FINAL REPORT

LOSS OF SEPARATION BETWEEN

BOEING B747- 400, REGISTRATION 9V-SPI AND

AIRBUS A320, REGISTRATION 9V-JSD

ON 13 MAY 2009

AIB/AAI/CAS.058

Air Accident Investigation Bureau of Singapore
Ministry of Transport
Singapore

10 December 2010

The Air Accident Investigation Bureau of Singapore

The Air Accident Investigation Bureau (AAIB) is the air accidents and incidents investigation authority in Singapore responsible to the Ministry of Transport. Its mission is to promote aviation safety through the conduct of independent and objective investigations into air accidents and incidents.

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> *"The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability."*

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SYNOPSIS

On 13 May 2009, a Boeing B747-400 was on approach from the north to Changi Airport Runway 20R, descending from about 5,000 ft to 3,000 ft. At about the same time, an Airbus A320 was instructed by the air traffic control to descend from 6,000 ft to 2,500 ft and to make a left turn from a south-easterly direction to the north.

At about 1434 hours (local time), the Arrival Controller assessed that there could be a conflict in the flight paths of the two aircraft. He immediately took action to try to de-conflict the situation. The Traffic Alert and Collision Avoidance System (TCAS) on board the B747 activated momentarily. It issued a Resolution Advisory (RA) to descend and the B747 flight crew complied with the RA. The TCAS on board the A320 also activated momentarily and it issued a Traffic Advisory (TA) which warned the A320 flight crew of traffic in the vicinity of the flight path. The TA was noted by the A320 flight crew.

At the closest point, the two aircraft were separated laterally by 1.5 nautical miles (nm) and vertically by 500 ft. A loss of separation had occurred as the minimum separation required was either 3 nm of horizontal separation or 1,000 ft of vertical separation.

The Air Accident Investigation Bureau of Singapore (AAIB) was informed of the incident on 3 June 2009.

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1 FACTUAL INFORMATION

All times used in this report are Singapore times. Singapore time is eight hours ahead of Coordinated Universal Time (UTC).

1.1 History of the flights

Boeing B747, registration 9V-SPI

1.1.1 At about 1431 hours on 13 May 2009, the B747 aircraft was cleared by the Arrival Controller of the Singapore Air Traffic Control Centre (SATCC) for an Instrument Landing System[1] (ILS) approach to Changi Airport Runway 20R and to descend to 3,000 ft. The aircraft was about 20 nautical miles (nm) from touchdown and passing 5,200 ft.

1.1.2 The aircraft then reported to the Arrival Controller that it was established on localiser 20R and the Arrival Controller cleared the aircraft to continue with its approach to land. The aircraft continued descending to below 5,000 ft.

1.1.3 At about 1434 hours when the aircraft was at an altitude of about 3,500 ft, it was instructed by the Arrival Controller to descend to 2,000 ft.

1.1.4 While descending past 3,000 ft, the Traffic Alert and Collision Avoidance System[2] (TCAS) on board the aircraft activated momentarily. It issued a Resolution Advisory[3] (RA) for the aircraft to descend. The flight crew complied with the RA.

1.1.5 At 1435 hours, the aircraft was cleared of the flight conflict at an altitude of about 2,700 ft. The flight crew informed the Arrival Controller that the aircraft was "cleared of conflict" and was continuing with the approach to land. The Arrival Controller cleared the aircraft to continue with the ILS approach to Runway 20R. The aircraft continued its flight and landed without further incident.

1.1.6 The Singapore Air Traffic Services (ATS) has a requirement for pilots to inform the controller through radio communications of TCAS RA that entails deviation from ATC instruction or clearance and then to file a report after the aircraft has landed. The RA issued by the TCAS was for the aircraft to descend, which was not a deviation from the ATC instruction to descend to 2,000 feet. The aircraft operator, on its part, requires its crews to report to the ATC through radio communications

[1] The Instrument Landing System (ILS) is a ground-based instrument approach system that provides precision guidance to an aircraft approaching and landing on a runway.

