Chapter 3 Introduction to airspace

This chapter introduces the key concepts and issues that relate to airspace operations, including a summary of how airspace is managed and key airspace terms.

It also explains the factors that can affect airspace operations. A range of factors play an important role in the operation of airspace and the safe and efficient movement of aircraft, such as time of day, traffic demand (including the number of arriving and departing aircraft), flight paths (including origin and destination), aircraft separation and sequencing, runway modes of operation and capacity, noise abatement procedures and weather conditions. Understanding the influence these factors can have on how aircraft are required to operate within airspace is important.

The new aircraft operations at WSI must integrate into the operations of the broader Sydney Basin airspace. Airspace in the Sydney Basin is likely the most complex and busiest in Australia and the interaction of WSI within this airspace is discussed in this chapter. Interactions with other airspace users is also briefly discussed, with further detail on the existing conditions within the Sydney Basin airspace included in Chapter 4 (Project setting).

Information in this chapter will assist with understanding Chapter 6 (Project development and alternatives) and Chapter 7 (The project), as well as provide the basis for discussions regarding noise (Chapter 11) and air quality (Chapter 12).

3.1 Airspace and how it is managed

Airspace is the term used for the three-dimensional space in which aircraft fly (refer to Figure 3.1). Most of the Australian airspace is available for civil aviation use, with overall responsibility for management of the airspace shared by Airservices Australia and the Australian Department of Defence (Defence). Airservices Australia and Defence work closely together to provide a seamless service to aircraft users.

Airservices Australia manages the non-military airspace and provides the necessary air traffic control services and equipment to maintain a safe and efficient flow of air traffic. Air traffic at WSI would be managed by Airservices Australia. Airservices Australia under established agreements also manages some military airspace including elements of the Royal Australian Air Force (RAAF) Base Richmond. As the national Air Navigation Service Provider (ANSP), Airservices Australia ensures that aircraft are separated (for safety) throughout their flight, and sequenced (for efficiency) during arrival to and departure from an airport.

The Civil Aviation Safety Authority (CASA) is a government body that regulates aviation safety in Australia. CASA sets policies and standards, based on the International Civil Aviation Organization (ICAO) standards and recommended practices, which govern the use of the non-military portion of the airspace.

The ICAO is a specialised agency of the United Nations (UN) and serves as the global forum of 193 Member States (including Australia) for international civil aviation. Its vision is to achieve the sustainable growth of the global civil aviation system, with the strategic objectives of managing the projected growth in global air transport capacity without unnecessary adverse impacts on safety, efficiency, convenience or environmental performance. In doing so, ICAO develops policies and standards, and performs compliance audits, research and analysis.

Daily management of the airspace is achieved through air traffic controllers directing the various phases of flight (refer to Figure 3.2). Management procedures are published for each airport including standard instrument procedures for departures and arrivals, and noise management and abatement procedures.

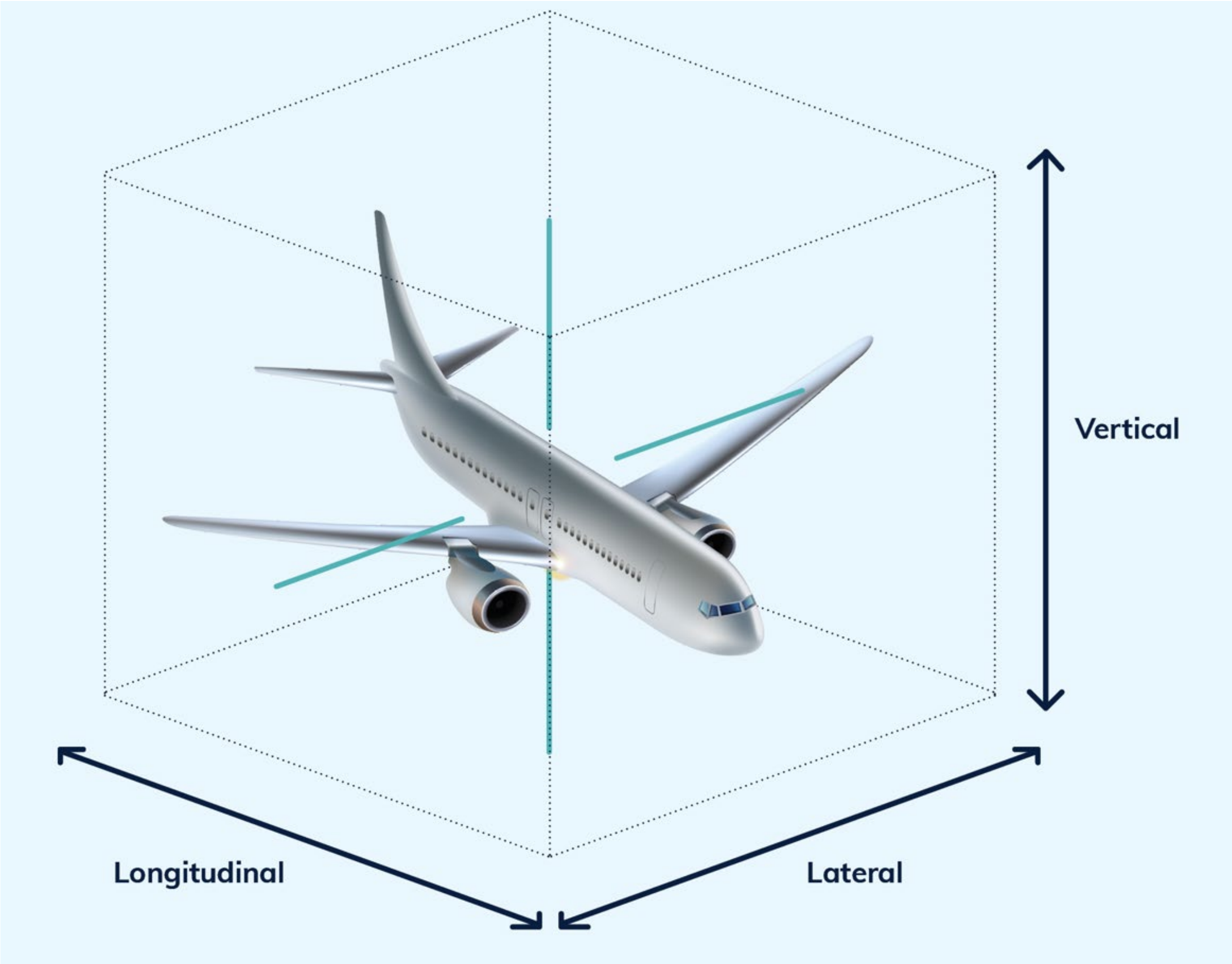


Figure 3.1 Three-dimensional space in which aircraft fly

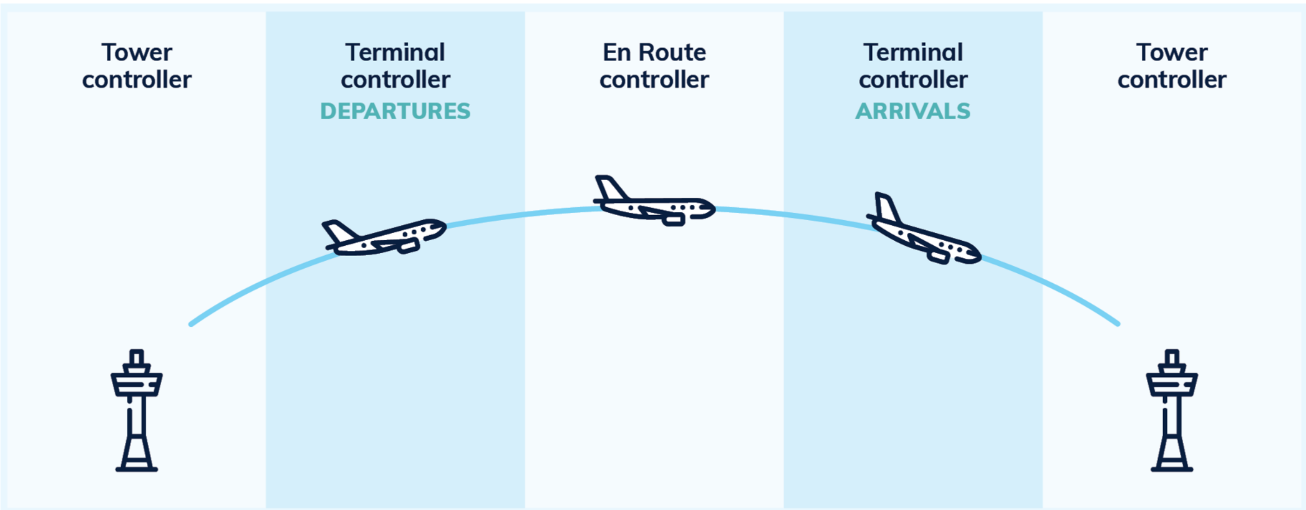


Figure 3.2 How air traffic control works

Elements of airspace include:

- **Controlled airspace**. Controlled airspace is a generic term for airspace with defined dimensions and within which air traffic control services are provided to aircraft. The primary role of air traffic services is to safely separate one aircraft from another both laterally and/or vertically. Controlled airspace in Australia is actively monitored and managed by air traffic controllers. To enter controlled airspace, an aircraft must first gain a clearance from an air traffic controller. Controlled airspace comprises control zones and control terminal areas.
- **Control zone (CTR)**. A control zone (refer to Figure 3.3) is a volume of airspace surrounding major airports down to ground level within which all aircraft movements are subject to a defined level of control. This airspace is usually dedicated to a tower controller. There are currently 3 existing civil control zones within the Sydney Basin airspace located at Sydney (Kingsford Smith) Airport, Bankstown Airport and Camden Airport. WSI will introduce a fourth control zone.

