

FINAL REPORT

LOSS OF SEPARATION INCIDENT ON 10 NOVEMBER 2008

AIB/AAI/CAS.051

**Air Accident Investigation Bureau of Singapore
Ministry of Transport
Singapore**

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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.

The AAIB conducts the investigations in accordance with the Singapore Air Navigation (Investigation of Accidents and Incidents) Order 2003 and Annex 13 to the Convention on International Civil Aviation, which governs how member States of the International Civil Aviation Organisation (ICAO) conduct aircraft accident investigations internationally.

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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."

Synopsis

On 10 November 2008 at about 2107 hours, two Singapore military aircraft were on a training sortie when one of them declared an emergency because of an engine problem. They aborted the training sortie. On the return flight to their airbase, the aircraft that was accompanying its companion in emergency became involved in a loss of separation incident with an Airbus A380 aircraft that had taken off from Singapore Changi Airport some minutes earlier.

The occurrence was classified as a serious incident by the Air Accident Investigation Bureau of Singapore.

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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 flight**

1.1.1 On 10 November 2008 at about 2107 hours, two Singapore military aircraft (A/C 1 and A/C 2) were on a training sortie when A/C 1 declared an emergency because of an engine problem. They aborted the training sortie. On the return flight to their airbase, A/C 2, which was trailing A/C 1, was involved in a loss of separation incident with an Airbus A380 aircraft (registration 9V-SKA) that had taken off from Singapore Changi Airport some minutes earlier. There were no injuries to persons or damage to the aircraft.

1.1.2 A/C 1 and A/C 2 had taken off from an airbase in Singapore at about 2100 hours under the control of the air traffic control tower of the airbase (the airbase tower). After the take-off, they flew towards the east. Their flight involved a transition through the Terminal Area (TMA) around Changi Airport that is controlled by the Singapore Air Traffic Control Centre (SATCC). Thus, when A/C 1 and A/C 2 had reached about 2,000 ft, the airbase tower handed over the control of the two aircraft to SATCC's Approach Control (Approach). The Approach Controller cleared the two aircraft to climb to 4,000 ft. During the climb the pilot of A/C 1 heard an unusual sound and felt an unusual vibration. He continued the climb while troubleshooting the possible faults.

1.1.3 For the transitioning of military aircraft through the SATCC-controlled TMA, there was a system of coordination between SATCC and the military air traffic control unit (hereinafter referred to as Singapore Radar) through one telephone line. The Singapore Radar end of the telephone line was manned by a military radar controller (hereinafter referred to as the RC) who coordinated with SATCC on departure and arrival clearances. All information flow between SATCC and Singapore Radar was through the RC. The RC had an assistant who helped the RC coordinate the arrivals and departures of military aircraft with the different airbases but who had no authority to coordinate with SATCC on departure and arrival clearances. At the SATCC end of the telephone line, there was also an air traffic controller (the Approach Coordinator) who performed the coordination function with the RC from Singapore Radar. However, two other SATCC air traffic controllers, the Approach Controller and the Arrival Controller could also call the RC using the same telephone line for coordination purposes, and they would keep the Approach Coordinator informed of their coordination with the RC. (The Approach Coordinator was seated between the Approach Controller and the Arrival Controller.)

