Australian Government

Australian Transport Safety Bureau

Runway incursion involving Boeing 737 VH-XZM resulting in a rejected take-off involving Boeing 737 VH-VZL

Perth Airport, Western Australia, on 28 April 2018

ATSB Transport Safety Report

Aviation Occurrence Investigation

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Addendum

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Safety summary

What happened

On 28 April 2018, a Qantas Boeing 737 (VH-XZM) landed on runway 03 at Perth, Western Australia. The aircraft exited the runway onto taxiway J2, which led to a holding point for crossing runway 06. The aircraft did not stop at the holding point and crossed an illuminated stop bar without an air traffic control clearance.

At that time, a second Qantas Boeing 737 (VH-VZL) had commenced take-off from runway 06. An automated warning alerted the aerodrome controller (ADC) of the stop bar violation and the controller issued an instruction for the departing 737 to stop immediately. Soon after, the flight crew of VH-XZM became situationally aware of their position and stopped just before crossing the edge of runway 06. VH-VZL's wingtip passed about 15 m from VH-XZM's nose at low speed.

What the ATSB found

The captain of VH-XZM developed an incorrect mental model of the exit taxiways off runway 03, believing the aircraft would not have to cross runway 06 after exiting onto either of the potential taxiways (J2 or D). Due to this incorrect mental model, and a combination of workload and distractions at key times, the flight crew did not detect the runway crossing issue until their aircraft had almost reached the edge of runway 06.

Taxiway J2 was the preferred runway exit for jet aircraft landing on runway 03. However, the location and design of the taxiway significantly increased the risk of a runway incursion onto runway 06/24. In particular, it had a relatively shallow intersection angle with the runway and a relatively wide turn radius, leading to higher taxi speeds, and a short distance to the holding point for runway 06/24.

Although the junction around taxiway J2 was identified as a 'hot spot', there was no detailed information about the reasons why it was a hot spot on aerodrome charts, and Qantas did not specifically require pilots to brief hot spots during departure and approach briefings.

What's been done as a result

In response to the runway incursion, Airservices Australia made taxiway J2 unavailable for use. Subsequently, Perth Airport removed taxiway J2 from aerodrome charts.

In addition, Airservices Australia changed the settings of an alerting system to ensure tower controllers at Perth Airport performing multiple roles received appropriate aural and visual alerts at their workstation.

Qantas published a safety information notice to all pilots containing information about the background of runway incursions, details of two recent runway incursion occurrences and safety educational information related to influencing factors, stop bar techniques and strategies to avoid a runway incursion. Qantas also updated its *Flight Administration Manual* to include a requirement for pilots to brief relevant airport hot spots and their contingency planning to mitigate against the possibility of collision or runway incursion.

Safety message

Runway incursions are one of the most significant risks to safe aviation operations and a key global safety priority. Airport operators and local runway safety teams are strongly encouraged to identify and mitigate the risk of hot spots, especially those that involve short distances between runways, complicated junctions, and the potential for higher taxi speeds.

Pilots are strongly encouraged to identify runway hot spots during departure and approach briefings, and discuss the actions they will take to reduce the risk of a runway incursion at such hot spots.

Air traffic controllers are strongly encouraged to provide safety alerts and/or clear instructions (such as ‘stop immediately’) to the flight crews of all aircraft involved in runway incursions and related occurrences.

Contents

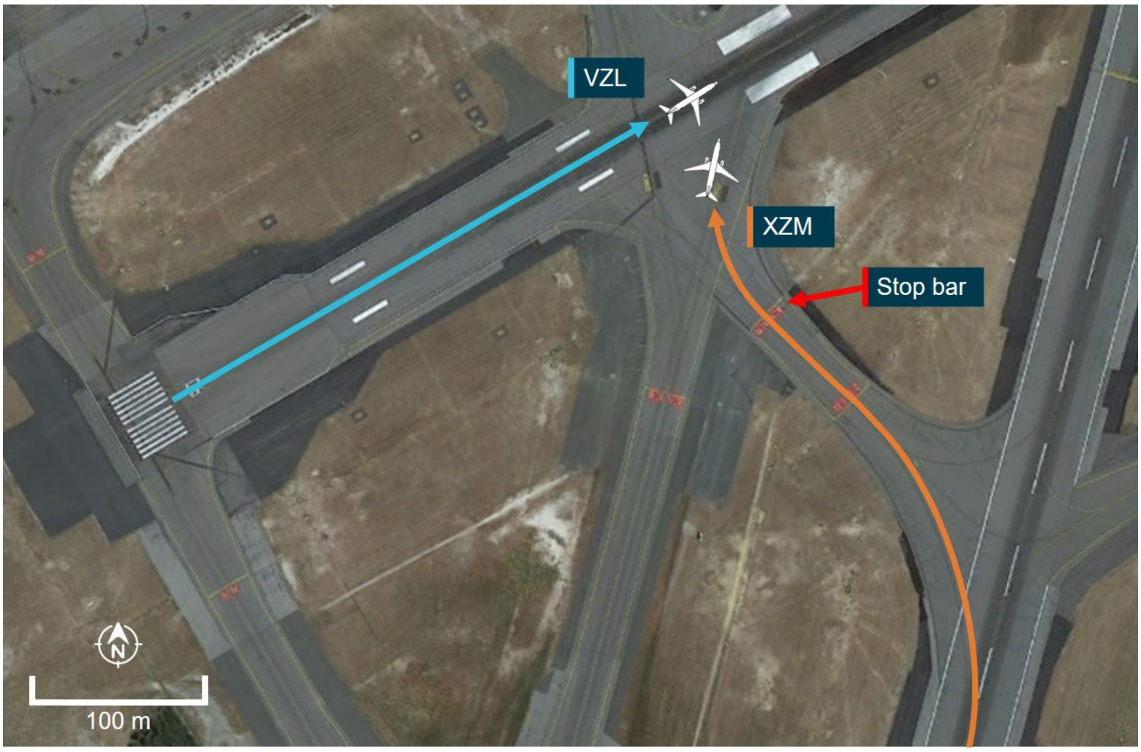
The occurrence

Overview

On 28 April 2018, a Boeing 737-838 (737) aircraft, registered VH-XZM, was being operated by Qantas Airways Limited (Qantas) on a regular public transport flight from Sydney, New South Wales to Perth, Western Australia. The aircraft landed on runway 03 and exited using taxiway J2 (Figure 1). The aircraft did not stop at the runway 06 holding point and crossed an illuminated stop bar without an air traffic control (ATC) clearance.

VH-XZM's incursion into the flight strip of runway 06 resulted in a rejected take-off of another Qantas Boeing 737 aircraft (VH-VZL), which was taking off from runway 06. VH-VZL's wingtip passed about 15 m from the nose of VH-XZM at low speed before stopping.

Figure 1: Overview of the runway incursion



Source: Google Earth, modified by ATSB

Events prior to the occurrence

VH-XZM departed Sydney at 1033 Western Standard Time[1] on the scheduled flight to Perth. During their review of NOTAMs,[2] the flight crew noted the recent installation of stop bars at Perth Airport.

1 Western Standard Time (WST) was Coordinated Universal Time (UTC) + 8 hours. All times in this report are WST unless otherwise stated.

2 NOTAM: notice to airmen, which alerts pilots to any potential safety hazards along a flight route.

On this sector the captain was pilot monitoring and the first officer (FO) was pilot flying.[3] Prior to descent, the approach controller cleared the flight crew for an area navigation (RNAV-X) runway 03[4] approach. Weather conditions for the descent and approach were good.

Prior to descent, the FO conducted an approach briefing, noting taxiway J2 (Figure 2) was the preferred exit and they would need to get an ATC clearance to cross runway 06. The FO recalled being aware that taxiway J2 was a designated 'hot spot' but did not brief it as a hot spot or state that runway incursions happened there. The captain expressed a preference to request taxiway D, which was closer to the terminal building. At the completion of the briefing, the FO believed that the captain understood they would vacate runway 03 onto taxiway J2 unless they had a clearance to exit at taxiway D.

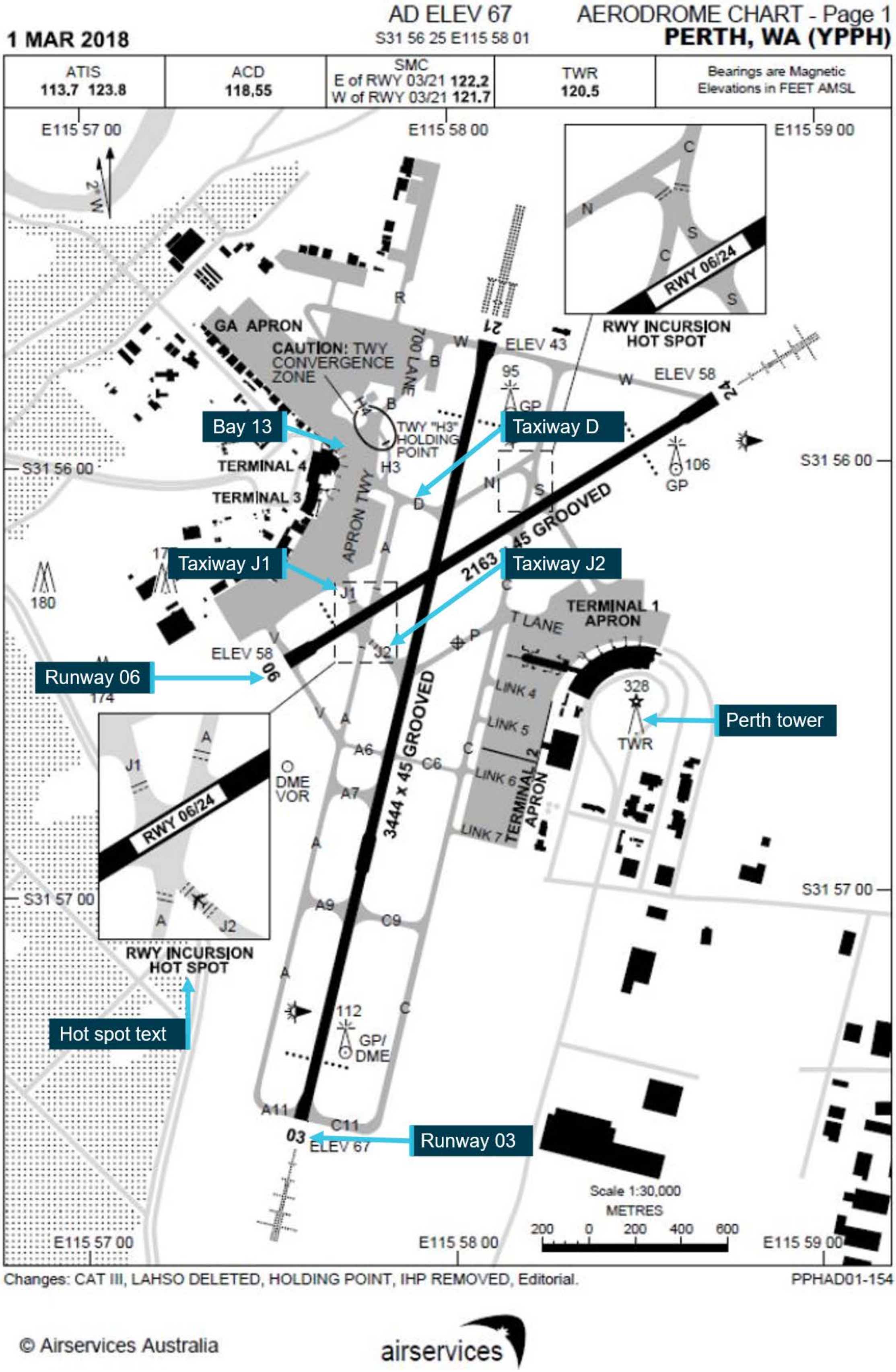
The captain recalled the briefing as professional and very thorough, but did not fully absorb all of the FO's briefing points (due to the level of detail in the briefing). The captain also recalled, that when discussing the taxi route to their assigned parking bay (13), being mainly focussed on vacating onto taxiway D, which led directly onto the apron, with taxiway J2 being the secondary plan. Having referenced the smaller apron chart (Figure 3) and not the larger aerodrome chart, the captain's mental model of the taxiway J layout was that if they used taxiway J2 they would vacate the landing runway 03 directly on taxiway J1, which led directly to the apron area. The captain interpreted the FO's point about a requirement to cross runway 06 as being during the landing roll on runway 03.

During the approach phase, another aircraft, also on approach to land on Perth runway 03, was following VH-XZM. It had been slowed down by ATC to coordinate the two arriving aircraft. ATC requested the flight crew of VH-XZM to maintain a high speed descent, which they accepted.