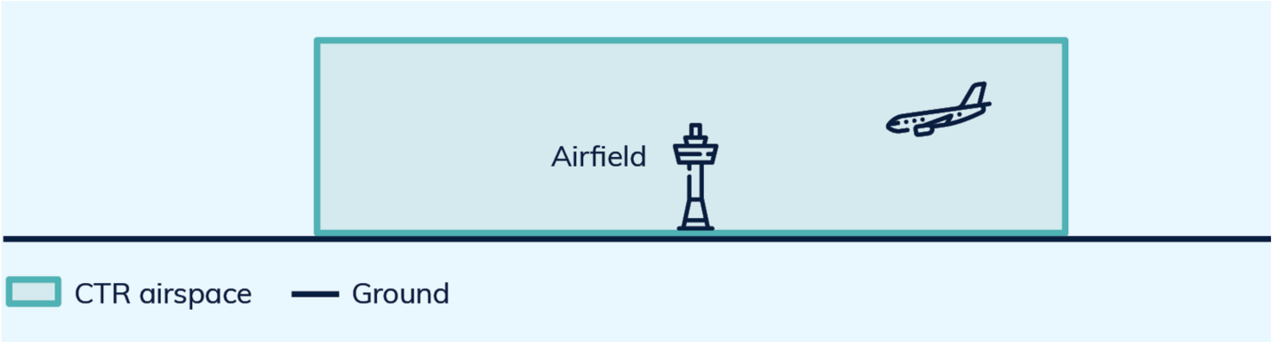


Figure 3.3 Control zone (CTR)

- **Control area (CTA)**. A control area (refer to Figure 3.4) is a volume of airspace with defined upper and lower altitude bands, within which aircraft movements are subject to a defined level of control. The control areas within the Sydney Basin airspace are mainly Class C airspace (refer to Figure 3.6 for a description of classes of airspace). Some Class A airspace exists at high level above the Class C.

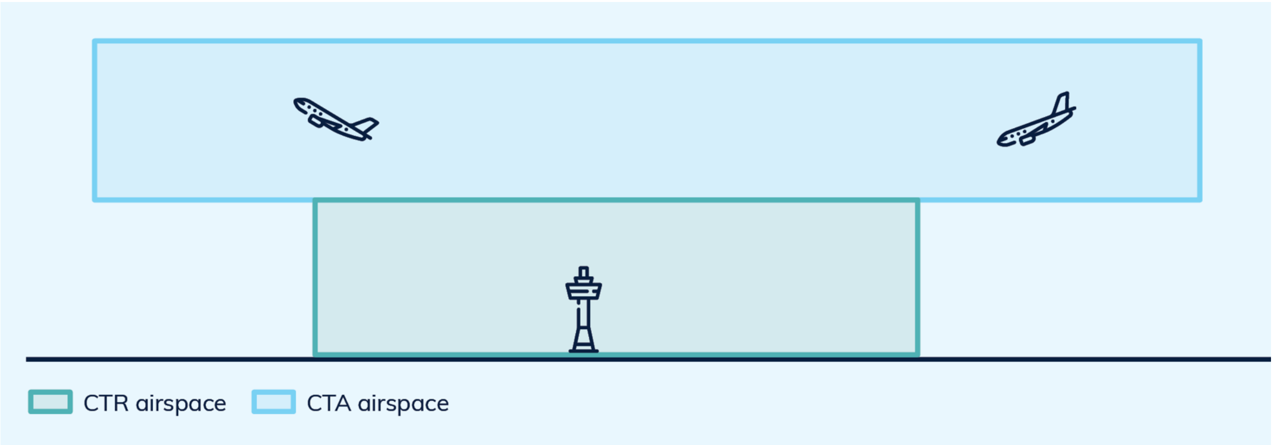


Figure 3.4 Control area (CTA)

- **Terminal airspace** (also known as the terminal control area (TMA)). Terminal airspace (refer to Figure 3.5) generally encompasses the area within 30 to 50 nautical miles (nm) (or approximately 55 to 93 kilometres (km)) of a major airport. The vertical extent of terminal airspace varies depending on the operational parameters at an airport. As the distance from the airport increases, the lower boundary of controlled airspace rises in steps, until reaching the lower level of the overlying enroute airspace. Enroute controlled airspace is typically above 10,000 feet (ft) (around 3 km) above sea level and encompasses the major routes between cities.

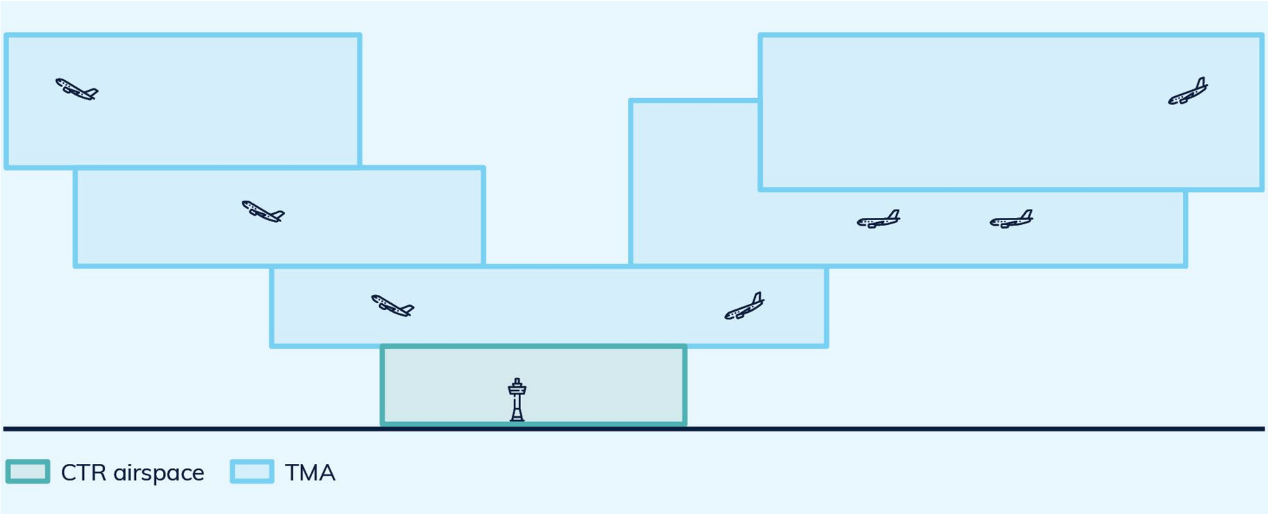
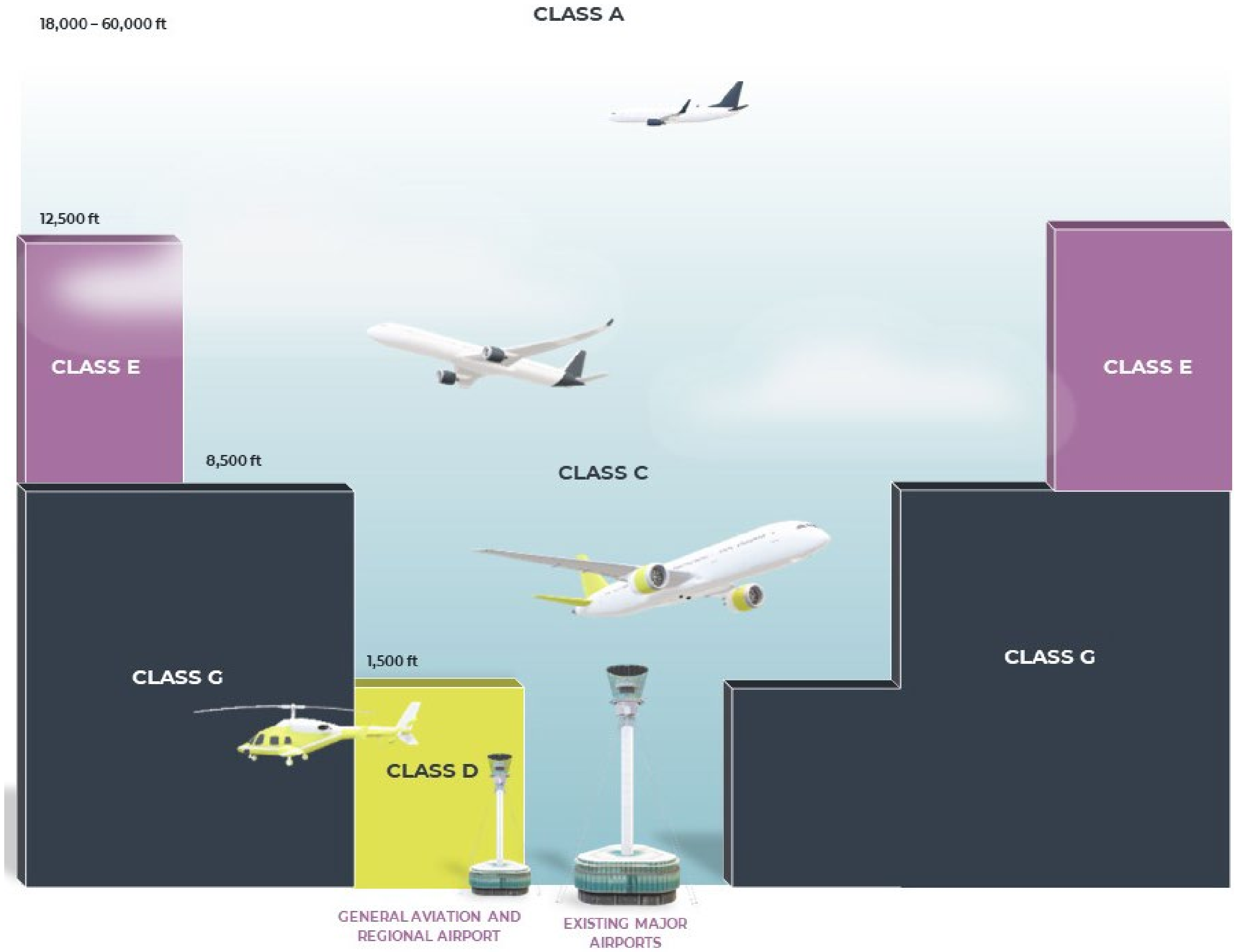


Figure 3.5 Terminal airspace

- **Uncontrolled airspace**. Uncontrolled airspace has no supervision by air traffic control. Therefore, no clearance is required by aircraft to operate in uncontrolled airspace. Most light aircraft and helicopters operate outside or underneath controlled airspace. Air traffic control may still provide basic information services to aircraft in radio contact.
- **Restricted airspace**. Restricted airspace is airspace that has restrictions placed on its use and aircraft movements are confined to those with certain specified permissions. This is generally associated with military installations including airports and associated flying training areas or other installations where safety is an issue, for example explosives storage facilities or artillery firing ranges. It can also be established for national security purposes or temporarily established to protect high-density flying operations at an air show or other large public event. It may also be temporarily requested by police or other emergency services for safety reasons (such as near bushfires or major crime scenes). CASA's Office of Airspace Regulation (OAR) is responsible for circulating the designation of restricted airspace. Restricted areas are also allocated a conditional status (restricted area 1, restricted area 2 or restricted area 3) which provides an indication as to the likelihood of obtaining a clearance to fly through the airspace. Restricted area 1 is the most likely to obtain a clearance from air traffic control.
- **Danger areas**. Danger areas are declared where an activity is considered by CASA to pose a potential danger to aircraft. Danger areas only warn airspace users about hazardous activities and do not restrict entry. Danger areas generally relate to airspace over hazardous areas such as mining and quarrying sites, or in areas of special use such as flying training areas, hang-gliding, parachuting and unmanned aerial vehicle testing. Approval to fly through a danger area outside controlled airspace is not required. However, pilots are expected to maintain a high level of vigilance when transiting a danger area.
- **Prohibited areas** (also known as no-fly zones). Prohibited areas are areas of airspace within which aircraft are prohibited from flying, usually due to security or other reasons associated with national welfare.

