Annex C

CASA Position on Airbus A380 Operations at Code E Aerodromes

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A380 Airport Compatibility in Australia

Airbus

In the late 1990's Airbus began a worldwide awareness program for the A380–800 focusing on nations whose major international airports could ultimately introduce the new large aircraft. The Australian program included presentations to airport operators, airlines and CASA covering all aspects of the aircraft including the important issue of aircraft/airport compatibility.

The manufacturer had indicated at the time the A380 would be certified for operations on 45m wide runways.

The aircraft has a wider wingspan (80m) and is heavier than the largest civil aircraft currently in scheduled commercial use. However other dimensions such as the outer main gear wheel span and fuselage length are less than other larger aircraft currently in regular service, such as the A340–600 and B777–300.

Aircraft Characteristics - Aerodrome Reference Code

The A380 is an ICAO code letter F aerodrome reference code aeroplane and a US FAA Group VI category aeroplane. Australia follows the ICAO method of grouping aeroplanes and has adopted the corresponding ICAO aerodrome physical characteristics for code F aeroplanes from Annex 14, Volume 1 – Aerodromes.

The infrastructure dimensions corresponding to each code or group are based on the maximum aircraft dimensions within it. For example a code F aeroplane is one whose wing span varies from 65m up to but not including 80m and outer main gear wheel span 14m up to but not including 16m. The outer main gear wheel span of the A380 is 14.4m, which makes its footprint closer to that of a code E aeroplane, which ranges from 9m up to but not including 14m. The wingspan is at the top end for code F aeroplanes.

The A380's main wheel assembly suggests a code E runway and a code E taxiway may be tailored to the aircraft's characteristics. This is not something new as CASA already allows higher code letter aeroplanes to operate on narrower or lesser code letter runways with certain conditions.

This process is also recognised by ICAO and the US FAA, who both allow a specific aircraft to be evaluated and a corresponding tailored infrastructure developed provided the application is supported by an 'aeronautical study' to ensure that the desired level of safety is achieved. When ICAO published Circular 305 in June 2004 *'Operation of New Large Aircraft at Existing Aerodromes'*, ICAO recognised that generic aerodrome physical characteristics, as defined in Annex 14, are not the only means of safely accommodating specific aircraft types at airports.

ICAO Runway Width for Code F Aeroplanes

ICAO has determined the minimum runway width for code F aeroplanes at 60m. The concept of a 60m runway width was derived from the work done by the ICAO Aerodrome Reference Code Panel over 20 years ago when it established the runway width requirements for aeroplane categories A to F. The concept was based on an outer main gear wheel span (OMGWS) of 18m, a standards deviation (SD) of 3.6m and an offset of the normal curve from the runway centerline (X) of 2.6m. The equation used was:

$$W_R = 10\ SD + 2\ X + OMGWS$$

Substituting the values above in the formula results in a runway width of 59.2m.

The Aerodrome Design Working Group (ADWG), tasked by the ICAO Aerodromes Panel to look at Annex 14 Volume 1 provisions related to aerodrome physical characteristics, reviewed the methodology used by ICAO to determine the Code F requirements.

For example in the formula above it has been suggested that in light of new information on the design and behaviour of modern aeroplanes when landing and taking–off, certain parameters could be varied. The maximum OMGWS for a code F aeroplane is 16m, the standard deviation used should be closer to that used for code C, D and E which is an average of 2.9 and it is questionable whether it is still appropriate to use a 10 times standard deviation to assess extreme values of deviation.

In the ICAO *Aerodrome Design Manual Part 1 – Runways* the runway width (W_R) may be represented by the OMGWS plus the clearance (C) between the OMGWS and the runway edge.

$$W_R = OMGWS + 2\ C$$

Using this formula for a code F aeroplane with a maximum OMGWS of 16m and runway width of 60m the resulting clearance to the runway edge is 22m. A study presented at a meeting of the ADWG in September 2005 found that for code D and E operations the clearance to the edge of the runway was in both cases 15.5m. When comparing code D/E and code F the clearance to runway edge is disproportionately high given the change in OMGWS is just 2m.

