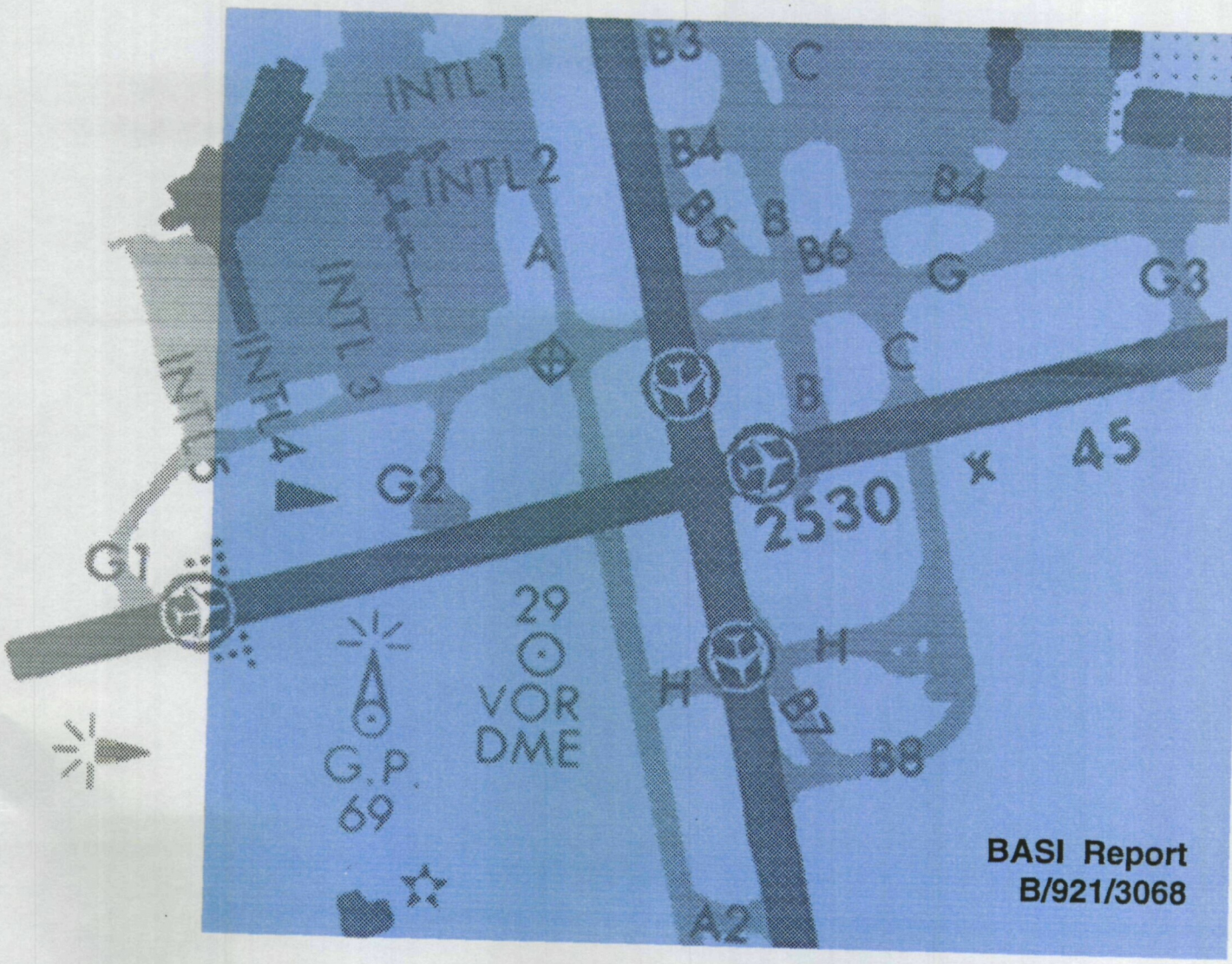
INVESTIGATION REPORT

BUREAU OF AIR SAFETY INVESTIGATION



BASI Report
B/921/3068

Breakdown in Runway Separation Standard during Landings on Runways 16 and 07 Sydney (Kingsford Smith) Airport 12 March 1992

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Bureau of Air Safety Investigation

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under the provisions of Air Navigation Regulation 283

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BASI does not have the resources to carry out a full cost-benefit analysis of every recommendation. The cost of any recommendation must always be balanced against its benefits to safety, and aviation safety involves the whole community. Such analysis is a matter for the CAA and the industry.

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CONTENTS

ABBREVIATIONS

ADC	Aerodrome Control
ADC1	Aerodrome Controller
ADC2	Aerodrome Control Co-ordinator
AIP	Aeronautical Information Publication
APP CTL	Approach Control
APP N	Approach North
APP/DEP	Approach/Departures
CAA	Civil Aviation Authority
COORD	Tower Co-ordination
CRDA	Converging Runway Display Aid
CRM	Cockpit Resource Management
FPS	Flight Progress Strip
ILS	Instrument Landing System
MATS	Manual of Air Traffic Services
OPS CTL	Operations in Controlled Airspace
OPS NCTL	Operations at Non-controlled Aerodromes
RAAF	Royal Australian Air Force
RAC	Air Traffic Rules and Services
SMC	Surface Movement Control
SMR	Surface Movement Radar
STWR	Senior Tower Controller

Unless otherwise indicated all times are Eastern Standard Time (UTC+10 h).

SYNOPSIS

At 0832.29 hours on 12 March 1992, a Boeing 767 aircraft VH-EAO was cleared to land on runway 16 at Sydney (Kingsford Smith) Airport. At the same time, a Boeing 727 aircraft VH-TBR was on final approach to the intersecting runway 07. During the approach air traffic control monitored the progress of both aircraft on radar. The B727 was instructed to continue the approach and to expect a late landing clearance. After the B767 landed it was instructed to expedite its movement through the intersecting runway. Subsequently, the B727 crossed the runway 07 threshold before the B767 had cleared the intersection, thereby infringing runway separation standards.

