airfares. Airfares are likely to decrease as services and frequencies increase. However, companies may have already adapted travel policies to reduce travel, creating a further headwind to domestic business travel growth.

International business travel demand may prove more resilient in the long-term

International business travel demand may prove more resilient than domestic travel to changing ways of working. Due to its high cost, international business travel has historically been saved for important, high value in person interactions, e.g., international conferences, major sales meetings, and board meetings.

[35] Transport & Environment, Too few businesses pledge to reduce business flying, new corporate ranking finds (May 2022)

These in-person meetings are harder to replicate virtually.

In the short-term, border closures, reduced levels of international connectivity, and high international airfares reduced absolute business travel levels by c.75% between 2019 and 2022.[36] However, business trips as a proportion of all trips into Australia remained relatively constant between 2019 and 2022, at c.12%.[37] Absolute business travel levels are expected to return to pre-pandemic levels in the mid-2020s as air services resume and airfares normalise.

In the medium- to long-term, international business travel is likely to continue to grow at rates comparable to those pre-pandemic. While 'triple bottom line' accounting could reduce the need for some trips, the rarity and importance of international business travel could mean this travel type is less affected by policy changes.[38]

Increased work from home could support other changes to aviation, such as AAM growth

Greater work from home rates could create new aviation opportunities in the medium- to long-term.

Work from home has made it increasingly viable for professional office workers to live away from CBDs, i.e., in peri-urban areas of major cities or major regional centres. These workers are willing to tolerate longer, infrequent commutes into the office in return for the benefits of living outside of cities.

In the long-term, workers living away from major cities could comprise an important user group for AAM. AAM could make it easier for office workers to live further from major cities, while still being sufficiently cost and time effective to support infrequent commutes by air.

[36] Tourism Research Australia, International Visitor Survey results 2022-2019 comparison (Dec 2022) © Commonwealth of Australia 2020

[37] ACCC, Airline competition in Australia (various years) © Commonwealth of Australia 2020

[38] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)

3.3 Supply Drivers

Source: Soheb Zaidi (Sydney Airport)

Outlook

Short- to medium-term, workforce shortages may limit activity in general aviation and other areas. In the long term, the aviation industry is likely to have sufficient infrastructure and aeronautical capacity to meet demand growth, with increased competition supporting growth; AAM could create a new aviation segment for the industry.

Figure 10
Driver outlook - supply drivers

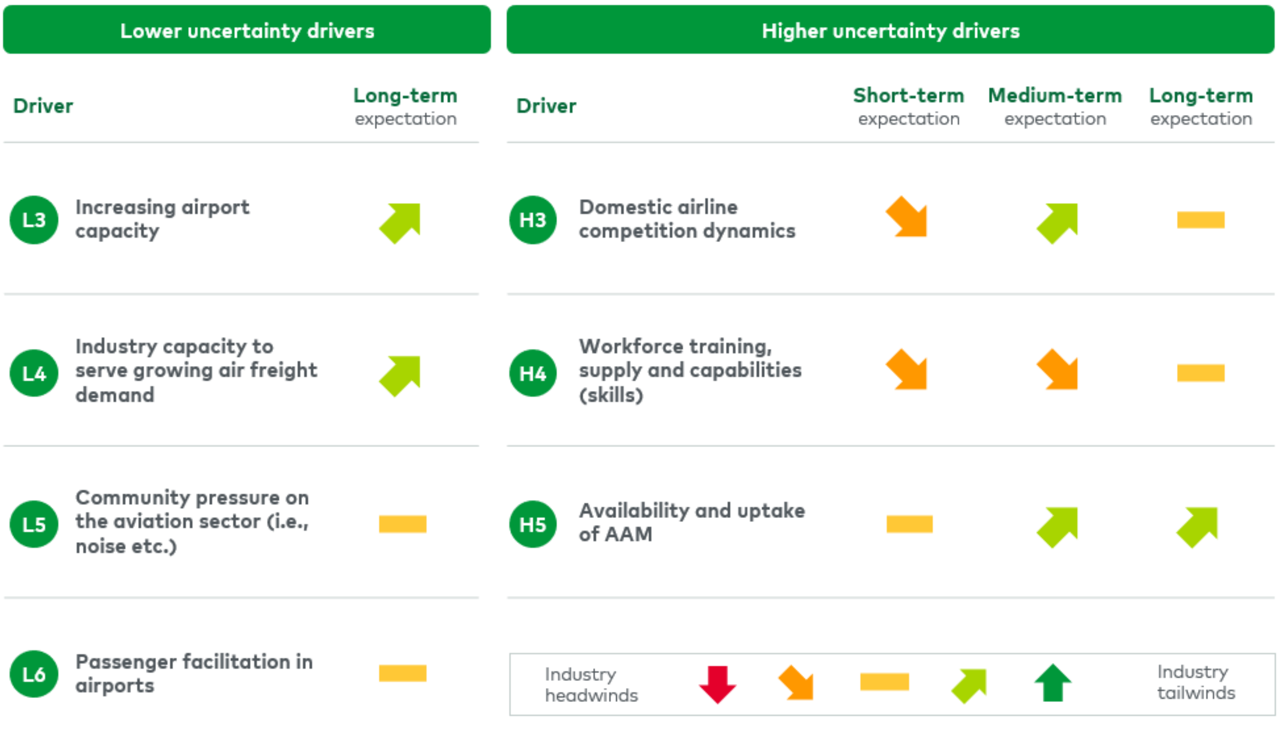
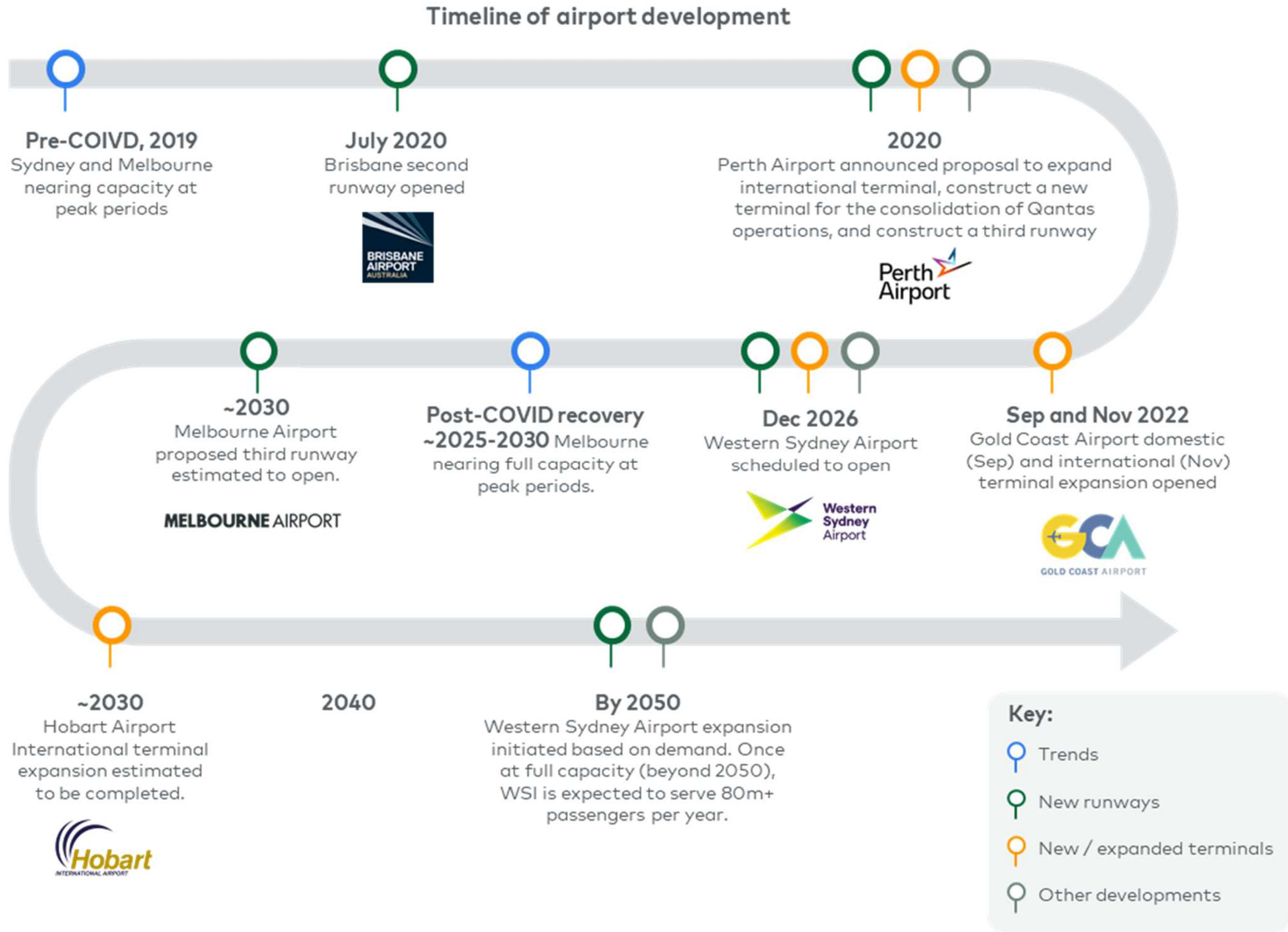


Figure 11
Australian airport development (CY2020-2050)



Source: Airport websites and media releases

L3. Increasing airport capacity

Airport capacity is an important growth enabler

Sufficient airport capacity, particularly during peak periods, is a prerequisite for future air transport growth. Both Sydney and Melbourne Airports are at or near capacity limits during peak periods.[39] Some regional airports face constraints in their capacity to safely service larger aircraft types.[40] To address these challenges, capital and non-capital city airports across Australia have announced or begun substantial infrastructure and technology improvements.

Airports across Australia have planned or embarked upon major expansion projects

Major airports across Australia have substantial infrastructure programs for the short- to medium-term:[41]

- Brisbane Airport opened a new runway in 2020 and has a planned program of terminal upgrades and expansion to maximise its capacity and efficiency
- In Sydney, the planned opening of Western Sydney Airport (WSI) in 2026 as a 10 MAP airport will substantially increase capacity into the Sydney basin, particularly during peak periods. WSI will make the Blue Mountains and other areas to Sydney's west more accessible

[39] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[40] Ibid
[41] Ibid

- Melbourne Airport has proposed a third runway for potential opening in c.2030, to alleviate capacity constraints during peak periods
- Perth Airport has plans to develop a consolidated international and domestic terminal. The airport is also considering a new runway in the short-term
- Hobart Airport's masterplan includes planned terminal improvements and runway upgrades to accommodate Code E (widebody) aircraf

There is likely to be sufficient capacity in the long-term to meet expected aeronautical growth

The infrastructure works programs at Australian airports is likely to ensure sufficient capacity for aeronautical growth under most scenarios.

Regional airports, particularly at centres like Wagga Wagga and Mildura, may need to be upgraded if aging turboprop services are replaced by larger aircraft. These larger aircraft, or increased demand, could require new terminal, apron, and runway upgrades.

International airports may require upgrades to accommodate higher international passenger volumes, for example, infrastructure upgrades for increased widebody frequencies, and space for international processing facilities.

L4. Industry capacity to serve air freight demand

Air freight demand is an important area of international and domestic aviation activity

International air freight capacity is essential to the transportation of high-value goods. International air freight comprises c.1% of international trade by volume, but c.20% of trade by value.[42] Fresh agricultural products going to China, Singapore, Hong Kong, New Zealand, and USA account for almost two-thirds of air freight exports.[53] Air freight imports to Australia mostly comprise consumer electronics and ecommerce goods from Asia and USA.[53]

Domestic air freight serves two primary functions: the rapid transportation of high-value goods and mail on domestic trunk routes, and the provision of essential cargos to remote communities.[43]

Next-generation international aircraft will increase air freight capacity to and from Australia

Most international air freight is carried in the bellies of aircraft operating RPT flights.[44] Air freight capacity is therefore dependent on fleet mix and aircraft type.

International airfreight capacity is likely to be sufficient for demand in the medium-term. Next generation widebody aircraft, i.e., the Boeing 787 and Airbus, have greater freight capacity than most aircraft that they are replacing (the Airbus A330, Airbus A380 and Boeing 747).[45] The entry of these aircraft into international fleets could structurally increase air freight capacity to and from Australia.

Additional aircraft may be needed for sufficient domestic capacity

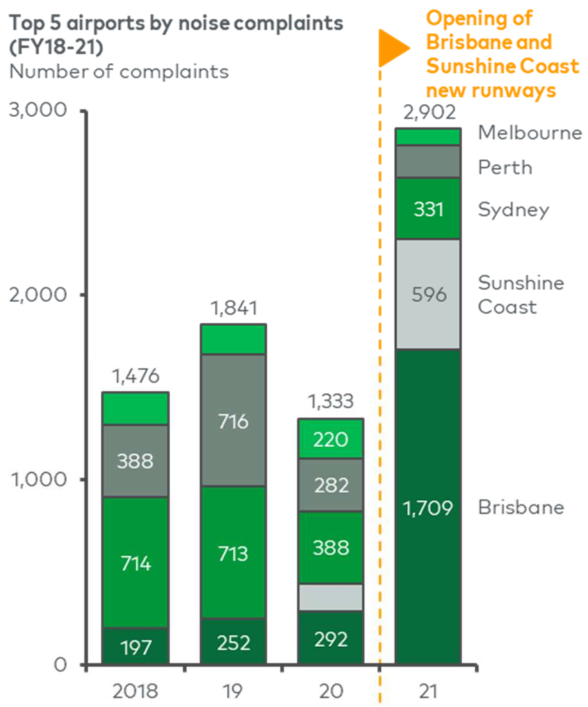
The outlook for domestic air freight capacity is less clear. However, it is highly likely that there will be sufficient airfreight capacity.

The opening of Western Sydney Airport (WSI) will increase domestic air freight capacity. WSI will alleviate the constraints of SYD's curfewed freight operations, creating a third major 24-hour freight facility in Eastern Australia.[46] WSI's proximity to the Western Sydney freight precincts could enable multi-modal freight connectivity.

Domestically, declining numbers of widebody services may create a temporary shortage of freight capacity, particularly on transcontinental routes. However, airlines appear to be responding to this issue using passenger to freighter (P2F) conversions, notably Qantas Freight's conversion of Airbus A321s. Further conversions could be used to ensure domestic freight capacity.

Figure 12

Top 5 airports by noise complaints (FY18-21)



Source: Transparency.gov

[42] Infrastructure Partnerships Australia, Airfreight Indicator (Dec 2021)
[43] Australian Government, Supporting Paper No. 1 Air Freight: Inquiry into National Freight and Supply Chain Priorities (2010) © Commonwealth of Australia 2022
[44] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[45] OEM websites
[46] Austrade, Clear skies for Western Sydney Airport (Oct 2022) © Commonwealth of Australia 2022

L5. Community pressures on aviation, i.e., noise

Noise and other concerns are major issues for communities living around airports and flight paths

Aviation impinges on communities close to airports and flightpaths through noise and air pollution from aircraft and ground operations, visual pollution from airport lighting, and additional road congestion. Long-term growth in aeronautical activity will increase the impacts of aviation on communities.

Communities located near airports may respond to these impacts by increasing pressure on airports, airlines, and regulators to curtail or change operations.

Outside of substantial policy change, the focus of operational change to reduce community pressures will likely lie with airports and airlines in the medium- to long-term. The opening of Brisbane Airport's second runway in 2020 led to a substantial increase in the airport's noise complaints.[47] Brisbane Airport has since collaborated with Airservices Australia to adjust its operations to reduce aircraft noise impacts, e.g., through maximising the use of overwater Moreton Bay approaches.[48]

New forms of aviation could generate pushback from communities

While there is relatively low uncertainty in how traditional aviation operations will evolve in response to community pressures, there is greater uncertainty regarding the potential impacts of new technologies, i.e., AAM. The extent to which noise and visual pollution of AAM is tolerated at the community and regulatory levels is currently uncertain (see driver H5 for additional detail).

L6. Passenger facilitation in airports

Advancements in screening technologies could increase airport processing capacity and improve the airport experience

The airport experience can be a major pain point for both domestic and international travellers, particularly when travelling internationally, with queues typically forming at security, immigration, and boarding.

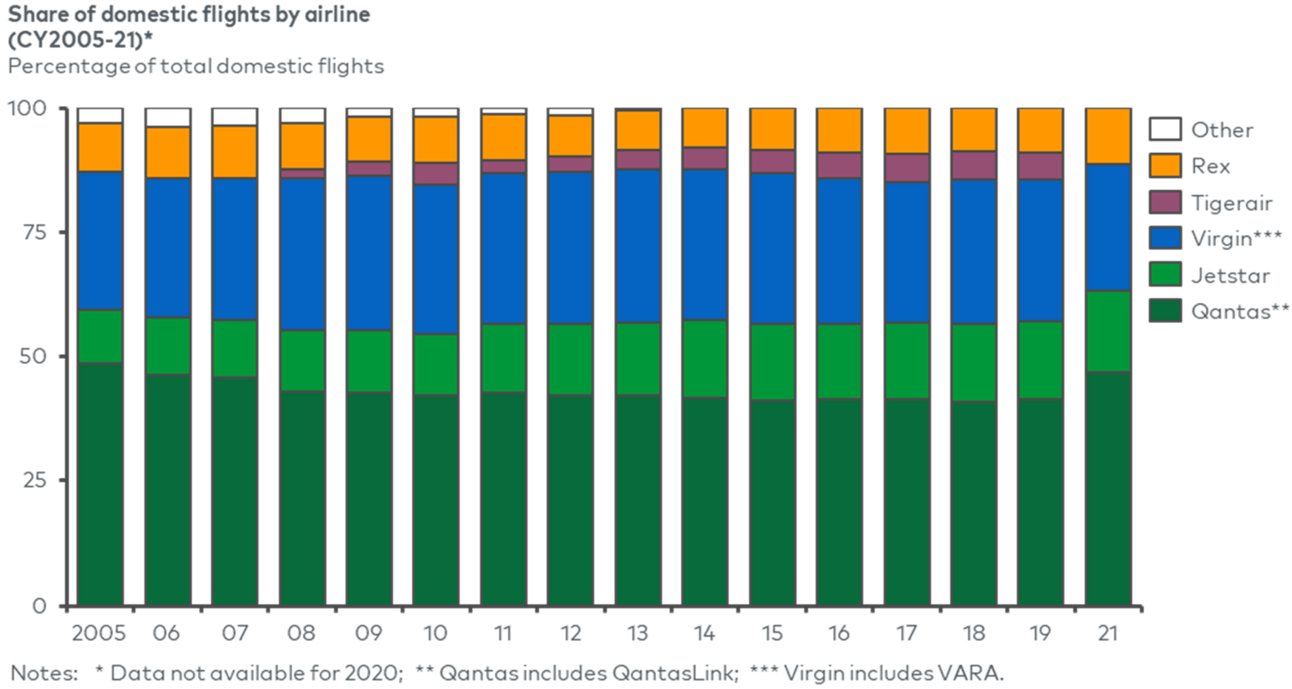
Airports, airlines and regulators have historically addressed this issue using automation, e.g., e-passport smart gates and automated bag drops, to shorten passenger queuing time.[49]

Further advancements in processing may come through further automation and biometrics. Systems may use biometric data such as facial scans to reduce the level of passenger information required.[50] For example, a scan at check-in could be used at security screening, immigration and boarding, reducing processing time at each stage. The distribution of biometric scanning throughout terminals could further reduce bottlenecks.[51]

Australia's major international airports have trialled biometric systems, as well as other IT and business intelligence initiatives like aircraft turnaround management and baggage processing, with the intention of permanent installation to streamline passenger processing speed.[52] New processing technologies could be introduced as part of terminal upgrades or new terminals. These investments could increase airport processing capacity in the medium- to long-term.

[47] Transparency.gov, Airservices Australia Annual Report 2020-21 (2021)
[48] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[49] Infrastructure Magazine, Creating Australia's first smart airport (Feb 2021)
[50] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[51] Ibid
[52] Airport websites

Figure 13
Domestic flight share by airline (CY2005-21)



Source: BITRE

H3. Domestic airline competitive dynamics

Two airline groups currently hold the majority of domestic market share, reflecting historical trends

The Australian domestic market has experienced periods of higher and lower price and service competition, and has typically comprised two major airlines and several smaller regional or leisure carriers.[53] At present, Qantas Group (including Qantas, QantasLink, and Jetstar) and Virgin have c.89% domestic market share.

Both Qantas Group and Virgin have strong competitive positions. Both airlines have substantial network reach and popular frequent flyer programs. Qantas Group is distinguished by its regional and international network, multiple service offerings through its Jetstar, Qantas Freight and QantasLink subsidiaries, and strong international alliance and partners.

At present, airlines appear primarily focused on rebuilding their operations and profitability following COVID-19. This follows a period of relative stability in the market shares of Qantas Group, Virgin, Rex, and their subsidiaries. Load factors, prices and yields are consequently higher than pre-pandemic.[54]

Structural changes in the Australian market could create an opportunity for greater competition

In the short-term, substantial change in market competitive dynamics is unlikely. The initial public offering of Virgin Australia, expected in 2023 or 2024, could lead to greater domestic competition. However, a material change in competition, i.e., a return to the 'capacity wars' of the early 2010s, is unlikely given potential negative impacts on profitability.

[53] ACCC, Airline Competition in Australia, (2022) © Commonwealth of Australia 2020

[54] Ibid

New market entrants and smaller airlines are unlikely to disrupt domestic aviation in the short-term. Rex has signalled its intention to continue expanding its 737 fleet, but capacity limitations at Sydney Airport will continue the carrier's ability to compete on the golden triangle. Similarly, Bonza's proposed low-cost operations and leisure-destination oriented route network mean that it will not directly compete with Qantas Group and Virgin on most routes.

Ongoing demand growth introduces further uncertainty into future competitive dynamics

The Australian market has historically been viewed as too small to accommodate a third carrier comparable to Qantas or Virgin.[55] However, ongoing market growth, combined with structural increases in capacity on the golden triangle, could create an opportunity for a new carrier to scale up and sustainably compete with Virgin or Qantas.

The opening of WSI in 2026 could create a structural opportunity for greater competition. WSI will increase capacity in and out of Sydney, particularly during peak times. Supported by runway upgrades at Brisbane and Melbourne, there could be an opportunity for greater competition on golden triangle routes.

A larger domestic aviation market and greater capacity at capital city airports could create an opportunity for a third carrier operating a significant and sustainable domestic network, together with niche airlines targeting specific market segments and routes. Such a carrier could substantially increase competition in the domestic market by placing downwards pressure on airfares or increasing frequencies and flight services. These changes could accelerate domestic aviation growth and create additional competitive opportunities.

Qantas and Virgin might also capitalise on domestic market growth and structural changes to airport capacity before a major challenger emerges. Should this occur, the domestic market could continue to display similar competitive dynamics to today in the long-term.

[55] L.E.K., Stakeholder consultations (Dec 2022 – Jan 2023)

Source: Samuel T (Perth Airport)

H4. Workforce training, supply and capabilities (skills)

There is currently a pilot shortage within the Australian airline industry

Multiple stakeholders expressed concern for the availability of pilots to support industry growth in the short- to medium-term.[56]

COVID-19 exacerbated an existing pilot shortage. During the pandemic, c.23% of Australian Federation of Air Pilot members were made redundant.[57] The slow recovery of air traffic encouraged pilots towards the end of their careers to retire.

The causes of the pilot shortage are multi-faceted, with challenges at all career stages

High barriers to entry deter prospective pilots. Gaining a commercial pilot's licence can cost more than c.$95,000, significantly more than many other undergraduate and postgraduate courses (eligible trainee pilots can apply for Higher Education Loan Program (HELP) loans).[58] Once qualified, junior pilots often need to relocate to regional areas to gain sufficient hours working in GA to apply for airline roles.

Workforce challenges persist once pilots have gained employment at major airlines. Upon reaching certain hour thresholds, pilots may be attracted to foreign carriers offering substantially better pay and working conditions than Australian airlines.[59] By some estimates, hundreds of Australian pilots relocated overseas in the past year (c.1000-2000 pilot licenses are issued annually).[60]

Compulsory retirement ages (typically 65 years) in jurisdictions such as USA further exacerbate the shortage by removing willing and able pilots from the industry.

Training challenges and uncertain career paths have contributed to a shortage of licenced aircraft engineers

Industry participants also identified a shortage of licenced aircraft maintenance engineers (LAMEs) as a key industry issue.[61] The number of apprentice engineers has declined steadily since the early 2000s: between FY2007-16, an average of 297 licences were granted per year, compared to an average of 135 between FY2017-21.

[56] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[57] Australian Federation of Air Pilots, Submission to The Future of Australia's Aviation Sector (Nov 2020) © Commonwealth of Australia 2022
[58] Ibid
[59] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[60] Ibid
[61] Ibid

Industry participants cited changed training requirements as a potential cause of the aircraft engineer shortage. The adoption of the European Union Aviation Safety Agency (EASA) based Part 66 licencing system in 2011 changed the syllabus and funding arrangements for apprentice engineers.[62] Within the industry, there is concern that the new syllabus is more difficult to complete than the previous industry apprenticeship model, is unclear in its pathways (the Certificate IV in Aeroskills provides insufficient practical training to become licenced), and is difficult and expensive to complete outside of major cities.[63]

The offshoring of maintenance has further reduced the attractiveness of becoming an aircraft engineer. Both Qantas and Virgin have offshored significant portions of their engineering operations, particularly heavy maintenance. Both airlines maintain onshore maintenance facilities. Some stakeholders noted that offshoring has both decreased the number of roles required in Australia and introduced uncertainty into the career prospects for apprentice engineers.[64]

In the short- to medium-term, continued growth in pilot demand could exacerbate the shortage, at the expense of general and regional aviation

With continued growth in air travel demand, Oceania will require an estimated c.10,000 new pilots within the next 20 years.[65]

The current pilot shortage is likely to endure in the short- to medium-term. Competition from international airlines for Australian pilots is likely to remain strong, given that these airlines themselves are labour constrained, with Australia viewed as a source of high-quality pilots.[66]

General and smaller regional aviation operators are likely to be the most affected by the pilot shortage. These operators typically have a lesser capacity to attract pilots than the major airlines, either through competitive pay or conditions. Major airlines are more willing to run pilot training programs: Rex has an apprenticeship program and Qantas established a pilot academy in 2020 to provide introductory training for prospective pilots.[67]

Fewer pilots in general and regional aviation could affect the pipeline of pilots, in the medium- to long-term. Smaller operators typically provide a pathway for junior pilots to gain hours before moving to larger airlines. Major airlines may need to address this issue by lowering their hour thresholds for hiring new pilots or expanding their training capacities.[68]

Technological and operating improvements are unlikely to materially reduce pilot demand

Some jurisdictions are investigating operational and technological changes to enable reduced crew operations. Proposed changes include extended Minimum Crew Operations (eMCO) such as prolonging inflight pilot rests to reduce pilot requirements, and 'single pilot operations.' However, reduced crew operations have received substantial pushback from industry on safety grounds.[69]

Reduced crew operations may not alleviate the pilot shortage. The implementation of eMCO in short- to medium-term would only partially alleviate demand for pilots on long-haul flights, which require additional pilots. Allowing single pilot crews is unlikely to occur in the medium- to long-term, given the associated safety considerations. Even if it were implemented, 'ground pilots' may be required depending on the model, reducing its efficacy.

[62] RAAA, Aircraft maintenance engineer shortage – crisis and opportunities (Oct 22)
[63] Ibid
[64] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[65] Ibid
[66] Ibid
[67] Ibid
[68] Ibid
[69] Ibid

Aircraft maintenance shortages are likely to continue in the medium-term

As with pilots, there are no immediate solutions to the current shortage in licenced aircraft engineers.

Airlines will likely adapt to this issue by increasing their training capacities and / or offshoring maintenance. However, GA operators and smaller regional operators could find it difficult to attract engineers. This could inhibit GA activity, particularly in regional areas.

Airlines could respond to these shortages through increasingly taking on the responsibility of training engineers. Alliance Airlines announced a new aviation maintenance, repair, and overhaul (MRO) facility in Rockhampton in 2022, with the plan to offer at least 16 local traineeships and apprenticeships.[70] Other airlines may opt to develop similar facilities or expand their training programs.

Alternatively, airlines may seek to offshore light maintenance. Offshoring would reduce the pressure on the existing maintenance workforce but could further reduce the attractiveness of aircraft maintenance as a career.

Ground handling roles face short-term challenges

For unskilled roles, increased casualisation has led to high workforce turnover and periodic labour shortages.[71] COVID-19 has exacerbated these issues, with illness and irregular operations placing further pressure on the workforce.

In the medium- to long-term, the partial automation of ground operations could partially alleviate workforce demand pressures.

In the long-term, new technologies may change skill requirements for engineers and ground staff

Changing skill requirements add further complexity to the future aviation workforce. Electric and hydrogen aircraft will require upskilling and the development of new skillsets and training processes catering for electricity and hydrogen-based propulsion systems.[72]

As AAM is adopted, skills in demand will shift towards technical capabilities around digital, electrical renewable and autonomation. A new onshore workforce may be required to produce, maintain and operate these aircraft.

The new aircraft engineering workforce would require a broader skillset than the existing MRO workforce. Potential skills could relate to caring for digital interfaces, electrical engineering, renewables production and handling, and the maintenance of automated systems.[73] The AAM workforce may also need to train in manufacturing processes to support the local aircraft production.

At present, it is unclear how the industry will develop this workforce. The future aviation workforce will need to integrate into a broader ecosystem of new technologies, manufacturing opportunities and processes. Successfully building a future aviation workforce could deliver substantial employment opportunities, potentially revitalising aviation as a career in Australia.

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[70] Queensland Government, Alliance Rocky aviation maintenance facility powering ahead (Mar 2022)
[71] Ibid
[72] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[73] Ibid

H5. Availability and uptake of AAM

AAM is an emerging area of aviation technology

AAM is the use of small, highly automated aircraft to carry passengers or cargo, or deliver other services, at lower altitudes over shorter distances than typical of existing conventional fixed-wing or rotary-wing aircraft.

The primary form of AAM under development is electric vertical take-off and landing (eVTOL) aircraft. Electric short take-off and landing (eSTOL) are also emerging AAM modes.

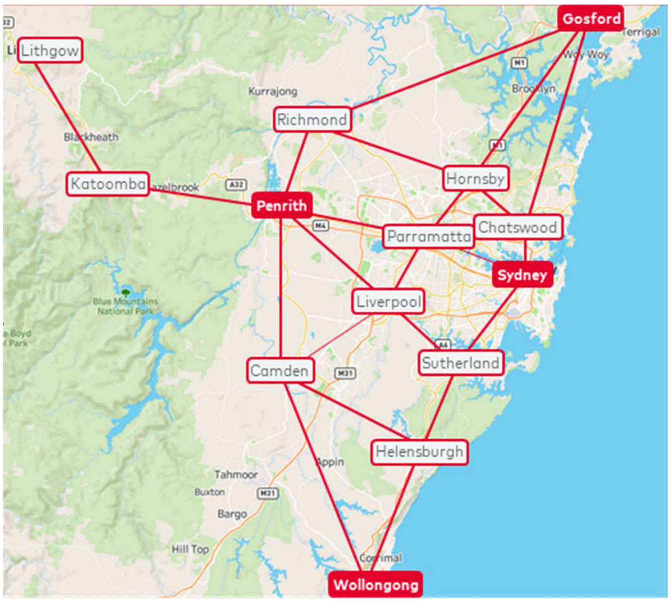
AAM is distinct from small UAS or "drones," i.e., those used for delivery services. Drones typically have a freight capacity of up to c.10kg and have use cases involving aerial surveillance and photography, or last mile delivery of small parcels and consumer goods.[74] By contrast, AAM aircraft have larger payloads (c.50kg plus) and are able to take on a broader set of use cases including passenger and heavy freight transport.

Industry stakeholders expect eVTOLs to enter service with on-board pilots for limited uses in the late 2020s.[75] Remote piloted AAM are expected to commence in the 2030s, dependent on further technological advancements and regulatory changes.[76] Initially, eVTOLs will likely be battery electric, with hybrid-electric and hydrogen fuel cell propulsion systems being explored in the medium-term.

Compared to traditional rotary wing aircraft, i.e., helicopters, eVTOLs are expected to be quieter, cleaner, and cheaper to operate.[77] However, eVTOLs are unlikely to offer the same range, speed, or capacity as helicopters in the short- to medium-term.