The ADWG nevertheless agreed to retain the 60m runway width for code F runways and the overall width of a code F runway and shoulders retained as 75m.

CASA position in 2001

In December 2001 CASA wrote to all major Australian international aerodrome operators likely to introduce the A380 at their airport, advising them that CASA would permit the aircraft to operate on a runway not less than 45m wide, subject to the aircraft being certified to operate on 45m wide runways.

A380 Airport Compatibility Group (AACG)

An informal group consisting of a number of European Aviation Authorities, Airport and Industry representatives was established in 2001 called the A380 Airport Compatibility Group (AACG). Its aim was to try to agree and promote a common position among the group members on the application of ICAO requirements, with respect to the A380 aircraft, for infrastructure and operations at existing airports which did not meet the ICAO requirements for code letter F aeroplanes. The result was the publication of the Common Agreement Document of the AACG in December 2002.

This document provides a number of alternative measures, operational procedures and operating restrictions that can be implemented to permit A380 aircraft operations without the burden of high investment cost and infrastructure changes. The recommendations for runway width and runway separations were subject to the A380 aircraft being certified to operate on a code E runway (minimum 45m wide) for each type of operation (autoland, flight director and manual modes).

In relation to runway width the AACG concluded:

"a minimum central 45m of pavement of full load bearing strength shall be provided with a minimum of two 15m wide shoulders on existing 45m wide runways, these being made up of 7.5m wide 'inner' portion of runway shoulder to support the occasional pass of the A380 and an additional 7.5m 'outer' portion of runway shoulder prepared for jet blast protection, engine ingestion protection and for supporting ground vehicles".

In relation to taxiway width the AACG concluded the A380 required to operate on a taxiway not less than 23m wide provided within a code F compliant graded taxiway strip not less than 60m wide protected against shoulder erosion and engine ingestion (paved or natural surface).

Existing Airports Infrastructure Compatibility

The minimum aerodrome regulatory requirements, which would allow an aeroplane to land at a particular aerodrome, are a runway of sufficient length and width. In addition a means to clear the runway is also necessary, either by way of a suitable taxiway or a runway turn pad.

Although CASA has implemented the new code F requirements it has become clear some airports in Australia will have difficulties in complying with these specifications when determining changes to existing infrastructure.

Figures from airports worldwide show that where existing aerodromes are upgraded to meet the minimum AACG recommendations the savings in cost over providing full code F compliant infrastructure is of the order of 70 percent. This cost saving according to the AACG study is achievable without diminishing safety.

Master planning principles require the future aeroplane likely to operate at the aerodrome say for a twenty year projected horizon to be established now in order to plan for the future aerodrome infrastructure required.

Discussion at the ICAO Aerodromes Panel, ADWG level agreed that, for master planning purposes at major international airports, construction or redevelopment consideration must be given to future generic code F aeroplanes and even larger aircraft types, for instance the code letter G aeroplane, an aeroplane possibly fitting a projected 90m by 90m envelope.

CASR Part 139

The new Australian aerodrome regulatory framework under CASR Part 139 was made in May 2003 with supporting aerodrome standards in the Manual of Standards (MOS) Part 139 – Aerodromes. CASA adopted the current ICAO Annex 14 code F recommendations as standard and included these in the first amendment to MOS Part 139 in September 2004.

ICAO – New Large Aeroplane Operations at Existing Aerodromes

In June 2004 ICAO developed Circular 305 - *New Larger Aeroplane Operations at Existing Aerodromes*. This circular identifies all issues, which are of relevance to the operations of new large aeroplanes (NLA), and proposes possible mitigation measures for accommodation of NLAs at those airports that are unable to comply with Annex 14, code F provisions.

The circular discusses and incorporates the work and findings of the AACG.

The circular does not specify what is acceptable and what is not but refers this responsibility to the State's authority. Advice from ICAO is the State should decide on the suitability of lower requirements than those given by Annex 14, based on aeronautical studies. The principle is that although safety requirements must be met efficiency of operations should also be considered. At airports such as those identified as alternates, which have a very low number of A380 movements and therefore whose infrastructure is unlikely to be code F (or AACG) compliant, efficiency would be a minor issue.

