Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Aviation Occurrence Report – 200505170

Final

Runway Incursion – Sydney (Kingsford Smith) Airport, NSW – 20 October 2005

HL-7530

Boeing Company 777

Tug Red Golf

Aircraft tow tug

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Sydney Airport diagram at Figure 1 adapted from Airservices Australia Aeronautical Information Publication aerodrome chart.

Aerial photograph at Figure 2 courtesy of Sydney Airports Corporation.

Abstract

On 20 October 2005, a Boeing Company 777-2B5ER aircraft (777), registered HL-7530, was taking off from runway 34 left (34L) at Sydney (Kingsford Smith) Airport on a scheduled passenger flight to Seoul, South Korea. After the 777 commenced the take-off run, an aircraft tug, radio callsign Qantas Tug Red Golf, with a Boeing Company 747-400 freighter aircraft (747) in tow crossed the departure end of the same runway. There was a runway incursion.

The investigation found that the tug driver involved in the occurrence had 17 years experience in driving a tug at Sydney Airport. In that time he had not been involved in any other recorded incident. Despite his extensive experience and the ongoing training and checking regime that was in place by the tug operator and at Sydney Airport leading up to the occurrence, the driver of tug red golf thought that a clearance issued to the pilot of a taxiing aircraft was for the tug driver.

The driver believed he heard a clearance to cross runway 34 left from the surface movement controller east (SMC E). The driver acknowledged that clearance in accordance with published procedures but the SMC E remained unaware of the situation due to a radio overtransmission. In the absence of any response from the SMC E the driver continued to cross the runway. From that point on, there was limited time available to prevent the runway incursion.

In the absence of stop bar lights and advanced pilot/driver/controller alerting systems, enhanced training emphasising the importance of crew resource management support during towing operations and the importance of removing any doubt from information contained in clearances and instructions are important elements to reduce the risk of similar runway incursions.

Airservices Australia and the tug operator reviewed procedures and made a number of changes to prevent similar occurrences.

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. Accordingly, the ATSB also conducts investigations and studies of the transport system to identify underlying factors and trends that have the potential to adversely affect safety.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and, where applicable, relevant international agreements. The object of a safety investigation is to determine the circumstances in order to prevent other similar events. The results of these determinations form the basis for safety action, including recommendations where necessary. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations.

It is not the object of an investigation to determine blame or liability. However, it should be recognised that an investigation report must include factual material of sufficient weight to support the analysis and findings. That material will at times contain information reflecting on the performance of individuals and organisations, and how their actions may have contributed to the outcomes of the matter under investigation. 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.

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. While the Bureau issues recommendations to regulatory authorities, industry, or other agencies in order to address safety issues, its preference is for organisations to make safety enhancements during the course of an investigation. The Bureau prefers to report positive safety action in its final reports rather than making formal recommendations. Recommendations may be issued in conjunction with ATSB reports or independently. A safety issue may lead to a number of similar recommendations, each issued to a different agency.

The ATSB does not have the resources to carry out a full cost-benefit analysis of each safety recommendation. The cost of a recommendation must be balanced against its benefits to safety, and transport safety involves the whole community. Such analysis is a matter for the body to which the recommendation is addressed (for example, the relevant regulatory authority in aviation, marine or rail in consultation with the industry).

FACTUAL INFORMATION

Sequence of events

On 20 October 2005, a Boeing Company 777-2B5ER aircraft (777), registered HL-7530, was taking off from runway 34 left (34L) at Sydney (Kingsford Smith) Airport on a scheduled passenger flight to Seoul, South Korea. After the 777 commenced the take-off run, an aircraft tug, radio callsign Qantas Tug Red Golf, with a Boeing Company 747-400 freighter aircraft (747) in tow crossed the departure end of the same runway. There was a runway incursion.

The driver of tug red golf was tasked to tow the 747 from the international cargo area, located in the northwest sector of the airport, to the maintenance area adjacent to the domestic terminals in the north-eastern sector of the airport. This operation involved crossing runway 34L and was normally accomplished by using one of the three northern taxiways, Alpha 1, Foxtrot or Golf. (Figure 1)

At 0833:42 Eastern Standard Time[1], the surface movement controller west (SMC W) cleared the tug driver to tow the 747 to the runway 34L holding point at taxiway Alpha 1. At 0834:05, as the tug and aircraft approached the holding point, the SMC W controller instructed the driver to contact the surface movement controller east (SMC E) for a clearance to cross the runway.

At 0834:50, the driver transmitted to the SMC E, 'Sydney ground, Qantas tug red golf with you alpha one holding short three four left' which indicated to the SMC E that the tug was holding short of runway 34L on taxiway Alpha 1 and the driver was expecting a clearance to cross the runway. That transmission was not acknowledged by the controller. At that time, there were a number of taxiing aircraft, with associated radio transmissions, on the SMC E frequency. A replay of recorded surface movement radar (SMR) data showed that at 0834:55, the labelled plot for tug red golf had stopped at the holding point on taxiway Alpha 1.

At 0839:22, the driver transmitted again on the SMC E frequency, 'Ground, tug red golf's with you'. Again, the SMC E did not respond to or acknowledge that radio call. At 0839:33, the driver of another aircraft tug (tug red sierra), was towing a Boeing Company 767 aircraft (767) from the western sector of the airport to the eastern sector. He reported to the SMC E that he was '…at [taxiway] foxtrot holding short of three four left'. That transmission was acknowledged by the SMC E controller.