During the approaches to their respective runway thresholds, the spacing of the aircraft was in accordance with accepted sequencing practices. However, during the approach, the B727 was affected by a tail wind and the B767 by a head wind, thus the B727 was approaching at a higher ground speed than the B767. The extent of the speed differential became more apparent to air traffic control as the aircraft approached the runways and it was noted that they may conflict. Although go-around instructions were co-ordinated for the B727, they were not issued. The B727 pilot saw the situation developing and prepared himself for a go-around if the intersection was not cleared in time for him to carry out a safe landing; however, he elected to land.

1. FACTUAL INFORMATION

1.1 Circumstances.

Boeing 767 (B767) aircraft, registered VH-EAO, operating as Qantas flight QFA 98, was making an Instrument Landing System (ILS) approach to runway 16. The aircraft was given a landing clearance by the Aerodrome Controller (ADC1) at 0832.29 Eastern Standard Time. At the same time, Boeing 727 (B727) aircraft, registered VH-TBR, operating as Australian Airlines flight TN 56 was making an ILS approach to runway 07. Sydney Approach Control (APP CTL) had been monitoring the progress of the arriving aircraft by radar and saw that the spacing of the aircraft (i.e. the comparison of the distances of each aircraft from the respective runway thresholds) was reducing. Approach North (APP N) then enquired of the ADC Co-ordinator (ADC2) if he wished to redirect the B727 off the approach to runway 07 and position it behind the B767 for runway 16. The ADC2 decided to allow the B727 to continue the approach to runway 07.

At 0832.40 hours, the B727 was instructed by the ADC1 to continue the approach and to expect a late landing clearance due to the B767 landing on runway 16. At 0833.13 hours, the ADC2 recognised that the spacing between the two aircraft was deteriorating to the extent that the runway separation standard was in jeopardy, and advised APP N that there was a possibility of a go-around for the B727. A missed approach instruction was then issued by the Approach/Departures (APP/DEP) cell and this was written on the B727 flight progress strip by the ADC1.

At 0833.36 hours, the ADC1 again told the B727 to continue the approach. He then instructed the B767, which was by this time on the runway and approaching the runway intersection, to expedite its movement through the runway intersection. At 0833.50 hours, the ADC1 cleared the B727 to land. At this time the aircraft was approximately 500 m past the threshold of runway 07. The B767 had cleared the intersection by the time the landing clearance was acknowledged, and the B727 touched down about 100 m beyond the runway 16 centreline.

1.2 Injuries to persons

No injury to any person resulted from this occurrence.

1.3 Damage to aircraft

No damage to either aircraft resulted from this occurrence.

1.4 Other damage

No damage to other property was reported.

1.5 Personnel information

1.5.1 Crew of B767 VH-EAO

The captain was aged 42 years. He held an Airline Transport Pilot Licence appropriately endorsed for command of B767 aircraft. He had a total of 10,146 h flying experience, of which 3,256 were on B767 aircraft.

The first officer was aged 38 years. He held an Airline Transport Pilot Licence appropriately endorsed for B767 aircraft. He had a total of 7,601 h flying experience, of which 1,146 were on B767 aircraft.

1.5.2 Crew of B727 VH-TBR

The captain was aged 46 years. He held an Airline Transport Pilot Licence appropriately endorsed for B727 aircraft. He had 12,430 h flying experience, of which 1,960 were on B727 aircraft.

The first officer was aged 38 years. He held an Airline Transport Pilot Licence appropriately endorsed for the B727 aircraft. He had 5,700 h flying experience, of which 2,200 were on B727 aircraft.

The flight engineer was aged 45 years. He held a Flight Engineer Licence endorsed for B727 aircraft. He had 926 h total flying experience, all of which were on B727 aircraft.

1.5.3 Air Traffic Services personnel

All staff held current ratings appropriate to the positions they occupied. They had all received performance checks within the statutory period.

Tower Cabin personnel

The ADC1 was aged 34 years. He held ratings for the Surface Movement Control (SMC), Tower Co-ordination (COORD) and Aerodrome Control (ADC) positions.

The ADC2 was aged 46 years. He held ratings for the SMC, COORD and ADC positions.

The ADC2 under supervision was aged 30 years and held ratings for the SMC, COORD and ADC positions. He was performing the ADC2 function under supervision for re-familiarisation after a period of leave.

The SMC at the time of the incident was aged 29 years. She held ratings for the SMC, COORD and ADC positions.

The COORD was aged 45 years. He held ratings for the SMC and COORD positions.

The Senior Tower Controller (STWR) was aged 43 years. He held ratings for all Tower positions.

Other Air Traffic Services personnel

The Approach South Controller was aged 43 years. He held ratings for the APP/DEP and Flow Director positions.

APP N was aged 48 years. He held ratings for APP/DEP and Flow Director positions.

1.6 Aircraft information

VH-EAO, a B767-238 passenger aircraft, was operated by Qantas Airways Ltd. The aircraft was serviceable, and was arriving at Sydney on a scheduled flight from Fukuoka, Japan via Cairns, Qld.

VH-TBR, a B727-276 passenger aircraft, was operated by Australian Airlines Ltd. The aircraft was serviceable, and was arriving at Sydney on a scheduled flight from Melbourne.

1.7 Meteorological information

At the time of the incident the Sydney Automatic Terminal Information Service facility was transmitting terminal information 'Hotel' indicating that the wind was 170° at 12 kts, giving a crosswind of 11 kts, a downwind component of 4 kts on runway 07, and a headwind component of 11 kts on runway 16. The ADC1 reported that the actual wind velocity was south-easterly at 10 kts. The QNH was 1,022 hPa and the temperature 23°C. Cloud was 2 oktas at 1,000 ft and 2 oktas at 2,500 ft, with some showers in the area but the runway was dry.