3 Pilot Flying (PF) and Pilot Monitoring (PM): procedurally assigned roles with specifically assigned duties at specific stages of a flight. The PF does most of the flying, except in defined circumstances; such as planning for descent, approach and landing. The PM carries out support duties and monitors the PF's actions and the aircraft's flight path.

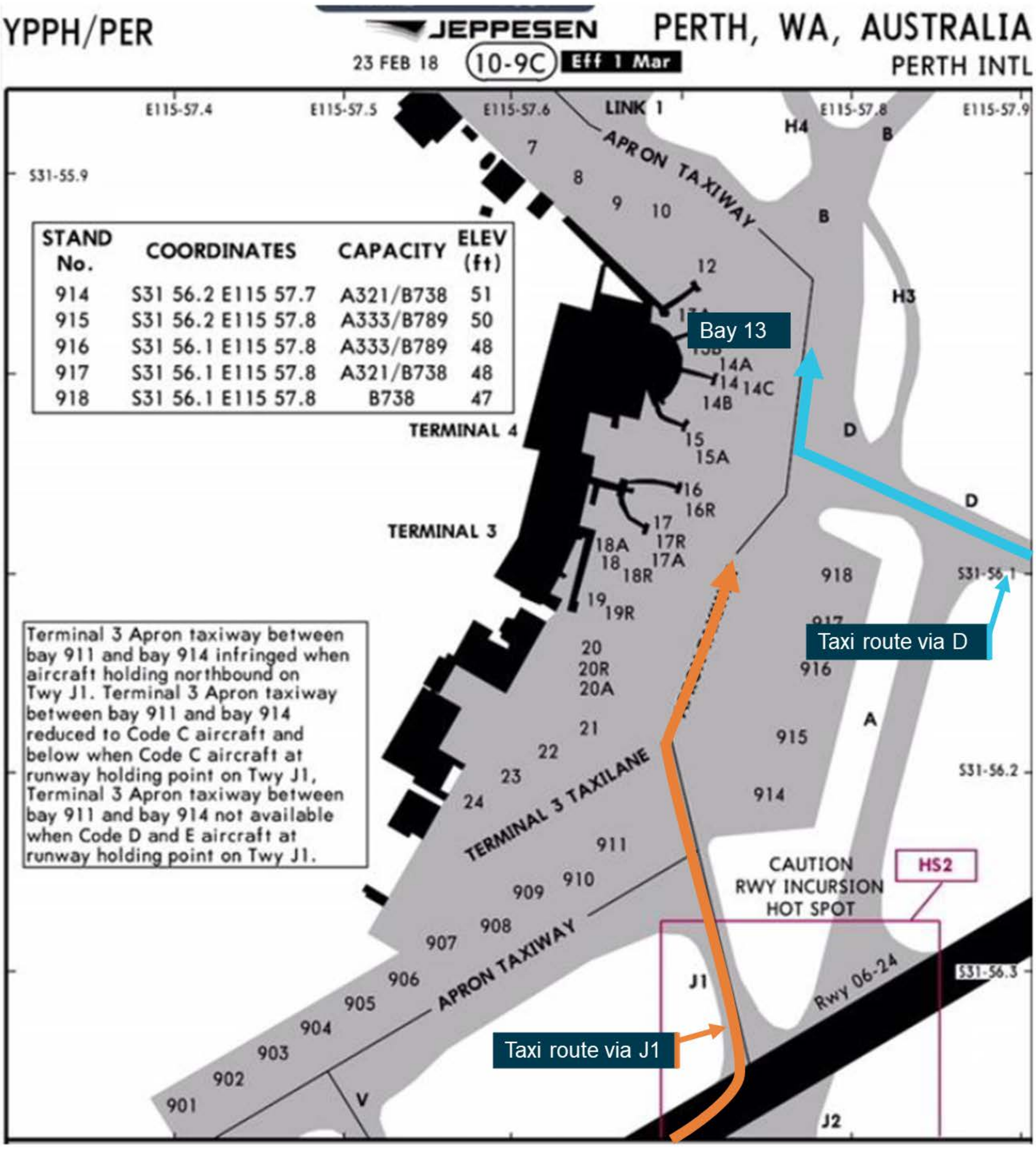
4 Runways are numbered in relation to their magnetic direction rounded off to the nearest 10°. This is the runway designation.

Figure 2: Perth aerodrome chart



Source: Airservices Australia, annotated by ATSB

Figure 3: Perth apron chart showing captain's mental model of taxi routes to bay 13



Source: Qantas, annotated by ATSB

Final approach and landing

The RNAV-X runway 03 approach required a descending right turn from about 2,180 ft to 790 ft. The FO recalled the captain commenting that, when flying the RNAV-X runway 03 approach, it could be difficult to slow the aircraft down and they would need to conservatively configure the aircraft for the arrival.

At 1438:55, the captain made first contact with the aerodrome controller (ADC) on the Perth ADC (tower) frequency. The captain recalled that the radio call was made during a period of high workload while closely monitoring the FO, the aircraft speed and the approach profile, and that the aircraft was not slowing down as quickly as desired.

The aircraft descended through 1,600 ft, configured with gear down and flaps 15 set, and the airspeed about 175 kt. As that speed was the flaps extension limit speed for flaps 30 (the intended flaps setting for landing), the captain suggested to the FO they select flaps 25 (a non-normal setting) to decelerate to enable selection of flaps 30, which they did once the aircraft slowed.

The captain recalled being ‘totally focused’ on the FO flying an accurate approach profile and descending turn. Due to this high workload, the request to take taxiway D after landing was forgotten. The captain also forgot to pre-set the Perth ground frequency in the radio’s standby frequency position, a routinely-performed task.

The captain started actioning the landing checklist. At 1439:28, that process was interrupted by the ADC issuing them a clearance to land on runway 03. At that time the aircraft was passing approximately 1,100 ft and still in a descending right turn to final approach. The flight crew completed the landing checklist and continued the approach within the requirements of the Qantas stabilised approach criteria.

During this time, VH-VZL was taxiing to runway 06 for departure and its flight crew were monitoring the Perth surface movement controller (SMC/ground) frequency. At 1440:59, that flight crew changed to the ADC frequency and advised the ADC they were ready. At 1441:02, the ADC cleared them to line up and wait on runway 06.

At 1441:21, VH-XZM landed on runway 03 and the FO selected idle reverse thrust. While the aircraft was decelerating, the captain realised that an egress onto taxiway D had not been requested from the ADC and believed they were now committed to vacate via taxiway J2. At about 60 kt, the captain took control of the aircraft from the FO (consistent with normal procedures)[5] and applied heavier braking so the aircraft could make taxiway J2.

Approaching taxiway J2 for the first time, the captain thought it appeared to be a rapid exit taxiway (RET). The aircraft’s groundspeed was about 53 kt when, at 1441:42, the captain started to turn off the runway centreline towards taxiway J2, continuing to slow throughout the turn and passing over the left edge of runway 03 at 1441:47 at 35 kt.

Taxi and runway incursion

At 1441:51, once certain that VH-XZM would vacate runway 03 onto taxiway J2, the ADC issued VH-VZL’s flight crew a take-off clearance on runway 06, which was then read back by the crew of VH-VZL. At 1441:59, another aircraft, which had been following VH-XZM and was now on final approach to runway 03, also made a transmission on the ADC frequency.

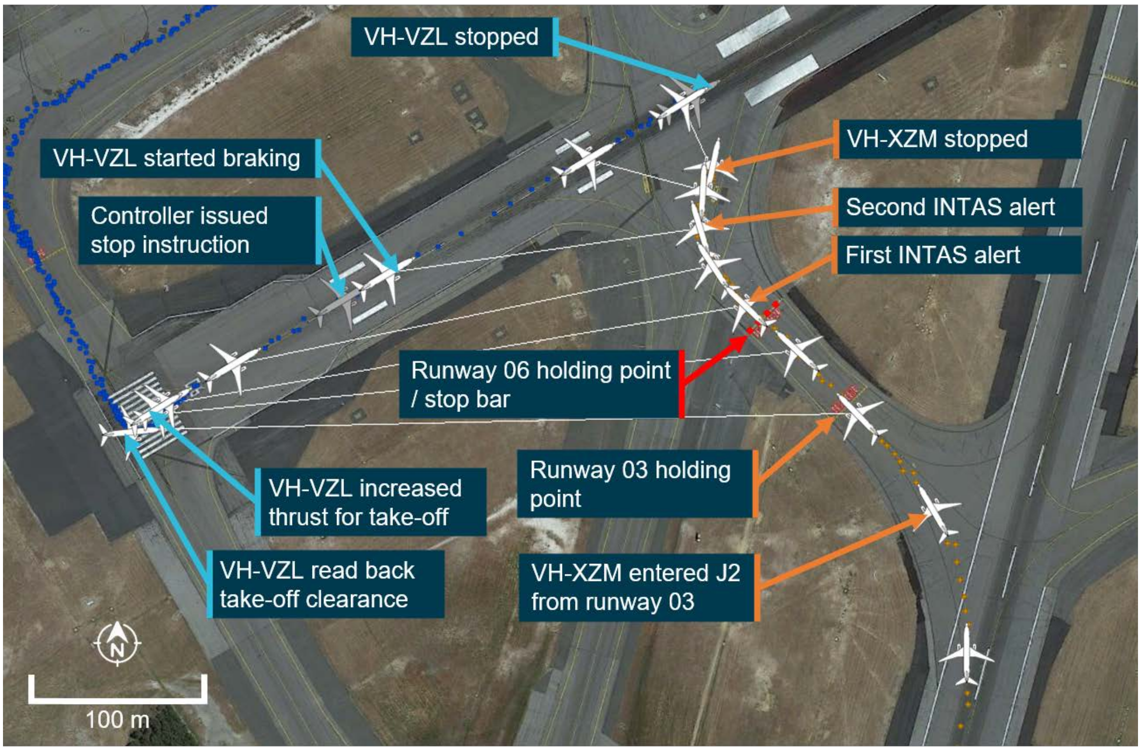
The captain of VH-XZM recalled hearing the ADC issue a take-off clearance to another Qantas aircraft but did not recall hearing the words ‘runway 06’ and did not associate it with a potential threat at the time. The FO did not recall hearing any ATC transmission at that time.

The SMC reported being aware that VH-XZM was on taxiway J2 and the flight crew would soon be calling on the SMC frequency to report they were at the holding point. However, when the ADC gave VH-VZL a take-off clearance, the SMC switched attention to other aircraft on the apron area, knowing that VH-XZM would not be able to cross runway 06 for a while.

Figure 4 shows the relative positions of VH-XZM and VH-VZL during the remainder of the occurrence sequence.

[5] It is standard operating procedure on the Boeing 737 for the captain to take control of the aircraft after landing. The 737 has a single steering tiller located on the captain’s side of the flight deck. The tiller provides nose wheel steering control while the aircraft is taxiing.

Figure 4: Overview of the runway incursion



White aircraft symbols show the aircraft positions at 5-second intervals. White lines show the angle between the two aircraft at some of those times. Labels show events that occur within 1 second of the aircraft's position illustrated.
Source: Google Earth, modified by ATSB

At 1441:55, VH-XZM passed over the holding point for runway 03 at a groundspeed of about 22 kt. At about this time, the FO assessed that the captain was still slowing the aircraft at a rate to stop at the runway 06 holding point; the FO was aware that they needed an ATC clearance to cross runway 06 and assumed that the captain would stop.

The FO then refocused their attention inside the flight deck and noticed that the Perth SMC frequency had not been pre-set as the radio's standby frequency. As a result, reference was made to the aerodrome chart to find the frequency to set. This led to a delay in contacting the SMC to receive taxi instructions. The captain recalled also briefly looking down to understand the reason for the delay, and telling the FO the required frequency.

Although being aware that stop bars had recently been installed at Perth, the captain recalled being surprised to see an illuminated stop bar ahead on the taxiway, and thought it strange that a stop bar would be positioned at that location. The captain believed they were on taxiway J1, which did not require a runway crossing, and rationalised that the stop bar had been mistakenly constructed with omnidirectional lighting[6] and that it was for aircraft taxiing from the opposite direction entering runway 03. The captain also thought that, given their current taxi speed and how quickly it appeared after exiting the runway, the stop bar could not be meant for their aircraft. The captain did not recall noticing any markings that identified runway 06. Consequently, they taxied over the illuminated stop bar and through the runway 06 holding point.

At 1442:01, the nose of VH-XZM passed the runway 06 holding point (with an illuminated stop bar) at a groundspeed of 17 kt. At 1442:04, in the tower, the integrated tower automation suite (INTAS) made the first of two aural and text alerts on the ADC's workstation. The aural alert comprised a synthetic voice stating 'warning runway zero six stop bar violation'. The alert was

6 Omnidirectional lighting is visible from all directions. Stop bar lighting is unidirectional (only visible from one direction).

designed to trigger when the aircraft was registered to be 8 m past the stop bar. At this time, the aircraft was travelling at about 14 kt.

