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- independent investigation of transport accidents and other safety occurrences
- safety data recording, analysis and research
- fostering safety awareness, knowledge and action.

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# Instrument departure procedure design

## Abstract

Following the construction of a new hangar adjacent to runway 28 right (28R) at Archerfield Airport, Queensland, the Australian Transport Safety Bureau (ATSB) received a number of submissions asserting that the building infringed safety standards or reduced flight safety.

Drawing on an independent third-party review, the ATSB determined that the building does not breach obstacle limitation surfaces. The ATSB also conducted an initial examination of the instrument departure procedure from runway 28R. The ATSB found that the procedure complied with the extant instrument departure design requirements, but identified an ambiguity in the guidance for designing instrument departure procedures.

The ATSB assessed that this ambiguity could lead to inconsistent expectations about the extent of clearance from obstacles provided to aircraft when pilots were following an instrument departure procedure. This had the potential to increase the risk of a collision with an obstacle. In response, on 30 May 2008, the (then) Executive Director of the ATSB commenced a safety issue investigation in accordance with sections 21 and 23 of the *Transport Safety Investigation Act 2003*.

As a result of that investigation, the Civil Aviation Safety Authority and Airservices Australia have, in consultation, reviewed their understanding of how the design standards for instrument departure procedures should apply in Australia. They have also re-examined the runway 28 instrument departure procedure at Archerfield in the light of that review and have advised that they intend to amend the requirements for instrument departures from runway 28R.

The potential for inconsistent interpretation of the instrument departure procedure design

requirements has also been notified to the International Civil Aviation Organization instrument flight procedures panel, which monitors the international standards for the design of instrument procedures.

## FACTUAL INFORMATION

### Background

In early 2008, the Australian Transport Safety Bureau (ATSB) received a number of submissions that questioned the separation assurance of aircraft from airport obstacles when conducting instrument departure procedures from runway 28 right (28R) at Archerfield Airport, Queensland. In particular, the reporters expressed concern with the clearance from a recently-constructed hangar to the right of the runway flight strip (Figure 1).

**Figure 1. Runway 28R, showing the recently-constructed hangar**



The ATSB conducted an initial examination of the standards for instrument procedure design as they applied to the instrument departure procedure for runway 28R. The ATSB found that the procedure complied with the extant design requirements but also identified a potential for inconsistent interpretation of the available instrument departure procedure design standards.

In response, on 30 May 2008, the (then) Executive Director of the ATSB commenced a

safety issue investigation in accordance with Sections 21 and 23 of the *Transport Safety Investigation Act 2003*.

## Runway obstacle clearance requirements

Zones that are free of obstacles are established at airports to allow aircraft to take off and land without the risk of colliding with an obstacle during normal operations. A runway's obstacle-free zone is defined by a series of obstacle limitation surfaces (OLS) surrounding the runway (Figure 2). The location of the surfaces is dependent on the code<sup>1</sup> of the runway.

The standards and requirements for the establishment of an OLS are defined under International Civil Aviation Organization (ICAO) Annex 14<sup>2</sup>, and in Civil Aviation Safety Regulations (1998) Part 139 and the Civil Aviation Safety Authority (CASA) Manual of Standards (MOS) Part 139. A transitional surface extends out at an angle from the edge of the runway strip, allowing for aircraft to drift laterally during the climb after takeoff, or as they approach the runway to land.

An independent review by a third-party consultant of the OLS requirements affecting runway 28R at Archerfield Airport determined that the OLS was not infringed by any obstacles.

## Obstacle clearance requirements for a published instrument procedure

Archerfield Airport runway 28R also had an omnidirectional Standard Instrument Departure (SID)<sup>3,4</sup> procedure that allowed instrument flight rules (IFR) aircraft to take off when the weather was below visual meteorological conditions. Guidance for the design and construction of

instrument departures, including SIDs, was contained in ICAO document 8168<sup>5</sup> (PANS-OPS).

