

FINAL REPORT

RUNWAY INCURSION BY MAINTENANCE VEHICLE 3 OCTOBER 2013

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

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The Air Accident Investigation Bureau of Singapore

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GLOSSARY OF ABBREVIATIONS

ADP	Airfield Driving Permit
A-SMGCS	Advanced-Surface Movement Guidance and Control System
ATC	Air Traffic Control
CVR	Cockpit Voice Recorder
FDR	Flight Data Recorder
FO	First Officer
PIC	Pilot-in-command
QAR	Quick Access Recorder
RET	Rapid Exit Taxiway

SYNOPSIS

On 3 October 2013, an aerodrome maintenance vehicle was tasked by Changi Tower to remove a bird carcass on Runway 02/20C. It entered the runway at 1125 hours and stopped on the eastern edge of the runway between Rapid Exit Taxiways E4 and E5.

At 1126 hours, Changi Tower cleared a Boeing B777 aircraft to land on the runway. Changi Tower noticed the presence of the vehicle on the runway just after the aircraft had touched down and issued an urgent instruction to the vehicle to vacate the runway. However, there was insufficient time for the maintenance crew in the vehicle to vacate the runway.

As the aircraft rolled down the runway towards the south after touchdown, the flight crew sighted the maintenance vehicle on the left (eastern) edge of the runway and manoeuvred the aircraft slightly to the right. The left wing of the aircraft was above the top of the vehicle as the aircraft rolled past the vehicle. Thereafter, the aircraft and the maintenance vehicle vacated the runway safely.

There was no damage to the aircraft or injury to any person in this occurrence.

The AAIB Singapore has classified this occurrence as a serious incident.

AIRCRAFT DETAILS

Aircraft type	:	Boeing B777-312ER
Operator	:	Singapore Airlines
Aircraft registration	:	9V-SWG
Date and time of incident	:	3 October 2013, 1126 hours (Local Time)
Location of occurrence	:	Changi Airport, Runway 02/20C
Type of flight	:	Scheduled passenger flight
Persons on board	:	209

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 Sequence of events

- 1.1.1 At 1122 hours on 3 October 2013, a Changi Tower controller (Controller 1), who was responsible for the movement of ground vehicles on Runway 02/20C (known also as Runway 2), informed an aerodrome maintenance vehicle (callsign Rover 39) of the presence of a bird carcass on Runway 02/20C. Controller 1 requested Rover 39 to proceed to Rapid Exit Taxiway (RET) E4.
- 1.1.2 Controller 2, who was controlling arriving aircraft, had planned to allow five more aircraft landings on Runway 20C before allowing Rover 39 to enter the runway to remove the bird carcass.
- 1.1.3 Rover 39¹ reached the E4 holding point at 1124 hours and informed Tower of its position. The vehicle was positioned behind the illuminated red stop bar lights². Controller 1 informed Rover 39 to wait for three to four minutes.
- 1.1.4 Controller 1 informed Controller 2 that Rover 39 was waiting at the E4 holding point. Controller 2 stood up and shifted his body sideways to visually verify the presence of Rover 39 at the E4 holding point, as there was a beam in front of him blocking his view.
- 1.1.5 Controller 3, a controller in a supervisory role, was unaware that Controller 1 had coordinated with Rover 39 earlier and that the vehicle was already at the RET E4 holding point. At 1125 hours, he initiated contact with Rover 39 with a view to expediting the bird carcass removal by positioning the vehicle near the runway. The exchange between Controller 3 and Rover 39 was as follows:

Controller 3: *Rover 39 Changi Tower*

Rover 39: *Tower 39*

Controller 3: *Ok ahh... proceed for Runway 2, prepare to enter Runway 2 to pick up a bird carcass*

Rover 39: *Ahh... roger Tower 39 Runway 2 thank you*

The co-worker of the Rover 39 driver handled the above exchange with Controller 3. Subsequently, there were no further exchanges between Controller 3 and Rover 39. Controller 3 heard only the words “*thank you*” but did not ask Rover 39 to repeat the readback.

¹ In this report, Rover 39 refers to the vehicle or the occupants of the vehicle, as the context may suggest.

² The red stop bar lights are a row of lights embedded in the ground. The lights are normally switched on to indicate that all traffic shall stop to obtain verbal clearance from the control tower to enter the runway.