Controlled and uncontrolled airspace is further divided into different classes, where internationally agreed rules for visual flight and instrument flying applies (refer to Figure 3.6 which shows the classes of airspace in Australia and how they connect and overlap). An aircraft may travel through different classes of airspace, depending on the flight path taken. Class B and Class F airspace have not been adopted for use in Australia.

The class of airspace in which an aircraft can fly is determined by whether it is operating under visual flight rules (VFR – most light aircraft and helicopters) or instrument flight rules (IFR – all large aircraft). These terms are explained further in Section 3.2. The class of airspace may change subject to the time of day at airports with a control tower facility.



Class A — This high-level enroute controlled airspace is used predominately by commercial and passenger jets. Only IFR flights are permitted and they require a clearance from air traffic control. All flights are provided with an air traffic control service and are positively separated from each other.

Class C — This is the controlled airspace surrounding major airports. Both IFR and VFR flights are permitted and must communicate with air traffic control. IFR aircraft are positively separated from both IFR and VFR aircraft. VFR aircraft are provided traffic information on other VFR aircraft.

Class D — This is the controlled airspace that surrounds general aviation and regional airports equipped with a control tower. All flights require clearance from air traffic control.

Class E — This mid-level enroute controlled airspace is open to both IFR and VFR aircraft. IFR flights are required to communicate with air traffic control and must request clearance from air traffic control.

Class G — This airspace is uncontrolled. Both IFR and VFR aircraft are permitted and neither require clearance from air traffic control.

Figure 3.6 Classes of airspace

3.2 Key airspace terms

This section provides an outline of terms used when describing the key concepts and issues that relate to airspace operations.

3.2.1 Air traffic management and control

Air traffic management is an aviation term encompassing all systems that assist aircraft to depart from an aerodrome, transit airspace and land at a destination aerodrome. The purpose of air traffic management is safe, efficient and expeditious movement of aircraft in the airspace. Its 2 major principles are air traffic control and traffic flow management:

- **Air traffic control** is a service provided by ground-based air traffic controllers who direct aircraft on an airport and through a given section of controlled airspace. Can also provide advisory services to aircraft in uncontrolled airspace.
- **Air traffic flow management** is the regulation of air traffic so that the handling capacity of an airport or air traffic control is not exceeded and/or is used efficiently.

Air traffic control procedures are specific operating procedures or rules that apply to all aircraft flights within controlled airspace. The rules may vary under differing operational circumstances including time of day, traffic demand (the number of arriving or departing aircraft) and prevailing weather conditions.

While a generic set of air traffic control procedures based on the international standards set by ICAO and regulated by CASA apply to Australian airspace, each controlled airport has a set of procedures specific to its operation. These are published by Airservices Australia and are available to pilots operating in Australian airspace. Air traffic control procedures include:

- SIDs (Standard Instrument Departure) and STARs (Standard Instrument Arrival)
- flight planning requirements
- weather criteria for visual and instrument landings
- criteria for selecting the operating runway (or the 'nominated' runway) (discussed further in Section 3.3.4)
- airport specific separation requirements for arriving and departing aircraft (discussed further in Section 3.3.4)
- airport specific sequencing requirements (discussed further in Section 3.3.5)
- noise abatement procedures (NAPs) (discussed further in Section 3.3.7)
- intersection departures.

3.2.2 Continuous climb and descent operations

Continuous climb operations (CCO) involve an aircraft maintaining a steady angle of departure (refer to Figure 3.7). It is a technique facilitated through the design of the airspace and SIDs, and the air traffic control procedures. It allows the flight profile to be optimised to the performance of the aircraft, leading to significant fuel economy and environmental benefits in terms of noise and emissions reduction.

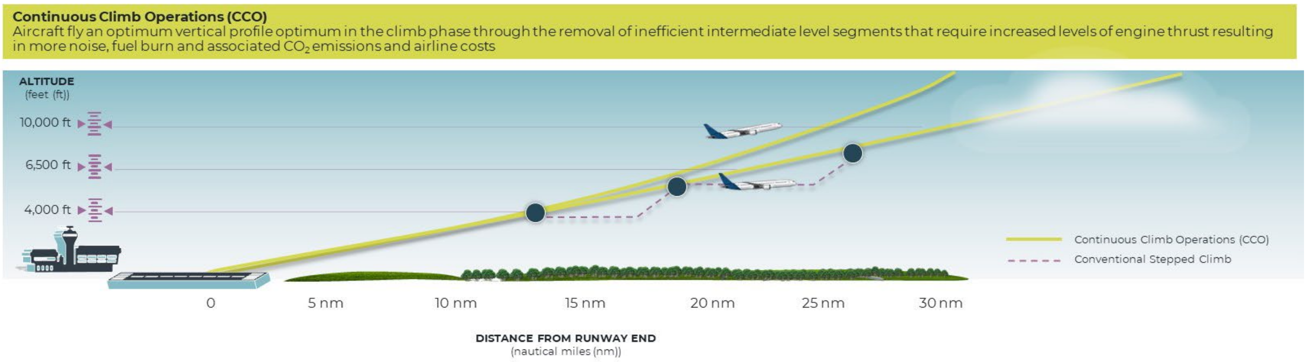


Figure 3.7 Continuous climb operations

Continuous descent operations (CDO) involves an aircraft maintaining a steady angle of arrival (refer to Figure 3.8). It is a technique facilitated through the design of the airspace and STARs, and the air traffic control procedures. It allows an arriving aircraft to descend from an optimal position with minimum thrust. It avoids level flight to the extent possible while meeting safety requirements and compliance with air traffic control procedures. This provides fuel economy and environmental benefits (in terms of noise and emissions reduction) by keeping aircraft higher for longer and smoothing the approach of the aircraft by limiting the use of the throttle to maintain altitude.

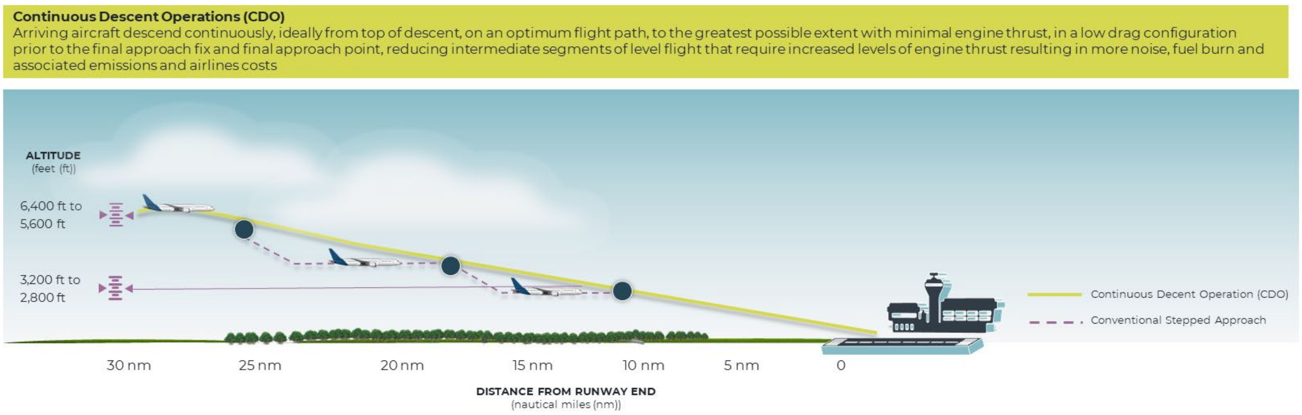


Figure 3.8 Continuous descent operations

3.2.3 Flight rules

Visual and Instrument Flight Rules (VFR / IFR) govern how aircraft are flown and how safe separations are maintained in differing meteorological conditions. Weather conditions determine which approach will be flown and this may vary slightly from airport to airport.

When flying using VFR, pilots may navigate by sight as well as by reference to specialised instruments in the aircraft's cockpit. Flights using VFR should fly in clear weather, known as visual meteorological conditions (VMC). Clouds, heavy precipitation, low visibility and otherwise adverse weather conditions must be avoided under VFR.

When flying using IFR, pilots fly by reference to the specialised instruments in the aircraft's cockpit alone. Flights using IFR can fly in VMC as well as in poor weather, known as instrument meteorological conditions (IMC). Flights in IMC require increased separation between aircraft.

3.2.4 Instrument landing system

An **instrument landing system** (ILS) allows a pilot to attempt to approach an airport in reduced visual conditions (refer to Figure 3.9). An ILS is a precision runway approach aid employing 2 radio beams to provide pilots with vertical and lateral guidance during the landing approach:

- a localiser, which keeps aircraft heading direct to the runway (lateral guidance)
- a glide path, which provides descent guidance to touch down on the runway (vertical guidance).