1.8 Aids to navigation

The ILS systems for both runways 07 and 16 were serviceable. The Tower was advising pilots to expect an ILS approach, and that radar vectors could also be expected to assist with these approaches to suit the traffic sequence.

1.9 Communications equipment

At the time of the incident, there were no identifiable problems with radio communications equipment in Sydney Tower.

1.10 Aerodrome information

1.10.1 The aerodrome

The operator of Sydney (Kingsford Smith) Airport is the Federal Airports Corporation. The complex includes two sealed runways, 16/34 and 07/25, which are 3,962 m and 2,529 m in length respectively.

Runway 07/25 has a slope of 0.1% up to the east, and is 45 m wide. The distance from the threshold of runway 07 to the centreline of runway 16 is 1,059 m.

Runway 16/34 has an overall slope of 0.2% up to the south, and is 45 m wide. The distance from the threshold of runway 16 to the centreline of runway 07 is 1,253 m.

At the time of the incident, runway 16 was in operation for departures and runways 16 and 07 were in operation for arrivals. Simultaneous runway operations were in use for Performance Category A aircraft only. Both aircraft involved in this occurrence were Category C aircraft and were therefore not processed for simultaneous runway operations.

1.10.2 The Sydney Air Traffic Control Tower

The Sydney Air Traffic Control (ATC) Tower is configured with four operator positions facing northwards from an elevated tower cabin located south-west of the intersection of runways 07 and 16. There is also provision for one additional supervisory position or shift manager. The Airways Data Systems Officer sits on the opposite side of the console facing south and is responsible for the flight-strip preparation. The officer does not have an ATC licence function.

From left to right, the operator positions and part of their functions are as follows:

SMC: The occupant of this position is responsible for ground separation by issuing

instructions, clearances and information to all aircraft and vehicular traffic operating on the manoeuvring area of the aerodrome, excluding the duty runway(s). Surface Movement Radar (SMR) is available to the controller for reference only.

COORD: The occupant of this position relays procedural messages to and from other airways units, and has various operational and weather information liaison functions, including the alerting of emergency services.

ADC 2: Duties at this position include the relay of flight progress strips and departure/ arrival sequencing instructions to and from the ADC1 and other airways units such as the APP/DEP cell in the Area Approach Control Centre.

ADC 1: Duties at this position include the responsibility for maintaining separation between arriving and departing aircraft using the duty runway(s). This officer shares access to the SMR and a 20-NM radius Terminal Area Radar display with the ADC 2.

STWR: The supervisor has a separate console positioned at the rear of the cabin facing east. The occupant of this position is responsible for overseeing all operations within the Control Tower cabin, and has the authority to intercede or take over any ATC position if deemed necessary.

1.10.3 Control Tower operations

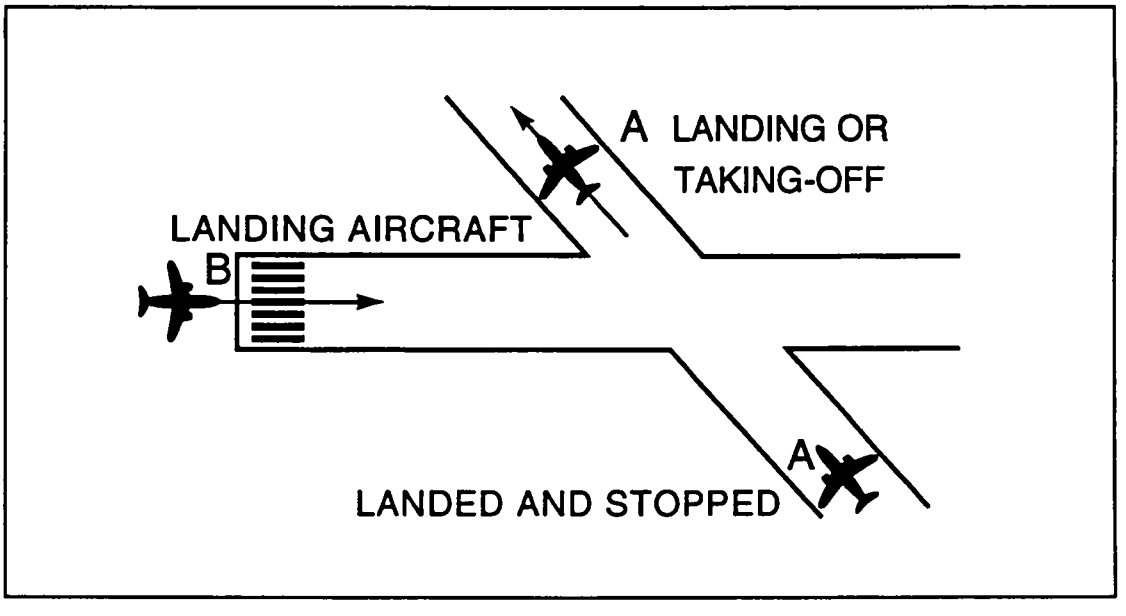
The Manual of Air Traffic Services (MATS) ch. 6 details the procedures and responsibilities for ADC.

The Tower Cabin staff are supervised by the STWR, who has the responsibility to ensure the safe, orderly and expeditious flow of traffic on and in the vicinity of the aerodrome.

Separation standards: MATS ch. 6 sect. 3 details the separation standards to be used in various circumstances.

The appropriate standard relating to the circumstances at the time of the incident was documented in MATS 6-3-6, para. 32, case (f) (see fig. 1).