Figure 14

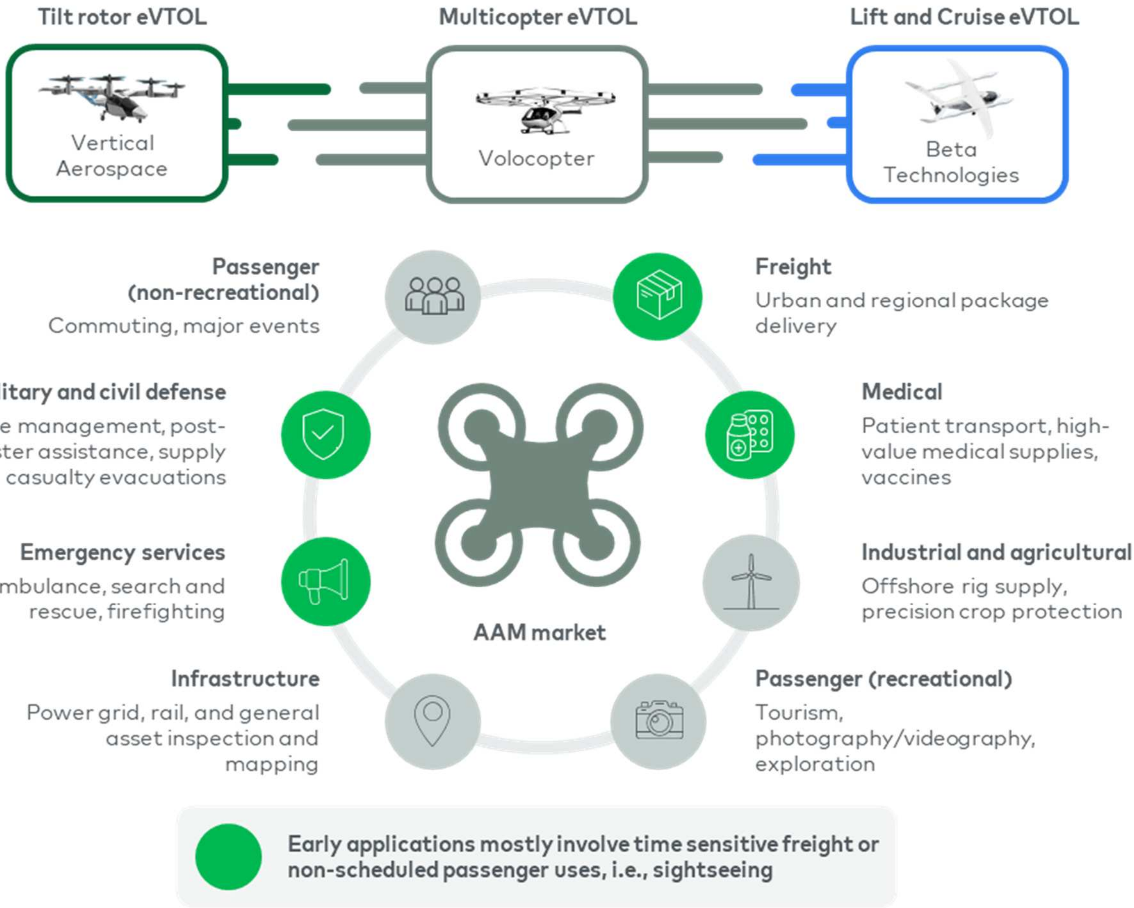
Indicative point-to-point AAM routes in New South Wales enabled at c.70km range



Source: L.E.K. research and analysis

[74] Examples include Wing's delivery drones, or Swoop Aero's Kite aircraft
[75] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[76] Ibid
[77] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)

Figure 15
Potential AAM use cases



Source: L.E.K. research

AAM could initially replace GA aircraft for passenger flying. As the industry develops, AAM may enable point-to-point passenger trips across urban and regional areas

AAM is a potentially disruptive aircraft technology that could support the creation of new transport networks connecting points not traditionally served by aviation. With its ability to enable new point-to-point services across and around cities and major regional centres, AAM could provide faster and more efficient transportation options for people and goods.

Early commercial AAM flights will likely involve the transportation of freight weighing up to 500kg or 2-5 passengers within a radius of up to c.70km of the departure vertiport.[78] These capacity and range limitations could support early passenger use cases involving tourism and luxury private transport. For these use cases, crewed AAM aircraft would replace traditional rotary wing aircraft, lowering operating costs, reducing vehicle emissions, and providing customers with a quieter, more sustainable service offering.

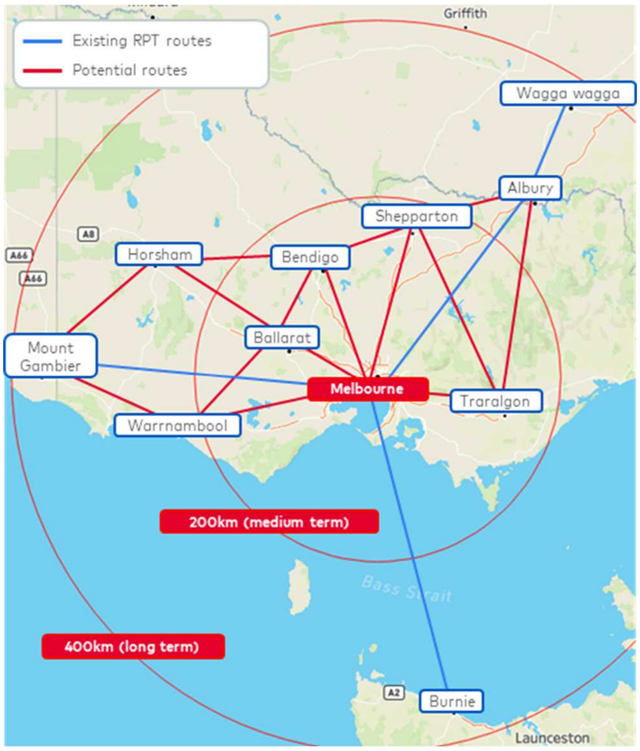
As AAM technology and certification progresses to enable autonomous flying, AAM could replace taxi and rideshare trips for some private point to point travel. Indicatively, in the medium- to long-term, AAM automation could allow travel costs comparable on a per kilometre basis to travelling by taxi.[79] With these route economics, AAM could feasibly offer a fast, efficient option for journeys like airport transfers, commuter trips connecting

[78] L.E.K. research and experience

[79] L.E.K., The Potential for Advanced Air Mobility Beyond the Congestion Use Case (Dec 2021)

remote areas to regional hubs, and cross city flights to avoid congestion.

Figure 16
Indicative point to point routes enabled with c.200-400km range (medium- to long-term)



Source: L.E.K. research and analysis

AAM freight transport could enable faster last mile delivery and direct point-to-point transportation

Freight transportation, particularly last mile delivery, is important AAM use case. Last mile delivery is a critical aspect of the logistics industry due to increasing demand for same-day delivery and ecommerce. In the short- to medium-term, AAM could offer an efficient solution for heavier last mile delivery cargos, augmenting smaller delivery drone services.[80]

In the medium- to long-term, AAM could support the development of direct, point-to-point freight transportation networks. These networks would bypass intermediate stops or transfers, resulting in faster delivery times and reduced costs for businesses and consumers.

AAM could enhance medical and emergency services with faster transportation of supplies, personnel and patients

Medical and emergency services could be an early AAM use case. In the short term, AAM could be used to quickly and efficiently transport time sensitive medical supplies, blood and organs for transplantation (this role may also be undertaken by lighter drones).[81] In the medium- to long-term, AAM could replace traditional rotary wing aircraft in transporting medical personnel to remote areas or disaster zones.[82] With sufficient range, AAM could also be used for medical transport such as air ambulances or search and rescue vehicles.[83]

For these use cases, AAM could offer lower operating costs and greater flexibility than traditional rotary wing aircraft. This may allow for service expansion, particularly in regional areas, better connecting patients and communities to healthcare services.

AAM has potential military applications for logistics, surveillance, combat, and search and rescue

The military is exploring various applications for AAM in the short- and long-term.[84] In the short term, AAM could be used for logistics and supply chain management, such as transporting equipment and supplies quickly and efficiently. AAM could also be used for reconnaissance and surveillance missions, providing real-time data and situational awareness to military personnel on the ground.[85]

[80] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[81] Ibid
[82] Ibid
[83] Ibid
[84] Ibid
[85] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)

Source: Skyportz © Skyportz

Agricultural flying, including crop management and livestock monitoring, could be early AAM use cases

AAM has potential applications in agriculture in both the short- and long-term. While drones are already being used in agriculture for crop monitoring, mapping, and spraying, the greater payload of AAM aircraft could support wider uses in agriculture. For example, greater payload could allow crewed and uncrewed AAM aircraft to carry people, crop samples or equipment across large agricultural properties, and from properties to regional centres. Unlike smaller drones, AAM aircraft would also have sufficient payload to conduct automated crop spraying and monitoring activities. The use of AAM in agriculture could improve crop yields, reduce waste and increase efficiency. Further use cases may emerge as the technology improves, with additional benefit to the agriculture industry.

AAM is likely to supplement rather than replace traditional aviation

While initial AAM use cases will likely involve these aircraft replacing traditional rotary wing aircraft, participants within the AAM industry are optimistic regarding the potential for AAM to form a new mode of point-to-point transport of freight and passengers. Some see AAM as an alternative to land transport for customers seeking greater convenience than public transport and faster travel than congestion-affected road transport.[86]

In the medium-term, AAM is likely to complement commercial aviation. For example, AAM could increase connectivity out of regional centres, e.g., connecting Dubbo to other central NSW towns or providing feeder services for traditional RPT services to capital cities.

In the long-term, advanced AAM aircraft with c.5-10 seats and c.200-400km range could replace some RPT services such as Sydney-Newcastle. However, range, speed and capacity limitations mean that AAM is likely to supplement, rather than replace, traditional RPT aviation in the long-term.

AAM could create new job opportunities, enhance sustainability, and improve connectivity

AAM has the potential to create new job opportunities in various sectors. Opportunities include software development for AAM systems, maintenance and repair of AAM vehicles and infrastructure, piloting, and operation of AAM vehicles, and related support services. These areas could experience significant growth as AAM technology develops and becomes more widely adopted.

Another potential benefit of AAM is increased sustainability through reduction in the number of passenger and freight vehicles on the roads.

[86] Ibid

This could help reduce traffic congestion, lower emissions and improve air quality.

Additionally, AAM could improve connectivity by enabling people to better access services and opportunities, supporting industries and services previously limited by lack of accessibility.

It is anticipated that the industry will invest in a network of vertiports to support AAM adoption

The development of a 'vertiport' network, from which AAM aircraft will operate, is one of the most significant infrastructure requirements for AAM. Initially, existing general aviation and regional aviation airports (e.g., Bankstown, Archerfield, Essendon Airports) and helipads could be upgraded to accommodate AAM aircraft.[87] These upgrades could improve operating economics for regional and general aviation airports by facilitating the integration of AAM aircraft into existing aviation infrastructure.

As AAM scales, additional vertiports will be required to provide convenient points of origin and destinations for point-to-point trips. Vertiport network development is likely to scale quickly as operators seek to increase network coverage.[88]

The location of these vertiports will play an important role in their success. Vertiports may require additional grid upgrades in the surrounding area to support the rapid charging of AAM aircraft.[89] This will require collaboration between utilities and AAM operators to ensure sufficient capacity to support the expected demand.

The commercialisation timeline for AAM is uncertain and will require regulatory changes longer term

While the timing for AAM aircraft launch and certification is uncertain, the AAM industry is likely to scale in the medium- to long-term. Scaling AAM will require airspace, ATM, and infrastructure upgrades.

Airspace design

At scale, AAM aircraft will significantly increase daily flight volumes. Preliminary analysis indicates that AAM could add an additional 3-10 million flights per annum by 2050. Many of these additional flights will be replacing ground transport trips (e.g., taxi/rideshare journeys between the CBD and the airport). By way of reference, there are approximately c.2 million GA landings per annum.[90]

A significant proportion of AAM flights could take place over or around urban areas. The sheer volume of aircraft in the skies could create noise, visual amenity, and safety concerns for residents, particularly for trips over suburban areas where general aviation activity is unusual.

Regulators designing airspace to manage this traffic volume must consider community needs. Rules may change as communities become increasingly accustomed to seeing AAM (and drone) aircraft in the skies.

ATM operations

The successful scaling of AAM will require substantial changes to how airspace is managed in Australia. Currently, non-commercial aviation primarily takes place in 'uncontrolled' Class G airspace. AAM trips will mostly occur in historically Class G airspace, except for specific use cases (e.g., trips to airports). While not directly a part of AAM, last mile 'wing delivery' freight drones will also primarily use Class G airspace.

The volume of new aviation trips expected to occur once AAM reaches scale will increasingly remove the distinction between controlled and uncontrolled airspace. To ensure aircraft, passenger, and community safety, an uncrewed air traffic management (UTM) system will likely be required to prevent

[87] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[88] Ibid
[89] Ibid

[90] BITRE, Australian Aircraft Activity 2021 Statistical Report (2021) © Commonwealth of Australia 2022

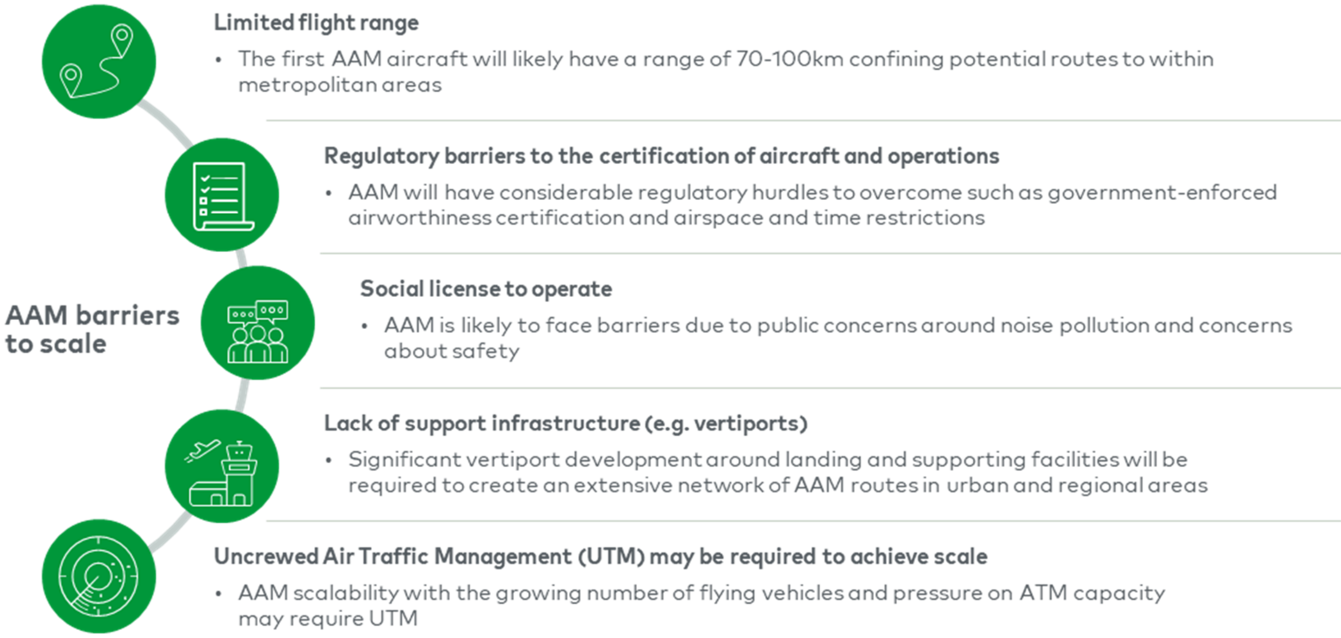
conflicts between uncrewed aircraft. The UTM system will need to advance in capability as AAM scales and uncrewed flights with passengers become more common (see driver H10 for more details).

To effectively scale, the AAM industry will need to meet multiple other regulatory hurdles. Major regulatory challenges include certification of automated flying, the use of remote back-up pilots and pilot training standards.[91] Stakeholders also identified a need to update flight rules (i.e., to a new digital flight rules standard) to enable uncrewed flight.[92] Importantly, these regulatory hurdles can be addressed while AAM aircraft are in testing or limited service.

Government and industry will need to work together to update airspace and implement new UTM / ATM systems to support wider AAM adoption

Airspace design will be an important consideration in the construction of vertiports for AAM. AAM vehicles will operate in both urban and rural environments, which may require different airspace features to handle the challenges presented by each environment. In urban areas, airspace may need to balance the noise and amenity impact of the aircraft with the level of connectivity provided (i.e., by not having vertiports next to houses where possible, and mandating minimum altitudes). In less densely populated and regional areas, airspace design may be more flexible to support a wider variety of AAM use cases such as aerial surveillance or agriculture. The establishment of no-fly zones in certain areas may also be required to ensure safe and efficient operation.

Figure 17
Challenges facing the AAM industry



Source: L.E.K. research and analysis

[91] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)

[92] Ibid

Moreover, the UTM and ATM systems must be updated to accommodate the new AAM vehicles. This will require collaboration between government agencies (CASA, Airservices), AAM operators, and technology providers to ensure systems are properly integrated (see H10 for additional detail).

Investment may be required to ensure reliable, low latency communication networks for UTM/ATM

The digitisation of communication is vital for the safe, scaled operation of AAM vehicles. The UTM and ATM systems that will manage the operation of AAM (and drone) aircraft will require a robust communication network to support real-time strategic and tactical deconfliction decision making. The communication network must be highly reliable and low latency. Low latency is necessary in all environments, but particularly urban ones where there will be greater traffic levels.

To meet these communication network requirements, advanced network technologies such as 5G may be necessary. These technologies can offer high bandwidth, low latency, and robustness in communication links, essential for the safe operation of AAM vehicles. Moreover, as AAM scales, the volume of data generated and transmitted by AAM vehicles will increase significantly. This will require supporting networks that can handle large volumes of data, analyse it quickly, and make critical decisions in real-time.

Therefore, investment in communication network infrastructure and digitisation of information is crucial to ensuring the safe and efficient operation of AAM vehicles, particularly in high-traffic environments. However, the responsibility for funding the improved communications network infrastructure remains uncertain.

3.4 Sustainability Drivers

Source: Billy Joachim (Qantas 717 at Gold Coast Airport)

Outlook

The industry will face headwinds as it decarbonises in the short- to medium-term, due to the level of technological progress required, costs associated, and implications for industry growth and profitability. In the long-term, technological advancements may accelerate decarbonisation for domestic and international flying.

Figure 18

Driver outlook - Sustainability drivers

Lower uncertainty drivers

Driver	Long-term expectation
L7 Ongoing fleet renewal with newer generation aircraft	—

Higher uncertainty drivers

Driver	Short-term expectation	Medium-term expectation	Long-term expectation
H6 Emissions reduction ambitions and pressures	—	—	—
H7 Availability and uptake of SAF	—	↘	—
H8 Availability and uptake of electric planes	—	—	↗
H9 Availability and uptake of hydrogen planes	—	—	↗
H10 Evolution of air traffic management	—	↗	↗

Industry headwinds ↓ ↘ — ↗ ↑ Industry tailwinds

L7. Ongoing fleet renewal with a newer generation of aircraft

There is a significant backlog for next-generation aircraft that will enter fleets in the medium-term

There is currently a substantial global backlog of next-generation aircraft orders (see table below). These aircraft are expected to enter global fleets over the next 6-15 years.[93]

Table 2
Major aircraft manufacturer order books for select next-generation airplanes since FY2006

Aircraft model	Orders	Deliveries	Backlog
A220	773	246	**527**
A320NEO	8,505	2,526	**5,979**
A350	1,650	797	**853**
B737MAX	1,259	507	**752**
B777	1,608	1,039	**569**
B787	6,667	980	**5,687**
Totals	20,462	6,095	**13,514**

Source: OEM websites

Qantas and Virgin have strong order books for next-generation aircraft, with c.250 aircraft on order and purchase rights for another 124 aircraft.[94]

Table 3
Major Australian airline current orders (at Feb 23)

Airline	Aircraft model	Orders
Qantas Group	A220-300	**20**
	A32X	**165**
	A350-1000	**12**
	B787-9	**3**
	Total	**213**
Virgin	B737-700	**4**
	B737 MAX 8	**8**
	B737 MAX 10	**25**
	Total	**37**

Source: airline websites

Next-generation aircraft will provide efficiency and emissions gains in the short- to medium-term

The ongoing replacement of the current fleet with next-generation aircraft will reduce fuel burn and emissions in the short- to medium-term on a per seat and per ASK basis. New aircraft typically bring reductions in fuel burn of c.15-20% per seat and 20-30% per air seat kilometre, although aggregate improvements are unlikely to be more than c.2% p.a.[95] In aggregate, the introduction of these aircraft could contribute to as much as a 25% reduction in fuel burn and emissions by 2050.[96]

While the introduction of next-generation aircraft will make airlines more efficient and sustainable, the rate of improvement in conventional aircraft technology is diminishing.[97] If the aviation sector wants to maintain its rates of continuous improvement, investment in and adoption of more ambitious technologies will be required in future.

The timing of the introduction of next-generation aircraft into Australian fleets may slow the adoption of new aircraft technologies

Australian airlines are expected to soon announce full replacements for their existing fleets. In the short- to medium-term, next-generation orders by Australian airlines will likely provide sufficient aircraft capacity to meet their current needs and provide for additional aeronautical growth. As a result, airlines may have sufficient aviation capacity in the medium- to long-term and be unwilling to invest in new, commercially viable electric or hydrogen aircraft.

[93] Defense & Security Monitor, Airbus and Boeing Report December and Full-Year 2022 Commercial Aircraft Orders and Deliveries (Jan 2023)
[94] L.E.K. research
[95] Ibid
[96] Airlines for Australia & New Zealand; An Australian Roadmap for Sustainable Flying
[97] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)

H6: Emission reduction ambitions and pressures

The airline industry will likely face competing pressures to achieve sustainability outcomes without substantial changes to price or operations

The long timelines and investment required to decarbonise aviation mean that airports, airlines, and other stakeholders may face conflicting choices between meeting growth or sustainability targets.

In the foreseeable future, the aviation industry will be required to balance pressures to reduce emissions with commercial considerations.

Stakeholder pressure to adopt more sustainable practices will increase in the coming years

Customers, investors, and international policies are likely to pressure the industry to decarbonise in the long-term.

Increasingly environmentally conscious generations may call for airlines to accelerate their emission reductions timelines or they may reduce their own travel to reduce emissions.[98] Where customers previously prioritised cost, convenience and quality when purchasing airline tickets, consumer sentiment is shifting to include sustainability as a fourth criterion.[99] Some customers may use their purchasing power to pressure airlines and other industry participants to reduce emissions.

Investors concerned for climate change may increasingly pressure airlines and airports to reduce emissions. This could lead to conflict between airline investors, depending on their respective priorities.

International policy pressure may influence airlines to decarbonise in the short- to medium-term. Australia's airlines may be subject to stricter requirements enforced by international jurisdictions such as Europe, i.e., minimum SAF usage or aircraft emissions levels.[100] These requirements could change how Australian airlines access overseas markets.

The industry has begun responding to these pressures by making long-term commitments to decarbonise

Both Qantas and Virgin have adopted initiatives to increase sustainability. Both airlines have carbon offset programs (Qantas matches each dollar spent by customers). In December 2022, Qantas signed a purchase agreement for 10 million litres of SAF for all Heathrow flights .[101] Virgin has implemented similar programs and is running an SAF trial through Brisbane airport.[102]

Airports are also pursuing emissions reductions programs. Melbourne and Brisbane Airports have both committed to net zero emissions by 2025, Sydney Airport by 2030, all including Scope 1 and 2 emissions.[103] Some airports have entered into corporate power purchase agreements for renewable energy and developed financial instruments like sustainability-linked bonds and loans.[104] Melbourne Airport has recently commissioned a 12-megawatt solar farm that will power all four terminals.[105]

The impact of the industry's long term sustainability commitments on profitability and passenger growth is uncertain

Achieving sustainability targets will increase operating costs for airlines and airports in the short- to medium-term. For airlines, the adoption of SAF and new aircraft technologies will increase fuel and capital costs in the short-medium term. Airports will need to invest in new infrastructure to support the adoption of SAF or new aircraft technologies. Climate adaptation may also

[98] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[99] Ibid
[100] Ibid
[101] L.E.K. research
[102] Ibid
[103] Ibid
[104] Ibid
[105] Ibid

increase operating costs, should airlines and airports include additional 'operating slack' in response to increased adverse weather events.

To retain profit margins, the industry may need to consider increasing prices or offering more sustainable options at a premium. In the short-medium term, environmental commitments could lead to an increase in airfares, particularly for international travel. The impact of sustainability-driven cost increases remains unclear as passengers may be more willing to pay for higher airfares if they are perceived to be 'greener.' However, passengers may equally reduce their flying, at the expense of industry growth.

These price elevations will likely only be short-term. In the medium- to long-term, advancements in sustainable aviation technologies like SAF and electric/hydrogen aircraft could reduce the trade-off between sustainability and profitability. Airlines may create a competitive advantage by catering to environmentally conscious travellers through early adoption of new technologies.

H7: Availability and uptake of SAF

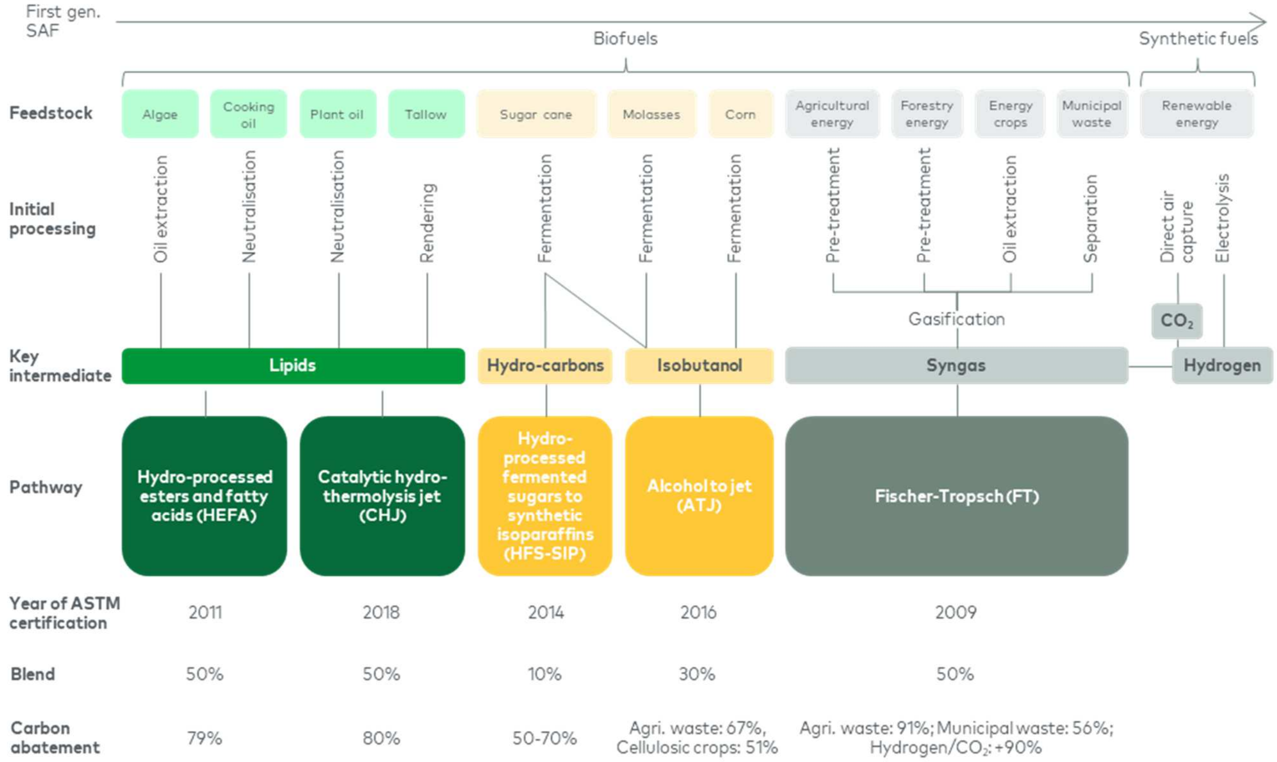
Sustainable aviation fuels (SAF) are synthetic or bio-fuel derived alternatives to traditional aviation fuels

SAF is an alternative for kerosene-based fuels made from other biological materials or synthesised from hydrogen or CO_2. As opposed to other combustion agents like hydrogen, SAF is largely 'drop in' fuel that requires minimal change to existing aircraft technologies. SAF offers up to a 91% reduction in CO¬2 emissions over the lifecycle of the fuel compared to traditional jet fuels, without any substantial difference in the amount of energy produced.[106]

There are multiple pathways for creating SAF, each with different levels of maturity and employing different feedstocks. 'First generation' SAF pathways use biological feedstocks (e.g., waste oils, biomass, algae, or agricultural waste) to create biofuels.[107] Depending on the pathway, inputs are treated or fermented to produce either a base oil or alcohol for producing the jet fuel. The most common biofuel pathways are the HEFA and ATJ pathways, which use waste oils / lipids and biomass / energy crops respectively.

SAF producers are also exploring second generation SAF production pathways. These pathways synthesise SAF from gases produced through either electrolysis (Power to Jet) or the gasification of waste materials via the Fisher-Tropsch method. Second generation SAF pathways can create synthetic fuels, which have higher emissions reduction potential than traditional biofuels. Synthetic fuel pathways are currently less progressed than biofuel pathways but could form part of future SAF capacity.

Figure 19
SAF production pathways

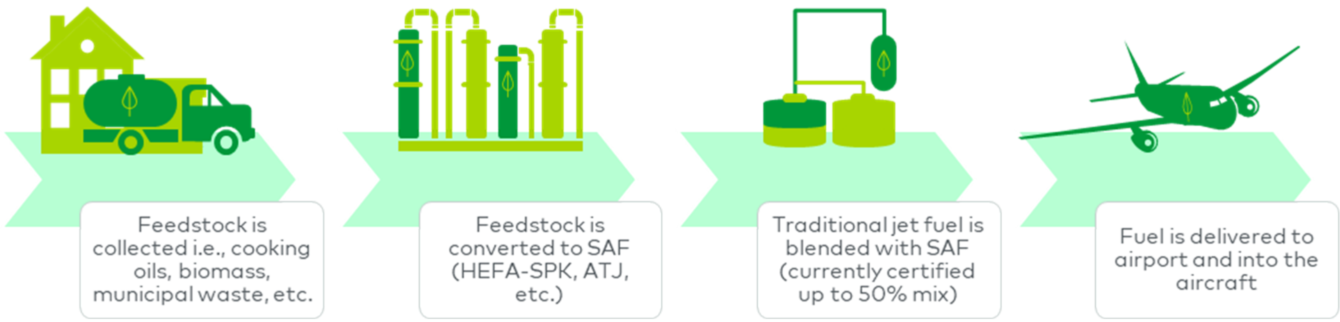


Source: Qantas, L.E.K. research

[106] Aerospace Technology Institute, The Case for the UK to Accelerate Zero-Carbon Emission Air Travel (2022)

[107] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)

Figure 20
SAF production and use pathway



Source: Bioenergy Australia

The industry expects SAF to play an important role in supporting decarbonisation

SAF could play an important role in the decarbonisation of the aviation industry. Depending on the production method used, SAF could reduce whole of life emissions by between 30-91% (c.80% for the most common HEFA pathway) compared to kerosene derived jet fuel.[108] By some estimates, the widespread adoption of SAF could contribute up to c.65% of the emissions reductions required for aviation to become net zero by 2050.[109]

SAF is likely to be the main technology pathway for decarbonising medium and long-haul flying in the medium- to long-term. Long-haul flying is a significant contributor to aviation emissions, with flights to and from Australia over c.5,000km kilometres accounting for c.68% of ASKs in FY2019.[110] Electric and hydrogen aircraft are unlikely to reach sufficient energy densities to replace current jet-fuel powered engines on long-haul aircraft in the medium- to long-term.[111]

The Australian airline industry has committed to SAF as its primary decarbonisation pathway. Both Qantas Group and Virgin have pledged to achieve net zero emissions by 2050 and to increase SAF usage across their fleet.

The Australian airline industry has committed to SAF as its primary decarbonisation pathway. Both Qantas Group and Virgin have pledged to achieve net zero emissions by 2050 and to increase SAF usage across their fleets.

- Qantas has committed to 10% SAF usage by 2030 and 60% by 2050. Qantas has made a deal with Airbus to invest $200 million to accelerate SAF production in Australia[112]
- Virgin Australia views SAF as an important mechanism for achieving net zero emissions but is yet to commit to specific uptake targets. Virgin has previously undertaken SAF trials out of Brisbane Airport[113]
- Both Qantas and Virgin are members of the Sustainable Aviation Fuel Alliance of Australia and New Zealand (SAFAANZ)[114]

Australia's SAF production is increasing but further capacity is required to meet uptake targets

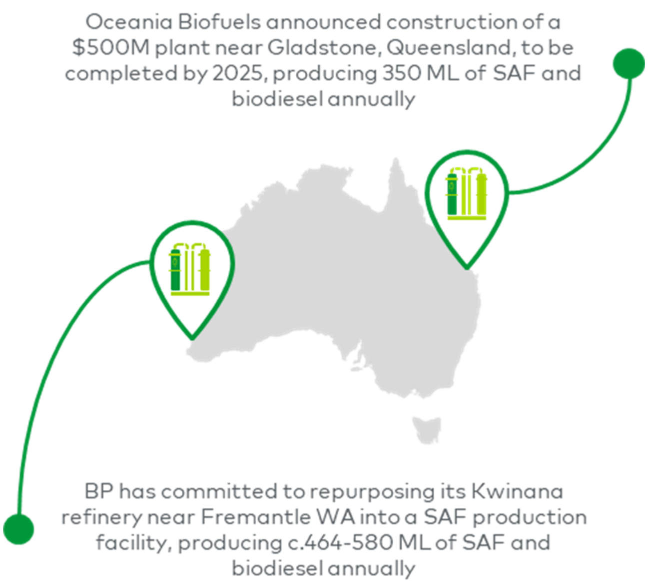
Two SAF production facilities are planned in the short-term, with a combined production capacity of c.930 million litres. In Western

Australia, BP has announced its plan to repurpose its Kwinana refinery to produce SAF and biodiesel from 2025.[115] The plant will produce up to 580 million litres of SAF and

[108] Aerospace Technology Institute, The Case for the UK to Accelerate Zero-Carbon Emission Air Travel (2022).
[109] IATA, Net zero 2050: sustainable aviation fuels (2022) © International Air Transport Association, 2019
[110] BITRE data (sourced by L.E.K. request) © Commonwealth of Australia 2020
[111] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[112] Ibid
[113] Ibid
[114] Bioenergy Australia, The Sustainable Aviation Fuel Alliance of Australian and New Zealand (2023)
[115] L.E.K. research

renewable diesel. In Queensland Oceania Biofuels has announced the construction of a 350 million litre SAF and renewable diesel production facility for completion in 2025.[116] Both plants will produce SAF using waste oils and other waste products.

Figure 21
Planned SAF production capacity - short-term



Source: AFR

The combined production capacity of both plants will be insufficient to support industry SAF requirements in the short-term. Australia will require more than 1,000 million litres of SAF by 2030, assuming that c.10% of total jet fuel is SAF.[117] If both Kwinana and Gladstone plants dedicated production capacity to SAF, Australia would still require an additional 100-200 million litres of SAF.

However, it is more likely these plants will be mostly dedicated to the production of renewable diesel, which has a more immediate market purpose.[118] Australia therefore requires a substantial increase in SAF production capacity to meet short-term targets.

International SAF providers are likely to establish production facilities in Australia in the short-term. Multiple SAF producers, including Lanzajet, Gevo, Eneos, and Fulcrum Bioenergy are members of SAFAANZ.[119] However, as at the time of writing, none have announced plans to develop facilities.