- 1.1.6 Controller 1 heard the transmission to Rover 39, but not knowing from whom, responded with a general announcement that he had already told Rover 39 to stand by for Runway 2.
- 1.1.7 After the exchange with Controller 3, Rover 39 moved off from the E4 holding point at 1125:43 hours and entered the runway³ at 1126:01 hours. The red stop bar lights remained illuminated when Rover 39 moved off⁴. It stopped on the eastern edge of the runway beside the bird carcass at 1126:31 hours. According to Rover 39, before entering the runway, it had looked out for and did not notice any aircraft approaching to land⁵.
- 1.1.8 In the meantime, at 1126:09 hours, Controller 2 issued a clearance for a Boeing 777 aircraft (registration 9V-SWG) to land on Runway 20C.
- 1.1.9 Before issuing the landing clearance, Controller 2 had visually scanned the runway but he did not notice Rover 39 which was travelling towards the location of the bird carcass. Controller 2 did not use the Tower's Advanced-Surface Movement Guidance and Control System (A-SMGCS)⁶ to double-check for the presence or absence of traffic on the runway.
- 1.1.10 When Rover 39 entered the runway, the A-SMGCS would have generated both visual and aural runway incursion warnings to the controllers of the incorrect presence of Rover 39 on the runway. According to the controllers involved in this occurrence, they did not hear the aural warning nor noticed the visual warning on the A-SMGCS display units.
- 1.1.11 After receiving the clearance to land, the First Officer (FO) of the aircraft, who was the pilot flying, checked the touchdown zone and saw that it was clear. On his part, the Pilot-in-command (PIC), who was the pilot monitoring, scanned the entire runway length. He did not notice any anomaly.
- 1.1.12 At 1126:46 hours, Controller 1 noticed that Rover 39 was no longer at the E4 holding point. Next moment, when he saw the vehicle on the runway, he shouted loudly, "*What's the rover doing on the runway?*" At this point, Controller 2 looked out and saw that the aircraft had just touched down.
- 1.1.13 After the aircraft had touched down, the thrust reversers were deployed at 1126.47 hours. The FO and PIC saw Rover 39 on the left side of the runway when the aircraft had decelerated to about 100 knots. The FO

³ When interviewed by the investigation team shortly after the occurrence, the two occupants in Rover 39 were very certain that they heard "*enter Runway 2 to pick up a bird carcass*".

⁴ At the time of the occurrence, the Tower's practice was for the red stop bar lights to be turned off momentarily for an aircraft to enter the runway when clearance was given to the aircraft. It was not the Tower's practice to similarly turn off the lights for vehicles that were cleared to enter the runway.

⁵ The aircraft was then about 7 km away.

⁶ The A-SMGCS is a surveillance system to augment visual observation of traffic on the manoeuvring area. It can display traffic on those parts of the manoeuvring area that cannot be seen from the Tower. More on the A-SMGCS in paragraph 1.7.

immediately disconnected the auto-braking system and applied manual braking to decelerate the aircraft at a faster rate. The PIC took over the control of the aircraft while continuing to apply as much manual braking pressure as he could. He manoeuvred the aircraft slightly to the right of the runway centreline to increase the lateral separation from the vehicle.

1.1.14 Upon hearing Controller 1 asking what the rover was doing on the runway, Controller 4, who was taking a break, reacted by grabbing, at 1126:51 hours, the closest handset to try to communicate with Rover 39. At 1126:58 hours, Controller 4 instructed Rover 39 to vacate the runway quickly. At 1127:05 hours, as Rover 39 began to move away from its position, the aircraft's left wing passed over the vehicle.

1.1.15 The aircraft subsequently vacated the runway safely via RET E6 on the right of the runway. Rover 39 vacated the runway via a service road on the left of the runway.

1.2 **Injuries to persons**

1.2.1 There was no injury to any person in this incident.

1.3 **Damage to aircraft**

1.3.1 There was no damage to the aircraft in this incident.

1.4 **Other damage**

1.4.1 There was no other damage in this incident.

1.5 **Personnel information**

1.5.1 Rover 39

1.5.1.1 There were two persons in Rover 39, the driver and his co-worker. They were deployed by a runway maintenance company contracted by the aerodrome operator.