The ICAO circular also gives guidance on how to conduct aeronautical studies. Together with ICAO Annex 14 and the AACG recommendations, ICAO Circular 305 forms a basis for the minimum acceptable infrastructure requirements at existing code E aerodromes to enable the code F A380 to be safely accommodated.

ICAO has also produced operational information for States wishing to introduce new large aeroplane operations into existing code E aerodromes having precision approach category I, II and III runways. The information is based on studies carried out by the US Federal Aviation Administration (FAA) which suggests the dimension of the code E Obstacle Free Zone (OFZ) baulked landing surface would be adequate for protecting aircraft aborting a landing after passing the decision height when either the autopilot or flight director is in use and a 'ground track hold' function is in use. This information is found in ICAO Circular 301 – *New Larger Aeroplanes– Infringement of the Obstacle Free Zone: Operational Measures and Aeronautical Study.*

The Case for 45m Wide Runways

(a) Aircraft certification

The ability to use a runway of a given width (i.e. 45m or 60m) is related to the aircraft performance and specifically its capacity to correct any accidental lateral variation (a function of control surfaces aerodynamics, flight control efficiency, landing gear geometry, etc). This forms part of aircraft design specifications and can consequently only be validated during the design validation process, the aircraft certification.

Certification validates aircraft handling qualities and performance in an environment equivalent to the expected operating environment with a standard of piloting equivalent to that of normal airline pilots.

Certification process takes into account all operating conditions which the aircraft will meet, including climates that are much more extreme than those experienced at any particular aerodrome.

According to the "*Certification Specifications for All Weather Operations*" *(CS-AWO)*, published in 2003 by the European Aviation Safety Agency (EASA), a wheel to edge clearance of 4.5m is compliant with the aircraft performance required by EASA and therefore does not affect operational safety. The European Aviation Safety Agency (EASA) carried out the A380 certification according to EASA rules and concluded the A380 is capable of safely operating on a 45m wide runway.

The US FAA operations evaluation of the A380 was completed in July 2007. Throughout the development and certification flight program, all runway centreline lateral deviation data was recorded for all take–offs and landings for both normal and failure cases 45m wide runways. Centreline lateral deviation data was compared to pre–existing A330/A340 runway centerline lateral deviation data obtained under approximately same configuration, pilot and meteorological conditions. Subjective evaluations were conducted by the FAA Flight Standarisation Board and operations evaluation pilots assisted by FAA certification flight test pilots. The team found the A380 could be safely operated on runways as narrow as 45 m with the use of average pilot skills and knowledge.

(b) ICAO Aerodrome Design Working Group (ADWG)

In respect of A380 operations on existing 45m wide runways the ICAO ADWG agreed that each State was responsible for carrying out the safety study to satisfy itself the A380 could operate on 45m wide runways, provided the aircraft was certified to do so.

(c) Risk assessment – A380 on existing 45m wide runways

The likely risks to an A380 aircraft operating on existing code letter E runways are:

1. structural damage to aircraft operating on runway pavement and runway pavement overlying structures of insufficient strength;
2. runway lateral diversions;
3. structural damage to aircraft diverting onto runway shoulder of insufficient strength;
4. damage to runway elevated edge lights;

5. ground service vehicles unable to use runway shoulder or runway outer shoulder area; and
6. erosion of surface of runway outer shoulders resulting in engine ingestion.

Pavement strength

Although the A380 is heavier than the largest commercial aeroplanes currently operating, the footprint and hence pavement load distribution of the A380 is similar to that of a B747/B777 aircraft. Existing code E runway pavements designed for Boeing B747 operations are expected to be capable of safely supporting the anticipated low frequency A380 operations. A pavement management system approach will ensure pavement performance is suitably monitored and corrective action taken before pavement deterioration becomes a safety issue.

Where a runway pavement is located over a tunnel or bridge the load bearing strength of the structure must be determined if it is capable of withstanding the static and rolling loads of the A380. If necessary strengthening work on the structure is to be carried out.