- 1.1.4 Shortly after A/C 1 and A/C 2 had taken off from their airbase, the Airbus A380 (A/C 3) took off from Runway 02L of Changi Airport. A/C 3 contacted SATCC Approach while climbing at 600 ft. The SATCC Approach Controller cleared A/C 3 to climb to 7,000 ft and to head to the east on a heading of 110°.
- 1.1.5 At about 2107 hours, after A/C 1 and A/C 2 had reached 4,000 ft, the SATCC Approach Controller handed the control of A/C 1 and A/C 2 to the RC in Singapore Radar. Shortly after the hand-over the pilot of A/C 1 established he had an engine problem and declared an emergency to the RC.
- 1.1.6 The RC asked the pilot of A/C 1 what assistance he would need. The pilot requested a climb to 10,000 ft¹. The RC, considering that there was another aircraft at about 8,000 ft in the vicinity to the east of A/C 1 and A/C 2, cleared A/C 1 and A/C 2 to climb to 7,000 ft for the time being. The RC gave the clearance to A/C 1 and A/C 2 without coordinating with SATCC
- 1.1.7 At about this time the SATCC Arrival Controller happened to call the RC on the telephone to coordinate the arrival of an aircraft. The RC informed the SATCC Arrival Controller of the emergency and that A/C 1 and A/C 2 were cleared to 7,000 ft², and were flying to waypoint HOSBA. The Arrival Controller was not informed of the nature or type of emergency, i.e. the fact that the single-engined aircraft was experiencing engine trouble. The RC also told the Arrival Controller to keep A/C 3 clear. Once the information was passed to the Arrival Controller, the RC hung up the telephone. The Arrival Controller communicated the information to his colleagues in SATCC (Approach Controller and Approach Coordinator). The Arrival Controller then called the RC again to coordinate the arrival clearance for which purpose he had called the RC earlier.
- 1.1.8 Being aware that A/C 3, like A/C 1 and A/C 2, would be approaching HOSBA on its present heading of 110°, the SATCC Approach Controller instructed A/C 3 to turn to a heading of 170° so as to provide lateral separation. Being also aware that A/C 1 and A/C 2 were cleared to 7,000 ft, the Approach Controller instructed A/C 3 to climb to 8,000 ft to provide a vertical separation of 1,000 ft between A/C 3 and A/C 1 and A/C 2.
- 1.1.9 The Supervisor in Singapore Radar was monitoring A/C 1's emergency. Seeing that the RC was busy coordinating with SATCC,

¹ The pilot stated that he asked for 10,000 ft because he needed the altitude to glide the aircraft for a safe landing in case his aircraft had a total engine failure.

² Military aircraft can only transit through the Changi TMA by following a coordinated route. Singapore Radar needs to coordinate further with SATCC on any deviation from the coordinated route and will give a deviation clearance only after concurrence by SATCC. The SOPs for emergency coordination clearly states "Where more than one ATC unit is involved full and complete coordination shall be established between units." (See paragraph 1.3.3 (b))

he stepped in to assist the RC. He told the RC to concentrate on coordinating the recovery of A/C 1 and A/C 2 with SATCC while he (the Supervisor) would handle the communication with A/C 1 and A/C 2³. A/C 1 and A/C 2 informed the Supervisor that they were level at 7,000 ft and requested for a further climb if possible. The Supervisor in consultation with the RC cleared A/C 1 and A/C 2 to climb to 9,000 ft. The Supervisor then instructed A/C 1 to transmit the emergency code through the aircraft's transponder.

- 1.1.10 The SATCC Approach Coordinator then contacted the RC to ascertain the intention of A/C 1 and A/C 2. The Supervisor in Singapore Radar instructed the RC to tell SATCC to turn A/C 3 away. The RC noticed that A/C 3 was turning, but he was not aware that A/C 3 was cleared to a heading of 170°. The RC asked SATCC if A/C 3 could continue his turn to the right. The RC did not specify a heading that he wanted A/C 3 to turn to⁴. The RC also informed SATCC that A/C 1 and A/C 2 were climbing to 10,000 ft heading towards HOSBA. The SATCC Approach Coordinator read back the altitude of 10,000 ft. (As mentioned in paragraph 1.1.9, A/C 1 and A/C 2 were actually cleared to climb only to 9,000 ft. The information provided to SATCC by Singapore Radar was inaccurate. The RC was aware of the request by A/C 1 to climb to 10,000 ft and had told SATCC 10,000 ft so as to reserve the airspace.)
- 1.1.11 The SATCC Approach Controller overheard the readback by the Approach Coordinator. He maintained A/C 3 on a heading of 170° at 8,000 ft as this would provide lateral separation (as the A/C 1 and A/C 2 were heading towards HOSBA away from A/C 3 at this time) and an eventual vertical separation of 2,000 ft between the aircraft (according to the last known information, A/C 1 and A/C 2 were climbing to an altitude of 10,000 ft).
- 1.1.12 The Supervisor asked A/C 1 for its intention. The pilot of A/C 1 informed the Supervisor that he intended to return to the airbase. A/C 1 and A/C 2 then turned right to fly back to their airbase⁵. A/C 2 trailed A/C 1 to monitor its flight. The Supervisor instructed the RC to tell SATCC that the aircraft were returning to the airbase. The pilot of A/C 1 then informed the Supervisor that he intended to align his aircraft for a straight approach into runway 02R.