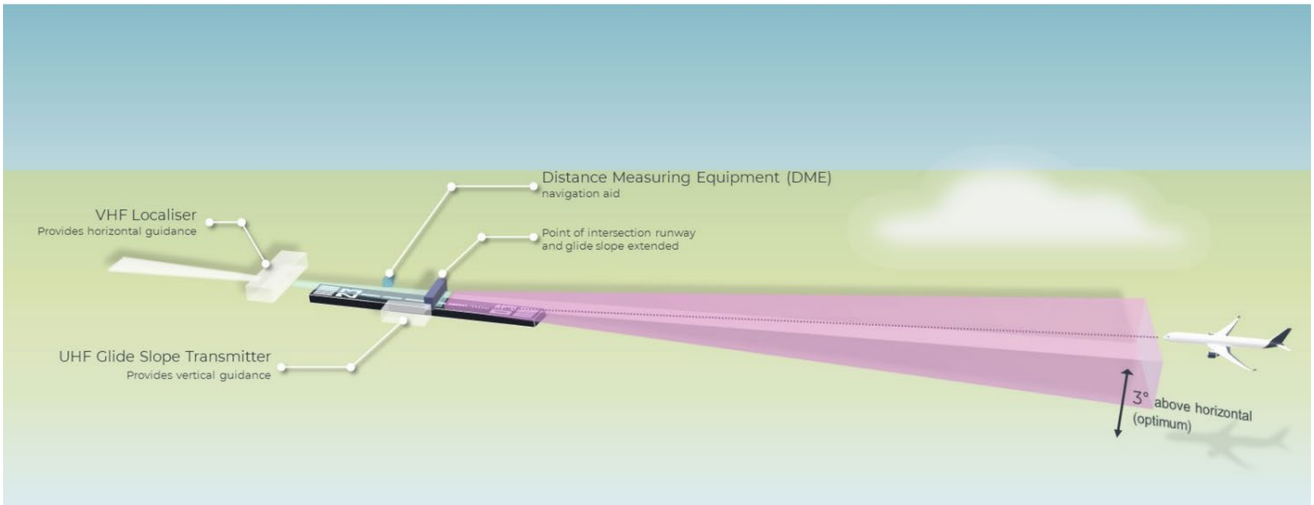


Figure 3.9 Instrument landing system

3.2.5 Intersection departures

An intersection departure is a take-off that starts at a position different than the end of a runway. This means that some of the runway would not be available for the take-off run. The main benefits associated with intersection departures include:

- separation facilitation
- runway capacity improvement
- reduced taxi time
- air pollution and greenhouse gas emissions reduction (optimal taxi distances).

Typically, intersection departures are only facilitated at taxiways aligned at or close to 90 degrees to the runway. This ensures appropriate pilot visibility of both runway directions from the cockpit and an accurate understanding of the resulting runway length available for departure. Non-jet aircraft are the principal user of intersection departures, but domestic jet operations may also use an intersection departure when their destination and reduced take-off runway length requirements ensure it is safe to do so.

An intersection departure may be at pilot request, to save taxiing time and fuel burn, or at air traffic control discretion to manage a departing aircraft sequence to minimise cumulative delay for a group of presenting aircraft. The use of intersection departures by jet aircraft is governed by the time of the day when specific noise abatement procedures apply.

3.2.6 Navigation

Aircraft navigation methods today rely on aircraft flight management systems and satellites for positioning and navigation. This provides greater precision and flexibility compared with conventional methods which employed fixed ground-based beacons to guide aircraft along published routes via waypoints. Figure 3.10 depicts the evolution of navigation performance with regard to airspace routing.

Area navigation (RNAV) is a method of IFR navigation. It allows aircraft to choose any course within a network of waypoints defined by geographic coordinates. Benefits of RNAV include reduced flight distance, reduced congestion and the permitting of IFR flights into airports without ground-based navigation beacons. Its use has been facilitated by the development and wide-spread deployment of mature satellite navigation systems.

Performance-based navigation (PBN) requires that aircraft be capable of meeting navigation performance requirements for accuracy, integrity, continuity, availability and functionality. Australia's implementation of PBN uses the required navigation performance (RNP) family of navigation specifications dependent on global navigation satellite systems (GNSS) such as the Global Positioning System (GPS) and on-board navigation performance monitoring to ensure precise flight path management. PBN in Australia is not reliant on ground-based radio navigation aids.

PBN has the major advantage of flexibility. Providing the aircraft has the means of determining its current position it can then operate anywhere within space that the positioning system will allow. PBN allows more direct routing along a flight path and more efficient landings and take-offs, which means a reduction in fuel burn and aircraft emissions. PBN also facilitates a high utilisation of continuous climb and descent operations (CCO / CDO) with resulting community benefits from reduced noise.

PBN is the basis for design of the WSI SIDs and STARs which ensures aircraft will be strategically separated, thereby reducing the level of interaction required by air traffic control to separate aircraft.

Required Navigation Performance Authorisation Required (RNP-AR) is a highly accurate procedure to approach and land on a runway. It can allow for 'curved' approaches to be made and can be more flexible than an instrument landing approach. Aircraft can line up with the runway much closer to the airport. RNP-AR approaches result in less distances flown (and the associated environmental benefits) compared to a traditional approach. Another potential advantage is a greater ability to avoid direct overflight of populated areas.

This is a new technology and requires aircraft to be fitted with certain equipment. New aircraft have this equipment installed. For older aircraft, the installation of the required equipment can be cost prohibitive or unfeasible. Crews also need to be specifically trained and not all aircraft operators will invest in this necessarily.

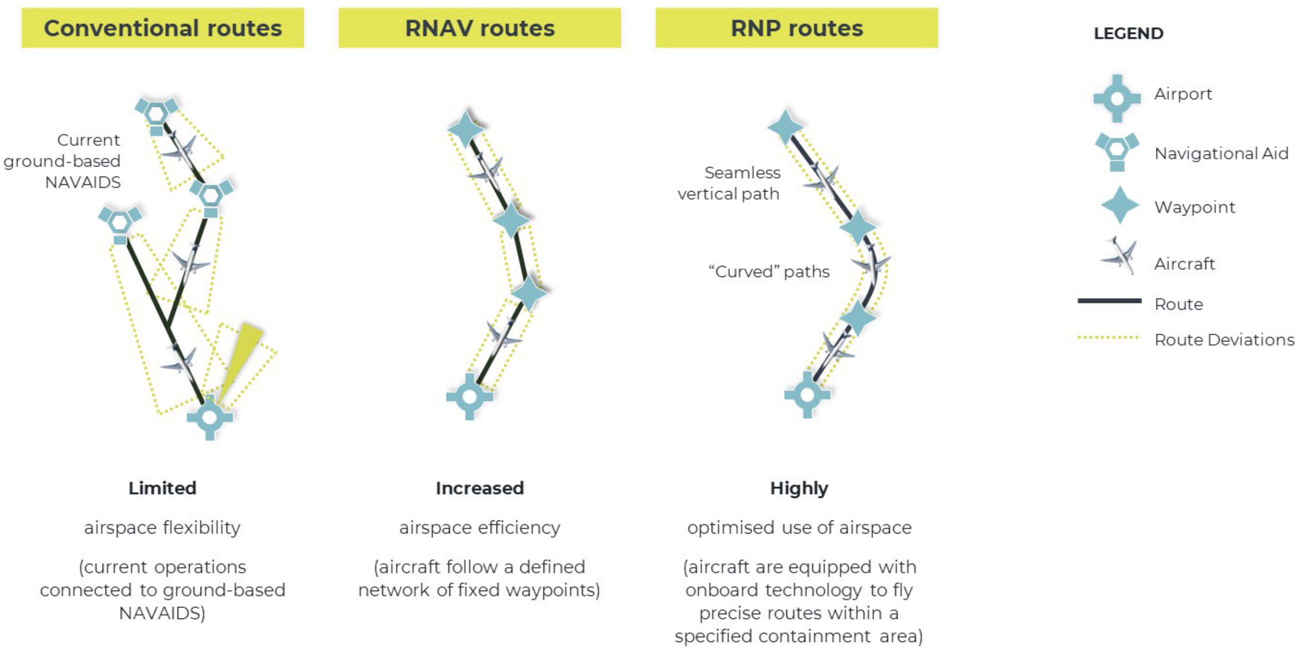


Figure 3.10 Conventional airspace routing versus RNAV and RNP routing

Radar vectoring happens when an aircraft is visible to an air traffic controller on a radar screen, and the controller tells the pilot to fly a specific heading. Radar vectoring is mainly used by air traffic control as a tool to ensure and enhance:

- the air traffic flow management in the arrival and/or approach phase of flight
- the aircraft sequence in any phase of flight
- the horizontal separation between aircraft.

The term **containment** is used in various air navigation standards. Arrival and departure flight paths in controlled airspace are required to be contained within that controlled airspace in accordance with buffers prescribed by CASA, to protect aircraft using the flight paths from other aircraft and from terrain. There can be different containment areas between the day period and night period.

3.2.7 Runway modes of operation

Runway modes of operation refers to the direction in which aircraft take off and land. Operating modes are informed by assessing runway orientation and availability against factors such as meteorological conditions (especially wind direction and strength), runway surface status, aircraft profile and capability, demand and traffic volumes, airspace management procedures, and potential impacts on surrounding communities (such as noise).

3.2.8 SIDs and STARs

Standard Instrument Departure (SID) and **Standard Instrument Arrival** (STAR) are IFR flight procedures that set defined departure or arrival routes to facilitate safe and efficient flow of air traffic. These procedures manage traffic flows using defined routes, speed and altitude restrictions, and enable safe flight in all weather and visibility conditions. An aircraft will follow a SID from take-off to join the enroute phase of the flight (refer to Figure 3.11). The enroute phase of a flight comprises the segment of flight from the termination point of a departure procedure to the origination point of an arrival procedure (Federal Aviation Administration, 2017). An aircraft will follow a STAR from the enroute phase of flight to the commencement of the approach and landing phase, commencing at the Initial Approach Fix (IAF). The arrival approach may include a holding pattern (fixed circling pattern in which aircraft fly whilst they wait to land).