Runway lateral diversion

According to available reports there were no code E aeroplane fatal accidents due to runway lateral diversion alone in the period 1980 to 2000. ICAO notes that runway lateral diversion is linked to specific aircraft characteristics, performance/handling qualities, controllability in events such as aircraft mechanical failures, pavement contamination and cross wind conditions.

In a study of Boeing B747 runway lateral diversions over the period 1969 to 2001 there were 96 recorded runway diversions covering landing, takeoff or turnoff to exit taxiway. Landing diversions occurred nearly twice as many times as takeoff diversions. Unfavourable weather and/or poor runway pavement surface condition was frequently present during runway diversions.

Airbus has advised the A380 has been designed to operate without any specific limitations on 45m wide runways and the certification process has vindicated this. The aircraft has advanced aerodynamic characteristics and modern fly–by–wire control systems which improve significantly the ground handling and precision available during landings. The risk to an A380 of runway lateral diversion on a 45m wide runway is as low as that of an existing code E aircraft operating on code E 45m wide runways.

Runway longitudinal and transverse slopes necessary for the safe controllability of aircraft on a runway must comply with the standards for code 4 runways set out in MOS Part 139.

Prevailing weather conditions in Australia are generally moderate and no extreme phenomenon is likely. Nevertheless good surface friction characteristics must be maintained to prevent lateral diversions due to a slippery surface caused by rubber build–up or water and slush contamination. This is particularly important during high rainfall, critical cross winds and poor visibility.

Aerodrome serviceability inspections and annual technical inspections must be carried out to ensure the pavement surface is maintained in accordance with standards. Warnings must be issued to flight crew in the event of a reduction in runway surface friction to critical levels as identified in MOS Part 139.

Some airports such as Sydney Airport are also equipped with wind shear warning equipment in addition to the normal meteorological services.

Runway shoulders

Accident studies show there is a probability of runway lateral diversion for all aircraft, independent of their certification basis. The mitigating measure for this risk is the provision of runway shoulders, which should be capable of supporting the occasional pass of an aeroplane without damaging the aeroplane.

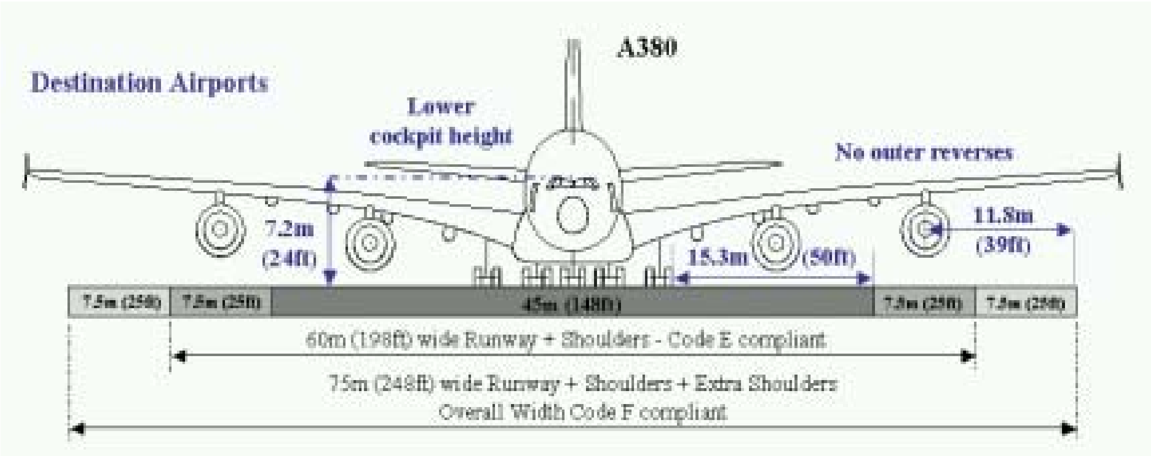
The AACG recommendations state that a 45m wide runway with 7.5m shoulders on both sides can be used for A380 operations if the runway is also provided with additional ‘outer’ shoulders. These outer shoulders must be at least 7.5m wide and be prepared for jet blast protection, engine ingestion protection and for supporting emergency and service vehicles.