The MOS Part 173 stated that the instrument flight procedure design standards used in Australia were contained in PANS-OPS, unless there was a difference in the MOS, in which case the MOS requirements would prevail. The requirements affecting the design of the Archerfield Airport runway 28 omnidirectional SID were based on the PANS-OPS Omnidirectional Departure criteria.

Under PANS-OPS, the design of each instrument departure procedure has its own set of obstacle identification surfaces (OIS)<sup>6</sup> that are required to meet the criteria as defined in PANS-OPS. Risk mitigation procedures are required if any obstacle penetrates an OIS, in order to manage the potential risk of collision of an aircraft with an obstacle when the aircraft is flown in accordance with the instrument flight procedure. The OIS include provision for an aircraft to make a turn as/when required by the inclusion of a Turn Initiation Area (TIA)<sup>7</sup> (Figure 3).

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1 Runways are assigned a code between 1 and 4 under the Manual of Standards Part 139, Chapter 7: 7.1.3.5. In general, larger aircraft require runways with a higher runway code for an instrument departure.

2 International Civil Aviation Organization, Annex 14 to the Convention on International Civil Aviation: Aerodromes.

3 A designated instrument flight rules departure route that linked an aerodrome or specified runway with a specified point, from where the en route phase of a flight was commenced.

4 In the case of an omnidirectional SID, there was no track guidance to a certain point, from which an aircraft could turn and depart in any direction.

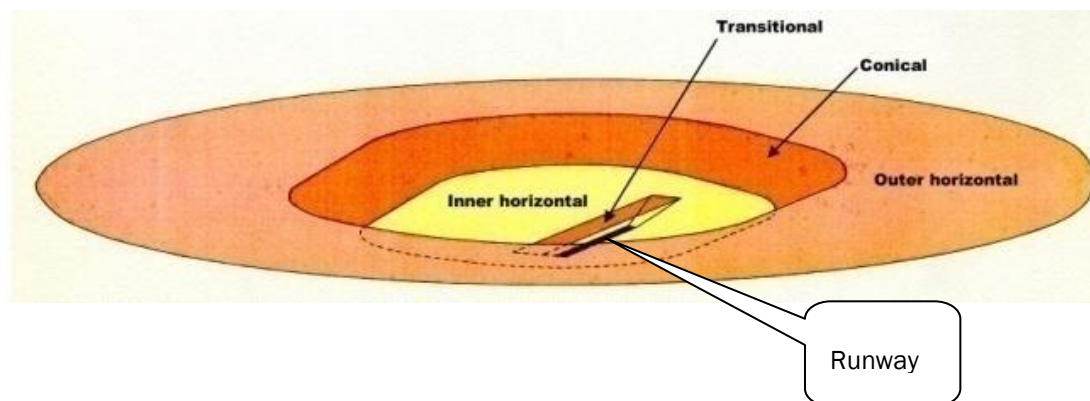
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5 International Civil Aviation Organization Document 8168 OPS/611: *Procedures for Air Navigation Services: Aircraft Operations*. This document is commonly known as PANS-OPS.

6 For ease of understanding, **OLS** refers to general runway requirements that apply to all runways, as described in MOS Part 139, and **OIS** refers to the requirements for specific instrument procedures, as described in PANS-OPS.

7 Turn Initiation Area. An area from which a turn may be initiated during a SID. It is defined in PANS-OPS vol 2, 3.3.2.1 as starting at a point 600 m from the commencement of the runway, unless the departure chart prohibits a turn prior to the departure end of the runway (DER), in which case the TIA starts at the DER.

