FINAL REPORT

RUNWAY INCURSION BY A TOW TUG IN CHANGI AIRPORT 6 AUGUST 2016

AIB/AAI/CAS.123

Transport Safety Investigation Bureau
Ministry of Transport
Singapore

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The Transport Safety Investigation Bureau

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SYNOPSIS

On 6 August 2016, at about 0358LT, a tow tug was to tow a B787 to Bay 300 in Singapore Changi Airport for the aircraft to be prepared for departure. The towing started at a maintenance hangar on the west side of the southern end of Runway 02L/20R and involved crossing Runway 02L/20R.

The tow tug, with the aircraft in tow, moved towards Runway 02L/20R on Taxiway SA after leaving the maintenance hangar. A microwave barrier detector on Taxiway SA detected the tow tug approaching the runway and triggered an alert at the Changi Control Tower. The alert was noticed by the runway controller.

At that time, an arriving B737 had just passed the northern threshold of Runway 02L/20R and was about to touch down. The towing crew saw the approaching aircraft, stopped the towing, and reported to the runway controller that they saw the arriving aircraft. The runway controller observed that the B787 on tow was apparently not moving and informed the towing crew that they did not have the clearance to cross Runway 02L/20R. The B737 landed safely and vacated the runway without any incident.

The occurrence was classified as an incident.

1 FACTUAL INFORMATION

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

1.1 Sequence of events

1.1.1 In the early morning of 6 August 2016, a tow tug was to tow a B787 aircraft to Bay 300 in Singapore Changi Airport for the aircraft to be prepared for departure. The B787 had some maintenance work done by an aircraft maintenance, repair and overhaul organisation (MRO) located on the west side of the southern end of Runway 02L/20R. The towing would involve crossing Runway 02L/20R via Taxiway SA onto Taxiway W9 (see **Figure 1**).

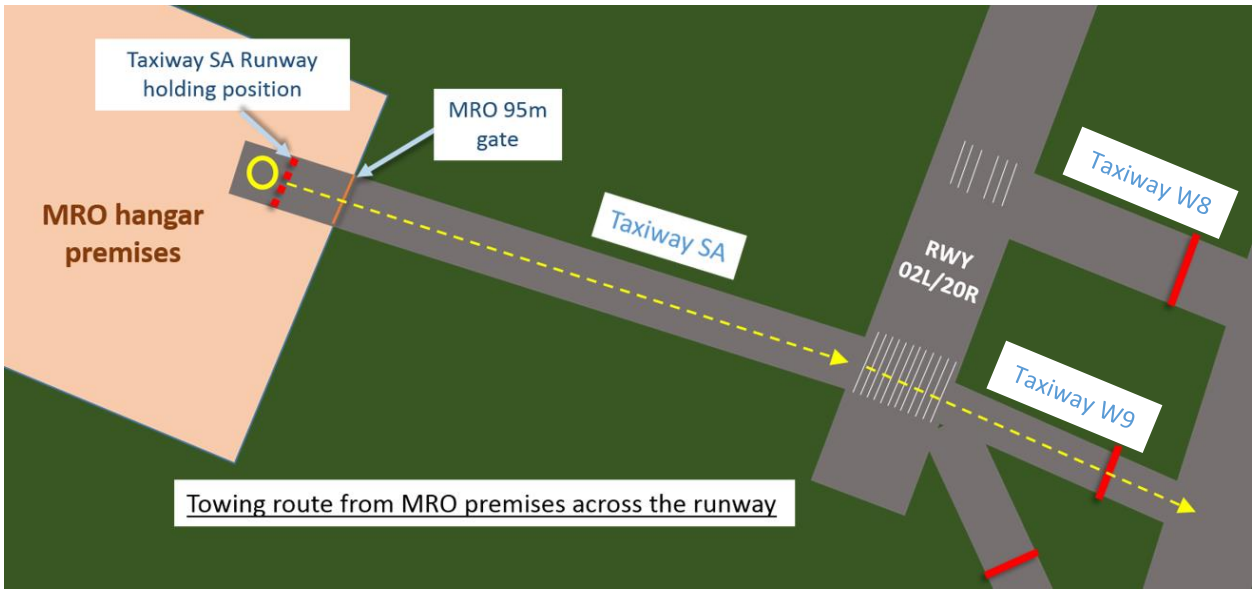

Figure 1. Planned towing route

1.1.2 The towing crew comprised the following personnel from the MRO: three aircraft maintenance engineers, a headset man and a tow tug driver. One of the aircraft maintenance engineers was designated as the Flight Deck Engineer cum Engineer-in-charge (EIC) of the towing crew. The other two engineers were assigned to carry out checks on the aircraft cockpit avionics to prepare the aircraft for departure.

1.1.3 The towing started from within the MRO's premises. The EIC briefed the towing crew at about 0330LT and prepared the B787 for towing and conducted communications check with Changi Apron Control to test communications equipment serviceability. Then, using a tow tug of the MRO, the towing crew towed the B787 to a point on Taxiway SA such that the

MRO's tow tug was just beyond the MRO's gate[1] to the aerodrome (the MRO called this the 95m gate because of its width) (see **Figure 2**). Here the MRO's tow tug and tow tug driver were replaced by a tow tug and tow tug driver from a ground service provider (GSP) at Changi Airport engaged by the MRO.