³ According to Singapore Radar, the Supervisor position in Singapore Radar is the pinnacle position in the control room. The Supervisor is conversant with all operating instructions, policies and directives and is capable of performing supervisory, operational and instructional roles.

⁴ Since the RC did not indicate his desired heading for A/C 3, the SATCC Approach Controller gave a heading of 170° to A/C 3 (see paragraph 1.1.8) as he judged that, with A/C 1 and A/C 2 travelling eastward to HOSBA, this heading for A/C 3 was sufficient to provide lateral clearance.

⁵ The pilot of a civil or military aircraft may need to depart from the rules or prior clearances in emergency circumstances that render such departure absolutely necessary in the interest of safety, but the pilot will have to inform ATC of such a departure as soon as possible. The pilot of A/C 1 was informing Singapore Radar in accordance with this operating principle.

- 1.1.13 The next nine paragraphs (1.1.14 to 1.1.22) describe events that took place within 72 seconds. Many of the events took place simultaneously.
- 1.1.14 The SATCC Approach Coordinator saw A/C 1 and A/C 2 turning to their right which would bring the aircraft into a converging path with A/C 3. He immediately queried the RC as to the intention of A/C1 and A/C 2. The RC told the Approach Coordinator that A/C 1 and A/C 2 were returning to the airbase. However, both the Approach Coordinator and RC were talking at the same time. Then the telephone line became disconnected. The RC repeated the information, that A/C 1 and A/C 2 were returning to the airbase, not aware that the telephone line to SATCC was disconnected. As a result, this piece of information was missed by the Approach Coordinator.
- 1.1.15 Just when the RC realised that the connection was lost another controller from SATCC called him on the telephone line to query about the intention of A/C 1 and A/C 2 (the intention of the controller was to help rectify the situation). The RC thought that the caller was the Approach Coordinator. While the conversation between the RC and this other controller was on-going, the Approach Coordinator picked up the telephone. However, before the Approach Coordinator could ask the RC for the intention of A/C 1 and A/C 2, the RC informed the other controller that he would call him back and hung up the telephone. The Approach Coordinator heard what the RC said about calling back before the RC hung up.
- 1.1.16 The Approach Coordinator called the RC again immediately. When the RC picked up the telephone, the Approach Coordinator asked what A/C 1 and A/C 2 were doing. The RC appeared to be confused by the request since he believed he had told the Approach Coordinator (actually it was the other controller) that he would call back. The telephone line was disconnected again before the RC could reply to the Approach Coordinator. The Approach Coordinator, thinking that the RC was busy, opted not to call back immediately and waited approximately 30 seconds before trying to call the RC again.
- 1.1.17 The Approach Controller also saw A/C 1 and A/C 2 turning on his radar and overheard the Approach Coordinator querying the RC. He opted to maintain A/C 3 on its current heading of 170° and altitude of 8,000 ft until the intention of A/C 1 and A/C 2 became clear. The last information that the Approach Controller had concerning A/C 1 and A/C 2 was that they were climbing to 10,000 ft flying eastwards to HOSBA. Although A/C 1 and A/C 2 were no longer maintaining their direction of flight, at the expected altitude of 10,000 ft there would be 2,000 ft vertical separation as A/C 3 was maintaining 8,000 ft.