Jet blast issues for A380

The A380 flight tests to date have indicated that for landing – engine ingestion, blast and erosion protection is not deemed critical for the A380, as the outboard engines are essentially at idle thrust, are located relatively high (ground clearance of 1.9m at maximum ramp weight) and are not fitted with thrust reversers. The landing does not present a specific risk and therefore special procedures are not necessary (although runway inspection is advisable).

For take–off the critical phase is at brake release (combination of low speed and high thrust). For runways and shoulders with a width of less than 75m, the condition of the surface of the area outside the runway shoulders (sealed/paved, grass without stones, grass with loose stones, arid) is a matter of importance. The absence of shoulders could result in foreign object damage (FOD) on the runway or on ‘inner’ shoulders, which could be hazardous to the following aircraft movement.

The following diagram illustrates the minimum AACG runway width and shoulders required at aerodromes used for regular operations by the A380.



At destination alternate aerodromes where the same level of ‘outer’ shoulder protection is not available runway sweeping may need to be carried out after each take–off to ensure the runway and runway shoulder surfaces are clean of any loose material which may damage the aircraft or any following aircraft.

Runway edge lights

Runway edge lights are provided along both sides of the runway. They are located on the edge of the runway or a maximum of three meters to the outside of the edge. In most cases elevated (and frangible) constructions are used that could be subject to engine blast as the edge lights are almost in line with the outboard engines of the A380. Tests have been carried out to see if some elevated lights, currently available on the market, can withstand blast profiles comparable with an A380 engine. These tests have shown that these light fittings should resist the A380 blast.

The airport or local authority can perform runway edge light and signs inspection after each A380 departure (which may be required for FOD reasons). As the outer engines of an A380 are not fitted with thrust reverse systems, it is not required to perform a runway edge light inspection after the landing of an A380.

The decision to provide runway inset edge lights is still being debated. If accepted it does remove the risk of damage to the aircraft if it strikes the elevated lights. However it does mean that more frequent cleaning of the inset lights, which become dirty more quickly than the elevated runway edge lights, is an ongoing maintenance requirement.

Ground service vehicles unable to use runway shoulder or outer runway shoulder

The runway shoulders illustrated in the destination airport diagram above must be constructed to support occasional passes of the A380 and the outer runway shoulders prepared to support the weight of ground service vehicles, including rescue and fire fighting service (RFFS) vehicles.

Erosion of surface of area adjacent to runway shoulder
To prevent jet blast erosion from the outer mounted engine on the A380 an area at least 7.5 wide adjacent to the runway shoulder is to be prepared so that it is protected against jet blast and risk to engine ingestion is minimised.

(d) Taxiways
The ICAO Annex 14 code F taxiway width is 25m, or 2m more than a code E taxiway. The A380 has a wheel track 0.4m larger than the code E upper limit. Extensive deviation studies, carried out at several airports around the world, including Sydney Airport, have shown that the deviation of current operating code E aircraft is much less than the 4.5m margin used in the formula to determine the taxiway width.

Results show that a deviation of less than 2.5m is a very realistic value under the condition that proper guidance such as centreline lights offset in relation to centreline markings, side stripe marking and edge lights, camera, reduced taxiing speeds, use of specific taxiing routes or equivalent guidance is provided for night or low visibility operations.

In addition the actual wheel to edge clearance (4.3m) of the A380 is more than the 2.5m if the aircraft is taxiing on a code E taxiway.

The US FAA runway width certification process also looked at taxiway width operations. They found the A380 could be safely taxied on 23m wide taxiways under normal visibility conditions without taxiway centreline lighting using average pilot skills and knowledge. As well the onboard camera was found not to be necessary for safe taxiing on 23m wide taxiways using average pilot skills and knowledge.

Providing the proper guidance is maintained it can be concluded that an A380 can taxi safely on a 23m code E taxiway.

