

Final Report

B737-300, Registration PK-YGW Runway Incursion, Singapore Changi Airport

28 November 2020

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The Transport Safety Investigation Bureau of Singapore

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GLOSSARY OF ABBREVIATIONS

AFCM	Augmented Flight Crew Member
ATC	Air Traffic Control
BTO	Before Take-off
CRM	Cockpit Resource Management
FCTM	Flight Crew Training Manual
FO	First Officer
FOO	Flight Operations Officer
JKT	Jakarta Time, seven hours ahead of UTC time
LT	Singapore Time, eight hours ahead of UTC time
MBD	Microwave Barrier Detector
PANS-ATM	Procedures for Air Navigation Services Air Traffic Management
PF	Pilot Flying
PIC	Pilot-In-Command
PM	Pilot Monitoring
UTC	Coordinated Universal Time

SYNOPSIS

On 28 November 2020, a B737-300 freighter aircraft was scheduled to depart Singapore Changi Airport for Jakarta Halim Perdanakusuma Airport in Indonesia. The aircraft was instructed by Air Traffic Control (ATC) to hold short of Runway 02C on Taxiway E11. However, the aircraft entered the runway without ATC clearance.

At about 0740LT, the aircraft crossed the runway-holding position marking. The Microwave Barrier Detector system triggered an alert to the Runway Controller of the incursion. The Runway Controller then instructed the flight crew to vacate the runway as another aircraft was on approach.

The aircraft exited the runway thereafter and was subsequently cleared for take-off. There was no further incident.

The Transport Safety Investigation Bureau classified this occurrence as an incident.

AIRCRAFT DETAILS

Aircraft type	:	B737-300 Freighter
Operator	:	Tri MG Intra Asia
Aircraft registration	:	PK-YGW
Numbers and type of engines	:	2 x CFM56 3C1 engines
Date and time of incident	:	28 November 2020, 0740LT
Location of occurrence	:	Singapore Changi Airport
Type of flight	:	Scheduled
Persons on board	:	6

1 FACTUAL INFORMATION

All times used in this report are Singapore Local Time (LT) unless otherwise stated. Singapore Local Time is eight hours ahead of Coordinated Universal Time (UTC).

1.1 History of the flight

1.1.1 On 28 November 2020, a B737-300 freighter aircraft was scheduled to depart Singapore Changi Airport (SIN) for Jakarta Halim Perdanakusuma Airport (HLP) as Flight TMG019. The flight was the last of six sectors that the flight crew had been rostered to operate.

1.1.2 The flight crew comprised two Captains (Captain 1 and Captain 2) and a First Officer (FO). For this SIN-HLP sector, Captain 1 was the Pilot-in-command (PIC) and Pilot Flying (PF), the FO was the Pilot Monitoring (PM) and Captain 2 was the Augmented Flight Crew Member (AFCM)¹. There were also one Flight Engineer, one Mechanic, and one Flight Operations Officer (FOO) on board TMG019.

1.1.3 TMG019 was pushed back from Bay 304 at 0726LT. When the aircraft was ready for taxi, the flight crew requested for their taxi instructions from the Ground Controller. The Ground Controller instructed the flight crew to taxi via Taxiway P, Taxiway P1, Taxiway P4, Taxiway EP and to hold before Taxiway South Cross 1 (SC1) (see **Figure 1**).