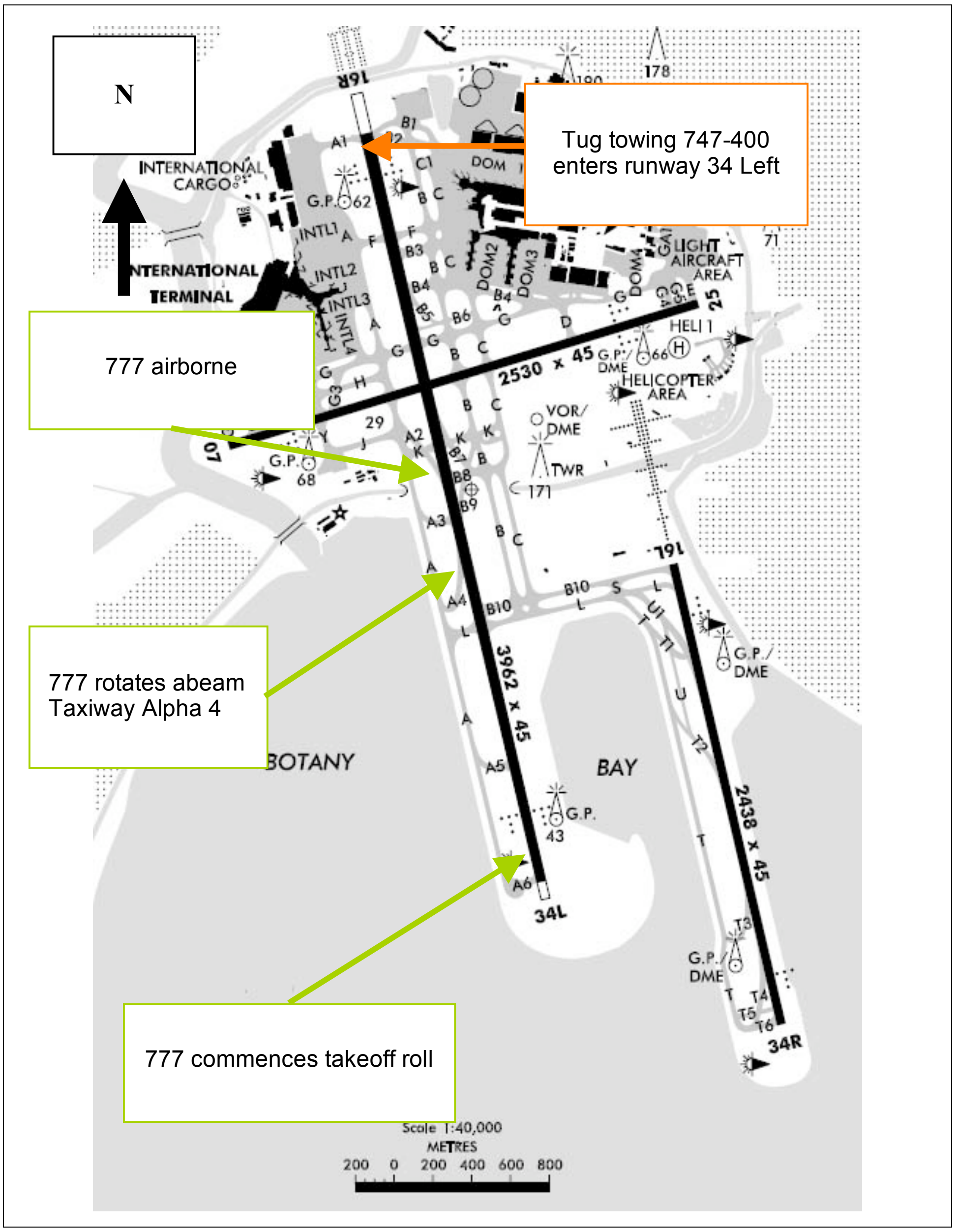
At 0845:52, another 767, radio callsign Qantas Four Twelve landed on runway 34L. Once that aircraft had vacated the runway, the aerodrome controller west (ADC W) conducted a visual scan of the runway and issued a takeoff clearance to the crew of the 777.

The SMR replay showed that at 0845:53, the plot of the 777 was moving on taxiway Alpha 6 and entering runway 34L. At that time, the plot of tug red golf was

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.

stationary on taxiway Alpha 1 and the plot of the 767, that had landed, was exiting the runway at taxiway Bravo 9.

Figure 1: Location of runway incursion on Sydney Airport



At 0846:08, the SMC E transmitted to the crew of the 767 that was now on taxiway Bravo 9, ‘Qantas Four Twelve, cross runway zero seven and hold short of bravo two’. A replay of the recorded radio transmissions revealed that the crew of the 767 read back the clearance correctly, and that this was immediately followed by a quick clipped transmission of ‘red golf’. The SMC E later reported that he heard the read back of the clearance from the pilot of the 767, but did not hear the ‘red golf’ transmission. There was no perceptible break between the acknowledgement from the pilot of 767 and that of the driver of tug red golf.

The tug driver later reported that he heard a clearance to cross a runway, which he thought was intended for him. He read back that clearance on the SMC E frequency, using his radio callsign, and proceeded to cross the runway. However, the tug driver's response was over-transmitted by the readback from the pilot of Qantas four twelve, who had been issued with the clearance by the SMC E to cross runway 07. The tug driver had used the clearance that was issued to the pilot of the 767.

A replay of the SMR showed that at 0846:32, as the 777 commenced its take-off run and was about 250 m along runway 34L, the plot of tug red golf was moving on taxiway Alpha 1. The investigation estimated that at 0847:00, the plot of the 777 was about 1200 m along the runway and that tug red golf was crossing the runway edge. The tug driver reported that when the tug was near the centreline of the runway he looked to the south and saw the 777 approaching. At that that stage there was little that he could do except to hasten the crossing by the tug and towed 747.