SAF is currently more expensive than jet fuel and price parity is not expected to occur in the short- to medium-term

SAF uptake has historically been limited for many reasons including the cost of SAF relative to jet fuel, immature production pathways and limited production capacity, and limited availability of sustainable feedstocks. In 2021, airlines used c.100 million litres of alternative jet fuels, or less than 0.1% of total fuel used.[120]

The price of SAF relative to conventional jet fuel will likely be a major barrier to uptake in the short- to medium-term. The per litre cost of SAF is currently c.2-5 times more expensive than traditional jet fuel due to limited production capacity and feedstock costs.[121] The SAF-jet fuel cost differential should decline as production capacity increases and new, cheaper feedstocks become available. However, price parity is still unlikely to occur in the medium-term, unless carbon costs are levied on jet fuel use.[122]

The decarbonisation of road transport could put downwards pressure on oil prices in the medium-term, making SAF price parity more difficult to achieve. Globally, road transport is one of the largest sources of oil demand.[123] Oil demand from road transport will reduce as personal vehicles electrify and commercial vehicles transition to biodiesel and other fuel

[116] Queensland Government, Oceania Biofuels – why a world-leading renewables company chose Queensland for their newest project (Jun 2022) © The State of Queensland 2022
[117] Based on L.E.K. analysis of Australian Petroleum Statistics data, assuming a return to pre-COVID levels of travel in 2024 and 2% p.a., growth in fuel needs to 2030
[118] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[119] Bioenergy Australia website
[120] The International Council on Clean Transportation, Sustainable Aviation Fuels: What Does Real Leadership Look Like (2022)
[121] L.E.K. research
[122] Ibid
[123] L.E.K. research and analysis

sources. This could place downwards pressure on oil prices, which may discourage SAF uptake given the additional price premium.

The Australian SAF industry will face competition from other jurisdictions and other transport decarbonisation programs for production capacity and feedstock

Competition for production capacity and feedstock may further slow SAF adoption. Most production facilities, including the two planned Australian plants, will also be capable of producing other biofuels such as renewable diesel. As SAF production is costlier and more difficult than general biofuel production, plants may prioritise production capacity for non-SAF purposes.[124]

Where SAF is produced in dedicated facilities, the aviation sector could face competition from other sectors for feedstocks. Biofuels, in particular renewable diesel, will be competing for the same feedstocks as are used in SAF production.[125] This may inflate the price of SAF in the short- to medium-term.

In the long-term, the electrification of the private vehicle fleet and conversion of other transport modes to biodiesel and hydrogen should alleviate feedstock constraints.[126]

Feedstock security may also hinder SAF adoption in Australia. Australia could be a major producer of feedstocks for first generation SAF such as energy and lignocellulosic crop residue (e.g., bagasse). However, the current lack of an established domestic industry has created an opportunity for other jurisdictions to purchase arable land to grow feedstocks or sign feedstock agreements with biowaste producers. This could reduce the availability of domestically produced feedstocks in the short- to medium-term, leading to higher SAF prices for domestic airlines.[127]

In the medium- to long-term, the commercialisation of second-generation biofuel pathways may partly alleviate this issue.

[124] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[125] Ibid
[126] Ibid
[127] Ibid

H8: Availability and uptake of electric planes

Electric propulsion systems are an emerging technology most applicable to regional propellor driven CTOL aircraft

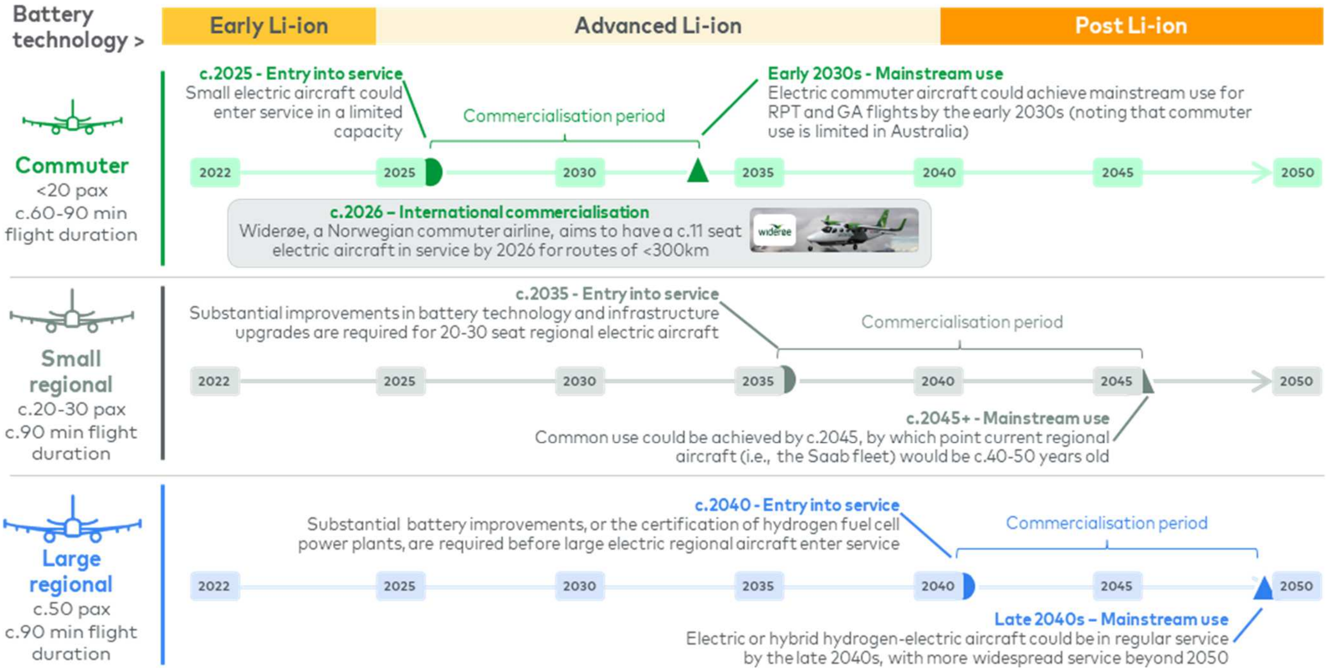
Electric fixed wing, conventional take-off and landing planes are an emerging form of powered flight. Electric planes use battery electric propulsion systems, replacing traditional fuel powered turboprop engines with electric propellors.

There is significant industry interest in the potential for electric planes to decarbonise regional and short-haul flying for aircraft with c.20-30 seats, including from governments and incumbent and emerging OEMs. Recent developments for electric aircraft include:

- In 2018, the Norwegian Government committed to all flights under 90 minutes duration being electrified by 2040
- MagniX has successfully trialled battery electric propulsion systems retrofitted to small aircraft, including the De Havilland DHC-2 Beaver in 2019 and Cessna 208B Grand Caravan in 2020[128]
- In 2021, Widerøe, a Norwegian regional airline, announced its intention to operate c.9 seat electric aircraft produced by Tecnam, an Italian manufacturer, from 2026[129]
- In 2022, Eviation trialled its 'Alice' aircraft, a sub-19 seat twin propellor battery electric commuter aircraft with c.250 nautical miles of range.[130] Air New Zealand has signed a statement of intent to order three Alice aircraft, with further options for 20 aircraft, as part of its Mission Next Gen project[131]
- Air New Zealand has partnered with multiple other OEMs, including Airbus, ATR, Embraer, Universal Hydrogen and Heart Aerospace as part of its 'Mission Next Gen' project to develop a commercially viable electric or hydrogen aircraft by 2030[132]

Figure 22

Indicative timelines for electric aircraft commercialisation



Source: L.E.K. research

[128] MagniX website
[129] Tecnam website
[130] Eviation website
[131] Ibid
[132] Air New Zealand website

Figure 23
Current Australian airline regional fleets – Dec 2022

Regional airline fleets

Airline	Aircraft	In-service / parked	Orders	Seats	Avg. age (years)
QANTASLINK	Airbus A320	10 / 1	0	140-170	18.0
	Boeing 717	18 / 2	0	110-125	20.8
	DHC-8-200	**3 / 0**	**0**	**40-50**	**26.7**
	DHC-8-300	**15 / 1**	**0**	**40-50**	**20.2**
	DHC-8-400	**30 / 1**	**0**	**67-74**	**13.5**
	ERJ-190	10 / 0	4	94-106	14.8
	Fokker F70/F100	15 / 3	0	72-100	29.3
rex.	**Saab 340**	**44 / 14**	**0**	**30-36**	**28.6**
Alliance AIRLINES	ERJ-190	24 / 4	5	94-106	15
	Fokker F70/100	34 / 5	1	72-100	29.7
LINK airways	**Saab 340**	**10 / 1**	**0**	**30-36**	**25.7**
airnorth together we fly	ERJ-170	3 / 0	0	70 / 76	14.9
	ERJ-190	3 / 0	0	94-106	16.2
SKYTRANS	**DHC-8-100**	**5 / 0**	**0**	**37-40**	**35.8**
	DHC-8-300	**0 / 1**	**0**	**40-50**	**24.5**

Propellor aircraft that are the most suitable for electrification

Source: L.E.K. research

OEMs and airlines are also exploring conversions of existing airframes to hybrid-electric or electric propulsion systems

In addition to new build aircraft, major airframers are exploring opportunities to convert existing airframes to hybrid-electric or electric propulsion systems. For example, De Havilland Canada has partnered with Pratt and Whitney to develop a hybrid-electric Dash-8-100 conversion. This demonstrator accompanies another program to extend the lifespan of the Dash-8-100 from 120,000 cycles to 160,000 cycles.[133] An extension of this program to other Dash-8 series aircraft in the short- to medium-term could provide a pathway for airlines to upgrade aging regional aircraft without incurring substantial capital costs.

Larger electric aircraft in development are likely to have fuel-cell based propulsion systems

Some manufacturers are exploring larger, fuel-cell based electric aircraft. Wright Aircraft is developing two electric aircraft with 100+ seat capacities. The first, the Wright Spirit, is an electric retrofit of the British Aerospace 146 (BAE-146) using electric turbofans and either aluminium or hydrogen fuel cells.[134] This aircraft has a target entry into service of 2026. Wright is also developing a 186-seat electric aircraft with c.500km in range in partnership with EasyJet, for entry into service by 2030.[135] However, most investment and research into battery electric aircraft appears to be for commuter and small regional plane.

[133] De Havilland Canada media release (2022)
[134] Wright Electric website
[135] Ibid

Electric aircraft could play an important role in regional aviation by replacing aging turboprop aircraft

Regional flying in Australia is primarily operated by turboprop aircraft carrying between 30-70 passengers. The Dash-8 200/300/400 series and Saab 340 are the primary aircraft types operated, with QantasLink, Rex, and Link Airways collectively operating 100+ turboprop aircraft.[136] Smaller c.19 seat commuter aircraft are operated by minor regional airlines.

A significant portion of the regional fleet will approach end of life in the short- to medium-term. Except for QantasLink's Dash-8-400 fleet, all of Australia's Dash 8 and Saab fleets have average ages above 20 years.[137] Assuming that Australia's turboprop aircraft reach end of life at c.35 years of age, c.57 Dash-8 and Saab aircraft will need to be retired or substantially refurbished between 2030 and 2040.[138]

Electric aircraft could potentially be a viable replacement for some regional turboprop aircraft reaching retirement age. The focus of the industry on commuter and regional aircraft suggests that c.20-30 seat aircraft may be available to replace the Saab and Dash-8 200/300 fleets for some routes. Increased frequencies may be required where electric aircraft replace Dash-8 aircraft.

Range and payload constraints are likely to limit use cases for electric commercial aviation

While electric short-haul aircraft may offer sufficient capacity to replace some domestic turboprop areas, there are significant barriers to adoption.

Electric aircraft will likely be range limited to c.300-500km routes due to battery density limitations. With a 300km range and a c.20-30 seat payload, electric aircraft would only be suitable replacements for c.5% of routes in Australia, e.g., Brisbane to Bundaberg, Sydney to Newcastle or Adelaide to Port Lincoln.[139] Capacity limitations may limit electric aircraft use on higher capacity routes like Sydney to Canberra. Even if electric aircraft of c.30-50 seats with ranges of c.500km enter Australian fleets in the long-term, their use will be limited to less than 20% of routes.[140]

The economics of electric aviation, when considered in terms of 'total cost of ownership', are uncertain

The extent to which electric aircraft will require substantial changes to regional operating models is also uncertain. The use of older, non-capital-intensive aircraft allows regional airlines to offer infrequent services to smaller regional ports with substantial downtime between flights.[141] While this approach would be operationally feasible for electric aircraft, as the downtime would ensure adequate time to recharge or swap the aircraft's batteries, it may not be commercially viable.

Airlines procuring new electric aircraft would likely incur substantial capital costs, which would typically be offset through high aircraft utilisation. Higher utilisation rates may be operationally feasible, but could introduce additional costs into regional aviation, e.g., for extended airport operations. Increasing utilisation on routes between capital cities and regional ports would also be subject to slot constraints.

Indicatively, electric aircraft operating costs could be c.15-20%+ lower than conventional turboprops, depending on their size.[142] Reduced operating costs are largely due to the lack of substantial fuel costs and the electric propulsion system being simpler and cheaper to maintain. These savings may help mitigate the increased capital costs, and costs of changed aircraft utilisation patterns.

The total cost of ownership for electric aircraft remains uncertain. Electric aircraft

[136] L.E.K. research
[137] L.E.K. analysis of aircraft fleet data
[138] Ibid
[139] L.E.K. analysis of BITRE data
[140] Ibid
[141] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[142] Ibid

are more expensive to purchase than conventional aircraft and will incur substantial capital costs during battery replacements cycles. As road transport electrifies, declining fuel costs could reduce any operating cost advantages for electric aircraft.

The commercial viability of electric aircraft remains uncertain and electric aviation is likely to be more expensive than conventional aviation in the short- to medium-term. In the medium- to long-term, improvements in battery and aircraft production may reduce electric aircraft capital costs, which could lead to price parity on a total cost of ownership level.

Figure 24
Challenges to the adoption of electric aircraft

Technical feasibility Challenges associated with the development of electric airplane technology	**Battery energy density**	• The primary technical challenge faced by electric airplane developers is energy density - batteries have limited energy density compared to fossil fuels, which restricts range and payload
	Motor power density and cooling	• Developers also have to address technical challenges in achieving motor power density and cooling
	Airport infrastructure	• Airports will need to upgrade their electrical infrastructure, and power transmission companies will likely need to upgrade grid infrastructure. This is likely to be particularly challenging for regional airports
	Regulatory challenges	• With limited existing certification standards, developers will initially need to undergo a lengthy and costly certification process to ensure the safety and reliability of electric aircraft
Commercial feasibility Commercial challenges to achieving widespread adoption	**Development cost**	• Developing and manufacturing electric planes is costly and will likely require considerable investment before returning profit for OEMs
	Route economics	• New airplanes typically need to be highly utilised in order to cover the up-front capital cost, however, regional operations in Australia are currently designed around low aircraft utilisation
	Maintenance cost / CAPEX	• Maintenance costs are expected to be lower for electric planes than traditional fossil fuel planes
	Labour cost	• Labour cost per available seat kilometre (CASK) is likely to be higher because of limited capacity
Resource / product availability Challenges related to the availability of materials and products	**Resource availability**	• The availability of electric airplanes may be limited by resource availability (i.e., copper, palladium, etc. required for battery manufacturing), particularly given global ambitions for vehicle electrification
	Product availability	• Once technically and commercially viable electric airplanes are available, Australian airlines will likely face competition from other global airlines for available supply

Source: L.E.K. research and stakeholder consultations

Hybrid-electric conversions may prove more attractive in the short- to medium-term

Hybrid-electric and hybrid-conversions of existing turboprop airframes may offer more attractive whole-of-life operating costs and fewer limitations than new electric aircraft. If conversion and lifecycle programs are offered for aircraft types common in the Australian fleet, regional airlines may opt to continue operating older airframes with reduced emissions in the medium- to long-term.

Regional and remote airports will require infrastructure upgrades to enable electric commercial and GA

Regional airports will require upgrades to enable widespread adoption of electric regional aircraft. Upgrades could include the installation of battery charging facilities and grid upgrades to ensure adequate power supply. Remote airports, particularly in Far North Queensland and the Northern Territory, may also require the installation of specific power units (solar farms, additional generators) and storage facilities to ensure sufficient power supply for charging. This may be prohibitively expensive in the short- to medium-term. Regional and remote airports owned by local councils may require financial support for infrastructure works.[143]

Availability of precious metals and manufacturing facilities could hinder electric aircraft adoption

The commercialisation and production of electric aircraft will occur in parallel to other major electrification programs, i.e., the electrification of road transport. This could lead to competition between aviation and other transport modes for battery production resources such as lithium, and production facilities. Competition for resources could increase in the long-term as road vehicle electrification accelerates.

Electric aircraft could increase GA activity in the short- to medium-term

GA electric aircraft are unlikely to face the same barriers to adoption as commercial aircraft. One- to five-seater electric GA aircraft are likely to be available in the short term.[144] These aircraft could quickly enter Australian fleets as older GA aircraft are retired.

Electric aircraft could have applications in aviation areas with high utilisation, e.g., tourism, charter flying and pilot training.[145] For these types of aviation, high utilisation rates would likely offset higher initial purchase prices.

GA operators would also benefit from the lower operating costs of electric aircraft, in particular lower maintenance costs. This could reduce the cost of some types of GA activity, i.e., tourist flights or pilot training, which could encourage a proliferation of GA flying in the short- to medium-term.

[143] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)

[144] Ibid

[145] Ibid

Source: ZeroAvia (hydrogen aircraft)

H9: Availability and uptake of hydrogen planes

Hydrogen propulsion systems could offer a low-emissions replacement for traditional turboprop and turbofan engines on aircraft of up to c.200 seats

There are two main types of hydrogen propulsion systems being explored in aviation: hydrogen-electric fuel cells and hydrogen turbines.

Hydrogen fuel-cell aircraft are an alternative to battery electric aircraft. These aircraft use liquid or gaseous hydrogen fuel cells to create electricity to power electric propellor or turbine engines. Hydrogen fuel-cell aircraft offer substantial emissions benefits over traditional turboprops, including reduced CO_2 and NOx.[146]

Aircraft hydrogen turbine engines combust hydrogen to produce thrust. This propulsion system is more applicable to larger aircraft, i.e., short-medium haul jet replacements, which have greater thrust requirements. Hydrogen combustion produces significantly less CO_2 than conventional jet engines, although other emissions benefits are limited.[147]

Hydrogen fuel cell and turbine engine aircraft have broad industry support, including from major OEMs:

- Airbus launched its ZEROe program in 2020 to build four hydrogen powered aircraft with c.100-200 seats and c.1000-2000nm of range. These aircraft will use hydrogen turbines and hydrogen-electric fuel cells.[148] Airbus has stated that regional hydrogen aircraft may be able to enter service by 2035, with larger aircraft to follow in the 2040s[149]
- Boeing won a tender in early 2023 to partner with NASA to build a 100-200 seat hydrogen demonstrator aircraft.[150] Boeing is more conservative than Airbus about the potential for hydrogen aircraft, stating that hydrogen aircraft are unlikely to comprise a material portion of the global fleet by 2050[151]

Smaller manufacturers are also developing hydrogen aircraft for commuter, regional and short-haul routes. Zeroavia, a British American hybrid manufacturer, is developing a Dornier 228-derived hydrogen-electric commuter aircraft, for entry into service in

[146] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[147] Ibid
[148] Ibid
[149] Ibid
[150] Ibid
[151] Ibid

2025.[152] The aircraft conducted a successful air-test with one hydrogen powered engine in early 2023. Zeroavia has ambitions to build larger aircraft of up to c.200 seats in the medium- to long-term.

In Australia, Queensland-based Stralis Aero is developing a hydrogen conversion program for 15 seat Beechcraft B1900D aircraft, with a planned entry into service in 2026. Stralis is targeting a 2032 introduction for a c.50 seat clean-sheet design with c.1620nm of range.[153]

As with electric aircraft, hydrogen conversion programs for existing airframes are also in development. In Australia, Rex has partnered with Dovetail Electric Aviation to trial a Saab 340 in 2024 fitted with a single hydrogen-electric engine (powered by fuel cell and batteries).[154] This trial is intended to be a precursor to wider scale conversions. Similar propulsion system conversions could allow existing regional aircraft operators to adopt hydrogen propulsion systems without the cost and lead times of procuring new build aircraft.

Hydrogen powered aircraft could enter service on regional and short-medium haul routes in the medium- to long-term

Hydrogen-electric light and commuter aircraft (<20 seats) may enter limited general and RPT service in the short- to medium-term. These aircraft could offer low emissions replacements on short routes, e.g., sightseeing or sky diving flights, or intra-state RPT services. Widespread adoption is unlikely to occur due to issues regarding hydrogen production capacity and airport infrastructure.

Hydrogen-electric aircraft at scale to replace existing turboprops are not expected to enter service until 2035 at the earliest.[155] Hydrogen regional aircraft of c.50 seats could offer a replacement to aging turboprop aircraft without the range and payload constraints of battery electric aircraft.

In the medium- to long-term, larger hydrogen aircraft may enter service in Australia to replace or supplement fleets of smaller jet aircraft, i.e., existing Embraer 190 fleets.[156] Long range hydrogen aircraft are unlikely to enter Australian fleets until after 2050, if at all.

To support adoption, Australia needs to improve (green) hydrogen production capacity and airport infrastructure

Beyond significant advancements in existing technologies and certification, hydrogen aircraft will require substantial improvements to hydrogen production and transport capacity in Australia. Australia's hydrogen production capacity is currently limited. While capacity is expected to increase, competition from other industries such as heavy vehicles, may limit availability for aviation purposes.

Hydrogen is inefficient to transport and store, losing as much as 1% in volume per day as a gas during transportation.[157] Short supply chains are therefore necessary to prevent substantial efficiency losses. Airports may require hydrogen facilities in proximity to mitigate volume loss issues.

This may be possible for airports in capital cities and major regional centres. Smaller regional airports may face difficulties in ensuring hydrogen supply, potentially limiting adoption of hydrogen aircraft for regional routes.

[152] Zeroavia website
[153] Stralis.aero website
[154] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[155] Ibid
[156] Ibid
[157] Popov and Baldynov, Evaluation of energy efficiency of the long distance energy transport systems for renewable energy, Energy Systems Research (2019)

H10: Evolution of ATM

Australia and other jurisdictions are exploring multiple advancements in Air Traffic Management (ATM)

Air navigation service providers (ANSPs) are in the process of evolving ATM practices. Recent legislation in Europe has instituted improved airspace designs and queue management systems. In Australia, Airservices has partnered with the Department of Defence on the OneSKY Program to create a more efficient ATM system integrating civilian and defence air space.[158]

There are multiple opportunities to improve air traffic management in the short-term

Some of the most substantial short-term improvements to ATM practice could occur in the management of Class A and Class C airspace (controlled airspace). For example:

- The introduction of free route airspace, which removes all fixed routes and waypoints, could allow aircraft to fly more direct, efficient flight paths
- More flexible and efficient integration of defence and civilian airspace (i.e., dynamic airspace requirements, rather than fixed no-fly areas)

Better technological integration and data-sharing between different stakeholders through expanded Collaborative Decision Making (CDM) could enable improved decision making. Airservices Australia already employs CDM principles through its Ground Delay Program (GDP) for Melbourne, Sydney, Brisbane, and Perth Airports.[159]

Evolving CDM practices to include Airport Collaborative Decision Making (A-CDM) could lead to further traffic management improvements. A-CDM would involve greater integration of data and decision support technology between airports, aircraft operators, ground handling and air traffic control. Benefits of A-CDM could include improved runway utilisation, faster recovery from adverse events and greater scheduling predictability.[160] ANSPs are likely to implement A-CDM in the short- to medium-term.

ATM improvements could reduce fuel burn and emissions, and support aeronautical growth

Improving Australia's ATM practices could reduce fuel burn and emissions by increasing the efficiency with which aircraft depart and arrive at airports and transit to their destinations.

Indicatively, with free route airspace and improved queue management at airports, short-haul domestic flights could see emissions reductions of c.5-7%, based on analysis conducted on comparable routes in the UK.[161] Emissions benefits would be less for medium-haul and long-haul flights, due to airspace management typically being more efficient for longer routes.[162]

ATM advancements could also support aeronautical growth, including the adoption of low-emissions AAM aircraft, further supporting industry efficiency and lower emissions.

The introduction of uncrewed air traffic management (UTM) in the short-term and integration of UTM with traditional ATM could significantly alter how airspace is managed

The introduction of freight drones and passenger and freight AAM aircraft into Australian airspace could significantly increase the volume of air traffic in currently 'uncontrolled' Class G airspace. Whereas operators in Class G airspace have historically relied on visual flight rules and instrument flight rules means to avoid conflicts, the sheer volume of aircraft within this airspace will require the introduction of a UTM system to

158 L.E.K. research
159 L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
160 Ibid
161 Ibid
162 Ibid

ensure the safety of aircraft, passengers, and communities.

UTM would involve the autonomous, real time sharing of the airspace status of uncrewed aircraft with other crewed and uncrewed aircraft, ensuring safe operations in otherwise uncontrolled spaces.[163] In its most advanced form, UTM could involve machine to machine interactions that remove the need for human interaction. [164]

Government and industry are both investigating UTM systems, with an initial form of UTM likely to be implemented in the mid-2020s.[165] The introduction of this system will initially support the management of drones operating in uncontrolled airspace and could later be expanded to supporting AAM operations. The first forms of UTM would likely only have the capacity for strategic deconfliction, i.e., planning the movements of aircraft to avoid each other.[166] This level of UTM would still require substantial human intervention.

In the medium- to long-term, UTM will likely advance in both its sophistication. Future UTM systems could have the capacity to perform pre-tactical and tactical deconfliction, i.e., recognising when a conflict is going to occur and resolving the conflict without human intervention.[167]

This level of UTM is required for fully autonomous AAM operations at scale. With tactical deconfliction, UTM may nearly replace the need for human intervention in the management of AAM aircraft operating in both controlled and uncontrolled air space.

In the long-term, there remains significant uncertainty regarding the role of humans in traditional ATM systems. UTM systems that can replicate the tactical confliction

responsibilities of human air traffic controllers could integrate into mainstream ATM practices in the long-term, depending on the regulator and public's level of comfort for this approach. The integration of UTM with traditional ATM could support more efficient and safer airspace management.

The speed at which ATM improvements are adopted is dependent on progress in other jurisdictions

Certain ATM improvements have lower levels of uncertainty regarding their implementation. In the short-term, it is likely that free route airspace will be adopted in at least a limited form for Australian airspace. This would make Australian ATM practices in line with other jurisdictions such as Europe, which already use employee free route airspace. ATM may increasingly adopt A-CDM principles in the short-term and improve ATM practices as communications and dynamic route planning technologies improve.

There is greater uncertainty regarding the introduction of technology dependent ATM advancements. AI-enabled dynamic route planning may not be fully implemented until the medium-term, dependent on the sophistication of planning algorithms.

Similarly, the full implementation of UTM is dependent on regulatory approval for UTM systems. UTM may require regulatory changes to improve the sharing of information between crewed and un-crewed aircraft, e.g., satellite position beacons fitted to GA aircraft, and more stringent data and cyber security processes.[168] The required regulatory changes, and program of work required to outfit older aircraft to the required communications standards, may mean UTM is only fully implemented in the long-term.

The objectives of ATM and airspace design need clarification with regards to sustainability and noise

The significant increase in noise complaints for airports coming out of COVID-19 raises

[163] Federal Aviation Authority, Unmanned Aircraft System Traffic Management (UTM) (2022)
[164] Ibid
[165] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[166] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)
[167] Ibid
[168] L.E.K., Stakeholder consultations (Dec 2022 – Feb 2023)

the issue of whether ATM practices should prioritise sustainability or community wellbeing concerns.

Australian airspace design already accommodates community noise concerns. In Brisbane, aircraft are only allowed to fly certain routes to limit noise on approach. This approach requires aircraft to fly longer, less efficient routes.

Future airspace design may need to clarify whether flightpaths should take the most efficient route, or the route with the lowest community impact.

3.5 A note on East Coast passenger rail upgrades

The potential for substantial upgrades to the East Coast passenger rail network is a deprioritised issue for this report, but is important for the industry to watch

There was interest in the potential impact of major upgrades to the East Coast passenger rail network during the scenario development process. For the purposes of this report, this issue is not considered likely to materialise in the long-term.

Such upgrades, depending on their scale, point of introduction and train speeds, and frequencies enabled, could change passenger demand for some East Coast routes.

Internationally, long-distance rail networks have had greatest success connecting large cities with journeys of 1-3 hours of in-vehicle travel time, enabled through high train speeds. Currently, the most advanced networks can support train speeds of up to c.250-350km/h, connecting major cities c.200-600km apart.[169]

Sydney and Canberra are the only Australian paired cities meeting this criterion. Air and road travel are the primary means of travelling between these cities. However, compared to international city pairs with major fast rail links (e.g., London to Paris or Barcelona to Madrid), Sydney to Canberra is notable for its small market size. The Sydney to Canberra air route represents less than 2% of total domestic traffic.[170]

Passenger rail upgrades offering reduced journey times and increased frequencies along the Sydney to Canberra corridor may materialise in the medium- to long-term. A rail alternative along this route would likely take substantial market share from existing air services, with only passengers connecting to other flights continuing to take direct air services.

A full upgrade to the Brisbane – Sydney – Canberra – Melbourne rail corridor appears highly unlikely to occur before 2050. This route would require substantial infrastructure works to enable sufficiently high speeds, route capacities and frequencies for rail to compete with air travel.

[169] L.E.K. analysis

[170] BITRE, Domestic air traffic statistics (2023) © Commonwealth of Australia 2020

4. Scenarios for the industry

4.1 Introduction

Source: Troy Mortier (Qantas A380 leaving Sydney Airport)

The purpose of scenarios

High levels of uncertainty associated with many of the drivers of change make it difficult to provide a single view of how the industry will evolve.

Scenarios provide a useful mechanism to test different future states for the industry and the industry's sensitivity to different drivers.

Importantly, the scenarios focus on testing how the traditional aviation industry will evolve. As such, new technologies receive limited attention except where they augment or replace traditional aviation. Technologies that fall entirely outside the scope of the traditional aviation industry (e.g., UAS or drones with payloads less than 50kg), are not discussed outside of the dedicated scenario on new technologies (S7). No attempt has been made to quantify the adoption of UAS or small drone aircraft.

It is important to note that the scenarios described in this report illustrate seven of the many potential versions of the future. They were designed as aids to facilitate discussion on the future of Australia's aviation sector and provide the Department and industry stakeholders with information to help inform thinking around potential policy implications during the Aviation White Paper development process. The scenarios should not be treated as forecasts or predictions and should not be interpreted as preferred or official versions of the future. Importantly, the complexity of estimating how policy changes might affect industry development means that the scenarios assume current Australian, state, and local government settings, except where specified.

All scenarios assume 'BAU' policy settings for all levels of Australian government. Therefore, the range of settings and outcomes represent the extent of change considered feasible if driven by only market forces.

Five objectives informed scenario development:

- Scenarios should **test and challenge**, capturing a diversity of growth rates and levels of optimism and pessimism
- Scenarios should be **plausible and realistic**. They should combine drivers appropriately and be internally consistent in their logic
- Scenarios should be **dynamic**, with settings changing in response to impetuses over the scenario period
- The drivers underlying each scenario should be **neutral** (reflective of current trends or settings) unless critical to the scenario narrative

- Scenarios should **complement** each other, offering a wide but balanced range of visions and outcomes for the industry

Scenario development approach

L.E.K.'s scenario development used top-down and bottom-up approaches. The top-down approach involved identifying potential scenarios based on major themes that emerged from stakeholder consultations and secondary research. The bottom-up approach grouped logical combinations of drivers together to form scenarios.

Using both approaches led to a list of 11 scenarios (see appendix). The scenarios varied in breadth: some adopted an industry wide view, others focused on specific drivers.

L.E.K. tested and validated the list of 11 scenarios in a workshop with the senior members of the Department's aviation team. Feedback from this workshop was incorporated into both the scenarios and the drivers.

The 11 validated scenarios were plotted against a matrix comparing the level of industry growth against industry focus on meeting sustainability issues implied within each scenario. Scenarios with similar drivers and / or outcomes were then grouped, based on their position in the matrix. Grouping produced a final list of 7 scenarios (see overleaf).

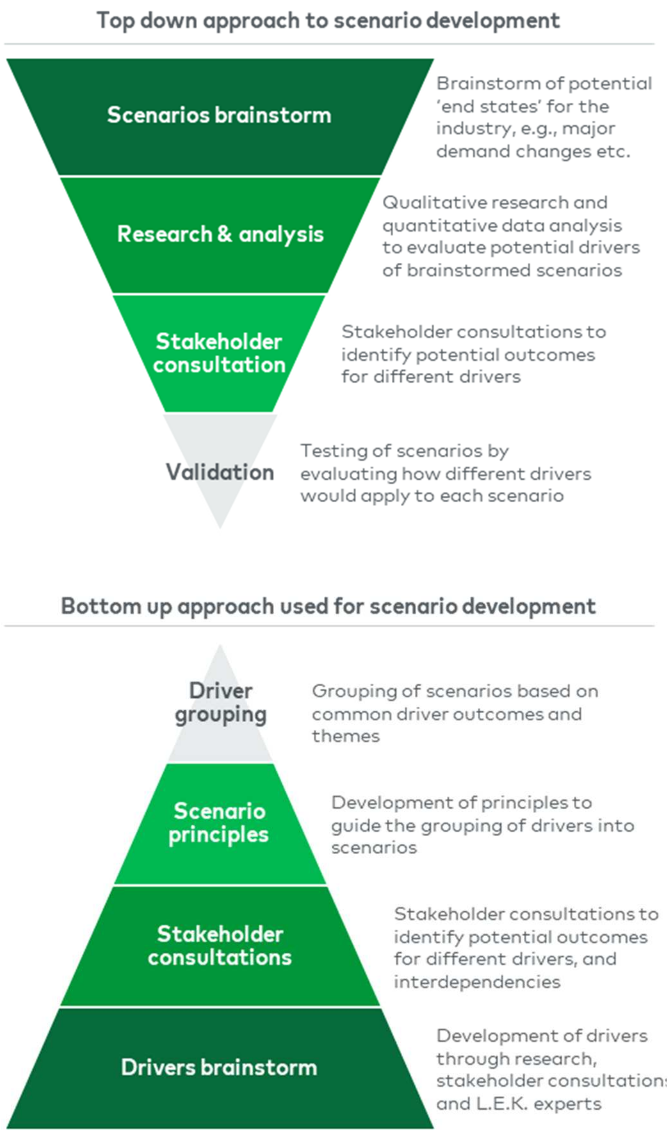
Scenario analysis

A high-level analysis of commercial aircraft traffic and emissions was developed to assist in understanding quantifiable impacts of the scenarios. The analysis uses historical real GDP-based demand elasticities to quantify total passengers, seats, aircraft movements, ASKs and CO_2 emissions to 2050 under the scenarios.