1.5.1.2 The driver held a valid Category 1 Airfield Driving Permit (ADP) issued by the aerodrome operator. The holder of a Category 1 ADP is allowed to operate appropriately equipped vehicles on the runways and taxiways. As part of their training and certification, Category 1 ADP holders are required to meet the requirements for radio-telephony procedures set by the aerodrome operator.

1.5.1.3 The co-worker did not hold a Category 1 ADP.

1.5.2 Air Traffic Controllers

1.5.2.1 The air traffic controllers involved in this occurrence all held a valid air traffic controller licence with the appropriate rating.

1.6 Meteorological information

1.6.1 At the time of occurrence, the weather was clear and visibility was good.

1.7 Advanced-Surface Movement Guidance and Control System (A-SMGCS)

1.7.1 The A-SMGCS is used to augment visual observation of traffic on the manoeuvring area and to provide surveillance of traffic on those parts of the manoeuvring area that cannot be observed visually. A-SMGCS is able to identify aircraft and vehicles moving on the airport surface even during bad weather conditions (e.g. heavy rain) if they are equipped with an appropriate transponder (as was the case with Rover 39). The investigation team understands that, when the visibility is good, air traffic controllers will normally not refer to the A-SMGCS display to help themselves in assessing whether a runway is clear of traffic.

1.7.2 There are five A-SMGCS terminals in the control tower cabin. Each terminal consists of a display unit, a speaker, a keyboard and a mouse. The A-SMGCS system presents traffic information through the display units. There was one A-SMGCS terminal between Controller 1 and Controller 2.

1.7.3 The A-SMGCS can generate visual as well as aural warning when there is a runway incursion situation.

- Aural warning in the form of audio text messages will be played through all the speakers connected to the system. Controllers can manually vary the volume of the speakers.
- Visual warning will be shown on all A-SMGCS display units.

1.7.4 The aural warning can be cancelled by a controller in any control position but the visual warning will remain displayed until the runway incursion situation is resolved.

1.8 Radio-telephony communication with ATC by airside personnel

1.8.1 The aerodrome operator required⁷ a person to possess a Category 1 ADP if the person needs to operate a vehicle in the aircraft manoeuvring area and to also perform radio-telephony communication. There was no

⁷ See the aerodrome operator's *Airside Driving Theory Handbook*.

specific aerodrome rule stipulating that only Category 1 ADP holders are allowed to perform radio-telephony communication on the airside⁸.

1.8.2 The aerodrome operator performed random checks on the airside to verify that drivers who operated vehicles in the aircraft manoeuvring area held a Category 1 ADP.

1.9 Recorded data

1.9.1 The aircraft was installed with a Cockpit Voice Recorder (CVR) and a Flight Data Recorder (FDR). As the CVR and FDR were not deactivated immediately after the aircraft had completed the flight, data around the time of the occurrence from both the recorders were not available for analysis by the investigation team.

1.9.2 The aircraft operator's procedure required that the CVR and FDR be deactivated at the end of a flight following a significant occurrence. However, the flight crew did not ask the engineering staff to effectuate the deactivation, although they appreciated that the occurrence was significant.

1.9.3 The aircraft was installed with a Quick Access Recorder (QAR) and the data was downloaded and analysed.

1.9.4 The A-SMGCS and relevant air traffic control (ATC) recordings were made available to the investigation team.

- Recordings of the A-SMGCS visual display show that there was a runway incursion warning triggered by Rover 39 (see **Figure 1**).
- Control cabin ambient recordings did not register any corresponding aural warning.