Due to default settings within INTAS, no aural or text alert was provided on the SMC's workstation. The SMC later reported hearing the aural alert through a speaker on the ADC's workstation, and then saw VH-XZM entering the runway and VH-VZL rolling for take-off. At this time the SMC was part way through providing a pushback clearance to another aircraft and the flight crew of that aircraft then read back the clearance details on the SMC frequency.

At the time of the first INTAS alert, the flight crew of VH-VZL had just commenced rolling for take-off on runway 06 and were setting engine thrust. The ADC recalled having communication with VH-VZL and considered that, as VH-XZM had vacated runway 03, it should have transferred to the SMC frequency. Initially, a radio transmission from another aircraft prevented the ADC from transmitting on the ADC frequency. As soon as it stopped, at 1442:11, the ADC instructed VH-VZL's flight crew to 'stop immediately, stop immediately, runway incursion ahead'.

The captain of VH-VZL subsequently reported being aware of the other aircraft when it was taxiing on taxiway J2. When the stop instruction from the ADC was received, the captain was just starting to have an element of doubt as to whether the other aircraft would stop, and during the instruction initiated a rejected take-off by bringing the thrust levers back and braking. At that time the aircraft's groundspeed was 58 kt.

As VH-XZM's flight crew had transferred to the SMC frequency at some point before 1442:11, they did not hear the stop instruction issued to VH-VZL and were unaware of that aircraft's presence and proximity. The captain continued taxiing towards runway 06 at about 10 kt, and then observed another aircraft (a Boeing 787) ahead on the apron (Figure 5). It had recently pushed back and was now blocking taxiway J1. The captain reported being distracted by the aircraft on the apron as it blocked their intended route on taxiway J1 and now required their aircraft to turn onto taxiway A.

Figure 5: Aircraft on the apron as XZM taxis toward runway 06

Source: Perth Airport

At 1442:16, the second INTAS aural ('warning runway zero six occupied') and text alert activated while the flight crew of VH-VZL was rejecting the take-off. As with the previous alert, the second alert was not presented at the SMC's workstation. As the first INTAS alert was still active, the controllers now had multiple warnings sounding, which increased the noise level in the tower.

At the same time as the second INTAS alert, VH-XZM's FO contacted the SMC advising they were taxiing for bay 13. The SMC did not respond to that transmission, and subsequently could not recall whether that transmission was heard.

The captain of VH-XZM recalled seeing (in peripheral vision) an aircraft (VH-VZL) going faster than would be expected on a taxiway, then applying the brakes to stop the aircraft. The FO recalled that, when looking up, probably about the time the captain began braking, they realised they were in a different position to that expected and called 'stop, stop, stop'.

The captain applied VH-XZM's brakes at 1442:19, when the speed was 9 kt, and the aircraft came to a full stop at 1442:25. At 1442:29, VH-VZL came to a stop on runway 06, having just passed ahead of VH-XZM. The wingtip of VH-VZL passed about 15 m from the nose of VH-XZM at low speed.

At 1442:26, just before VH-VZL stopped, the SMC asked if VH-XZM was ‘on this frequency’ and the FO responded with ‘affirm’, their callsign, and the intended bay. The SMC advised VH-XZM’s crew that they had crossed a stop bar and had a runway incursion, and to hold position. The flight crew of VH-VZL were subsequently cleared to taxi back to runway 06 for departure. The flight crew of VH-XZM were cleared to taxi to bay 13.

Context

Personnel information

Flight crew of VH-XZM

The captain held an Airline Transport Pilot (Aeroplane) Licence (ATPL) and was appropriately qualified to conduct the flight. Having flown 737s since 2007, the captain had operated into Perth Airport many times, including three to four times in the last 4–5 months. Most of the landings at Perth were on runway 21 or 24, using taxiway J1 from runway 24. The captain had rarely landed on runway 03 and only recalled using taxiway D off that runway, and had not previously used taxiway J2. Although aware that stop bars had been installed at Perth Airport, and having encountered them at other airports, the captain had not previously encountered them at Perth.

The first officer (FO) held an ATPL and was appropriately qualified to conduct the flight. The occurrence flight was the third set of flights since completing FO training on the 737, having previously operated as an Airbus A330 second officer. The FO had landed at Perth on five previous occasions, including two landings on runway 03 (which had exited on taxiway D). The occurrence flight was the first time the FO had landed on runway 03 and vacated via taxiway J2.

Both flight crew were based in Brisbane. They both had 3 days off duty during 24–26 April 2018, then on 27 April they commenced a 3-day trip together. On 27 April they signed on at 0530 Eastern Standard Time (EST)[7] and flew a series of flights, ending their duty time at about 1530 EST. On 28 April, they signed on for duty at Gold Coast Airport about 0725 EST, then operated a flight from the Gold Coast to Sydney. Following a transit in Sydney they then commenced the flight to Perth. At the time of the occurrence both of them had been on duty for 10.3 hours. They described the workload during the day as not being significant or unusual. They departed Sydney about 1 hour behind schedule due to connecting aircraft, and reported not feeling any commercial pressure.

The flight crew's roster provided both flight crew with sufficient sleep opportunity in the nights prior to the occurrence. The captain reported having about 7 hours sleep the night before the occurrence and normal sleep in the nights before. The FO reported having a normal amount of sleep the night before the occurrence and the nights before that. Both flight crew reported being a little tired at the time of the occurrence. However, given the other available information, there was insufficient evidence to suggest they were experiencing a level of fatigue that has been demonstrated to adversely influence performance.

Air traffic controllers

At the time of the occurrence, Perth tower was staffed by two air traffic controllers:

- the aerodrome controller (ADC), who was responsible for controlling all aircraft and vehicle movements on all runways
- the surface movement controller (SMC), who was performing the combined duties of SMC (responsible for controlling all aircraft and vehicle movements on the airport aprons and other manoeuvring areas) and airways clearance delivery controller (responsible for issuing airways clearances to departing aircraft).

Both controllers were correctly endorsed for their roles. The ADC on duty at the time of the occurrence had over 30 years' experience and was fully endorsed for all roles in the Perth tower. The SMC had 3 years' experience at Perth tower (and prior experience overseas), and was endorsed for all roles in the Perth tower.

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[7] Eastern Standard Time (EST) was Coordinated Universal Time (UTC) + 10 hours, or Western Standard Time (WST) + 2 hours.

The controllers reported that aircraft movements had been 'quiet' in the period leading up to the occurrence, with only 4 or 5 aircraft movements occurring at intermittent times.

The ADC reported having about 8 hours sleep the night before the occurrence and normal sleep in the nights before. On 28 April, the ADC signed on for duty at 0730 WST and had several rest periods during the shift. At the time of the occurrence, the ADC had been on duty for 7.2 hours, due to sign off at 1530.

The SMC reported having a normal sleep the night before the occurrence and normal sleep in the nights before. On 28 April, the SMC signed on for duty at 1345, and had been performing the role for about 45 minutes prior to the occurrence.

Both of the controllers recalled feeling alert at the time of the occurrence and had sufficient sleep opportunity in the nights prior to the occurrence. There was no evidence to suggest they were experiencing a level of fatigue that has been demonstrated to adversely influence performance.

Meteorological information

At the time of the occurrence, the Perth automatic terminal information service (ATIS) broadcast the wind was variable at 5 kt with a maximum tailwind on runway 03 of 5 kt. The conditions were CAVOK[8] and the temperature was 28 °C. The ATIS also advised that stop bars were active at all runway holding points.

The flight crew of VH-XZM reported the weather conditions as fine with light winds and good visibility. The captain stated there was no tailwind during landing on runway 03. There were no reported concerns with sun glare or other factors affecting visibility for the flight crew of VH-XZM. The controllers stated the weather conditions were fine with no restrictions on visibility from the tower.

Closed-circuit television footage at the terminal verified all recollections of weather and visibility conditions made by flight crews and controllers.

Recorded information

On-board recordings

Both 737 aircraft involved in the occurrence (VH-XZM and VH-VZL) were fitted with a flight data recorder (FDR) and cockpit voice recorder (CVR) as required by the applicable legislation.

Qantas downloaded both FDRs and sent the digital files to the ATSB. Both FDRs included data over the period of the occurrence. This information has been included in this report where relevant.

Each CVR was capable of recording 2 hours of data, which would have included communications between the flight crew, communications with air traffic control and various flight deck sounds, alerts and warnings. The CVR for VH-XZM was not preserved before being overwritten during ground activities.[9]

There were no reported defects associated with VH-XZM.

Air traffic control recordings

Air traffic control (ATC) audio recordings and integrated tower automation suite (INTAS) data records were obtained from Airservices Australia. The audio recordings provided all relevant radio communications between controllers and flight crews, and the synthetic voice INTAS warnings.

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8 Ceiling and visibility okay (CAVOK): visibility, cloud and present weather are better than prescribed conditions. For an aerodrome weather report, those conditions are visibility 10 km or more, no significant cloud below 5,000 ft, no cumulonimbus cloud and no other significant weather.

9 Civil Aviation Order 82.5 (Conditions on Air Operators' Certificates authorising regular public transport operations in high capacity aircraft) required operators to preserve a CVR in the case of an immediately reportable matter.

INTAS data records provided aircraft position information that could be compared with other sources of recorded data.

Flight crew briefing requirements

Operator information

The Qantas *Flight Administration Manual* (FAM) outlined standard operating procedures and detailed guidance to flight crew on the conduct of briefings.

The FAM stated:

> The objective of a briefing is to ensure all Flight Crew understand and share a common mental model for the proposed plan of action.

Furthermore, it stated that for the briefings to remain effective they should be:

- **Interactive** – engaging all Flight Crew members and ensuring a practical understanding of what is proposed.
- **Threat and Error Management Based** – briefing points should include identification and assessment of threats. Plans for dealing with identified threat should be discussed. The depth of the briefing content should be commensurate with the assessed threat environment.
- **Concise and Relevant** – content must serve to refresh knowledge considered necessary for crew coordination. It is unnecessary to reiterate standard operating procedures or discuss every detail of published procedures as each Flight Crew member must review pertinent information and FMS [flight management system] setup in preparation for the briefing.

  Briefing emphasis should be directed to plans or requirements which vary from those routinely used.

  On a multi-sector tour of duty involving Australian ports, there is no requirement for repetition of items previously briefed for the same departure or arrival, provided that the Pilot In Command is satisfied that the pertinent information is understood by all Flight Crew.
- **Timely and Logical** – to assist delivery and understanding, briefings must be scheduled so as not to interfere with operational tasks and the content should follow a logical sequence based on phase of flight. The briefing framework must conform to the following structure and sequence:
  - Considerations with emphasis on threat identification, assessment and implementation of management strategies.
  - Normal operations with emphasis on sharing plans of action.
  - Contingency and non-normal aspects with emphasis on contingency planning.

For approach and arrivals at an airport, it was standard practice for the briefing to be completed prior to commencing the descent.

The FAM section 21.2.4.4 gave flight crew the following guidance:

> **Considerations** – identify and assess the threats and considerations that may affect the arrival plan which may include but not necessarily be limited to terrain, adverse weather, airport conditions, NOTAMs, aircraft maintenance status, RMS [route manual supplement] or specific state requirements, traffic, ATC, ground support and fuel conservation opportunities.
>
> **Normal Operations**
>
> - **Arrival and Approach** – brief chart page number, together with relevant charted requirements. For runways where there is no published instrument procedure the anticipated arrival plan should be briefed. Nominate planned approach procedures.
> - **Navigation and Altimetry** – brief the relevant navigation and altimetry requirements.
> - **Automation** – brief the planned level of automation to be used and the transition to manual flight.
> - **Landing** – brief landing flap configuration, level of reverse thrust and auto-brake setting for planned runway exit.

– **Contingency Planning** – brief contingency plans for all threats assessed as requiring crew management.

The FAM guidance did not specifically require flight crews to brief hot spot locations or describe how runway incursion threats would be mitigated.

Other guidance for flight crew briefings

International Civil Aviation Organization (ICAO) document 9870 *Manual on the Prevention of Runway Incursions* stated:

> The “before start” and “descent” briefings should also contain a complete review of the expected taxi routes with special attention to the hot spots.

Guidance from the United States Federal Aviation Administration (FAA) in 2012 called for operators to develop and implement specific procedures to prevent runway incursions. The FAA advisory circular AC 120-74B (*Parts 91, 121, 125, and 135 Flightcrew procedures during taxi operations*) emphasised that a thorough taxi briefing should include a review of the airport diagram and identify critical locations on a taxi route, including, but not limited to, hot spots, complex taxiway intersections and runway crossing points. In addition, the circular called for procedures that would require flight crews to describe how runway incursion threats would be mitigated: by briefing the timing and execution of checklists and communications, so that no flight crew member was preoccupied or head-down when approaching an active runway.

