Australian Government
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ATSB TRANSPORT SAFETY INVESTIGATION REPORT
Aviation Occurrence Report – 200602099
Final

Runway incursion
Brisbane Airport, Qld – 21 April 2006
VH-VXS
Boeing Company 737–838
Tug 92
Aircraft tow vehicle

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Acknowledgements

Extract from Airservices Australia Brisbane Aerodrome Chart (Figure 1) - Airservices Australia

Extract of Brisbane Airport runway 01 and taxiway H4 intersection (Figure 2) - Google Earth

Brisbane Airport Runway Incursions January 2000 – May 2005 (Figure 4) - Airservices Australia

Abstract

On 21 April 2006, a Brisbane Airport surface movement controller (SMC) issued a clearance for the driver of an aircraft tow vehicle to cross an active runway in front of a Boeing Company 737 aircraft which had been lined-up on the runway ready for departure. The crew of the 737 aircraft had been issued with a take-off clearance by the aerodrome controller (ADC) and subsequently commenced takeoff. The SMC and ADC services were being provided on separate radio frequencies.

The crew of the tow vehicle later reported that they were still within the runway strip when the 737 aircraft passed behind them airborne. The flight crew of the 737 had observed the tow vehicle crossing the runway during the take-off roll, but had assessed that the vehicle would be clear of the runway prior to them reaching its observed position and decided to continue the take-off. The SMC later reported that he had wrongly believed that he had coordinated and received a clearance for the tug to cross the runway from the ADC.

As a result of this occurrence Airservices Australia has made changes to the coordination of runway crossing clearances, including the content, form and readback requirements and has mandated the use of movement strips for the SMC position at Brisbane. It reported that it has continued with efforts to reduce the number or required runway crossings, in consultation with the airport owner and is also in the early stages of a project to procure an Advanced Surface Movement Guidance System (A-SMGCS). Airservices Australia is also actively considering and pursuing the concept of having all runway crossings occurring on the ADC frequency as recommended by the International Civil Aviation Organization.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Transport and Regional Services. ATSB investigations are independent of regulatory, operator or other external bodies.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth 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 fare-paying passenger operations.

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 enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, 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 proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

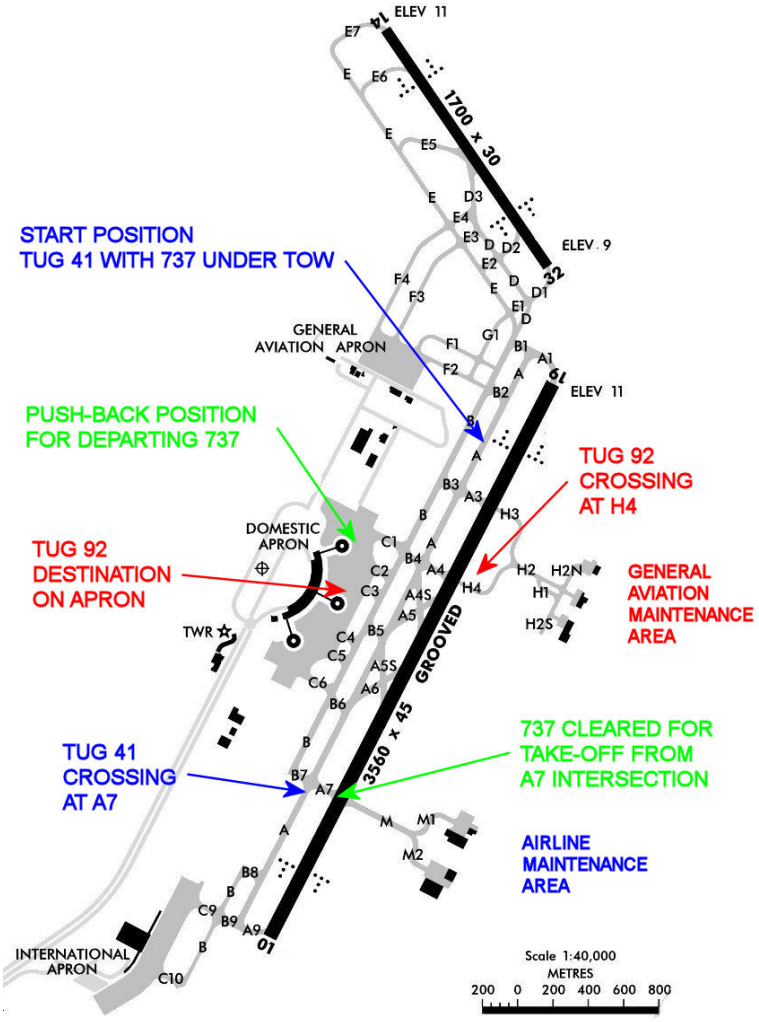
The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

About ATSB investigation reports: How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au.