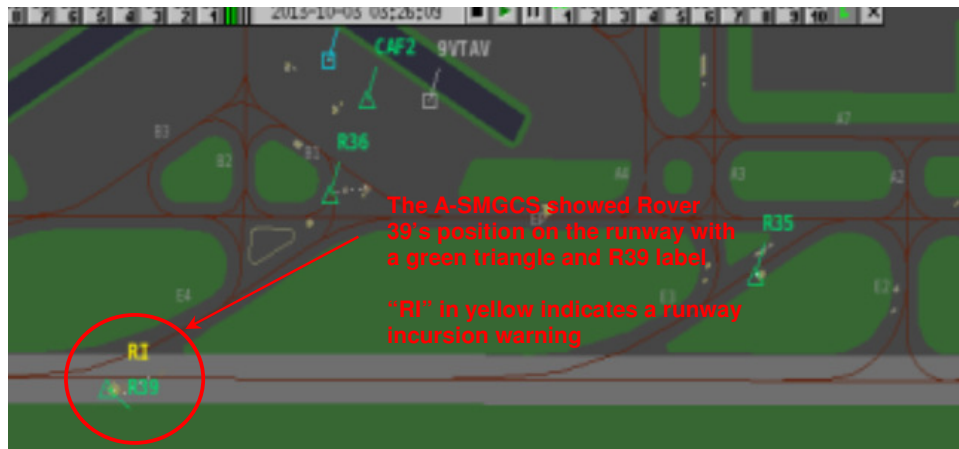


Figure 1: The A-SMGCS display at 1126:09 hours

⁸ The investigation team understands from the aerodrome operator that an aerodrome maintenance personnel who is intended to be deployed to perform radio-telephony communication with ATC but who is not intended to be deployed as driver would nevertheless need to obtain a Category 1 ADP.

2 ANALYSIS

The following aspects will be discussed:

- (a) Controller 3's awareness of Rover 39's position
- (b) Communication between Controller 3 and Rover 39
- (c) Radio-telephony communication by non-Category 1 ADP holder
- (d) Issuance of landing clearance
- (e) Red stop bar lights
- (f) Use of the A-SMGCS

2.1 Controller 3's awareness of Rover 39's position

- 2.1.1 At 1125 hours, Controller 3 initiated contact with Rover 39 with a view to expediting the bird carcass removal by positioning the vehicle near the runway. He was unaware that Controller 1 had coordinated with Rover 39 earlier and the vehicle was already at the RET E4 holding point, waiting for the clearance to enter the runway.
- 2.1.2 As Controller 1 was responsible for the movement of ground vehicles on Runway 02/20C, a more prudent approach would have been for Controller 3 to coordinate and discuss his intended actions with Controller 1. Had this coordination been made, Controller 3 would have been aware that Rover 39 was already near the runway.
- 2.1.3 Alternatively, the A-SMGCS could have been used by Controller 3 to locate Rover 39's location. A search function in the A-SMGCS allows controllers to select the vehicle or aircraft which they need to locate⁹.
- 2.1.4 Controller 3 would probably not have contacted Rover 39 had he been aware of the vehicle's location.

2.2 Communication between Controller 3 and Rover 39

- 2.2.1 Controller 3's transmission to Rover 39 was "...*proceed for Runway 2, prepare to enter Runway 2 to pick up a bird carcass*", which did not constitute a clearance to enter the runway. However, Rover 39 apparently heard only the partial transmission of "*enter Runway 2 to pick up a bird carcass*".
- 2.2.2 The readback to Controller 3 by the co-worker in Rover 39 was "...*roger Tower 39 Runway 2 thank you*". It was not in accordance with standard radio-telephony practice and did not give much indication as to whether the ATC message had been understood.

⁹ If the vehicle or aircraft is within A-SMGCS' surveillance range, its identifier ("R39" in this occurrence case) will appear on a list on the A-SMGCS display. The controller only has to click on the identifier and the location of the vehicle or aircraft will be highlighted on the display.

- 2.2.3 Controller 3 heard only the words “*thank you*” from Rover 39’s readback to his message. He never intended his message to be a clearance to enter the runway. He probably assumed that Rover 39 had understood his message and therefore did not ask Rover 39 to repeat the readback. Had he pressed Rover 39 for a repeat of the readback, the miscommunication could have been detected.
- 2.2.4 On the one hand, the embedding of the phrase “*enter Runway 2*” in “... *proceed for Runway 2, prepare to enter Runway 2 to pick up a bird carcass*”, which was not intended to be a clearance, created opportunities for miscommunication, as this incident has shown¹⁰.
- 2.2.6 On the other hand, having been instructed by Controller 1 to wait for three to four minutes, Rover 39 was probably expecting that the next transmission from the Tower would be a clearance to enter the runway. Such confirmation bias could be a factor in Rover 39’s hearing or registering only the second half of Controller 3’s message.
- 2.2.7 The assurance of safety requires that the parties at either end of a communication line must ensure that their message is correctly understood. It cannot be overemphasised that radio-telephony procedures must be adhered to strictly in order to ensure effective communication.

