FINAL REPORT

RUNWAY INCURSION
BY RUNWAY SURFACE FRICTION TESTER
SINGAPORE CHANGI AIRPORT
4 APRIL 2013

AIB/AAI/CAS.090

Air Accident Investigation Bureau of Singapore
Ministry of Transport
Singapore

17 December 2013

The Air Accident Investigation Bureau of Singapore

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SYNOPSIS

At 1349 hours on 4 April 2013, Changi Airport Runway I (R02L/20R) was closed for a 5-minute runway daily inspection by an Airside Safety Inspection Team (ASIT). At about 1353LT, a surface friction tester (callsign Rover 18) entered Runway I from Taxiway W10 (at the southern end of Runway I) without authorisation from Changi Tower. Rover 18 had tried to call Changi Tower for permission to enter Runway I via Taxiway W10. The request was not received by Changi Tower, but was received instead by Seletar Airport which is 16 km to the west of Changi Airport. The quality of radio transmission and reception at the time was bad, and despite not getting a confirmation from Changi Tower, Rover 18 entered Runway 1. The ASIT leader did not know that Rover 18 had entered Runway I.

After its inspection, the ASIT left the runway, which was re-opened at 1355 hours for aircraft operations. The first aircraft arriving after the runway re-opening was cleared to land on Runway 20R. Rover 18 was still on the runway, near the rapid exit Taxiway W4 and moving southwards, when it was spotted by a Changi Tower controller. The Changi Tower controller instructed the landing aircraft to go around after trying in vain to contact Rover 18.

The Air Accident Investigation Bureau of Singapore classified this runway incursion occurrence as an incident.

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 1349 hours on 4 April 2013, Changi Airport Runway 1 (Runway 02L/20R) was closed for a 5-minute runway daily inspection. An Airside Safety Inspection Team (ASIT), comprising vehicles with callsigns Rovers 34, 35 and 39[1], entered the runway to perform the inspection. Rover 34 was the ASIT leader.

1.1.2 A Runway 1 surface friction test had been scheduled in conjunction with the 5-minute runway closure. A runway friction tester[2] (callsign Rover 18[3]) from the aerodrome operator's office located near parking bay A10, had been informed by Rover 34 at about 1330 hours to get ready for the runway friction test. Rover 18 was expected to move towards and position near Runway 1 and be ready to enter the runway once the runway closure was announced and the necessary Changi Tower clearance to enter the runway obtained. However, Rover 18 did not do so. It left the office only at 1350:37 hours, after the runway had already been closed for about a minute.

1.1.3 Vehicles wishing to enter the runway were to seek permission from Changi Tower on 121.9 MHz. Rover 18 started calling Changi Tower on the radio set as soon as he left the office. The transmissions were not received by Changi Tower nor heard by Rovers 34, 35 and 39. Instead, they were received on 122.9 MHz by Seletar Tower (which is 16 km to the west of Changi Airport), but with a lot of cracking sound. As Seletar Tower could only hear disjointed words and could not identify the caller (Rover 18), it tried to establish communication with the caller and at no time did it issue a clearance to the caller for entering the runway. According to Rover 18, he only received distorted transmissions and had no idea that they were coming from Seletar Tower. At one point, Rover 18 asked Rover 34 via handphone if Rover 34 had heard Changi Tower's reply. Rover 34 said he did not hear anything. According to Rover 18, he also did not hear any transmission between Changi Tower and Rovers 34, 35 and 39.

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[1] In this report, "Rover XX" refers to the vehicle or the driver of the vehicle, as the context may suggest.

[2] More information on the runway friction tester is in paragraph 1.3.

[3] Rover 18 held a valid Class 1 Airside Driving Permit (ADP). The holder of a Class 1 ADP is allowed to operate appropriately equipped vehicles on the runways and taxiways. As part of their training and certification, Class 1 ADP holders are required to be familiar with radio-telephony procedures, including the procedure for seeking Changi Tower's permission before entering runways and taxiways.

1.1.4 Despite not being in radio communication with Changi Tower and with no authorisation from the Tower, Rover 18 continued driving towards Taxiway W10 and entered Runway 1 at 1353 hours via the Runway 02L end (i.e. the southern end of Runway 1). Moving northwards on the runway, Rover 18 drove past Rover 39 near Taxiway W8 at 1353:22 hours, and past Rover 35 between Taxiways W7 and W8 at 1353:36 hours.