FACTUAL INFORMATION

At 1545 Eastern Standard Time[1] on 21 April 2006, a Boeing Company 737-838 (737) aircraft, registered VH-VXS, taxied at Brisbane, Qld, on a scheduled passenger service to Mount Isa, Qld. The crew of the 737 did not operationally require the full length of the duty runway 01 for their departure and had requested a takeoff from the taxiway Alpha 7 (A7) intersection (Figure 1). The Brisbane Tower surface movement controller (SMC) had provided the crew with a clearance to taxi to the A7 holding point.

Figure 1: Extract from Airservices Australia Brisbane Aerodrome Chart



At 1542, the driver of an aircraft tow vehicle, callsign Tug 41, had requested a clearance from the SMC to tow a 737 aircraft to the airline maintenance area. This aircraft was located on taxiway Alpha, between taxiways Bravo 2 and Bravo 3, which required the tug driver to tow the 737 across runway 01. The SMC had

1 The 24-hour clock is used in this report to describe the local time of day, Eastern Standard Time (EST), as particular events occurred. Eastern Standard Time was Coordinated Universal Time (UTC) + 10 hours.

provided the driver of Tug 41 with a clearance to tow the 737 via taxiways Alpha and Bravo to the A7 holding point.

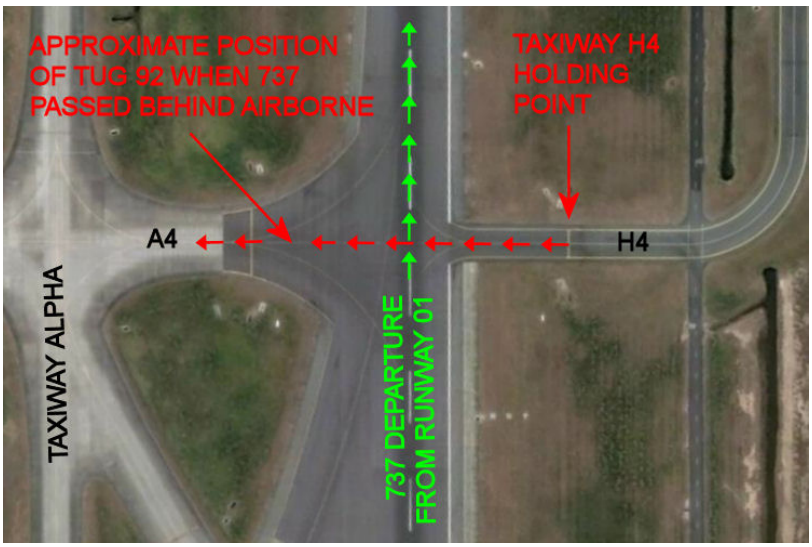
At 1550, the driver of another aircraft tow vehicle, callsign Tug 92, had requested a clearance from the SMC to proceed from the general aviation maintenance area to the domestic apron. As the tug crew were required to tow an aircraft from the domestic apron, there was an aircraft tow bar attached behind the vehicle. To reach the apron area, the driver of Tug 92 was also required to cross runway 01 and the SMC had provided the driver of Tug 92 with a clearance to proceed via taxiway Hotel to the Hotel 4 (H4) holding point.

At 1554, the Brisbane Tower aerodrome controller (ADC) had issued an instruction to the crew of the taxiing 737, who had previously reported ready at the A7 holding point, to enter and line up on runway 01. At that time, Tug 41 was behind the taxiing 737 on taxiway Bravo 7, and Tug 92 was at the H4 holding point. The drivers of both vehicles were waiting for a clearance from the SMC to cross the runway.

At 1556:07, the ADC issued the crew of the 737 with a take-off clearance. Seven seconds later at 1556:14, the SMC issued the driver of Tug 92 with a clearance to cross runway 01. The crew of the 737 later reported to their operating company that during their take-off roll they had observed the tug on the runway moving from their right to left. They believed that the tug would be clear of the runway prior to their aircraft reaching the tug's initially observed position and elected to continue the takeoff. The aircraft rotated at a position prior to reaching the location where the tug was crossing the runway and the crew observed the tug to be off the runway as the aircraft climbed. There had been a runway incursion.

The driver of Tug 92 later reported to his company that the vehicle was 'still within the runway strip, short of the Alpha 4 holding point, when the 737 passed behind them airborne' (Figure 2).