2.3 **Radio-telephony communication by non-Category 1 ADP holder**

- 2.3.1 The runway maintenance company that deployed the Rover 39 driver and the co-worker was not aware that persons who did not hold a Category 1 ADP were not supposed to handle radio-telephony communication with ATC. The company had developed its own radio-telephony training and assessment criteria for those of its personnel who were not required to operate vehicles, to allow them to perform radio-telephony communication with ATC.
- 2.3.2 The aerodrome operator was not aware that there were aerodrome maintenance personnel, who did not hold a Category 1 ADP, performing radio-telephony communication. The aerodrome operator’s random checks on the drivers to verify that they held a Category 1 ADP was not intended to detect any performance of radio-telephony communication by passengers who did not hold a Category 1 ADP.
- 2.3.3 The aerodrome operator may wish to consider a permit system for non-drivers to perform radio-telephony communication with ATC on the airside without the need for them to qualify as a Category 1 ADP holder.

¹⁰ An instruction such as “*Proceed and hold short of Runway 2*” could be a better alternative.

2.4 Issuance of landing clearance

2.4.1 Before Controller 2 issued the landing clearance for the approaching aircraft, he had visually scanned the runway but he did not notice Rover 39 which at that time was travelling towards the location of the bird carcass. He might have missed Rover 39 as the vehicle was small¹¹. His view might also have been blocked by a beam in the frame that held up the glass panels of the control cabin (see **Figure 2**). Controller 2 indicated that he did not shift his body to see what was behind the beam. It is possible that Rover 39 would be spotted had he done so.

2.4.2 Controller 2 did not use the A-SMGCS to double-check for the presence or absence of traffic on the runway. Had he referred to the A-SMGCS, there was a chance that he would see the runway incursion visual warning.



Figure 2: View from Controller 2's working position

2.5 Red stop bar lights

2.5.1 The red stop bar lights, when illuminated, serve to indicate that all traffic shall stop to obtain verbal clearance from the control tower to enter the runway. At the time of the occurrence, the Tower's practice was for the red stop bar lights to be turned off momentarily for an aircraft to enter the runway when clearance was given to the aircraft. It was not the Tower's

¹¹ The investigation team observed that the Tower was about 800 m from where Rover 39 could have stopped on Runway 2, and that it would take some effort to spot visually a vehicle of Rover 39's size at that distance.

practice to similarly turn off the lights for vehicles that were cleared to enter the runway.

- 2.5.2 The momentary switching off of the red stop bar lights would have been a confirmation to the verbal clearance given for vehicles to enter the runway.

2.6 **Use of the A-SMGCS**

- 2.6.1 Following the occurrence, the serviceability of the A-SMGCS was checked. No anomaly was found and there was no evidence that the system's runway incursion aural warning function did not work at the time of the occurrence. The fact that none of the controllers heard the aural warning suggests that the volume of the speakers at all the five A-SMGCS terminals might have been set to an inaudible level.
- 2.6.2 To the extent that there was no operational procedure to require controllers to check the volume setting of the A-SMGCS when they were taking up a control position, it seems that the A-SMGCS had not been given due emphasis.
- 2.6.3 Trainee controllers were trained on the use of the A-SMGCS by their mentors during the on-the-job phase of their training. However, there was no structured format or formal syllabus for the mentors to conduct the A-SMGCS training.
- 2.6.4 The lack of operational emphasis and formal training on the A-SMGCS might have resulted in a lack of appreciation on the part of the controllers that the A-SMGCS could provide critical information even in good-visibility conditions, e.g. when the visual targets are small or when there is obstruction to a controller's view. It appears that the ATC did not harness the full capabilities of the A-SMGCS.

3 CONCLUSIONS

From the information gathered, 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 runway incursion resulted from a miscommunication between Controller 3 and Rover 39. Rover 39 apparently heard only half of Controller 3's message and interpreted the partial message as a clearance for it to enter the runway. The co-worker of Rover 39 was not qualified to perform radio-telephony communication with ATC and did not read back Controller 3's message in a proper manner. This improper readback was not challenged by Controller 3 and an opportunity to stop Rover 39 from entering the runway was missed.
- 3.2 Controller 2 did not spot Rover 39 on the runway despite having scanned the runway before issuing the landing clearance to the approaching aircraft. He did not refer to the A-SMCGS which was at that time displaying the visual warning due to the runway incursion by Rover 39.
- 3.3 The air navigation service provider had made the A-SMCGS available to the controllers as an equipment to augment visual observation of traffic on the manoeuvring area. Had there been a more systematic approach to utilise the full capabilities of the system, the controllers might have been alerted by the aural and visual warnings of Rover 39's runway incursion.