1.1.5 At 1355:07 hours, Rover 34 reported to Changi Tower that the ASIT had left Runway 1. Runway 1 was then re-opened. At that time, Rover 18 was moving northwards and had just passed Taxiway W3, about 1,000 m to the Runway 20R end (i.e. the northern end of Runway 1). It continued northwards and later entered into the displaced threshold area (740 m long) at the Runway 20R end.

1.1.6 Soon after the re-opening of Runway 1 (1355:32 hours), Changi Tower cleared an aircraft to land on Runway 20R. Meanwhile, Rover 35 called Rover 34 on the walkie-talkie to tell the latter that Rover 18 was still on the runway. Rover 34 then tried to call and alert Changi Tower accordingly, but the radio frequency was busy with other communication traffic. Rover 34 then tried to call Rover 18 via handphone, but there was no reply.

1.1.7 By then Changi Tower had spotted a vehicle (Rover 18) moving southwards on the runway and approaching Taxiway W4, outside the displaced threshold area. The landing aircraft was then about 3 NM from touchdown. Over a period of 43 seconds, Changi Tower tried to communicate with the vehicle to establish its identity. However, Rover 18 did not hear the Tower calling him. Meanwhile, the landing aircraft continued its approach to Runway 20R and was not advised by Changi Tower of any essential local traffic[4]. The landing clearance was only superseded at 1357:47 hours when Tower instructed the aircraft to go around. The aircraft was then about 0.89 NM from touchdown.

1.1.8 After issuing the go-around instruction, Changi Tower again tried calling Rover 18 over a period of 44 seconds but to no avail. By then, Rover 18 was about to exit the runway. Rover 18 tried calling Changi Tower to inform of its exit from Runway 1. Again, the transmission was received by Seletar Tower which, again, tried to ascertain the identity of the caller, but without success. About one minute later, at 1359:54 hours, Rover 18 finally established communication with Changi Tower on 121.9 MHz. This communication was heard by Rovers 34, 35 and 39.

[4] Essential local traffic is defined as any aircraft, vehicle or personnel on or near the manoeuvring area or traffic operating in the vicinity of the aerodrome, which may constitute a hazard to the aircraft concerned.

1.2 Runway surface friction

1.2.1 Runway surface friction affects the effectiveness of the aircraft's braking action during deceleration on the runway. A runway must be maintained to ensure it has the minimum surface friction coefficient along the length of the runway. Runway friction tests are performed regularly to verify that the friction coefficient requirements are met.

1.2.2 The runway friction test is carried out once a week. The runway friction test consists of measuring the friction coefficients along one or two lines on the runway surface throughout the runway length[5].

1.2.3 A runway friction tester is used to do the friction coefficient measurement (see paragraph 1.3). The test is carried out during the day, in conjunction with a runway maintenance inspection so as to minimise the need for runway closure[6].

1.3 Runway friction tester

1.3.1 The runway friction tester is a car that is equipped with a system for measuring a surface's friction coefficient (see **Figure 1**). This friction tester is used for runway friction measurement in both Changi and Seletar Airport.

1.3.2 The runway friction tester is designed to be operated by one person, i.e. the driver[7]. The driver drives the vehicle and operates the friction measurement equipment. During measurement operation, the vehicle is to be driven straight at a speed of 96 km/h.