There was no CASA guidance regarding the inclusion of runway hot spots or incursion threats in pre-flight or in-flight briefings. The ATSB reviewed the documentation of two other Australian airlines and found that one specified a mandatory requirement for flight crews to verbally brief runway hot spots, and the other provided detailed guidance material regarding runway hot spots and recommended that flight crews verbally brief them.

Airport information

General information

Perth Airport had two runways. The main runway was oriented 03/21 and the cross runway 06/24 (Figure 2). Both were 45 m wide and had a 150-m wide flight strip.[10]

Preferred taxiway

Since 2014, the Aeronautical Information Publication (AIP) entry for Perth Airport stated the preferred exit taxiways for arriving aircraft on each runway and for different types of aircraft. The preferred taxiway for jet aircraft landing on runway 03 was J2 and for turboprop aircraft it was A6. The AIP stated that the preferred taxiways were to ‘ensure minimum runway occupancy time and support optimum spacing on final [approach]’.[11]

Data provided by Airservices Australia indicated that, from May 2017 to April 2018, about 24 per cent of all aircraft landing on runway 03 exited via J2. Data provided by Qantas showed that, of its 737 fleet landings on runway 03, about 44 per cent vacated runway 03 at taxiway J2. Qantas noted that its pilots preferred to exit runway 03 at taxiway D as it resulted in a shorter and more direct route to the terminal.

The AIP stated that, unless specified otherwise by ATC, an aircraft must promptly vacate the runway after landing without backtracking. There was no requirement under the AIP for an aircraft to use the first available taxiway.

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[10] The flight strip was an area surrounding the runway provided to reduce the risk of damage to aircraft running off a runway; it was not available for use by vehicles or aircraft.

[11] The preferred taxiways for different runways were agreed by the joint Airservices Australia and Perth Airport Capacity Enhancement group.

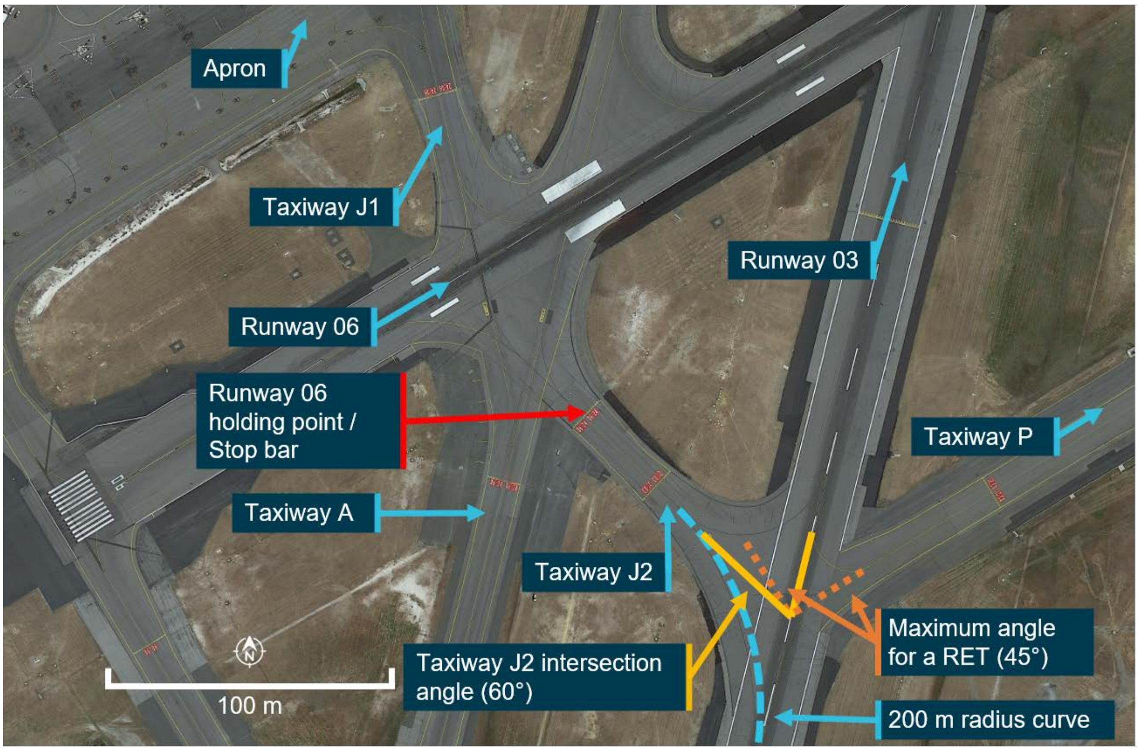
Taxiway J2

Arrangement

Taxiway J2 was located approximately 1,911 m from the threshold of runway 03. It led to a 6-way intersection comprising runway 06/24 and three other taxiways (Figure 6).

Taxiway J2 intersected runway 03 at a 60° angle. The straight distance from the edge of runway 03 to the runway 06 holding point was approximately 176 m, and the distance from the runway 03 holding point and the runway 06 holding point was about 70 m. The distance from the runway 06 holding point to the edge of runway 06 was about 102 m.

Figure 6: Taxiway J2 in relation to runways and other taxiways



All annotations are approximate and for illustration purposes only.
Source: Google earth annotated by ATSB

The Civil Aviation Safety Authority (CASA) outlined Australian requirements for aerodromes in Civil Aviation Safety Regulation (CASR) Part 139 and the associated Manual of Standards (MOS). As an airport operator licensed by CASA, Perth Airport was responsible for the safety of the aerodrome in accordance with those requirements.

The MOS section 6.3.3 *Taxiway Curves* defined the minimum curve radius required for taxiway design speeds, which are listed in Table 1. For taxiway J2, with a curve radius of 200 m, the taxiway design speed was about 31 kt. VH-XZM’s turn from the runway onto the taxiway was made at an average speed of 34 kt.

Table 1: Taxiway design speed for minimum radius of curve

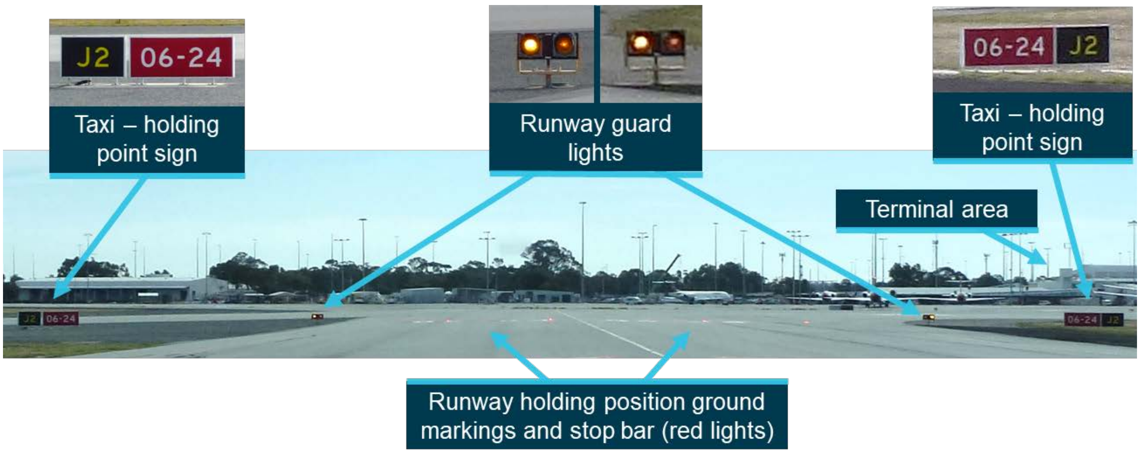
Taxiway design speed	Curve radius
20 km/h (11 kt)	24 m
30 km/h (16 kt)	54 m
40 km/h (22 kt)	96 m
50 km/h (27 kt)	150 m
60 km/h (32 kt)	216 m
70 km/h (38 kt)	294 m
80 km/h (43 kt)	384 m
90 km/h (49 kt)	486 m
100 km/h (54 kt)	600 m

Runway holding point markings

Perth Airport runway holding points (or runway-holding positions) were equipped with signage and ground markings to provide flight crews with visual cues indicating their position and proximity to a runway. Those markings identified the location where an aircraft was required to stop when it did not have an ATC clearance to proceed onto or to cross a runway.

For flight crew vacating runway 03 on taxiway J2, the holding point for runway 06/24 was marked with red and white ground markings identifying the runway ahead,[12] taxi-holding point signs and location signs. The runway holding point was also equipped with unidirectional[13] runway guard lights, which flashed continuously, and a stop bar (Figure 7).

Figure 7: View of the runway 06/24 holding point on taxiway J2



The central panoramic image was taken from the entrance to taxiway J2 from runway 03/21. The other images were taken from close to the runway holding point. All images were taken at a height lower than that of the flight crew of a Boeing 737.
Source: ATSB

Stop bars

Stop bars were intended to provide additional protection of runway/taxiway intersections to prevent runway incursions. They were a series of unidirectional lights at right angles to a taxiway centreline (Figure 8). The lights were spaced 3 m apart and located 0.3 m before a holding point. Stop bars showed red in the direction of approach to the stop bar. They were controlled by ATC

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12 Painted runway identifier markings (see Figure 8) were included in the ICAO standards and recommended practices but were not standard markings in the CASA MOS Part 139. The airport operator advised it sought CASA approval to install these markings as a runway incursion reduction measure.

13 Unidirectional lights are only visible in the direction of travel

and were independent of the runway guard lights. Additional raised lights at each end of the stop bar were not installed, nor were they required to be.[14]

Figure 8: Runway identifier (red and white markings) and stop bar (red lights) installed on taxiway J2

Source: ATSB

When seated in the normal position, the flight crew of a Boeing 737-800 cannot see the ground that is less than 11.5 m ahead of the aircraft's nose (due to the obstruction of the flight deck glareshield). Consequently, the VH-XZM flight crew's last opportunity to see the stop bar on taxiway J2 was at 1442:00, about 5 seconds after completing the turn onto the taxiway and 1 second prior to crossing the stop bar (Figure 9).

[14] Raised lights at the ends of stop bars were installed at other airports in Australia, such as Brisbane, Sydney and Canberra.

Figure 9: Last point when stop bar was visible from flight deck of VH-XZM

Source: Google Earth, modified by ATSB.

The AIP required flight crew to stop and hold their aircraft at all illuminated stop bars. Flight crew could only proceed to taxi an aircraft further once an ATC clearance to enter or cross a runway had been received and the stop bar lights had been switched off.

Stop bars were implemented at Perth on 30 March 2018. At the time of the occurrence (28 April 2018), all stop bars were reported to be operating correctly.

Other taxiways

In terms of the other taxiways off runway 03 (see Figure 2):

- Most taxiways intersected at 90° with a curve radius of about 100 m.
- Taxiway D intersected at 80° with a curve radius of about 60 m.
- Taxiways P intersected at 45° with a turn radius of 100 m, with 318 m between the edge of runway 03 and the next (taxiway) holding point.
- Taxiway N intersected at 45° with a turn radius of 100 m. In addition to taxiway J2, it was the only taxiway at Perth with a single holding point and a relatively short distance between the two runways. It led to a somewhat complicated four-way intersection. Two of the taxiways crossed runway 06/24 and shared a single holding point from taxiway N, set back about 120 m from the runway 06/24 flight strip. Both required a turn after the holding point to cross the other runway. The distance between the edge of runway 03 and the runway 06/24 holding point was about 350 m (with the first 280 m being a straight line).

Flight data analysed by Qantas indicated that the average exit speed of Qantas aircraft onto taxiway J2 over a 2-year period was 28 kt, compared with the average exit speed of 17 kt onto the tighter, near-right angle exit at taxiway D. The exit speed of VH-XZM was about 35 kt, and about 20 per cent of the landings over the 2-year period had an exit speed of 35 kt or higher (and about 5 per cent having an exit speed of over 40 kt).

Qantas reported that the distance between the runway 03 exit and the holding point for runway 06 on J2 at Perth was much shorter than any other runway exit taxiway leading directly to another runway on its 737 route network. The next shortest was about 397 m at Sydney Airport (for taxiway A2 off runway 34L that led to runway 25).

Rapid exit taxiway information

Requirements for rapid exit taxiways

As noted in *The occurrence*, the captain of VH-XZM thought that, when approaching taxiway J2 during the landing roll, the taxiway was a rapid exit taxiway (RET). Accordingly, the ATSB considered the design requirements for RETs.

The MOS defined a rapid exit taxiway (RET) as:

> A taxiway connected to a runway at an acute angle, designed and intended to allow landing aeroplanes to turn off the runway at higher speeds than are achieved on exit taxiways, thereby minimizing runway occupancy times.