GA activity, workforce requirements and competitive dynamics between airlines have not been quantified in the analysis. These aspects are qualitatively discussed as appropriate for each scenario.

Importantly, unless noted, the analysis represents unconstrained demand. These scenarios are neither predictions nor indicative of the position of any organisation. They are only intended to understand the relativities of different scenarios.

Figure 25
Scenarios development approaches

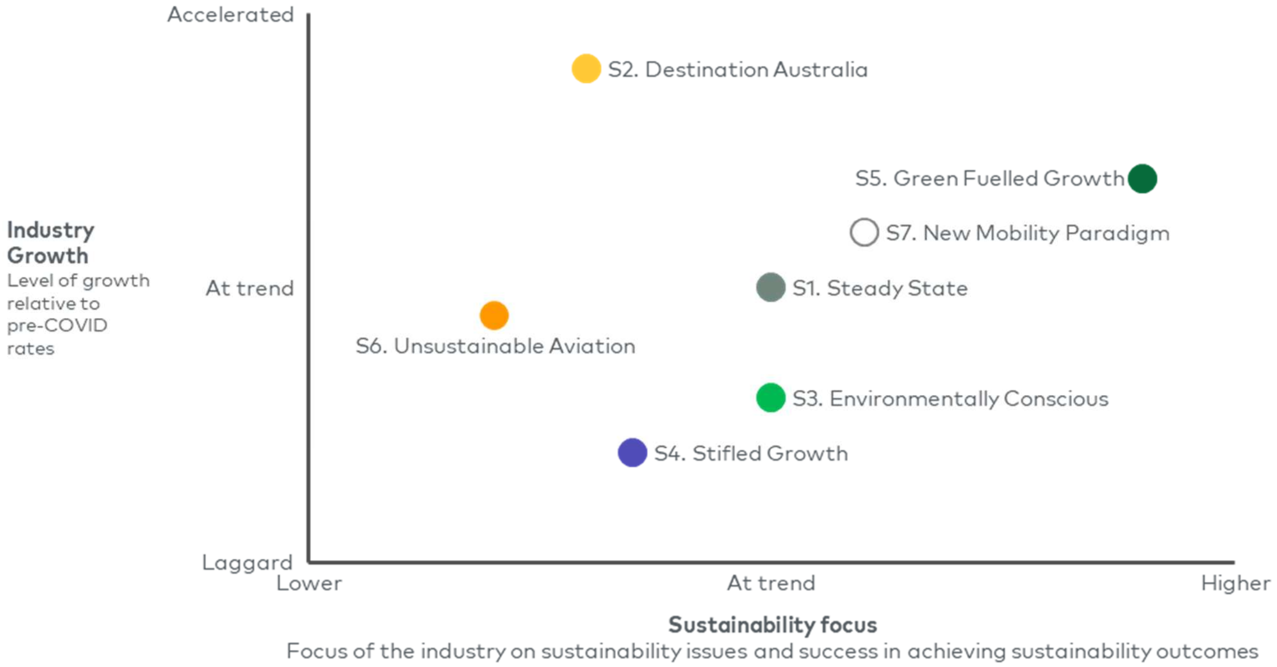


Summary of scenarios

Scenario	Summary description
S1. Steady State	The industry evolves in line with historical growth rates and trends, with some usage of SAF and new technologies
S2. Destination Australia	Australian domestic and international traffic increases substantially due to significant improvements to Australia's tourism proposition and / or a stronger propensity to visit Australia. Domestic competition increases due to Australia's increasing profile as a tourism destination, driving high inbound international and domestic air traffic growth
S3. Environmentally conscious	Demand is structurally reduced by the rise of virtual ways of working and changed leisure traveller preferences, as consumers reduce travel due to environmental concerns
S4. Stifled Growth	Airline, airport and / or labour constraints act as a drag on industry growth, creating excess demand and putting upward pressure on real airfares
S5. Green Fuelled Growth	Green technology and sustainability ambitions are achieved and exceeded. SAF usage, entry into service of electric and hydrogen powered aircraft (in the medium-long term), and ATM advancements help flying become more sustainable and support consumer demand growth
S6. Unsustainable Aviation	Australian airlines are unable to achieve their SAF uptake targets due to insufficient domestic production capacity and competition for imported SAF. Airlines fail to substantially decarbonise, with demand suffering in the long-term
S7. New Mobility Paradigm	AAM successfully commercialises for a wide range of use cases, materially increasing aircraft movements, improving passenger and freight mobility, and creating additional airspace complexity

Scenario grouping matrix

Figure 26
Scenario matrix



4.2 Scenario settings for standardised inputs

Introduction

Standardised settings are assigned to several assumptions to reduce variability in the analysis. These assumptions include:

- The adoption rate and pricing differential with traditional jet fuel for sustainable aviation fuel (SAF)
- The adoption rate of electric or hydrogen aircraft for routes below 500km
- The adoption rate of hydrogen aircraft for routes between 500-4000km

For each assumption, three setting levels have been used. The 'tailwind' setting represents the best feasible outcome for the industry based on the drivers, research, and stakeholder consultations. The 'neutral' setting represents a mid-case. This setting attempts to balance the aviation industry's stated ambitions with challenges in achieving these ambitions. The 'tailwind' setting is a plausible low case for the industry.

This section outlines the tailwind, neutral and headwind settings chosen for each assumption and steps through the salient assumptions and logic for each.

SAF adoption

Tailwind | All industry players agree upon and achieve SAF targets of c.10% by 2030 and 60% by 2050 of all fuel usage

The highest setting for SAF adoption assumes that all Australian domestic airlines and all airlines operating internationally into Australia broadly agree upon and achieve a SAF uplift of c.60% by 2050 and c.10% by 2030. This uplift is slightly below IATA's target of c.65% to achieve net zero emissions by 2050.[171]

Such an uplift will be difficult to achieve. It assumes that there is sufficient feedstock and production capacity (domestically and overseas) to meet demand by 2050. It also assumes that aviation can effectively compete with other industries and modes of transport (i.e., trucks, cars) for biofuels and the feedstock required to produce it.

The target SAF levels included within this scenario would likely require the extensive use of second generation SAF produced through the Fischer-Tropsch or Power to Liquid pathways. SAF prices close to or at parity with jet fuel would also likely be required.[172] For simplicity, it is assumed that price parity is achieved by 2050.

[171] IATA, Net zero 2050: sustainable aviation fuels (2022) © International Air Transport Association, 2019

[172] SAF price relative to traditional jet fuel is not directly linked to the uptake of SAF in the analysis. However, under each of the scenarios the setting for SAF uptake and SAF price relative to traditional jet fuel do correspond e.g., if the high setting for SAF uptake is selected then the high setting for SAF price relative to traditional jet fuel is also selected. This assumes that a substantial improvement in SAF manufacturing / processing capacity will produce economies of scale that reduce the price of SAF relative to traditional jet fuel in the long term. Importantly, the impact on demand of high SAF uptake and high SAF prices relative to traditional jet fuel is minimal. For example, under the Green Fuelled Growth scenario, if SAF adoption remained on the highest setting but prices were also increased to the highest setting, there would be a c.9% difference in demand in 2050 compared to the settings where price parity is achieved. Even then, preferences for environmentally friendly aviation could make consumers considerably less price elastic to SAF driven air fare increases, which may further reduce the impact of SAF adoption on demand.

Neutral | Domestic and international airlines have varying SAF targets. Airlines with targets achieve those targets

This setting assumes that not all domestic and international airlines are able to agree upon targets for SAF. Airlines set varying targets for the short-, medium-, and long-term, depending on availability of SAF in their home market, regulations in their key markets and their own strategic priorities. For example, this scenario assumes that airlines with substantial operations to Europe, including Middle East / Asian hub airlines, have higher SAF targets to allow them to continue operating to Europe. However, airlines operating primarily domestic and regional routes have lower targets (in large part due to an assumption of limited domestic availability of SAF).

Production capacity and feedstock availability are both challenges in this scenario. To achieve these targets will require a significant increase in Australian production capacity, as well as overseas production capacity at key airports. As with the tailwind setting, achieving SAF uptake of c.45% SAF by 2050 would likely require a shift from first to second generation SAF.

This setting is more conservative than the tailwind setting. It assumes that parity is not achieved by 2050 between SAF and conventional jet fuel, with SAF c.1.7x more expensive than jet fuel.

Headwind | Most airlines fail to achieve or materially reduce SAF uptake targets due to production constraints and / or high prices

The headwind setting for SAF adoption assumes that most airlines do not set, or are unable to achieve, or materially reduce their SAF adoption targets for 2050.

This setting reflects the significant challenges that the industry faces in achieving its SAF targets. These challenges include insufficient feedstock and production capacity for SAF due to competition from other transport modes, and the high cost of SAF relative to kerosene. Implicitly, this setting assumes that second generation SAF pathways do not successfully commercialise, leaving the airline industry to compete for energy crops, tallow, and other feedstocks.

In this scenario, price parity is not achieved by 2050. SAF prices only decrease to c.2.1x the cost of kerosene.

Electric aircraft or hydrogen fuel cell aircraft adoption on sub-500km routes

The analysis is agnostic as to the propulsion system used on sub-500km routes

Battery electric, hybrid-electric, or hydrogen fuel cell aircraft could all have potential applications in short-haul regional flying (routes up to c.500km). Therefore, a single adoption curve has been used to simplify analysis of the decarbonisation effects of these aircraft.

Tailwind | In the long-term, most propellor flights less than 500km and some of the jet fleet convert to or are replaced by electric or hydrogen fuel cell propulsion systems

The highest setting for electric or hydrogen fuel cell aircraft adoption assumes that c.75% of current domestic propellor routes and c.50% of jet routes under 500km are operated by hydrogen and / or electric aircraft by 2050. This uptake is equivalent to c.18% of domestic movements and would represent a significant adoption of electric or hydrogen fuel cell aircraft (c.70 aircraft in the domestic fleet under the Environmentally Conscious scenario, or c.13% of the 2050 domestic fleet). No uptake is assumed for international flights due to range and size (i.e., passenger capacity) requirement for most international travel to / from Australia.

At present, electric aircraft technology is significantly further advanced than hydrogen fuel cell technology, with some manufacturers targeting 100+ seat capacity electric aircraft before 2030[173]. The uptake levels included in this scenario would still need to overcome sizeable challenges such as airport infrastructure upgrades, route economics considerations, and improvements in battery energy density levels.

Neutral | In the long-term, a significant proportion of the Australian propellor fleet servicing routes less than 500km are converted to, or are replaced by, electric or hydrogen fuel cell propulsion systems

This setting assumes that there is a moderate uptake of electric or hydrogen fuel cell aircraft for routes under 500km, with approximately c.50% of the propellor flights under 500km replaced by electric aircraft by 2050. The neutral setting also assumes that electric aircraft operate 50% of the Sydney to Canberra traffic. This uptake is equivalent to c.11% of domestic movements and would represent a moderate adoption of electric or hydrogen aircraft. There is no uptake for international flights due to range constraints.

This setting is more conservative and reflects the uncertainty in adoption and commercialisation of electric or hydrogen fuel cell technology. This setting also reflects how airlines may pursue other decarbonisation technologies (i.e., SAF) alongside adoption of low emissions aircraft.

Headwind | Limited uptake of electric or hydrogen fuel cell propulsion systems even in the long term, as these systems are not technologically or commercially viable

The headwind setting for electric or hydrogen fuel cell aircraft adoption for routes under 500km assumes these technologies are not commercially or technologically viable for most use cases by 2050. The settings assumes that c.25% of the domestic propellor fleet is converted to or is replaced by electric or hydrogen fuel cell propulsion systems by 2050, equivalent to c.5% of domestic movements. No jet uptake occurs as these propulsion systems are insufficiently advanced to replace larger jet aircraft.

This setting reflects the uncertainty surrounding the range, payload, and operating economics of electric, hybrid-electric and hydrogen fuel cell regional aircraft.

Hydrogen turbine aircraft adoption on 500km – 4,000km routes

Tailwind | Hydrogen turbine aircraft are viable alternatives to conventional jet aircraft by the mid 2030s, supporting uptake in the 2040s

This setting assumes that hydrogen turbine aircraft will be the only viable alternative to traditional and SAF fuelled aircraft out to 2050, for 500km to c.4,000km routes. This setting assumes that hydrogen turbine aircraft are technically and commercially viable by the late 2030s, in line with Airbus' stated target, with aircraft available for delivery by 2035.[174]

It also assumes domestic Australian airlines can secure aircraft orders and deliveries. The uptake rate is assumed at c.5-6 aircraft per year over 2040-2050, with limited uptake pre-2040. Under this scenario setting, hydrogen aircraft uptake is equivalent to 11% of domestic movements by 2050, representing an ambitious adoption of hydrogen aircraft: c.65 aircraft in the domestic fleet under the Environmentally Conscious scenario, or c.12% of the 2050 domestic fleet. Hydrogen aircraft are not expected to be used for international flights due to anticipated range and infrastructure constraints, except for New Zealand.

Neutral | Hydrogen turbine aircraft do not enter into service until the 2040s, limiting potential uptake in the long term

This setting assumes that hydrogen turbine aircraft technology is commercialised in line with Airbus' goals of the late 2030s, with

[173] Wright Electric website

[174] Ibid

aircraft available for delivery in the 2040s.[175] The setting assumes that hydrogen aircraft are conservatively adopted in the 2040s while the novel technology is tested by industry and supporting ground infrastructure is built. This setting still relies on significant technological and commercial challenges being overcome by the 2040s.

Hydrogen aircraft uptake under this setting is equivalent to 4% of domestic movements by 2050 or c.30 aircraft under the Steady State scenario. Hydrogen aircraft are not expected to be used for international flights except for New Zealand, due to expected range constraints.

Headwind | Hydrogen turbine aircraft do not successfully commercialise by 2050

This scenario setting reflects research and stakeholder consultation feedback regarding uncertainty associated with the development path for hydrogen technology, and the potential timing for entry into service.[176] In this setting, hydrogen aircraft do not successfully commercialise by 2050. This setting does not preclude smaller scale hydrogen powered flight, i.e., for general aviation (GA).

Demand, supply, and real airfares (pricing) settings

Demand and supply settings vary independently between scenarios

Apart from real GDP growth, there are no standardised assumptions for the demand and supply settings in each scenario. Different adjustments to demand, supply, and real airfares (prices) are used to capture specific market effects, e.g., increased domestic competition, workforce shortages, or faster growth in specific markets.

The tailwind setting assumes real GDP growth of 0.5% p.a. above forecast, reflecting periods of stronger growth and fewer recessions. The neutral setting assumes the forecast real GDP growth rate. Lastly, the headwind setting assumes real GDP growth of 0.5% p.a. below forecast, reflecting a greater frequency of recessions and disruptions to growth.

The point at which air traffic levels are expected to reach pre-COVID-19 levels is different for the domestic and international markets

For simplicity, the scenarios assume that in 2023, domestic traffic returns to a level broadly comparable to 2019. All domestic air traffic analysis is done on a 2023 to 2050 basis.

International air traffic demand is assumed to reach pre-pandemic levels in 2025. All international air traffic analysis is done on a 2025 to 2050 basis.

Air traffic analysis is in absolute terms. As such, the mix of business and leisure domestic demand in 2023 may be different to the approximate mix in 2019.

Note on emissions assumptions

The settings used for SAF, electric aircraft and hydrogen aircraft adoption assume that the Australian aviation industry is unable to achieve absolute zero emissions by 2050. However, this does not mean that absolute zero cannot be achieved beyond the analysis period. By 2050, hydrogen aircraft technology is expected to reach a point at which hydrogen aircraft could quickly enter global fleets. It is feasible that further, substantial decarbonisation could happen in the period between 2050-2060.

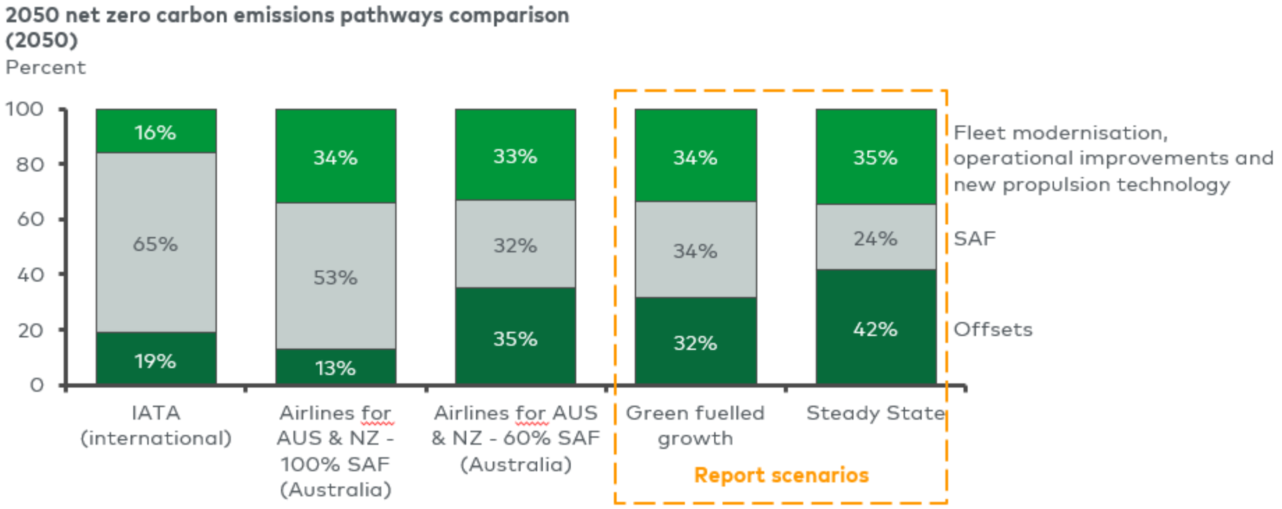
The report's settings align to the assumptions made for decarbonisation by major aviation bodies such as A4ANZ and IATA. Most assume that absolute zero is not feasible by 2050 and that achieving net zero within this period will require the substantial use of offsets. Importantly, it is assumed that all airlines achieve their obligations under the Safeguard Mechanism in all scenarios through technology upgrades, SAF, and offsets. .

[175] L.E.K. research

[176] L.E.K., Stakeholder Consultations (Dec 2022 – Feb 2023)

Figure 27

2050 net zero carbon emissions pathways comparison



Source: A4ANZ, L.E.K. analysis

4.3 Scenario narratives

S1. Steady State

The industry evolves in line with historical growth rates and trends, with some usage of SAF and new technologies

In the immediate post-COVID era, leisure air travel (holiday and visiting friends and relatives, or VFR) continues to drive demand for commercial air travel. Over the longer-term, leisure travel demand continues to grow at rates comparable to, but slightly lower than, pre-COVID-19 growth rates due to natural moderation of demand. Australians continue to travel whenever they can.

While business travel takes longer to recover than leisure travel and faces a degree of structural reduction in demand (c.10-25% less business travel), it remains critical to Australian commercial aviation. Business travel (external meetings, business development, conferences, and events) returns post-pandemic and grows reasonably well. FIFO demand, not significantly diminished by COVID-19, continues to grow strongly, driving RPT and general aviation charter activity in the regions. Combined business-leisure ('bleisure') travel continues to gain popularity.

The propensity to travel for internal meetings does not return to pre-pandemic levels due to changed ways of working (video calls and remote collaboration), corporate budgets, and corporate focus on emissions reduction. Consequently, in the medium- to long-term, the already mature business travel market grows in line with the broader domestic market.

Demand for domestic and international travel exceeds supply throughout the mid-2020s, resulting in higher real airfares versus pre-COVID-19. Airfares normalise from the late-2020s as demand and capacity reach equilibrium.

Figure 28
Settings for S1. Steady State

		Headwind	Neutral	Tailwind
Demand	Changing leisure traveller preferences and behaviours	International and domestic leisure travel demand is depressed	International and domestic leisure travel grows at pre-COVID levels	Strong growth in international and domestic leisure travel
Demand	Changing ways of working	Domestic and international business travel grows slower than pre-COVID	Domestic business travel recovers slowly. International business travel grows at pre-COVID rates	Domestic and international business travel grows at or above pre-COVID rates
Supply	Domestic airline competitive dynamics	Competition worsens in the long-term	Competition remains broadly at pre-COVID levels	Sustained, substantial increase in domestic competition in long-term
Supply	Workforce training, supply, and capabilities	Labour is a hindrance to demand growth	Labour broadly sufficient to enable demand growth	Surplus of skilled labour supports demand growth
Supply	Availability and uptake of AAM	AAM fails to successfully commercialise outside of fringe GA use cases	AAM commercialises in the long-term on traditional GA use cases	AAM commercialises with new and expanded GA use cases
Sustainability	Emissions reduction ambitions and pressures	Continued pressure on airlines to decarbonise		
Sustainability	Availability and uptake of SAFs	2% of fuel in 2030 25% of fuel in 2050 SAF 2.1x traditional jet fuel in 2050	5% of fuel in 2030 45% of fuel in 2050 SAF 1.7x traditional jet fuel in 2050	10% of fuel in 2030 60% of fuel in 2050 SAF 1x traditional jet fuel in 2050
Sustainability	Availability and uptake of electric or hydrogen fuel cell aircraft on sub-500km routes	18% share of eligible ASKs by 2050. Limited service from 2031. Equivalent of 5% of domestic movements	40% share of eligible ASKs by 2050. Limited service from 2031. Equivalent of 11% of domestic movements	68% share of eligible ASKs by 2050. Limited service from 2026. Equivalent of 18% of domestic movements
Sustainability	Availability and uptake of hydrogen turbine aircraft	Never enters service	Entry into service from 2041. 5% share of eligible ASKs by 2050 or equivalent of 4% of movements for domestic market	Entry into service from 2036. 15% share of eligible ASKs by 2050 or equivalent of 11% of movements for domestic market
Sustainability	Evolution of air traffic management	A lack of ATM evolution acts as a barrier to industry growth	ATM evolves to support demand and sustainability	ATM evolves to support sustainability objectives and new technologies

International growth slows naturally as Australia's large international tourist and VFR markets continue to mature, notably China, USA, NZ and Japan. Emerging markets such as India, Vietnam and Indonesia 'backfill' some of the lost growth.

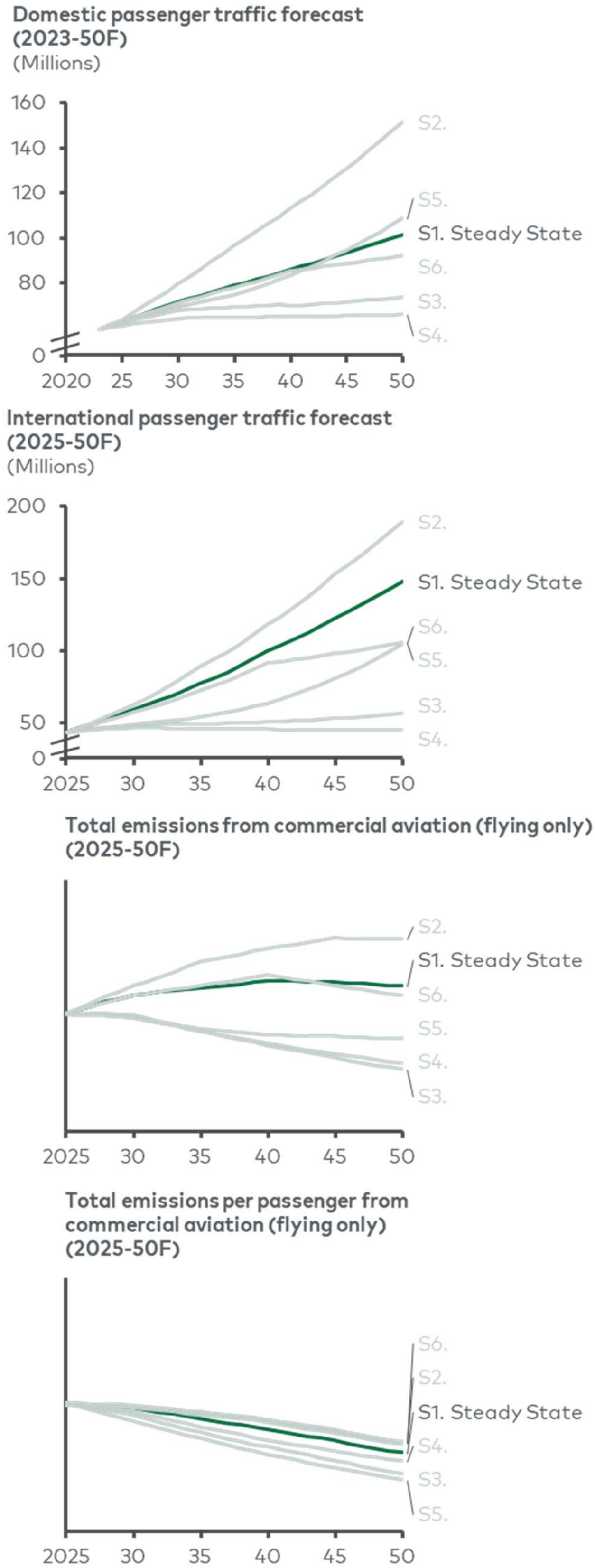
Overall, domestic passenger traffic grows at c.2.0% in the long-term – on par with the pre-pandemic growth rate of c.2.0% per annum between 2009-2019 – reflecting the maturing of the Australian domestic market. By 2050, domestic passengers reach c.100 million per annum, up from c.61 million per annum in 2019.[177]

In the long-term, international traffic grows at c.5.0% per annum, slightly below the pre-pandemic market growth rate of c.5.8% per annum between 2009-2019. This growth reflects the maturation of key inbound markets and long-term moderation in real GDP growth. Total passenger volumes increase to c.150 million passengers by 2050, up from c.43 million in 2019.

While airline competition remains healthy, the domestic market continues to support a limited number of domestic carriers of significant scale. International airlines continue to seek greater access to Australia and advocate for greater capacity within air service agreements. Limited peak slot availability at major capital city airports acts as a slight drag on unconstrained competition, to the benefit of incumbent slot holders.

Airports cater for traffic growth by continuing to deliver capacity. New runways are added in several major capital cities in the 2020s and 2030s (Western Sydney Airport, Melbourne Airport, Perth Airport). These additional runways provide the necessary capacity to serve the commercial market through to 2050, although peak capacity is ultimately exhausted at the East Coast airports. GA and private aviation operators continue to shift operations to secondary airports such as Bankstown.

Figure 29
Passenger and emissions outcomes for S1. Steady State



Source: L.E.K. analysis

177 Please note that all scenarios present unconstrained demand, unless otherwise stated

Ongoing delivery of newer aircraft models – ultra long-haul widebodies, long-range narrowbodies – continues to open / expand point-to-point routes, particularly into Asia, but also the Americas and Europe.

SAF usage gradually increases as production capacity increases. Australian production capacity is slow to establish and there is difficulty securing feedstocks for domestic production in the short- to medium-term. Some Australian airlines meet SAF targets through available domestic production, imports and by uplifting fuel at foreign airports like Los Angeles, San Francisco, and London. However, demand exceeds available supply, and SAF usage amongst most Australian airlines is modest.

In the medium- to long-term, both domestic SAF production and imports increase, enabling greater SAF usage across a greater number of airlines.

This greater uptake of SAF – in combination with other net zero initiatives, such as carbon offset purchases – leads to rising real airfares during the 2030s and 2040s. These higher prices act as a slight drag on demand for both domestic and international travel.

Regional aviation grows slowly, driven by continued demand for commercial travel to regions and regional residents seeking to access services in major cities. Limited slot availability at major airports and the consolidation of regional populations around major regional centres like Dubbo, Rockhampton, and Mildura leads to route consolidation in the medium-term. The breadth of regional services reduces as a result.

Electric or hybrid-electric regional turboprops (c.20-50 seats) begin entering service on regional routes in the 2030s but are limited in number (electric GA aircraft are already in service). These electric / hybrid aircraft are either new airframes (i.e., new aircraft with new propulsion systems) or existing aircraft with propulsion system conversions (e.g., Saab, or Q-300 with new electric / hybrid engines). Aircraft with hydrogen propulsion systems begin entering the regional fleet in the 2040s, also in limited numbers.

The Australian aviation sector has mixed success recruiting and maintaining its workforce in the short- to medium-term, particularly for licensed aircraft maintenance engineers and pilots. However, Australian airlines meet their workforce needs – including c.80% more commercial pilots by 2050 compared to 2019 – to serve domestic and international operations.

General aviation (GA) grows slowly over the long-term. Workforce constraints (particularly engineers and pilots) impact GA operators more heavily than commercial airlines, creating challenges for many in the GA community.

Emissions growth slows in the short- to medium-term as airlines take delivery of next-generation aircraft such as Airbus A320NEOs, as well as electric / hybrid / hydrogen fuel cell regional aircraft. In the long-term, emissions growth slows considerably as SAF adoption accelerates and electric / hybrid / hydrogen fuel cell aircraft technology matures.

AAM slowly commercialises. The 2032 Olympics in South East Queensland serves as a catalyst for AAM to replace traditional fixed and rotary wing aircraft for some GA activity, e.g., tourism and sightseeing, in the medium-term. In the long-term AAM activity increases, but a major point-to-point network does not materialise before 2050.

S2. Destination Australia

Australian domestic and international traffic increases substantially due to significant improvements to Australia's tourism proposition and / or a stronger propensity to visit Australia. Domestic competition increases as a result Australia's increased profile as a tourism destination, driving high inbound international and domestic air traffic growth

In the 2020s and beyond, there is a wave of investment in Australia's tourism assets – hotels, hospitality, national parks, and events / conference spaces. This investment is combined with global tourism marketing campaigns and an expansion of hospitality and tourism infrastructure to accommodate growth. The investments pay off: international tourist demand for Australian holidays grows strongly and VFR travellers visit more frequently. Growth is supported by an expanding, increasingly wealthy Asian middle- to upper-class. The 2032 Olympics draw attention, creating a long-lasting halo effect around Australia as a tourism destination.

Australia's natural endowment is a major draw, offering increasingly rare experiences for tourists from nations experiencing ongoing urbanisation. Australia offers tourists a wide variety of scenery and activities from thriving cities to the Great Barrier Reef and the desert.

Australia rises in attractiveness as a conference and events destination, particularly as the post-pandemic popularity of combined business-leisure ('bleisure') trips grows. Partly supported by the growth of conferences, events and 'bleisure' travel, inbound international business returns to pre-COVID-19 growth rates.

Migration friendly policies support travel to Australia for work and study. Inbound VFR demand grows as a result, particularly to and from Asia.

Figure 30

Settings for S2. Destination Australia

		Headwind	Neutral	Tailwind
Demand	Changing leisure traveller preferences and behaviours	International and domestic leisure travel demand is depressed	International and domestic leisure travel grows at pre-COVID levels	Strong growth in international and domestic leisure travel
Demand	Changing ways of working	Domestic and international business travel grows slower than pre-COVID	Domestic business travel recovers slowly. International business travel grows at pre-COVID rates	Domestic and international business travel grows at or above pre-COVID rates
Supply	Domestic airline competitive dynamics	Competition worsens in the long-term	Competition remains broadly at pre-COVID levels	Sustained, substantial increase in domestic competition in long-term
Supply	Workforce training, supply, and capabilities	Labour is a hindrance to demand growth	Labour broadly sufficient to enable demand growth	Surplus of skilled labour supports demand growth
Supply	Availability and uptake of AAM	AAM fails to successfully commercialise outside of fringe GA use cases	AAM commercialises in the long-term on traditional GA use cases	AAM commercialises with new and expanded GA use cases
Sustainability	Emissions reduction ambitions and pressures	Continued pressure on airlines to decarbonise		
Sustainability	Availability and uptake of SAFs	2% of fuel in 2030 25% of fuel in 2050 SAF 2.1x traditional jet fuel in 2050	5% of fuel in 2030 45% of fuel in 2050 SAF 1.7x traditional jet fuel in 2050	10% of fuel in 2030 60% of fuel in 2050 SAF 1x traditional jet fuel in 2050
Sustainability	Availability and uptake of electric or hydrogen fuel cell aircraft on sub-500km routes	18% share of eligible ASKs by 2050. Limited service from 2031. Equivalent of 5% of domestic movements	40% share of eligible ASKs by 2050. Limited service from 2031. Equivalent of 11% of domestic movements	68% share of eligible ASKs by 2050. Limited service from 2026. Equivalent of 18% of domestic movements
Sustainability	Availability and uptake of hydrogen turbine aircraft	Never enters service	Entry into service from 2041. 5% share of eligible ASKs by 2050 or equivalent of 4% of movements for domestic market	Entry into service from 2036. 15% share of eligible ASKs by 2050 or equivalent of 11% of movements for domestic market
Sustainability	Evolution of air traffic management	A lack of ATM evolution acts as a barrier to industry growth	ATM evolves to support demand and sustainability	ATM evolves to support sustainability objectives and new technologies

Australian tourists increasingly choose to holiday domestically, where historically they may have travelled overseas. Australian's increased interest in exploring their own country was established during COVID-19, and investment in tourism assets sustain and encourage that interest in the future.

As with international business travellers, domestic business travellers increasingly adopt 'bleisure' travel patterns. The ability to work remotely enables more people to travel more frequently for leisure (and work remotely while away) or add leisure travel to the start or end of a business trip.