Figure 2: Intersection of Runway 01 with Taxiway H4



Air traffic services

The Manual of Air Traffic Services (MATS) 2.1.1 described the objectives of air traffic services and in part specified that they shall be to 'prevent collisions between aircraft on the manoeuvring area and obstructions on that area'. The MATS 6.3.1.1 reiterated this objective when providing advice about the issuing of aerodrome clearances. It stated:

> Aerodrome control towers shall issue information and clearances to aircraft under their control to achieve a safe, orderly and expeditious flow of traffic on and in the vicinity of an aerodrome with the object of preventing collision(s) between… aircraft and vehicles operating on the manoeuvring area…

One component in the provision of air traffic services was an Aerodrome Control Service, which the Aeronautical Information Publication (AIP) described:

> is provided to aerodrome traffic at aerodromes at which a control tower is operating. The control function in respect of aerodrome and other traffic operating on the surface outside the landing area in use may be provided separately and is termed Surface Movement Control, the remaining function then being termed Aerodrome Control.

At the time of the occurrence there were a number of controllers providing air traffic services functions within the Brisbane Tower, including separate ADC and SMC positions. Airservices Australia (Airservices) reported that the controllers providing the ADC and SMC functions were appropriately licensed, endorsed, current and recent at the time of the incident. It also stated that there were no equipment failures or technical issues existing at the time of the incident. No significant weather was reported and the visibility was stated to be in excess of 10 kilometres.

The ADC and SMC services were provided on separate radio frequencies. The Air Traffic Control Operations Manual Volume 1 (Operations Manual) provided advice relating to frequency procedures for vehicles on runways. It stated:

> Except at GAAP aerodromes, vehicles and pedestrians operating on an active runway or within the runway strip of an active runway shall be on the appropriate ADC frequency.

However, the Operations Manual allowed for three specific exceptions to this requirement, one of which was for 'vehicles crossing an active runway'.

The Air Traffic Control Operations Manual Volume 2 (Local Instructions) provided instructions for Brisbane Tower controllers relating to vehicles on the aerodrome. It stated that 'vehicular access to the manoeuvring area is restricted to those deemed to be operationally essential.' A listing of vehicles permitted to operate on the runways or taxiways included 'aircraft under tow or repositioning' and 'tugs positioning for a tow.'

The MATS specified that 'Where a runway crossing clearance is required the SMC shall make a visual check for approaching and departing aircraft, and obtain a crossing instruction or restriction from the ADC.' The MATS also provided specific coordination phraseology that was required to be used between the SMC and ADC.

In response to a request to cross / enter a runway	SMC/ADC "...(aircraft type or description and number of vehicles) ON...(location) TO CROSS/ENTER...(RWY No)"	ADC "... (aircraft type or vehicle(s) ON... (location) CROSS/ENTER... (RWY No)" or "NEGATIVE. HOLD SHORT" SMC "CROSS/ENTER/HOLD SHORT" **The above phraseologies shall not be abbreviated to responses such as "AFFIRM, YES or OK" which can be heard out of context.**

The MATS 6.5.1.4 specified that 'coordination should normally be effected on intercom or liaison channels'. Coordination exchanges on these types of channels would normally be recorded. Airservices reported that the coordination between the SMC and ADC was not conducted on intercom lines and was therefore not recorded and available for review. In determining the sequence of events Airservices utilised a replay of the audio recording of the air-ground programs of both controllers, together with the controllers' recollection of events provided at interview.

Most tower controllers utilised an ericaphon[2] for all communications. While headsets were available for controller use, they had relatively short cords and many controllers considered that they restricted their movement. Coordination between the SMC and ADC was normally completed verbally on a face-to-face basis from opposite ends of the tower console.

Tower controllers utilised TAAATS[3] printed paper flight progress strips to provide them with information relating to aircraft arrivals, departures and movements on the aerodrome. The ADC position also had available pre-prepared strips to highlight other movements that might occur within the active runway strip such as mowing, runway inspections and runway crossing traffic. Local instructions specified that with respect to runway crossing clearances the

> ADC shall display the 'CROSSING RUNWAY' strip in the ADC sequence bay until the crossing traffic has vacated the runway. The SMC shall advise the ADC when the traffic crossing the runway is clear.

The SMC position did not have pre-prepared strips available. In the absence of an aircraft flight progress strip, the SMC was required to hand-write any other information onto a 'scratch pad', which provided their only record and memory prompt.

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2 Telephone handset with a wide base that rests unsupported on the tower console. It has an in-built press-to-talk button and is attached to the console by a long stretchable cord that allows a wide range of movement.

3 The Australian Advanced Air Traffic System.

At Brisbane Airport, situational awareness of traffic moving on the aerodrome was provided predominantly to tower controllers by visual observation. The airport was not equipped with any supplementary form of surveillance of the runways and taxiways such as surface movement radar. Airservices reported that it is in the early stages of a project to procure an Advanced Surface Movement Guidance System (A-SMGCS) for Brisbane and other major airports.