[2] The Traffic Alert and Collision Avoidance System (TCAS) is designed to prevent mid-air collisions between aircraft. The TCAS on an aircraft monitors the airspace around the aircraft and warns the pilots of the presence of other aircraft that may present a collision threat.

[3] A "Resolution Advisory" (RA) from the TCAS provides the pilot voice instructions to avoid danger. When a threat has passed, the TCAS announces "*clear of traffic*".

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any RA, even if the RA does not constitute a deviation from the ATC instruction. The First Officer (FO) of the B747 was manning the radio communications. He was aware of the company's requirement. He did not inform the Arrival Controller that there was a TCAS RA as he was busy with preparing the aircraft for landing. However, he did inform the Arrival Controller that his flight was "cleared of conflict".

1.1.7 The FO telephoned the SATCC after the aircraft had landed, about an hour after the TCAS RA event, to notify the Watch Manager of the incident. There was a change of the watch manager's shift at the time the FO made the telephone call and it was the incoming Watch Manager who answered the FO's call. The FO told the incoming Watch Manager that "there was a TCAS on our aircraft" and that he wanted the controller to also be "aware that we had a TCAS".

1.1.8 As the incident had taken place when the outgoing Watch Manager was on duty, the incoming Watch Manager handed the FO's call to the outgoing Watch Manager. The FO said to the outgoing Watch Manager that he wanted the controller to be aware that his flight had a "TCAS descent" and that he was going to submit an incident report. But he did not mention specifically to either Watch Manager that there was a TCAS RA as he had assumed that they already knew about the event.

Airbus A320, registration 9V-JSD

1.1.9 The A320 aircraft was approaching the Terminal Area (TMA) around Changi Airport from the north. At 1432 hours when the aircraft was at about 6,000 ft, the flight crew contacted the SATCC Arrival Controller. The Arrival Controller instructed the aircraft to descend to 2,500 ft and turn left to heading 360°. The aircraft was in a region where the minimum sector altitude[4] (MSA) was 3,400 ft. The Arrival Controller assigned the aircraft to land on Runway 20R. (At about this time the B747 was descending from about 5,000 ft to 3,000 ft.)

1.1.10 The flight crew initiated a left turn to the instructed heading of 360°. When the aircraft was approaching heading 130°, the flight crew requested a heading change to 130° instead of 360°. The flight crew were unaware that they were third in the sequence to land. They had thought that a heading to 130° would put them to the flight path for landing. The Arrival Controller did not accede to the flight crew's request but instead instructed the aircraft to "turn further left now heading 340".

1.1.11 At about 1434 hours, when the A320 was at about 3,800 ft, the Arrival Controller assessed that there could be a conflict in the flight path of the A320 with that of the B747. He immediately instructed the A320 to stop its descent at 3,000 ft and to turn further left heading 330°. Realising

[4] Minimum sector altitude. An altitude depicted on an approach chart which provides at least 1,000 ft of obstacle clearance within a 25 nm radius of the navigation facility.

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that the corrective action was insufficient, he further instructed the A320 to climb to 4,000 ft. He also instructed the B747 to descend to 2,000 ft. (This relates to paragraph 1.1.3.)

1.1.12 The flight crew of the A320 then reported to the Arrival Controller that they had visual contact with the B747. At about this time, the TCAS of the A320 activated momentarily and issued a Traffic Advisory[5] (TA). By then, the two aircraft were cleared of conflict. The A320 continued its flight and landed later without further incident.

Arrival Controller

1.1.13 On the day of the incident, the SATCC Arrival Controller had had two days off and was on the first day of a "split-shift" pattern, as follows:

First day:	1300 - 2000 hours
Second day:	0800 - 1300 hours
Night shift:	2000 (of the second day) - 0800 hours. The Night shift is followed by two days off

1.1.14 During the interview, the Arrival Controller stated that the traffic on that day was normal and the weather was clear. He did not feel tired and was not on any medication. At the time of the incident, he was controlling the approach for three aircraft, including the two incident aircraft.