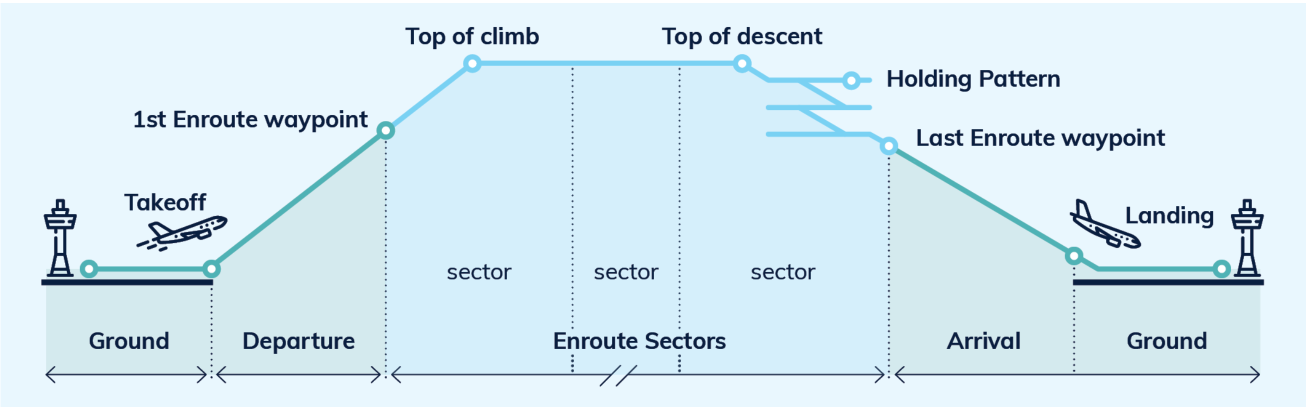


Figure 3.11 Phases of flight

Most of the modern domestic and international aircraft fleet operating to or from major Australian airports have flight management systems that the SIDs and STARs will be coded into, largely automating arrival and departure operations.

SIDs and STARs are developed for jet and non-jet aircraft. These can differ between jet and non-jet aircraft to account for differing aircraft performance.

The SIDs and STARs are designed to the rules and standards applicable to ICAO’s PBN Standards, which have been adopted by CASA for airspace throughout Australia.

There are occasions where SIDs and STARs are cancelled for varied reasons and aircraft are radar vectored. Air traffic control initiated cancellations of SIDs can also be for reasons of route efficiency, better noise outcomes or better emissions outcomes. Any one of the 3 elements (track, vertical profile and speed) of a SID can be cancelled individually or collectively. Aircraft will eventually either re-join the published procedure at a later waypoint or will connect with the enroute network at a designated waypoint.

3.2.9 Terminal instrument flight procedure

Terminal instrument flight procedures, also known as instrument approach procedures, is a series of predetermined manoeuvres that provide specific protection from obstacles and terrain. The term terminal instrument flight procedure is used throughout the EIS. It is used for the orderly transfer of an aircraft from the end of the STAR to a landing, or to a point from which a landing may be executed visually, and commences at an IAF.

3.2.10 Waypoint

A **waypoint** is a specified location used to define positions along an air navigation route. Waypoints are defined by:

- geographic coordinates
- a name, which typically takes the form of a 5 letter capitalized word (for example, RIVET, ODALE and SABER).

They are identified as either fly over or fly by (refer to Figure 3.12) to indicate whether the aircraft flies over or by the waypoint. A SID or a STAR may incorporate a string of waypoints which require an aircraft to execute actions and adjust heading or altitude.

Some air routes have a small number of waypoints defined by a ground-based radio navigation aid immediately underneath the air route. These ground-based waypoints are identified by an internationally recognised 3 letter code.

Figure 3.12 Waypoints – fly by and fly over

Reference to some waypoints in the EIS may not reflect current waypoints. This is due to these waypoints being:

- a placeholder for a future waypoint which is waiting for detailed design to confirm its exact location and assigned name from ICAO, or
- a current waypoint that has been renamed since the commencement of preparing the EIS.

3.3 Airspace considerations

The following factors play an important role in the operation of airspace and the safe and efficient movement of aircraft:

- meteorological conditions (wind direction, air pressure and temperature, visibility, storm activity, rain etc and daily, weekly and seasonal variations in weather)
- aircraft flight paths
- demand, type, volume and nature of aircraft traffic, including origin and destination
- runway modes of operation and capacity
- aircraft separation and sequencing
- time of day (including peak demand period)
- noise abatement procedures
- temporary measures during emergency (medevac, police and fire fighting) response operations
- local airspace coordination, particularly separation from other airspace users and the operating restrictions at other airports.

In airspace design, flight safety is always the primary consideration. The *Civil Aviation Act 1988* is the primary legislation relating to aviation safety in Australia and is overseen by CASA (discussed further in Chapter 5 (Statutory context)).

The National Airports Safeguarding Framework (NASF) provides guidance for ensuring developments in the vicinity of airports and certain airspaces (in the case of wind farms) do not infringe on the safety of aircraft operations. In the case of leased federal airports, such as WSI, this function is covered by the legislation. The NASF also provides guidance for land use planners in maximising the compatibility of development surrounding airports with the nature of impacts from aircraft operations, such as noise and public safety. The NASF principles and guidelines can be found on the Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA) website. Further discussion is provided in Chapter 5 (Statutory context) and Chapter 14 (Land use).

3.3.1 Meteorological conditions

Meteorological conditions are a major influence on aircraft operations into and out of an airport, the nomination of the operating runways and associated flight paths. Weather patterns influence aircraft operations in several ways, and can be on an hourly, daily, weekly and seasonal basis, including:

- wind direction and speed, this determines the direction of the operating runways (that is, the direction from which aircraft arrive or depart)
- rain, different operating rules apply if the runway is wet or dry
- low visibility conditions (for example, fog and bushfires), this determines which departure/arrival procedures and operating rules apply.

Weather conditions across the Sydney Basin are largely influenced by topography in and around the Greater Sydney region. Generally, the weather conditions experienced at a given location depends upon proximity to the ocean or some other body of water, elevation, and the surrounding terrain. These factors influence daily and seasonal temperature ranges and variability, humidity, rainfall, fog occurrence, and wind speed, direction and gustiness. The Bureau of Meteorology (BOM) works closely with Airservices Australia and CASA in providing meteorological services for civil aviation.

The location of WSI in the western part of the Sydney Basin means that the climate and weather phenomena can be significantly different to those experienced at other airports in the Sydney Basin. Topography in the Sydney Basin is likely to cause local disparities in temperature, moisture, pressure, rainfall and wind. Any combination of these factors will indirectly affect the frequency and severity of weather phenomena such as fog, thunderstorms, turbulence, wind shear and low cloud.

The following sections provide an outline of key meteorological conditions that can influence aircraft or airport operations, and how this can influence WSI operations with reference to data collected from the BOM's Badgerys Creek weather station for the period 1 January 2012 to 31 December 2021.

3.3.1.1 Wind

Wind at an airport is typically described as either crosswind, headwind or tailwind. Crosswind is the component of the wind that blows across the runway. The headwind or tailwind is the component of the wind that predominantly blows in line with the runway.

Runways can operate in both directions. Wind affects what runways at an airport are operationally suitable for arrivals and departures, and the direction in which those runways can be used. Generally, aircraft land and take-off into the wind, with a headwind. This enables aircraft to achieve the required lift for take-off at a slower ground speed and reduces the distance required for decelerating upon landing. Up to 5 knots tailwind is also permissible and considered to be normal operations.

The Aeronautical Information Publication (AIP) provides criteria for air traffic control to apply when selecting a nominated runway to accommodate noise abatement procedures. The criteria provide limits on crosswind (20 knots), tailwind (5 knots) and whether the runway is dry or wet. At a single runway airport, air traffic control will advise the strength of the crosswind and the Pilots in Command will determine the safety of landing or taking off having due regard to the operational crosswind limits of their aircraft. Wind direction can also change with short notice, and this may affect the flight paths and runways used. Runway direction may also be changed in anticipation of a wind change. Runway changes can add complexity to operations and there can be lead and lag times in setting up a runway direction change. For operational and safety reasons, air traffic control will hold a runway direction for a minimum amount of time (typically an hour) and similarly the frequency of runway changes minimised.

Wind direction and speed was a key factor in the selection of the runway alignment at WSI. It is expected that the north-east/south-west orientation of WSI's single runway (05/23) would be usable approximately 99.9 per cent of the time based on the ICAO standard crosswind limitation of 20 knots for runway nomination. The ICAO standard of maximum 20 knot crosswind applies where there are other runways that could be nominated. As there is only a single runway at WSI, the runway can be nominated at all times (that is, aircraft can land at WSI with more than 20 knots crosswind). However, if the crosswind is over 20 knots (around 0.1 per cent of the time), a pilot in command may seek an alternative such as delaying operation until conditions ease.

Local topography effectively blocks wind in all seasons from the west to north-westerly direction. Analysis of the BOM data indicates that there is a threshold (approximately 20–25 knots) in which the north-westerly synoptic winds are sufficiently strong to overcome the terrain and produce a crosswind at WSI. Crosswinds exceeding 20 knots at WSI are most likely to occur between August to November, with most crosswind events occurring from the north-west.

Figure 3.13 shows a wind rose plot for WSI based on data collected from 2012 to 2021.