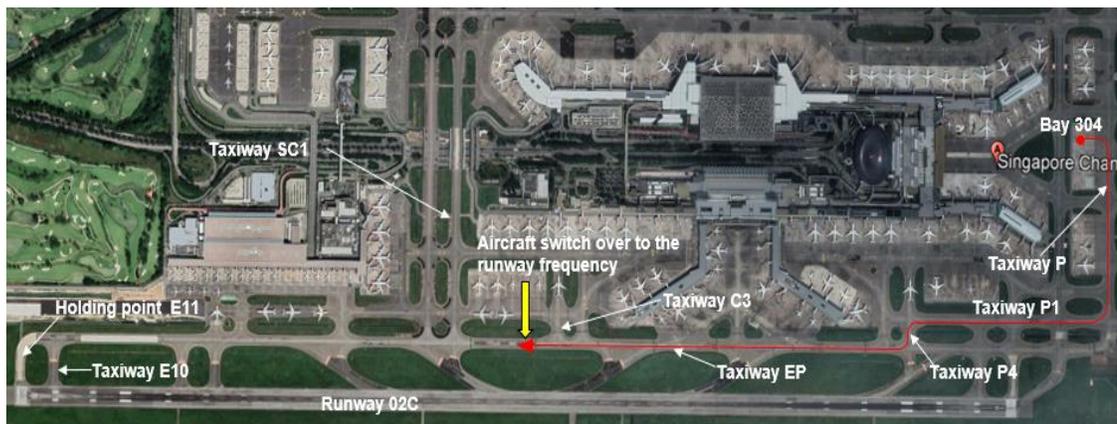


Figure 1: Overview of TMG019's taxi route from Bay 304, holding short of Taxiway SC1 (Source: Google Earth, annotated by TSIB)

1.1.4 At about 0737LT, before reaching Taxiway SC1 and when TMG019 was

¹ An AFCM was needed to extend the maximum duty time from 14 hours to 16 hours. See paragraph 1.10.2.1.

passing Taxiway C3, the flight crew were instructed by the Ground Controller to switch to the runway frequency and contact the Runway Controller. The flight crew did so accordingly.

- 1.1.5 The Runway Controller then issued the instruction “TMG019 Singapore Tower ... continue holding point E11 hold short Runway 02C” to direct the flight crew to continue taxiing to the holding point of Runway 02C at Taxiway E11 and hold short of Runway 02C (see **Figure 2**).



Figure 2: Overview of TMG019’s taxi route continuing from Taxiway EP (near SC1) to holding point on Taxiway E11 (Source: Google Earth, annotated by TSIB)

- 1.1.6 The PM read back the instruction as “continue holding point² E11 Runway 02C”, i.e. without reading back the words “hold short”³. Nevertheless, the PM understood that they did not have clearance to enter Runway 02C and were required to hold at Taxiway E11. The Runway Controller did not challenge the PM’s readback as it was clear to the Controller that the readback, which contained the words “holding point E11”, meant that the PM had understood that TMG019 was to hold at the runway holding position at Taxiway E11.

² According to ICAO Document 4444 [Procedures for Air Navigation Services Air Traffic Management (PANS-ATM)], the expression “holding point” in radiotelephony phraseology is used to designate the runway holding position.

³ According to ICAO Annex 11, guidance Document 9432 (Manual of Telephony), Document 4444 (PANS-ATM) and Document 9870 (Manual on the Prevention of Runway Incursions),

- a clearance or instruction to enter or to hold short of a runway must always be readback by the flight crew;
- the controller shall ascertain that the clearance or instruction had been correctly acknowledged by the flight crew and shall take immediate action to correct any discrepancies revealed by the readback; and
- taxi instructions issued by a controller will always contain a clearance limit, which is the point at which the aircraft must stop until further permission to proceed is given. For departing aircraft, the clearance limit will normally be the holding point of the runway in use.

- 1.1.7 According to the PF, he was informed by the PM to continue to taxi via EP, Taxiway E11 and Runway 02C, and the PM did not say anything about holding short of Runway 02C or holding at the holding point at Taxiway E11. Therefore, the PF assumed that there was clearance to enter runway.
- 1.1.8 The PF believed that TMG019 was the only aircraft using Runway 02C as there was no traffic visible on the navigation display in the cockpit, and there were also no communication exchanges over the runway frequency between the Runway Controller and other aircraft when he was taxiing TMG019 to the holding point at Taxiway E11.
- 1.1.9 As TMG019 was approaching Taxiway E11, the PF asked the PM to do the Before Take-Off (BTO) Checklist⁴. The flight crew continued taxiing TMG019 into Taxiway E11 and entered Runway 02C at about 0740LT. According to the PM, he was still carrying out the checklist which entailed him reading out the check items and the PF responding to him regarding the check items⁵. He had yet to announce to the PF the completion of the checklist, and he did not have a chance to remind the PF that TMG019 had not been given clearance to enter the runway. According to the PF, he did not notice the red stop bar lights in front of the runway holding position marking⁶ nor the runway guard lights. The AFCM had not been paying attention to the PM's communication with the Runway Controller and did not know that clearance had not been given to enter Runway 02C.
- 1.1.10 As TMG019 taxied past the holding point at Taxiway E11, the Microwave Barrier Detectors (MBDs) triggered an alert to the Runway Controller. At that moment, there was an aircraft on approach⁷ to land at about three nautical miles from touchdown which the flight crew of TMG019 were unaware of.
- 1.1.11 Upon being alerted, the Runway Controller instructed TMG019 to vacate the runway via Taxiway E10⁸. The PM acknowledged the instruction and TMG019 exited the runway via Taxiway E10.
- 1.1.12 After TMG019 exited and was clear of the runway, the Runway Controller cleared the aircraft on approach to land. The aircraft landed uneventfully. Subsequently, TMG019 was cleared for take-off. The rest of the flight was