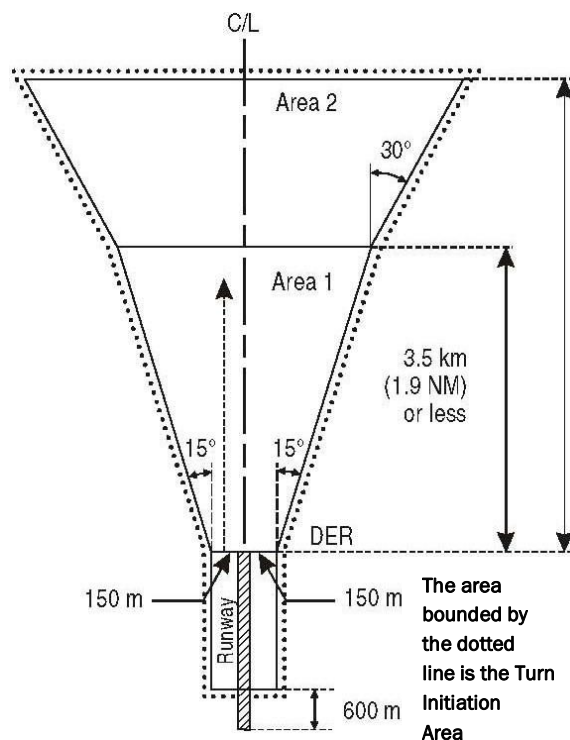
Figure 2: Runway obstacle limitation surfaces



A TIA includes two components:

- Initially, two rectangular areas are established on either side of the runway, commencing 600 m along the runway from the runway threshold and continuing to the departure end of the runway (DER). These areas extend out 150 m on each side from the runway centreline. PANS-OPS does not specify a height for the two rectangular areas, and they are not described in the procedures as 'OIS'.
- The OIS for the Archerfield RWY 28 instrument departure commenced at the DER at a width of 300 m and a height of 5 m, initially widened out at 15° from each side of the runway edge, and climbed at a gradient of 2.5 %. The OIS then widened at an angle of 30° beyond a distance no greater than 3.5 km from the DER. The OIS continued to an altitude from which a turn could be made safely in any direction.

Figure 3: OIS and TIA (plan view) for an omnidirectional instrument departure procedure



For turns after takeoff, PANS-OPS stipulates that an aircraft cannot initiate a turn until it has climbed to at least 394 ft to ensure obstacle clearance if no significant obstacles exist, and higher if significant obstacles do exist.

The intent of the areas beside the runway, as defined in PANS-OPS Vol II, 3.3.2.1, is that an aircraft conducting an instrument departure would initiate a turn from not below 394 ft and at least 600 m along the runway from the runway threshold. However, few IFR aircraft could climb 394 ft from a stationary position in a distance of 600 m. The purpose of the areas may have been



contemplated as OIS for turns that commenced before the DER; however, there is no height specified in PANS-OPS for those areas to be considered as constituting OIS.

### Implications for an instrument departure procedure

The opening paragraph to ICAO Document 8168, Volume II, Part 1, Section 3, Chapter 1 stated that:

(a)... [a] departure procedure designed in accordance with this section provides obstacle clearance immediately after take-off until the aircraft intercepts the en-route segment.

Chapter 2, section 2.3.1.1 of that document stated that:

The departure procedure begins at the departure end of the runway (DER), which is the end of the area declared suitable for take-off (i.e. the end of the runway or clearway as appropriate.)

Aircraft were required to be airborne before the DER when taking off, so the two statements provided for different starting points for an instrument departure procedure.