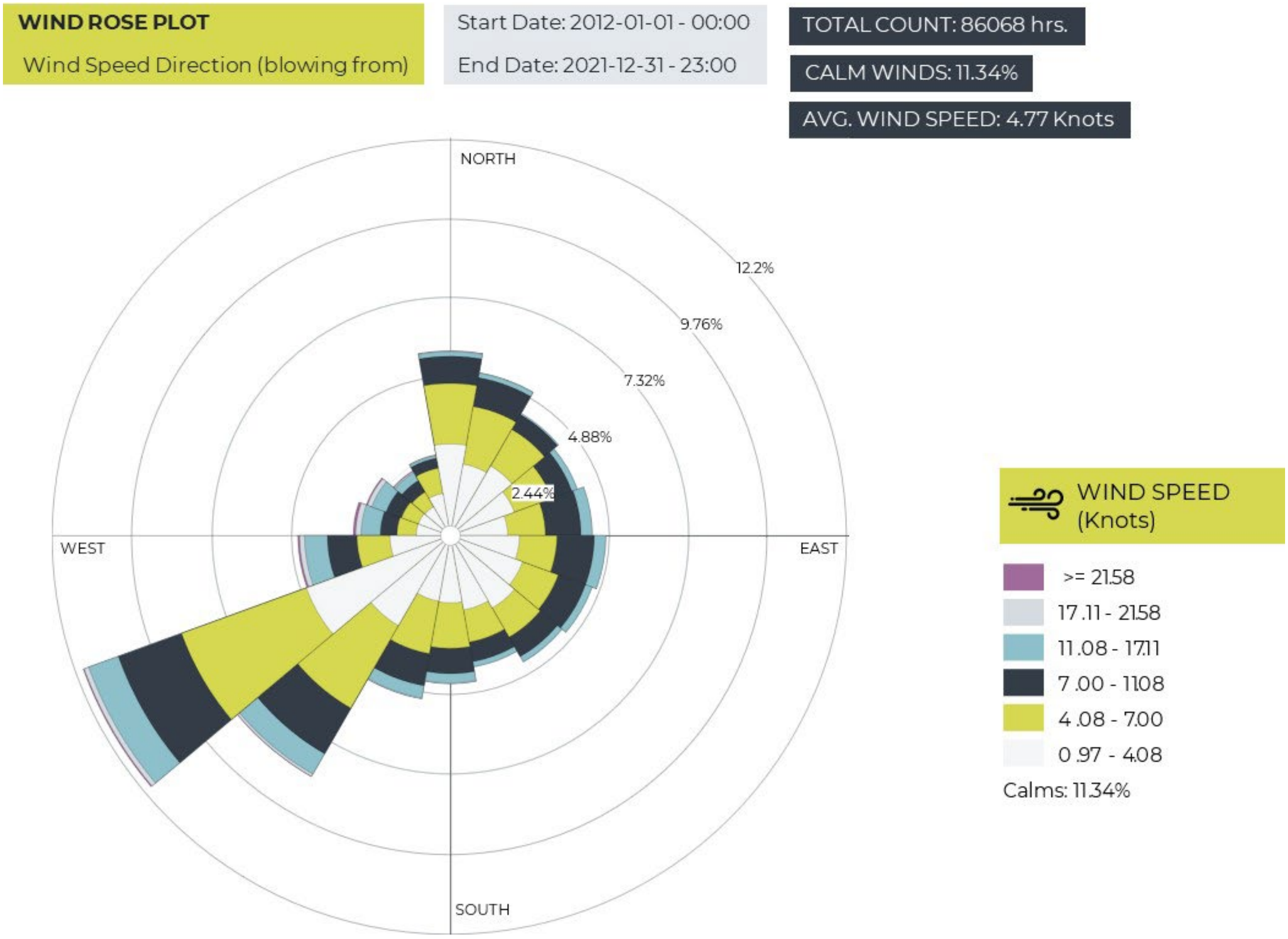


Figure 3.13 WSI wind rose

3.3.1.2 Visibility

Good visibility is important for aircraft operations particularly when the aircraft is close to the ground (take-off and initial climb, and approach and landing). Optimum conditions include clear weather and little or no cloud cover. Visibility can be reduced by rain, cloud, fog or smoke. VFR flights may not be able to operate in reduced visibility conditions. In a controlled airspace (like that surrounding WSI) air traffic control reports local conditions to the pilot.

Most Australian international airports are equipped with an ILS which allows a pilot to attempt to approach an airport in reduced visual conditions. Where fog has reduced visibility, the ILS may allow aircraft to land in dense fog subject to specific circumstances (including pilot certification). WSI will be equipped with a Category (CAT) IIIB ILS and all ancillary equipment required for it to allow aircraft to approach and land in extremely low cloud and visibility conditions.

3.3.1.3 Rain

The operating rules for aircraft are different if the runway is deemed to be wet (that is, potentially slippery). This can occur if it has recently rained or is currently raining, even if the rain is only very light. When a runway is deemed to be wet, operations with any tailwind element are generally not allowed due to safety considerations. The runway distance required for aircraft to depart and land generally increases when a runway is wet.

Rainfall data for WSI has been extracted and analysed from the most recent BOM data and findings show that the average annual rainfall at Badgerys Creek is 762.7 millimetres with rain recorded on average on around 112 days per year. Monthly rainfall more than 50 millimetres on average occurs in the months October to April at Badgerys Creek.

3.3.1.4 Air pressure and temperature

Aircraft performance, and therefore departure profile, is affected by air pressure, temperature and many other factors. Extreme high or low temperatures can have the most impact on airport operations generally.

High temperatures can affect airport operations and temperature has an indirect relationship with air density. As temperature climbs the air becomes less dense and affects the climb performance of aircraft. High temperatures can also affect fuel, causing it to expand and restrict the capacity to adequately refuel aircraft in some cases. Low temperatures increase the air density and enable all aircraft to climb at a more optimum rate.

Temperatures below zero degrees Celsius at surface level can produce adverse weather conditions that affect aircraft operations including hail, snow, sleet, frost, icing and freezing fog. Freezing fog can result in ice to form on an aircraft surface, which can reduce the performance of the aircraft due to increased weight, decreased thrust and increased drag. These conditions can also result in ice forming on paved areas such as the runway, especially after rain. Ice can present a risk to aircraft skidding due to loss of traction. De-icing equipment can mitigate the impact of icing on aircraft operations and hard surfaces.

At WSI, January has the most days on average above 30 degrees Celsius (15.1 days) and 35 degrees Celsius (6.1 days). July has the greatest number of days on average below zero degrees Celsius (2.8 days).

Frost and freezing fog at WSI could potentially occur between June to September, and May to September, respectively. Frost is most likely to occur in July, whereas freezing fog is more common from June to August. Frost is most likely to occur near sunrise. Freezing fog would most commonly occur in the hours between 5 am and 8 am prior to sunrise during the winter months.

Further temperature information at WSI is presented in Chapter 10 (Aircraft noise).

3.3.1.5 Thunderstorms

Thunderstorms, and the rapidly rising or falling air currents which usually accompany them, can be hazardous to aviation, regardless of size or intensity. Aircraft are unable to take-off or land during a thunderstorm and will often be re-routed around thunderstorm cells or diverted from their destinations. Thunderstorms and lightning strikes near airports may also stop ground operations until they pass. Aviation hazards encountered in and near thunderstorms include severe wind shear and turbulence, severe icing, downbursts, hail, lightning, heavy rain, low cloud, poor visibility, and rapid air pressure fluctuations. While most ordinary thunderstorms would occur over thirty minutes to an hour, thunderstorms can occur for several hours.

BOM data analysis suggests that the thunderstorm season in the vicinity of WSI appears to start and finish earlier in the year by approximately one month when compared to Sydney (Kingsford Smith) Airport. Outside of the thunderstorm season, there is expected to be less thunderstorm activity at WSI when compared to Sydney (Kingsford Smith) Airport. Most thunderstorms in the region develop over the Great Dividing Range moving eastwards into the Sydney Basin. The proximity of WSI to the Great Dividing Range may mean a relatively short lead time for thunderstorm impacts at the airport. For example, a thunderstorm that initiates over the Great Dividing Range and moving at 20 knots would reach WSI in approximately 30 minutes.

3.3.1.6 Turbulence and windshear

Turbulence is caused by a disruption to air flow. This can be created by the flow of air around an obstacle (such as topography or buildings) or due to meteorological conditions (such as temperature inversions). Turbulence can occur at any height. The Blue Mountains is a topographical obstacle, and strong wind conditions with a westerly influence are known to produce turbulence in the vicinity of WSI.

Turbulence impacts the control of an aircraft and is often experienced in-flight as aircraft bumpiness. Every aircraft also generates wake turbulence while in flight. Wake turbulence forms behind an aircraft as it passes through the air.

Windshear is a sudden change in wind direction or speed and is usually associated with thunderstorm activity. Windshear can be either vertical or horizontal and can have a significant impact on the control of aircraft during take-off and landing. Windshear is always present in turbulent air, but windshear can occur without turbulence being present.

Moderate and severe turbulence at WSI from these conditions would be most common in the winter months. When turbulence and windshear conditions occur, air traffic control will increase the standard separation distances between aircraft to maintain safe operations.

The NASF provides guidance on planning requirements for development to manage the risk of turbulence and windshear on airport operations. Controls have also been set in the *State Environmental Planning Policy (Precincts – Western Parkland City) 2021*.

3.3.2 Flight paths

Flight paths define the anticipated routes of aircraft both in the enroute phase of flight as well as when arriving and departing from an airport. Flight paths can be thought of as the highways in the sky. They are designated three-dimensional routes that guide safe flight between destinations, including manoeuvres for aircraft arriving and departing from an airport.

In the arrival or departure phase aircraft can fly either a SID (departure) or a STAR (arrival) under instrument guidance, or operate under VMC. Ideally, aircraft would fly by the most direct route and at the optimum altitude for reasons of economy and efficiency of flight operations. However, it is not always possible for aircraft to fly optimum routes because of safety considerations, the competing demands of other airspace users and consideration of noise impacts.

In controlled airspace, air traffic control endeavour to maintain aircraft on the designated flight path whenever possible. However, for reasons of safety (for example, separation with other aircraft or thunderstorm avoidance), maintenance of runway capacity (minimising aircraft delay and fuel burn) or avoidance of temporary restricted airspace, some aircraft may be processed off the designated flight path through the application of surveillance techniques.

Runway orientation at an airport is the major factor influencing the design of aircraft traffic flow patterns and flight path arrangements. Wherever operationally feasible, it is also desirable that aircraft traffic flow patterns are sufficiently flexible to deliver efficiencies in track-distance flown while minimising the effects of aircraft noise on surrounding residential and other noise sensitive areas.

Because of the greater manoeuvring options available for aircraft immediately after take-off, there is more flexibility in determining flight paths for departing aircraft than for aircraft landing at an airport. Landings need to aligned on the runway centreline and in a stable condition as an aircraft approaches the airport.

Aircraft will not adhere to a rigidly defined flight path and do not fly with the same level of consistency as a train running on a linear railway track, or a truck on a highway. This means that there will be some variation as to where different aircraft will be on the flight path because all aircraft perform slightly differently or may be affected by weather conditions, which can cause deviation to the left or right or vary positioning when flying a turning point. The variation of aircraft around a nominated flight path is referred to as dispersion.