⁴ According to the aircraft operator, the BTO Checklist must be completed prior to entering the runway.

⁵ These checking steps required the PM to look at the instrument areas and not outside the aircraft.

⁶ The holding point is demarcated by runway holding position marking painted on the ground. There are also red stop bar lights a short distance beyond the runway holding position marking. The red stop bar lights will be switched off by the ATC when clearance is given to enter the runway.

⁷ According to the Runway Controller, the plan was to hold TMG019 at the holding point at Taxiway E11 for the arrival aircraft to land.

⁸ The Runway Controller did not instruct the arriving aircraft to go around as he assessed that there was sufficient time for TMG019 to vacate the runway.

uneventful.

1.2 Injuries to persons

1.2.1 There was no injury to any person on board TMG019.

1.3 Damage to aircraft

1.3.1 TMG019 did not sustain any damage.

1.4 Personnel information

1.4.1 As mentioned in paragraph 1.1.1, the flight was the last of six sectors that the flight crew had been rostered to operate. All the flying times in paragraphs 1.4.2 to 1.4.4 are with respect to the time before the start of the first flight sector.

1.4.2 Captain 1

Role	Pilot Flying (PF)
Age	37
Gender	Male
Nationality	Indonesian
Licence Type	Airline Transport Pilot Licence (ATPL)
Aircraft rating	B737
Medical certificate date	Valid until 31 January 2021
Last base check	11 July 2020
Last line check	11 November 2020
Duty time before incident	12 h 50 min
Total flying time	5,662 h 5 min
Total flying on this type	1,576 h 6 min
Flying time in last 90 days	127 h 42 min
Flying time in last 28 days	83 h 35 min
Flying time in last 24 hours	Nil
Rest period before start of flight duty	21 h 10 min

1.4.3 First Officer (FO)

Role	Pilot Monitoring (PM)
Age	26
Gender	Male
Nationality	Indonesian

Licence Type	Commercial Pilot Licence (CPL)
Aircraft rating	B737
Medical certificate date	Valid till 15 December 2020
Last base check	15 November 2020
Last line check	3 June 2020
Duty time before incident	6 h 30 min
Total flying time	742 h 20 min
Total flying on this type	591 h 55 min
Flying time in last 90 days	245 h 10 min
Flying time in last 28 days	87 h 25 min
Flying time in last 24 hours	Nil
Rest period before start of flight duty	24 h

1.4.4 Captain 2

Role	AFCM (No duty assigned during the incident sector)
Age	34
Gender	Male
Nationality	Indonesian
Licence Type	Airline Transport Pilot Licence (ATPL)
Aircraft rating	B737
Medical certificate date	Valid till 23 May 2021
Last base check	9 November 2020
Last line check	19 November 2020
Duty time before incident	13 h 25 min
Total flying time	7,811 h
Total flying on this type	7,717 h 19 min
Flying time in last 90 days	246 h 55 min
Flying time in last 28 days	73 h 50 min
Flying time in last 24 hours	Nil
Rest period before start of flight duty	24 h

1.4.5 Runway Controller

Age	30
Gender	Male
Working Experience	2.5 years
License/Rating/	Valid air traffic control licence with a single rating on Changi Aerodrome.
Last proficiency check	September 2020