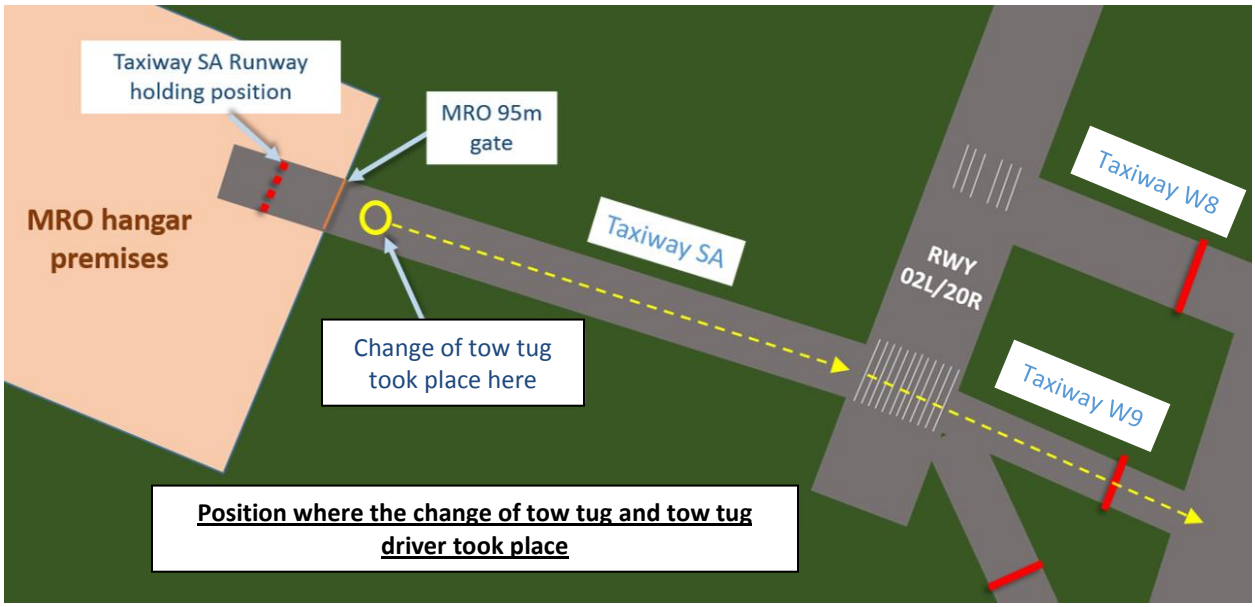

Figure 2. Change of tow tug and tow tug driver took place here

1.1.4 At about 0355LT, while the headset man was with the replaced tow tug, the EIC and the other two engineers entered the B787's cockpit and contacted Changi Apron Control to seek the necessary clearance for towing across Runway 02L/20R to proceed to Bay 300. Changi Apron Control relayed the request to the runway controller at Changi Control Tower. The runway controller contacted the EIC on frequency 121.9MHz and said,

"… expect to tow across 20R in about two …correction, in about three minutes' time."

1.1.5 The EIC thought he heard the runway controller say "…expedite to tow across the runway in 2-3 minutes' time". Believing that it was possible to cross Runway 02L/20R quickly, the EIC read back,

"… we'll cross the Runway 02L in two minutes' time."

1.1.6 The runway controller acknowledged with "Affirm." The towing column then moved forward. The red stop bar lights[2] indication on the Airfield Ground

[1] More on this in paragraph 1.6.3.3
[2] More on red stop bar lights in 1.6.1

Lighting Control and Monitoring System (AGLCMS) at the Control Tower was not deactivated by the runway controller.

1.1.7 As the towing column was moving forward, the tow tug driver spotted an aircraft approaching the airport from the north. He informed the headset man who was beside him. The headset man in turn informed the EIC. The EIC and engineers at the cockpit saw the aircraft and instructed the tow tug driver to stop. The EIC reported to the runway controller that they saw an aircraft approaching Runway 02L/20R. The runway controller saw that the towing column was apparently not moving and told the EIC that he was not given clearance to cross the runway[3].

1.1.8 In the meantime, the microwave barrier detector (MBD) of the airport's runway incursion alerting system[4] installed at Taxiway SA (see **Figure 3**) also triggered an alarm that alerted the runway controller.