Procedural departure flight paths commence as an extension of the runway centreline. Due to dispersion, the path will progressively widen to notionally 2 km either side of the nominal centreline of the SID flight path, transitioning to 5 km as the aircraft join the enroute flight network. This broad band is known as the flight path corridor. This caters for aircraft dispersion either side of the nominal centreline.

All departure aircraft must follow a departure flight path unless otherwise instructed by air traffic control. The day-to-day direction of air traffic, including the choice of a departure flight path, is primarily determined by the aircraft's departure point and its destination. Air traffic control will vary this flight path for reasons of safety or traffic sequencing when required.

For arriving flights, the flight path must be designed to ensure that an aircraft can safely leave the established higher level enroute airspace system to execute a safe landing onto the nominated runway. Aircraft arriving at WSI would normally be cleared by air traffic control to join a pre-determined STAR that provides standard vertical and lateral tracking guidance when leaving the enroute cruise phase of flight. Arriving aircraft would generally be required to join the final flight path using agreed instrument flight procedures such as an ILS approach.

The introduction of a set of SIDs and STARs to a new airport or an adjustment to SIDs and STARs at an existing airport may require an adjustment to enroute flight paths. Any such enroute changes will be made taking account of safety, efficiency, capacity and environment.

Airports are a destination or origin for a flight. An airport may also be overflown by aircraft transiting the airspace above while enroute to or from other airports. These transiting flight paths must be accommodated safely, efficiency, not impact the overflown airport capacity and minimise the effects of aircraft noise on surrounding residential and other noise sensitive areas when at lower altitudes.

The design of the flight paths must comply with all relevant national and international practices and regulations for safe and efficient air navigation and aircraft operations. It must also be compatible with the operational performance of the current and anticipated future aircraft fleets that could be expected to use an airport.

Chapter 6 (Project development and alternatives) and Chapter 7 (The project) provide detailed information on the flight path design for WSI.

3.3.3 Demand, type, volume and nature of aircraft traffic

The number of aircraft that arrive and depart an airport varies not only throughout the day but also between days and months.

For aircraft movement related planning such as airfield, airspace and flight paths, as well as operational environmental related impacts, there are important distinctions between:

- jet versus non-jet operations (turboprop aircraft typically operating on flights of less than 2-hours flight duration and with lighter passenger payloads)
- narrowbody jet (Airbus A320 and Boeing B737 families, typically on routes up to 7,000 km, with some new models now capable of flying more than 8,000 km) versus higher payload widebody jets (Airbus A330/A350 and Boeing B777/B787 with ranges up to, and in some cases beyond, 14,000 km)
- long haul (international destinations typically over 10-hours flight time) and short to medium haul operations (domestic, trans-Tasman and some of the closer Asian and Pacific ports) whether operated by narrowbody or widebody jets.

Longer flights generally have higher thrust settings and lower climb profiles due to the requirements for these aircraft to carry more fuel when departing. This typically means that aircraft on longer flights produce higher noise levels than shorter flights when departing. The noise emissions of arriving aircraft are generally independent of the distance flown.

The route densities by geographical direction, as well as aircraft type, are important in airspace planning. The aircraft movements at WSI are forecast to be dominated by domestic and short-haul international operations (refer to Chapter 2 (Strategic context and need)).

3.3.4 Runway modes and capacity

Generally, aircraft land and take-off into the wind. Runway operating modes are informed by assessing runway orientation and availability against factors such as current and forecast meteorological conditions (especially wind direction and strength), runway surface status, aircraft profile and capability, demand and traffic volumes, airspace management procedures, and potential impacts on surrounding communities (such as noise). Air traffic control is responsible for selecting the operating runway (or 'nominated' runway) at an airport.

Runways can operate in 2 ways:

- aircraft arrive and take-off in the same direction (for example, all aircraft arrive from the south-west and take-off to the north-east)
- aircraft arrive and take-off in opposing directions (or head-to-head) (for example, all aircraft arrive from the south-west and take-off to the south-west). This is known as Reciprocal Runway Operations (RRO) and is a low capacity mode. It is also dependant on weather conditions to ensure safe operations.

The Stage 1 Development infrastructure at WSI comprises a single runway orientated on a north-east/south-west axis. The airfield geometry and infrastructure were approved in the Airport Plan (DITRDC, 2021) and is currently under construction. This approval has set the runway orientation and length, and the location of runway taxiway entries and exits.

The initial and final flight path segments connecting to the runway are also fixed to ensure that aircraft can safely make the required turns following take-off or to stabilise on the final approach to the runway for landing.

Depending on the prevailing wind conditions at WSI, aircraft would be either on a north-easterly (Runway 05) or south-westerly (Runway 23) direction of operations (refer to Figure 3.14 and Figure 3.15). The Airport Plan also identified the potential for RRO as a third possible operating mode, with the viability of this mode to be investigated during the airspace and flight path design. Further discussion on this mode of operation at WSI is provided in Chapter 6 (Project development and alternatives) and Chapter 7 (The project).

Navigational aids (and associated systems) would be provided at WSI to support airport operations and are approved as part of the Stage 1 Development. Further information on the navigational aids is presented in Chapter 4 (Project setting).

The capacity of the runway mode (the mode capacity) is the maximum number of aircraft movements per hour that can be processed safely and consistently.

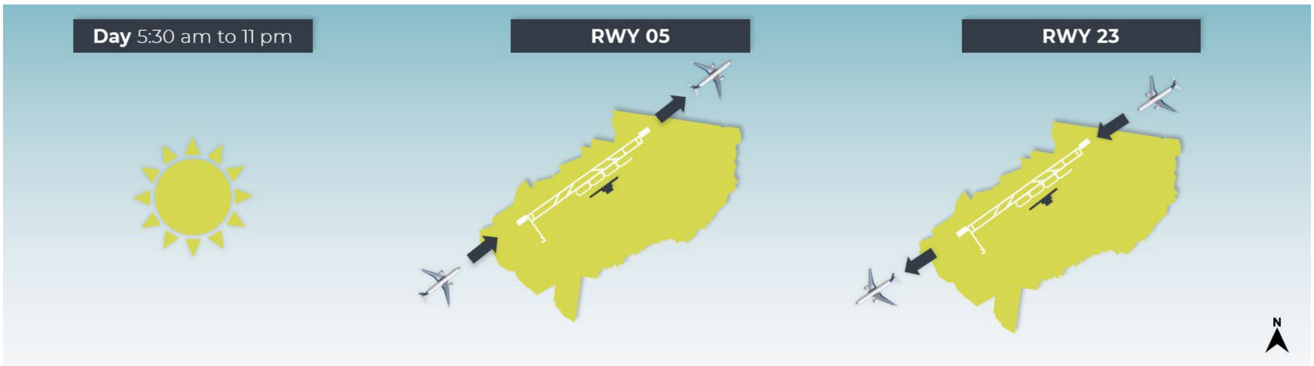


Figure 3.14 Arrival and departure models for Runway 05 and Runway 23 at WSI (day)

Figure 3.15 Arrival and departure models for Runway 05 and Runway 23 at WSI (night)

3.3.4.1 Aircraft separation

Separation standards refer to the minimum distance that aircraft operating in controlled airspace and at airports with an operational control tower must be kept apart. Different separation standards apply to aircraft operating under IFR or VFR. Air traffic controllers must keep aircraft separated vertically or horizontally.

CASA's Manual of Standards Part 172 – Air Traffic Services sets the minimum separation requirements for aircraft (vertical or lateral) which are applied in the design of SIDs and STARs. This is referred to as strategic separation assurance or 'Safety by Design'. The use of a Safety by Design approach is internationally accepted best practice in the design and integration of multiple flight paths servicing high density airports. A core element of Safety by Design is to deliver standardised procedures wherever possible and the introduction of variability in procedure must balance efficiency against safety.

Safety by Design develops SIDs and STARs in such a way that the safety requirements of either lateral or vertical separation standards needed to ensure collision avoidance can be programmed into the onboard cockpit computer systems of aircraft. The lateral and vertical separation requirements of a SID or STAR are also programmed into the air traffic control software systems providing air traffic controllers and pilots with the aligned information.

When separation assurance is built into the system, air traffic control no longer has to provide instructions to pilots (as they do for example for Sydney (Kingsford Smith) Airport) to maintain separation and process aircraft to final approach. Instead, aircraft are able to be monitored with the instructions built into the arrival procedure design, allowing safety to be introduced by design.

3.3.4.2 IFR aircraft

In Australia, aircraft flying under IFR in controlled airspace up to 41,000 ft (12.5 km) must be separated by approximately 1,000 ft (305 metres (m)) vertically unless they are separated horizontally (refer to Figure 3.16). Above 41,000 ft (12.5 km), the vertical separation increases to approximately 2,000 ft (600 m).

When aircraft are separated vertically, horizontal separation can be reduced without compromising safety.

In controlled enroute airspace, the horizontal separation standard between aircraft flying at the same altitude is 5 nm (9 km). In terminal area airspace, the minimum separation is 3 nm (around 5.6 km) (refer to Figure 3.16). Within the confines of an airport control zone, the separation can be as close as practicable as long as the aircraft remain separated.