1.5 Aircraft information

1.5.1 Aircraft defects

1.5.1.1 There were no technical issues with TMG019 reported since the start of the series of six sectors.

1.5.2 Seats available on aircraft

1.5.2.1 The cockpit has two pilot seats and two observer seats. There is a two-man seat at Door 1 Left outside the cockpit. During the taxi, the seating arrangement of the six people on board was as follows (see **Figure 3**):

- (a) PF was in the left pilot seat and PM was in the right pilot seat.
- (b) The AFCM was seated at the observer seat behind the control stand. The FOO was seated at the observer seat to the left of AFCM and behind the PF.
- (c) The Flight Engineer and the Mechanic were seated at the two-man seat⁹ at Door 1 Left.



Figure 3: Aircraft seating arrangement

1.5.3 Before Take-off (BTO) Checklist

1.5.3.1 According to the flight crew, they would typically cross-check with each other on whether take-off/line-up clearance had been obtained before lining up on the runway for departure. This was part of their training as stipulated in the aircraft manufacturer's Flight Crew Training Manual (FCTM). This cross-checking of clearances was not included as a checklist item in the aircraft operator's BTO Checklist. The PM is responsible for reading out the checklist as specified in the aircraft operator's operation manual (see 1.10.4) and for

⁹ The two-man seat is not considered a passenger seat by the State of the Operator.

remembering to carry out the memory items¹⁰.

1.5.3.2 The aircraft operator was using the aircraft manufacturer's BTO Checklist, which comprised two check items: (1) "Flaps" and (2) "Stabiliser trim"¹¹.

1.5.3.3 According to the aircraft manufacturer:

(a) The execution of a checklist requires one pilot to read out the check items in the checklist and the other pilot to perform the items in the checklist. After completion of the checklist, the pilot reading the checklist calls out, "___ CHECKLIST COMPLETE". For example, the BTO Checklist will be called for by the PF, read by the PM and responded by the PF. Both pilots visually verify that each item is in the required configuration or that a required step is taken.

(b) The BTO Checklist has only the minimum items needed to operate the aircraft safely. The cross-checking of clearances, which is considered basic airmanship, is not included in the checklist. The aircraft manufacturer leaves it to aircraft operators to decide what other items to add to the checklist to suit their operations.

(c) The BTO Checklist is meant to be completed before entering the runway to avoid high workload period such as taking off from a runway.

1.6 Meteorological information

1.6.1 On the day of the occurrence, while there was rain over Changi Airport, the Runway Visual Range at Runway 02C was above 2,000m¹².

1.7 Communications

1.7.1 There were no reported communication issues between TMG019 and ATC.

1.7.2 From the time TMG019 switched to the runway frequency until the runway incursion, there were no radio transmissions between the Runway Controller and any other aircraft over the runway frequency.

¹⁰ Items that need to be checked but are not included in a checklist are termed memory items. Checking that clearance has been obtained prior to entering a runway is one such example.

¹¹ "Flaps" refers to the setting of the trailing edge flaps indicated on the centre instrument panel. "Stabiliser trim" refers to the aircraft trim setting scale found beside the stabiliser trim wheel of the control stand.

¹² The measured visibility of the runway was fluctuating between 5000m and 8000m between 0736LT and 0750LT.

1.8 Aerodrome information

1.8.1 All taxiways leading into a runway have each in place a holding point. The holding point has the following features (see **Figure 4**) as visual aids to prevent runway incursions:

- (a) There are runway holding position marking and mandatory instruction marking on the ground across the taxiway.
- (b) There are red stop bar lights embedded on the ground at the runway holding position marking.
- (c) There are runway guard lights on each side of the taxiway.
- (d) There is enhanced centre taxiway centreline marking to visually warn flight crew that the aircraft is approaching the runway holding position marking and should be prepared to stop unless the aircraft has been cleared to enter the runway.
- (e) The MBDs are positioned a short distance beyond the red stop bar lights and runway holding position marking.