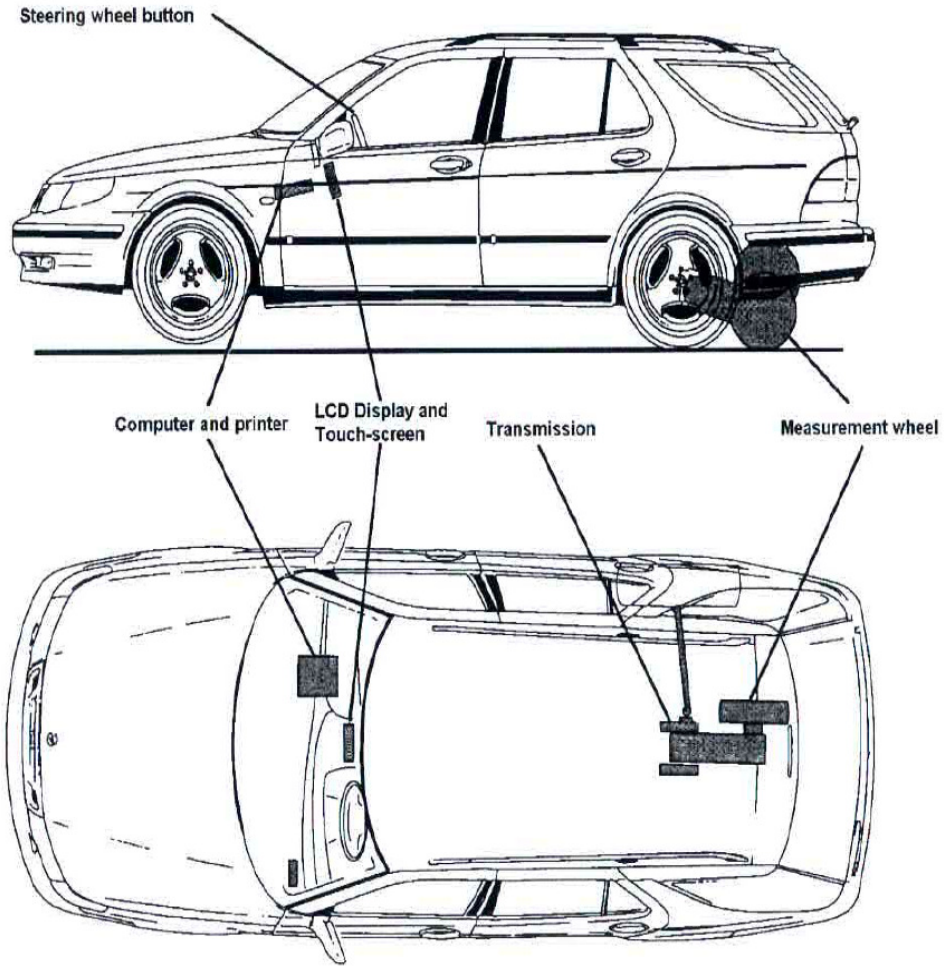
1.3.3 The friction measurement equipment includes a measurement wheel at the rear of the vehicle. The part of the measurement wheel system that is inside the cabin of the vehicle is boxed up with a cover (see **Figure 2**). There is also a water tank from which water will be metered out to just in front of the measurement wheel, to simulate a 1 mm depth of water on the runway. The instruments for the control of the operation of the equipment are within the driver's reach from his seat. Thus, the driver does not have to

[5] The tests will take friction coefficient measurement of the following line configurations in turn: (1) 3 m on both sides of the runway centerline, (2) 6 m on both sides of the centerline, (3) 9 m on both sides of the centerline, and (4) 15 m east of the centreline.

[6] The aerodrome operator performs maintenance inspections of Runway 1 five times a day for conditions of the pavement and lightings. The inspections are scheduled around 0305-0315, 0700-0705, 1025-1040, 1430-1435 and 1800-1810 hours, during which the runway is closed. The duration of these closures is 10, 5, 15, 5 and 10 minutes respectively. The actual closure timing will be decided by Changi Tower, taking into consideration the aircraft movement situation.

[7] On the day of occurrence, the driver was accompanied by another person during the friction test, but he was not part of the team and did not take part in the friction test.

stretch or bend himself to reach any instrument, which could make it difficult for him to maintain driving straight.



Position of measurement equipment in the car.

Figure 1. Surface Friction Tester

Figure 2. Measurement wheel

1.3.4 For two-way communication with the aerodrome control tower, the runway friction tester is equipped with a radio set. Although the radio set was within reach of the driver from his seat, it was positioned on the opposite of the vehicle's central pedestal (see **Figure 3**) and in such a way that it would be difficult for the driver to operate it (e.g. turning the tuning dial, viewing the frequency setting) without bending his body. Thus, if the driver needs to use the radio set for any reason during the friction test, he would need to abandon the test as he would not be able to drive straight and operate the radio set at the same time.