The first valid radar plot from the Australian Advanced Air Traffic System (TAAATS) for the 777 was at 0847:12 (Figure 2) when it had passed the intersection of taxiway Golf with runway 34L. The displayed altitude of the aircraft was about 200 ft above mean sea level (AMSL). At 0847:24, the plot of the 777 passed just behind the plot of tug red golf as it exited the runway at taxiway Bravo 2. At that time, the displayed altitude of the 777 was 800 ft AMSL. The elevation of the northern end of runway 34L is 8 ft AMSL. The top of the tail section of the towed 747 was 63 ft 8 in above ground level.

The ADC W controller saw the tug crossing the runway as the 777 became airborne abeam taxiway Alpha 4 and was not aware of any SMR alert.

Aerodrome information

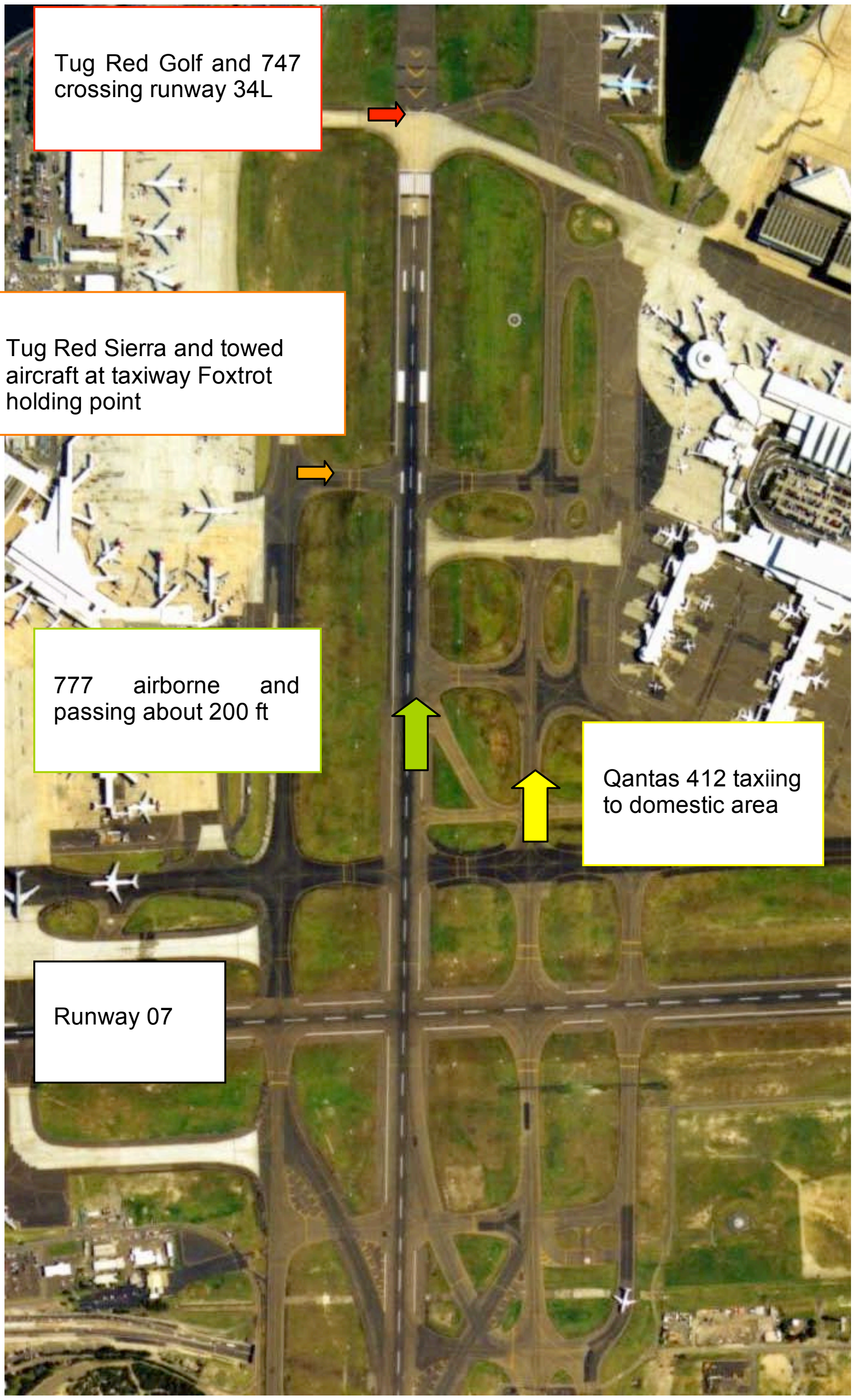
The automatic terminal information service (ATIS) indicated that runways 34L and 34 right (34R) were available for arrivals and departures, with parallel operations and independent departures in progress. Taxiway Alpha north of taxiway Foxtrot was unavailable and the runways were damp. The wind direction was 050 degrees T at a speed of 10 kts, with a crosswind of 10 kts. Visibility was 10 km reducing to 8 km in passing rain showers. There was scattered[2] cloud at 500 ft, a few cloud at 1,100 ft and broken cloud at 3,000 ft. The temperature was 18 degrees C and the atmospheric pressure was 1019 hectapascals.

At the time of the commencement of the tow, the work that had previously closed part of taxiway Alpha, north of taxiway Foxtrot, as notified on the ATIS had been completed and the area was available for use.