The aerodrome controller (ADC)

The ADC reported that he was fully aware of the operation of a tug with an aircraft under tow (Tug 41) wishing to cross the runway at A7. However, while the SMC had provided coordination about this tug, the ADC was not aware of the tug's callsign. The ADC stated that there was no requirement for the ADC to know the callsigns of vehicles crossing the runway and that callsigns were not normally used in the coordination between the SMC and ADC positions.

The ADC reported that he did not recall any coordination from the SMC about the operation of Tug 92. He therefore was not aware that this tug had been cleared to, and was waiting at, the H4 holding point.

The MATS 6.3.1.6 required controllers to complete a visual check of the runway before issuing a take-off clearance:

> A visual check of the take-off path shall be made to ensure no obstructions exist before clearing an aircraft for take-off, and immediately before the take-off is commenced.

The ADC recalled that after he had instructed the departing 737 to enter and line up on the runway, he completed a scan of the runway and noted that nothing obstructed the take-off path, before issuing the take-off clearance. He stated that his normal practise was to then watch aircraft commence the take-off roll and become airborne, however he could not remember if he followed this procedure in this instance.

Airservices investigation staff noted that the location of Brisbane Tower could be perceived as being 'a long way from the action'. They considered that

> small vehicles such as Tug 92 can be difficult to see particularly when environmental factors such as glare, background colouring and weather are taken into consideration. Additionally the tower has concrete support pillars that obscure the view of certain parts of the airfield from various positions within the tower. One such concrete support pillar obscures the view of the area in the vicinity of [runway 01 and taxiway H4 and A4] from the [ADC] position.

Figure 3 shows a view from the Brisbane Tower looking towards the runway 01 and H4 intersection, with the general aviation maintenance buildings visible in the centre of the photograph. Also shown is an aircraft holding at the H4 intersection waiting to cross the runway. This photograph was taken from the far left of the tower cabin and the concrete pillar and ADC position are located out-of-shot to the right of the photograph.

Figure 3: View from Brisbane Tower towards the Runway 01 / H4 intersection.

The ADC recalled that after issuing the take-off clearance to the crew of the departing 737, he provided the required coordination to the SMC to cross the tug with the 737 under tow at A7, behind the departing 737.

The surface movement controller (SMC)

Airservices advised that the SMC had stated that at the time of the incident he had 'formed a mindset or belief' that the required coordination for both tugs had been completed, when in fact only the coordination for Tug 41 had been passed to the ADC. The SMC indicated that he also wrongly believed that he had a clearance from the ADC for both Tug 92 and Tug 41 to cross the runway.

The SMC also recalled that the coordination relating to the tug at A7 was for the tug to cross the runway behind the departing 737. Recorded information showed that the SMC issued the clearance for Tug 92 at H4 to cross the runway 7 seconds after the crew of the departing 737 had been issued the take-off clearance. The SMC subsequently issued a clearance for Tug 41 to cross the runway at 1556:57, 50 seconds after the 737 take-off clearance was issued. The SMC had preceded this clearance to the driver of Tug 41 by initially transmitting the wrong callsign, Tug 92, which was challenged by the driver of Tug 41 and corrected by the SMC.

Those facts, together with some additional information received, led the Airservices' investigation to initially consider the possibility that the SMC may have used the incorrect callsign, intending to cross Tug 41 at A7 but using the Tug 92 callsign. After subsequent interviews and statements by the SMC, the Airservices' investigation dismissed this theory as a contributing safety factor. However, the Airservices' investigation considered that the possibility of this callsign confusion scenario occurring was something that could easily occur. They reported that the risk was 'real and actions should be taken to reduce this risk to a level as low as reasonably practical'.

The SMC reported that the clearance for Tug 92 to cross the runway was issued after he had observed the departing 737 lining up. The clearance was correctly read back by the driver of Tug 92 who then commenced to cross the runway. Later review of the audio recording showed that the clearance to cross the runway contained no reference to the 737 aircraft as recommended by Local Instructions which stated

> If an aircraft is on the runway when a clearance to cross is given to a vehicle, then the vehicle driver should be advised that the aircraft is holding.

The SMC could not recall where he was looking at the time the clearance was issued but, stated that he would normally have been looking at the tug and his expectation was that the tug would cross from H4 to A4. He also stated that he saw the departing 737 at the start of the take-off roll and at that time believed he had observed Tug 92 to be clear of the runway. There was no information available to the investigation to indicate that the SMC informed the ADC that the tug was clear of the runway as required by the Local Instructions.