- 1.1.18 The Supervisor in Singapore Radar noticed that A/C 3 was at an altitude of 8,000 ft and would be in the path of A/C 1 and A/C 2's returning flight. The Supervisor was not aware that A/C 3 had been told to maintain 8,000 ft and he had expected the aircraft to be climbing out of the TMA. The Supervisor instructed A/C 1 and A/C 2, which were at 9,000 ft, to descend to 8,000 ft⁶ without coordinating with the Approach Coordinator⁷ and gave A/C 1 and A/C 2 position information of A/C 3. The Supervisor also told A/C 1 and A/C 2 that Singapore Radar was trying to turn A/C 3 away.
- 1.1.19 A/C 1 requested again to climb to 10,000 ft. However, the Supervisor in Singapore Radar instructed A/C 1 to descend to 8,000 ft. The Supervisor did not give a heading change to A/C 1 and A/C 2 to provide lateral separation at this time.
- 1.1.20 The Approach Coordinator noticed from the radar that A/C 1 was descending and called the RC to ask A/C 1 and A/C 2 to maintain their last altitude which was 9,000 ft. Instead, the RC told the Approach Coordinator to turn A/C 3 to the west. The Approach Coordinator repeated that A/C 1 and A/C 2 were descending below 9,000 ft and again asked the RC to climb A/C 1 and A/C 2. The response from the RC was that they were descending.
- 1.1.21 In an attempt to separate the aircraft, the Approach Controller instructed A/C 3 to turn left from a 170° heading to 090° and then to 050° and finally to 360° (towards the north and the tail of A/C 2). The position of A/C 1 relative to A/C 3 and the fact that A/C 1 was in an emergency was communicated to A/C 3.
- 1.1.22 The Approach Coordinator then told the RC to tell A/C 1 and A/C 2 to climb. The RC again told the Approach Coordinator to turn A/C 3 to the west. The Approach Coordinator replied that A/C 3 was turning, but without stating that it was turning to the east.
- 1.1.23 The Supervisor in Singapore Radar provided A/C 1 with the distance and bearing information of A/C 3. A/C 1 informed Singapore Radar that he was visual with A/C 3. Almost immediately the Supervisor instructed A/C 1 to descend to 7,000 ft to separate the aircraft. As soon as A/C 1 was cleared of the conflict, the

⁶ When interviewed, the Supervisor in Singapore Radar explained that he had instructed A/C 1 to descend to 8,000 ft because he was expecting A/C 3 to be climbing out of the Terminal Area, and that he did not want, for the safety of A/C 3, to clear A/C 1 (whose engine problem might develop into a complete engine failure) to be above A/C 3. The Supervisor saw this situation as a safety threat and felt he did not have sufficient time to inform SATCC of his decision.

⁷ Although A/C 1 was in an emergency, Singapore Radar should coordinate with SATCC on the movements of A/C 1 (see paragraph 1.3.3 (b)). However, the Supervisor felt there was insufficient time to coordinate with SATCC for A/C1 and A/C2, as A/C1 was in a situation that required an immediate return to the airbase.

Supervisor provided A/C 2 with the distance and bearing information of A/C 3 and instructed A/C 2 to expedite its descent to 7,000 ft. A/C 2 also told Singapore Radar he was visual with A/C 3.

- 1.1.24 The Traffic Alert and Collision Avoidance System (TCAS) on board A/C 3 detected A/C 1. A/C 1 had by then descended below A/C 3 and A/C 3's TCAS registered only a Traffic Advisory. However, A/C 2, which was behind A/C 1 and was above A/C 3 but was descending, showed up as a TCAS Resolution Advisory in A/C 3. The Resolution Advisory commanded A/C 3 to descend as A/C 2 was above A/C 3. The flight crew of A/C 3 informed SATCC of the TCAS Resolution Advisory. Not equipped with a TCAS itself, A/C 2 had no way of knowing that there was a TCAS descent command to A/C 3. Thus, A/C 2 continued its descent, as instructed by Singapore Radar. This caused the TCAS on A/C 3 to issue a change of command to "climb, climb" for A/C 3.
- 1.1.25 Data from A/C 3's Quick Access Recorder showed that the vertical separation between A/C 2 and A/C 3 was about 700 ft when A/C 2 was passing below A/C 3. This was at about 2111 hours. On review of the radar data it was noted that, at the time of the TCAS Resolution Advisory in A/C 3, A/C 1 was more than 4 NM away from A/C 2. A/C 1 had accelerated in its attempt to descend to avoid A/C 3. A/C 2 noticed the increase in separation with A/C 1 and tried to query A/C 1 regarding its speed just before A/C 2 was instructed by the Supervisor to expedite its descent to 7,000 ft.
- 1.1.26 A/C 1 and A/C 2 subsequently landed at their airbase without further incident, and A/C 3 continued its flight to destination after informing SATCC of the TCAS Resolution Advisory.