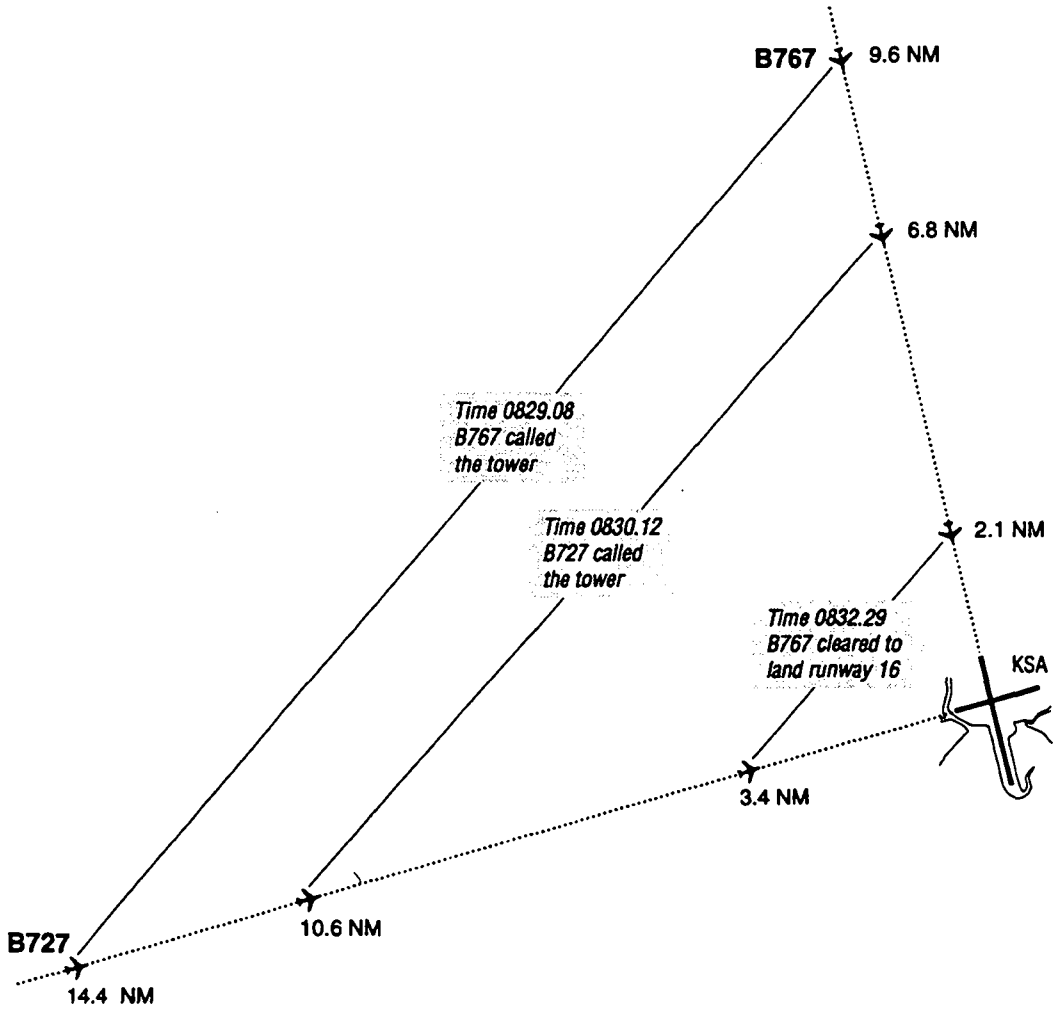
Figure 1



B (the B727) shall not be permitted to cross the runway threshold until the preceding departing or landing aircraft A (the B767) has crossed the relevant runway intersection or has stopped short of the intersection.

1.11 Flight recorders and recorded radar data

Both aircraft were fitted with a digital flight data recorder. Both recorders were serviceable and a readout of the recorders and recorded radar data indicated the following:



Relative positions (approximate) of both aircraft between 0829.08 and 0832.29 hours