Airservices reported that the commonly applied practice was that if the SMC believed that the traffic situation was such that a runway crossing clearance would not be available, they would not request the crossing clearance from the ADC until it was likely to be available. It was also not recommended that the SMC suggest a course of action to the ADC, due to a potential lack of full situational awareness of the ADC's traffic picture.

Recorded information showed that when the driver of Tug 92 had requested a clearance to cross the runway at 1550:23, the SMC had issued an instruction to proceed to H4 and hold short of the runway. It was almost 6 minutes later at 1556:14, when the SMC then issued the clearance for the driver of Tug 92 to cross the runway. This was not an unusual time-frame and could be expected during busy periods.

The SMC later reported to Airservices that he recalled two possible sources of distraction during the incident shift. However, he was not able to recall whether these distractions contributed to the incident. Airservices also considered the SMC's fatigue levels[4] during the shift to be in the standard range.

The tug crew

The crew of Tug 92 reported to their company that they had observed the departing 737 lined up on the runway when the clearance for them to cross the runway was issued. At that time, they had observed the aircraft to be stationary with no visible heat haze being emitted from the engines. As they crossed the runway they observed the heat haze build up behind the 737 and realised that the crew of the 737 had commenced their take-off roll. They accelerated to clear the runway and recalled that they were still within the runway strip, short of the A4 holding point, when the 737 passed behind them airborne. The tug driver later reported that his perception of the incident was that the SMC may have made an error when issuing

4 Airservices used the Fatigue Audit InterDyne (FAID) process for their calculations of fatigue levels. A standard score represents fatigue levels up to the maximum score produced by a Monday to Friday 0900h to 1700h standard work week.

the runway crossing clearance and that the crossing clearance was actually intended for Tug 41, not them.

The flight crew

The crew of the departing 737 later reported to their operating company that on departure, the copilot was the pilot flying and the pilot in command was the pilot not flying. When the crew received their take-off clearance, and as the pilot in command was setting the thrust, the copilot saw some movement on the runway from right to left. He could not identify the object as it was very small and at a position about 1,500 m ahead of their position.[5] He reported that the initial thought was that the object may have been a C172 or similar light aircraft and had stated 'something on the runway'. At that time, the aircraft was accelerating through about 50 kts in the take-off roll. The pilot in command had looked up and both pilots confirmed having seen a small tug travelling quickly across the runway. The pilot in command had assessed that the tug would be clear by the time they reached that position on the runway, and at about 80 kts called 'continue'. At that stage the aircraft was about 1,200 m from the position of the tug. The takeoff continued normally and the 737 was airborne prior to reaching the intersection with taxiway A4. Both pilots noted the tug was clear of the runway and moving away as they were climbing away.

Aircraft maintenance facilities

Brisbane Tower Local Instructions stated that aircraft engine ground running was the responsibility of Brisbane Airport Corporation (BAC). Airservices reported that appropriate facilities for aircraft engine test running were not available at the Airline and General Aviation maintenance areas and BAC did not allow engine runs to be conducted on the eastern side of the aerodrome. Runway crossings were therefore a common event for aircraft requiring ground maintenance engine runs.

The position on the airport that the ground runs were to be conducted was determined after consultation between BAC, Brisbane tower staff and the relevant aircraft maintenance company. Factors that were considered included the runway in use, traffic density and complexity, and prevailing weather conditions. On the day of the incident, the agreed engine ground run position for the towed 737 aircraft was on taxiway Alpha, between taxiways Bravo 2 and Bravo 3.

On completion of the engine ground run, the maintenance team were required to tow the aircraft back to the airline maintenance area. The most suitable route for the tow vehicle was to cross runway 01 at A7 then proceed via taxiway Mike to the hangar.

Runway incursion safety developments

In 2001, the International Civil Aviation Organization (ICAO) Air Navigation Commission, in conjunction with other organisations, began to take action to address the increasing problem of runway incursions, which it defined as

5 Airservices reported that the distance between taxiways A7 and H4 is 1418 m.

> 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.

The ICAO runway safety group identified several critical areas that required investigation and commenced a process to educate and raise awareness of these issues. A plan was developed that was based on a system safety approach that would identify actual and potential hazards, provide remedial action and the monitoring and assessment of hazards. Between 2002 and 2005, runway safety seminars were held around the world. In April 2004, Eurocontrol[6] approved an action plan[7] and undertook to rapidly implement the recommendations to improve safety.