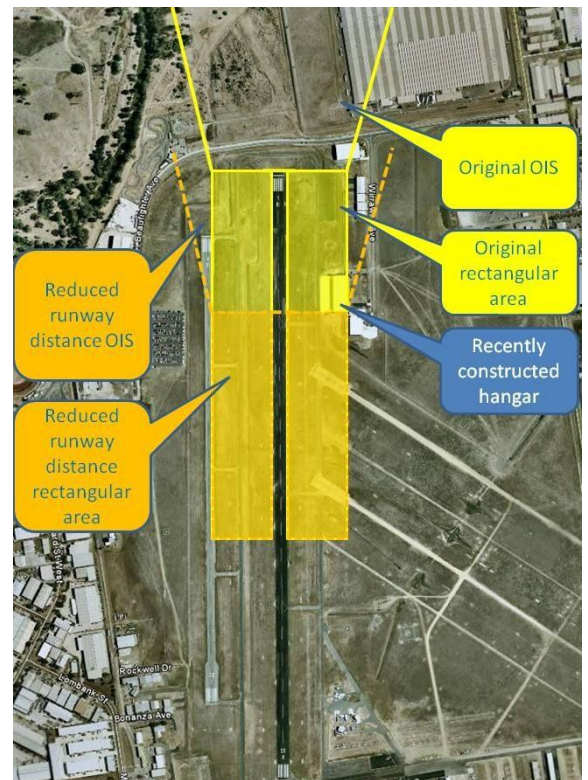
### Archerfield Airport runway 28 SID

The Archerfield Airport runway 28 SID required an aircraft to continue tracking on the runway heading until the aircraft had climbed to 900 ft above mean sea level (AMSL) (a height of 837 ft above the runway), and had passed the DER; which was originally 1,479 m from the runway threshold. Few IFR aircraft could climb 837 ft from a standing start in less than 1,500 m, so a departing aircraft could be expected to normally continue tracking on the runway heading until some distance after the DER.

Airservices Australia (Airservices) was the responsible agency for designing the Archerfield Airport runway 28 SID procedure. When Airservices became aware of a potential ambiguity in the PANS-OPS procedural requirements, the runway 28R SID procedure was redesigned to ensure it complied with a 'conservative approach' to the interpretation of the PANS-OPS requirements at that time. As a result, Airservices

issued NOTAM<sup>8</sup> C250/07 on 15 October 2007, to implement the redesigned procedure. The NOTAM reduced the take-off run and distance available on runway 28R for instrument departures from over 1,400 m to 1,095 m. The reduced runway length ended abeam the start of the recently constructed hangar, which was located to the north of the runway strip (Figure 1). Shortening the available runway excluded the hangar from the 150 m rectangular area associated with the SID design requirements (see Figure 4).

**Figure 4:** OIS and TIA (plan view) for Archerfield runway 28 SID before and after the issue of NOTAM C250/07



Following a request from Airservices, the modification was agreed to by the Civil Aviation Safety Authority (CASA).

CASA has since provided a letter to Airservices clarifying the interpretation and application of the standards when designing instrument departure procedures. CASA indicated that it considered the

<sup>8</sup> A NOTAM is a 'Notice to Airmen'. It is widely disseminated to give information on the establishment, condition or change in any aeronautical facility, service, procedure or hazard.

areas beside the runway as a 'protected area'<sup>9</sup>, and that a surface was to be considered as existing at a height of 5 m above ground level (AGL). CASA also provided a procedure for ensuring the avoidance of obstacles that penetrated the OIS for an instrument departure, by requiring that:

- Obstacle avoidance was to be based on visual separation by the pilot.
- The standard take-off visibility minima could not be reduced.
- Increased visibility minima were to be specified as follows:
  - the cloud ceiling was to be higher than 110% of an infringing obstacle's height
  - the horizontal visibility was to be greater than 110% of the distance between the runway threshold and an infringing obstacle.
- The obstacle would be lit in accordance with the requirements of the MOS Part 139.
- The obstacle would be charted and the specific visibility minima published on the applicable departure chart.

Airservices has since incorporated the CASA requirements into its instrument departure procedures design requirements.

## ANALYSIS

During takeoff, an aircraft may be at risk of colliding with obstacles in the vicinity of the departure runway if it drifts laterally immediately after takeoff. This risk is managed for takeoffs under both the visual and instrument flight rules by the application of transitional Obstacle Limitation Surfaces (OLS) as specified in *Civil Aviation Safety Regulations (1998) Part 139 Manual of Standards (MOS Part 139)*.