The holding points on taxiways leading to all runways including runway 16R/34L were fitted with runway guard lights. Runway guard lights are installed on either side of a taxiway and consist of twin yellow coloured lenses that flash alternatively as a warning to pilots or drivers of vehicles that they are approaching a runway and a holding point. The lights were required by Civil Aviation Safety Regulation Part

2 Cloud amounts are reported in oktas. An okta is a unit of sky area equal to one-eighth of total sky visible to the celestial horizon. Few = 1 to 2 oktas, scattered = 3 to 4 oktas, broken = 5 to 7 oktas and overcast = 8 oktas.

Figure 2: Approximate location of tug, Boeing 777 and taxiing 767 at 0847:12[3]



139 Manual of Standards (MOS) – Aerodromes. The airport operator's mode of operation for guard lights was to have them operating at all times, whether a

3 Actual aircraft shown do not represent those present at the time of the occurrence. The labelled arrow symbols depict pertinent aircraft/vehicle traffic in the area at the time of the occurrence

runway was in use or not. The lights to runway 16R/34L were operating at the time of the occurrence.

Air traffic control aspects

The ADC W managed the arrivals, departures and ground operations involving runway 34L. The ADC E managed similar activities for runway 34R, plus the management of vehicles and aircraft on the taxiways east of the intersection of taxiway Charlie with taxiways Bravo 10 and Lima.

The SMC E provided surface movement control services east of runway 34L, except the taxiways managed by ADC E, on very high frequency (VHF) 121.7 MHz. The surface movement control west (SMC W) controller provided surface movement control services west of runway 34L using 126.5 MHz.

The controllers managed their respective areas of responsibility using visual observation and information from TAAATS and the SMR. The SMR displayed aircraft and vehicles on the airport movement area, subject to line of sight limitations, while TAAATS displayed airborne aircraft and provided information on aircraft that had been issued a clearance and/or were taxiing for a departure.

The controllers issued clearances and instructions to the pilots of aircraft and drivers of vehicles via VHF radio. Controller/pilot radio transmissions, TAAATS data and the SMR were all recorded.

The SMC E was a full performance[4] controller with 21 years ATC experience including the last 10 years in Sydney Tower. The controller reported after the occurrence that at the time of the incident, he was using a headset with a microphone. He was aware of the position of tug red golf, but was focused on aircraft at the domestic terminals at the time of the occurrence.

There had been a busy traffic period and he felt that it was better to leave the tug at the holding point and not risk the possibility of confusing the tug driver by responding. It was only when he was issuing a clearance to the driver of tug red sierra, to cross runway 34L after the 777 had passed, that he noticed that tug red golf was halfway across the runway.

Prior to issuing a takeoff or landing clearance an ADC is required to scan the runway to ensure that there are no obstructions on the runway. The ADC W reported that a scan of runway 34L had been conducted before issuing the take-off clearance and no obstructions were seen.

Tug driver

The tug driver had 17 years experience in aircraft tug operations. He held a current category 4 airside driving authority (ADA), issued by the airport operator that was valid until April 2006. The category 4 ADA authorised the driver to operate an authorised vehicle on the taxiways and runways, subject to an air traffic control clearance. The driver also held a current Aircraft Radio Operator Certificate of

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4 A full performance controller is rated and endorsed on those operational positions specified for the qualification.

Proficiency[5], which was issued on 25 February 1994. The tug driver had no other recorded driving infringements during the 17 years he had been employed as a tug driver at Sydney Airport.

The tug operator conducted 6 monthly hearing testing of tug drivers to monitor the occupational health of drivers. Following the occurrence, the tug driver underwent an audiometry test on 1 November 2005. That testing showed that the driver's hearing was normal.

The driver reported after the occurrence that he thought his first radio call to the SMC E, requesting approval to cross runway 34L, may have been over-transmitted by another radio call. He waited some time before calling again, but did not get any response to that second call from the SMC E. The driver reported that generally when a clearance is not immediately available, a surface movement controller will instruct a driver to 'hold position'. That instruction confirms that a driver's request has been received but approval is not immediately available. The driver recalled hearing the radio broadcast from the driver of tug red sierra to the SMC E and that controller's acknowledgement of that broadcast.

The tug driver had been waiting about 11 minutes before he heard the clearance intended for the pilot of the 767. He reported that as he commenced to move after acknowledging the clearance to the SMC E, he was confused as to how he was to hold short of taxi Bravo 2. That taxiway was the only one he could use to exit the runway and he would not be able to stop before entering it. The driver reported later that as the SMC had not queried the driver's readback of the clearance to cross runway 34L, he continued to cross the runway. He felt that if the clearance was incorrect the controller would have corrected him immediately after the driver's readback.

Tug driver qualification

The airport operator was responsible for managing the licensing of drivers with vehicular access to airside.

The airport operator set the rules for an airside driving authority. A driver wishing to gain an airside driving authority was required to hold a current NSW State motor vehicle licence, an aircraft radio operator certificate of proficiency from the Civil Aviation Safety Authority (CASA) and had to successfully pass a test following training. Testing was conducted by the airport operator and the authority was valid for 2 years, after which a driver had to be retrained and retested. The testing consisted of a computer based test, an aerodrome geography test and a night time driving test. During the course of a test the candidate is asked to demonstrate the appropriate radio procedure for obtaining ATC approval to cross a runway.

The tug operator required new tug drivers to successfully complete a 6 week induction course and obtain an airside driving authority and other related endorsements before undertaking the towing role. The induction course included examples of the required radio transmissions to ATC to enable tugs drivers to

5 The certificate is for ground operators, for example licensed maintenance engineers or tug drivers that need to talk to individuals operating in the air or air traffic control. A Flight Radiotelephone Operator Licence is required for individuals operating in the air (pilots) or air traffic control.