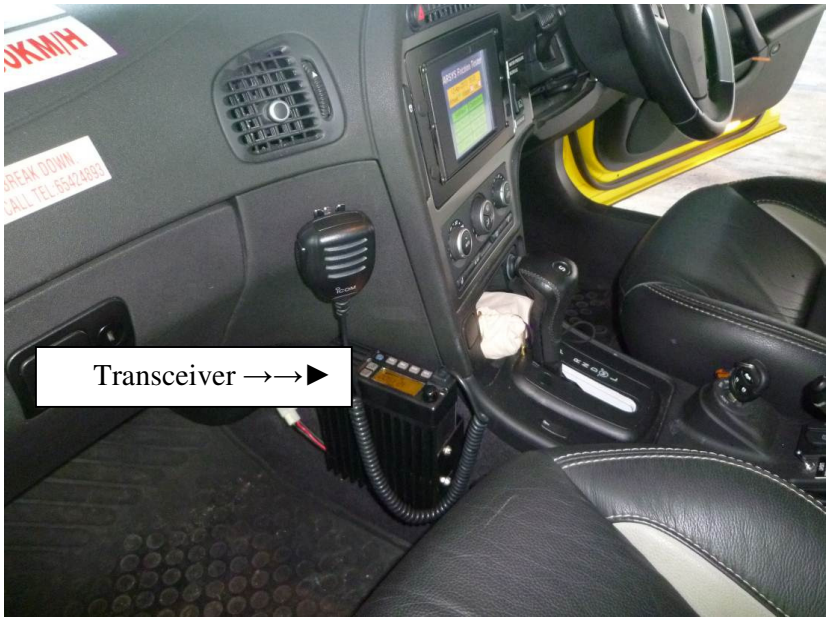


Figure 3. Position of the radio set

1.3.5 The radio set is a multi-band transceiver with many frequency selection possibilities. The radio set was not pre-selected to 121.9 MHz and 122.9 MHz.

1.3.6 The investigation team noted that, when the friction tester was running, the level of the noise generated by the measurement wheel was quite high. Radio transmission could not be clearly heard even when the audio output level was set to maximum. The hearing difficulty was compounded by the intermittent sound of radio static from the radio set.

1.4 Testing of the radio set of the runway friction tester

1.4.1 The radio set was found to be fully serviceable from a bench test. There is no evidence that the radio set could receive signals on 122.9 MHz when it was set to 121.9 MHz or could receive signals on 121.9 MHz when it was set to 122.9 MHz.

1.5 Additional information

1.5.1 On 2 April 2013, (i.e. two days before the incident), the runway friction tester was used in Seletar Airport. According to the driver of 2 April 2013, he had set the frequency back to 121.9 MHz after completing the friction test at Seletar Airport. The driver of 4 April

2013 indicated that he did not verify the frequency selected on the radio set.

1.5.2 Changi Tower has an Advanced-Surface Movement Guidance and Control System (A-SMGCS) to augment visual observation of traffic on the manoeuvring area and to provide surveillance of traffic on those parts of the manoeuvring area which cannot be seen from the Tower. The A-SMGCS is able to identify aircraft and vehicles if they are equipped with a Mode-S transponder.[8] The investigation team understands that, when the visibility is good, air traffic controllers will not need to use the information on the A-SMGCS display to help themselves in assessing whether a runway is clear of traffic.

[8] Mode S is a secondary surveillance radar technique that permits selective interrogation of aircraft or vehicle by means of a unique 24-bit aircraft address, thus avoiding the risk of confusion or mis-identification due to overlapping signals.

2 ANALYSIS

The following aspects will be discussed:

(a) Entering runway without authorisation
(b) Frequency setting on Rover 18's transceiver
(c) Spotting and handling of the runway incursion by Changi Tower controller
(d) The 5-minute inspection slot
(e) One-man operation of the runway friction tester

2.1 Entering runway without authorisation

2.1.1 It is clear that Rover 18 knew that he could not enter Runway 1 without an authorisation from Changi Tower. Yet he entered the runway without such an authorisation.

2.1.2 Rover 18 started calling Changi Tower on the radio set as soon as he left the office for Runway 1. His transmissions were received instead by Seletar Tower. As the reception was bad, Seletar Tower tried to establish communication with and identify the caller. Seletar Tower did not issue any clearance to the unidentified caller for entering the runway. Rover 18 received only distorted transmissions and had no idea that they could be coming from Seletar Tower. Yet, for unexplainable reason, he took such unclear transmissions as permission for him to enter the runway. He could have been very determined to enter the runway[9].