ICAO seminars held in the Asia/Pacific and Middle East regions generated a request for ICAO to produce a global manual with runway incursion prevention guidelines and in 2006 ICAO published a Manual for Preventing Runway Incursions.[8] This document contained information on runway incursions and establishing prevention programmes, and provided recommendations for prevention of incursions. It also provided advice on best practice in a number of areas including: communications, 'on the flight deck', air traffic control and airside vehicle driving. Appendix A - Communications Best Practices in part stated:

> From many investigation reports and surveys, regarding runway safety occurrences, it is apparent that communications issues are frequently a causal or contributory factor.
>
> To maintain high levels of situational awareness it is also recommended that communications for all operations on a runway (landing, departing, crossing aircraft, vehicles crossing and runway inspections etc.) take place on the VHF channel assigned for that runway.

Airservices had decided to take similar action to ICAO to mitigate the risk of runway incursions. In 2002, it conducted a runway incursion survey at Sydney Airport, similar to other surveys that had been conducted internationally. An outcome of that survey was that a Runway Incursion Group (RIG) should be established to take a national perspective on runway incursions and to facilitate greater awareness among operators and users. The group was formed in 2003 and operates under the terms of reference provided by the Airservices Safety Panel.

The Airservices website[9] contained information relating to runway safety initiatives and the activities of the RIG. Also available was a pictorial representation of runway incursions at various locations within Australia, including Brisbane Airport (Figure 4). This information showed that between 1 January 2000 and 31 May 2005, there were 17 reported runway incursions at Brisbane Airport, with 35% of those incidents involving cars/towing. Three incursions were reported as occurring at the runway 01 and taxiway H4 intersection, all of which involved cars/towing.

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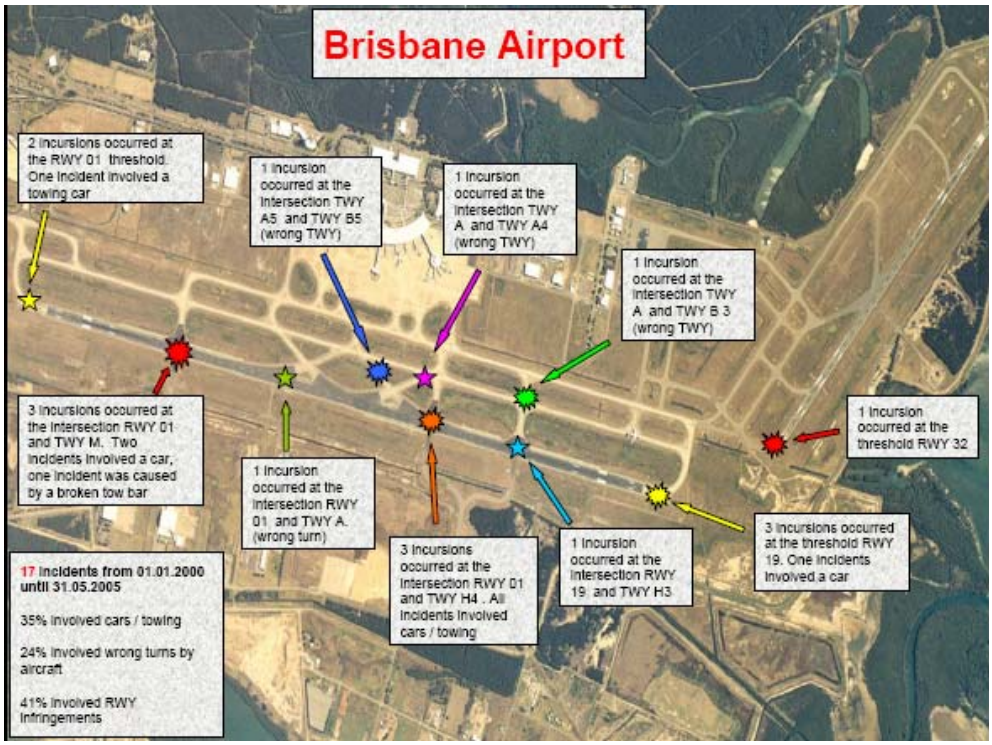
6 Eurocontrol is the European Organisation for the Safety of Air Navigation.

7 European Action Plan for the Prevention of Runway Incursions.

8 Manual for Preventing Runway Incursions - International Civil Aviation Organization Doc 9870 AN/463 First Edition – 2006.

9 www.airservicesaustralia.com/pilotcentre/training/runwaysafety.

Figure 4: Brisbane Airport Runway Incursion Incidents



In 2004, the Australian Transport Safety Bureau published an Aviation Safety Research Paper relating to Runway Incursions.[10] This report highlighted the fact that while:

> most runway incursions do not result in accidents, the potentially catastrophic consequences of runway incursions place them high on the agendas of aviation safety agencies internationally.
>
> The majority of runway incursions in Australia have a low potential to result in an accident. Australia has never experienced a large scale accident due to a runway incursion but vigilance is required to maintain this safety record.