It additionally noted:

> The provision of rapid exit taxiways is a financial decision for the aerodrome operator. The aerodrome operator should seek specialist advice on the geometric design of rapid exit taxiways.

The International Civil Aviation Organization (ICAO) specified standards and recommended practices (SARPs) for international aviation operations in a series of Annexes. ICAO Annex 14 (*Aerodromes, Volume 1 Aerodrome Design and Operations*) defined a taxiway as:

> A defined path on a land aerodrome established for the taxiing of aircraft and intended to provide a link between one part of the aerodrome and another, including:
>
> …c) Rapid exit taxiway. A taxiway connected to a runway at an acute angle and designed to allow landing aeroplanes to turn off at higher speeds than are achieved on other exit taxiways thereby minimizing runway occupancy times.

Annex 14 recommended that a RET should be designed with a curve radius of at least 550 m for certain types of runway (including those in Perth) to enable 93 km/h (50 kt) taxi under wet conditions. It also recommended that a RET should have a straight distance after the turn-off curve sufficient for an exiting aircraft to come to a full stop clear of any intersecting runway. There was no guidance regarding appropriate taxiway lengths, turn angles or curve radii.

ICAO also published other guidance about aerodrome taxiways. ICAO document 9157 (*Aerodrome Design Manual Part 2 Taxiways, Aprons and Holding Bays)* stated that the intersection angle of a RET with the runway should not be greater than 45° and preferably be 30°.

Neither the CASA MOS nor ICAO's Annex 14 provided restrictions or recommendations on direct access from one runway to another without an intermediate, transitional taxiway. The European Organisation for the Safety of Air Navigation (EUROCONTROL) in its November 2017 version of the *European Action Plan for the Prevention of Runway Incursions*, recommended:

> A RET should meet with a parallel taxiway, and never end directly onto another active runway (that is used for take-off/landing).

Similarly, the United States Federal Aviation Administration (FAA) Advisory Circular 150/5300 stated:

> Do not provide direct access from a high speed exit to another runway.

The Airports Council International *Runway Safety Handbook First Edition 2014* identified key elements to eliminate runway incursions, including:

- Rapid Exit Taxiways should be designed in such a way that crossing another runway via a rapid exit taxiway is not possible. A rapid exit taxiway should never be used for entry to a runway; and
- Complicated Taxiway Layouts linking adjacent runways – such as multi-taxiway intersections, Y-shaped taxiways, taxiways crossing high speed exits and taxiways connecting to V-shaped runways – should be avoided in the design. If any of these are unavoidable, mitigation measures for runway incursion should be included in the design.

Rapid exit taxiway identification

At airports equipped with RETs, aerodrome charts provided flight crews with information such as RET location, maximum design exit speed and lighting systems, if fitted. This information was included in text in the airport efficiency procedures section rather than annotated on a map of the aerodrome.

ICAO Annex 14 recommended aerodrome operators install rapid exit taxiway indicator lights (RETILs). RETILs consisted of six yellow lights adjacent to the runway centreline and configured in a three/two/one pattern spaced 100 m apart; the single light was 100 m from the start of the turn for the RET.

The Australian AIP detailed differences between Australian national aviation legislation and those specified by ICAO as SARPs. With regard to RETILs, Australia notified ICAO of a difference to the SARPs under the level of 'less protective, partially implemented or not implemented'. Accordingly, at the time of this occurrence, CASR Part 139 and the MOS did not require or recommend aerodrome operators to install RETILs.

Rapid exit taxiways in Australia

Taxiway J2 was not designated as a rapid exit taxiway (RET) and it did not meet the design requirements of CASA MOS or ICAO Annex 14 for a RET. There were no RETs at Perth.

RETs were provided at several other airports in Australia, including Brisbane, Melbourne and Sydney. None of these RETS had RETILs.

Runway incursion hot spots

Recommended practices for identification of hot spots on aerodrome charts

ICAO defined a runway incursion as 'any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft'.

ICAO document 9870 (*Manual on the Prevention of Runway Incursions*) defined a hot spot as:

> A location on an aerodrome movement area with a history or potential risk of collision or runway incursion, and where heightened attention by pilots/drivers is necessary.

The document stated that, once hot spots have been identified, suitable strategies should be implemented to either remove the hazard or to manage and mitigate the risk to be as low as reasonably practicable.

ICAO recommended that the local generation of AIP aerodrome charts show runway hot spots (see for example Figure 2). The criteria used to establish a hot spot on an aerodrome chart and the symbols to be used were contained in ICAO Annex 4 (*Aeronautical charts*), with more guidance provided in Annex 14 and document 9870.

Aerodrome charts for Perth

Aerodrome charts were published by Airservices Australia in the AIP. Jeppesen charts, used by Qantas, provided details similar to the AIP about the airport and taxiway layout and associated information, such as warnings and runway incursion hot spots.

Jeppesen charts identified the location of hot spots and marked the area of risk with a magenta box in accordance with the ICAO recommendation. Text on the aerodrome chart stated 'HS2 – Caution Runway Incursion Hot Spot'. No text or specific information was provided to explain the risk and reasons why previous runway incursions had occurred at those locations (in either the Airservices Australia or the Jeppesen charts).

Study of aerodrome chart effectiveness

In 2016, EUROCONTROL published a safety study report that examined how AIP hot spot information was transposed to commercially-produced aerodrome charts and promoted practices to help improve the accessibility, visibility and quality of the information. The study collected samples of AIP and commercial aerodrome diagrams for 64 European airports and a small number of samples from Australia, China and the United States for comparison purposes. It stated:

> Of those airports that did have Hot Spot information on their AIP charts, only 39% were judged to be effective or very effective. Effectiveness, in this case, being a combination of presentational clarity and usefulness of the information. However 45% of airport AIP charts were judged to be of no or low effectiveness.

The Australian samples included Adelaide, Darwin, Sydney and Perth. The report judged all of these AIP charts to be of low effectiveness, stating:

> The expanded graphic of the runway incursion Hot Spots are useful, but there is no text to enhance the pilot's understanding other than to use caution. Since it is not unreasonable to assume that pilots do exercise caution when taxying, the effectiveness of the Hot Spot information is low.

The report noted that in many countries, including Australia, there was variation in the manner in which hot spot information was presented at different airports.

The report also noted the following presentation styles that 'seemed to provide clarity and effectiveness' of hot spot information to flight crew:

- Each Hot Spot depicted by a clear bright red circle and joined to a red label box e.g. HS1
- Large tabulated textual information elaborating the action required of pilots in and around the Hot Spot. This may be on the main aerodrome diagram or on the obverse page if clarity is best served.
- The use of additional graphical boxes depicting the Hot Spots in greater detail. These additional boxes should be physically linked by lines or arrows to the Hot spot on the main diagram, if possible.
- Where the aerodrome diagram would otherwise be too cluttered to present Hot Spots effectively, the use of specific Hot Spot pages can be effective.
- The use of a colour-coded format which assists the depiction of runways, Hot Spot areas and normal taxiways.

In 2017, the FAA issued Safety Alert for Operators 17012 (*High collision risk during runway crossing*) that warned pilots of high-risk runway incursions and potential collisions in the first two-thirds of an active runway (with many such events occurring in the first third of the active runway). At Perth, the junction between taxiway J2 and runway 06 was within the first third of runway 06.

Runway incursions at Perth Airport

Airservices Australia recorded 44 runway incursions at Perth Airport between July 2015 and the day of the occurrence (Table 2). That equated to a rate of 11.6 incursions per 100,000 movements – higher than other major airports in Australia, including Sydney (2.0) and Melbourne (0.3).

Table 2: ICAO classification of the severity of runway incursions at Perth Airport, 1 July 2015 to 28 April 2018

ICAO severity classification	ICAO severity description	Number of runway incursions at Perth	Number of runway incursions on taxiway J2 at Perth
A	A serious incident in which a collision is narrowly avoided.	0	0
B	An incident in which separation decreases and there is significant potential for collision, which may result in a time-critical corrective/evasive response to avoid a collision.	1[a]	1[a]
C	An incident characterized by ample time and/or distance to avoid a collision.	10	4
D	An incident that meets the definition of runway incursion, such as the incorrect presence of a single vehicle, person, or aircraft on the protected area of a surface designated for the landing and takeoff of aircraft but with no immediate safety consequences.	31	10
E	Insufficient information or inconclusive or conflicting evidence precludes a severity assessment.	2	1

[a] Including the investigation occurrence.
Source: Airservices Australia

Of the 44 incursions, 16 involved taxiway J2 on both runway 03/21 and runway 06/24. For that reason, the taxiway intersection of J2, J1 and A with runway 06/24 was marked as a runway incursion hot spot on aerodrome charts.

The ATSB's occurrence database recorded 52 runway incursions at Perth involving turbine-engined aircraft (not under tow) over a 5-year period up to and including the 28 April 2018 occurrence. Exposure data was not available. Of these 52 incursions, the following types of incursion were excluded:

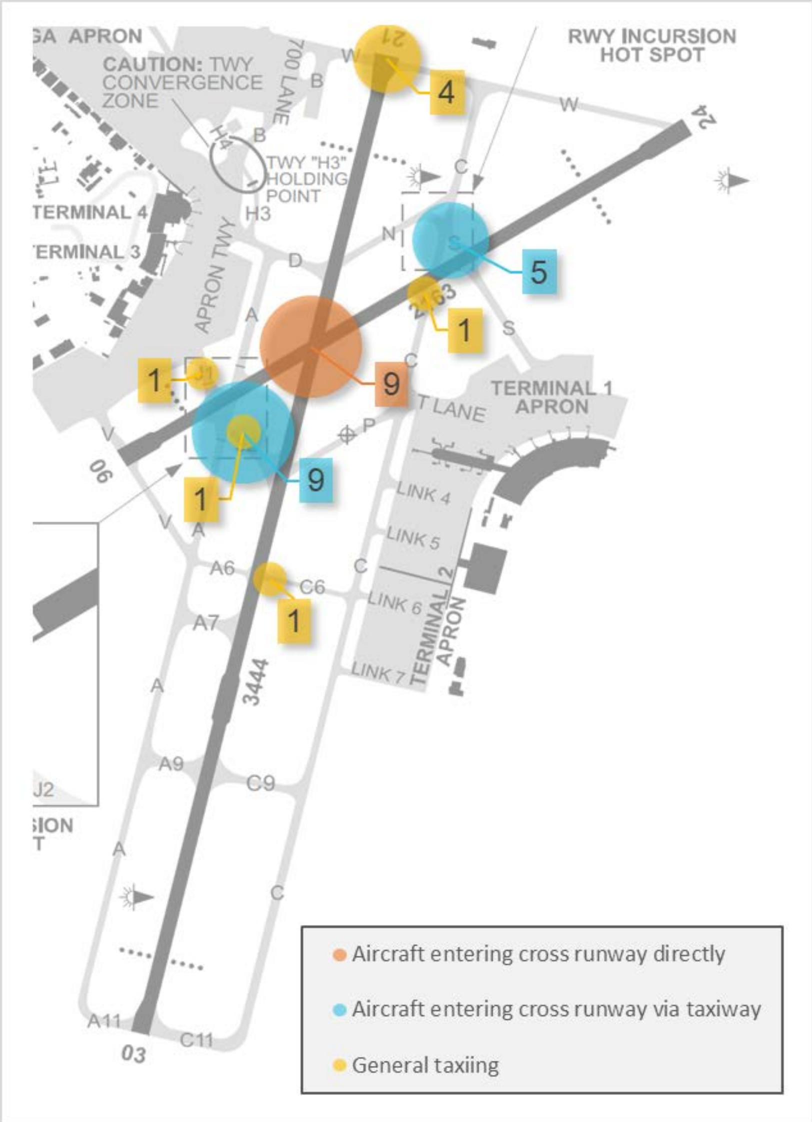
- 14 incursions that involved apparent ATC clearance errors (mostly not turning off stop bars after clearance was issued)
- 5 incursions involving a closed runway
- 2 incursions due to aircraft not departing the runway fully after landing.

Of the remaining 31 incursions, there were:

- 14 incursions on the cross runway via a taxiway immediately after landing (similar to the 28 April 2018 occurrence)
- 9 incursions that involved aircraft turning onto the cross runway instead of a taxiway
- 8 other incursions (general taxiing incursions).

Figure 10 shows the approximate location of incursions in these three groups, with most of the incursions on a cross runway via a taxiway happening near taxiway J2.

Figure 10: Selected types of runway incursion at Perth in a 5-year period



Source: Airservices, annotated by ATSB

Runway safety activities

ICAO have recognised runway safety as one of its highest priorities given it is currently one of the most significant threats to global aviation safety. In response, in 2011 the ICAO Runway Safety Programme (RSP) promoted the establishment of runway safety teams (RSTs) at airports as an effective means to reduce runway related accidents and serious incidents.