2.1.3 On the way from the office to Runway 1, Rover 18 did ask Rover 34 via handphone if Rover 34 had heard Changi Tower's reply. Rover 34 said he did not hear anything. Rover 34 probably could not make out what the matter was about and did not ask Rover 18 to clarify as he was busy with his own tasks. Rover 18 could have made it clear to Rover 34 that he was seeking permission from Changi Tower to enter the runway but did not receive any reply from the Tower. Rover 18 could also have asked Rover 34 to relay to the Tower his request for permission to enter the runway and to become its escort. Furthermore, Rover 18 could also have called Changi Tower via handphone since he had the telephone number for Changi Tower.

[9] A preventive maintenance work for Runway 1 had been scheduled on 6 April 2013 (i.e. two days later). The work would include rubber deposit removal from areas on the runway that were to be identified from an analysis of the results of the runway friction test. If Rover 18 did not complete the friction test on 4 April and if the friction test could not be conducted the following day (owing to, say, rain), then Rover 18 would fail its friction test mission.

2.2 Frequency setting on Rover 18's transceiver

2.2.1 It is noted that:

(a) the post-incident tests performed on the radio set of Rover 18 suggested that the radio set was functioning on the day of the incident and it was not possible for transmissions from the radio set on 121.9 MHz to be picked up by Seletar Tower on 122.9 MHz;
(b) Rovers 34, 35 and 39 did not hear any transmissions between Rover 18 and Changi Tower on 121.9 MHz even though they were all in the same area, nor did they hear any transmissions between Rover 18 and Seletar Tower on 121.9 MHz;
(c) according to Rover 18, he did not hear any radio transmissions from the other vehicles seeking permission from Changi Tower to enter the runway;
(d) Rover 18 did not hear the repeated calls from Changi Tower after the controller had spotted him on the runway; and
(e) radio transmissions recorded by the ATC show transmissions on 121.9 MHz from Rover 18 only after it had exited Runway 1.

2.2.2 According to the driver who operated the friction tester in Seletar Airport on 2 April 2013, he set the radio set to 122.9 MHz during the friction test but had reset it to 121.9 MHz after the friction test. It is not known if the frequency had been changed prior to the friction test on 4 April 2013. Rover 18 also did not verify the frequency selected on the transceiver.

2.2.3 On the balance of evidence, it is most likely that the radio set of Rover 18 was set to 122.9 MHz and that Rover 18 only got the frequency right after he had exited Runway 1.

2.3 Spotting and handling of the runway incursion by Changi Tower controller

2.3.1 Air traffic controllers were supposed to alert aircraft on final approach immediately of any sudden occurrence of hazards (e.g. unauthorised traffic on the runway) and any essential local traffic that could help aircraft crews avoid a collision. The Changi Tower controller spotted Rover 18 moving southwards on the runway and approaching Taxiway W4, outside the displaced threshold area. Instead of according priority to the approaching aircraft by cancelling the landing clearance[10] and passing essential local traffic information without delay to the aircraft, the controller tried to contact Rover 18, probably in the hope of getting it out of the runway in time and thus obviating the need to cancel the landing

[10] Landing clearance could be cancelled with an instruction like "CONTINUE APPROACH. PREPARE FOR POSSIBLE GO-AROUND DUE VEHICLE ON RUNWAY".

clearance. He only instructed the aircraft to go around when it was about 0.89 NM from touchdown, and the reason for the go-around was not told to the crew of the aircraft.

2.3.2 The controller was probably comfortable with the distance margin of the approaching aircraft when he opted to try to contact Rover 18 instead of to cancel the landing clearance. However, a more prudent approach would have been to cancel the landing clearance or to even issue a go-around instruction immediately and then deal with Rover 18 without having to worry about an approaching aircraft.

2.3.3 One could ask whether Rover 18 could have been spotted earlier by the Changi Tower controller when it was still within the 740 m long displaced threshold area of the Runway 20R end. This displaced threshold area was not to be used for landing but could be used for take-off and was subject to visual surveillance by the Changi Tower controller. It could not be established whether the Changi Tower controller had omitted to survey this portion of the runway or, if he did look at this portion of the runway, whether he could have spotted Rover 18, bearing in mind that it was a small vehicle. Nonetheless, controllers should always remember to scan the displaced threshold area.