Figure 2

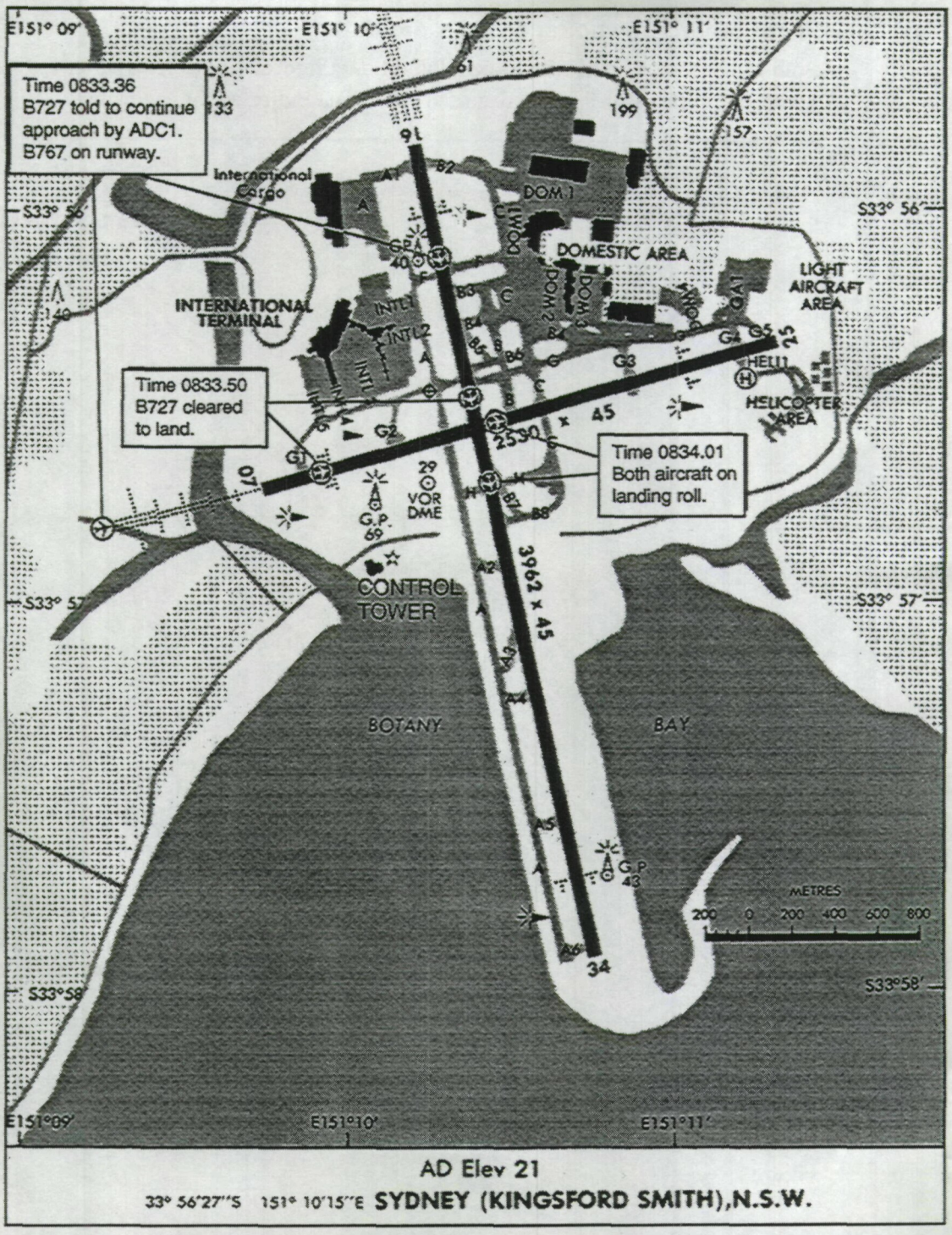


Figure 3 Relative positions (approximate) of both aircraft between 0833.36 and 0834.01 hours

1.12 Wreckage and impact information

Not applicable.

1.13 Medical and pathological information

Not applicable.

1.14 Fire

Not applicable.

1.15 Survival aspects

Not applicable.

1.16 Tests and research

1.16.1 Previous related incidents

The BASI Accident and Incident Data Recording System indicated that between February 1987 and February 1992 there were 17 related reported occurrences at controlled airports other than General Aviation Aerodrome Procedures airports. The criteria for selection were (1) a breakdown in separation between aircraft, (2) both aircraft were on the ground, or (3) one aircraft was on the ground and one aircraft was in flight. Within the five-year period, five of the reported occurrences were at Sydney Airport. Eight incidents occurred in the 12 months preceding this occurrence. Three of these occurred at Sydney Airport, with one of these involving two aircraft landing on intersecting runways.

1.16.2 ATC situation training

At present, on-the-job training is the primary method of training for tower controllers. While such training is operationally viable, it does have inherent difficulties. The most critical of these is that during high traffic density periods there is little time to explain to the inexperienced operator why some traffic patterns are better than others, and the reasoning behind particular traffic processing methods. Such experiences and explanations are important in developing the perceptual and cognitive foundations on which the trainee controller will base future judgements.

The inability to 'stop' traffic sequences to analyse and assess options, or to expose tower controllers to unusual or emergency situations, suggests that tower controller training would benefit from the introduction of a generic tower simulator, akin to that utilised by the Royal Australian Air Force (RAAF). With such a facility, the trainee could be exposed to situations which would not usually be experienced during training, e.g. unusual weather or emergency conditions. It would also allow the development of skills to minimise the risk of human error.

The Civil Aviation Authority (CAA) does not possess a simulator suitable for this purpose. However, the RAAF has a tower cabin simulator in use at its base in East Sale. This is used to train military tower controllers in unusual and/or emergency situations which would not normally present themselves during on-the-job training.

1.16.3 ATC checking system

The controller training system is arranged so that, prior to rating, a check controller assesses the competency of the controller under check. This assessment is made during high workload conditions. Because no suitable training facility is available, the controller's ability to handle emergency or other unusual situations is subjectively judged by the check controller on the basis of a controller's handling of normal traffic situations.

It was also noted that while the controller checking system identified potential deficiencies during a rating check, little remedial action was taken to rectify these deficiencies if the controller passed the check. Such a situation was also found in the United States following the runway collision between a Boeing 737 and a Fairchild Metroliner at Los Angeles International Airport on 1 February 1991.

1.16.4 Converging Runway Display Aid

It has been shown that the controller's task of separating aircraft on adjacent converging runways on a sustained basis using existing radar displays is, at times, difficult. Attaining the

maximum arrival rate by achieving optimum staggering of aircraft is an even more difficult task. The judgement of aircraft spacing is usually predicated upon visual observations by the controller, and visual judgement is almost entirely based on knowledge and experience. At present, there are few technological aids available to the ADC1 to assist decision making, and fewer still to detect any errors of judgement that might be made.

The investigation team reviewed literature concerning a device under development in the USA known as the Converging Runway Display Aid (CRDA). CRDA is expected to be of assistance at airports that conduct concurrent approaches to intersecting runways for both VMC and IMC conditions and could provide the controller with information not only on the spacing between aircraft, but also on the assessment of any relative closing speed between them. On these grounds, the CRDA may have been of some advantage to the ADC1 in this occurrence. However, it appears that its most significant potential is as a training aid.

In its primary mode, CRDA displays the position of an aircraft on approach to one runway on the radar display of a converging runway approach. The 'ghost' image allows the controller to more easily maintain the required radar separation between aircraft approaching converging runways and has application in both VMC and IMC conditions. Although primarily a tool for approach controllers, displays are also provided for aerodrome controllers.

1.17 Additional information

1.17.1 Aircraft spacing and sequencing technique

Sydney Approach Control

Approach control procedures are detailed in MATS ch. 8, sect. 3. Briefly, arriving aircraft are 'handed off' to Approach in a suggested landing sequence. Approach adjusts the sequence to best suit the prevailing conditions. Speed control and radar vectoring are among the techniques used for sequence and spacing adjustment. When a sequence for landing has been finalised, the information is passed to Tower (ADC2).