1.1.15 The Arrival Controller instructed the A320 to descend to 2,500 ft and turn left to heading 360° after the flight crew contacted the SATCC Arrival Controller at 1432 hours when the aircraft was at about 6,000 ft. (This relates to paragraph 1.1.9.)

1.1.16 The Arrival Controller was aware of the MSA requirement of 3,400 ft. He said that he had descended the A320 to 2,500 ft because he was going to clear it for approach to land later. He thought it would take a while for the aircraft to descend and by the time the aircraft had descended to below 3,400 ft, it would have been out of the MSA sector. (There was no instance that the A320 was below 3,400 ft while in the MSA sector.)

1.1.17 The Arrival Controller instructed the A320 to turn left because there was traffic to the right of the aircraft. He was aware of the position of the B747 and saw no conflict for the A320 to turn left.

1.1.18 The Arrival Controller recalled that he noticed that the A320 took an exceptionally wide turn and was slow to execute the turn. At about 1433 hours he instructed the A320 to turn further left to heading 340°. (The A320 was at about 4,250 ft and laterally separated by more than 6 nm

[5] A "Traffic Advisory" (TA) from the TCAS warns the pilot that another aircraft is nearby, announces *"traffic, traffic"*, but does not provide any instructions to the pilots. When a threat has passed, the TCAS announces "*clear of conflict*".

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from the descending B747 which was at 4,000 ft.) He did not stop the descent of the A320 at 4,000 ft. Thirty-one seconds later, he instructed the A320 (which was at 3,800 ft) to stop its descent at 3,000 ft and to turn further left to heading 330°. This latter clearance to stop descent at 3,000 ft was too late to achieve the required vertical separation as the B747 descended past 3,700 ft. At this point, the vertical separation between the two aircraft had reduced to about 50 ft while the lateral separation was about 5 nm.

1.1.19 Realising that the corrective action was insufficient, as the two aircraft moved closer to each other and with reducing lateral separation, the Arrival Controller then instructed the A320 to climb to 4,000 ft and instructed the B747 to descend to 2,000 ft (see also paragraphs 1.1.3 and 1.1.11). Both aircraft executed the instructions after confirming the instructions with the Arrival Controller. The A320 then reported to the Arrival Controller that it had visual contact with the B747. About one minute later, the B747 reported to the Arrival Controller that it was "cleared of conflict" and was continuing with its ILS approach to land. At the closest point, the two aircraft were separated laterally by 1.5 nautical miles (nm) and vertically by 500 ft.

1.1.20 The Arrival Controller did not provide information on the location of the conflicting traffic (i.e. the B747) which could have helped the A320 pilots to locate the conflicting traffic visually.

1.1.21 The Arrival Controller stated that neither of the aircraft informed him of any TCAS advisory in their radio communications. He only knew of the TCAS warning on the B747 when the FO of the B747 telephoned the SATCC Watch Manager to notify the Watch Manager of the incident, after the aircraft had landed, about an hour after the TCAS RA. The Arrival Controller said that the FO only mentioned to the incoming Watch Manager about the event (see paragraph 1.1.8) but not the TCAS RA. The Arrival Controller said that he was asked by the Watch Manager to raise an incident report.

1.1.22 The Arrival Controller stated that he was aware of the incident reporting procedures within the Air Traffic Services. However, he did not think that there was a reportable incident as (1) he had de-conflicted the flight paths of the two aircraft; (2) there was no TCAS advisory reported by the two aircraft through the radio communications; and (3) he did not notice any traffic alert on his radar[6].