2.3.4 After Runway 1 was reopened and since the weather was clear, the Changi Tower controller only checked the runway visually before clearing an aircraft to land. He did not check the A-SMGCS for any aircraft or vehicle traffic on the runway. There appears to be no reason why A-SMGCS should not be referred to even in good weather as a confirmation aid when assessing whether the runway is occupied by any aircraft or vehicle. Had the Changi Tower controller done so, Rover 18 might have been detected earlier[11].

2.4 The 5-minute inspection slot

2.4.1 The 5-minute inspection is so short that there is probably no place for any unplanned activity on the runway, but only for the routine time limited job. Such time pressure could have an effect on human performance, including a person's capacity to handle any untoward circumstances. For example, in his haste, Rover 18 could easily have missed verifying correctly the frequency selected on the radio set.

[11] Detected but not identified in the A-SMGCS, as the friction tester had then not yet been equipped with a Mode-S transponder. The transponder was installed in August 2013.

2.5 One-man operation of the runway friction tester

2.5.1 The runway friction tester is manned by one person who has to drive the vehicle (and drive it at a constant speed of 96 km/h during the test) and at the same time operate the runway friction measurement system and monitor the water pressure of the water tank. He also needs to look out for traffic on the runway and monitor the radio communication. If he has to deal with any unexpected situations (e.g. need to handle radio communication or avoid another vehicle), he would have to abandon the test. The postponement of the test may then in turn result in added pressure on him to complete the test mission. A two-man operation may be desirable, but the operator had carried out a risk assessment for the one-man operation. It concluded that the friction test could continue to be operated by one person and decided to continue with the one-man operation.

3 CONCLUSIONS

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 runway incursion was a result of Rover 18 entering the runway without Changi Tower's authorisation. He received distorted radio transmissions from an unidentified source but somehow interpreted them as an authorisation to enter the runway. .

3.2 The radio set in Rover 18 was most likely set to the Seletar Tower frequency of 122.9 MHz instead of the Changi Tower frequency of 121.9 MHZ. The driver was apparently not aware of the frequency setting, and thus was not able to communicate with Changi Tower despite his attempts.

4 SAFETY ACTION

During the course of the investigation and through discussions with the investigation team, the following safety actions were initiated by the aerodrome operator and the air navigation service provider.

4.1 The aerodrome operator intends to purchase an additional runway friction tester so that the Changi Airport and the Seletar Airport will each have its dedicated friction tester with the radio pre-selected to 121.9 MHz (for Changi Airport) and 122.9 MHz (for Seletar Airport). In the meantime, the aerodrome operator has added one radio set to the existing runway friction tester, so that one radio set is pre-selected to 121.9 MHz and one to 122.9 MHz and the frequencies are labelled accordingly to prevent human error in frequency selection. Also, the two radio sets are now mounted on the dashboard of the friction tester (instead of at the side of the central pedestal) for ease of operation.

4.2 To reduce the noise interference to the driver of the runway friction tester when friction testing is being carried out, the aerodrome operator has replaced the sealant around the edge of the cover of the box that houses the measurement wheel and has also installed a backboard over the box.

4.3 The operator has adopted a new operating procedure whereby runway maintenance works (e.g. runway sweeping, runway friction test, grass cutting) will be scheduled in conjunction with the 15-minute runway inspection slot.

4.4 The aerodrome operator had by 1 September 2013 required all Category 1 registered vehicles[12] to be installed with Mode-S transponder to enhance Changi Tower's 'visibility' of vehicles in the manoeuvring area.

4.5 The aerodrome operator has conducted refresher training for the relevant aerodrome officers and contractors to reinforce the need for strict adherence to airside driving rules.

4.6 The air navigation service provider has reminded its air traffic controllers of the need to scan the full length of the runway, including any displaced threshold areas, prior to issuance of landing or take-off clearances.

5 SAFETY RECOMMENDATION

A safety recommendation is for the purpose of preventive action and shall in no case create a presumption of blame or liability.

5.1 It is recommended that the regulatory authority consider making it a standard procedure for the Changi Tower to check the A-SMGCS, after every runway inspection, to ensure that the runway is clear of traffic prior to a landing or take-off, regardless of the visibility conditions.

[12] Category 1 registered vehicles refer to those vehicles that are permitted to enter the aircraft manoeuvring area (i.e. runways, taxiways and taxi-lanes) and are equipped with radio set and an appropriate transponder.