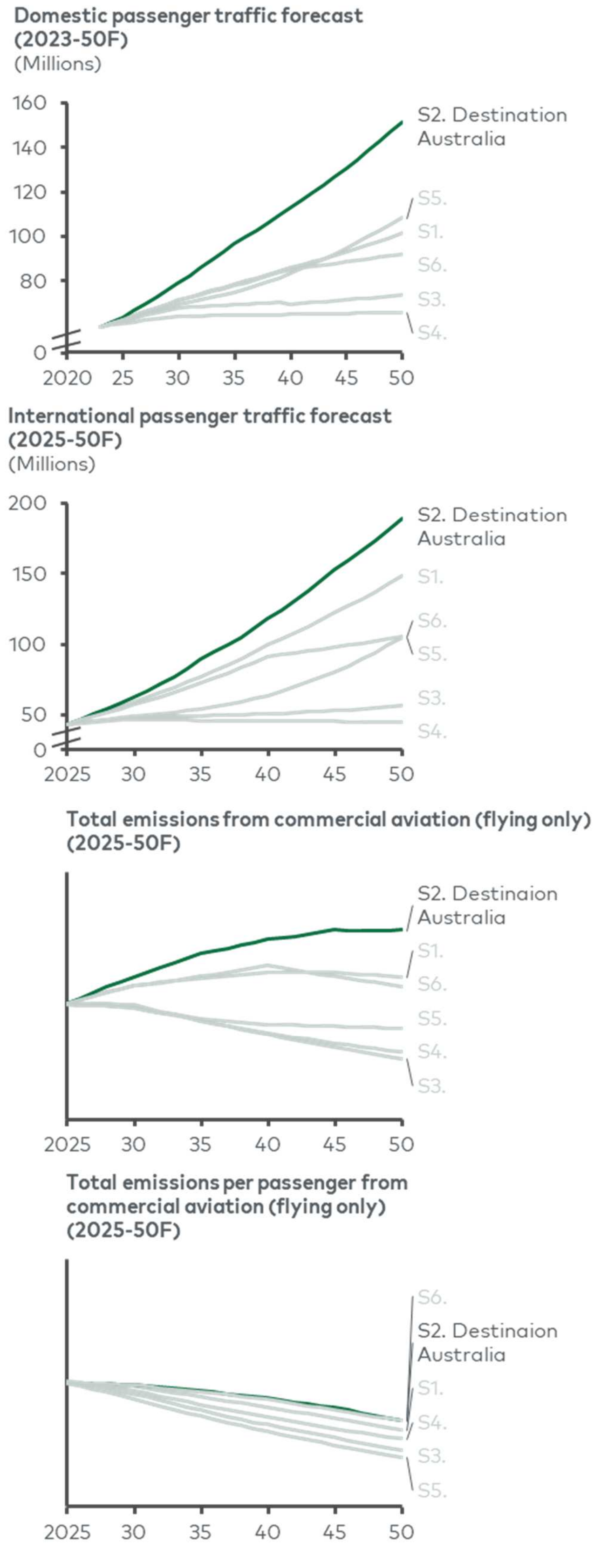
In the short- to medium-term, Australian airlines respond to increased leisure and VFR demand by increasing services to leisure destinations from capital cities. Capacity and frequency grow on existing international routes and new point-to-point routes open (particularly to Asia, Europe, and the Americas). Deliveries of new long-range aircraft (both widebody and narrowbody) enable and support this growth, particularly to and from secondary airports.

High demand growth leads to greater airline competition, which enables additional carriers to serve domestic and international markets. Greater competition drives growth at both capital and non-capital city airports and leads to lower real airfares in the medium-term for both domestic and international travel.

Airports respond to increased demand by accelerating infrastructure delivery, particularly to serve international traffic growth. New runways are added in several major capital cities in the 2020s and 2030s (Western Sydney Airport, Melbourne Airport, Perth Airport), and significant capacity expansions (terminals, gates, aprons) are required for all capital city airports to cater for additional international widebody aircraft.

This additional infrastructure provides the necessary capacity to serve the commercial market through to 2050, although all major

Figure 31
Passenger and emissions outcomes for S2. Destination Australia



Source: L.E.K. analysis

capital city airports – Sydney, Western Sydney, Melbourne, Brisbane, and Perth – are operating close to capacity by 2050. Airports such as Gold Coast, Newcastle and Avalon grow rapidly in later years as their natural catchments increase through population growth, and as their bigger neighbours become constrained.

Airports invest in and work with regulators to introduce technological advancements in passenger processing. Biometrics, lower-intervention security (i.e., trusted traveller programs) and automated check-in / bag-drop help speed passengers through airports, improving both airport efficiency and the passenger experience. Advancements in biometric coordination with other jurisdictions provide a seamless inbound travel experience for many travellers.

Strong air travel demand leads to greater investment in training pathways and real wage growth for aviation sector workers, particularly aircraft maintenance engineers and pilots. Careers in aviation become more attractive, more people enter training pathways and Australian airlines are successful in recruiting pilots and engineers from overseas.

In the long-term, the growth of international leisure, VFR and business travellers drive international growth of c.6.1 % per annum, above pre-pandemic rates. Total international passengers grow to c.190 million passengers per annum, up from c.43 million per annum in 2019.[178]

Domestic passenger traffic also grows above pre-COVID rates, at 3.5% per annum. Total passengers reach c.150 million in 2050, up from c.61 million in 2019. Traffic growth occurs across both capital city and non-capital city routes, particularly to serve tourist / leisure destinations.

Regional aviation is a major beneficiary of increased demand growth. Traveller demand for tourism attractions away from major cities, e.g., Uluru, the Murray River, Australia's wine regions and the outback, encourage airlines to establish additional routes and frequencies to regional airports. Regional RPT traffic growth occurs mostly on services to established regional centres, although some smaller and 'thinner' routes benefit from the increased demand. Regional airports respond to increased traffic by investing in infrastructure such as runway and tarmac upgrades, and new passenger facilities.

Increased tourism demand drives growth in GA, particularly for sightseeing and tourism flights. Tourism-driven GA demand growth creates opportunities for the AAM industry. AAM operators and OEMs capitalise on burgeoning domestic demand to launch crewed AAM aircraft services in tourist areas in the early 2030s. Autonomous / uncrewed AAM begins to grow in the late 2030s, enabled by appropriate safety regulation, airspace design and the deployment of uncrewed traffic management (UTM).

The AAM industry invests substantially in private vertiports to support scaled operations, working with government to locate vertiports in areas desirable for tourists. In regional areas, AAM services hub out of regional airports, providing additional connectivity for passengers travelling from major cities.

Relative to demand growth, Australia's domestic SAF production industry is slow to grow and SAF imports are limited. This creates significant excess demand for SAF domestically and limits meaningful uptake of SAF to international flights at overseas ports. High demand for air travel creates additional pressure and urgency around the need for domestic SAF production, spurring investment in the medium- to long-term. Growing domestic production capacity starting in the medium term helps increase availability and reduce SAF prices. Despite investment in SAF production capacity, the pace and scale of

[178] Please note that all scenarios present unconstrained demand, unless otherwise stated

demand growth prevents the industry from fully realising long term SAF targets.

Partly as a result, a stronger focus is placed on incorporating electric and hybrid-electric aircraft into regional fleets. This also helps better serve some regional tourism destinations. However, strong global demand for electric and hybrid-electric aircraft create supply constraints. Despite investment in SAF and electric aviation in the medium- to long-term, aviation emissions increase at a faster rate than pre-pandemic, driven by growth in the absolute traffic level. Aviation emissions increase to c.35 million tonnes, the highest level of any scenario.

S3. Environmentally Conscious

Demand is structurally reduced by the rise of virtual ways of working and changed leisure traveller preferences, as consumers reduce travel due to environmental concerns

The surge of post-pandemic travel subsides in the mid-2020s and the public is less willing to travel frequently.

In the late 2020s, Australian travellers become increasingly concerned about the environmental impacts of air travel. Consumer responses on how to limit emissions vary. Some travellers decide to curtail long-haul travel, as this has a particularly high emissions intensity. However, most 'save up' their emissions for overseas travel by reducing domestic flying and finding other ways to reduce their personal emissions. There is some increase in demand for carbon offset purchases, although the more common consumer reaction is simply to reduce the frequency of air travel. As a result, domestic and international leisure travel growth rates decline through the 2030s.

Business travel is similarly impacted, as corporate sustainability targets suppress business travel demand. Universal use and acceptability of virtual working and videoconferencing enables businesses to limit domestic flying to the highest priority trips. International travel is more resilient, as the distance and cost of accessing Australia means most pre-pandemic international business travel was already considered high priority. The net result is downward pressure on demand for business travel and lower long-term growth rates relative to pre-pandemic times.

The FIFO market remains strong, driven by a buoyant resources industry. While the resilience of FIFO demand supports regional and cross-country RPT and general aviation, business travel is structurally reduced post-pandemic due to lower corporate demand. New generations of business leaders, accustomed to video conferencing and

Figure 32
Settings for S3. Environmentally Conscious

		Headwind	Neutral	Tailwind
Demand	Changing leisure traveller preferences and behaviours	International and domestic leisure travel demand is depressed	International and domestic leisure travel grows at pre-COVID levels	Strong growth in international and domestic leisure travel
Demand	Changing ways of working	Domestic and international business travel grows slower than pre-COVID	Domestic business travel recovers slowly. International business travel grows at pre-COVID rates	Domestic and international business travel grows at or above pre-COVID rates
Supply	Domestic airline competitive dynamics	Competition worsens in the long-term	Competition remains broadly at pre-COVID levels	Sustained, substantial increase in domestic competition in long-term
Supply	Workforce training, supply, and capabilities	Labour is a hindrance to demand growth	Labour broadly sufficient to enable demand growth	Surplus of skilled labour supports demand growth
Supply	Availability and uptake of AAM	AAM fails to successfully commercialise outside of fringe GA use cases	AAM commercialises in the long-term on traditional GA use cases	AAM commercialises with new and expanded GA use cases
Sustainability	Emissions reduction ambitions and pressures	Continued pressure on airlines to decarbonise		
Sustainability	Availability and uptake of SAFs	2% of fuel in 2030 25% of fuel in 2050 SAF 2.1x traditional jet fuel in 2050	5% of fuel in 2030 45% of fuel in 2050 SAF 1.7x traditional jet fuel in 2050	10% of fuel in 2030 60% of fuel in 2050 SAF 1x traditional jet fuel in 2050
Sustainability	Availability and uptake of electric or hydrogen fuel cell aircraft on sub-500km routes	18% share of eligible ASKs by 2050. Limited service from 2031. Equivalent of 5% of domestic movements	40% share of eligible ASKs by 2050. Limited service from 2031. Equivalent of 11% of domestic movements	68% share of eligible ASKs by 2050. Limited service from 2026. Equivalent of 18% of domestic movements
Sustainability	Availability and uptake of hydrogen turbine aircraft	Never enters service	Entry into service from 2041. 5% share of eligible ASKs by 2050 or equivalent of 4% of movements for domestic market	Entry into service from 2036. 15% share of eligible ASKs by 2050 or equivalent of 11% of movements for domestic market
Sustainability	Evolution of air traffic management	A lack of ATM evolution acts as a barrier to industry growth	ATM evolves to support demand and sustainability	ATM evolves to support sustainability objectives and new technologies

working from home, further entrench low-travel policies.

Business travellers – regardless of the cabin of travel – pay higher airfares on average than leisure travellers. The structural reduction in business travel results in sustained higher real airfares in the short-to medium-term, particularly for domestic travel. Leisure travel demand is further negatively impacted in the short- to medium-term.

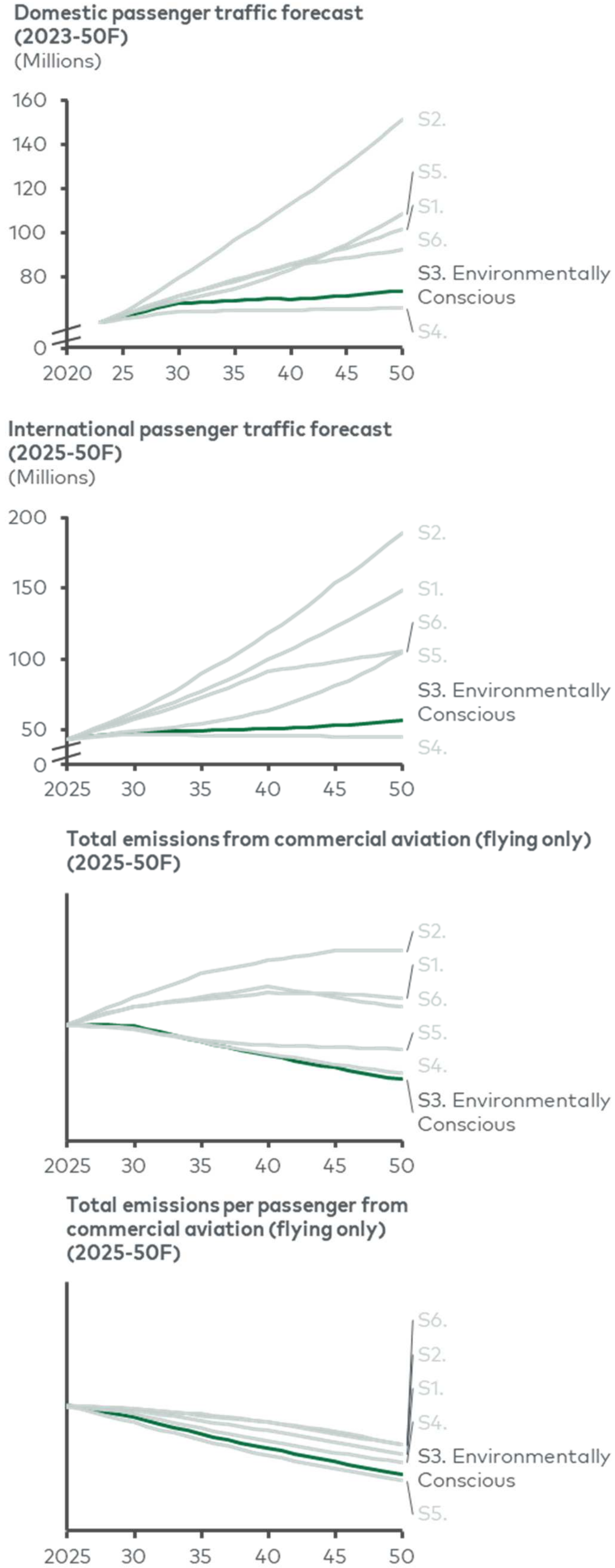
Internationally, the inbound European market – both leisure and business – softens significantly in the late 2020s and early 2030s as European governments enact more stringent environmental policies and as European consumers seek to reduce personal emissions.

This reduction in European traffic negatively impacts airline route economics to / from Australia for international airlines and further entrenches the low growth environment.

Greater emphasis on environmental issues within Australia encourages the Australian and NSW Governments to deliver passenger rail upgrades on the Canberra-Sydney corridor, materially reducing travel times and increasing train frequency. Opening in the late-2030s, the rail upgrades immediately reduce air traffic on the Sydney to Canberra route. Only connecting traffic (c.10% of passengers) remains on the air route, with all other passengers taking rail (a total reduction of c.1.4% in Australian domestic passenger traffic).

Consumer concerns around the environmental impact of air travel encourage investment in SAF production in the 2030s. Overseas competition for feedstocks limits domestic production. Other modes of transport (i.e., trucks) compete for the limited availability of imported and domestically produced biofuels, further reducing SAF availability. Consequently, airlines operating international services to and from Australia primarily rely on foreign ports for SAF.

Figure 33
Passenger and emissions outcomes for S3. Environmentally Conscious



Source: L.E.K. analysis

Airlines fall short of consumer sustainability expectations in the early 2030s due to limited adoption of first generation SAF. Airlines try to counter this by focusing on the adoption of electric, hybrid-electric and hydrogen aircraft. Electric aircraft begin to enter regional fleets from the early 2030s, replacing older turboprops. Hydrogen aircraft enter service on regional routes in the late 2030s and domestic routes from the mid-2040s. However, electric, hybrid and hydrogen aircraft can only serve a small portion of the overall market due to range and payload constraints.

In the long-term, greater investment is directed towards second generation SAF production. Some Australian airlines meet their SAF ambitions by 2050, alleviating the concerns of some customers and encouraging a return to flying though the 2040s.

GA operators invest in electric and hybrid aircraft. These light aircraft enter service from the late-2020s / early-2030s and serve primarily flight training, tourism, and very short-haul commuter passenger transport. Operators benefit from lower operating costs due to lower fuel and maintenance expenses, encouraging further adoption.

Sustainability concerns, suppressed business travel demand, and limited SAF adoption act as headwinds to domestic passenger growth. Domestic passenger traffic reaches c.75 million passengers per annum, with growth averaging 0.8% per annum between 2023 and 2050.[179]

Within the domestic market, regional aviation activity is more resilient than inter-state and capital city flying. The adoption of low carbon electric and hydrogen aircraft through the 2030s and 2040s, and lower levels of discretionary leisure and business travel, lead to strong long-term demand. However, some regional markets, particularly those within c.2-4 hours of major cities, decline as electric vehicles enter the Australian car parc, offering lower carbon travel options.

International air travel grows slightly faster than domestic, but slower than pre-pandemic rates, reaching c.55 million passengers by 2050. The pace of growth increases slightly in the 2040s as Australian and overseas airlines are better able to address customer sustainability concerns through newer, more efficient aircraft and SAF. Overall, international traffic grows at c.1.0% per annum between 2025 and 2050.

Lower demand growth results in slower growth in requirements for skilled labour. Consumer concern for the industry's environmental impacts creates new barriers to recruiting a younger generation of workers. The industry, including GA, meets most of its workforce needs in the long-term, but still struggles to attract people to the sector.

Despite a slow start to domestic SAF uptake, emissions decrease in the long-term by almost c.50% by 2050. This is a result of slow traffic growth and ongoing fleet replacement with more efficient next-generation aircraft. Despite the high level of interest in electric, hybrid-electric and hydrogen aircraft, technological limitations on range mean they only contribute c.7% to the overall reduction in 2050 (93% of the reduction is driven by SAF and aircraft / engine efficiency improvements).

[179] The international and domestic passenger movement scenarios represent unconstrained demand

S4. Stifled Growth

Airline, airport and / or labour constraints act as a drag on industry growth, creating excess demand and putting upward pressure on real airfares

By 2030, the Australian aviation industry does not have enough pilots to cater for growth. Australia's maintenance, repair, and overhaul (MRO) workforce is in a marginally better state, able to service maintenance needs out of major cities. In the regions, the situation is dire, with flying and MRO operations severely diminished due to insufficient workforce supply.

Post-pandemic, demand growth slows. While domestic and international leisure travel initially rebounds to pre-pandemic levels in the mid-2020s, growth moderates thereafter as economic growth within Australia slows due to periods of recession and a worsening economic outlook. Business travel demand remains structurally impaired post-pandemic. The resulting negative industry outlook makes aviation careers less attractive, exacerbating workforce issues.

There is a global pilot shortage. Despite offers of higher compensation and improved benefits, Australian airlines are uncompetitive with airlines in markets such as the US or Middle East in attracting and retaining pilots (primarily because these airlines offer materially higher compensation).

Programs to improve availability of licensed aircraft maintenance engineers (LAMEs) – such as Alliance's apprenticeships program in Rockhampton – partially alleviate shortages for some operators but cannot meet demand. Partially as a result, even more maintenance work is done offshore, the domestic Australian market for MRO shrinks, and career attractiveness suffers further.

By 2030, labour shortages prevent Australian airlines from adding new routes or additional frequencies domestically or internationally.

Figure 34
Settings for S4. Stifled Growth

		Headwind	Neutral	Tailwind
Demand	Changing leisure traveller preferences and behaviours	International and domestic leisure travel demand is depressed	International and domestic leisure travel grows at pre-COVID levels	Strong growth in international and domestic leisure travel
Demand	Changing ways of working	Domestic and international business travel grows slower than pre-COVID	Domestic business travel recovers slowly. International business travel grows at pre-COVID rates	Domestic and international business travel grows at or above pre-COVID rates
Supply	Domestic airline competitive dynamics	Competition worsens in the long-term	Competition remains broadly at pre-COVID levels	Sustained, substantial increase in domestic competition in long-term
Supply	Workforce training, supply, and capabilities	Labour is a hindrance to demand growth	Labour broadly sufficient to enable demand growth	Surplus of skilled labour supports demand growth
Supply	Availability and uptake of AAM	AAM fails to successfully commercialise outside of fringe GA use cases	AAM commercialises in the long-term on traditional GA use cases	AAM commercialises with new and expanded GA use cases
Sustainability	Emissions reduction ambitions and pressures	Continued pressure on airlines to decarbonise		
Sustainability	Availability and uptake of SAFs	2% of fuel in 2030 25% of fuel in 2050 SAF 2.1x traditional jet fuel in 2050	5% of fuel in 2030 45% of fuel in 2050 SAF 1.7x traditional jet fuel in 2050	10% of fuel in 2030 60% of fuel in 2050 SAF 1x traditional jet fuel in 2050
Sustainability	Availability and uptake of electric or hydrogen fuel cell aircraft on sub-500km routes	18% share of eligible ASKs by 2050. Limited service from 2031. Equivalent of 5% of domestic movements	40% share of eligible ASKs by 2050. Limited service from 2031. Equivalent of 11% of domestic movements	68% share of eligible ASKs by 2050. Limited service from 2026. Equivalent of 18% of domestic movements
Sustainability	Availability and uptake of hydrogen turbine aircraft	Never enters service	Entry into service from 2041. 5% share of eligible ASKs by 2050 or equivalent of 4% of movements for domestic market	Entry into service from 2036. 15% share of eligible ASKs by 2050 or equivalent of 11% of movements for domestic market
Sustainability	Evolution of air traffic management	A lack of ATM evolution acts as a barrier to industry growth	ATM evolves to support demand and sustainability	ATM evolves to support sustainability objectives and new technologies

In response, Australia's airlines use larger aircraft on domestic routes where possible, with relative limited impact and a knock-on impact of reducing international passenger and freight capacity. International airlines become even more important in providing passenger and freight capacity to and from Australia, but they too face skilled labour constraints.

Constrained supply leads to excess demand. The result is higher real airfares, creating downward pressure on demand for air travel.

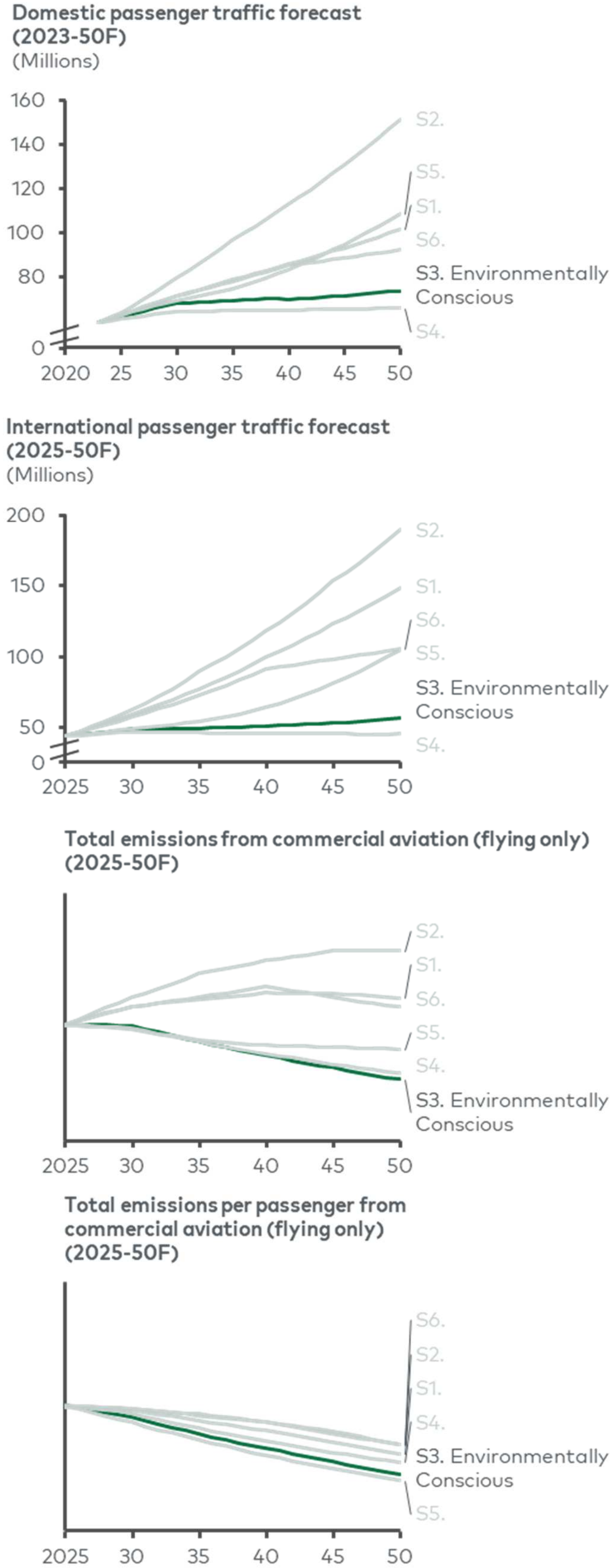
Airports have difficulty recruiting and retaining security, ground handling, check-in, and other staff. The result is a degraded passenger experience, with longer queues and poorer service.

Airports and airlines continue to invest in the automation of check-in, bag drop, and other passenger facilitation functions. There is a stronger push towards offsite check-in (i.e., online check-in) for both domestic and international flights. These initiatives help arrest the decline in passenger experience.

Regional aviation and GA are hardest hit by labour shortages. Airlines prioritise crewing their larger aircraft operating on higher yielding routes. Regional consolidation relieves pressure on regional airlines to replace aging turboprops on a like-for-like basis. Instead, they up-gauge to larger aircraft where possible and extend the life of smaller turboprops with spares and engines from their fleet. Consequently, in the medium term, regional flying concentrates into major regional airports that can accommodate larger aircraft (e.g., Dubbo, Wagga Wagga) while services to smaller regional destinations decline.

GA activity is significantly constrained in the medium-long term. Major tourism and charter operators struggle to find skilled labour to continue operations, with some going out of business. This loss of air connectivity negatively impacts regional areas and economies, particularly those dependent on tourism.

Figure 35
Passenger and emissions outcomes for S4. Stifled Growth



Source: L.E.K. analysis

Demand softens substantially for international and domestic travel through the 2030s and 2040s. Domestic travel is heavily affected by the labour shortages and high airfares. Domestic passenger traffic grows to c.65 million per annum by 2050, up from c.61 million per annum in 2019 (an average growth rate of 0.4% per annum).[180] International passenger traffic stays flat in the long-term at c.45 million passengers per annum by 2050.

The slow / no growth environment slightly reduces industry urgency to invest in sustainable technologies. Investment in domestic production capacity is slow in the 2020s and 2030s, limiting airlines' abilities to adopt SAF. In the long-term, domestic SAF production remains limited. Most Australian-produced feedstock is exported internationally under long-term supply contracts, further limiting SAF adoption by Australian airlines.

Pilot and engineer supply shortages slightly slow the adoption of electric and hydrogen aircraft. These aircraft have relatively low capacities and are in a labour constrained market for rapid, widespread uptake.

Despite the poor adoption of SAF and low emissions aircraft, total aviation emissions decline in the long-term by c.40% due to reduced aeronautical activity.

[180] Unlike in other scenarios, this scenario represents supply constrained growth in domestic and international passenger movements

S5. Green Fuelled Growth

Green technology and sustainability targets are achieved and exceeded. A combination of SAF usage, entry into service of electric and hydrogen aircraft (in the medium-long term), and ATM advancements enable lower emission air travel. Consumer concerns around the environmental impacts of air travel are alleviated, unlocking demand growth

The aviation industry, both in Australia and internationally, coalesces around an understanding that the environmental sustainability of air travel is vital to future industry growth, profitability, and resilience.

Through the 2020s, aircraft manufacturers, fuel suppliers, airlines, airports, and governments collaboratively invest in first generation SAF production facilities and feedstock security. SAF availability enables domestic and international airlines to rapidly increase SAF use (primarily for long-haul flights), albeit at higher prices than traditional jet fuel. Airlines achieve 2030 SAF adoption targets through a combination of uplift at both international and domestic airports.

In the 2030s, industry investments in SAF production pay dividends. First generation SAF production increases SAF supply, and costs decrease to near price parity with traditional jet fuel (parity achieved in 2050).

Buoyed by early successes, the industry starts investing in second generation SAF pathways through the late 2020s and 2030s, reducing reliance on highly sought after biomass and waste oil feedstocks.

Increasing supply and decreasing prices enable airlines to increase SAF use through the 2030s, in line with long-term net zero commitments.

Airlines publicise and market their SAF adoption, helping allay consumer concerns for the environmental impacts of air travel. Demand growth accelerates as a result.

Figure 36

Settings for S5. Green Fuelled Growth

		Headwind	Neutral	Tailwind
Demand	Changing leisure traveller preferences and behaviours	International and domestic leisure travel demand is depressed	International and domestic leisure travel grows at pre-COVID levels	Strong growth in international and domestic leisure travel
	Changing ways of working	Domestic and international business travel grows slower than pre-COVID	Domestic business travel recovers slowly. International business travel grows at pre-COVID rates	Domestic and international business travel grows at or above pre-COVID rates
Supply	Domestic airline competitive dynamics	Competition worsens in the long-term	Competition remains broadly at pre-COVID levels	Sustained, substantial increase in domestic competition in long-term
	Workforce training, supply, and capabilities	Labour is a hindrance to demand growth	Labour broadly sufficient to enable demand growth	Surplus of skilled labour supports demand growth
	Availability and uptake of AAM	AAM fails to successfully commercialise outside of fringe GA use cases	AAM commercialises in the long-term on traditional GA use cases	AAM commercialises with new and expanded GA use cases
Sustainability	Emissions reduction ambitions and pressures	Continued pressure on airlines to decarbonise		
	Availability and uptake of SAFs	2% of fuel in 2030 25% of fuel in 2050 SAF 2.1x traditional jet fuel in 2050	5% of fuel in 2030 45% of fuel in 2050 SAF 1.7x traditional jet fuel in 2050	10% of fuel in 2030 60% of fuel in 2050 SAF 1x traditional jet fuel in 2050
	Availability and uptake of electric or hydrogen fuel cell aircraft on sub-500km routes	18% share of eligible ASKs by 2050. Limited service from 2031. Equivalent of 5% of domestic movements	40% share of eligible ASKs by 2050. Limited service from 2031. Equivalent of 11% of domestic movements	68% share of eligible ASKs by 2050. Limited service from 2026. Equivalent of 18% of domestic movements
	Availability and uptake of hydrogen turbine aircraft	Never enters service	Entry into service from 2041. 5% share of eligible ASKs by 2050 or equivalent of 4% of movements for domestic market	Entry into service from 2036. 15% share of eligible ASKs by 2050 or equivalent of 11% of movements for domestic market
	Evolution of air traffic management	A lack of ATM evolution acts as a barrier to industry growth	ATM evolves to support demand and sustainability	ATM evolves to support sustainability objectives and new technologies

On key FIFO routes, mining companies reduce their scope 2 emissions by paying airlines and GA charter operators to ensure their workers travel on SAF fuelled flights. This supports SAF adoption within commercial and general aviation and drives domestic and regional aeronautical growth.

Overall domestic passenger traffic reaches c.110 million by 2050, up from c.61 million passengers in 2019 (growth of c.2.3% per annum from 2023). International passenger traffic reaches c.105 million by 2050, up from c.43 million in 2019 (growth of c.3.6% per annum from 2025).[181]

Domestically, aeronautical growth is strongest on routes between major cities. Regional growth is less affected, as regional passengers are typically less concerned for the emissions from flying.

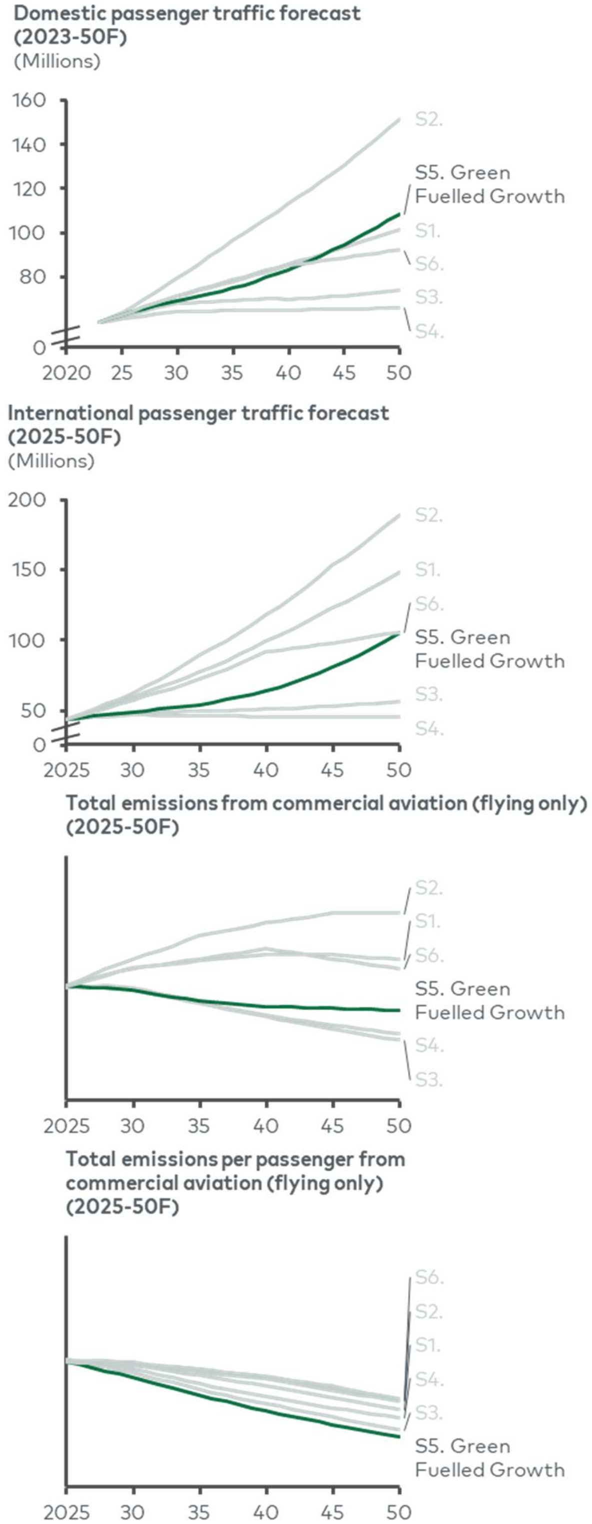
Despite strong growth in passenger traffic, successful decarbonisation efforts result in a slight decline in emissions long-term. The industry does not reach net zero by 2050, but it keeps emissions below 2025 levels and closes the gap to net zero with offsets.