As part of Australia's State Safety Programme, a National Runway Safety Group (NRSG) was established to perform a national advisory and coordination role, and promote the establishment and effectiveness of local runway safety teams (LRSTs). It utilised intelligence from these forums and other sources to develop and implement national strategies to improve runway safety and reduce runway related accidents and incidents.

An LRST consisted of local representatives addressing local runway safety issues. The purpose of an LRST was to identify current and potentially emerging issues related to runway safety and implement initiatives to assure the continuing safety of operations at their aerodrome.

Perth Airport had an LRST which met biannually and included the aerodrome operator, Airservices Australia, airline operators and other stakeholders operating at the airport.

Air traffic control information

Air traffic control at Perth Airport

Airservices Australia provided a 24-hour air traffic service at Perth Airport. The controllers responsible for all aircraft and vehicle movements on taxiways, runways and in the immediate vicinity of the airport were located in a tower on the eastern side of runway 03/21 (Figure 2).

The distance from the tower to the runway 06/24 holding point on taxiway J2 was about 1,200 m, and from the tower to the runway 06 threshold was about 3,000 m.

At the time of the occurrence the airport traffic flow was operating in a North flow. This permitted the most efficiency and therefore achieved the most operating capacity at Perth. A North flow traffic pattern had departures from both runway 03 and 06 and arrivals on runway 03.

Runway crossing procedures

The Australian AIP provided flight crew of domestic aircraft with procedures to follow when taxiing after landing. It stated:

> 2.16.2 After landing, unless specified otherwise by ATC, an aircraft must comply with the following:
>
> a. Promptly vacate the runway without backtracking.
>
> b. Change from the aerodrome frequency to the SMC frequency (where established) when vacating the runway strip, and obtain an ATC taxi instruction.
>
> c. Not cross any runway that intersects the taxi route unless in receipt of a taxi instruction and a "CROSS RUNWAY (number)" instruction from ATC…

The ICAO *Manual on the Prevention of Runway Incursions* outlined best practice for radio transmission guidelines and techniques. It stated:

> Communication with any aircraft using the runway for the purpose of taxiing should be transferred from the ground controller to the aerodrome controller prior to the aircraft entering/crossing a runway.

The requirement for domestic aircraft to automatically[15] transfer to the SMC frequency when vacating the runway strip had been in place since prior to 2003. In June 2010 Airservices Australia commenced a trial of aircraft and vehicles being on the ADC frequency when crossing runways in line with the ICAO recommendation. The trial was conducted at Sydney, Cairns, Brisbane, Coolangatta, Perth, Adelaide and Broome.[16]

A post implementation review found no evidence that the trial procedures reduced the risk associated with runway incursions. It also identified a number of safety issues and concerns, including the reduction in ADC and SMC situational awareness at airports where crossing of active runways was required (including crossing runway configurations such as at Perth). Airlines involved in the trial agreed at that time that the trial should be ceased. Consequently, Airservices Australia returned the procedures to the pre-trial requirements of the AIP (as stated above).

Qantas advised that the ICAO-recommended approach to runway crossings, with the crossing aircraft on the ADC frequency, was used overseas in countries such as the United Kingdom and the United States. The ATSB identified that other countries such as New Zealand used a similar approach to that specified in the Australian AIP, with aircraft required to automatically transfer to the SMC frequency after landing.

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15 In this context, automatically means that the controllers do not instruct the flight crews to change frequency.

16 The trial procedures required a flight crew to automatically switch to the SMC frequency when vacating a runway after landing (unless the ADC advised otherwise). They would then be asked to change back to the ADC frequency before being cleared to cross the runway.

Integrated tower automation suite

Tower controllers were responsible for separating aircraft visually but used a range of systems at their workstations to assist with performing that task. Each station in Perth tower was fitted with the integrated tower automation suite (INTAS), which included the advanced surface movement guidance and control system (A-SMGCS).

The INTAS provided controllers with electronic flight and operational information to enhance airport efficiency. The system combined flight and operational data, surveillance and voice communications into a single integrated, control tower-specific layout. Controller workstations were equipped with four customisable touch screens that displayed electronic flight strips, operational information, weather, terminal area radar displays, and, where available, surface surveillance data through the A-SMGCS.

The A-SMGCS provided automatic identification of all aircraft and transponder-equipped vehicles at Perth Airport. Using the collection of that surveillance data from multiple sources, the system provided controllers with an electronic picture of what was happening on the ground at any time. Additionally, the system added to a controller's situational awareness by predicting potential conflicts between vehicles and aircraft, and multiple aircraft movements, before they could occur. Those protections included runway incursions by aircraft or vehicles. Visual and aural alarms alerted controllers to potential problems, enabling them to take early corrective action.

During the implementation of INTAS in the Perth tower, the system was configured with associated alert settings assigned to each controller's position. The selection of a role (including combined position roles) by the tower shift manager automatically triggered the associated system alert settings that were assigned to each role in the INTAS adaptation settings.

At the time of the occurrence, due to the configuration of the Perth tower INTAS, when an SMC was operating the combined workstation roles of SMC, airways clearance delivery (ACD) and shift manager, the A-SMGCS alerts were off. This inhibited the SMC from receiving an aural and visual stop bar violation alert (and runway occupied alert) at their workstation.

Emergency response actions

The Australian *Manual of Air Traffic Standards* (MATS) defined a safety alert as:

> The provision of advice to an aircraft when an ATS Officer becomes aware that an aircraft is in a position which is considered to place it in unsafe proximity to terrain, obstructions or another aircraft.

The manual also stated:

> Unless the pilot has advised that action is being taken to resolve the situation or that the other aircraft is in sight, issue a Safety Alert prefixed by the phrase 'SAFETY ALERT' when you become aware that an aircraft is in a situation that places it in unsafe proximity to:
>
> a) terrain;
>
> b) obstruction;
>
> c) active restricted or prohibited areas; or
>
> d) other aircraft.

In addition, the manual stated:

> Do not assume that because another Controller has responsibility for an aircraft that an unsafe situation has been observed and a Safety Alert or avoidance advice has been issue.

The MATS procedures for aerodrome controllers stated that, for cancelling a take-off clearance:

> Only cancel a take-off clearance once an aircraft has commenced take-off roll in circumstances where an aircraft is in imminent danger e.g. 'STOP IMMEDIATELY (repeat aircraft callsign) STOP IMMEDIATELY (reason)'. Accompany any instruction to cancel take-off with a description of the nature of the emergency.

Compromised separation recovery training

Separation between aircraft is considered to be compromised when separation standards have been infringed, or where separation assurance is absent to the extent that a breakdown of separation is imminent.

In order to help ensure controllers provided effective response actions when separation is compromised, they undertook compromised separation recovery (CRT) training. The ATSB has previously noted limitations with the provision of such training by Airservices Australia and the Department of Defence to their controllers in several investigation reports. In 2014 and in 2016, Airservices undertook a series of actions to improve its CRT training.[17]

The ATS Training Operations Manual stated in 2014:

> Compromised separation recovery training must be included in all ATC endorsement training courses, and in particular, skills-based training in the simulator. The training must be assessed for competency…
>
> EGM [Executive General Manager] ATC has determined that all operational staff must successfully complete annual training and assessment in compromised separation recovery training. It is a mandatory requirement that all controllers are assessed in skills-based simulator Compromised Separation Recovery training at intervals not exceeding three years.

In September 2020, Airservices Australia confirmed that, since 2012, all endorsed controllers were required to complete the knowledge based component of compromised separation recovery training as part of the annual refresher training program. It also advised:

> The skills based component [of CRT training] only applies to tower controllers that hold the ADC endorsement. Given the role and responsibilities of a surface movement controller this continues to be appropriate. Separation on the manoeuvring area is a joint pilot controller responsibility and there are no defined separation standards.
>
> The skills based compromised separation training scenarios do not align with the responsibilities of an SMC. All SMC endorsed controllers are trained and assessed at recognising ground conflicts and taking action as required commensurate with the risk of the situation using standard phraseology and taking into consideration aspects of the local operational context. The records of such training is maintained in individual training files.
>
> In addition all controllers that complete a tower course do destination specific CSR exercises as a part of the aerodrome control course element.
>
> … all SMC endorsed controllers are trained and assessed at recognising ground conflicts and taking action as required commensurate with the risk of the situation using standard phraseology, as such no further rationale is required.

As noted in *Air traffic controllers*, both of the controllers involved in the 28 April 2018 occurrence sequence held an ADC endorsement, and therefore had undertaken skills-based as well as knowledge-based CRT training. The ADC reported the most recent training included a stop bar violation and runway incursion at Perth.

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17 These safety actions are summarised in ATSB AO-2014-074, Loss of separation assurance involving A330 9V-STQ and A320, VH-VFH, near Tindal, Northern Territory, 24 April 2014. Available at www.atsb.gov.au.

Safety analysis

Introduction

After landing on runway 03, VH-XZM vacated onto taxiway J2 and crossed the runway 06 holding point, with an illuminated stop bar, without an air traffic control (ATC) clearance. The aircraft continued to taxi toward runway 06. The aerodrome controller (ADC) received aural and visual alerts and instructed the crew of another aircraft (VH-VZL) taking off from runway 06 to stop immediately. The flight crew of the departing aircraft rejected their take-off, preventing further escalation of the occurrence.

This analysis will firstly discuss flight crew situational awareness, mental models and approach briefings associated with VH-XZM's incursion onto runway 06. It will then discuss the design characteristics of taxiway J2 that increased the risk of incursion into runway 06/24. Finally, it will discuss a range of other safety factors identified during the investigation.

Flight crew situational awareness and mental model

The captain's mental model of the expected taxi route from landing on runway 03 to the parking bay was incorrect. Instead of having to cross runway 06 on taxiway J2, the captain expected to be on a taxiway that connected straight to the apron and did not have cross the other active runway.

This incorrect mental model developed due to a combination of factors:

- The captain's prior experiences landing at Perth had not used taxiway J2, instead generally landing on runway 03 and vacating at taxiway D or, more commonly, landing on runway 24 and vacating at taxiway J1. Both of these taxiways led directly onto the apron area with no runway crossing.
- The captain's intention on this occasion was to use taxiway D, expecting they would be using taxiway D up until after they landed on runway 03.
- When taxiways were discussed during the approach briefing, the captain was referring to the apron chart rather than the full aerodrome chart, and this smaller chart did not include runway 03 or the full length of taxiway J2. When the first officer (FO) briefed that taxiway J2 needed to cross runway 06, the captain believed the FO was referring to crossing runway 06 while still on runway 03, and did not discuss this different (and incorrect) understanding with the FO.
- The approach briefing did not include a discussion of the airport's known hot spots, including the hot spot associated with taxiway J2 (see also *Approach briefing*).

After landing, the captain realised that the request for taxiway D had not been made and quickly re-planned an exit onto taxiway J2, although continuing to have the same expectation that they not need to cross an active runway to reach the apron.

The runway holding point markings and warning lights would normally provide enough cues that an aircraft was approaching a runway holding point. In this case these cues were also supplemented by the very salient illuminated stop bar. However, although the captain saw the stop bar, it was not identified as a problem and no revision was made to the mental model of the taxiways, instead rationalising in a time-compressed situation that the stop bar had been installed incorrectly.

This behaviour is consistent with confirmation bias, or the tendency for people to seek information that confirms their hypotheses, interpret ambiguous evidence as supporting their hypotheses, and either discount or not seek information that contradicts their hypotheses (Wickens and others 2013). Confirmation bias is an inherent aspect of human decision-making and has been demonstrated to occur in a wide range of contexts.

Workload and distraction

High workload and time pressure lead to a reduction in the number of information sources a person will search, and the frequency or amount of time these sources are checked (Staal 2004). They also result in people conducting tasks with simpler strategies, relying on responses or strategies with which they are familiar, and persevering with a response or strategy even when it has proven to be unsuccessful (Staal 2004, Wickens and others 2013). In addition, people are likely to miss important cues and experience difficulty integrating disparate pieces of information and making sense of them (Burian and others 2005). Associated with the reduced search of information sources and increased perseverance, the influence of confirmation bias will be enhanced (Wickens and others 2013).

The flight crew’s overall workload during the approach and landing was not abnormally high. However, workload and distraction at key points in time combined together to result in a situation where the problem with the captain’s mental model was not detected and corrected.

During the approach phase, the captain's workload as pilot monitoring was increased due to the FO’s low level of experience and air traffic control's (ATC’s) request for a high-speed descent. This workload contributed to an omission of routine secondary tasks prior to landing, such as requesting a taxiway D exit from the tower and pre-setting the surface movement control (SMC) frequency in the radio’s standby frequency position.