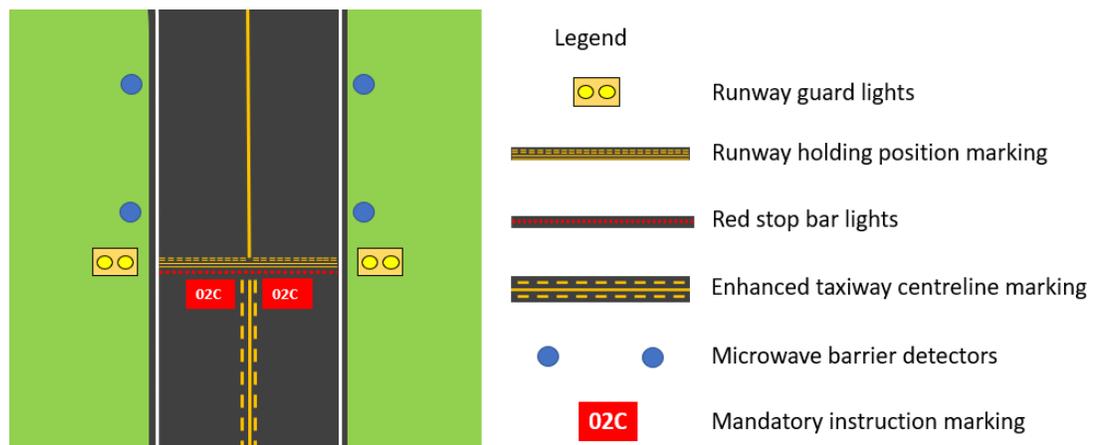


Figure 4: A typical holding position (*not to scale*)

1.8.2 The red stop bar lights and MBDs are connected, i.e. when the red stop bar lights are switched 'On', the MBDs are active and vice versa. When the MBDs are active and an aircraft or vehicle passes the holding point while the stop bar lights are illuminated, the Runway Controller will be alerted. The status of the stop bar lights and MBD alert signals are shown on a control display panel installed in the control tower. This is part of the Airfield Ground Lighting Control and Monitoring System. When a clearance to enter the runway is given, the

Runway Controller will switch off the red stop bar lights¹³ which automatically deactivates the MBDs.

1.8.3 In this incident, the red stop bar lights and runway guard lights were illuminated, the MBDs were active, and all the markings at the holding position were visible. There were no reported faults as regards the red stop bar lights and MBDs.

1.9 Flight recorders

1.9.1 TMG019's flight data recorder was available for readout and contained information pertaining to the occurrence.

1.9.2 The recordings in the TMG019's cockpit voice recorder pertaining to the occurrence were overwritten.

1.10 Additional information

1.10.1 Crew roster and duty/flight time

1.10.1.1 The incident flight was the last of a series of six sectors the flight crew were rostered to operate. The operator did not assign the roles of PF, PM, and ACFM for each sector in the roster. The roles assignment was left to the flight crew to decide amongst themselves.

1.10.1.2 The flight crew reported for duty at HLP at 1005 UTC on 27 November 2020 and completed their duty after the six-sector flight at 0140 UTC on 28 November 2020 (i.e. 15 hrs 35 mins). For the six-sector flight, the total flight time was 7 hours 50 minutes and the total duty time was 15 hours 35 minutes. The flight schedule of the six sectors and the roles performed by each flight crew member (i.e. PF, PM and ACFM) are shown in **Table 1** below.

Sector*	Departure time in UTC (JKT)**	Arrival time in UTC (JKT)	Flight time ¹⁴	Reporting time for flight duty in UTC (JKT)	PF	PM	ACFM
HLP-PKU	1115 (1815)	1235 (1935)	1 h 20 min	1005 (1705)	Captain 2	FO	Captain 1
PKU-KNO	1345 (2045)	1430 (2130)	0 h 45 min	-	FO	Captain 2	Captain 1

¹³ The red stop bar lights will be switched on automatically after a certain time interval after the passage of an aircraft or vehicle.

¹⁴ According to the aircraft operator, flight time is the time period from the moment chocks are removed from the aircraft for pushback to the next moment the chocks are placed to prevent the aircraft from moving after arrival.