1.2 **Coordination between air traffic control agencies**

- 1.2.1 SATCC is the agency for controlling the airspace in the TMA of Changi Airport. Thus SATCC has primacy over the airspace within the TMA. (All aircraft movements within or through Changi TMA are required to be cleared by SATCC.) Other ATC units controlling aircraft within or transiting through the TMA must obtain a clearance from SATCC.
- 1.2.2 Both Singapore Radar and SATCC have procedures in their respective manuals with regard to handling emergency aircraft. The procedures in the ATC units stress that an aircraft in distress is to be accorded priority (see paragraph 1.3.2(b)) so that the aircraft can be recovered expeditiously and safely.
- 1.2.3 SATCC and Singapore Radar were using different radio frequency bands. SATCC communicated with aircraft on VHF. As Singapore Radar used UHF to communicate with A/C 1 and A/C 2, SATCC was not in a position to monitor the communication between

Singapore Radar and A/C 1 and A/C2, and would have to rely on the RC for information regarding A/C 1 and A/C 2 and for Singapore Radar's plan for the two aircraft.

1.2.4 SATCC and Singapore Radar each had their own training arrangement for their air traffic controllers. The SATCC- Singapore Radar coordination function was covered in their respective training, but to different breadth and depth. There were no joint training sessions for controllers involved in the SATCC- Singapore Radar coordination.

1.2.5 It was noted from a review of the recordings of the communications between SATCC and Singapore Radar before and after the TCAS event on A/C 3 that non-standard radio telephony⁸ (RT) was used:

- There were times when both SATCC and Singapore Radar controllers were talking at the same time and apparently not listening to each other.
- There was no reading back of critical information or message, as standard RT practice would demand.
- The telephone line was disconnected at least twice and not answered at least once during the emergency situation and TCAS event. There was no dedicated telephone line for the RC and the SATCC controllers to maintain constant contact during an emergency.

1.3 Additional Information

1.3.1 The standard operating procedures (SOPs) in SATCC's Air Traffic Services Manual (ATSM) served as the basis for the coordination between SATCC and other ATC units (including Singapore Radar) for the control of aircraft in the TMA. Part 10 "Emergencies" of the ATSM addressed the handling of emergency situations. As an emergency situation is dynamic and not all possible scenarios could be anticipated, the SOPs provided general guidelines and responsibilities to assist the ATC units in dealing with such situations.

1.3.2 The ATSM general guidelines included the following:

- a) Since circumstances surrounding each emergency situation vary, exact detailed procedures cannot be given for every situation. The procedures outlined in this chapter are intended as a general guide and controllers should use their own judgement when handling each emergency.
- b) Priority shall be granted to an emergency aircraft

⁸ Standard radio telephony encompasses techniques to improve communications between parties. These consist of predetermined phraseology and transmission structure, proper enunciation, speech rate, volume and pitch, correct microphone operating techniques, readback of clearances, etc.

- c) The standard phraseology may also be varied to suit each emergency situation. Any reduction in separation which may be necessary to cope with the emergency shall be restored to normal as early as practicable.