These omissions were examples of prospective memory errors. Prospective memory relates to an intention to perform an action at a later time, and a delay between forming the intention and acting on it. It is known to be vulnerable to failure, and has been associated with many aviation accidents and incidents (Dismukes 2006). Conditions that increase this vulnerability include the delay between the intention to do a task and the execution of the task being filled with other activities, an interruption to a task sequence, and the cues or prompts to retrieve the intention from memory not being explicit. Neither of these tasks was associated with a specific checklist item (and by themselves were not important enough to be checklist items), and their omission was not detected until after landing.

After landing, when the captain realised the omission in not requesting taxiway D, the normal workload associated with landing was increased, associated with replanning the exit onto taxiway J2 while taking over control of the aircraft.

During the taxi phase, there was less time than would normally be the case to detect the problem. As the aircraft was crossing the runway edge, the runway 06 holding point was only about 176 m away. The captain’s delayed realisation that they needed to exit on taxiway J2, and misidentification of taxiway J2 as a rapid exit taxiway (RET), meant the aircraft entered J2 at a higher groundspeed than usual. The relatively high exit speed and relatively short distance to the runway 06 holding point meant that the flight crew only had limited time after leaving runway 03 to identify the problem before reaching the holding point.

During this period, a series of distractions occurred. More specifically:

- After vacating runway 03, the FO focussed attention inside the flight deck for a period of time to select the SMC frequency, instead of performing the more safety critical task of monitoring the aircraft's taxi path as it approached a known runway incursion hot spot. The FO assumed the captain would be stopping at the holding point and, focused on changing frequency and contacting the SMC, did not see that they had passed the holding point until about the time the captain was braking to stop.
- When approaching the holding point, the captain briefly went heads down to gain an understanding for the delay in changing to the SMC frequency and then advised the FO of the applicable SMC frequency. This reduced the time available to notice and comprehend the holding point signs, warning lights and stop bar lights ahead.

After passing the holding point, the presence of runway 06 ahead still provided an indication of a potential problem. However, the captain was distracted by the presence of another aircraft on the apron. This focused attention on the distant apron area and reduced the ability to visually identify the runway immediately in front of the aircraft. The FO was still primarily focused inside the flight deck during this period.

Approach briefing and approach briefing guidance

The approach briefing was the best opportunity for the flight crew to have established a shared and correct understanding of the requirements for the remainder of the flight, including the taxiway options. However, as already noted, they did not specifically discuss the taxiway J2 hot spot during the approach briefing, even though the FO had identified it on the aerodrome chart. Had the topic of the hot spot been raised and discussed in the briefing, as well as the main reason why it was a hot spot (that it led to another runway), the captain's mental model of the taxiway J1/J2 layout would probably have been enhanced.

The International Civil Aviation Organization (ICAO) has emphasised that flight crews should prepare well in advance for departure and arrival at any airport, including reviewing hot spots before taxiing from the gate and prior to beginning descent. Accordingly, departure and approach briefings should contain a complete review of not just the expected taxi routes but potential routes as well, with special attention to any hot spots.

Qantas provided detailed guidance to flight crews on the content of approach briefings. Hot spots should have been considered a threat under the threat and error management section of the briefing guidance. However, since that briefing guidance contained no specific requirement to brief hot spots or runway incursion threats, it is likely that the presence of hot spots on a taxi route would not always be noted by a flight crew.

Although the aerodrome chart for Perth identified that the area around taxiway J2 was a runway incursion hot spot, it did not provide specific information about the nature of the threat or why it was a hot spot. Such information would better enable flight crews to understand how the hot spot may affect them. If flight crews are to effectively identify and plan mitigating actions to avoid runway incursions, they should be provided with detailed information to assist their understanding of the common reasons why previous flight crews have incurred a runway at particular locations.

Taxiway location and design

Airservices Australia data identified that the rate of runway incursions at Perth Airport was significantly higher than other major airports across Australia. A significant proportion of the Perth incursions occurred on taxiway J2 and, accordingly, it was designated as a hot spot. To assist with minimising the risk of incursions, stop bars and CASA approved runway identifier markings (in addition to other holding point markings and lights) had recently been introduced.

In addition to providing salient or conspicuous markings and cues about the position of a holding point, it is also important to ensure flight crews are provided sufficient time during a high workload period after landing to identify and comprehend runway holding point visual cues and to allow for ATC to intervene, if required, before an aircraft incurs a runway.

Taxiway J2 was not a rapid exit taxiway (RET), but it had some similar qualities: a relatively shallow intersection angle and a relatively wide curve radius. These characteristics led some pilots to use higher speeds when exiting runway 03. Although the intersection angle was not acute enough to actually be a RET, the angle would be difficult to judge while approaching it from the runway.

Flight data showed VH-XZM entered taxiway J2 at about 35 kt, which was slightly higher than the taxiway design limit of 31 kt. Flight data analysis of other flights provided by Qantas showed its aircraft commonly vacated runway 03 onto taxiway J2 at a relatively high speed.

In addition, taxiway J2 had a relatively short distance from the exit from runway 03 to the runway 06 holding point. This meant that flight crews had less time to see the holding point markings and an illuminated stop bar, especially if taxiing at higher speeds.

Taxiway J2 also led to a relatively complicated runway crossing point, with other taxiways intersecting at the same point. A complicated intersection can be difficult for crews to navigate and can draw their attention.

Overall, the location and design of taxiway J2 significantly increased the risk of a runway incursion on runway 06/24 for aircraft landing on runway 03. In particular, the following features made taxiway J2 problematic:

- a relatively shallow intersection angle from runway 03
- a wider than usual entry curve radius
- a relatively short distance from the turn to the runway 06 holding point
- the next intersection leading directly to a runway rather than a parallel taxiway
- the next intersection being relatively complicated
- the intersection adjoining the first two-thirds of runway 06.

In addition, the risk associated with taxiway J2 and runway incursions was exacerbated by it being made the preferred exit for landing off runway 03. Although many flight crews elected to use taxiway D instead, this required the crew to proactively make that request.

The introduction of stop bars in March 2018 would certainly have reduced the risk but, depending on the situation, not eliminated the risk. Although the exact sequence of events associated with this particular occurrence would have been difficult to predict beforehand, there was undoubtedly an increased risk of runway incursions that needed to be managed, and a range of scenarios that could have resulted in a high-risk runway incursion given the inherent limitations of the taxiway J2 location and design.

As previously noted, taxiway J2 had some features that would have made it appear similar to a RET. Flight crews would normally become aware of the existence of a RET from tables of information about an airport in the aerodrome charts. However, a flight crew may forget or may not brief the existence or absence of a RET among the potential taxiways that could be used. At the time of the occurrence there was no requirement in Australia for airports to use indicator lights at RETs to distinguish them from other taxiways, so there was no immediate way to identify a taxiway as a RET or otherwise during the landing. However, unless all RETs were equipped with the appropriate indicator lights, the absence of indicator lights at a particular taxiway may not be that effective as a cue. Overall, unless briefed otherwise, it would be generally safer for a flight crew to assume that a taxiway was not a RET and adjust the aircraft's speed appropriately.

Air traffic control response

The ADC became aware of the problem on receipt of the first integrated tower automation suite (INTAS) alert. The ADC considered that, as VH-XZM had vacated and was clear of runway 03, the flight crew would most likely have changed over to the SMC frequency and therefore would have been unable to hear any safety alert instructions on the ADC frequency. Instead, an instruction was issued to VH-VZL to stop immediately.

A research study showed that the average time for tower controllers to act in response to a system alert was 4.6 seconds with a mean response duration of 2.3 seconds, with maximum response times being 8.1 seconds and 5.3 seconds respectively (Sanchez and others 2009). In this occurrence, the ADC transmitted the stop immediately instruction to the flight crew of VH-VZL about 7 seconds after the first alert, a time which included a period of blocked frequency from another aircraft transmitting.

The ADC's action was effective in mitigating the consequence of the runway incursion. The 'stop immediately' instruction was simple and easily comprehended by the captain of VH-VZL, who was actively monitoring the developing situation and responded promptly to the ADC's instruction.

However, although VH-VZL's flight crew received a timely and clear instruction from ATC, VH-XZM's flight crew did not receive any communication from ATC during the period after the first INTAS alert (1442:04) until 1442:26, when the SMC asked the flight crew if they were on the SMC frequency. This was after the captain had commenced braking (1442:19), and 10 seconds after the FO made initial contact with the SMC (when the FO was unware of the problem).

The exact reasons why the SMC did not issue an alert and instruction to the flight crew of VH-XZM are unclear. In response to the first INTAS alert, the SMC was aware of the developing problem. However, at that stage there may have been some doubt regarding whether the flight crew had switched over to the SMC frequency. In addition, the SMC was in the progress of providing a pushback clearance to another aircraft. The SMC had received training in issuing stop instructions as well as compromised separation recovery training.

The second INTAS alert at 1442:16 was broadcast on the ADC workstation's speaker at the same time as the VH-XZM FO's first transmission on the SMC frequency, to which the SMC did not reply. The SMC may have focussed on the more relevant event—the second INTAS alert—at this time and as a result did not process VH-XZM's transmission. Nevertheless, even after hearing the ADC provide the other aircraft with a stop instruction (1442:11), a prompt instruction to VH-XZM was warranted to further minimise any potential collision risk. A stop immediately instruction over any frequency that the flight crew might be using would have led to a more rapid response from that flight crew.

Although not directly related to this occurrence, the investigation identified some limitations with ATC processes that increased the potential risk of other occurrences:

- Due to the way INTAS was configured at Perth, the SMC's workstation did not directly receive INTAS alerts if the SMC position was combined with other positions. This meant that an SMC may not have received a salient warning that an aircraft under their control was at risk of collision. In this case, the SMC's awareness of the runway incursion was raised as a result of the INTAS aural alert played through a speaker on the ADC's workstation, but in other situations an SMC may not identify such an alert.
- Communication practices for runway crossings at Australian airports differed from those recommended by ICAO and used in some countries overseas. According to ICAO, runway crossings should be managed by the ADC, which ensured that flight crews of aircraft crossing a runway were aware of any instructions being issued to aircraft using that runway. In Australia (and some other countries), runway crossings were handled by the SMC and not the ADC. Having two aircraft on a runway at the same time but not requiring them to be on the same frequency does create the potential for flight crews not to be aware of the presence of the other aircraft at a critical point in time. However, Airservices Australia reported that it trialled a version of the ICAO-recommended approach and determined it did not reduce the risk of runway incursions and instead it introduced new safety issues and concerns in the Australian environment, including a potential reduction in controller situational awareness.
- Depending on how it was implemented, the ICAO-based approach could have required a flight crew to transfer to the SMC frequency, before the SMC then transferred them back to the ADC frequency prior to crossing the runway, which would have increased the complexity of communications at a location such as Perth Airport for aircraft landing on runway 03 and exiting on taxiway J2. One option that could have assisted with managing the unique problems associated with taxiway J2 was for the ADC to require flight crews landing on runway 03 and vacating on taxiway J2 to remain on the ADC frequency until after they crossed runway 06. However, introducing a unique approach to managing radio frequencies at one specific location in Australia could also increase risk. Alternatively, local procedures could have

included advising a flight crew landing on runway 03 and exiting at taxiway J2 of the crossing runway hazard ahead.

Findings

From the evidence available, the following findings are made with respect to the runway incursion involving a Boeing 737, registered VH-XZM, which resulted in a rejected take-off involving a Boeing 737, registered VH-VZL, at Perth Airport, Western Australia on 28 April 2018. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Safety issues, or system problems, are highlighted in bold to emphasise their importance. A safety issue is an event or condition that increases safety risk and (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operating environment at a specific point in time.