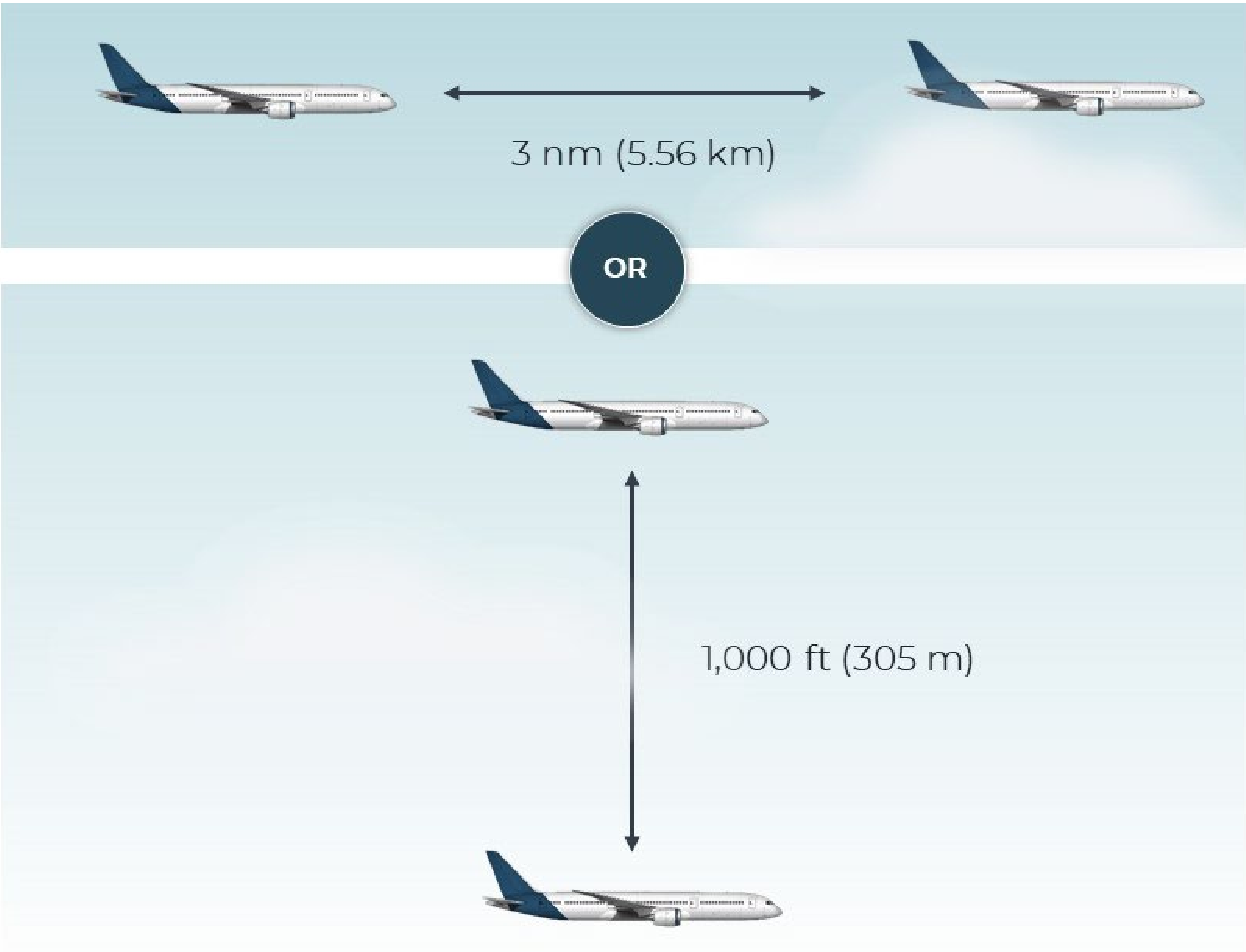


Figure 3.16 Separation distances for IFR aircraft

3.3.4.3 VFR aircraft

In uncontrolled airspace in Australia, aircraft flying under VFR are responsible for their own separation with other aircraft using ‘see and avoid’ procedures. In controlled airspace, these aircraft are generally separated from other aircraft by air traffic control.

3.3.5 Aircraft sequencing

Different types of aircraft require different separation between each other, depending on their size and weight. This separation is required to mitigate the effects of wake turbulence from aircraft that are departing or arriving. Wake turbulence, or wing tip vortices, is the rotating turbulence that is created behind a large aircraft. Its intensity is normally greatest when the large aircraft is flying at slow speeds with its wing flaps extended. It is a safety hazard to smaller aircraft and the separation distance behind large aircraft is increased to mitigate against its effects.

3.3.5.1 Arrivals

The maximum capacity of a runway can be achieved when departures occur between arriving aircraft operating in the same direction. This is known as mixed mode operations. Sufficient space must therefore be created between arriving aircraft to allow this to happen. Arriving aircraft must be sequenced in such a manner that the gap between subsequent arrivals allows a safe take-off to occur.

Normally a 2.5 minute gap between arriving aircraft will allow for a take-off to safely occur. This equates to 25 arrivals per hour and with a balanced arrival and departure sequence, 24 to 25 departures in that hour would result in a maximum single runway throughput rate of 49 to 50 aircraft movements per hour. The gap between arrivals can sometimes be:

- increased to allow for the added separation distance requirement for smaller aircraft following larger aircraft (wake vortices impact)
- reduced when there are no departures presenting and when similar type aircraft are in trail (heading on the same flight path in the same direction) and the runway and taxiway infrastructure allows for a rapid exit from the runway for such aircraft types
- increased during low cloud conditions, reduced visibility and/or strong headwinds to allow air traffic control to maintain the required separation standards when aircraft using the runways are not necessarily visible to the air traffic controllers.

Other factors such as airport infrastructure can impact on capacity. An aircraft may spend less time on a runway, for example, if rapid exit taxiways are available. This allows aircraft to vacate a runway at higher speed.

When short-term demand exceeds capacity in busy traffic conditions or when capacity decreases due to reduced visibility or low cloud, enroute holding may be used to manage and sequence traffic flow to the runway. In this type of situation, some traffic will be sequenced through speed reduction or increasing the distance an aircraft must fly to the runway (known as track stretching). Other aircraft may be required to enter a holding pattern as they wait to join the arrival sequence. Consistent with other major Australian airports, holding patterns for arrival aircraft would typically be beyond 40 nm (74 km) from WSI and above 10,000 ft (3 km).

Some aircraft in extremely rare instances, and in line with safety requirements, could be required to enter a lower altitude and closer holding pattern at approximately 4,000 ft (one km) if there is an unplanned major issue at WSI or a technical issue with the aircraft.

3.3.5.2 Departures

A departure sequence of aircraft is managed to a set of international standards. Departing aircraft are typically sequenced in between aircraft that are arriving. Departing aircraft are held on the taxiway short of the runway until the arriving aircraft has passed. Departing aircraft are cleared for take-off once the landing aircraft is clear of the runway.

For successive departures numerous factors determine when the second (following) aircraft is cleared to depart. Once the first aircraft is airborne and has reached a separation of at least 1.8 km ahead, the second aircraft can be cleared for take-off. Measured in time this normally equates to about one to 1.5 minutes between aircraft. When sequencing multiple consecutive departures during a departure demand peak, there could be more than 30 departures in an hour with a limited number of arrivals.

The separation distance may increase if the following aircraft is faster or if a smaller aircraft follows an aircraft that is larger (due to turbulence). Departure capacity is reduced during poor weather.

3.3.6 Time of day

As outlined in Section 3.2, air traffic control procedures define the specific rules that apply to every flight. These rules differ for varying operational circumstances and are affected by such factors including time of day.

The day period for WSI is defined as 5:30 am until 11 pm local time and the night period as 11 pm to 5:30 am. Ambient noise levels are generally higher during day-time hours. Further information on the time periods and the runway modes of operation are found in Chapter 7 (The project).

During the night period there are generally fewer aircraft arriving and departing. This lower demand, and the operation of the curfew at Sydney (Kingsford Smith) Airport, permits the use of different runway modes.

3.3.7 Noise abatement procedures

Every major airport has noise abatement procedures which are airspace operational procedures designed to reduce the impact of aircraft noise from flight operations on the community in the vicinity of an airport, especially near residential areas.

Noise abatement procedures are normally applicable to jet aircraft and other aircraft with a Maximum Take-off Weight exceeding 5,700 kilograms (kg).

Noise abatement procedures can include:

- the preferred flight track and/or runway modes of operation (to move traffic as efficiently as possible while reducing the noise impact over residential areas)
- noise abatement departure procedures, such as directing aircraft to depart over certain areas at night
- approach procedures, such as continuous descent operations and low power, low drag techniques
- modified flight path angles to adjust climb gradients
- on-airport controls such as restrictions on engine run-ups (a type of engine check) and/or ground equipment use
- departure speed controls below certain altitudes
- reduced wing flap settings on approach and/or delayed deployment of landing gear
- control of the application of reverse thrust during noise sensitive periods
- the times of the day when specific noise abatement procedures apply
- any exemptions such as medical, emergency or rescue flights, or aircraft subject to an in-flight emergency.

Communities near airports may be sensitive to operations at different times of the day and night. To minimise the noise impacts on these communities noise abatement procedures may also include requirements regarding the time of day that the specific noise abatement procedure is applicable, including noise abatement procedure criteria to prioritise a preferred runway nomination.

Noise abatement procedures are implemented by air traffic control, airports or airport owners.

Airservices Australia is responsible for the development and review of noise abatement procedures with stakeholders, including aircraft operators, airlines, the airport operator and community aviation consultation groups. Noise abatement procedures are periodically monitored and reviewed by Airservices Australia to check the effectiveness of the procedures.

The development and review of noise abatement procedures requires appropriate consideration of a range of factors, including potential environmental impacts. This includes the physical layout of the airport, the airport surroundings, and the capacity of the airport and airspace, particularly during high demand periods.

There are some limitations to the use of noise abatement procedures, for example if they generate delay and congestion, as this can cause consequential noise and emissions impacts. Air traffic control or pilots may not be able to use them in certain situations, for example weather conditions or operational requirements. Noise abatement procedures are also not legally enforceable.

Noise abatement procedures and approaches taken in the design of the airspace architecture for WSI to reduce the impact of aircraft noise on the community is discussed further in Chapter 6 (Project development and alternatives) and Chapter 7 (The project).

3.3.8 Interaction with other airspace users

The airspace around an airport and its interaction with other airports plays a critical role in the use of runways and flight path design.

The Sydney Basin airspace comprises an extensive network of flight paths associated with existing civil airports (Sydney (Kingsford Smith) Airport, Bankstown, Camden), Defence facilities (RAAF Base Richmond, Holsworthy Military Airport, overflight restrictions at the Defence Establishment Orchard Hills), recreational aviation activities (gliders, ballooning, parachuting), emergency response aircraft movements and transiting flights.

Restricted airspace at the abovementioned Defence facilities and the Lucas Heights nuclear facility also restricts the flight of aircraft within these areas in accordance with specified conditions.

CASA regulates Australian administered airspace and undertakes regular reviews of existing airspace arrangements.

Section 4.1 in Chapter 4 (Project setting) provides further detail on the existing conditions within the Sydney Basin airspace, and consideration of airspace changes to accommodate WSI is discussed further in Chapter 6 (Project development and alternatives) and Chapter 8 (Facilitated changes).