Sydney Approach Control is divided into Approach North and Approach South. These two positions work closely together as any change of instruction to one aircraft may affect other aircraft in the sequence. The sequencing procedures applied by Sydney Approach vary depending on weather conditions and runway(s) in use.

Aerodrome Control

The radar separation standard within 30 NM is 3 NM between aircraft at all times (see MATS ch. 9 sect. 2 para. 1).

In the interest of maintaining an expeditious flow, it is often necessary and desirable to have aircraft less than 3 NM apart when using intersecting runways. Under these circumstances, it becomes the responsibility of the Aerodrome Controllers to provide visual separation. This visual separation is routinely provided and is only varied when weather conditions do not permit the guaranteed sighting of aircraft prior to 3 NM from the aerodrome.

When the Aerodrome Controllers accept a sequence from APP CTL, it becomes their responsibility to monitor the aircraft and provide the relevant runway separation standard with the landing clearance. If this cannot be achieved, then alternative action must be co-ordinated with APP/DEP CTL.

1.17.2 Approach and landing sequence

Approach Control

The B767 was cleared for final by APP (N) in the normal course of events. The B727 was being

controlled by APP(S) who considered that separation could be maintained through speed control even though the B767 was being influenced by a headwind and the B727 by a tailwind. To this end, the B727 was reduced to an indicated airspeed of 210 kts at 30 NM from the aerodrome and APP(S) was considering the need for further speed reduction (B727 aircraft can be reduced to 170 kts from 15 NM) as the B727 was approaching 15 NM. At that time, however, a Rockwell 690 aircraft (VH-WLO) departing Bankstown experienced a cockpit instrument failure and diverted from its cleared track into the projected flight path of the B727. The APP(S) controller reported that this occurrence became the prime focus of his attention, and he was unable to return to the sequencing of the B727 until separation had been achieved between that aircraft and the Rockwell 690. When this problem was resolved, APP(S) again checked the positions of the B727 and the B767. The B727 was 12 NM from touchdown and the B767 was 7 NM from touchdown. APP(S) immediately instructed the B727 to reduce speed to 170 kts.

As the spacing between the two aircraft continued to reduce, APP(S) assessed that the separation standard could be infringed and offered to radar vector the B727 to increase the spacing. However, the ADC2 considered that the B727's proximity to the aerodrome (approximately 4 NM) was such that the most appropriate course of action was to allow the aircraft to continue its approach with the option of a go-around should separation be inadequate. He therefore co-ordinated 'go-around' instructions to enable the B727, if it later became necessary, to discontinue its approach and climb on runway heading to 2,000 ft.

When the B767 was 1.75 NM from the threshold of runway 16, the B727 was 2.5 NM from the threshold of runway 07. The ADC2 and APP(S) again discussed the spacing between the aircraft and concluded that the B727 would have to go around. The ADC2 kept the ADC1 informed of these developments and the ADC1 wrote the go-around instructions on the B727's flight strip.

Tower control

STWR: During the lead up to the occurrence, the STWR was attending to a managerial task at the rear of the Control Tower cabin. He did not become aware of a problem until called by the ADC2 (see next para.).

ADC2: Both the ADC2 on familiarisation, and his supervisor, stated that they expected that the ADC1 would instruct the B727 to go around. When this expectation was not realised, the ADC2 urged the ADC1 to send the B727 around. (At this point the B727 was on short final for runway 07 and the B767 was about to touch down on runway 16.) When the B727 had crossed the threshold of runway 07 and the B767 was in its landing roll on runway 16 north of the runway intersection, both ADC2 Controllers more forcefully urged the ADC1 to send the aircraft around. At this point, the supervising ADC2 called the STWR to review the situation. However, events had proceeded to such a point that the STWR was unable to intervene to prevent a breakdown in runway separation standards.

ADC1: The ADC1 recognised that the arrival sequence of the B767 and the B727 would be close. However, he believed that there was sufficient separation between the aircraft to meet the specified runway separation standard. He made this perceptual judgement based on the relative positions of the aircraft and the radar display at his disposal. As the two aircraft came closer, he made a visual assessment of their positioning and elected to allow the B727 to continue and instructed the aircraft to 'continue approach' in expectation of a late landing clearance.

The ADC1 stated that he believed the separation standard could be achieved, and this judgement was reinforced by the fact that:

(a) the STWR was not brought in by the ADC2 to review the situation which the controller

considered would have been the case if the ADC2 thought the separation standard was going to be breached; and

(b) the pilot did not question the instruction to continue approach.

The co-ordination of the go-around instruction between the Aerodrome Controllers and APP (S) did not lead the ADC1 to assume that a go-around would be required. Controllers interviewed during the course of the investigation estimated that the missed approach instruction is only instigated in approximately 5% of the cases in which it is co-ordinated.

Following the landing of the B767, the ADC1 still believed that a separation standard would exist. However, the ADC1 stated that the B767 was slower once on the ground than he had anticipated and therefore asked it to 'expedite through the intersection' in an attempt to achieve the required separation standard. This instruction was given as he believed that the B727 was committed to a landing at that stage. The ADC1 thought that the B727 was just over the runway threshold when he issued the landing clearance. Although urged by both ADC2s to send the B727 around, the ADC1 believed his judgement was correct and allowed that aircraft to continue its approach.

1.17.3 Aircraft performance

The B767 had landed approximately 470 m after the threshold of runway 16, and had decelerated to approximately 89 kts ground speed when the pilot was asked to expedite crossing the runway intersection. The pilot had then cancelled reverse thrust at approximately 76 kts ground speed and reapplied power to comply with the request. This brief application of power had resulted in an acceleration to approximately 80 kts ground speed whilst the aircraft was crossing the intersection.

The B727 captain stated that he had been prepared to make a go-around had the runway not become clear. He expected to touch down well into the runway after having been told to expect a late landing clearance. He also stated that although a go-around appeared imminent, he considered that a landing east of the intersection would have been unacceptable as there would be insufficient runway available. This was confirmed in the published company landing performance data.