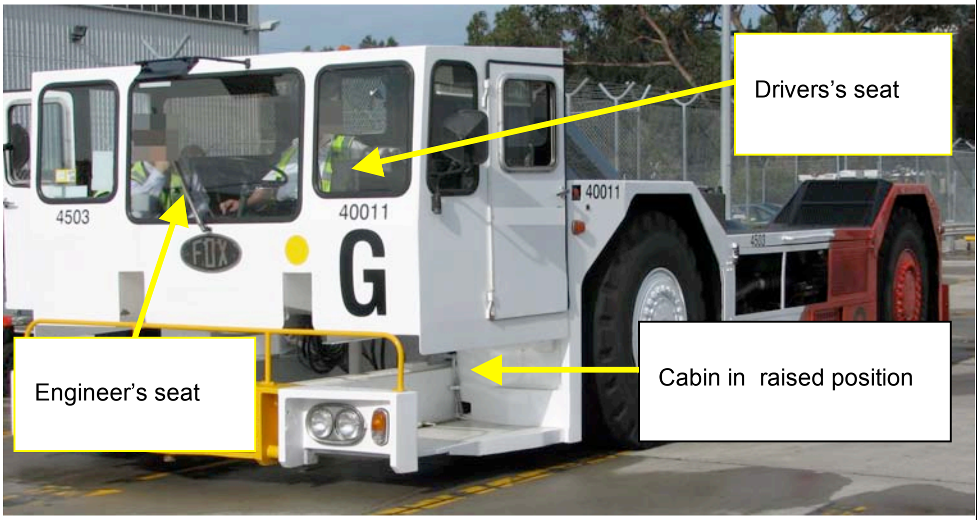
operate on the airport manoeuvring area[6]. That training included alternative procedures to use should a driver lose radio communication with ATC. That procedure required a driver to use the operator's radio to contact the operations manager to request an escort. Tug drivers were tested by the operator every two years. The aerodrome operator's airside driving authority testing was also conducted every two years and alternated with the operator's testing schedule.

Aircraft towing operations

The tug operator reported that between 20 to 30 aircraft were towed across runway 34L/16R each day and that tug drivers were used to being assigned less priority than taxiing aircraft for use of the movement area[7]. It was not uncommon for a tug with an aircraft in tow to be delayed for 20 minutes or more during busy periods at the airport.

The driver's cabin of the tug could be raised about 0.5 m in height (Figure 3) to assist the driver's view when towing. It was normal practice for the tug driver to raise the cabin when towing aircraft and the driver reported that the cabin was raised during the tow. The cabin was fitted with a VHF radio. The driver used a headset and handheld microphone to communicate with air traffic control when operating on the airport movement area. There was a second radio available to the driver to communicate with a company operations manager. The driver monitored that radio via a speaker in the cabin and used a separate handheld microphone.

Figure 3: Tug Red Golf



6 The manoeuvring area was that part of an aerodrome used for the take-off, landing and taxiing of aircraft and excluded apron areas.

7 The movement area was that part of an aerodrome to be used for the take-off, landing, and taxiing of aircraft, consisting of the manoeuvring area and the apron area(s).

In addition to the tug driver, the airline required an engineer to be present in the cabin of the tug and another engineer to be in an aircraft's cockpit whenever aircraft were being towed. The role of the engineer in the tug was to advise the engineer in the aircraft to operate the towed aircraft's brakes if required during a tow. The engineer in the 747 reported that at the time of the towing operation he was seated in the left seat of the aircraft's cockpit and that one of the aircraft's radios was operating on 126.5 Mhz[8]. There was no requirement for the engineer in a towed aircraft to monitor the relevant SMC frequency and he could not recall hearing the clearance. There were no other persons in the aircraft. The engineers were able to communicate through an intercom line and headsets. The tug driver was seated on the left seat of the tug and the engineer was seated in the right seat.

Both the driver of the tug and the engineer located in the tug cab reported that they were able to hear and speak to each other while in the tug cab despite the ambient noise from the tug's twin V8 engines and their use of headsets to monitor the SMC frequency and the intercom respectively. The engineer could not recall the content of the clearance.

Once a tow was underway, the tug driver was responsible for the conduct of the tow. There was no requirement for either of the engineers to confirm ATC clearances or to assist the tug driver in monitoring other airport ground traffic during a tow. In aviation, flight and cabin crew are commonly trained to use crew resource management[9] (CRM) practices and procedures during operations. The tug driver and the engineers had not been trained in CRM.

The maximum recommended towing speed for a tug and aircraft combination was 15 kph. Normal practice when towing was to operate the tug in third gear only.

View from the tug cabin

The investigation estimated that based on the profile of runway 34L, the raised position of the tug's cabin and the dimensions of a 777 that:

- the top half of the 777 fuselage would have been in the line of sight from the taxiway Alpha 1 holding point when the 777 was lined up on runway 34L
- when the 777 passed taxiway Lima, that aircraft's fuselage, wings and engines would have been in the line of sight from the taxiway Alpha 1 holding point.

The investigation of a midair collision between two general aviation aircraft at Bankstown Airport, NSW (ASTB investigation 200201846) reviewed 'see and avoid' issues associated with the collision. That review (Appendix C of ASTB report 200201846) discussed aspects of cockpit visibility, target conspicuity, contrast, speed of relative movement, visual search performance, workload and expectancy and how they might limit the ability of participants in an occurrence to see each other.