1.1.23 The Arrival Controller was not aware of the link between "cleared of conflict" and TCAS RA. He was not aware of the change in TCAS RA reporting made by ICAO to the "Procedures for Air Navigation Services - Aircraft Operations (PANS-OPS), Volume I - Flight Procedures" (see paragraph 1.4 below) whereby the crew receiving a TCAS RA message had to report "clear of conflict" after the conflict was resolved. The Arrival Controller said he did not remember having read any circular

[6] The current LORADS II system does not have any conflict or alert feature for aircraft operating below 12,000 feet.

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notifying of the change. The investigation established later that the change was not made known to the controllers.

Watch Managers

1.1.24 When the FO of the B747 called the Watch Managers after his aircraft had landed, he told the incoming Watch Manager that he had wanted the Arrival Controller to be "aware that we had a TCAS". He said to the outgoing Watch Manager that his flight had "a TCAS descent" and that he was going to submit an incident report. But he did not mention specifically to either Watch Manager that there was a TCAS RA.

1.1.25 Although "TCAS" was mentioned several times by the FO to both the incoming and outgoing Watch Managers, neither manager asked the FO whether it was a TCAS RA or TCAS TA. The outgoing Watch Manager merely asked the FO, "There's no issue?" and the FO replied, "No issue."

1.1.26 After the telephone conversation with the FO, the outgoing Watch Manager asked the Arrival Controller whether there was a loss of separation between the B747 and the A320. The Arrival Controller told him that there was no loss of separation. Although he was aware of the telephone call by the FO, it did not occur to the Arrival Controller to check on the separation situation before replying to the Watch Manager.

1.1.27 Although the Watch Manager did not perceive that there was a loss of separation incident, he did inform the Deputy Chief of SATCC about the telephone call.

1.1.28 Two days later on 15 May 2009, the Deputy Chief of SATCC received an aircraft flight incident report from the B747 operator. SATCC launched an investigation subsequently.

1.2 Personnel Information

1.2.1 Arrival Controller

Age:	40 (Male)
Licence:	Air Traffic Controller Licence issued by the Civil Aviation Authority of Singapore
Licence expiry date:	14 May 2012
Experience:	18 years
Work schedule:	11 May – off day 12 May – off day 13 May – 1300 hours to 2000 hours
Last proficiency check for Approach Control:	2 April 2009 (rated "Good")

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Last medical check: 3 April 2008 (valid from 14 May 2008 to 14 May 2012)

1.3 Flight recorders

1.3.1 The data of the flight data recorders of both aircraft relevant to the incident had been overwritten by the time the incident was reported to the AAIB. The flight data obtained from the quick access recorders of both aircraft were provided to the investigators for analysis.

1.4 Additional information

1.4.1 In the course of this investigation, the investigation team became aware of another TCAS RA event involving an Airbus A340 and a Short 360 aircraft on 4 December 2009, in which the A340 pilot used the words "TCAS avoidance and TCAS climb" when informing the air traffic controller of the TCAS RA. The air traffic controller did not ask the pilot whether that meant a TCAS RA but treated it as a TCAS RA, judging by the contents of the pilot's report.

1.4.2 Before November 2007, ICAO stated in "Procedures for Air Navigation Services - Aircraft Operations (PANS-OPS), Volume I - Flight Procedures" that in the event of a TCAS RA, pilot shall as soon as possible, as permitted by flight crew workload, notify the appropriate ATC unit of the RA, including the direction of any deviation from the current ATC instruction or clearance.

1.4.3 In November 2007, ICAO amended the provision for pilot to notify the ATC unit of only those RAs requiring deviation from the current ATC instruction through the air-ground communication channel, using the standard phraseology "TCAS RA". The reason for the amendment is to reduce the pilot-controller workload and communications requirements. When the conflict is resolved, the pilot shall return to the terms of the ATC instruction promptly and notify ATC using standard phraseology "clear of conflict, returning to (clearance/ instruction by ATC)". In any case, the crew will need to file a written RA report to the ATC later.