1.17.4 Summary of B727 crew's comments

All B727 crew members stated that they thought the approach and landing was going to be 'tight' but, as they had been told to expect a late landing clearance, the expectation was that they would probably be able to land from the approach. During the approach, the pilot flying (the first officer) indicated to the captain that he would fly the approach slightly high as this would facilitate a go-around should it be required.

The flight engineer said the crew continually monitored the situation and were fully prepared to make a go-around. He did not notice how close the B767 was when they landed because his attention was focused on his duties inside the cockpit.

The captain stated that he had allowed the approach to continue as he had assessed that the runway would probably become clear. He decided to accept a landing at or before the intersection should a landing clearance be issued, but beyond the intersection he would go around. In the event, before the B767 reached the intersection, he perceived that there would be no risk of collision with the crossing B767 and accepted the landing clearance.

The crew interpreted the runway separation standard in the Aeronautical Information Publication (AIP) as an ATC responsibility.

1.17.5 Summary of B767 crew's comments

The second officer was seated in the cabin on the right-hand side during the landing and became alarmed when he saw the proximity of the B727. The close proximity of the B727 prompted a transmission from the B767, 'Qantas 98 I think that was a little bit close'. The opinion of the B767 crew was that the B727 should have gone around, or should have been instructed to go around by the Tower.

1.17.6 Separation minima for landing.

AIP Australia contains primary operational information which may be required in the cockpit for the safe conduct of a (domestic) flight. The relevant separation minima are published in AIP Operations in Controlled Airspace (OPS CTL) p. 15 para. 22.5.1 (c). The document states:

> A landing aircraft will not be permitted to cross the threshold of a runway on its final approach until...a preceding aircraft, using a different runway, has crossed or stopped short of the landing aircraft's runway. In the above situations a landing clearance may be issued if ATC expect that the required runway separation standard will exist.

1.17.7 Clearances—pilot responsibility.

The AIP documents the pilot's responsibility with regard to clearances issued by ATC in Air Traffic Rules and Services (RAC) p. 57 para. 47. The document states in part:

> The clearance [issued by ATC] is not an authorisation for a pilot to deviate from any regulation, order, operating standard or procedure, or minimum altitude nor to conduct unsafe operations in his/her aircraft.

1.17.8 Organisational changes

An air safety incident cannot be considered in isolation, but must be reviewed in the context of changes which may impact on the total operating system. In the case of the incident under review, the CAA is in the process of introducing both the 'journeyman' and 'team' concepts into Sydney Airport Tower operations.

The 'journeyman' concept demands that all controllers be rated on each of the control positions in the Tower, thereby allowing greater flexibility. Its implementation should ensure that controllers rotate through positions during shifts.

The 'team' concept is a method of operational supervision and staff support under which staff are organised into small groups, each of which is managed by a team leader.

Indications are that both concepts will be implemented by late 1993.

2. ANALYSIS

As with many complex systems, aviation has numerous features which provide redundancy so that a failure in one element of the system will be identified and corrected by another element. In this occurrence, there were a number of areas in which redundancy was incomplete. Sections 2.1 to 2.5 of the following analysis relate to the ATS system. Sections 2.6 and 2.7 relate to the technical crew of the aircraft involved.

2.1 ATS personnel

The air traffic controllers on duty were all suitably qualified and licensed for the tasks they were performing. There was no evidence that any were suffering from any physiological or psychological problems which might have affected their ability to carry out the duties and responsibilities of their respective positions. Workload was considered by the controllers to be moderate.

2.2 Air traffic management at Sydney Airport

The system of traffic management being utilised at Sydney Airport was appropriate for the runway configuration. Multiple runway utilisation enabled an expeditious traffic flow, commensurate with safety and within promulgated separation standards.

Beyond 10 NM from the relevant runway thresholds, the aircraft were spaced in accordance with accepted sequencing practices. After this point, however, differing ground speeds resulted in a marked reduction in the spacing between the two aircraft. Such reduction of spacing between aircraft during final approach with multiple runway operations, while a common occurrence, requires careful monitoring by the controllers. Aerodrome Controllers co-ordinate a missed approach instruction with the approach cell if they believe the separation standard may not be achieved. Such co-ordination was carried out prior to the incident and both the ADC2 and the Approach Controller expected that the ADC1 would instruct the B727 to go around.

All the applicable ATC procedures were properly followed in this instance and the evidence indicates that runway separation standards would not have been breached had the ADC1 instructed the B727 to go around.

2.3 Controller performance

ADC1's decision-making process regarding the ability of the two aircraft to meet the runway separation standard involved two separate but complementary considerations. The first was his visual assessment that the spacing between the aircraft was adequate. The second was reinforcement of his assessment by the fact that the STWR was not brought in to review the situation and also the pilot's response to his instructions (see sect. 1.17.2).

The investigation could not determine why ADC1 misjudged the separation between the aircraft. However, US Federal Aviation Administration research has confirmed that human performance errors in the areas of perception and judgement are normal in ATC (Aviation Safety Journal, Winter 1991, Vol. 1 No. 1). In the vast majority of instances such errors are identified by the controller or pilot before they breach the safety net.

2.4 Control Tower management

STWR is responsible for the overall management of the Control Tower. He is not required, nor would it be possible for him, to closely monitor every single event which takes place in the dynamic Tower environment. However STWR does have the authority to intercede or take over any ATC position if considered necessary.

The Control Tower personnel operate at their stations individually, but communicate frequently to achieve the information flow demanded by various levels of traffic movement. Dependence on individual perception, judgement and self-monitoring are likely to lead to uncorrected human error, as was evident in the circumstances of this occurrence.