4 SAFETY ACTIONS

During the course of the investigation and through discussions with the investigation team, the following safety actions were initiated.

Radio-telephony communication

- 4.1 The runway maintenance contractor ceased the practice of deploying personnel who did not hold a Category 1 ADP to perform radio-telephony communication with ATC.
- 4.2 Since January 2014, the aerodrome operator's Airside Operations Officers perform compliance checks as a passenger in the vehicles operating in the aircraft manoeuvring area. The officers verify if the person performing radio-telephony holds a valid Category 1 ADP and if the requirements for standard phraseology are complied with.
- 4.3 The aerodrome operator issued a circular on 7 October 2013 to companies involved in aerodrome ground operations to reiterate the personnel and equipment requirements for driving on the runways and taxiways. The circular also gave examples of common radio telephony standard phraseology exchanges between ground personnel and the tower controllers.
- 4.4 The air navigation service provider also issued a similar circular to the air traffic controllers on 10 October 2013.

Air traffic control

- 4.5 Changi Tower instructed its watch managers to remind controllers on the following:
- To be vigilant and scan the full length of the runway constantly (not just prior to issuance of landing or take-off clearance) for traffic or any unauthorised entry
 - To ascertain the position of vehicle(s) before issuing instructions
 - To use standard phraseology at all times
 - To always end the instruction with "*Hold short of runway 1 or 2*" when it is not possible to allow an aircraft or vehicle to enter the runway
- 4.6 The air navigation service provider arranged for the volume of all the A-SMGCS speakers to be pre-set and for the volume control knobs of the speakers to be removed. At the start of each shift, controllers are required to test the functioning of the aural warning and to ensure that the aural warning is audible.
- 4.7 The air navigation service provider has included the ground frequency 121.9 MHz to the suite of frequencies to be randomly monitored to ensure

controllers adhere to the standard phraseology. It will inform the aerodrome operator if it detects any use of non-standard phraseology by Category 1 ADP holders on the ground frequency.

- 4.8 The air navigation service provider and aerodrome operator are currently evaluating the feasibility of having communications for all operations on a runway conducted on a single frequency channel assigned to the runway¹² to enhance the situational awareness of all the parties using the runway.

Entrance into runway

- 4.9 The air navigation service provider and aerodrome operator plan to implement the system of switching off the red stop bar lights, in addition to verbal clearances issued by controllers, for vehicles to enter or cross the runway by July 2014.
- 4.10 The aerodrome operator plans to install microwave barrier detectors at all entrances to the runways¹³ by December 2014. If an aircraft or vehicle crosses a microwave barrier detector without clearance from the control tower, an alarm will be generated in the control tower to alert the controllers.

Others

- 4.11 Following the occurrence, the runway maintenance contractor has required its staff to park vehicles facing the runway landing direction when performing runway maintenance, so as be able to see any aircraft landing. The aerodrome operator is currently evaluating if this practice should be applied to all vehicles working on the runway.
- 4.12 The aerodrome operator plans to engage a runway safety specialist consultant to review the robustness of runway safety measures at Changi Airport.

¹² Currently, there are two frequency channels assigned to each runway in the aerodrome. One channel is used solely for the flight crew to communicate with the controllers. The other channel is solely for maintenance vehicles to communicate with the controllers.

¹³ Currently, the microwave barrier detectors are only installed at selected taxiways which are commonly used as aircraft holding points prior to departure.

5 SAFETY RECOMMENDATIONS

It is recommended that:

- 5.1 The air navigation service provider adopt a more systematic approach to utilise the full capabilities of the A-SMGCS, even in good visibility conditions, to assist the controllers in performing their duties. [AAIB Recommendation R-2014-001]
- 5.2 The airline operator review its procedures to ensure that flight recorders are deactivated at the end of a flight following a significant occurrence. [AAIB Recommendation R-2014-002]
- 5.3 The regulatory authority ensure that the Singapore Air Operator Certificate holders have procedures implemented to meet the requirement in paragraph 37(4) of the Air Navigation Order regarding deactivation of flight recorders upon completion of a flight following an accident or a serious incident. [AAIB Recommendation R-2014-003]