Air traffic management (ATM) improvements also play a role in reducing emissions. Through the 2020s and 2030s, Airservices Australia and air navigation service providers (ANSPs) in other jurisdictions implement a series of ATM technology and operating procedures improvements. These include free route airspace, dynamic route planning and improved machine enabled decision-making. Improvements lead to more efficient flying, lower fuel burn and lower aircraft emissions. UTM systems advance during this period, with UTM and ATM systems integrating in the long-term.

The industry's success with SAF somewhat discourages investment in alternative emissions reductions pathways. Airlines, able to achieve most of their decarbonisation targets through SAF, largely avoid committing to electric or hydrogen aircraft.

Figure 37

Passenger and emissions outcomes for S5. Green Fuelled Growth



Source: L.E.K. analysis

[181] Please note that all scenarios present unconstrained demand, unless otherwise stated

Smaller electric and hydrogen planes successfully commercialise in the late 2030s and early 2040s. These aircraft gradually replace traditional fossil fuel-powered aircraft on short-haul regional routes in the 2040s. However, due to a greater reliance on SAF, adoption of electric, hybrid-electric and hydrogen aircraft is limited to short-haul routes and only contributes c.0.3% to overall emissions reduction in 2050.

Hydrogen and electric aircraft do find some success in GA applications. Major use cases include AAM and flight training, where lower operating costs offer attractive economics for operators. Resources companies adopt small electric and hydrogen aircraft for short flights around and to their sites. These aircraft leverage established infrastructure for hydrogen-based truck, crane, and digger fleets. Regionally, the slow adoption of hydrogen and electric aircraft encourages operators to continue operating their existing aircraft. Airlines invest in major engine refurbishments, supporting continued turboprop usage in the long-term.

Spurred by passenger demand growth and advances in both ATM and UTM, AAM successfully commercialises and scales-up in the long-term. AAM forms a part of Australia's low carbon aviation proposition, finding use cases in tourism and sightseeing, agriculture, and freight applications. AAM supplements some regional aviation, providing further passenger connectivity out of regional airports.

S6. Unsustainable Aviation

Australian airlines are unable to achieve SAF uptake targets due to insufficient domestic production capacity and competition for imported SAF. Airlines fail to substantially decarbonise, with demand suffering in the long-term

In the late 2020s, a global reliance on HEFA-based SAF pathways for both SAF and renewable diesel leads to competition for feedstock, driving up price. The costs of other, more advanced SAF production pathways – such as using biomass, municipal waste, or waste gases – prove too high for widespread adoption.

Australia's limited renewable fuel production capacity is dedicated to renewable diesel. Renewable diesel offers a better return on investment as mining companies are willing to pay whatever is required to reduce their emissions. Australian airlines are forced to turn to costly imported SAF, but this proves uneconomic to use at scale without substantial increases in airfares. In the 2030s, the Australian aviation industry comes to terms with the fact that it cannot rely on SAF to achieve decarbonisation targets.

Australian airlines focus on regional air travel as an opportunity to decarbonise, with the need to replace or life-extend aging turboprops a catalyst for investment. Airlines primarily invest in electric and hybrid propulsion system conversions, with limited investment in new aircraft. The converted electric / hydrogen aircraft enter commercial service in a limited capacity during the late 2030s and 2040s, injecting new life into ailing regional networks. The aircrafts' lower operating costs and the need to operate high frequencies to offset their capital costs encourage airlines to operate new services and frequencies.

Australian travellers are initially unfazed by the airline's limited progress in adopting SAF. In the short-term, domestic and international demand continues to grow at pre-pandemic

Figure 38
Settings for S6. Unsustainable Aviation

		Headwind	Neutral	Tailwind
Demand	Changing leisure traveller preferences and behaviours	International and domestic leisure travel demand is depressed	International and domestic leisure travel grows at pre-COVID levels	Strong growth in international and domestic leisure travel
Demand	Changing ways of working	Domestic and international business travel grows slower than pre-COVID	Domestic business travel recovers slowly. International business travel grows at pre-COVID rates	Domestic and international business travel grows at or above pre-COVID rates
Supply	Domestic airline competitive dynamics	Competition worsens in the long-term	Competition remains broadly at pre-COVID levels	Sustained, substantial increase in domestic competition in long-term
Supply	Workforce training, supply, and capabilities	Labour is a hindrance to demand growth	Labour broadly sufficient to enable demand growth	Surplus of skilled labour supports demand growth
Supply	Availability and uptake of AAM	AAM fails to successfully commercialise outside of fringe GA use cases	AAM commercialises in the long-term on traditional GA use cases	AAM commercialises with new and expanded GA use cases
Sustainability	Emissions reduction ambitions and pressures	Continued pressure on airlines to decarbonise		
Sustainability	Availability and uptake of SAFs	2% of fuel in 2030 25% of fuel in 2050 SAF 2.1x traditional jet fuel in 2050	5% of fuel in 2030 45% of fuel in 2050 SAF 1.7x traditional jet fuel in 2050	10% of fuel in 2030 60% of fuel in 2050 SAF 1x traditional jet fuel in 2050
Sustainability	Availability and uptake of electric or hydrogen fuel cell aircraft on sub-500km routes	18% share of eligible ASKs by 2050. Limited service from 2031. Equivalent of 5% of domestic movements	40% share of eligible ASKs by 2050. Limited service from 2031. Equivalent of 11% of domestic movements	68% share of eligible ASKs by 2050. Limited service from 2026. Equivalent of 18% of domestic movements
Sustainability	Availability and uptake of hydrogen turbine aircraft	Never enters service	Entry into service from 2041. 5% share of eligible ASKs by 2050 or equivalent of 4% of movements for domestic market	Entry into service from 2036. 15% share of eligible ASKs by 2050 or equivalent of 11% of movements for domestic market
Sustainability	Evolution of air traffic management	A lack of ATM evolution acts as a barrier to industry growth	ATM evolves to support demand and sustainability	ATM evolves to support sustainability objectives and new technologies

rates, having rebounded to pre-pandemic traffic levels in the mid-2020s.

Through the 2030s, domestic and outbound international demand remains strong, growing at pre-pandemic levels to most markets. Travel between Australia and Europe becomes more expensive, putting downward pressure on demand, as European governments impose restrictions on airlines not meeting minimum SAF uptake levels.

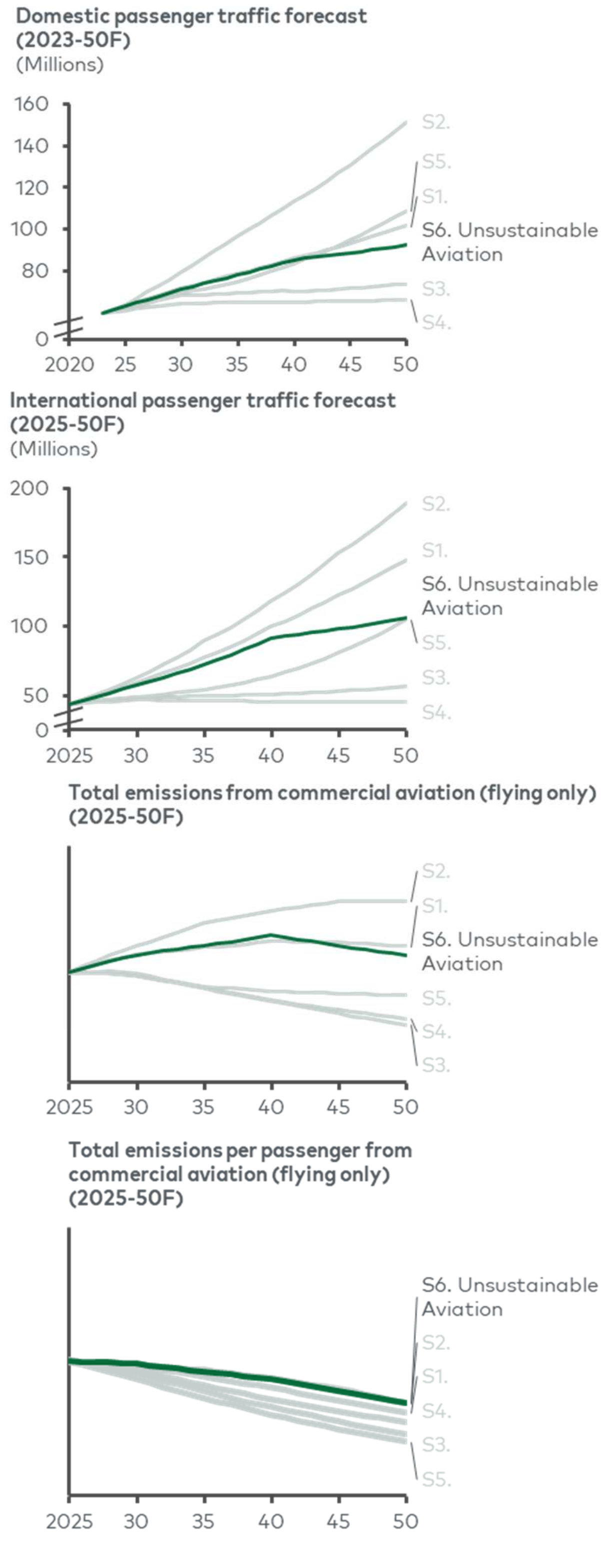
From c.2040 onwards, younger generations of travellers become increasingly concerned about the industry's lack of success in decarbonising. Australian domestic and international demand growth slows as passengers reduce flying to reduce personal emissions.

In the long-term, the industry's failure to decarbonise has workforce implications for the major airlines. Younger generations avoid entering aviation roles, concerned for their impact on climate change. The industry struggles to recruit and retain talent and offers substantial bonuses to attract overseas talent.

In the 2030s, zero emission aircraft adoption has greater success in GA than elsewhere in the industry. Many GA participants – particularly those operating in pilot training, sightseeing, tourism, skydiving and short-haul commuter services – replace end-of-life aircraft with new electric and hydrogen aircraft (or pursue engine conversions) in response to public pressure to decarbonise and operating cost benefits.

Despite investments in electric and hydrogen aircraft, air travel demand growth slows in the long-term. By 2050, c.90 million passengers travel domestically per annum, up from c.61 million passengers in 2019 (growth of c.1.7% per annum from 2023).[182] International traffic grows to c.105 million passengers per annum by 2050, up from c.43m in 2019 (growth of c.3.6% per annum from 2025).

Figure 39
Passenger and emissions outcomes for S6. Unsustainable Aviation



Source: L.E.K. analysis

[182] Please note that all scenarios present unconstrained demand, unless otherwise state

Emissions grow steadily to 2040 as air travel demand remains strong. The introduction of more fuel-efficient next-generation aircraft reduces emissions growth slightly. However, failure to adopt SAF results in emissions continuing to grow well above 2025 levels: by 2040, emissions are c.35% higher than 2025. Emissions peak in 2040. The rapid reduction in passenger travel demand growth as passengers become increasingly nervous about the environmental impacts of flying, and the slow adoption of second generation SAF through the 2040s, leads to a reduction in emissions of c.13% by 2050 compared to 2040 levels.

S7. New Mobility Paradigm

AAM successfully commercialises for a wide range of use cases, materially increasing aircraft movements, airspace complexity, and passenger and freight mobility

By 2030, crewed commercial AAM aircraft have successfully entered service in Australia. eVTOL aircraft are the primary variants used, operating tourism, last-mile freight, agriculture, and emergency services missions. Buoyed by initial success, the AAM industry develops other AAM aircraft, including longer range eVTOL and STOL (short take-off and landing) aircraft to support longer range passenger and freight transport missions.

Public perception and acceptance of AAM technology improves rapidly through the 2030s, enabling AAM traffic to grow.

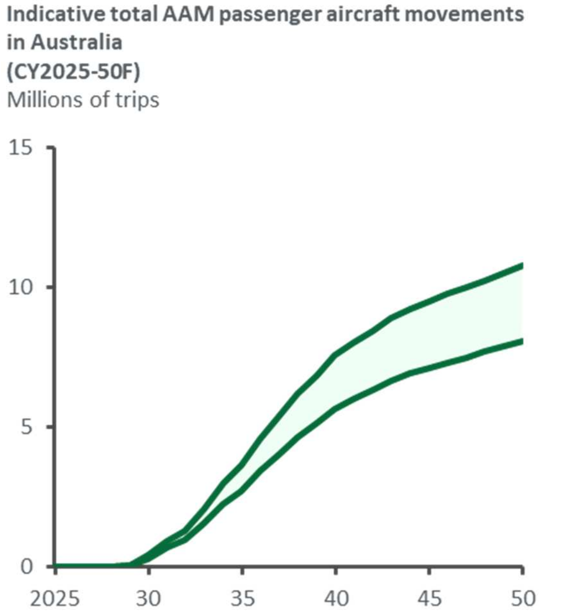
Initially, AAM aircraft operate out of existing regional and GA airports and established helipads. In regional areas, these operations improve the economics of regional airport infrastructure, encouraging council owners to support adoption for passenger, freight, and emergency services operations.

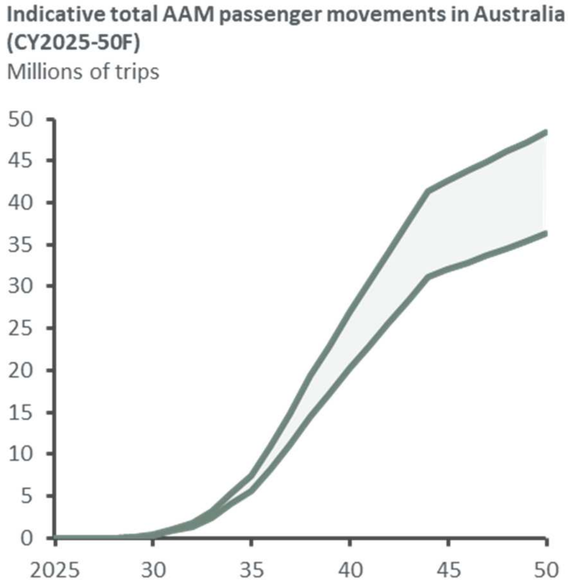
As technology advances, governments and private investors increasingly recognise the economic and social potential of AAMs. Public support for AAM prompts investors to explore investment opportunities in vertiport and grid infrastructure, driving technology adoption and growth.

Through the 2020s and 2030s, CASA and Airservices Australia continue efforts to develop regulation and policy around AAM. This begins to create a regulatory environment conducive to private investment and innovation in the space. Industry and regulators work together to streamline development, manufacturing and certification, supporting rapid adoption of AAM at scale.

From the mid 2020s, Airservices Australia, CASA and industry begin the implementation

Figure 40
Total number of AAM passenger trips and trips – passengers and freight only





Source: L.E.K. analysis

of Uncrewed Air Traffic Management (UTM) to support scale AAM (and drone) flying. By 2040, UTM governs all uncontrolled airspace activity, creating the requisite air traffic management capacity for a substantial increase in AAM activity.

Beyond AAM, UTM adoption supports increased use of smaller cargo drones for last mile delivery. These drones proliferate in urban areas, offering increased convenience for consumers.

Broader adoption and commercialisation of AAM technology lead to increased commercial and industrial applications. Traditional GA operators are the earliest adopters, replacing fuel powered vehicles with crewed AAM aircraft from the late 2020s. Initially, AAM aircraft are employed in emergency services, freight, sightseeing / tourism, and defence roles. Operators can achieve cost savings, improved safety and increased operational efficiency. This encourages greater adoption across GA, inducing additional GA activity through lower cost services. AAM use for these activities leads to a reduction in general aviation emissions, increasing industry sustainability in the long-term.

Within regional areas, AAM aircraft become the mode of choice for freight and agriculture flying.

By the 2030-2040, AAM technology has sufficiently improved for regulators to certify uncrewed flight. Initially, these flights are remote piloted and operate outside densely populated areas or in areas with low ground risk. Uncrewed passenger flights follow thereafter.

The introduction of uncrewed operations significantly reduces the cost of AAM flights. The cost economics of flight improve, supported by increases in aircraft range and expanded vertiport infrastructure.

Post 2030 operators offer services across urban and regional areas, establishing a web of point-to-point services around regional and capital cities. AAM allows for the return of air services to towns that had previously lost regular RPT services, connecting them directly to capital cities or regional transport hubs.

For the most part, AAM supplements traditional aviation. Extended ranges and low-cost, uncrewed operations allow AAM aircraft to replace some shorter, irregular RPT serves in the long-term, e.g., Sydney to Newcastle flights.

By 2050, AAM aircraft have successfully taken a significant market share from traditional rideshare and taxi services on journeys longer than c.15 km, e.g., airport trips. AAM trips, fast and convenient, are a popular choice for longer, time sensitive trips. AAM adoption further reduces emissions (although the emissions reductions potential diminishes as the road based vehicle fleet electrifies).

The shift from road-based modes to air travel substantially increases aviation activity across Australia, with total AAM movements for freight and passenger trips reaching over c.8-9 million by 2050 (up from c.3 million movements by commercial and general aviation aircraft today).[183]

[183] Assumes that vertiport infrastructure is sufficient to meet demand

5. Implications

5.1 Introduction

Source: Josh Withers (Jetstar Boeing 787-8)

Purpose of the chapter

This work into the drivers of change to 2050 and sector evolution scenarios pointed to seven areas for which industry and government may potentially need to intervene, to ensure or enable:

- Sufficient SAF feedstock availability and domestic production capacity
- Net zero emissions targets
- Pilot and engineer workforce availability
- Inbound international demand growth
- Electric aircraft adoption
- Hydrogen aircraft adoption
- Commercialisation and scale up of AAM

This chapter explores potential interventions for the above areas and the 'triggers' for intervention timing. Given the uncertainty associated with these triggers, a range of timelines is shown, based on the scenarios.

Defining "triggers"

Triggers refer to events, milestones or industry developments that could represent inflection points for the industry to take notably different paths.

For example, the trigger for electric aircraft adoption could be the entry of a c.30 seat regional electric aircraft into commercial service. This trigger signals the potential start of regional fleet electrification and activities required before entry into service, including installation of charging infrastructure at airports, and regulatory approval. There may also have been opportunities for domestic industries to become involved in the development / manufacture of electric aircraft or key components.

5.2 Industry challenges for further consideration

SAF feedstock and production capacity

There is significant uncertainty regarding SAF adoption in the long-term. To meet industry targets for SAF adoption, a domestic SAF industry must be established and domestic feedstock supplies secured.

Lack of a domestic SAF industry could leave Australian airlines and operators dependent on SAF imports. This creates potential for greater exposure to global market prices and fuel security risks, and would likely inhibit the industry's ability to meet SAF adoption and decarbonisation targets.

Developing a domestic SAF industry requires ongoing investment by different stakeholders in production facilities and feedstock. The window of opportunity for establishing capacity and securing feedstock lies primarily between now and 2030. Realising this window could require initial seed funding to support SAF projects and helping SAF producers to secure feedstocks.

Table 4
Triggers and interventions - SAF

Trigger	Potential intervention	Timing
Meeting 2030 SAF targets for Australian airlines	Secure feedstock agreements for Australian SAF producers	From now
	Support the development of Australian SAF production facilities	From now
Meeting 2050 SAF targets for Australian airlines	Support electrification and decarbonisation of other transport modes to reduce competition for SAF feedstocks and production capacity	From now
	Reserve SAF (from potential export) for use by Australian airlines	From now
	Invest in 2nd generation SAF pathways	From mid-2020s
	Support SAF pricing to reduce the cost differential with traditional jet fuel	From 2030

Net zero targets

Even with improvements in aircraft efficiency and industry wide adoption of c.60% SAF by 2050, the Australian airline industry will need offsets to achieve net zero emissions.

Under the 'Steady State' scenario, the industry is required to offset c.26 million tonnes of CO_2e, or c.42% of its emissions (with no change from today). Even with the highest level of SAF adoption, as captured in the 'Green Fuelled Growth' scenario, the industry still needs to offset c.17 million tonnes of CO_2e, or c.35% of emissions (with no change from today).

Multiple industry stakeholders including major airports, airlines, and the Australian Government, have committed to achieving net zero emissions by 2050. Failure to secure sufficient offsets to meet these objectives, or to support low emissions technologies, will result in the industry and other stakeholders failing to meet these targets.

The window for action to achieve net zero emissions is now. Success will require large scale change to industry operations, technologies, and prioritisation of sustainability. Changes, in particular the adoption of SAF or new aircraft types, come with long lead times. Therefore, action is needed now to begin preparing for net zero.

Table 5
Triggers and interventions - net zero

Trigger	Potential intervention	Timing
Meeting 2050 net zero targets	Support SAF adoption (see SAF triggers)	From now
	Support the adoption of electric aircraft	From now
	Support the adoption of hydrogen aircraft	From now
	Assist with forecasting the quantum of offsets likely to be required by 2050	From now
	Invest in offset and carbon sequestration schemes, e.g., land purchases	From now

Pilot and engineer workforce availability for commercial and general aviation

Australia's shortage of pilots, aircraft maintenance engineers and other aviation workers is an industry challenge. Without sufficient investment in attracting, training, and retaining skilled workers, the aviation industry could be constrained by labour shortages in the short- to medium-term.

While it is uncertain how the pilot and engineer workforce shortage will evolve, the industry appears to already be at a trigger point in addressing its supply of highly skilled workers. Lead times for training pilots and engineers mean that interventions are likely required in the next 12-24 months, to address labour shortages by the early 2030s. Failure to implement enduring changes to how aviation workers are recruited, trained and retained will lead to further shortages in future.

Table 6
Triggers and interventions - workforce

Trigger	Potential intervention	Timing
Acute labour shortage in the near-term (2020s)	Improve the attractiveness of a career in the aviation industry	From now
	Increase the capacity of training pathways for pilots, engineers, and other highly skilled roles	From now
	Improve alignment of training with industry requirements (i.e., skill requirements)	From now
	Explore opportunities to offer greater financial support	From now
	Adjust the skilled migration programs to help attract skilled aviation workers	From now
Pre-empting future labour shortages (2030 onwards)	All of the above, plus: Investigate demand side opportunities, i.e., reduced crew operations	From mid-2020s

Inbound demand growth

The 'Destination Australia' scenario sets out the implications of Australia becoming an increasingly popular tourism destination. Achieving greater inbound visitation – and accompanying economic benefits – requires both demand and supply driven measures. Examples include improving the attractiveness of Australia's tourism and hospitality assets, increasing Australia's tourism marketing, and supporting growth in international capacity to cater for demand for affordable airfares.

Tourism has historically operated at the nexus of private and public sector enterprises. Support, above and beyond current and planned commitments, may be required to increase Australia's attractiveness as a tourism destination and to broadcast this to global tourism markets. This is particularly true for regional, semi-regional and remote areas, which are the home to many of Australia's natural wonders.

Timing for these interventions is at the discretion of industry and government. Immediate interventions could provide a foundation for strong inbound international passenger movement growth.

Table 7
Triggers and interventions - inbound tourism demand

Trigger	Potential intervention	Timing
c.90 million international passenger movements by 2035 (Destination Australia)	Invest in regional tourism and hospitality infrastructure near major attractions (above current and planned commitments)	From now
	Expand international marketing campaigns advertising Australia (above current and planned commitments)	From now
	Expand bilateral traffic rights with key inbound markets (above current and planned commitments)	From now

Adoption of electric / hybrid aircraft

In the medium- to long-term, electric aircraft are likely to be equivalent in size to current turboprop aircraft, with ranges of up to c.500km. The introduction of electric aircraft will require development of charging facilities and supporting infrastructure at both capital city and regional airports.

Electric and hybrid-electric aircraft could play an important role in decarbonising regional and general aviation. Failure to support the development and adoption of these aircraft could hinder the net zero ambitions for industry and government.

Successful commercialisation of electric and hybrid-electric aircraft requires appropriate infrastructure at commercial and GA airports across Australia. Several potential interventions could be used to encourage uptake, including airport infrastructure development to accommodate these aircraft types.

The timing of these interventions will depend on the speed at which electric and hybrid aircraft technology progresses. To provide Australia with an advantage in this space, interventions to support a domestic conversion industry should happen within the next few years.

Table 8
Triggers and interventions - electric aircraft

Trigger	Potential intervention	Timing
Entry into service (EIS) of commercially viable c.30 seat aircraft (2030s)	Deliver charging infrastructure at airports (particularly regional)	From late-2020s
	Upgrade grids / power supplies to support airport charging infrastructure	From late-2020s
	Certify electric propulsion systems and new aircraft	Late-2020s – early-2030s
EIS of viable hybrid conversion product (2030s)	Support programs to establish domestic conversion industry	From now
	Certify hybrid-electric conversion propulsion systems	Late-2020s – early-2030s
Scale up of viable electric aircraft	Conduct further grid and power production upgrades at regional airports	From mid-2030s

Adoption of hydrogen aircraft

Hydrogen propulsion systems (both turbine and fuel cell) could play an important role in decarbonising short- to medium-haul aviation in the long-term.

Hydrogen aircraft have more complex infrastructure requirements than electric aircraft. Airports will require new hydrogen storage facilities larger than the fuel storage facilities in use today. Fuel losses during transportation and storage will require airports to be closely integrated into hydrogen production and logistics networks.

The cost and technical challenges of producing hydrogen mean support may be needed to ensure sufficient supply is available when hydrogen aircraft enter service. To be truly net zero, hydrogen production will also require connections to green power sources such as windfarms or solar farms.

Several interventions may be required, aligned to entry of service of different sizes of hydrogen aircraft. Given the lead times for establishing major energy facilities, the window of opportunity for developing a domestic hydrogen industry begins now.

Table 9
Triggers and interventions - hydrogen aircraft

Trigger	Potential intervention	Timing
EIS of a viable c.30 seat hydrogen aircraft (mid-2030s)	Invest in hydrogen industry, incl. production capacity and logistics pathways	From now
	Develop of airport hydrogen storage / refuelling facilities (particularly regional)	From early - 2030s
	Train staff in hydrogen refuelling	From late-2020s
	Certify small hydrogen aircraft	Mid-2030s
EIS of viable c.100-200 seat hydrogen aircraft (2040s)	Certify larger hydrogen aircraft	From 2040
	Expand airport hydrogen storage and refuelling facilities	From 2040
Scale up of viable hydrogen aircraft	Invest in hydrogen industry production capacity and logistics pathways	From now

Commercialisation and scale up of AAM

AAM has the potential to substantially change passenger and freight mobility around urban and regional areas in the long-term.

AAM commercialisation will require the development of supporting infrastructure and a regulatory approach considering issues such as:

- AAM operations over densely populated areas
- AAM impacts the amenity of communities
- Airspace design to safely integrate AAM aircraft with conventional aircraft
- High-speed, resilient communications infrastructure to enable uncrewed AAM flights
- Flight rules for AAM, including the development of new 'digital' flight rules
- Crewing requirements for AAM aircraft, including training and oversight requirements for backup remote pilots for uncrewed aircraft

While the AAM industry will likely use privately funded infrastructure (e.g., vertiports and other facilities), regulatory, safety and airspace issues require government involvement.

It is unclear whether the pace of aircraft technology improvement, regulatory progress or community acceptance will determine the speed at which AAM adoption occurs. Industry and government have a window of opportunity in which they can begin designing airspace rules to govern the use of AAM and implementing a UTM system to support adoption. Action within the next few years will ensure that airspace design does not slow adoption if aircraft are technologically ready. Industry and government should consider the development of high-speed communications infrastructure in the short-term to ensure that AAM adoption is not delayed. Other interventions, such as supporting certification, will depend on the speed of technological progress.

Table 10
Triggers and interventions - AAM

Trigger	Potential intervention	Timing
Entry into service of AAM (crewed, limited use cases) – late 2020s-early 2030s	Design airspace and traffic management principles	From now
	Airspace modernisation supporting AAM (UTM etc.)	From mid-2020s
	Implement infrastructure regulatory framework	From mid-2020s
	Develop vertiport infrastructure	From mid-2020s
	Certify crewed AAM aircraft	From mid-2020s
Scale up of AAM – 2030s and 2040s	Deliver high speed, resilient communications infrastructure	From mid-2020s
	Develop new flight rules for uncrewed AAM	From late-2020s
	Certify uncrewed AAM aircraft	From mid-2030s

6. Conclusion

This report is intended to be used by the Department as an input into the Aviation White Paper. The report has outlined perspectives on the expected key drivers of change in the aviation sector to 2050 and scenarios for potential industry evolution. The scenarios in this report are designed to facilitate discussion on the future of Australia's aviation sector and provide the Department and industry stakeholders with information to help inform thinking around potential policy implications during the Aviation White Paper development process.

The drivers of change, stakeholder consultations and scenarios analysis highlight several emerging findings:

Underlying demand is strong and enduring

Underlying passenger and freight growth is likely to be robust to 2050 unless there is a major shift in consumer preferences and behaviours. There is likely to be enduring demand growth for domestic, international, regional, and general aviation activity within Australia. In all scenarios, passenger demand increases in the long-term, despite potential environmental concerns and / or higher real airfares to pay for the cost of decarbonisation. International demand is expected to grow faster than domestic demand, with international passenger movements overtaking domestic movements in the 2030s. Growth will naturally moderate over time, but Australia's geography, population dispersion and remoteness mean aviation will continue be important.

Decarbonisation will be a key driver of change

Decarbonisation is a strategic imperative for the industry. Stakeholders consistently highlighted decarbonisation as one of the key drivers of change. Most industry participants will use SAF as their main lever to decarbonise in the period to 2050. However, achievement of industry's current SAF targets is not guaranteed. Competition for Australian feedstocks from other jurisdictions, and competition for domestic biofuel production capacity could slow SAF availability and adoption. The high price of SAF relative to traditional fuel is another barrier.

SAF alone cannot deliver net zero. Due to demand growth, emissions are likely to increase in the long term, even with further improvements in aircraft efficiency. The result is an 'emissions gap' to net zero of c.40% of total emissions by 2050 (under S1).

Electric and / or hydrogen aircraft are unlikely to fill this gap by 2050. The current timelines of major aircraft / engine manufacturers for new propulsion systems, expected range limitations to the new technology, uncertain operating economics, and natural fleet replacement cycles mean that these technologies are likely to contribute less than 10% of the emissions reductions required to reach net zero by 2050. Nonetheless, new propulsion technologies and fuel sources will likely play a key role in sector decarbonisation beyond 2050.

In the period to 2050 the aviation industry will likely need to rely on the significant use of offsets to reach net zero goals. The aviation industry will not be alone in its need to use offsets to achieve net zero, and competition from other industries for offsets raises concerns around the availability and quality of offsets. In the period to 2050, securing high-quality offsets will be as critical as securing SAF.

Capacity growth is unlikely to constrain demand growth

In general, commercial motivations will likely ensure that capacity growth of airlines, airports and supporting industries keeps pace with demand growth.

Multiple stakeholders have flagged that limited availability of skilled labour – notably aircraft maintenance engineers – may impact parts of the sector, particularly GA and regional aviation. Some stakeholders noted that workforce issues are, to a degree, cyclical. Nonetheless, prolonged shortages could structurally damage some industry areas. There may be a case for intervention to preserve critical industry capabilities and connectivity in general and regional aviation.

Australia's skies will get busier

While the scenarios illustrate a range of potential growth scenarios, there is a high degree of confidence that aircraft movements will continue to grow. In the highest growth scenario, movements will approximately triple by 2050.

AAM could present the biggest change to Australia's skies. Passenger and freight drones could lead to a significant increase in air traffic movements and airspace complexity, particularly in urban areas. If the industry successfully scales in the long-term, AAM aircraft movements could become c.8-10 million per annum. This is a huge increase on today's c.3 million movements of traditional aircraft per annum.

The increase in air traffic highlights the importance of next generation ATM systems (including UTM) and will likely intensify debates around the balance of community concerns (e.g., noise, safety) with the social and economic benefits of aviation growth. All stakeholders – industry, government, and community – must collaborate to achieve a future where aviation is accessible and beneficial to as many people as possible.

7. Appendix A – Drivers prioritisation approach

7.1 Approach to driver prioritisation

Introduction

Drivers of change (“drivers”) refer to the forces that influence the aviation sector’s direction and pace of change to 2050. Drivers are both internal and external to the industry and include shifts in consumer behaviour, technological advancements, competitive dynamics, and other factors.

The process of developing and refining drivers began with creating a preliminary list of drivers with inputs from the L.E.K. panel of experts, L.E.K.’s prior experience, and secondary research. This list was refined through stakeholder input and further research.

Short-listed drivers are classified into three categories: “market – demand,” “market – supply” and “exogenous - sustainability.” Definitions for each driver can be found in the table below.

Once categorised, drivers were assigned a rating of "high," "medium," or "low" for each criterion below (with a corresponding score of three, two, one). Secondary research, stakeholder consultations and input from a panel of aviation experts. The three criteria were:

- **Materiality of impact |** The extent of the impacts on Australia’s aviation and connected industries including impacts on the environment and communities
- **Breadth of impact |** The breadth of sectors in aviation and connected industries, impacted by the driver
- **Level of uncertainty |** The level of uncertainty surrounding the driver’s breadth, magnitude, and timing of impact (for all plausible changes)

Drivers were then grouped according to the sum of their score. Three groups were used:

- Drivers that scored seven or more were classified as "higher uncertainty" drivers (denoted by the letter "H"). These drivers received the greatest focus throughout the research process and form the basis of the scenarios
- Drivers that scored six or seven were classified as "lower uncertainty" drivers (denoted by the letter "L"). These drivers are important underlying drivers of the industry and provide 'base settings' for the scenarios
- Drivers that scored below six were deprioritised for further research and analysis (and denoted as "deprioritised")

Further information on the ratings for each driver is available in Table 14.

Initial ratings and classifications were not static. Ratings and classifications changed as further perspectives were gathered with each consultation and additional research.