Sector*	Departure time in UTC (JKT)**	Arrival time in UTC (JKT)	Flight time ¹⁴	Reporting time for flight duty in UTC (JKT)	PF	PM	AFCM
KNO-SIN	1610 (2310)	1710 (0010 on 28 November 2020)	1 h 0 min	-	Captain 2	FO	Captain 1
SIN-SGN	1750 (0050)	1925 (0225)	1 h 45 min	-	Captain 1	Captain 2	FO
SGN-SIN	2025 (0325)	2205 (0505)	1 h 40 min	-	Captain 1	FO	Captain 2
SIN-HLP	2345 (0645)	0105 (0805)	1 h 20 min	0140 (0840)	Captain 1	FO	Captain 2
Total:			7 h 50 min	15 h 35 min			

* HLP = Jakarta (Halim Perdanakusuma Airport)
 PKU = Pekanbaru (Sultan Syarif Kasim II Airport)
 KNO = Medan (Kualanamu Airport)
 SIN = Singapore (Changi Airport)
 SGN = Ho Chi Minh (Tan Son Nhat Airport)

** JKT = Jakarta time

Table 1: Flight schedule and flight duties

- 1.10.1.3 According to the flight crew, they had adequate rest prior to the start of the six-sector flight duty.
- 1.10.2 Duty time¹⁵ and flight time limitations for flight crew
- 1.10.2.1 **Table 2** shows the maximum duty times and flight times for flight crew set by the State of the Operator's regulations for a flight duty (regardless of whether the flight consists of a single or multiple sectors):

Basic number of flight crew members	Number of AFCM	Within any 24 consecutive hours	
		Maximum duty time (hours)	Maximum flight time (hours)
2	Nil	14	9
2	1	16	12

¹⁵ Duty time means the time period from the moment the flight crew report for the start of their flight duty to the next moment they are released from the flight duty.

Table 2: Maximum duty times and flight times

- 1.10.2.2 In addition to requiring an AFCM, the regulations have also the following conditions, amongst others, for the extension of the maximum duty time:
- (a) The AFCM occupies an observer seat in the cockpit during take-off and landing;
 - (b) A passenger seat is available for a pilot in the role of AFCM, when he or she is not required to be in the cockpit, to rest in; and
 - (c) The maximum flight time within any 24 consecutive hours for any pilot is 12 hours.
- 1.10.2.3 According to ICAO guidance Document 9966 (Manual for the Oversight of Fatigue Management Approaches), researchers have found that the workload of pilot in fixed-wing operations increases with the number of sectors operated in a flight duty period. Document 9966 suggests that the number of sectors be a planning parameter when setting the maximum duty time.
- 1.10.2.4 The aircraft operator did not set a limit on the number of sectors that could be flown within the maximum duty time.
- 1.10.2.5 The regulations of the State of the Operator have included the number of sectors as a planning parameter for setting the maximum duty time for long haul flights but not for short haul flights with multiple sectors.
- 1.10.3 Resting arrangement in the aircraft
- 1.10.3.1 The aircraft operator did not have any guidance for the flight crew on how an AFCM may rest inflight when he or she is not required to be in the cockpit.
- 1.10.3.2 For the extension of the maximum duty time with an AFCM, the State of the Operator requires a passenger seat for a pilot in the role of AFCM to rest in when he or she is not required to be in the cockpit. The regulations of the State of the Operator do not define what a passenger seat is, but the investigation team has understood from the State of the Operator that none of the seats in TMG019 met the requirements of a passenger seat.
- 1.10.3.3 The aircraft operator issued sleeping bags to the pilots. For a flight with an AFCM, the pilot in the role of AFCM, when he or she is not required to be in the cockpit (i.e. during the period when the aircraft has ascended past 10,000ft after the take-off and before the aircraft has descended below 10,000ft for the landing), could choose to rest in a sleeping bag on the galley floor. However, there was no restraint system for the person resting in such a sleeping bag.