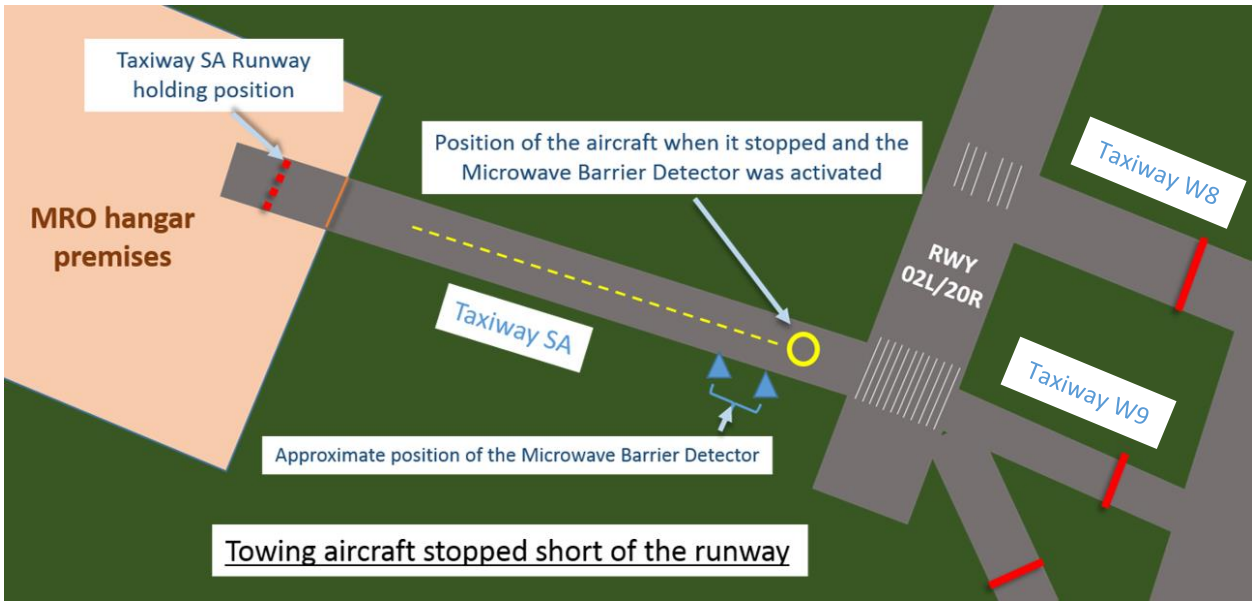

Figure 3. Approximate position of MBD

1.1.9 The arriving aircraft landed safely and vacated the runway at Taxiway W8 without any incident. The towing column had stopped at about 115m from the centreline of Runway 02L/20R (i.e. 85m from the edge of the runway[5]).

[3] At about that time, the approaching aircraft, a B737, had passed the northern threshold of Runway 02L/20R and was about to touch down.
[4] More on the runway incursion alerting system in 1.6.1
[5] Runway 02L/20R was 60m wide.

1.2 Personnel information

1.2.1 EIC

Age	32
Qualifications	Licenced aircraft engineer (LAE), holding Aircraft Radio Operator's Approval issued by the Civil Aviation Authority of Singapore and valid from 29 June 2012 to 31 May 2018
Working hours	0300 – 1300 hours
Experience as LAE	9 years
Experience as aircraft radio operator	6 years

1.2.2 Tow tug driver

Age	31
Qualifications	Airfield Driving Permit (ADP) issued by the aerodrome operator and valid from 1 February 2016 to 28 March 2018 (The tow tug driver did not hold a Category 1 ADP.)
Working hours	2200 – 0700 hours
Experience as tow tug driver	3 years

1.2.3 Runway controller

Age	29
Qualifications	Licenced air traffic controller, holding Aerodrome Control (Changi) rating issued on 27 February 2015 by the Civil Aviation Authority of Singapore
Working hours	2300 – 0900 hours
Experience as Aerodrome Controller	1 year 5 months

1.3 Meteorological information

1.3.1 At the time of the incident, the weather was clear and the ground was dry.

1.4 Recorded data

1.4.1 The investigation team had access to the following data:

(a) Air traffic control audio transcripts, from the air traffic service provider;

(b) Surface movement radar plots, from the air traffic service provider;

(c) Airfield Ground Lighting Control and Monitoring System (AGLCMS) and MBD recordings, from the aerodrome operator;

(d) Closed-circuit TV recordings of the area in the vicinity of Taxiway SA, from the aerodrome operator.

1.5 Radiotelephony communications

1.5.1 Aircraft Radio Operator's Approval

1.5.1.1 The EIC held a valid Aircraft Radio Operator's Approval (AROA). The EIC is authorised by the AROA to:

(a) perform aircraft radiotelephony equipment tests;
(b) obtain clearance to perform engine ground run;
(c) obtain clearance to perform aircraft compass swing; and
(d) obtain clearance to move aircraft on ground.

1.5.2 Airside driving permits

1.5.2.1 The aerodrome operator issues two types of driving permits for drivers of vehicles operating on the airside, viz. Airside Driving Permits (ADP) and Category 1 Airside Driving Permit (CAT 1 ADP). CAT 1 ADP holders are allowed to operate vehicles on the airside, including the runways and taxiways. ADP holders are allowed to operate vehicles on the airside other than on the runways and taxiways.

1.5.2.2 To obtain a CAT 1 ADP, an applicant needs to undergo a radiotelephony (RT) communication training and an airfield familiarisation training (involving some practices in communication with the apron/tower control) conducted by the aerodrome operator. Following the training, the applicant had to pass the CAT 1 ADP test (which includes a written test and oral test on RT phraseology) conducted by the aerodrome operator.

1.5.2.3 Tow tug drivers are required to hold an ADP, but they are not required to hold a CAT 1 ADP. During a towing operation, a tow tug driver without a CAT 1 ADP would have to work together with another person who was qualified and responsible for communication with air traffic control.

1.6 Aerodrome information

1.6.1 Runway incursion alerting system

1.6.1.1 The aerodrome has a runway incursion alerting system comprising a number of microwave barrier detectors (MBDs) for the detection of unauthorised entry of aircraft or vehicles into the runway. The MBDs (see **Figure 4**) are installed at all taxiways leading to a runway and are controlled by controllers at Changi Control Tower with the same switch that controls the red stop bar lights.