Table 11
Driver category definitions

Category	Definition
Market – Demand	The forces affecting demand for commercial and GA activity (including freight), e.g., traveller preferences
Market – Supply	How the industry responds to and meets market demand, enabling growth, e.g., through workforce or airport capacity
Exogenous – Sustainability	The ambitions of and pressures faced by the industry to become more sustainable, and the technologies and operational approaches available to achieve this

Long list of drivers

Table 12
List of drivers and definitions

Category	Driver	Definition
Market – Demand	H1. Traveller preferences (domestic and international leisure travel)	The demand for leisure travel flights (inbound, outbound international and domestic) and how 'flight shame,' geopolitical shocks and Australia's attractiveness may impact consumer preferences
	H2. Changing ways of working (domestic and international business travel)	The impact of working from home and video conferencing technology on demand for business travel
	L1. Underlying macro-driven demand	Underlying drivers of aviation demand, particularly Australian real GDP
	L2. Demand for inbound international VFR travel (inbound and outbound)	The impact on the aviation industry of demand for inbound and outbound flights for the purpose of visiting friends and family
	D1. Australian outbound tourism	How Australians' demand for international travel for leisure reasons drives demand for international and domestic aviation
	D9. Competition from other transport modes	The impacts of other transport modes (rail, bus, truck, car and boat) on aviation demands
	D10. Population dispersion across Australia	Australia's population distribution across cities, states, and regions
	D14. Real airfares e.g., driven by fuel costs	The impact of aviation costs for travellers (airfares)
Market – Supply	H3. Domestic airline competitive dynamics	The level of market competition, and resulting airfares / capacity dynamics in the Australian domestic context
	H4. Workforce training, supply, and capabilities (skills)	How the future of aviation is influenced by the demand for skilled aviation workers (e.g., pilots and engineers), and the availability of training providers to ensure adequate supply, skill levels, and skill mix
	H5. Availability & uptake of Advanced Air Mobility (AAM)	How AAM (large, typically uncrewed aircraft used for passenger, freight, and other purposes) commercialisation and uptake impacts the aviation industry
	L3. Increasing airport capacity	The impact of increasing airport capacity (new airports, runways, terminals) on airlines, competition dynamics and the wider aviation industry
	L4. Industry capacity to service air freight growth	The impact of express freight demands on dedicated freighter and belly freight capacity
	L5. Community pressures on the aviation sector (i.e., noise)	The level of community concern for the externalities of aviation (particularly noise) and its impact on the industry
	L6. Passenger facilitation in airports	New technology such as automated security gates and the resulting impact on the aviation industry
	D2. Competition between Australian & overseas carriers e.g., traffic rights to/from AUS	The level of competition between Australian and overseas-based carriers and the resulting impact on traffic rights, and airfares / capacity dynamics to / from Australia
	D3. Changes to operational constraints e.g., curfews, runway caps	The impact of changes to operational constraints like curfews, runway caps have on the wider aviation industry
	D4. Improved airport access infrastructure	The impact of improved ground access infrastructure, such as airport rail, on airports

Category	Driver	Definition
	D5. Availability & uptake of delivery drones (wing delivery)	The impact of small cargo drones (less than c.50kg freight capacity) on aviation, beyond additional ATM, in urban areas
	D7. Other long-term aircraft tech advancements	The impact that technology advancements like supersonic aircraft would have on the aviation industry
	D12. Future of Australian freight (types of freight, intermodal connectivity etc.)	The impact of developments in the Australian freight landscape, e.g., intermodal connectivity with Western Sydney Airport or inland rail, on freight demand and capacity
	D13. Ground handling / service efficiency	How improvements in ground handling and service efficiency will materially impact the aviation industry
	D15. Proliferation of High-Altitude Platform Systems	The impact of High-Altitude Platform Station systems (HAPS) on ATM and aircraft communication
Exogenous – Sustainability	H6. Emission reductions ambitions and pressures	The ambitions, targets and external pressures faced by the industry to achieve environmental outcomes, which may impact growth and / or profits
	H7. Availability & uptake of SAF	SAF's impact on demand and emissions, and the capacity required to meet industry needs
	H8. Availability & uptake of electric planes	The impact of the commercialisation and uptake of electric aircraft on demand, supply, and emissions
	H9. Availability & uptake of hydrogen aircraft	The impact of the commercialisation and uptake of hydrogen aircraft on demand, supply, and emissions
	H10. Evolution of ATM	The impact of ATM technology evolution, practices and priorities can affect fuel burn and emissions and airport operational efficiency
	L7. Ongoing fleet renewal with new generation aircraft	The gradual replacement of current and future fleet with incrementally better aircraft technology
	D11. Airline adaptation to environmental change	The adjustment, change, and improvement of operations, routes, and schedules to prepare for environmental changes and limit adverse impacts

Prioritisation categories

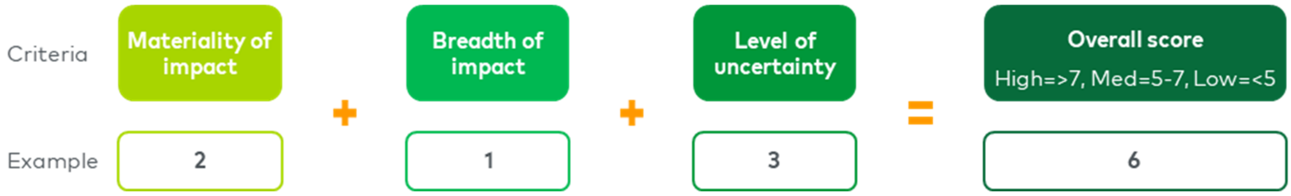
Table 13

Driver rating criteria and definitions

Criteria	Definition	High (3)	Medium (2)	Low (1)
Materiality of impact	The extent of the impacts on Australia's aviation and connected industries including impacts on the environment and communities	Significant impacts to profitability, or operational changes required, or changes to the consumer experience	Moderate impacts to the area depending on the extent of change, but can largely be accommodated within existing operations	Minor impacts expected regardless of extent of change
Breadth of impact	Driver impacts on the breadth of sectors within aviation and connected industries	Impacts most aeronautical sectors, workforce, and community sectors	Impacts only some industry sector groups, with some flow on impacts to other sectors	Impact contained within a handful of sectors, with very limited flow on impacts
Level of uncertainty	The level of uncertainty surrounding the driver's breadth, magnitude, and timing of impact (for all plausible changes)	Significant risk of variation in the driver over the short- to medium- to long-term	Some risk of variation in mostly the medium- to long-term	Limited risk of variation in the medium- to long-term

Figure 41

Driver score calculation methodology



7.2 Outcomes of driver prioritisation

High-level categorisation of drivers

Table 14
Overall ratings for all drivers

Category	Driver	Ratings				Outcome
		Overall score	Materiality of impact	Breadth of impact	Level of uncertainty	
Demand	Changing leisure traveller preferences and behaviours (domestic and international leisure travel)	**9**	3	3	3	H1: Higher uncertainty
	Changing ways of working (domestic and international business travel)	**8**	3	3	2	H2: Higher uncertainty
	Underlying macro-driven demand	**7**	3	3	1	L1: Lower uncertainty
	Demand for inbound and outbound international VFR travel	**6**	3	2	1	L2: Lower uncertainty
	Australian domestic and outbound tourism	**5**	2	2	1	D1: Deprioritised
	Competition from other transport modes	**5**	2	1	2	D2: Deprioritised
	Real airfares (e.g., driven by fuel costs)	**5**	2	1	2	D3: Deprioritised
	Population dispersion across Australia	**4**	2	1	1	D4: Deprioritised
Supply and capacity	Domestic airline competitive dynamics	**8**	3	3	2	H3: Higher uncertainty
	Workforce training, supply, and capabilities (skills)	**8**	3	3	2	H4: Higher uncertainty
	AAM availability and uptake	**8**	3	2	3	H5: Higher uncertainty
	Increasing airport capacity	**6**	2	3	1	L3: Lower uncertainty
	Industry capacity to service air freight growth	**6**	3	2	1	L4: Lower uncertainty
	Community pressures on the aviation sector (e.g., noise)	**6**	3	2	1	L5: Lower uncertainty
	Passenger facilitation in airports	**6**	2	2	2	L6: Lower uncertainty
	Competition between Australian and overseas carriers (e.g., traffic rights to / from AUS)	**5**	2	2	1	D5: Deprioritised
	Changes to operational constraints (curfews, runway caps)	**5**	2	2	1	D6: Deprioritised

Category	Driver	Ratings				Outcome
		Overall score	Materiality of impact	Breadth of impact	Level of uncertainty	
	Improved airport access infrastructure	**3**	1	1	1	D7: Deprioritised
	Availability and uptake of delivery drones (wing delivery)	**4**	1	1	2	D8: Deprioritised
	Other long-term aircraft tech advancements	**5**	1	1	3	D9: Deprioritised
	New airport processing technology / safety	**3**	1	1	1	D10: Deprioritised
	Future of Australian freight (types of freight, intermodal connectivity)	**3**	1	1	1	D11: Deprioritised
	Ground handling / service efficiency	**3**	1	1	1	D12: Deprioritised
	Proliferation of High-Altitude Platform Systems	**4**	1	1	2	D13: Deprioritised
Sustainability	Emission reductions ambitions and pressures	**8**	3	3	2	H6: Higher uncertainty
	SAF availability and uptake	**9**	3	3	3	H7: Higher uncertainty
	Availability and uptake of electric planes	**8**	2	3	3	H8: Higher uncertainty
	Availability and uptake of hydrogen aircraft	**8**	2	3	3	H9: Higher uncertainty
	Evolution of ATM	**8**	2	3	3	H10: Higher uncertainty
	Ongoing fleet renewal with new generation aircraft	**6**	2	3	1	L7: Lower uncertainty
	Airline adaption to environmental change	**4**	1	1	2	D15: Deprioritised

Detailed categorisation – Demand drivers

Table 15

Rationales for driver ratings – Demand

Driver	Ratings				Rationale
	Overall score	Materiality of impact	Breadth of impact	Level of uncertainty	
Higher uncertainty					
H1. Traveller preferences (domestic and international leisure travel)	**9**	3	3	3	Customer travel preferences could have a large impact on the aviation industry. Several pressures are likely to continue to change travel preferences, such as airfare costs, environmental concerns (personal and public, e.g., flight shame), and market shocks. For inbound traffic, Australia's status as an attractive holiday destination is not assured. As leisure is the main reason for most international travel, and a substantial portion of domestic travel, any change will have far reaching implications
H2. Changing ways of working (domestic and international business travel)	**8**	3	3	2	Changing ways of working, i.e., working from home and greater use of video conferencing technology, have and may continue to impact demand for business travel. Indicatively, there has been a structural reduction in domestic business travel, with international more resilient. How this issue evolves is currently unclear. Given the importance of business travel to industry profitability, it is an important driver
Lower uncertainty					
L1. Underlying macro-driven demand	**7**	3	3	1	Real GDP is the primary underlying driver of passenger movements. The relationship between real GDP and passenger growth, and the long-term average growth rate for real GDP is unlikely to deviate significantly from historical levels. Demand growth may slowly moderate as markets mature
L2. Demand for inbound international VFR travel	**6**	3	2	1	VFR constitutes a significant portion of inbound international air traffic (c.30% pre-COVID) and domestic traffic. With growth in immigration, the expat workforce, and international student numbers in Australia, VFR will likely continue to drive demand for flights. No substantial change in net migration trends in short- to medium-term is assumed. Country mix shifts may occur
Deprioritised					
D1. Australian domestic & outbound tourism	**5**	2	2	1	No major deviations in Australian preference for domestic vs. international tourism expected. Other drivers like traveller preferences (leisure) and aggregate demand, expected to drive any change in tourism mix
D2. Competition from other transport modes	**5**	2	1	2	Potential competition for domestic aviation could come from an upgraded passenger rail connection along the Brisbane – Sydney – Canberra – Melbourne corridor. This rail connection has not yet been confirmed. While passenger rail upgrades may introduce competition on the Sydney to Canberra route, or regional routes, the main Brisbane to Melbourne via Sydney corridor is unlikely to be affected

Driver	Ratings				Rationale
	Overall score	Materiality of impact	Breadth of impact	Level of uncertainty	
D3. Real airfares (e.g., driven by fuel costs)	**5**	2	1	2	Real airfares (which are currently elevated) are expected to normalise in the long-term. Other drivers (the proliferation of SAF) may impact real airfares. Customers have demonstrated a strong willingness to travel despite airfare increases, so the impact of any long-term fare change is assumed to be low (unless the change is substantial)
D4. Population dispersion across Australia	**4**	2	1	1	In the long-term, it is anticipated that the regional-urban population distribution will remain broadly consistent (with a slight decline in regional populations relative to urban populations), absent any major exogenous driver, such as new transport technologies like eVTOLS

Detailed categorisation – Supply drivers

Table 16
Rationales for driver ratings – Supply

Driver	Ratings				Rationale
	Overall score	Materiality of impact	Breadth of impact	Level of uncertainty	
Higher uncertainty					
H3. Domestic airline competitive dynamics	**8**	3	3	2	The level of market competition has large and broad impacts, resulting in changes to airfares / capacity dynamics in the Australian domestic context. Historically, the Australian market has had two main airlines but market changes, (e.g., WSI opening, Bonza entering, VA floating), could change the competitive landscape in the short- to medium-term
H4. Workforce training, supply, and capabilities (skills)	**8**	3	3	2	The current shortage of skilled aviation workers could have substantial industry impacts in the short-to medium-term. These impacts would most likely be felt in general and regional aviation, which could see a substantial reduction in the availability of pilots and engineers. There is no clear solution for this issue
H5. Availability and uptake of Advanced Air mobility (eVTOLS)	**8**	3	2	3	AAM timing and commercialisation is uncertain. If commercialised, AAM could largely impact some industry areas such as ATM, regional RPT flying, GA (particularly non-scheduled aviation), community and customer issues, and regulators
Lower uncertainty					
L3. Increasing airport capacity	**6**	2	3	1	Airport capacity directly impacts aeronautical growth, competition levels and customer experience. It is assumed that the opening of WSI in 2026 and addition of new runways at MEL, BNE and PER in the 2020s and 2030s will provide sufficient capacity to support industry growth, including during peak times. Regional airports may need upgrades to support larger aircraft, although this is largely immaterial
L4. Industry capacity to service air freight growth	**6**	3	2	1	Air freight growth is likely to continue in line with historical rates (driven by consumer demand for high value electronics, medicine, and perishables). Air freight capacity is expected to grow roughly in line with growth in aircraft movements (as most freight is carried in the belly of passenger aircraft). Capacity may be impacted by changes in fleet mix (i.e., new aircraft types may have a higher or lower freight capacity)
L5. Community pressures on the aviation sector (e.g., noise)	**6**	3	2	1	Community complaints regarding noise and other externalities will increase as movements increase at Australian airports. It is assumed that these pressures do not materially affect airport operations
L6. Passenger facilitation in airports	**6**	2	2	2	The industry is currently considering various improvements to passenger processing such as biometric security or automated security processing. There is some uncertainty regarding the timing of

Driver	Ratings				Rationale
	Overall score	Materiality of impact	Breadth of impact	Level of uncertainty	
					introduction for new processes and their potential impact
Deprioritised					
D5. Competition between Australian and overseas carriers (e.g., traffic rights to / from AUS)	**5**	2	2	1	Qantas has provided international services since 1935. It is anticipated that at least one Australian airline will provide international services in the long-term, so long as Australia remains an attractive tourism, immigration, and business destination (already captured in other drivers)
D6. Changes to operational constraints (e.g., curfews, runway caps)	**5**	2	2	1	Operational constraints that widely impact the industry are not expected to change. Constraints in Sydney become less pertinent following the opening of Western Sydney Airport. It is assumed that airports with no current curfews will not have curfews imposed in the future
D7. Improved airport access infrastructure	**3**	1	1	1	Airport access infrastructure such as highways, rail, etc., although important to individual cities and airports, has little impact on the wider aviation industry. Most airports have long-term plans to improve ground access
D8. Availability & uptake of delivery drones (wing delivery)	**4**	1	1	2	The proliferation of delivery drones is not anticipated to have major aviation impacts beyond the potential for additional regulation / UTM in urban areas (this will also be required for AAM)
D9. Other long-term aircraft tech advancements	**5**	1	1	3	Technology advancements such as supersonic aircraft could become a reality over the medium- to long-term but are unlikely to materially impact the industry due to limiting factors (e.g., higher fuel burn and cost), preventing widespread uptake
D10. Future of Australian freight (types of freight, intermodal connectivity)	**3**	1	1	1	Significant developments in the Australian freight landscape, such as intermodal connectivity with Western Sydney Airport or inland rail, are not expected to materiality impact air freight demand or supply. This is due to the relatively limited competition between air freight and other modes
D11. Ground handling / service efficiency	**3**	1	1	1	Improvements in ground handling and service efficiency can lead to operational and environmental benefits. These are incremental changes which are unlikely to have a material impact on the aviation industry
D12. Proliferation of High Altitude Platform Station systems	**4**	1	1	2	High Altitude Platform Station systems (HAPS) will have minor implications for ATM and aircraft communication, but are otherwise unlikely to materially affect the industry

Detailed categorisation – Sustainability drivers

Table 17
Rationales for driver ratings – Sustainability

Driver	Ratings				Rationale
	Overall score	Materiality of impact	Breadth of impact	Level of uncertainty	
Higher uncertainty					
H6. Emission reductions ambitions and pressures	**8**	3	3	2	The extent to which emissions reduction pressures increase is uncertain. How the industry responds to these pressures, particularly where they conflict with other industry priorities, including growth or profitability, is highly uncertain. The pressures themselves will not materially affect the industry, but industry response will have an effect
H7. SAF availability and uptake	**9**	3	3	3	SAF adoption will likely increase across the industry. There is significant uncertainty about supply: whether it will keep up with demand, where it will come from, and how the industry will compete with other industries for feedstock and production capacity. As the industry is currently basing decarbonisation ambitions on SAF availability, this issue is of major importance
H8. Availability and uptake of electric planes	**8**	2	3	3	The adoption of electric planes could assist with the decarbonisation of regional flying. Many uncertainties remain: commercialisation timing, the extent of electrification, the operating economics of electric aircraft, and the industry's interest in electric aircraft
H9. Availability and uptake of hydrogen aircraft	**8**	2	3	3	The adoption of hydrogen planes could assist with the decarbonisation of regional and short- to medium-haul flying Many uncertainties remain: commercialisation timing, technological limitations of hydrogen aircraft, operating economics, and the industry's interest in hydrogen aircraft
H10. Evolution of ATM	**8**	2	3	3	Changes in ATM systems could reduce fuel burn, improve airport efficiency, and enable new aviation technologies, impacting many industry participants. The introduction of UTM could also create a step change in how ATM occurs in the long-term. Timing and magnitude of ATM changes are unclear as proposed changes have been under consideration for a substantial period
Lower uncertainty					
L7. Ongoing fleet renewal with new generation aircraft	**6**	2	3	1	There is a substantial backlog of next generation aircraft yet to enter the Australian fleet. These aircraft will deliver incremental environmental and noise benefits in the short- to medium-term. There is some concern that aircraft technology is plateauing
Deprioritised					
D13. Airline adaption to environmental change	**4**	1	1	2	Adaptations are not expected to have a material industry impact as they are location or route specific. Airline and airport procedures for inclement weather may need to evolve if major weather events increase in frequency

8. Appendix B – Major stakeholder consultation themes

8.1 List of organisations consulted

Table 18
List of organisations consulted, grouped by industry

Industry	Organisation
Aircraft manufacturers	Airbus
	AMSL Aero
	Boeing
	Eve Air Mobility
	Wisk Aero
Airlines	Alliance Airlines
	Emirates
	Qantas
	Rex
	Singapore Airlines
	Virgin Australia
Airports	Brisbane Airport
	Melbourne Airport
	Perth Airport
	Sydney Airport
Australian Government	Airservices Australia
	Austrade
	Civil Aviation Safety Authority (CASA)
	Department of Climate Change, Energy, the Environment and Water (DCCEEW)
	Department of Employment and Workplace Relations (DEWR)
	Home Affairs
	Treasury
GA services	Microflite
	Sydney Seaplanes
Professional association / unions	Airlines for Australia and New Zealand (A4ANZ)
	Australian Airports Association (AAA)
	Australian Association for Uncrewed Systems (AAUS)
	Australian Federation of Air Pilots (AFAP)
	Board of Airline Representatives Australia (BARA)
	Bioenergy Australia
	General Aviation Advisory Network (GAAN)
	International Air Transport Association (IATA)
	Regional Aviation Association of Australia (RAAA)
	Transport Workers Union (TWU)
State governments	Department of Transport NSW
	Department of Transport WA
	Department of Transport and Main Roads (DTMR)
	Invest Victoria / Department of Jobs, Skills, Industry and Regions (DJSIR)
University	Griffith University

8.2 Aviation expert panel (consulted on this project)

Table 19
Aviation experts consulted as part of this work

Expert	Biography
Adrian Littlewood	Adrian Littlewood is a prominent business leader and former CEO of Auckland Airport. Adrian joined Auckland Airport in 2009 as General Manager of Retail and Commercial and was appointed Chief Executive in 2012, a position that he held for nine years. Prior to Auckland Airport, Adrian held leadership positions at Spark, a New Zealand-based telecommunications company, and worked as a management consultant and lawyer.
Lyell Strambi	Lyell Strambi is an aviation expert with 40 years' experience. He was the CEO and Managing Director of the Australia Pacific Airports Corporation for five years, where he was responsible for the operation and development of Melbourne and Launceston airports. Before joining Australia Pacific Airports, Lyell was the CEO of Qantas Domestic.
Mark Pesce	Mark Pesce is a futurist who co-invented the technology for creating 3D environments on the web, laying the foundations for the metaverse. He has written eight books, was a judge for seven years on the ABC's The New Inventors, is a multiple-award-winning columnist, and is professional futurist and public speaker. Mark consults as a futurist and bridge-builder to organisations such as the G20 and World Bank, and mentors start-ups working in technologically advanced areas.
Mike Mrdak	Mike is a policy expert with over 30 years' experience working in the public service on a range of infrastructure, transport, regional development and communications, and digital economy issues. He was previously Deputy Secretary of the Department of Transport and Regional Development and is currently a Chair of NEC Australia, Chair of Airport Development Group, and a member of L.E.K.'s Advisory Board.
Richard Deakin	Richard Deakin is an air traffic management and unmanned aerial vehicles expert with over 25 years' experience. He was previously the CEO of NATS (the UK's ANSP), is currently the CEO of UK-based Stratospheric Platforms, and works alongside manufacturers and investors in aerospace, telecoms, and technology. He is a Member of the UK Government's Drone Industry Action Group.
Tony Dillon	Tony Dillon is an expert in airlines, regional / general aviation, and freight, with extensive experience working in the Australian aviation industry. He held several senior positions at Qantas group during his 20+ year tenure at the company, including Head of Commercial Strategy and Analysis for Qantas and Head of Network and Margin for Qantas Freight.

8.3 Major issues by theme

Theme 1 | International aviation demand

The consensus among stakeholders was that international aviation demand is likely to remain strong in the long-term

- Stakeholders generally acknowledged that Australian and other international leisure travellers are likely to continue to travel in the long-term. Post-COVID, airlines indicated that forward bookings are strong as travellers return, suggesting that the pandemic had not impacted leisure demand
- Generally, stakeholders identified the Asia Pacific region as likely to remain Australia's main source of leisure and VFR traffic due to a growing and increasingly wealthy population. However, stakeholders recognised that inbound international air travel for tourism, education and VFR may see country mix shifts, e.g., Chinese travellers becoming proportionally less important
- There were mixed reactions on the issue of whether environmental concerns would change traveller behaviours. Some stakeholders acknowledged this might be an issue, but most did not believe it would substantially change international demand, particularly given the planned decarbonisation efforts of airlines and airports

"… We probably will not see much of a change [in travel for emissions reasons] in the next 10 years…it probably will not be an issue if the airlines and airports demonstrate that they are on the journey [to decarbonisation] with customers …"

- Australian Airline

Theme 2 | Domestic aviation demand

Aviation is viewed as an essential component of Australia's transport infrastructure. However, reduced business travel may temper domestic growth in the long-term

- Overwhelmingly, stakeholders reiterated that Australia is dependent on commercial aviation due to the significant distances between major cities, dispersed population, and lack of alternatives. Most stakeholders considered it likely that aviation demand would remain strong
- There is consensus that COVID-19 will have an enduring negative impact on domestic business travel. However, some types of business travel may benefit from changing ways of working, e.g., travel for sales or relationship building (particularly international)

"… Business travel will return, but as a share of the market it will be less. That's an enduring trend. The work proposition has changed permanently on a global basis. There isn't a great appetite to go back to previous patterns. The work life balance isn't going to change …"

- Independent Aviation expert, 2022

- Other corporate markets including FIFO and regional business / government travel, are expected to remain strong in the long-term due to limited alternatives and an inability to substitute travel for video conferencing
- There was some speculation as to what will happen to airfares in the long-term. Some stakeholders felt that airfares would remain higher than pre-COVID due to increasing fuel prices and other pressures

Theme 3 | Regional aviation

Discussions on regional aviation produced future themes including: potential shifts in demand, the need for and impact of upgauging, and concerns for airport accessibility and cost at regional and city ports

- The demand outlook for regional aviation is likely to be strong. Regional flying typically takes place for non-discretionary reasons, i.e., business, corporate and government travel. There is less discretionary leisure travel than other forms of aviation
- There were mixed views on the impact of regional population dynamics. The adoption of teleconferencing and WFH during the pandemic may make working remotely from regional towns more viable. A shift of urban workers to regional areas will likely benefit major centres
- Aircraft availability and upgauging is a concern for regional airlines. While current regional fleets have signfiicant life left, there is no clear replacement for existing turboprops in the long-term. Upgauging may occur at some airports (e.g., Wagga Wagga) but thinner, marignal services may be cut
- Regional operators frequently raised isses regarding airport pricing and accessibility. This issue extends to both regional and capital city airports:
    - For regional airports, stakeholders raised concerns for airport charging practices, security requirements, the quality of infrastructure, and a dwindling workforce to support regional operations
    - Capital city airports are not incentivised to offer slots to regional airlines, leading to difficulty getting slots and high airport charges

Theme 4.1 | Sustainability - General

Sustainability was frequently identified as the most significant industry issue; views were mixed on whether proposed sustainable technologies will deliver on sustainability objectives

- Some stakeholders believe that community expectations will grow, leading to calls for decarbonisation targets to be met earlier than 2050
- It is uncertain who will bear the cost of decarbonisation - and who will be willing to pay - but it will likely include a combination of consumers (travellers), businesses and government

Theme 4.2 | Sustainability - SAF

There was stakeholder consensus on the importance of SAF to the industry; some stakeholders expressed concern for how successful airlines will be in adopting SAF in the short- to medium-term

- Stakeholders generally viewed SAFs as the only short- to medium-term means of reducing aviation emissions, particularly for long-haul flying. Several stakeholders have publicly committed to using or supporting the use of SAFs
- It is unclear how SAF will be produced or secured in sufficient volumes, and there is concern for the cost premium over kerosene-based jet fuel. Stakeholders expressed concern for the availability of and competition for production facilities and feedstocks, and how the industry or government will fund SAF adoption
- Some stakeholders were uncertain as to whether the industry would achieve its SAF-led decarbonisation targets

"... You would be naïve not to include a scenario where we fail to meet our carbon objectives ..."

- Major airport, 2022

Theme 4.3 | Sustainability – Electric and hydrogen aircraft

Electric and hydrogen aircraft are likely to play a role in decarbonising aviation. Outlooks differed on when and what technologies would be available in the long-term

- Electric and hydrogen-electric powered aircraft are seen as important long-term drivers of industry decarbonisation, but are a long way off
- Small, short range passenger aircraft are expected to be in regular use in 2035-2040. Larger and / or longer-range aircraft (i.e., hydrogen turbine aircraft) are expected after 2050
- How the Australian aviation industry will adopt these aircraft is unclear. The industry is watching the development of different propulsion technologies but have not committed to a particular technology
- Beyond decarbonising commercial aviation, some commentators identified general aviation use cases for electric aircraft, e.g., flight schools

Theme 5 | General aviation

General aviation is expected to continue as an important component of the aviation industry. Stakeholders expressed concerns for GA's workforce availability, and regulatory environment

- GA is expected to continue to be an important part of the Australian aviation in the long-term. Stakeholders reiterated the diversity of operations that take place under the GA umbrella, including flight training, charter, emergency services, tourism/sightseeing, medivac, and agricultural flying
- Workforce issues, particularly the shortage of aircraft engineers, are a major issue for GA operators. It is becoming harder for GA operators, particularly in regional areas, to maintain their aircraft within viable timeframes
- GA operators are concerned about an inflexible regulatory environment. There is a perception that current regulatory approaches are too heavily geared towards commercial aviation needs
- Equitable access to airspace and infrastructure is also of concern. Some stakeholders identified a need to ensure that GA airports are not inhibited by non-aeronautical developments or policies that prioritise other forms of aviation

Theme 6 | Airports

Stakeholders raised infrastructure improvements, passenger processing and airport charging as major issues

- The opening of new runways and terminals across capital cities in the mid-to late-2020s onwards (notably WSI, MEL and BNE) will provide substantial capacity increases at Australia's largest and most important airports. The results will be additional peak capacity and greater airline competition
- Some regional airports may require runway upgrades to accept larger aircraft types (i.e., 737s / A320s)
- Passenger processing facility upgrades may improve passenger experience and processing efficiency. Several stakeholders recognised opportunities to use improved biometric scanning, AI, and other technologies to improve freight and passenger processing at security, customs, and quarantine checkpoints
- Stakeholders provided mixed views on the issue of airport charging. Some

stakeholders expressed concern for a perceived disparity between airport charging structures, and the infrastructure and facilities needs of airlines operating out of these airports. Regional aviation was of greatest concern

Theme 7 | Airlines

In general, stakeholders did not expect substantial changes to domestic and international competition in the long term. Some stakeholders raised inflexible international traffic rights as a potential issue

- Domestic airlines are adding capacity and returning to growth, with a focus on profitability over market share. Domestic supply is therefore somewhat constrained and is likely to remain so in the short-term
- In general, the medium-long term outlook for domestic airline competition and capacity additions is less clear. Many stakeholders expect the current situation of two main airlines holding most market share to continue, with other carriers operating sustainably in smaller markets. There was general scepticism regarding the potential for new entrants to significantly disrupt the market
- International airlines are slowly adding capacity to / from Australia, but it will take several years to return to pre-COVID levels. Markets such as China are expected to take even longer
- Some stakeholders expressed concern for how traffic rights may limit international airline capacity. They are concerned for existing arrangements that prevent otherwise willing and able international airlines, from serving Australian markets

Theme 8 | Workforce

Workforce issues are a major concern across the industry, with pilot and aircraft engineer workforces the greatest concern

- Significant uncertainty surrounds the supply of skilled aviation workers due to declining relative attractiveness of working in aviation versus other industries, and the attractiveness of working in Australia versus overseas
- The issue of larger international airlines offering better salary and conditions than Australian airlines to attract pilots was raised several times, as a risk to the Australian pilot workforce. The same concerns were raised regarding Australian aircraft mechanics
- Difficult and complex training pathways were cited multiple times as the main cause of the current shortage in the LAME and AME workforce. Issues raised included: the misalignment between CASA licensing requirements and Australian Skills Quality Authority (ASQA) course requirements, the need to travel for training, and higher pay offered in other sectors
- Stakeholders were unable to identify any clear solutions to this issue. Additional support for students (such as greater financial assistance) and training pathways, may assist. There was a view that this issue may partially resolve itself through natural industry cyclicality
- For other roles, growing casualisation is seen as an important issue in the short-term

Theme 9 | AAM

Most stakeholders believe AAM will play a role in aviation in the long-term but opinions differed on how AAM will materially change the industry in the long-term

- The industry recognises the potential of AAM to create new point-to-point connections. Proponents of AAM identified multiple use cases for AAM, including advanced options such as the replacement of other transport modes such as private cars over some distances

- The most extensive use case, in which AAM becomes a new form of personal transport, is dependent on aircraft automation and cost reductions. Some stakeholders believe this use case will occur before 2050

"... Once autonomous eVTOLs become a thing – and if this is not done before 2050, it will not happen – then the price point will radically reduce and people will start switching to AAM. This will be a fundamental change in how we use our skies ..."

- AAM industry participant

- There is scepticism as how long it will take for AAM technology to be technically and commercially viable, and achieve regulatory approval

"... eVTOLS will come but they won't be as taxis buzzing around the sky like some start ups are saying... these aircraft will integrate and be another rotary wing type platform in the industry, used in certain cases..."

- International aerospace corporation

Theme 10 | Freight

Most stakeholders did not view freight as a substantial issue in the long-term

- Most airfreight is carried in the bellies of commercial aircrafts. Stakeholders generally did not expect this to change in the long-term, although some noted that capacity may increase as next generation widebody aircraft with greater freight capacity enter fleets
- Most stakeholders did not consider regional freight connectivity an issue. Some stakeholders identified a misalignment between the expectations of some industries for international freight connectivity in regional areas, and the poor economics of operating these services

Theme 11 | ATM

Air traffic management practices are expected to continue to evolve to meet sustainability, operational efficiency, and community objectives. Opinions differ on the potential for automation

- Air traffic management processes are generally improving through the introduction of free route airspace practices, the OneSKY program, and improvements to route planning and optimisation. Stakeholders also raised the ongoing need for airspace design to optimise for different, and sometimes competing, objectives such as reducing aircraft noise, improving operating efficiency, and reducing fuel burn and emissions
- The most significant change raised by stakeholders is the introduction of uncrewed air traffic management systems (UTM) into the broader ATM landscape:
  - Stakeholders generally expect early UTM systems to be in place in the short-term, to support drone and AAM aircraft management
  - In the long-term, there are mixed views on the degree to which UTM will integrate into and replace traditional AAM practices, creating 'machine to machine' linkages that reduce the need for person-in-the-loop ATM practices

9. Appendix C – Scenario refinement approach

9.1 Approach to driver prioritisation

Scenario refinement approach

L.E.K. developed future industry scenarios using top-down and bottom-up approaches. The top-down approach involved identifying potential scenarios based on major themes emerging from stakeholder consultations and secondary research. The bottom-up approach grouped logical combinations of drivers together to form scenarios.

Using both approaches, L.E.K. developed a list of 11 scenarios (see below). The scenarios varied in breadth: some scenarios adopted an industry wide view, others focused on specific drivers.

L.E.K. tested and validated the 11 scenarios in a workshop with senior members of the Department's aviation team. Workshop feedback was incorporated into the scenarios and the drivers.