1.3.3 The responsibilities of the controllers as stated in the ATSM and in Singapore Radar's operations manual were as follows:

- a) Controllers must always bear in mind the possibility of an aircraft emergency. Calm coordinated actions are essential in the handling of aircraft emergencies. Every means available to assist the pilot shall be employed. Each situation must be dealt with according to the prevailing circumstances.
- b) Where more than one air traffic service unit is involved, full and complete coordination shall be established between units.
- c) Alerting action shall be taken immediately when circumstances demand.

2 ANALYSIS

The analysis covered the following areas:

- Standard operating procedures
 - Priority for aircraft in an emergency situation
 - Issuing of deviation clearances
 - Primacy of control
 - Formation flights
 - Taking over a control position
- Human factors
- Training for coordinators

2.1 Standard operating procedures

Priority for aircraft in an emergency situation

- 2.1.1 In an emergency situation, the pilot in command may in the interest of safety deviate from the rules of the air or from the clearances given. If he has to do so, he shall inform the ATC as soon as possible so that the ATC can take the necessary actions to help him achieve a safe landing. In this incident, the pilot of A/C 1 complied with these requirements by making his intention to deviate known to Singapore Radar before he deviated from his cleared flight path. He also made known to Singapore Radar that he desired a straight-in landing at the airbase.
- 2.1.2 The ATC will accord priority to an aircraft that is in an emergency situation. The ATC will ascertain the intention of the pilot and assist him as necessary so that the aircraft can land safely, while ensuring safe separation of aircraft. Both SATCC and Singapore Radar subscribe to the practice of according priority to an emergency aircraft. However, the actions the controllers take will depend on the nature or type of the aircraft emergency and on the intention of the emergency aircraft. If the aircraft has difficulties maintaining altitude or a heading (e.g. flight control or engine problems), then the airspace in the vicinity of the aircraft will be cleared of other aircraft. Singapore Radar, being aware of A/C 1's engine problem, expected the airspace in the vicinity of A/C 1 and A/C 2 to be cleared of other traffic. However, it did not communicate the nature of the emergency to SATCC. And SATCC, not being aware of the nature of A/C 1's emergency, allowed A/C 3 to fly under A/C 1 and A/C 2.
- 2.1.3 It is understandable that when an emergency aircraft is suffering from an engine failure, manoeuvring should be kept to a minimum. However, this does not mean that the aircraft cannot be asked to manoeuvre. It appears that the Supervisor in Singapore Radar did not attempt to consider devising alternative flight paths for the

emergency aircraft because he considered that the single-engine aircraft was in a dire situation and needed the most direct and expeditious flight path for recovery. Although A/C 1 was in distress, the Supervisor would not need to hesitate to propose such alternatives to the pilot. The pilot, without prejudice to his prerogative in an emergency situation, could reject the Supervisor's alternative clearance if the emergency situation so required it.

Issuing of deviation clearances

- 2.1.4 As mentioned in paragraph 1.1.10, the RC in Singapore Radar informed SATCC that A/C 1 and A/C 2 were climbing to 10,000 ft when in fact the aircraft had been cleared by the Supervisor in Singapore Radar to only 9,000 ft. The RC had intended to reserve more airspace for the aircraft, but the inaccurate information gave an incorrect picture to SATCC. SATCC was controlling A/C 3 on the assumption that A/C 1 and A/C 2 were climbing to 10,000 ft. Subsequently, the situation changed. Singapore Radar did not intend to climb A/C 1 and A/C 2 from 9,000 ft, but the RC did not update SATCC to amend the earlier information that the aircraft were climbing to 10,000 ft.
- 2.1.5 As mentioned in paragraph 1.1.18, the Supervisor in Singapore Radar did not make prior coordination with SATCC when he instructed A/C 1 and A/C 2 to descend to 8,000 ft, where A/C 3 was at, because he judged that he did not have time to do so. Having to deal with an aircraft in emergency does not absolve Singapore Radar from keeping SATCC informed as soon as possible of the intention of the pilot involved in the emergency and of the instructions that Singapore Radar had given to the emergency aircraft. The Supervisor should have informed SATCC through the RC or he should change the assigned altitude on the radar information tags⁹.