The ability of the tug driver to see the 777 when it was at the other end of the runway and during the take-off run was likely to be limited by factors including a lack of relative movement as that aircraft came straight towards the tug, a lack of

8 SMC W frequency.

9 Using all available resources, information and people to achieve safe and efficient operations.

contrast between the background and the aircraft and the small target conspicuity of the aircraft.

Perception

The driver was experienced in the runway crossing procedure and the radio telephony phraseology used between drivers of airport ground vehicles and the surface movement controller. Based on that previous experience, the driver understood the options available to the SMC E, in response to a call, were to either acknowledge the call, instruct the tug to hold position or issue a clearance to cross the runway.

The phenomenon of expectation is well known in aviation and is particularly common in the readback and confirmation of messages. Frank H Hawkins, in the 1987 book *Human Factors in Flight,* notes that it is not unusual for an individual, when expecting to be 'approved' by an air traffic controller, to hear that response, even when, in fact, it was 'not approved'. Hawkins also suggests that the more speech content is 'lost through clipping, distortion, noise or personal hearing loss the greater the risk of expectation playing a role- possibly a disastrous one – in the interpretation of aural messages'. Hawkins provides a number of ways to protect against the impact of expectation. They include ensuring that radiotelephony is not delivered too quickly and that verbal stress is placed on the critical elements of a clearance or instruction.

Surface movement radar parameters

The surface movement radar (SMR) parameters were set to detect and display aircraft and vehicles on the taxiways and runways only. The SMR did not display a scaled version of an aircraft or vehicle that had been detected by the system. It estimated an average location that was then presented as a '+'on a controller's display. The system tolerance for the estimated position was plus or minus 30 m.

The SMR could provide a runway incursion monitoring (RIM) visual alert that was displayed when two plots were detected within a designated area at the same time. The system did not provide an audio alert. For a RIM to be effective, a controller had to be monitoring the display at the time of a visual alert. For runway 34L, the designated area was 45 m wide (the width of the runway) and 4,000 m long (the length of the runway including overrun areas).

Runways have a defined area, called the 'runway strip', that consists of an area either side of the runway and the stopways. The purpose of the runway strip is to reduce the risk of damage in the event of an aircraft running off a runway, and to protect aircraft from obstructions when flying over it during takeoff or landing operations[10]. Operations by vehicles and aircraft within a runway strip are restricted to those periods when aircraft are not using the runway for landing or takeoff, and prior approval is required from the ADC responsible for the runway. Runway 34L was 45 m wide, 3,962 m long and the runway strip was 150 m[11]. The runway strip

10 Civil Aviation Safety Regulation (CASR) Part 130 Aerodromes – Manual of Standards (MOS).

11 MOS Chapter 6.2.18.3.

was delineated on the airport by taxiway holding point markings and lights and gable markers on grassed/dirt areas. The taxiway holding points located on taxiways that intersect runway 34L are located 90 m from the centreline of that runway. The gable markers are located 75 m from the runway centreline. As a result, the SMR detection area was within the runway strip.

With the SMR designated alert area current at the time of the occurrence, it was possible for an aircraft or vehicle to enter a runway before a RIM alert was activated. A problem with setting SMR parameters is balancing the need to provide an effective alert while not desensitizing controllers to alerts because of an increased level of alerts due to false detections.

If the designated alert area was set to detect a plot at the 90 m holding point instead of the runway boundary then, for example, a vehicle/aircraft travelling at an average of 15 kph and intruding into that area should provide an alert about 1.5 seconds before reaching the runway edge. For a vehicle/aircraft that had stopped at the holding point and had to accelerate to 15 kph, an alert should be provided about 2.8 seconds before the vehicle/aircraft reaches the runway edge.

Runway incursion safety developments

International

In October 2002, the International Civil Aviation Organization (ICAO) presented a plan[12] to address runway incursions. That plan was based on a system safety approach that would identify actual and potential hazards, provide remedial action and the monitoring and assessment of hazards in the following areas:

- Radiotelephony phraseology
- Language proficiency
- ATC procedures
- Performance requirements for equipment
- Aerodrome lighting and markings
- Aerodrome charts
- Operational aspects
- Situational awareness
- Human factors.

In April 2004, the European organisation for the safety of air navigation, Eurocontrol approved the European Action Plan for the prevention of Runway Incursions[13]. One of the recommendations from that plan was to, 'Improve situational awareness, when practicable, by conducting all communications

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12 ICAO NAM/CAR/SAM Runway Safety/Incursion Conference (Mexico City, 22 to 25 October 2002).

13 See: http://www.eurocontrol.int/runwaysafety/public/subsite_homepage/homepage.html.

associated with runway operations on a common frequency. (note - aerodromes with multiple runways may use a different frequency for each runway)'.

Australia

Airservices Australia (Airservices) decided to take similar action to ICAO to mitigate the risk of runway incursions. In 2002, Airservices conducted a runway incursion survey at Sydney Airport, similar to other surveys that had been conducted internationally. An outcome of the 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, comprising representatives from Airservices, was formed in 2003 and operates under the terms of reference provided by the Airservices Safety Panel.

The group reviews runway incursion incident data and has implemented a confidential human factors based survey which is issued to pilots and airside ground staff involved in a runway incursion. Another important activity has been the promotion of runway safety teams at controlled aerodromes and the:

- development of hotspot posters for display in airline briefing centres and at aero clubs and other organisations
- coordination of hotspot aerodrome diagrams for inclusion in the En Route Supplement
- development of runway safety posters
- development of a runway safety brochure to be distributed to all pilots

Additionally, Airservices is discussing with the Civil Aviation Safety Authority (CASA) the possibility of producing a video, in conjunction with CASA, that would detail runway safety issues from a pilot's perspective.