Figure 4. Microwave Barrier Detectors on Taxiway SA

1.6.1.2 The runway incursion alerting system is integrated with the aerodrome's AGLCMS. It will generate an incursion alarm for the display panel at Changi Control Tower when a MBD detects an unauthorised entry into a runway.

1.6.1.3 When the red stop bar lights[6] at a runway holding position is turned off by the controller at Changi Control Tower to authorise an aircraft or a vehicle to enter the runway, the MBD will also be deactivated automatically. The red stop bar lights and the MBD will be reactivated automatically after about 60 seconds.

[6] In Changi Airport, red stop bar lights are provided at every runway holding position serving a runway.

1.6.1.4 The MBD at Taxiway SA is located about 85m away from the edge of the Runway 02L/20R.

1.6.2 Taxiway SA

1.6.2.1 The MRO had a cluster of hangars on the west side of the southern end of Runway 02L/20R. Taxiway SA linked the MRO's hangar premises directly to Runway 02L/20R. Under an agreement with the then aerodrome operator[7] in June 1993, the MRO constructed Taxiway SA (as well as the associated runway holding position, and the related markings, signage and lightings on the ground), as approved by the then aerodrome operator, when it developed its hangar facilities. The agreement also required the MRO to operate and maintain Taxiway SA.

1.6.2.2 The MRO's 95m gate separates its hangars from the aerodrome. The gate would be opened only for aircraft movement on Taxiway SA.

1.6.3 MRO's towing procedure

1.6.3.1 Arriving aircraft could taxi to the MRO's premises for maintenance work, subject to prior coordination with Changi Control Tower. No towing was needed.

1.6.3.2 However, aircraft were not allowed to taxi out from the MRO's premises after the maintenance work. They had to be towed across Runway 02L/20R to an aircraft bay for departure. The procedure for the start of tow was not specified in the MRO's standard operating procedure. The MRO said that the towing column was supposed to start at the runway holding position for Taxiway SA (which was located inside the MRO's premises), behind the illuminated red stop bar lights for this holding position, and seek clearance from Changi Apron Control and Changi Control Tower for crossing Runway 02L/20R to proceed to an aircraft bay for departure. The towing column was not allowed to move forward beyond the runway holding position without the necessary air traffic control clearance. The red illuminated stop bar lights must be switched off by Changi Control Tower before proceeding with the towing.

1.6.3.3 Over time, the towing practice for the start of tow was altered. During MRO's construction of a new hangar in its premises in October 2012, some power cables were damaged resulting in the red stop bar lights being disabled and there was no repair of these lights[8] (see paragraph 1.6.4.4). The location where the towing column would seek clearance from Changi Apron Control and Changi Control Tower was shifted to a point on Taxiway SA just outside

[7] The current aerodrome operator took over Changi Airport operations on 1 July 2009.

[8] The MRO apparently also did not initiate any discussion with the aerodrome operator or air traffic service provider regarding the towing arrangement during the period when the red stop bar lights were not repaired.

of the 95m gate[9], which became the de facto runway holding position for Taxiway SA. It is not known who in the MRO had decided on this shift and whether any risk assessment had been conducted. The aerodrome operator told the investigation team that it was not aware of this shift.

1.6.4 Runway holding position

1.6.4.1 For each taxiway that leads to a runway, there is a runway holding position[10] where an aircraft or a vehicle will hold until clearance is given for it to enter or cross the runway.

1.6.4.2 The MRO constructed, within the MRO's premises, the runway holding position and the associated red stop bar lights for Taxiway SA at a location about 380m from the edge of Runway 02L/20R[11]. (Other runway holding positions at the aerodrome were typically at about 120m from the edge of a runway.) The investigation team understood that this was to avoid possible interference with the glide path signal of Runway 02L and the localiser signal of Runway 20R when an aircraft or vehicle was on Taxiway SA.

1.6.4.3 Although the runway holding position for Taxiway SA was within the MRO's premises, it was marked as being located within the aerodrome both on the AGLCMS display panel at Changi Control Tower (see **Figure 5**) and in the aerodrome chart in the Singapore Aeronautical Information Publication.

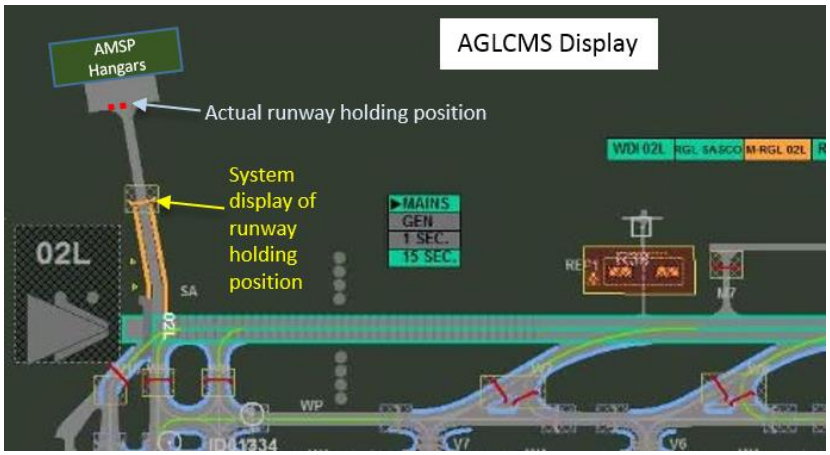

Figure 5. Incorrect display of Taxiway SA's runway holding position on the AGLCMS

[9] It appears that towing personnel believed that such a position was not illogical as it would allow Changi Control Tower personnel to see the aircraft on tow prior to issuing a towing clearance. However, there was no requirement that Changi Control Tower personnel must be able to see the aircraft on tow on Taxiway SA prior to issuing a towing clearance.