Primacy of Control

- 2.1.6 Although the Supervisor had descended A/C 1 and A/C 2 to 8,000 ft without coordinating with SATCC, the SATCC coordinator was aware that A/C 1 was descending (see paragraph 1.1.20). Even though SATCC is the controlling agency for the airspace in which A/C 1 and A/C 2 were operating, and has primacy, the phraseology used by the Approach Coordinator was not appropriate for an issuance of an instruction to Singapore Radar to maintain A/C 1 and A/C 2 at 9,000 ft. This resulted in Singapore Radar suggesting

⁹ The radar information in both SATCC and Singapore Radar is the same. There is an information tag associated with each aircraft on the radar screen. When an aircraft had been cleared to a new altitude by an ATC agency, this ATC agency should update the altitude information in the information tag concerned. Thus, other ATC agencies can see the latest assigned altitude. In this incident Singapore Radar did not update the altitude information in the information tag.

alternative separation clearances to resolve the situation to the Approach Coordinator. During the interview with the Approach Coordinator, he was positive he had instructed the RC to maintain A/C 1 and A/C 2 at 9,000 ft. However on review of the ATC recordings, it was noted that the instructions were phrased as questions rather than commands. The correct procedure for the Approach Coordinator to follow was to use standard phraseology to issue a command to Singapore Radar to maintain A/C 1 and A/C 2 at 9,000 ft.

Formation flights

- 2.1.7 A/C 1 and A/C2 were flying in formation. SATCC and Singapore Radar's practice is to control a formation flight as if it is a single entity. Paragraph 3.1.8(c) of ICAO Annex 2 "Rules of the Air", states that formation flights shall maintain a distance not exceeding 1 km (0.5 NM) laterally and longitudinally and 30 m (100 ft) vertically from the flight leader by each aircraft. On review of the radar data, it was noted that the distance that A/C 1 and A/C 2 maintained was approximately 2.6NM even before the aircraft turned around to head back to the airbase. After the aircraft were heading back to the base the distance increased further. As noted in paragraph 1.1.25, A/C 1 and A/C 2 were in excess of 4 NM apart at the time of A/C 3's TCAS Resolution Advisory. This was a result of A/C 1 accelerating in order to avoid A/C 3. In the course of its investigation, the investigation team found that there was no guideline for the allowable distance a formation flight should maintain when flying in the TMA around Changi Airport. It may be desirable for SATCC-Singapore Radar to have common procedures to deal with such a situation, although the absence of such procedures was not a factor in this occurrence.

Taking over a control position

- 2.1.8 A supervisor is the overall-in-charge of Singapore Radar and oversees not only the Radar Control position but also the Area Control position. All supervisors undergo simulator training as part of their qualification for the position. Part of their training is to take over a radar control position, when deemed necessary, to ensure safe conduct of operations (e.g. inability of a controller to perform a control task safely or effectively). However, before a supervisor can relieve a RC from the control position he has to have the required control position validation and currency for the position he is taking over and has to be monitoring the control position. And once he takes over control, he assumes full responsibility for the control position. In this occurrence, the Supervisor met the criteria for taking over and followed the SOPs.

2.2 Human Factors

2.2.1 Communication plays an important role in the aviation environment. Human performance and decision making can all be adversely affected by sub-standard communication between individuals. The ICAO Accident Prevention Manual (Doc 9422) highlights the importance of communication thus:

Adequate communication requires that the recipient receives, understands and can act on the information gained. For example, radio communication is one of the few areas of aviation in which complete redundancy is not incorporated. Consequently, particular care is required to ensure that the recipient receives and fully understands a radio communication.

2.2.2 The incident reveals a lack of effective communication between SATCC and Singapore Radar in the following aspects:

- Lack of effective communication techniques
- Use of non-standard radio telephony
- Telephone hardware limitations

2.2.3 The communication between the Approach Coordinator of SATCC and the RC of Singapore Radar was not always effective. There were times when both of them were talking simultaneously. This resulted in critical information not being received.