Airservices is also discussing with industry the implementation of enhanced surface monitoring systems at capital city airports. Similar systems are in use or are planned to augment airport surveillance at some international locations, including the United States[14]. Development work on these systems is ongoing with a view not only to improving information for air traffic controllers, but also to provide real time situational awareness to pilots through aircraft cockpit displays. The latter systems use Global Positing System or Automatic Dependent Surveillance to guide pilots along airport movement areas and provide notice of a runway conflict directly to a pilot, thus saving time by not having the notification of an alert relayed via a controller over a radio.

During fiscal year 2004-05, CASA distributed 3 sets of runway incursion posters to 800 Airways Operator Certificate holders to promote runway safety. The Authority also published a number of articles relating to runway incursions during 2005-06 in the Flight Safety magazine[15].

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14 The US Federal Aviation Administration is developing Airport Movement Area Safety System/Airport Surface Movement Detection Equipment (AMASS/ASDE) as part of the Enhanced Surface Management System and Runway Incursion Reduction Program (http://www.faa.gov/asd/BluePrint2002.htm).

15 See http://www.casa.gov.au/fsa/index.html.

Sydney Airport Runway Incursion Working Group

On 30 April 2004, the Sydney Airports Corporation Limited chaired a meeting to implement a runway incursion working group for Sydney Airport. The group included staff from the airport, major airlines and Airservices Australia. The group held seven meetings to address runway incursions and had developed an action plan that included the development of a Sydney Airport runway incursion hotspot map[16].

The working group had also been briefed on the use of runway stopbar lights, although they were not required by the Civil Aviation Safety Regulations[17]. Runway stopbar lights are red lights located across a taxiway that operate similar to vehicle traffic lights. When a runway is active, the lights are illuminated to warn pilots and drivers of vehicles that they are approaching an active runway and a holding point. The lights are used in conjunction with a clearance to confirm approval and to minimise inadvertent entry to an active runway. When ATC approves a pilot or driver to enter an active runway the runway stopbar lights are momentarily extinguished and green taxiway lead –in lights operate, as a confirmation of the clearance to enter the runway.

The working group forum was also used to coordinate the investigation effort of the agencies involved following this occurrence.

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16 See http://www.airservices.gov.au/pilotcentre/training/runwaysafety/incursions/Sydney.pdf.

17 Runway stopbar lights are required for runways that will be used during category II and III weather conditions. Sydney Airport is a category I airport.

ANALYSIS

Introduction

This runway incursion resulted from the tug driver's erroneous acknowledgement and subsequent use of a clearance intended for the pilot of an aircraft crossing a different runway. Although the Boeing Company 777 was able to overfly the tug and towed Boeing Company 747-400, there was the potential, if the aircraft taking off sustained degraded take-off performance or the takeoff was rejected, for a collision. The analysis will discuss the factors that may have influenced an experienced and appropriately qualified tug driver to believe that the runway crossing clearance was issued to him and evaluate the role of runway incursion risk controls.

Use of the 767 clearance

There was no evidence that factors with the potential to influence the tug driver's decision making, including time pressure or fatigue, existed. The tug driver's hearing, also a potential contributing factor, tested normal.

The use of the company name as a prefix in the radiotelephony callsign of both the operator's tugs and aircraft probably increased the risk of the tug driver responding to a clearance intended for the aircraft. Also, the instruction in the clearance to the crew of the 767 to cross a runway were similar to what the tug driver was expecting to hear in response to his request for a clearance. However, there were also a number of other items in the clearance issued to the crew of the 767 that were dissimilar to the clearance expected by the tug driver.

The surface movement controller east (SMC E) had opportunities to respond to the radio calls by the driver of the tug, but elected not to. This created doubt in the driver's mind about whether the radio calls had been received by the controller. While there is no evidence that the lack of response to the radio calls contributed to the driver's use of the clearance, acknowledgement of either of the driver's calls by the SMC E with an instruction to hold short of runway 34 left (34L) would have reinforced the need for the driver of the tug to hold position until instructed otherwise.

The tug driver had been waiting about 11 minutes before he heard the clearance intended for the pilot of the 767. This was not an inordinate amount of time for a tug driver to wait, especially during busy traffic periods. However, with a clearance to cross the runway expected at any time, the driver may have been influenced to some degree by the waiting period.

There was some doubt in the driver's mind about the clearance instruction to hold short of Bravo 2, as this was not possible without infringing the runway 34L strip. Instead of confirming the clearance before moving, the driver rationalised the instruction and relied on the controller to correct any discrepancies in the readback. However, the majority of the readback was over transmitted, which removed the opportunity for the controller to correct the error.

All persons, including vehicle drivers, when using an air traffic control radio frequency have a responsibility to advise the surface movement controller (SMC) when they are either uncertain about a clearance or instruction or that they are unable to proceed in accordance with the clearance issued. The SMC is then in a position to confirm the clearance or issue alternative instructions. Such cooperative communication is particularly important on a busy airport where controllers rely on the integrity of the information provided by vehicle drivers and pilots to ensure the safe, orderly and expeditious flow of air and vehicular traffic on the manoeuvring area.

Runway incursion risk controls

At the time of the incursion, the training and checking of drivers with Category 4 airside driving authorities included procedures for obtaining ATC approval to cross runways. While that training and checking reduced the risk of runway incursions, its effectiveness could be enhanced by operators including case studies of runway incursions and increased emphasis on the management of abnormal situations by drivers.

There was no formal structure for involving the engineers in the conduct of the tow, except for emergency braking of the towed aircraft. Accordingly, there was no assurance that the engineers would actively listen to the clearances and query the tug driver if they thought a clearance had been misunderstood by the driver. The use of crew resource management techniques can facilitate an environment in which the engineers involved in a tow can assist the tug driver in the interpretation of clearances and maintenance of a lookout for conflicting traffic.