Contributing factors

- The captain developed an incorrect mental model of the exit taxiways off runway 03, believing the aircraft would not have to cross runway 06 after exiting on either of the potential taxiways (J2 or D). As a result, the captain did not expect to cross a runway holding point or stop bar and, upon seeing the stop bar was illuminated, incorrectly thought that it must only apply to aircraft coming from the other direction.
- During the approach phase, the captain's workload as pilot monitoring was increased due to the first officer's low level of experience and air traffic control's request for a high-speed descent. This workload contributed to the omission of routine secondary tasks, such as requesting a taxiway D exit from the tower and pre-setting the surface movement control frequency.
- After vacating runway 03, the first officer focused inside the flight deck for a period of time to select the surface movement control frequency, instead of performing the more safety critical task of monitoring the aircraft's taxi path as it approached a known runway incursion hot spot.
- When approaching the holding point for runway 06, the captain briefly focused inside the flight deck to gain an understanding for the delay in changing to the next frequency. This reduced the time available to notice the holding point signs and lights ahead.
- The captain taxied passed the runway 06 holding point (with an illuminated stop bar) without an air traffic control clearance.
- After taxiing passed the illuminated stop bar, the captain was distracted by the presence of another aircraft on the apron. This focused the captain’s attention on the distant apron area, reducing the likelihood of visually identifying the runway immediately in front of the aircraft.
- During the approach briefing, the flight crew discussed taxiway J2 and taxiway D, but the flight crew did not discuss the potential threat of the hot spot associated with taxiway J2.
- **Although Qantas provided detailed guidance to flight crews about the content of departure and approach briefings, it did not specifically require aerodrome hot spots to be briefed. [Safety issue]**
- Although some aerodrome navigational charts in Australia had identified hot spot locations, they generally provided limited explanatory information to enhance flight crew understanding or awareness of why the hot spot was there and what actions they could take to mitigate the associated risk.
- **The location and design of taxiway J2 at Perth Airport significantly increased the risk of a runway incursion on runway 06/24 for aircraft landing on runway 03. Taxiway J2 was published as the preferred exit taxiway for jet aircraft and, although mitigation controls were in place, they were not sufficient to effectively reduce the risk of a runway incursion. [Safety issue]**

- Although the flight crew of VH-VZL taking off on runway 06 were provided with an instruction to stop immediately to reject their take-off, no safety alert or instruction was provided to the flight crew of VH-XZM during the period between when the controllers received a stop bar violation alert (1442:04) and the captain applied the brakes at 1442:19.

Other factors that increased risk

- **Airservices Australia's configuration of the integrated tower automation suite (INTAS) at Perth Airport had resulted in a situation where controllers performing some combined roles had the INTAS aural and visual alerts inhibited at their workstation. As a result, controllers performing such combined roles would not receive a stop bar violation alert or runway incursion alert at their workstation. [Safety issue]**

Other findings

- The stop bar alert and the aerodrome controller's high level of situational awareness led to a timely instruction to the flight crew of VH-VZL to stop immediately.
- The high level of situational awareness of the VH-VZL flight crew significantly aided their immediate action to reject their take-off on runway 06 following the controller's instruction.

Safety issues and actions

The safety issues identified during this investigation are listed in the Findings and Safety issues and 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 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 directly involved parties are provided with a draft report and invited to provide submissions. As part of that process, each organisation is asked to communicate what safety actions, if any, they have carried out or are planning to carry out in relation to each safety issue relevant to their organisation.

Depending on the level of risk of the safety issue, the extent of corrective action taken by the relevant organisation, or the desirability of directing a broad safety message to the aviation industry, the ATSB may issue safety recommendations or safety advisory notices as part of the final report.

Operator guidance for flight crew briefing of aerodrome hot spots

Safety issue number:	AO-2018-032-SI-01
Safety issue owner:	Qantas Airways
Operation affected:	Aviation: Air transport
Who it affects:	All of the operator’s flight crew

Safety issue description

Although Qantas provided detailed guidance to flight crews about the content of departure and approach briefings, it did not specifically require aerodrome hot spots to be briefed.

Proactive safety action

Action taken by:	Qantas Airways Limited
Action number:	AO-2018-032-NSA-39
Action type:	Proactive safety action
Action status:	Closed

Safety action taken:

As a result of this occurrence, Qantas advised the ATSB it initiated the following safety actions:

- On 16 May 2018 it published a safety information notice to all pilots, which contained information about the background of runway incursions, details of two recent runway incursion occurrences, and safety educational information related to influencing factors, stop bar techniques and strategies to avoid a runway incursion.
- On 6 June 2018 it issued Flight Standing Order (Operations) 048/18 to pilots, which communicated a policy update to its *Flight Administration Manual* (FAM) stating flight crew were to brief on relevant charted hot spots in their departure and arrival and approach briefings to mitigate against the possibility of collision or runway incursion.
- On 11 March 2019, updated the *Flight Administration Manual* to include the following in the ‘contingency planning’ requirements for both departure briefings and arrival and approach briefings: ‘brief contingency plans for all threats assessed as requiring crew management, including aerodrome hot spots’.

Status of the safety issue

Issue status: Closed – Adequately addressed

Justification: The ATSB is satisfied that the action taken by Qantas addresses this safety issue.

Location and design of taxiway J2 at Perth Airport

Safety issue number: AO-2018-032-SI-02

Safety issue owner: Perth Airport Pty Ltd

Operation affected: Aviation: Air transport

Who it affects: All flight crew and operators of jet aircraft using runway 03 at Perth Airport

Safety issue description

The location and design of taxiway J2 at Perth Airport significantly increased the risk of a runway incursion on runway 06/24 for aircraft landing on runway 03. Taxiway J2 was published as the preferred exit taxiway for jet aircraft and, although mitigation controls were in place, they were not sufficient to effectively reduce the risk of a runway incursion.

Proactive safety action

Action taken by: Airservices Australia

Action number: AO-2018-032-NSA-40

Action type: Proactive safety action

Action status: Closed

Safety action taken:

Effective 21 May 2018, Airservices Australia issued a temporary local instruction (TLI) requiring controllers at Perth Airport to issue an instruction to aircraft vacating at taxiway J2 to hold short of the other runway (when that runway was to be used for a subsequent arrival or departure). Subsequently, the Civil Aviation Safety Authority recommended that the TLI should be amended to require positive confirmation that an aircraft vacating via J2 has stopped.

Effective 26 June 2018, Airservices Australia issued a TLI requiring controllers at Perth Airport to not use taxiway J2. More specifically, the instruction stated:

> Due to a Runway Incursion into RWY 06 on the 28 April 2018…, CASA have requested consideration be given to removing the risk of the situation occurring again.
>
> AIP ERSA identifies RWY 06/24. TWY's J2, J1 and A intersection as a runway incursion hotspot.
>
> Airservices preliminary safety evaluation has determined that TWY J2 will not be used in any Perth Basin traffic management plans to reduce risk associated with aircraft operating within this hotspot.
>
> Therefore to reduce risk associated with aircraft operating within this hotspot Perth Tower will not utilise TWY J2 for any operations…

As part of the TLI, the Perth automatic terminal information service (ATIS) was to include the operational information that taxiway J2 was not available.

Concurrently with the June 2018 TLI, Airservices Australia advocated through the local runway safety team (LRST) for the re-modelling of taxiway J2 to provide a 90° exit from runway 03 in order to mitigate the infrastructure hazard associated with a high speed exit leading directly to a second runway. Perth Airport subsequently advised Airservices Australia, through the LRST, that taxiway J2 would be temporarily closed by NOTAM pending an assessment of mitigation options. Perth Airport later determined that taxiway J2 would be closed permanently and a NOTAM was issued to that effect (see safety action AO-2018-032-NSA-052). Pending Perth Airport's decision to close taxiway J2, the Airservices Australia TLI remained in effect to prevent aircraft exposure to the infrastructure hazard.

Proactive safety action

Action taken by: Perth Airport Pty Ltd

Action number: AO-2018-032-NSA-052

Action type: Proactive safety action

Action status: Closed

Safety action taken:

As a result of this occurrence, Perth Airport Pty Ltd advised the ATSB it initiated the following safety actions:

- After Airservices Australia issued a temporary local instruction to cease use of taxiway J2, Perth Airport took initial measures to close J2 by issuing a NOTAM making J2 unavailable and isolating airfield ground lighting and removing markings leading off runways 03/21 and 06/24 (and associated taxiways) into J2.
- Perth Airport and Airservices Australia opened discussions with the local runway safety team on potential physical changes, including changing the geometry of the taxiway J2 entry from runway 03 to make it less representative of a rapid exit taxiway, or to change its exit geometry to exit onto the parallel taxiway A and not directly onto runway 06/24, or permanent removal of J2 entirely.
- Following consultation with the local runway safety team, Perth Airport elected for the permanent removal of taxiway J2 and commenced pavement demolition early to mid-2019.
- Taxiway J2 (connecting runway 03/21 with runway 06/24) was removed from the aeronautical information package aerodrome chart for Perth Airport in August 2019.

Status of the safety issue

Issue status: Closed – Adequately addressed

Justification: The ATSB is satisfied that the action taken by Airservices Australia and Perth Airport Pty Ltd has addressed this safety issue.

Inhibition of safety alerts for combined air traffic control roles

Safety issue number: AO-2018-032-SI-03

Safety issue owner: Airservices Australia

Operation affected: Aviation: Airspace management

Who it affects: Tower controllers at Perth Airport

Safety issue description

Airservices Australia's configuration of the integrated tower automation suite (INTAS) at Perth Airport had resulted in a situation where controllers performing some combined roles had the INTAS aural and visual alerts inhibited at their workstation. As a result, controllers performing such combined roles would not receive a stop bar violation alert or runway incursion alert at their workstation.

Proactive safety action

Action taken by: Airservices Australia

Action number: AO-2018-032-NSA-051

Action type: Proactive safety action

Safety action taken:

Airservices Australia advised the ATSB that it raised a request for change to A-SMGCS alerting for the combined shift manager-surface movement controller-airways clearance delivery role in

Perth INTAS Adaptation data settings on 24th June 2018, with the associated change implemented in the INTAS data release on 18th July 2018. As a result, when the combined role was selected, the relevant aural and visual alerts would no longer be inhibited.

Status of the safety issue

Issue status:	Closed – Adequately addressed
Justification:	The ATSB is satisfied that the action taken by Airservices Australia addresses this safety issue.

Additional safety action

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following proactive safety action in response to this occurrence.

Qantas Airways advised that on 17 September 2019, following a runway incursion subsequent to this occurrence, it published a safety information notice to all pilots, which contained information about failure to comply with taxi clearances and details of the recent runway incursion occurrence. It also contained safety educational information related to influencing factors, mitigation techniques and strategies to avoid non-compliance with air traffic control ground clearances.

Airservices Australia and Qantas Airways advised they were in discussions to ascertain if there was merit in the conduct of a new trial of the ICAO-recommended approach to runway crossings, with the crossing aircraft on the ADC frequency,

The Civil Aviation Safety Authority (CASA) advised that in September 2019, CASR Part 139 (Aerodromes) Manual of Standards introduced guidance for rapid exit taxiway indicator lights (RETILs). The guidance stated ‘RETIL may be provided on a runway intended for use in RVR conditions less than 350 m or where the traffic density is heavy’. CASA advised the ‘optional’ application of subsection 9.89 (1) was consistent with ICAO SARPs (see Annex 14 volume I para 5.3.15.1), which set the application of RETIL as a Recommendation.

General details

Occurrence details

Date and time:	28 April 2018 – 1442 WST	
Occurrence category:	Serious incident	
Primary occurrence type:	Operational-Runway-Runway incursion	
Location:	Perth Airport, Western Australia	
	Latitude: 31º 55.536' S	Longitude: 115º 57.77' E

Aircraft 1 details

Manufacturer and model:	The Boeing Company 737-838	
Registration:	VH-XZM	
Operator:	Qantas Limited	
Serial number:	44574	
Type of operation:	Air Transport High Capacity	
Departure:	Sydney Aerodrome, New South Wales	
Destination:	Perth Aerodrome, Western Australia	
Persons on board:	Crew – 6	Passengers – Unknown
Injuries:	Crew – Nil	Passengers – Nil
Aircraft damage:	None	

Aircraft 2 details

Manufacturer and model:	The Boeing Company 737-838	
Registration:	VH-VZL	
Operator:	Qantas Limited	
Serial number:	34194	
Type of operation:	Air Transport High Capacity	
Departure:	Perth Aerodrome, Western Australia	
Destination:	Sydney Aerodrome, New South Wales	
Persons on board:	Crew – 6	Passengers – Unknown
Injuries:	Crew – Nil	Passengers – Nil
Aircraft damage:	None	

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the flight crew of VH-XZM
- the captain of VH-VZL
- the aerodrome controller
- the surface movement controller
- flight data recordings from VH-XZM and VH-VZL
- closed-circuit television recordings
- Qantas Airways Limited
- Airservices Australia
- Perth Airport Pty Ltd.

References

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Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), 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 draft of this report was provided to the flight crew of VH-XZM, the captain of VH-VZL, Qantas Airways Limited, the aerodrome controller, the surface movement controller, Airservices Australia, Perth Airport and the Civil Aviation Safety Authority.

Submissions were received from the captain of VH-XZM, Qantas Airways Limited, the aerodrome controller, Airservices Australia, Perth Airport and the Civil Aviation Safety Authority. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

The ATSB is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within the ATSB's jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Terminology used in this report

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing factor: a factor that, had it not occurred or existed at the time of an occurrence, then either:

(a) the occurrence would probably not have occurred; or

(b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or

(c) another contributing factor would probably not have occurred or existed.

Other factors that increased risk: a safety factor identified during an occurrence investigation, which did not meet the definition of contributing factor but was still considered to be important to communicate in an investigation report in the interest of improved transport safety.

Other findings: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which ‘saved the day’ or played an important role in reducing the risk associated with an occurrence.