[10] Runway holding positions are intended to protect a runway or an Instrument Landing System (ILS) critical/sensitive area at which taxiing aircraft and vehicles shall stop and hold, unless otherwise authorised by the aerodrome control tower.

[11] Under the June 1993 agreement with the aerodrome operator at that time, the MRO was required to construct the runway holding position for Taxiway SA and the red stop bar lights at least 375m away from the centreline of Runway 02l/20R (i.e. at least 345m from the edge of the runway).

1.6.4.4 The MRO started constructing a new hangar in its premises in October 2012. In March 2013, the power cables for the taxiway lights along Taxiway SA and for the red stop bar lights were accidentally disabled by the MRO's contractor. The taxiway lights along Taxiway SA were repaired but the repairs for the red stop bar lights within the MRO's premises were put on hold because the MRO was in discussion with the aerodrome operator whether the MRO's aircraft could taxi across Runway 02L/20R from a new runway holding position (see paragraph 1.6.4.5). According to the aerodrome operator, it was not aware that the red stop bar lights were not working[12]. The red stop bar lights were not reactivated after the new hangar was completed in September 2013 and the MRO did not inform the aerodrome operator or the air traffic service provider that the red stop bar lights remained deactivated.

1.6.4.5 In or around November 2010, the MRO explored with the air traffic service provider and the aerodrome operator the feasibility of shifting the runway holding position to a location outside the 95m gate and about 200m from the edge of the runway. Its intention was to allow an aircraft that had undergone maintenance work at the MRO to start taxiing from this location[13]. This would obviate the need for the aircraft to be towed across the runway to a bay in the aerodrome, which would take more time.

1.6.4.6 The idea of a new runway holding position was abandoned after some trials by the MRO. However, there is no record of when the MRO terminated the trials.

1.6.4.7 Subsequently, as mentioned in paragraph 1.6.3.3, the MRO used a point on Taxiway SA just outside of the 95m gate as the de factor runway holding position for Taxiway SA.

1.6.4.8 In 2014, the aerodrome operator became aware that the red stop bar lights within the MRO's premises were not working. It had on several occasions asked the MRO to rectify the red stop bar lights. The MRO did not follow-up with these requests and decided to put the repairs on hold. At around this time, the aerodrome operator had taken the initiative to install a set of MBDs on all taxiways leading to the runways to protect the runways. In order for the MBDs to work properly, the stop bar lights within the MRO's premises must not provide a false signal. According to the aerodrome operator, as the stop bar lights within the MRO's premises remained not working, the control of the MBD at Taxiway SA needed to be delinked from the control of these red stop bar lights to protect the runway. The aerodrome operator continued to remind the MRO to repair the red stop bar lights. However, the aerodrome operator

[12] According to the aerodrome operator, it had only become aware in 2014 that the red stop bar lights had not been working (see paragraph 1.6.4.8).

[13] The aircraft would still need to be towed from the MRO's premises to this location. A Hazard Identification Risk Assessment (HIRA) was conducted by the MRO for the trials.

did not inform Changi Control Tower of the fault associated with the Taxiway SA stop bar lights. A consequence of this lack of communication by the aerodrome operator was that the Changi Control Tower personnel still believed that the red stop bar lights for Taxiway SA were working and that turning off the red stop bar lights would also automatically turn off the MBD.

1.6.5 Runway guard lights

1.6.5.1 Runway guard lights (see **Figure 6**) are required[14] at each taxiway/runway intersection associated with a runway intended for use in:

(a) Runway visual range conditions less than a value of 550m where a stop bar light is not installed; and

(b) Runway visual range conditions of values between 550m and 1,200m where the traffic density is heavy.

1.6.5.2 Runway guard lights are for warning pilots of aircraft and drivers of vehicles when they are about to enter a runway from the taxiway. For Runway 02L/20R, the runway guard lights shall be at least 107.5m from the runway centreline[15].