Width of curved taxiway
To facilitate the movement of an A380 on curved taxiways and on junctions / intersections of taxiways with runways, aprons and other taxiways, fillets should be provided. The design of the fillet should ensure that a minimum wheel to edge clearance is maintained, based on Cockpit over Centre Line (COCL) steering technique. ICAO requires a minimum wheel to edge clearance of 4.5m for curved taxiway segments Also the AACG recommendations mention a 4.5m wheel to edge clearance for curved taxiways, however in some states the use of smaller wheel to edge clearances (i.e. 2.5m) for the design of taxiway fillets is under certain conditions accepted.

If the required wheel to edge clearance cannot be guaranteed when using COCL steering technique, judgemental oversteering is required. The use of judgemental oversteering must be published in the appropriate aeronautical publications. If even judgemental oversteering is not sufficient or if the airport / local authority does not feel comfortable with this, additional markings (for over steering guidance) could be a practical solution.

Taxiway shoulder width

Both ICAO Annex 14 and the AACG Common Agreement Document recommend a 60m wide strip to be protected against shoulder erosion and engine ingestion risk. The shoulders could be built up of a paved, stabilized or a natural surface. The A380 engine ground clearance is a factor. The inner engines are 0.5m higher and the outer engines 1.2m higher than those of the 747-400, which would decrease the ingestion and jet blast risks. Taxiing on two engines is not unusual but is mainly a practice after landing. Taxiing on two engines before take-off requires the outboard engines to be started up near or even at the runway, which can result in a long blockage of the runway and consequently disturbing other traffic flow.

Depending on the shoulder width, nature of the shoulder surface and given the location of A380 inboard and outboard engines, a specific procedure such as preferential use of some of the engines could be used.

CASA Position

CASA advised as early as 2001 that subject to certification approval it would accept 45m as the minimum with of runway for A380 operations. The European Aviation Safety Agency and US FAA have both certified the aircraft as being capable of operating safely on 45m wide runways.

CASA has favourably considered the recommendations of the ICAO Circular 305 and the work done by the AACG, their methodology, safety analyses and conclusions, and proposes to include these recommendations as standards to provide for specific A380 movement area facilities at existing code E aerodromes. The standards will be applicable only to existing code E runway and taxiway facilities, where it is considered too costly and disruptive to upgrade the existing facilities to meet the full code F provisions. Operators of existing code E aerodromes anticipating introduction of A380 operations at their aerodrome will be encouraged to upgrade to full code F requirements.

When a new airport is proposed to cater for the A380 or other code F aeroplanes as the design aeroplane, facilities meeting the full requirements of code F are to be provided.

Facilities meeting the full requirements of code F or greater, are to be provided when a major redevelopment of the movement area is being planned at existing code E aerodromes used by code F aeroplanes.

CASA acknowledges the taxiway deviation studies undertaken by Sydney Airport since monitoring began in November 2002. CASA also acknowledges the safety case studies carried out by Sydney Airport as part of the application for an exemption against the requirement to provide a 60m wide runway and 25m wide taxiways. The exemption is being used as an interim measure pending acceptance of the proposed changes to the MOS Part 139 standards allowing A380 operations at existing code E aerodromes.

With the exception of the minimum runway and minimum taxiway widths discussed herein the aerodrome operator is to develop a safety case where they are unable to provide the code F requirements for minimum wingtip clearance, holding point clearances and radio navigational aid signal protection.

In accepting the above CASA may also impose mitigating measures as necessary to ensure facilities are assured a similar level of safety as if they were provided to full code F requirements

References

ICAO Circulars 305 - Circular on New Large Aeroplane Operations at Existing Aerodromes, June 2004.

ICAO Circular 301 - New Larger Aeroplanes - Infringement of the Obstacle Free Zone: Operational Measures and Aeronautical Study, December 2005.

Common Agreement Document of the A380 Airport Compatibility Group (AACG), December 2002.

European Aviation Safety Agency (EASA) A380 runway width certification, December 2006.

US FAA A380 runway and taxiway width certification, July 2007.

Runway Width Studies - Undertaken by France and Paris Airport.

Taxiway Deviation Studies - Undertaken by Sydney Airports Corporation Ltd since November 2002.

Airbus A380 operations at alternate airports - Useful study done by French aviation regulator, June 2006.

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