10 www.atsb.gov.au/publications/2004/Runway_incursions_1997_to_2003.aspx.

ANALYSIS

Evidence that indicated runway incursions were becoming more prominent worldwide as traffic levels grew, together with a serious accident in 2001, prompted global and regional reviews to identify and mitigate risk factors inherent in runway operations. In the Australian context, while the majority of runway incursions might be considered to have a low potential to result in an accident, all incursions should be considered serious events because of their possible consequences.

This analysis will discuss possible factors that resulted in an experienced controller providing a clearance for a tug driver to cross an active runway in front of a departing aircraft. It will also consider other issues that became evident as part of the investigation.

The controllers providing the aerodrome control (ADC) and surface movement control (SMC) functions were experienced and appropriately rated. All facilities required for the provision of control services were operational. There was little evidence to suggest the SMC's fatigue levels or distractions contributed to the incident and there was no significant weather reported.

The SMC reported that at the time of the incident he had considered that the required coordination with the ADC had been completed and clearances had been obtained for both tugs to cross the active runway. He later realised that he had not coordinated or obtained a clearance for Tug 92, but was unable to provide any reason for the oversight. It is considered likely that one or more of the following factors lead to this 'mindset':

- the SMC did not have any strips or memory prompts relating to vehicles on the runway other than hand-written scratch pad entries
- coordination was not required to be completed on intercom lines, and the required coordination did not include reference to the vehicle callsigns
- callsigns of the two tugs were only distinguished by the two-digit number suffix
- the normal practice was to not coordinate with the ADC for a clearance to cross the runway until it was thought one would become available.

In theory, the process of the SMC waiting for an appropriate time to coordinate with the ADC for a crossing clearance would appear reasonable. However, if there were long delays between when a tug driver called for a clearance and when the coordination was completed, which would be common in the busiest periods, there would be an increased risk of it being overlooked or forgotten. This action may also act to reduce the situational awareness of the ADC. If the ADC is not aware of vehicles taxiing or holding, there is a greater risk of failing to observe incursions during a visual scan, especially in locations that are difficult to see or in poor visibility conditions.

Situational awareness for tower controllers is predominantly based on visual observation. In assessing the ability of both the ADC and SMC controllers to visually scan the runways and taxiways, it was recognised that limitations in the positioning, construction and layout of a tower cabin may result in small areas of limited visibility. In these situations, a supplementary surveillance system such as surface movement radar would be appropriate.

These limitations in visibility, together with normal operational requirements for sighting aircraft and vehicles in all locations around the airport, meant that tower controllers relied on mobility within the tower cabin. The preferred use of the ericaphon to facilitate this ease of movement, rather than the headset with a shorter cord, did not preclude the use of an intercom for coordination, although it may have restricted its practical application.

Controllers also rely to some extent on listening to what is happening around them to maintain a situational awareness of pending traffic. Within the tower environment, while the SMC and ADC are located at opposite ends of the tower console, when the two controllers are not attending to their own tasks, it is sometimes possible to hear the air-ground program and transmissions of the other controller. The use of vehicle callsigns and locations in both coordination and issuing clearances may provide an additional system defence.

Airservices documents allowed for the presence of aircraft tow vehicles on the airport and permitted vehicles crossing an active runway to remain on the SMC frequency. This allowed a situation where the drivers of the tugs and the crew of the departing aircraft had little or no situational awareness about the presence or actions of the other. The 737 flight crew had no opportunity to hear the runway crossing clearance issued to the tug driver after they had received their take-off clearance. The tug driver, while observing the 737 on the runway when he received his clearance to cross the runway, was also unaware that the 737 crew had already been issued a take-off clearance. While the Local Instructions specified that the SMC should have advised the tug driver that the 737 was holding, it was not a mandatory requirement.

The investigation also considered the circumstances of the event which led the Airservices' investigation to initially believe that the SMC may have mistakenly used the wrong callsign, intending to clear the tug waiting at A7 to cross the runway. While a number of factors supported this hypothesis, the investigation also could not reconcile the controller's statements with the other evidence and discounted this as a contributing safety factor. However, for the reasons already discussed, it agrees with the Airservices Australia viewpoint that the risk of this scenario with callsign confusion or transposition occurring was 'real' and should be addressed.

Airport design and layout would ideally have no runway crossings required other than those associated with aircraft landing and taking off. In reality, most airports need to address the requirements of aircraft maintenance, repositioning and other services on the airport. They also need to balance the competing demands of airport infrastructure, development and facilities with environmental concerns such as noise issues. At Brisbane Airport, the location of aircraft maintenance facilities on the eastern side of the runway, without the ability to conduct engine maintenance ground running nearby, requires frequent crossing of the runway by tugs and towed aircraft. Additionally, the selection of suitable locations for the engine ground running west of the runway on the northern portion of taxiway Alpha, may add to the perceived problems of visibility from the tower, together with the management of taxiing aircraft.