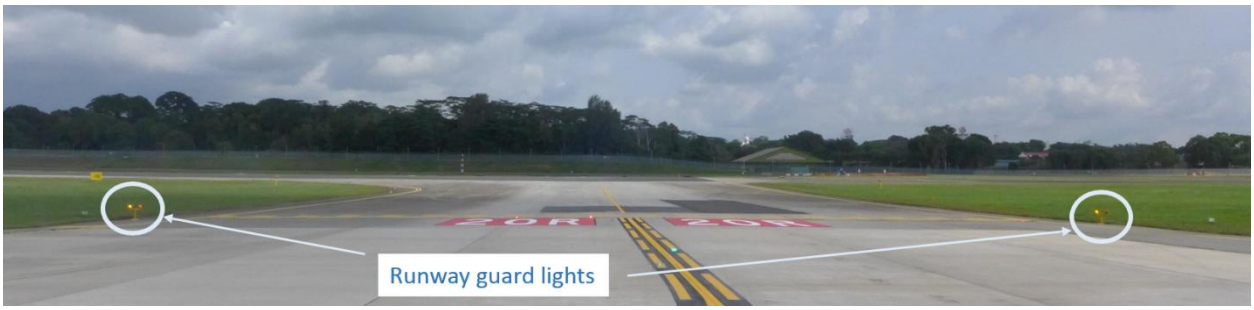

Figure 6. Runway guard lights at the side of a taxiway

1.6.5.3 There were no runway guard lights at the intersection of Taxiway SA and Runway 02L/20R.

[14] Paragraph 9.2.3.23.1 of CAAS Manual of Aerodrome Standards and Standard 5.3.23.1 of Annex 14 "Aerodromes" to the Convention on International Civil Aviation

[15] Paragraph 9.2.23.4 and Table 7-2 of CAAS Manual of Aerodrome Standards and Standard 5.3.23.4 of ICAO Annex 14

2 DISCUSSION

2.1 The event was triggered by the towing team EIC's mishearing what the runway controller said (i.e. the controller said "…expect to tow across the runway in 2-3 minutes time …" but the EIC heard it as "… expedite to tow across …). It was fortunate that the towing crew was vigilant enough to have spotted an arriving aircraft and was in fact in the course of stopping the towing column when the MBD alarm was activated.

2.2 The investigation team also considered the following aspects:

(a) Prevention of runway incursion;

(b) Radiotelephony communications;

(c) Towing procedure for the MRO;

(d) Runway guard lights at intersection of Taxiway SA and Runway 02L/20R;

(e) Safety management – Coordination and Communication.

2.3 Prevention of runway incursion

2.3.1 Runway incursion is a key concern worldwide. At the time of the incident, the aerodrome operator had a runway incursion prevention system that included a multi-layered safety defence arrangement of the following:

(a) Runway holding positions and associated markings, signage and lightings;

(b) Red stop bar lights;

(c) Guard lights;

(d) Microwave barrier detectors (MDB).

2.3.2 Although the AGLCMS display panel at Changi Control Tower showed an incorrect location of Taxiway SA's runway holding position and red stop bar lights, the MBD detected the unauthorised entry by the towing column and set off an alarm to warn the controllers at Changi Control Tower of an impending runway incursion.

2.3.3 MBD is not an equipment mandated by Annex 14 to the Convention on International Civil Aviation. MBD is also not required in the Manual of Aerodrome Standards. This incident showed the value of such an equipment and suggested that it could be a worthwhile investment by an aerodrome operator.

2.4 Radiotelephony communications

2.4.1 Radiotelephony phraseology

2.4.1.1 The towing crew were aware that clearance had to be obtained from Changi Tower before entering a runway. In response to a request by the EIC for clearance to tow the aircraft across the runway, the tower controller, instead of instructing the EIC to wait by using a standard phraseology like "stand by", replied in plain language "… expect to tow across …". He was probably trying to be helpful to the EIC by indicating how much the EIC would have to wait. However, his plain language instruction was misinterpreted by the EIC as to "…expedite to tow across the runway in 2-3 minutes time".

2.4.1.2 The breakdown in communication was further compounded when the EIC replied in plain language, "…we'll cross the runway 02L in two minutes time." The tower controller misunderstood that the EIC would be crossing in two minutes' time and thought that the EIC confirmed that he was expecting a clearance in two minutes time. This was consistent with the fact that the tower controller did not deactivate the stop bar lights in the AGLCMS. When the tower controller acknowledged the transmission with "Affirm", the EIC accepted that as a clearance to start the towing operations. The lack of clear, concise and standard radiotelephony phraseology contributed to the misunderstanding between the controller and EIC.

2.4.1.3 The purpose of standard radiotelephony phraseology is to ensure uniformity in radiotelephony communications. Plain language shall only be used when standardised phraseology cannot serve an intended transmission[16]. This incident highlights the importance of the use of standard radiotelephony phraseology.

2.4.2 Aircraft Radio Operator's Approval

2.4.2.1 The EIC was the towing team's leader and had the task of operating the radiotelephony equipment on board the aircraft on tow and maintaining communications with Changi Apron Control and Changi Control Tower. The EIC held an Aircraft Radio Operator's Approval (AROA) issued by the Civil Aviation Authority of Singapore (CAAS).

2.4.2.2 For operating on runways/taxiways, a driver of a vehicle needs to hold a CAT 1 ADP. A CAT 1 ADP applicant needs to undergo a radiotelephony communication training and an airfield familiarisation training (involving some practices in communication with the apron/tower control) conducted by the aerodrome operator. Following the training, the applicant had to pass the CAT 1 ADP test (which includes a written test and oral test on RT phraseology) conducted by the aerodrome operator.

[16] ICAO Doc 9870 Manual on the Prevention of Runway Incursions

2.4.2.3 In contrast, an AROA holder, who may be tasked to lead a towing column through runways/taxiways, could have obtained the AROA through only a written test set by CAAS.