1.4.4 SATCC expected its air traffic controllers to know that there has been a TCAS RA when an aircraft reports "clear of conflict" even if a TCAS RA was not communicated to them earlier.

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2 ANALYSIS

2.1 The breakdown in separation between the B747 and A320 was the result of the instruction given by the Arrival Controller to the A320 to descend to 2,500 ft and turn left to heading 360° (see paragraph 1.1.15), although he was aware that the B747 was to the left of the A320 and was then descending from 5,000 ft to 3,000 ft on approach to land on Runway 20R. Had the Arrival Controller stopped the descent of the A320 at 4,000 ft (when the aircraft was laterally separated from the descending B747 by more than 6 nm), the loss of separation could have been avoided.

2.2 At the time of the incident, the workload of the Arrival Controller was considered to be moderate. None of the aircraft under the control of the Arrival Controller required any special attention nor was the Arrival Controller distracted in any way. He was properly rested prior to his duty on the day of the incident. Fatigue was not a factor in this incident.

2.3 The investigation team's analysis covered the following areas:

(a) Decision of the Arrival Controller to descend the A320 to below MSA
(b) Provision of traffic information
(c) Use of standard ATC phraseology
(d) Change in TCAS RA reporting
(e) Pilot's informing ATC of TCAS RA

2.4 Decision of the Arrival Controller to descend the A320 to below MSA

2.4.1 The Arrival Controller made an erroneous decision when he descended the A320 from 6,000 ft to 2,500 ft while the aircraft was in a sector that had an MSA requirement of 3,400 ft. He was aware of the MSA requirement. However, he thought it would take a while for the aircraft to descend to below 3,400 ft and by that time the aircraft would be out of the MSA sector. The normal ATC practice is to provide the descent clearance to 2,500 ft at a later stage of the flight. The operating procedures of the air traffic services provider also did not provide for clearing an aircraft to below MSA even if by then the aircraft would have been outside the MSA sector. By clearing the A320 to descend to 2,500 ft while the aircraft was still in the MSA sector, the Arrival Controller had not ensured obstacle clearance for the aircraft.

2.5 Provision of traffic information

2.5.1 The Arrival Controller issued corrective instructions to the A320 to de-conflict the paths of the A320 and B747. The Arrival Controller instructed the A320 to turn left because there was traffic to its right. He was aware of the position of the B747 but saw no conflict for the A320 to turn left. However, he did not provide information on the location of

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the B747 to the A320 crew. Although the A320 crew did see the B747 eventually, it would have been helpful to the A320 crew if the Arrival Controller had provided such information earlier.

2.6 Use of standard ATC phraseology

2.6.1 The Arrival Controller did not use standard phraseology to inject a sense of urgency to expedite the A320 in its turn. Instead of saying "expedite turn further left heading 340", he said, "turn further left now heading 340 sir". Instead of saying "immediately stop descent at 3,000 feet and turn further left heading 330", he said, "stop descent at 3,000 feet and turn further left sir heading 330."

2.6.2 The use of such terms as "expedite" and "immediate stop descent" would impress upon the pilots the urgency of the traffic situation.

2.7 Change in TCAS RA reporting

2.7.1 At the time of the event, the pilot of the B747 did not report to the Arrival Controller that there was a TCAS RA. However, he did report that his aircraft was "cleared of conflict". The Arrival Controller was not aware of the change in TCAS RA reporting made by ICAO to PANS – Ops. Otherwise he would have known that the B747 had a TCAS RA warning.

2.8 Pilot's informing ATC of TCAS RA

2.8.1 In his radio communications with the Arrival Controller, the FO of the B747 informed the Arrival Controller that his aircraft was "cleared of conflict" and was continuing with the approach to land. The FO's message was not interpreted by the Arrival Controller as a TCAS RA.