At the time of the runway incursion, the crew of the 777 and the driver of the tug were operating on separate radio frequencies. This meant that the driver was unaware that the crew of the 777 had been cleared for takeoff on the runway that he was about to cross. While driver-monitoring of the aerodrome control radio frequency has the potential to improve situational awareness of traffic on the runway, it may also decrease a driver’s awareness of taxiway traffic on the destination side of the runway. Any changes to communication procedures would need to consider possible safety implications to ensure new hazards are not introduced.

Verbal air traffic control clearances will always have the potential to be misinterpreted by the correct recipient or used by another station. That risk could be reduced by the installation of stopbars at runway crossing taxiways. The installation of stopbars could be limited to those intersections assessed as being more likely to be subject to a runway incursion compared with other intersections.

None of the controllers noticed a runway incursion monitoring alert on the surface movement radar (SMR). This was primarily due to the visual nature of the alert and the high proportion of attention controllers are required to direct outside the tower. The addition of an aural component to the alert would improve its effectiveness as a defence against runway incursions.

In any event, the SMR parameters were such that any runway incursion monitoring alert was likely to be too late to prevent a runway incursion. Modification of the SMR parameters to detect an incursion at the 90 m or greater runway strip edge would have increased the likelihood of an incursion being notified earlier to air traffic control.

A significant limitation of any alert to a controller is the time it takes for the controller to assimilate the information, confirm the situation, formulate the appropriate course of action and advise the involved parties. Methods such as Global Positioning System or Automatic Dependent Surveillance, broadcast-based systems which can alert the driver and/or aircraft crew directly, have a better chance of preventing or mitigating runway incursions.

Conclusion

The tug driver involved in the occurrence had 17 years experience in driving a tug at Sydney Airport. In that time he had not been involved in any other recorded incident. Despite his extensive experience and the ongoing training and checking regime that was in place at Sydney Airport leading up to the occurrence, the driver of tug red golf used a clearance issued to the pilot of the taxiing 767.

The driver believed he heard a clearance to cross runway 34L from the surface movement controller east (SMC E). The driver acknowledged that clearance in accordance with published procedures, but the SMC E remained unaware of the situation. In the absence of any contrary response from the SMC E, the driver continued to cross the runway. From that point on, there was limited time available to prevent the runway incursion.

In the absence of stopbar lights and advanced pilot/driver/controller alerting systems, enhanced training emphasising the importance of crew resource management support during towing operations and the importance of removing any doubt from information contained in clearances and instructions are important elements to reduce the risk of similar runway incursions. The training and checking of drivers must continue to emphasise the need for drivers to ensure that they clearly understand what is required of them before moving, and if there is any doubt that they confirm the clearance with air traffic control before acting on it.

FINDINGS

Contributing safety factors

- The driver of tug red golf used the clearance intended for an aircraft to cross runway 07, for his vehicle to cross runway 34 Left.
- The driver of tug red golf relied on his readback of the clearance to confirm the validity of the clearance.
- The majority of the tug driver's readback of the clearance was over transmitted and was not received by the surface movement controller.
- The tug driver did not question the clearance to cross the runway with the surface movement controller even though doubt existed in his mind about the contents of that clearance.
- Towing procedures and training did not highlight the safety benefits available in using crew resource management techniques.

Other safety factors

- There was lack of assurance that Category 4 airside driving authority training and checking optimised the learning from past runway incursions.
- The radio callsign for the tug and the taxiing Boeing Company 767 were prefixed with the same company name.
- The driver of the tug and pilot of the Boeing Company 777 were operating on separate radio frequencies.
- The surface movement radar parameters did not provide an alert in sufficient time to enable action to be taken to prevent a runway incursion.

Other key findings

- Airservices Australia has implemented initiatives to help identify the potential runway incursion risk to help avoid future runway incursions at airports around Australia.
- Sydney Airport Runway Incursion Working Group is working to implement initiatives to mitigate runway incursion risks at Sydney Airport.

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SAFETY ACTIONS

Airport operator

The airport operator is developing an updated version of the runway incursion chart for distribution and publishing on the internet.

Tug operator

The tug operator:

- in conjunction with the airport operator and the air traffic service provider, has deleted the company name from tug callsigns
- issued a safety alert notice to all company drivers on air traffic control surface movement radio communications that highlighted this occurrence, the safety issues involved and lessons learnt
- is reviewing towing procedures to ensure that all staff involved in the procedure operated as a team.

Air traffic service provider

As a result of their investigation into the occurrence the service provider has:

- distributed a runway incursion awareness information letter to all tug drivers at Sydney and Brisbane Airports.
- briefed tug drivers from one company operating at Sydney Airport following a request from the safety manager
- commenced consulting with industry regarding having all runway crossing traffic using the ADC frequency instead of the SMC frequency.

Additionally, the service provider is developing strategies on an ongoing basis to address runway incursions. Those strategies include:

- examining a proposal to amend surface radar movement parameters to provide an earlier alert of runway strip infringements
- the selection of a contractor to provide enhanced surface monitoring systems at Brisbane, Melbourne and Sydney Airports
- a review of the use of company names in callsigns of vehicles operating on airports
- inclusion of the Royal Australian Air Force in the Runway Incursion Group
- development of runway safety teams at other airports, including joint user airports.

Australian Transport Safety Bureau

The Bureau has commenced a research project to review radiotelephony readback compliance and to consider if there is a relationship with surface movement control frequency congestion.