2.4.2.4 There are differences in the qualifying requirements of an AROA holder and a CAT 1 ADP holder. An AROA holder is qualified based on theoretical radiotelephony knowledge, whereas a CAT 1 ADP holder is qualified based on practical radiotelephony, amongst other competencies like airside rules and airfield familiarity. It may be desirable for AROA applicants to be assessed on radiotelephony communication, through some form of oral test, and on airfield familiarity.

2.5 Towing procedure for the MRO

2.5.1 The towing column was to start the towing operations at the runway holding position behind the illuminated red stop bar lights. The towing column was to seek the necessary clearance from Changi Apron Control and Changi Control Tower before moving beyond the runway holding position.

2.5.2 The procedure for the start of towing was not included in the MRO's SOP. When the stop bar lights became not working, coupled with the taxi trials initiated by the MRO, the towing practice was altered over time. The starting point for the towing column was shifted forward ahead of the runway holding position, outside of the MRO's premises. It was an arrangement, commonly used by the EICs, so that the Tower controller could sight the towing aircraft prior to issuing a towing clearance. This deviation from the towing procedure had evolved to be accepted by the towing crew. There were no other established markings on the taxiway, beyond the MRO's premises, for a towing aircraft to stop, if required.

2.5.3 Following the incident, the MRO relocated the runway holding position and red stop bar lights for Taxiway SA with assistance from the aerodrome operator (see paragraph 3.1.1). The MRO had also reviewed and enhanced its procedure for towing aircraft across Runway 02L/20R. The MRO had arranged for all its aircraft towing personnel to undergo training on the enhanced towing procedure (see paragraph 3.4).

2.6 Runway guard lights at intersection of Taxiway SA and Runway 02L/20R

2.6.1 The investigation team could not establish why there were no runway guard lights at the intersection of Taxiway SA and Runway 02L/20R, although it could be surmised that the reason had to do with the fact that there were red

stop bar lights installed and that the traffic density on Taxiway SA was not heavy.

2.6.2 Following the incident, the MRO installed runway guard lights at the intersection of Taxiway SA and Runway 02L/20R with assistance from the aerodrome operator (see paragraph 3.1.4).

2.7 Safety management – Coordination and Communication

2.7.1 In the course of its investigation, the investigation team came across a number of instances of the stakeholders involved not coordinating or communicating with other stakeholders on activities that could have a bearing on the safety and efficiency of aerodrome operations. For example:

(a) The MRO apparently did not initiate any discussion with the aerodrome operator or air traffic service provider regarding the towing arrangement during the period when the red stop bar lights were not in operation (see Footnote 7 in paragraph 1.6.3.3).

(b) The MRO did not reactivate the red stop bar lights after its new hangar was completed and did not inform the aerodrome operator or the air traffic service provider that the red stop bar lights remained deactivated (see paragraph 1.6.4.6).

(c) The aerodrome operator apparently did not inform Changi Control Tower of its action to delink the control of the MBD for Taxiway SA from the control of the red stop bar lights (see paragraph 1.6.4.8) and that Taxiway SA's stop bar lights were unserviceable.

2.7.2 It is important that stakeholders in an aerodrome environment track systematically the status of their activities and projects (as highlighted in the preceding paragraph) and keep other stakeholders informed accordingly.

3 SAFETY ACTIONS

During the course of the investigation, the following safety actions were initiated by the ground service provider, air traffic service provider and aerodrome operator.

3.1 Runway holding positions and associated visual aids

3.1.1 Following discussions with the stakeholders concerned, the MRO relocated the runway holding position and red stop bar lights for Taxiway SA to a location about 220m from the edge of Runway 02L/20R (see **Figure 7**) with assistance from the aerodrome operator. This location is outside the MRO's premises. The new runway holding position became operational on 14 December 2016[17].