At present, there is no automated monitoring system which can detect human performance errors in the Tower. Consequently, it can be argued that training and procedures for Tower Controllers should more fully accommodate the occurrence of human error. Two areas that appear to have considerable potential in this respect are training for unusual situations (see sect. 1.16.2) and the CRDA (see sect. 1.16.4). A third area with significant potential is that of controller resource management.

2.5 Controller resource management

The occurrence reflects the need for immediate corrective decision making and action to take place once an error has been detected. This requirement is made more critical by the constantly and sometimes rapidly changing situations which can be brought about by some unexpected event or circumstance.

At present, there is no mechanism or procedure by which the ADC1, or any other Tower Controller, can be authoritatively countermanded by any controller other than the STWR.

A philosophy similar to that used by many airlines in their cockpit resource management (CRM) programs may have application in the Air Traffic Services environment. This environment has a number of requirements comparable to those of the cockpit, e.g. to maintain the command prerogative of each ATC position while ensuring that each operator is aware of all the relevant information and is made aware of any error of judgement when it is obvious to another controller. Obviously, a delicate balance must be achieved between intervention and interference. It is inappropriate, for example, for a controller to assume control if another rated controller issues an instruction which does not comply with his/her appreciation of how to process the traffic. To achieve this balance in the cockpit, some airlines have developed a phraseology which is only utilised in situations in which the non-flying pilot believes that safety standards will be (or have been) breached (e.g. 'You must go around'). In such cases, if the pilot in command does not comply with the instruction, an internal review within the company is conducted to determine the reason(s) for the non-compliance.

2.6 Aircrew performance

The aircrew of both aircraft were all suitably qualified and there was no evidence that any of them were suffering from any physiological or psychological problem which may have affected their performance.

The crew of the B727 utilised CRM techniques, incorporated within their Aircrew Team Management training, to determine their response to the developing situation. The first officer (pilot flying) had indicated to the captain that he would fly the approach higher than normal due to his expectation that there may be a requirement to go around. The captain monitored the approach of the B767 and constantly reviewed the requirement for a go-around.

The B727 crew did not consider that the runway separation standard had been infringed, either before or after receiving their landing clearance, but they did acknowledge that the B767 was closer than usual. In this regard, the crew misinterpreted AIP OPS CTL in relation to the runway separation standard. The crew also misinterpreted the AIP in understanding that the runway separation standard was solely an ATC responsibility.

2.7 Interpretation of AIP OPS/CTL p. 15 para. 22.5.1

During the investigation, 20 experienced aircraft captains from a wide variety of flying backgrounds were asked whether the opening statement in AIP OPS CTL p.15 para. 22.5.1 ('A landing aircraft will not be permitted to cross the threshold of the runway on its final approach until...') applied to ATC or to the crew of the landing aircraft. Fifteen of those surveyed felt that only the controller had the obligation to comply with this provision.

The CAA advised that the intention of the instruction is that the pilot, the controller or anyone responsible for the safe operation of the aircraft, will not permit the aircraft to cross the threshold before the required conditions are met by the preceding aircraft.

This same standard applies in the uncontrolled aerodrome situation where the responsibility quite clearly rests with the pilot. AIP Operations at Non-controlled Aerodromes (OPS NCTL) para. 54.1 states:

> An aircraft shall not continue its approach to land beyond the threshold of the runway until...(c) a preceding aircraft using another runway, has crossed or stopped short of the landing aircraft's runway.

3. CONCLUSIONS

3.1 Findings

The investigation found that:

1. The relevant air traffic controllers and flight crew on duty were all suitably qualified and licensed for the tasks they were performing.
2. ATC workload at the time of the incident was moderate.
3. The wind conditions on final approach were such that the B767 experienced a headwind, and the B727 a tailwind.
4. When the B767 was approximately 10 NM from the threshold of runway 16, the B727 was approximately 15 NM from the threshold of runway 07. This spacing was constantly reducing in excess of normal expectation due to the unusually high difference in ground speeds between the two aircraft.
5. The APP(S) controller's attention was diverted at the time he intended applying a further speed reduction to the B727.
6. An alternative method of approach for the B727 was considered, but due to the limited room for the aircraft to manoeuvre, it was decided that the best course of action was to allow the approach to continue.
7. When it was assessed that the runway separation standard might not be attained, missed approach instructions were co-ordinated for the B727.
8. When the B727 crossed the threshold of runway 07, the B767 had not crossed the runway intersection.
9. Both ADC2s advised the ADC1 to instruct the B727 to go around.
10. The ADC 1 cleared the B727 to land under circumstances which were contrary to the runway separation standard published in MATS.
11. The crew of the B727 allowed the aircraft to proceed beyond the threshold of runway 07 contrary to AIP OPS CTL 22.5.1.
12. The intent of AIP OPS CTL para. 22.5.1 is not clear.
13. The B727 passed approximately 240 m behind the B767.

3.2 Significant factors

1. Differing ground speeds inside 10 NM from the aerodrome resulted in a marked reduction in spacing between the two aircraft.
2. The ADC 1 did not appreciate the rate at which the separation between the two aircraft was reducing.
3. Despite the concerns expressed by the ADC 2 controllers, the ADC 1 did not instruct the B727 to go around.
4. The crew of the B727 misinterpreted AIP instructions in relation to runway separation and did not execute a go-around.

4. RECOMMENDATIONS

The investigation, whilst focused on the circumstances surrounding the incident, also sought to address other issues which may have wider implications for the ATS system. The Bureau of Air Safety Investigation therefore recommends that:

1. The CAA adopt a philosophy in the training of control tower personnel which incorporates the principles of CRM.
2. The CAA consider the use of control tower simulation to better prepare controllers to cope with unusual situations.
3. The CAA determine the applicability, and consider the introduction, of a system such as the CRDA to assist in the management of separation standards by providing a more precise display of aircraft positions relative to converging runways.
4. The CAA review and revise the AIP document to state more clearly the joint responsibility for maintenance of the runway separation standard.

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