The driver of Tug 92 complied with all documented procedures and proceeded in accordance with the clearances issued by the SMC. After waiting at the holding point for some time, with the expectation of a crossing clearance, there was no reason or requirement to question the presence of the 737 stationary on the runway.

After observing the 737 commencing the take-off run, the most appropriate action was to continue and expedite the crossing.

There is insufficient data available to make a thorough assessment with regard to the decision of the 737 crew to continue with their departure, after observing the tug crossing the runway. However, given the good visual conditions, the distances involved and the fact that both pilots had sighted the tug, there is no reason to believe the actions of the crew in continuing the takeoff was inappropriate.

SAFETY ACTIONS

Airservices Australia

On 2 August 2006, Airservices Australia made a number of changes to the Brisbane Tower Local Instructions. These included changes to the coordination of runway crossing clearances between the ADC and SMC, together with changes to the form and content of runway crossing clearances and their readback requirements.

> Whenever a runway crossing clearance is obtained from the ADC, the SMC readback shall include the designator for the taxiway and runway number.
>
> Examples:
>
> SMC "(aircraft type or description and number of vehicles) ON [taxiway designator] TO CROSS (or ENTER) RUNWAY (number)".
>
> ADC "(aircraft type or vehicle/s) ON [taxiway designator] CROSS (or ENTER or HOLD SHORT) RUNWAY (number)".
>
> SMC "CROSS (or ENTER or HOLD SHORT) ON [taxiway designator] RUNWAY (number)".
>
> Whenever a runway crossing clearance is issued to a vehicle or aircraft, the taxiway designator and runway number shall be included.
>
> Example:
>
> "(callsign) ON [taxiway designator] CROSS RUNWAY (number)" eg
>
> "TUG NINETY-TWO ON HOTEL 4 CROSS RUNWAY ZERO ONE"
>
> In circumstances where multiple runway crossing clearances are requested and a crossing clearance cannot be authorised to all aircraft (or vehicles) the crossing instruction shall be coordinated between the ADC and SMC using the word 'ONLY' to define the approved crossing.
>
> SMC "(aircraft type/s or description and numbers of vehicles) ON
>
> [taxiway designator] AND (aircraft type/s or description and number of vehicles) ON [taxiway designator] TO CROSS (or ENTER) RUNWAY (number)".
>
> ADC "(aircraft type/s or vehicle/s ON [taxiway designator] ONLY CROSS (or ENTER) RUNWAY (number)".
>
> SMC "CROSS (or ENTER) ON [taxiway designator] RUNWAY (number) ONLY".

The Local Instructions also included changes that mandated the use of a Movement Area Strip for ‘all movements on the aerodrome that involve vehicles or aircraft that do not have a TAAATS generated paper flight progress strip’. The purpose of this strip was to increase the situational awareness of the SMC, so that all movements under their control were captured via a strip.

Airservices Australia later reported that since the implementation of this strip, the benefits had been quickly realised by everybody involved. It reported that it was considered that the SMC display was more easily interpreted and that the situational

awareness of the SMC was significantly enhanced. In view of this, Airservices Australia is considering the national implementation of these changes within the tower environment.

Airservices Australia also reported that they had liaised with Brisbane Airport Corporation and local aircraft maintenance companies about the reason for the clearance issue and readback changes. It had also continued with efforts to reduce the number of runway crossings by ensuring these organisations limited crossings to those classified as operationally necessary, and that could not be achieved by other means such as the use of perimeter roads.

Airservices Australia reported that it is in the early stages of a project to procure an Advanced Surface Movement Guidance System (A-SMGCS) for Brisbane and other major airports. It believes that the successful installation and use of such a system should lower the risk of runway incursions occurring by providing additional system defences such as conflict alarms and improved surveillance of the airport.

Airservices Australia has advised that the Runway Incursion Working Group (RIG) continues to remain active and is involved with runway safety teams at various airports. The group has distributed an 'ICAO Runway Safety Toolkit' and also distributed a runway safety booklet to pilots in December 2006. In 2007, the group intends to provide the booklet in a form suitable as a ground based guide for engineers, tug drivers and others working on or around runways.

Airservices Australia has indicated that it is actively considering and pursuing the concept of having all runway crossings occurring on the ADC frequency. It acknowledged that the concept is utilised in other countries and one of the benefits includes added situational awareness by aircrew as to what is occurring on active runways. Additionally, the use of wireless headsets for tower staff is also been reviewed.