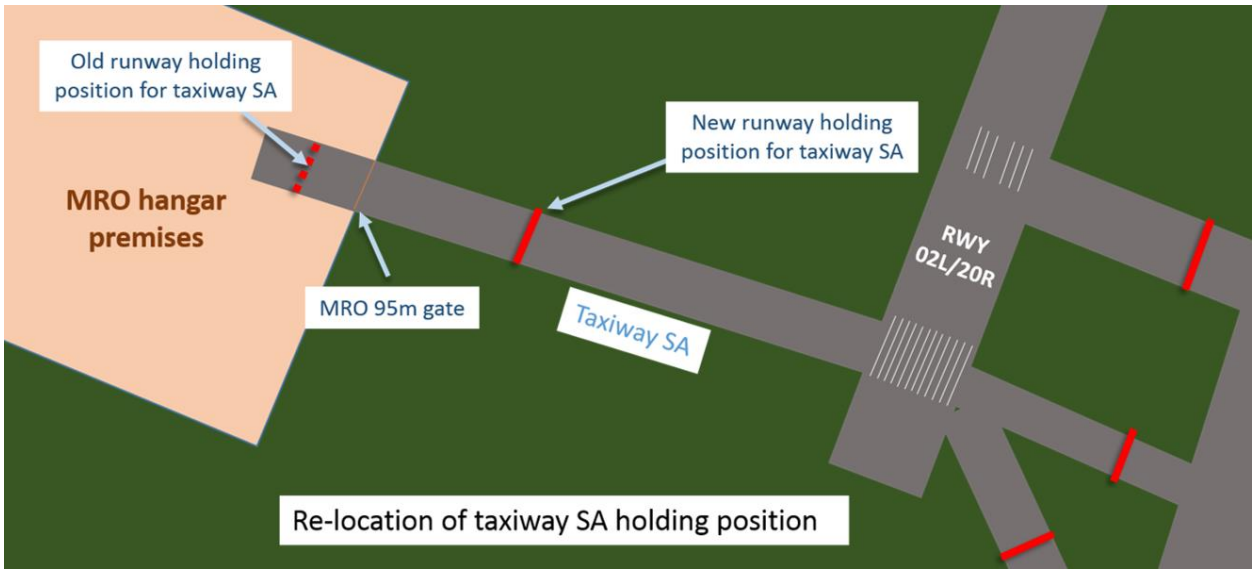

Figure 7. New Taxiway SA runway holding position

Note: Following the incident and prior to the relocation of the runway holding position for Taxiway SA, and as an interim measure, the aerodrome operator implemented a requirement that the MRO's towing column be escorted by one of the aerodrome operator's "Follow-Me" vehicles for the crossing of Runway 02L/20R. This interim measure was terminated on 12 January 2017, after Taxiway SA (including the portion inside the MRO's premises) was verified by the aerodrome regulator to be compliant to the requirements in the MOAS.

[17] The new runway holding position had been assessed to be not interfering with the glide path/localiser signal equipment installed by the air navigation service provider.

3.1.2 The display panel of the AGLCMS at Changi Control Tower and the aerodrome chart in the Singapore Aeronautical Information Publication were amended to reflect the correct location of the runway holding position.

3.1.3 The aerodrome operator and air traffic service provider also verified that the working of all the red stop bar lights in the aerodrome corresponded to the switch control by Changi Control Tower personnel.

3.1.4 The aerodrome operator reviewed the need for runway guard lights at the intersection of Taxiway SA and Runway 02L/20R and decided to install the guard lights. The lights became operational on 14 December 2016.

3.1.5 The aerodrome operator inspected all the runway holding positions in the aerodrome to ensure that all visual aids were in compliance with the Manual of Aerodrome Standards of the aerodrome regulator.

3.2 Radiotelephony phraseology

3.2.1 The air traffic service provider, aerodrome operator and MRO reviewed together the radiotelephony phraseology to be used for aircraft towing operations. Enhancement actions included the following:

(a) The standardisation of, and agreement on, the radiotelephony phraseology to be used between MRO personnel and Changi Control Tower regarding crossing of runway.

(b) The air traffic service provider reminded its controllers of the following:

(i) Need to avoid providing unnecessary information which might be wrongly interpreted;

(ii) Importance of proper readback;

(iii) Need to listen carefully to what is being read back;

(iv) Need to be vigilant and to always scan the areas in the aerodrome that are of concern.

3.3 Airside Safety Notice

3.3.1 The aerodrome operator issued an Airside Safety Notice on 8 August 2016 to the airside community to reiterate the need to adhere to runway incursion prevention measures (e.g. readback procedure, rule of never crossing a lighted stop bar) and seek clarification with air traffic controllers if their instructions are not clear.

3.4 MRO's towing procedure for crossing Runway 02L/20R

3.4.1 The MRO reviewed and enhanced its procedure for towing aircraft across Runway 02L/20R. The enhancement included the following:

(a) Use of standard phraseology in radio communication with Changi Control Tower for instructions to cross the runway (see also paragraph 3.2.1(a));

(b) Establishment of a position of Assistant Flight Deck Engineer[18] in the towing team to support the Engineer-in-charge.

3.4.2 The MRO also arranged for all its aircraft towing personnel to undergo training on the enhanced procedure. All the MRO's aircraft towing personnel have received training on the enhanced towing procedure and have been assessed by MRO to be cognizant of the towing requirements.

[18] The duties of the Assistant Flight Deck Engineer include the following:
- Assisting the Flight Deck Engineer during the towing operation
- Keeping a listening watch on Changi Control Tower ground frequency
- Recording the towing instructions of Changi Apron Control / Changi Control Tower and verifying the communication between the Flight Deck Engineer and Changi Apron Control / Changi Control Tower
- Monitoring the aircraft movement to ensure that towing is in accordance with the route cleared by Changi Apron Control / Changi Control Tower.

4 SAFETY RECOMMENDATION

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

It is recommended that:

4.1 The Civil Aviation Authority of Singapore, as the authority that issues Aircraft Radio Operator's Approval (AROA), consider requiring AROA applicants to be assessed in practical radiotelephony. [TSIB Recommendation RA-2017-31]

4.2 The MRO ensure that coordination with the stakeholders are conducted and systematically tracked for operations and projects that involve aerodrome visual aids (e.g. stop bar lights, guard lights) and ensure that appropriate information is communicated to other aerodrome stakeholders concerned. [TSIB Recommendation RA-2017-32]

4.3 The aerodrome operator review its coordination process with the stakeholders for operations and projects that involve aerodrome visual aids (e.g. stop bar lights, guard lights) and ensure that appropriate information is communicated to other aerodrome stakeholders concerned. [TSIB Recommendation RA-2017-33]