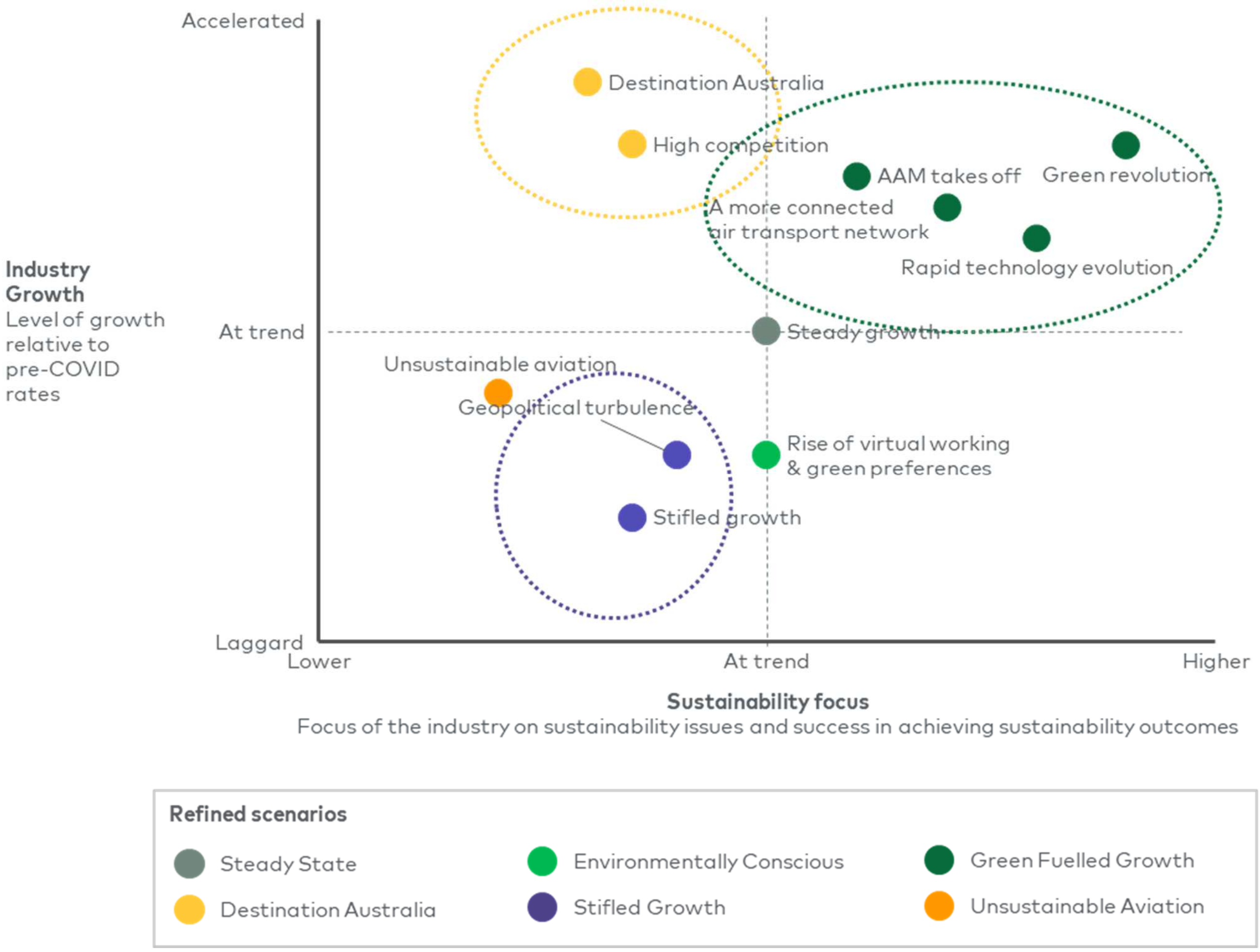
Table 20
Initial 11 scenarios developed

Scenario	Description	Timeframe of greatest change
1. **Steady growth**	The industry evolves in line with historical growth rates and trends	Short-Long Term (2023-2050)
2. **Rise of virtual working and green preferences (low growth)**	Demand is structurally reduced by changed traveller preferences and ways of working	Short-Medium Term (2023-40)
3. **Destination Australia (high growth)**	The sector returns to even higher growth than pre-pandemic, driven by pent-up demand for travel and investment in Australia's tourism assets. Growth is sustained by improvements to tourism assets in Australia	Short-Medium Term (2023-40)
4. **Green revolution**	Rapid commercialisation of new fuel sources, advances in aircraft / engine technology and air traffic management drive substantial reductions in emissions per passenger kilometre	Long Term (2040-50)
5. **Stifled growth**	Airline, airport and / or labour capacity shortages act as a drag on industry growth, creating excess demand, increasing real airfares (and airline profitability) and limiting Australia's air connectivity for people and freight	Short-Medium Term (2023-40)
6. **Geopolitical turbulence**	Foreign political instability structurally impairs inbound tourism and outbound travel, reducing capacity, slowing growth, increasing real airfares, and reducing Australia's connectedness to the world	Unknown
7. **High competition**	New airlines are successful in entering and expanding in the market, inducing demand with lower airfares, increasing customer choice, accelerating growth, and improving air connectivity (at the cost of emissions and airline profitability)	Short-Medium Term (2023-2040)
8. **A more connected air transport network**	Advances in conventional aircraft, eVTOLs and supersonic aircraft combine to create a more connected domestic, regional and international air network for Australia	Long Term (2040-50)
9. **AAM takes off**	AAM (eVTOLs) experience a rapid uptake in the 2030s, not only within metro areas, but improving air connectivity between metro-regional areas and within regional areas. However, some traditional regional services as subsequently displaced, negatively impacting freight	Medium Term (2030-50)
10. **Rapid technology evolution**	A range of technology across the sector evolves and is implemented rapidly, with benefits to safety, security, emissions, ATM, and the passenger experience, but with a lower reliance on humans	Long Term (2040-50)

Scenario	Description	Timeframe of greatest change
11. Unsustainable aviation	Decarbonisation technology pathways fail to deliver on industry targets in the medium-long term. Customers choose to fly less frequently and airfares rise due to the imposition of carbon offsets, stifling demand	Medium-Long Term (2030-2050)

L.E.K. plotted the 11 scenarios on a matrix (see below) comparing the level of industry growth against industry focus on meeting sustainability issues implied within each scenario. Scenarios with similar drivers and / or outcomes were grouped based on their position in the matrix. Grouping produced a final list of 6 scenarios (the seventh New Mobility Paradigm scenario was subsequently added).

Figure 42
Scenario association matrix



10. Appendix D – Scenario analysis approach

10.1 Approach to scenario analysis

Introduction

The following section describes the high-level methodologies and assumptions behind the scenario analysis. The purpose of the analysis is to provide a high-level quantitative overlay to each scenario to indicate how the scenario may develop out to 2050 in terms of RPT traffic and carbon emissions. The analysis is not intended to provide a detailed forecast of expected traffic or emissions for the industry.

There are seven levers in the analysis for traffic and emissions that are varied to derive different outcomes for each scenario.

These levers include:

- Real GDP
- Market demand adjustment
- Market supply adjustment
- Market price adjustment
- Portion of fuel use which is SAF
- SAF price relative to traditional jet fuel
- Electric / hydrogen aircraft uptake

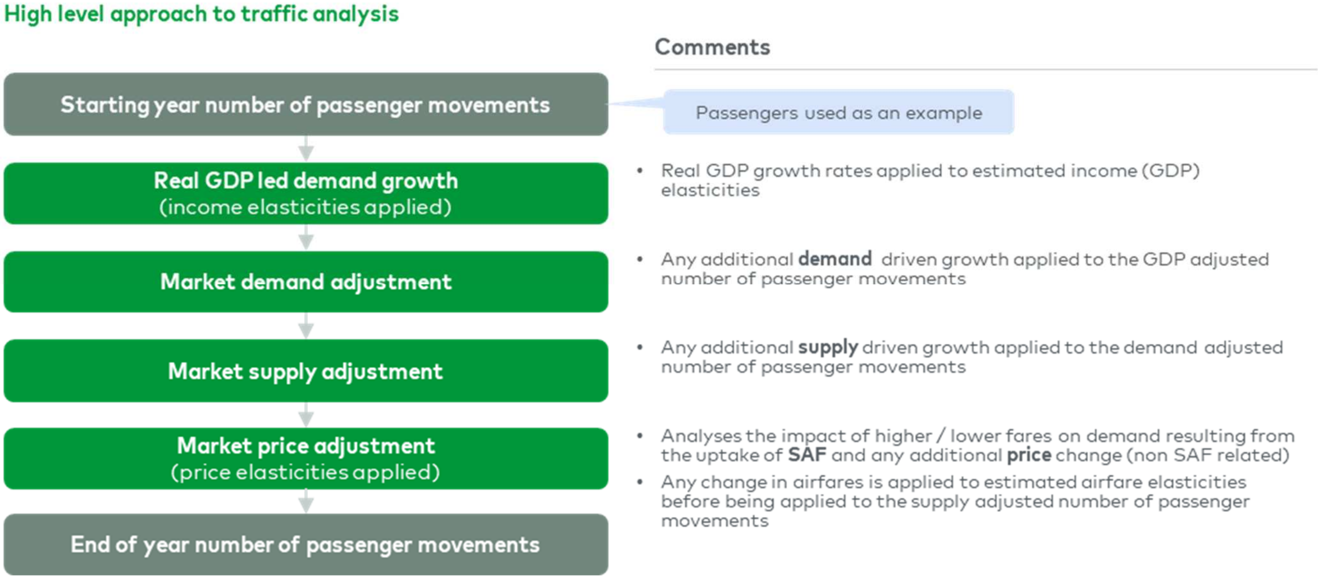
These scenarios represent the view of L.E.K. Consulting and do not represent the Australian Government's view of future RPT traffic or carbon emissions.

10.2 Traffic analysis approach

Overall approach

The figure below outlines the methodology used to calculate the number of passengers and ASKs for both the domestic and international market.

Figure 43
High level approach to traffic analysis methodology



The analysis uses several key underlying assumptions:

- **Analysis period |** The period of analysis for the domestic market is from 2023, when the market is expected to return to pre-pandemic levels, to 2050. The period of analysis for the international market is from 2025, when the market is expected to return to pre-pandemic levels, to 2050.
- **Domestic market |** Includes domestic airlines performing RPT services within Australia. Data includes passengers carried between domestic airports as part of an international flight operated by an Australian international carrier. General aviation traffic is not included.
- **International market |** Includes international airlines operating RPT services into or out of Australia. Includes passengers transiting Australia. General aviation traffic is not included.
- **Flight routes and distances |** The 2019 mix of routes flown, and associated share of ASKs / passengers is assumed to be stable in the long-term. Analysis is conducted on an aggregate level (not on a route-by-route basis).
- **AAM impact on RPT domestic flights |** AAM is assumed to not take share of trips from RPT domestic flights within the timeframe of this analysis.

Starting year traffic

The starting year traffic volumes used in the scenario analysis are sourced from the Bureau of Infrastructure and Transport Research Economics through publicly available data releases and specific data requests to the Bureau.

Key assumptions / approach:

- **Return to pre-COVID-19 industry traffic levels |** The domestic market is assumed to reach pre-pandemic (2019) levels of activity in 2023 and the international market in 2025.
- **Structural reduction in flying for business |** The 2019 domestic traffic data was adjusted to account for a structural reduction in domestic business travel resulting from changed ways of working. The analysis assumes an overall reduction of business-related traffic of 15% in 2023 compared to 2019 pre-pandemic figures.

Real GDP led demand growth

The figure below outlines the methodology used to calculate the real GDP adjusted number of passenger movements and ASKs.

Key assumptions / approach:

- **Real GDP |** Australia's forecast real GDP rates are applied to domestic and outbound international traffic. Respective country real GDP rates are applied to inbound international traffic for key markets including New Zealand, Singapore, China, UAE, Indonesia, USA, Hong Kong, Malaysia, Japan, Thailand, India, and Vietnam.
- **Income elasticities |** Regression analysis was performed to calculate elasticities for the domestic, Australian outbound international and key inbound international markets. Demand elasticates are assumed to moderate in the long-term due to market maturation.

Figure 44
Real GDP led demand growth methodology

Scenario levers:

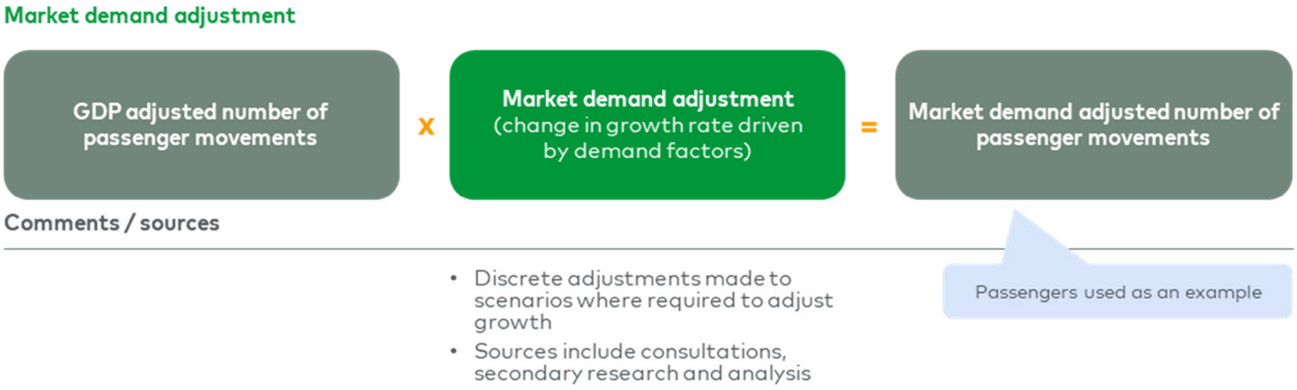
Table 21
Real GDP led demand growth scenario levers

	Low case	Base Case	High Case
Real GDP	0.5% p.a. lower than forecast	Forecasted real GDP	0.5% p.a. higher than forecast

Market demand adjustment

The figure below outlines the methodology used to calculate the market demand adjusted number of passenger movements and ASKs.

Figure 45
Market demand adjustment methodology



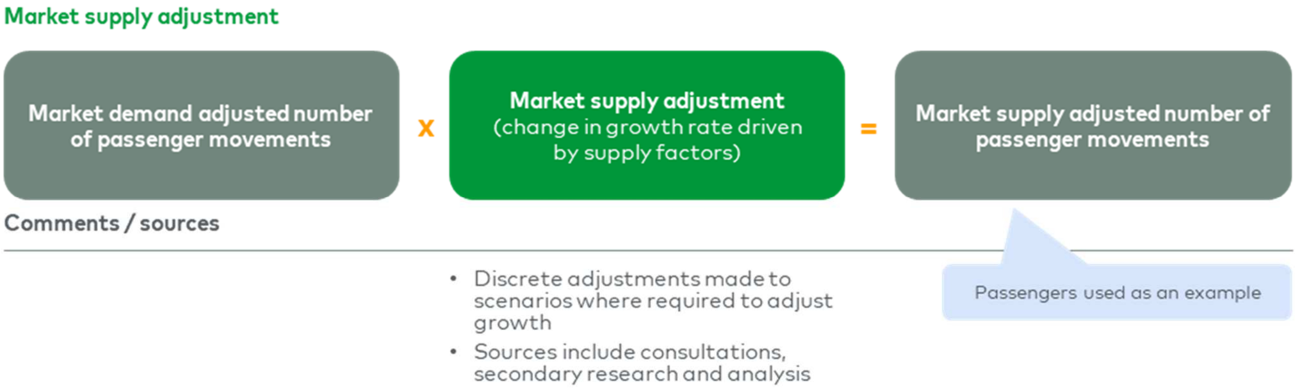
Scenario levers:

Discrete adjustments were made to relevant scenarios to reflect additional changes in demand (corresponding with demand changes articulated in the scenario descriptions in the body of the report). Consultations, secondary research, and analysis informed the adjustment rates (see the 'Scenario Settings' section of the Appendix for additional detail).

Market supply adjustment

The figure below outlines the methodology used to calculate the market supply adjusted number of passenger movements and ASKs.

Figure 46
Market supply adjustment methodology



Scenario levers:

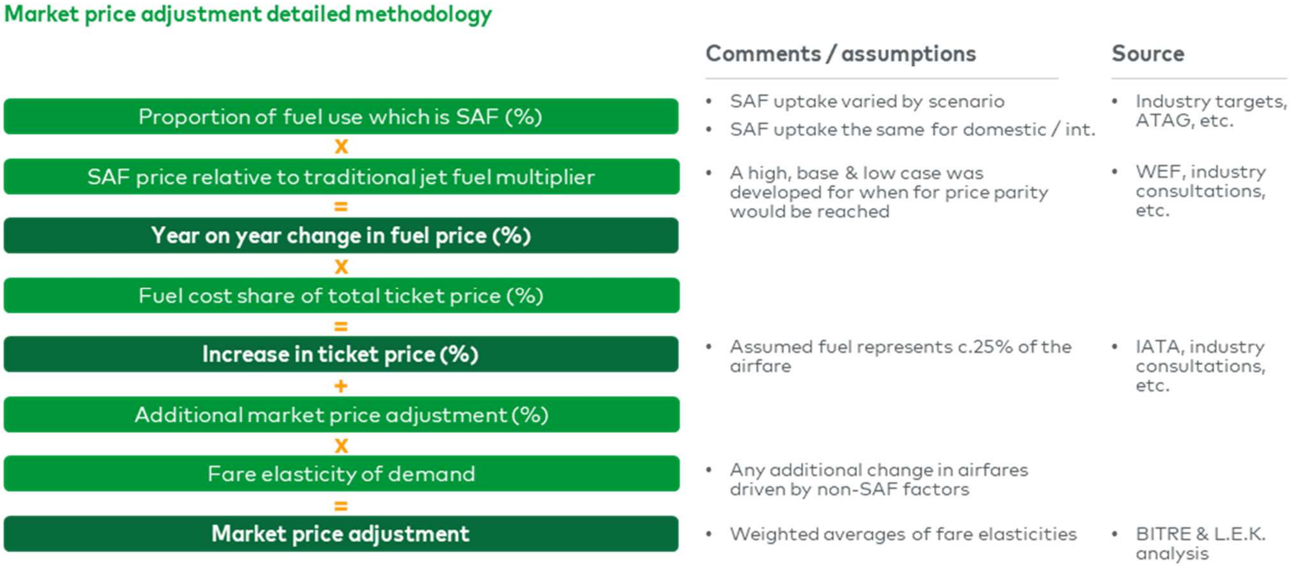
Discrete adjustments were made to relevant scenarios to reflect how changes in supply may impact growth. Consultations, secondary research, and analysis informed the adjustment rate (see the 'Scenario Settings' section of the appendix for additional detail).

Market price adjustment

The figures below outline the high level and detailed methodology used to calculate the market price adjusted number of passenger movements and ASKs.

Figure 47
Market price adjustment methodology

Figure 48
Market price adjustment detailed methodology



Key assumptions / approach:

- **Proportion of fuel use which is SAF |** SAF uptake scenarios were generated by considering available analysis in the public domain, industry targets, European Commission proposed targets, industry consultations and other sources.
- **SAF price relative to traditional jet fuel multiplier |** SAF pricing scenarios were generated by considering a variety of secondary sources and industry consultations. SAF price relative to traditional jet fuel is declined linearly.
- **Fuel cost share of total ticket price |** Fuel cost share of total ticket price was estimated as 25%, utilising a variety of sources including industry consultations, IATA reporting and specific industry examples. The fuel cost share of total ticket price is assumed constant over the period of analysis.
- **Fare elasticities |** Weighted averages of business and leisure elasticities were calculated using historical BITRE data. Fare elasticates were assumed to remain constant over the period of analysis.

Scenario levers:

See the ‘Scenario settings’ section of the Appendix for additional detail on specific market price adjustments for each scenario.

Table 22
Market price adjustment scenario levers

	Low case	Base Case	High Case
Proportion of fuel used which is SAF	**2030:** 2% (industry falls well short of target) **2050:** 25% (industry falls well short of target)	**2030:** 5% (mixed uptake from industry) **2050:** 45% (mixed uptake from industry)	**2030:** 10% (key industry participants reach or exceed industry targets) **2050:** 60% (key industry participants reach or exceed targets)
SAF price relative to traditional jet fuel	**2023:** 3.5x (est. current price) **2050:** 2.1x (limited SAF availability at 2050)	**2023: 3.5x** (est. current price) **2050: 1.7x** (growing SAF availability at 2050)	**2023:** 3.5x (est. current price) **2050:** 1x (price parity reached in 2050, with new SAF tech, & greater SAF availability)

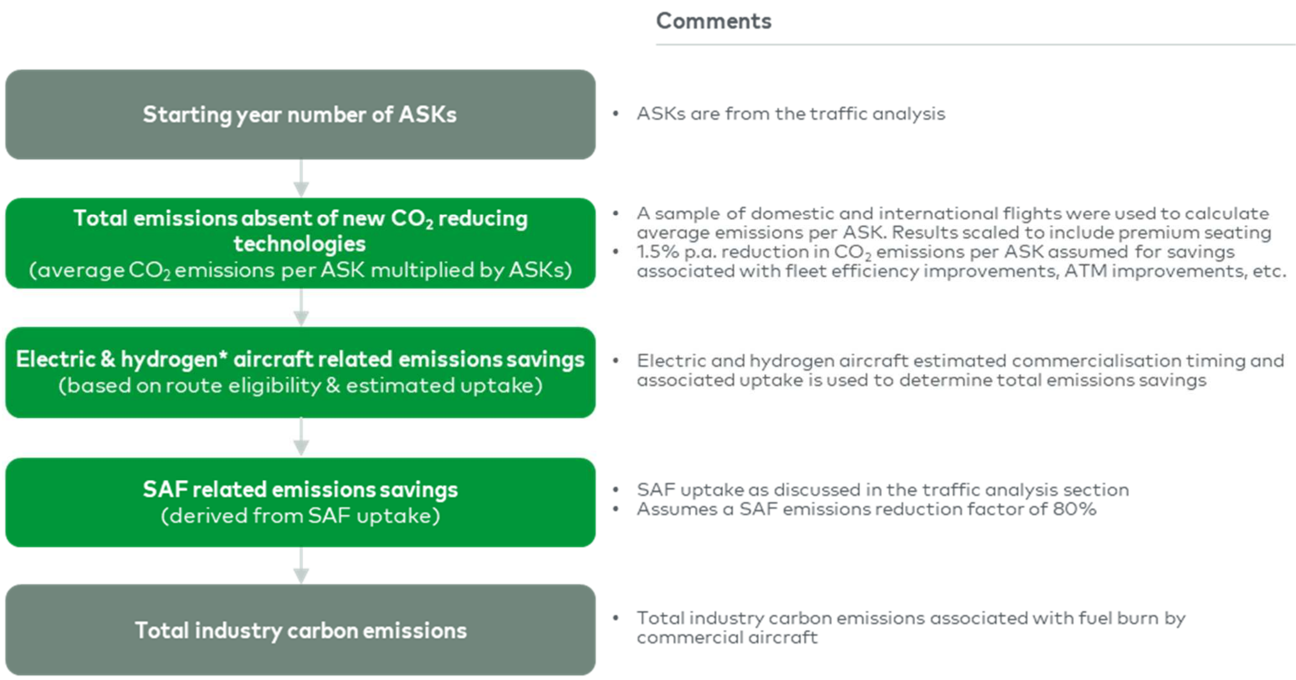
10.3 Emissions analysis approach

Overall approach

The figure below outlines the methodology used to calculate the carbon emissions for both the domestic and international market.

Figure 49
Emissions analysis methodology

High level approach to emissions analysis



Note: * Electric and hydrogen aircraft assumed to have zero emissions by being fuelled by green energy

The analysis uses several key underlying assumptions:

- **Emissions included |** For the purpose of emissions analysis, all domestic flights and outbound international flights are included. Inbound international flights are excluded.

Total emissions absent of new CO_2 technologies

Total carbon emissions excluding any reductions afforded by the uptake of electric aircraft, hydrogen aircraft, or SAF are calculated by multiplying total ASKs generated from the traffic analysis by the average emissions per ASK. Average emissions per ASK were calculated for a selection of common domestic and international flights, using Google Flights emissions data as the underlying source.

Key assumptions / approach:

- **Premium seating share of total ASKs |** Premium (non-economy) seating was assumed to be 3.6% of domestic ASKs and 18.7% of international ASKs, generated by analysing a selection of seating plans on commonly flown aircraft for domestic and international routes.

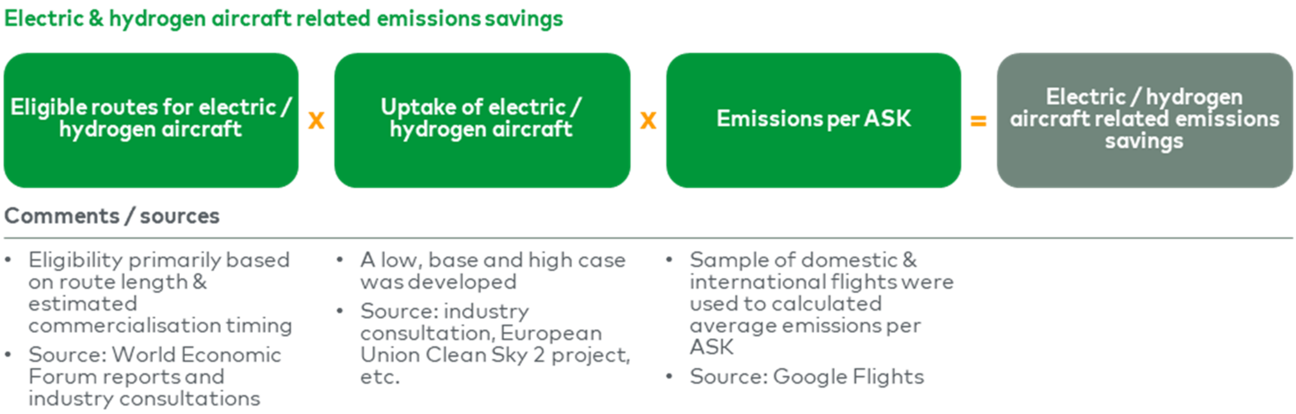
- **General emissions reduction factor |** A 1.5% p.a. reduction in emissions per ASK was assumed for savings associated with fleet efficiency and ATM improvements, based on a conservative estimate of Airbus historical improvements in aircraft efficiency.
- **Average load factor |** Google Flights default load factor of 84.5% was used as the basis of converting average emissions per RPK to ASK.
- **Average emissions per ASK |** Average emissions per ASK were calculated for a selection of common domestic and international flights, using Google Flights emissions data as the underlying source. As a result, emissions per ASK is an estimate and not calculated on a route-by-route basis.

Electric and hydrogen aircraft related emissions savings

The figure below outlines the high-level approach used to calculate the carbon emission savings derived from the adoption of electric / hydrogen aircraft.

Figure 50

Electric and hydrogen aircraft related emissions savings methodology



Eligible routes for electric / hydrogen aircraft:

- Routes eligible for electric or hydrogen fuel cell aircraft (on sub-500km routes):
  - **Domestic |** Routes less than 300km from 2026 (initial expected range of flight) and as technology improvements increases the range capacity, routes between 301-500km from 2036
    - Source: World Industry consultations and research
  - **International |** None, as no international routes are less than 500km
- Routes eligible for hydrogen turbine aircraft on longer routes:
  - **Domestic |** 500-2,000km routes from 2036 based on initial flight ranges expected by Airbus. 4,000km from 2046 as technology improvements increase the range capacity. Routes under 500km are excluded to prevent double counting of zero emissions technology
    - Source: Airbus and industry consultations
  - **International |** NZ routes between 500-2,000km from 2036 and under 4,000km from 2046. Most other markets are either over 4,000km or have been assumed to be unlikely to have hydrogen infrastructure by 2050
    - Source: Airbus and industry consultations

Key assumptions:

- **Electric / hydrogen emissions savings |** Electric and hydrogen aircraft are assumed to have zero emissions by being fuelled by green energy.

Scenario levers:

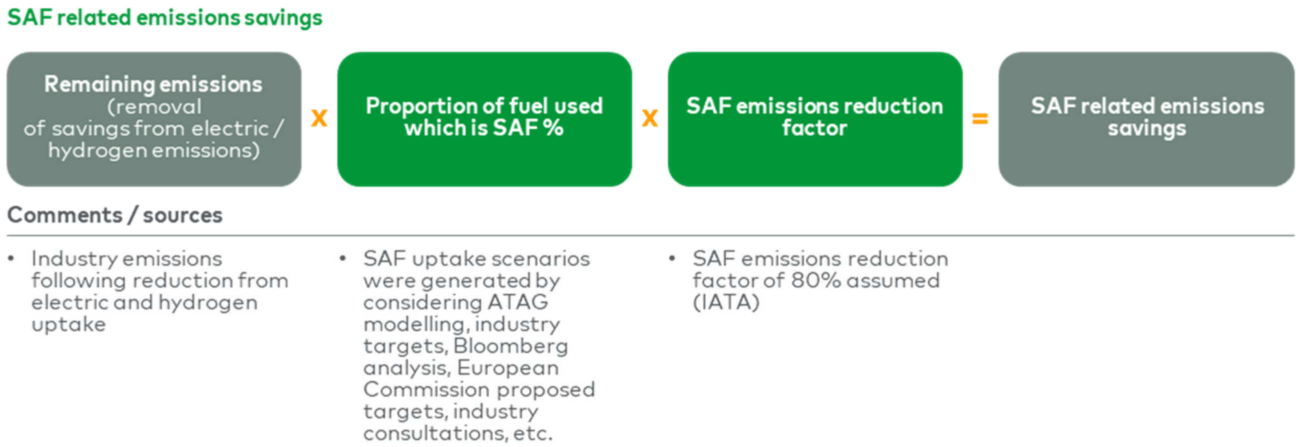
Table 23
Electric and hydrogen aircraft related emissions savings scenario levers

	Low case	Base Case	High Case
Electric or hydrogen fuel cell aircraft uptake on eligible shorter routes	**18% of ASKs by 2050** • Equivalent of replacing c.25% of prop flights on routes under 500km or c.5% of domestic movements	**40% of ASKs by 2050** • Equivalent of replacing c.50% of prop flights on routes under 500km & c.50% of Sydney to Canberra traffic or c.11% of domestic movements	**68% of ASKs by 2050** • Equivalent of replacing c.75% of prop & c.50% of jet flights on routes under 500km or c.18% of domestic movements
Hydrogen uptake on eligible longer routes	**0% by 2050** • Technology does not materialise	**5% of ASKs by 2050.** Start in 2040 • Equivalent of c.4% of domestic movements (excluding international)	**15% of ASKs by 2050.** Start in 2036 • Equivalent of c.11% of domestic movements (excluding international)

SAF related emissions savings

The figure below outlines the high-level approach used to calculate the carbon emissions savings derived from the adoption of SAF.

Figure 51
SAF related emissions savings methodology



Key assumptions:

- **SAF emissions reduction factor |** SAF assumed to reduce life cycle emissions compared to conventional jet fuels by 80% (source: IATA)
- **SAF uptake |** Based on available analysis in the public domain, industry targets, European Commission proposed targets, industry consultations and other sources.

Scenario levers:

Table 24
SAF related emissions savings scenario levers

	Low case	Base Case	High Case
Proportion of fuel used which is SAF	**2030:** 2% (industry falls well short of target) **2050:** 25% (industry falls well short of target)	**2030:** 5% (mixed uptake from industry) **2050:** 45% (mixed uptake from industry)	**2030:** 10% (key industry participants reach or exceed industry targets) **2050:** 60% (key industry participants reach or exceed targets)

10.4 Scenario settings

Scenario setting summary

The table below providers an overview of how the levers differ by scenario.

Table 25
Scenario settings summary

	1. Steady state	2. Destination Australia	3. Environmentally conscious	4. Stifled growth	5. Green fuelled growth	6. Unsustainable aviation
Real GDP	Base case	High case	Low case	Low case	Base case	Base case
Market demand adjustment	**Increased** growth from 2026 for **int.** to reach approximate pre-COVID growth levels (2.5% p.a. increase)	**Increased inbound int.** by 4.0% p.a. from 2026 to 2035 (to account for greater tourist traffic) (2026-30 has reduced rates). From 2036 4% p.a. reducing to 3% in 2050 **Increased domestic** by 0.8% p.a. (2026-30 has slightly reduced rates)	**Decreased domestic** by 0.5% p.a. from 2031 (driven by environmental concerns) **Int. outbound reduced** by 1% p.a. from 2031 (environment concerns) In 2040 **domestic reduced** to account for Canberra to Sydney faster rail. 90% of the route reduced, equivalent to c.0.3% of domestic ASKs	n/a	**Decrease** of 0.25% from 2026 to 2035 on **domestic & int. outbound** (driven by environmental concerns) **Increase** of 3.5% p.a. from 2041 for **int. outbound** (2036 ramp up begins) (driven by greener flying availability) **Domestic** is an **increase** of 0.5% p.a.	**Increased** growth from 2026 for **int. traffic** to get to pre COVID levels (2.5% p.a. increase) up to 2040 **Decrease** of 1% p.a. from 2041 **on all flying** (concerns around emissions reduce demand)
Market supply adjustment	n/a	n/a	n/a	GDP growth halved to due to supply reductions	n/a	n/a

	1. Steady state	2. Destination Australia	3. Environmentally conscious	4. Stifled growth	5. Green fuelled growth	6. Unsustainable aviation
Market price adjustment (increase in fares)	n/a	Slight **decrease in** airfares for **domestic & int.**, reduced by 20% by 2035, starting in 2026 (driven by increased competition) (-2.2% p.a. for 2026-35)	**Increase** in airfares for **domestic**, increasing by 20% starting in 2031 (0.9% p.a. for 2031-50) **Increase** in airfares for **int.**, increasing by 15% starting in 2031 (0.7% p.a. for 2031-50)	25% **increase** in **domestic & int. airfares** starting in 2031 (1.1% p.a. from 2031-50)	n/a	n/a
Proportion of fuel use which is SAF	Base case	Base case	Base case	Low case	High case	Low case
SAF vs. traditional jet fuel price	Base case	Base case	Base case	Low case	High case	Low case
Electric/ hydrogen mix	Base case	Base case	High case	Low case	Low case	Base case

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