2.2.4 Non-standard radio telephony (RT) was used, although the guidance procedures in both SATCC and Singapore Radar required the use of standard RT for the coordination through the telephone line. Standard RT ensures uniform interpretation of key words and phrases and promotes the effective transmission and receipt of messages. Furthermore, there was no reading back of critical information or message, as good RT practice would demand.

2.2.5 SATCC's Approach Coordinator, Approach Controller and Arrival Controller could call Singapore Radar to coordinate their own arrival and departure clearances using the same telephone line. The telephone system was replicated at the control stations of these three controllers and at three other control stations. This system appeared to work well in normal operations. However, in an emergency this practice may cause confusion, as the RC may be receiving telephone calls from various sources in SATCC. In this incident there were times when the RC appeared confused because of the calls from different control stations in SATCC. When an emergency situation arises, it may be better for all communications to be channelled through the respective coordinators, through a dedicated emergency telephone line that is not replicated at other stations, to prevent miscommunication and information demands from other sources.

2.3 Training for Coordinators

- 2.3.1 The coordination function in SATCC and Singapore Radar was performed by qualified air traffic controllers. The training and qualifying of the controllers concerning the coordinator's duties were conducted separately by the two agencies. The training had different breadth and depth and appeared to have been developed separately. There were no joint training sessions for the controllers involved in coordination. SATCC and Singapore Radar have different considerations in the way they control the aircraft owing to different operational requirements. The controllers may not be aware of the considerations of their counterparts in the other agency and of also the performance, complexity and limitations of the aircraft under the control of their counterparts in the other agency. This may result in the controllers of one agency not knowing and appreciating the working environment of their counterparts in the other agency and thus harbouring mistaken expectations of their counterparts in the performance of the coordination function.
- 2.3.2 Joint training or sharing procedural information between the two agencies may provide a better understanding of each other agency's limitations and concerns. The training may come in many forms. For example, each agency may make known to the other agency its standard operating procedures and manuals, and the two agencies may conduct joint training for their controllers (coordinators in particulars) as well as table top exercises to practise different emergency scenarios.

3 FINDINGS

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 air traffic controllers involved were appropriately qualified and current to perform their duties.
- 3.2 The standard radio telephony was not used in the telephone coordination communication between the coordinators in SATCC and Singapore Radar.
- 3.3 The Supervisor felt the emergency situation was such that the emergency aircraft needed to return to the airbase as soon as possible.
- 3.4 Coordination between Singapore Radar and SATCC was not carried out before A/C 1 and A/C 2 were deviated from their flight path.
- 3.5 The telephone procedures in SATCC allowed for more than one person to contact Singapore Radar.
- 3.6 Essential information was not effectively communicated between and understood by the coordinators in SATCC and Singapore Radar.
- 3.7 There was no joint training for the air traffic controllers in SATCC and Singapore Radar who were involved in the SATCC- Singapore Radar coordination function.

4 SAFETY ACTIONS

During the course of the investigation and through discussions with the investigation team, the following safety actions were initiated by the ATC units to improve the coordination system.

- 4.1 A dedicated emergency telephone line has been established between Singapore Radar and SATCC to improve coordination during an emergency.
- 4.2 Singapore Radar has reviewed and implemented the following:
 - The use of standard radio telephony has been emphasised to the controllers of Singapore Radar and is being enforced in daily operations.
 - The training syllabus for Singapore Radar controllers will continue to emphasise the use of standard radio telephony as well as priority of actions.
- 4.3 SATCC has issued a circular to remind its controllers to use Standard Radio Telephony in daily operations.
- 4.4 Exchange programmes between Singapore Radar and SATCC will continue and be expanded to include discussions on coordination between the two agencies.
- 4.5 Singapore Radar and SATCC have started table top exercises and training programmes on a regular basis to enhance the working relationship and coordination between the two agencies.

5 SAFETY RECOMMENDATION

- 5.1 It is recommended that SATCC and Singapore Radar develop common procedures for the allowable distance a formation flight is to maintain while transiting through the Terminal Area around Changi Airport. [AAIB Recommendation R-2010-002]