With respect to instrument flight rules (IFR) departures, the rectangular areas on each side of the runway, as stipulated in International Civil Aviation Organisation (ICAO) document 8168 (PANS-OPS), form part of the Turn Initiation

Area. However, it is not clear whether they also have a purpose with respect to obstacle clearance for IFR departures.

It was apparent that ambiguities existed in the ICAO PANS-OPS guidance material for application in the design of omnidirectional Standard Instrument Departure (SID) procedures. The ambiguities included differing guidance regarding the starting point for a SID, and the unclear purpose for the rectangular areas beside the runway for a SID.

Those ambiguities allowed different interpretations of what could be expected from an instrument departure procedure. This may have led to an increased risk of a collision with an obstacle during an instrument departure.

## FINDINGS

From the evidence available, the following findings are made with respect to the potential for ambiguity that was identified in the available guidance for designing instrument departure procedures, such as at Archerfield Airport, Queensland. They should not be read as apportioning blame or liability to any particular organisation or individual.

### Contributing safety factors

- Ambiguities existed in the guidance used in the design of omnidirectional Standard Instrument Departure procedures. Such ambiguities may lead to an increased risk of inconsistent procedure design or application and an increased risk of collision with obstacles for aircraft following an instrument departure procedure. [*Minor safety issue*]

### Other key findings

- The obstacle limitation surface requirements affecting runway 28 right at Archerfield Airport, Queensland were not infringed by the recently constructed hangar.

## SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In

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<sup>9</sup> A protected area provides an aircraft with protection from obstacles when its pilot is complying with an instrument procedure.

addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

## **Inconsistent interpretation and application of the design standards**

### *Minor safety issue*

Ambiguities existed in the guidance used in the design of omnidirectional Standard Instrument Departure procedures. Such ambiguities may lead to an increased risk of inconsistent procedure design or application and an increased risk of collision with obstacles for aircraft following an instrument departure procedure.

### *Civil Aviation Safety Authority*

As a result of this safety issue, the Civil Aviation Safety Authority (CASA) presented a submission to the International Civil Aviation Organization instrument flight procedures panel. The submission highlighted the potential for ambiguity in the interpretation of the standards for the design of omnidirectional Standard Instrument Departures. The intent of the submission was to raise awareness of the issue and to seek changes to improve the consistency of the relevant PANS-OPS guidance material.

In the interim, CASA has taken action to clarify the purpose of the rectangular areas to the sides of the runway and to provide additional procedures – including the provision of obstacle lighting to ensure obstacle clearance during instrument departures – to address the risk of a collision with obstacles.

### *ATSB assessment of CASA action*

The ATSB is satisfied that the action taken by CASA will adequately address the safety issue.

### *Airservices Australia*

As a result of this safety issue, Airservices Australia (Airservices) advised the ATSB that they had reviewed the Standard Instrument Departure procedure affecting runway 28 right (28R) at Archerfield Airport and, following clarification from CASA, that they intended to remove the requirements of NOTAM C250/07. In addition, Airservices will modify the instrument departure procedure to require that the hangar to the right of the runway 28R flight strip must be visible to a pilot before commencing takeoff.

Consistent with that modification, lighting will be required on the hangar to improve its visibility.

### *ATSB assessment of Airservices action*

The ATSB is satisfied that the action taken by Airservices adequately addresses the safety issue.

## **SOURCES AND SUBMISSIONS**

### **Sources of Information**

The sources of information during the investigation included:

- Airservices Australia (Airservices)
- the Civil Aviation Safety Authority (CASA)
- Archerfield Airport Corporation.

### **References**

ICAO Annex 14.

ICAO Document 8168.

Archerfield Airport runway 28 Standard Instrument Departure procedure chart.

Aerial images from Google Earth, Figures 1 and 4.

### **Submissions**

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a

confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A copy of the draft report was provided to Airservices, CASA and the Archerfield Airport Corporation.

Submissions were received from all of the parties. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.