2.8.2 In the TCAS event on 4 December 2009 involving an A340 and a Short 360, although the pilot did not specifically mention that it was a TCAS RA, the ATC officer treated it as a TCAS RA judging by the contents of the pilot's report. However, it may not always be obvious to the air traffic controller that the circumstances involved a TCAS RA. It would be much better for the ATC officers to elicit from the pilots whether it is a TCAS RA.

2.8.3 The FO of the B747 did not report to the ATC immediately the TCAS RA event as he was busy preparing the aircraft for landing. Since the TCAS RA in this case did not constitute a deviation from ATC clearance, there was no requirement for the TCAS RA event to be reported to the ATC, although the operator did require its crews to report any TCAS RA event to the ATC through radio communications. Anyway, the FO did inform the Arrival Controller through radio communications that his flight was "cleared of conflict" and he also telephoned the ATC after the aircraft

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had landed, except that he did not mention explicitly “TCAS RA” as he assumed that they already knew about the event. The watch managers should either assume that a TCAS RA had taken place or ask the crew to clarify whether it was a TA or RA. It may be desirable to have in place a mechanism (e.g. training, operational procedure, checklist) whereby the ATC personnel would become more proactive in asking pilots for clarification.

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3 CONCLUSION

From the evidence available, the following findings are made. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

3.1 The breakdown in separation between the B747 and the A320 was the result of the instruction given by the Arrival Controller to the A320 to descend from 6,000 ft to 2,500 ft (in a sector where the MSA is 3,400 ft) and turn left to heading 360°.

3.2 The Arrival Controller did not provide essential traffic information on the location of the conflicting traffic when issuing corrective instructions to the two aircraft. He also did not use standard phraseology to instil a sense of urgency in the A320 crew.

3.3 The First Officer of the B747 did not mention specifically "TCAS RA" when reporting the event to the watch managers as he had assumed that the watch managers already knew about the event, and the watch managers did not attempt to ascertain from the First Officer whether there was a TCAS RA

3.4 The Arrival Controller was not aware of the change in the ICAO TCAS RA reporting procedure. Otherwise he could have known that there was a TCAS RA event when the FO informed him that his aircraft was "cleared of conflict".

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4 SAFETY ACTIONS

In the course of the investigation and arising from discussions with the investigation team, the SATCC has taken the following safety actions.

4.1 SATCC issued a circular to inform its air traffic control officers of the change in TCAS RA reporting procedure made by ICAO to “Procedures for Air Navigation Services - Aircraft Operations (PANS-OPS), Volume I - Flight Procedures”.

4.2 SATCC disseminated the following lessons learnt to the watch managers for them to brief their air traffic control officers.

(a) Radar Controllers, to ensure that radar operations are conducted on a fail-safe basis, shall issue instructions to aircraft on converging tracks (that are climbing or descending through each other’s level) to fly on tracks which provide the required horizontal separation, unless vertical separation is established or until they have passed each other.

(b) Approach Sector Controllers shall comply with the applicable Minimum Sector Altitude (MSA) when vectoring aircraft.

(c) Controllers shall ensure that information pertaining to the conflicting traffic is passed on to aircraft when issuing corrective instructions for avoidance action.

(d) Controllers shall use phraseologies such as “descend immediately”, “climb now” or “expedite” to alert both pilots of the conflicting traffic situation, so as to impress upon the pilots the urgency of the traffic situation.

(e) Controllers shall inform the Watch Manager whenever they are unsure that separation between aircraft was infringed.

(f) Controllers shall be mindful of the change in TCAS RA reporting procedure made by ICAO to “Procedures for Air Navigation Services - Aircraft Operations (PANS-OPS), Volume I - Flight Procedures”.

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5 SAFETY RECOMMENDATIONS

It is recommended that:

5.1 SATCC review its procedure for the watch manager's station with regard to handling telephone calls to better ensure that useful information is elicited from parties calling in to inform of any event. [AAIB Recommendation R-2010-003]

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