- 1.10.3.4 There is no evidence that the aircraft operator has been approved by the State of the Operator to substitute the required passenger seat with a sleeping bag, notwithstanding that some pilots do find that it is more comfortable to rest on the floor than to rest on the observer seat or the two-man seat.
- 1.10.4 Role and responsibilities of a Pilot Monitoring (PM)
 - 1.10.4.1 The aircraft operator's operation manual described the general role of the PM during the flight phase as follows:
 - (a) Checklist reading
 - (b) Communications
 - (c) Execution of tasks asked by the PF
 - (d) Monitoring of taxiing, flight path, airspeed, airplane configuration and navigation.
- 1.10.5 Role and responsibilities of an Augmented Flight Crew Member (AFCM)
 - 1.10.5.1 The aircraft operator's operations manual does not assign any duties for a pilot in the role of AFCM when occupying the flight deck observer seat. According to the aircraft operator, it expects a pilot in the role of AFCM to pay attention to the flight operation (including radio transmissions) and monitor the PF and PM's actions during take-off and landing. However, this is not documented. There is no evidence that its pilots are made aware of this expectation.
 - 1.10.5.2 Nonetheless, the PIC may assign duties to the pilot in the role of AFCM. For the six-sector flight, the PIC did not assign any duty to the pilot in the role of AFCM, including to himself when he was in the role of AFCM.
- 1.10.6 Crew Resource Management (CRM)
 - 1.10.6.1 The aircraft manufacturer's FCTM described Crew Resource Management (CRM) as the application of a team management concept and the effective use of all available resources to operate a flight safely. Situation awareness, which is emphasised as a good CRM practice, requires ongoing monitoring, communication, questioning, cross-checking, and refinement of perception. It is important that all flight crew members identify and communicate any situation that appears unsafe or out of the ordinary.
- 1.10.7 Aerodrome control
 - 1.10.7.1 At times it is useful to make the flight crew of aircraft aware of the departure sequence. Such information can help manage the flight crew's expectation as

to their turn for departure and can also be beneficial to the flight crew in terms of situation awareness (e.g. which other aircraft are taxiing or taking off and how many aircraft are ahead waiting for departure).

1.10.7.2 The ATC service provider at Singapore Changi Airport will normally not provide unnecessary information to flight crew in order to minimise the chance of a miscommunication with them. However, the ATC service provider does practise providing the expected sequence of departure as additional information to flight crew when:

- (a) there are two taxiways leading to the same runway and two aircraft are reaching the two holding positions of the runway at about the same time;
- (b) allowing an aircraft to depart on a runway between two arrival aircraft landings on the same runway; and
- (c) there is a need to manage the expectation of a departure aircraft that has to wait for multiple arrival aircraft landings on a runway.

2 ANALYSIS

The investigation looked into the following:

- (a) Cause of the runway incursion
- (b) Flight crew rostering
- (c) Resting arrangement in the aircraft
- (d) Crew resource management
- (e) Standard operating procedures
- (f) Duty time limitation
- (g) ATC apprising departing flight crews of the departure sequence

2.1 Cause of the runway incursion

2.1.1 The aerodrome has a number of safety defences to prevent runway incursion at Taxiway E11:

- Clear indications of the runway holding position (where an aircraft should wait if there is no ATC clearance to enter the runway) in the form of (1) enhanced taxiway centreline marking just before the runway holding position marking, and (2) a pair of guard lights on either side of the runway holding position marking
- Red stop bar lights that will be switched off by the Runway Controller after the clearance to enter the runway is given
- Need for ATC clearance to enter the runway

Despite these defences, the PF taxied TMG019 into Runway 02C.

2.1.2 On the part of the PF, he did not notice the red stop bar lights nor the runway guard lights. He did not wait for the PM to announce to him that the BTO Checklist was completed before entering the runway. He did not call for, or wait for the PM to call for, the cross-checking of ATC clearance for entering the runway which was required by the aircraft operator's operations manual as a memory item.

2.1.3 On the part of the PM, after receiving the Runway Controller's clearance, he did not communicate clearly to the PF that they had to hold TMG019 at the

runway holding point. The PM assumed that the PF knew that there was no clearance to enter the runway. The PM did not expect the PF to taxi TMG019 past the holding point at Taxiway E11 when he had yet to announce the completion of the BTO Checklist. The PM appeared to have been in no rush to complete the checklist as the clearance to enter the runway was not yet given. Had he completed the checklist earlier, he would have been in a position to monitor the PF's actions and to warn the PF about the runway guard lights as well as the status of the ATC clearance and the red stop bar lights.

2.1.4 The investigation team suspects that the PF and PM might have suffered from some degree of tiredness, considering that they had been on duty for more than 13 hours at the time of the incident and that the PM had had a rest of only about 1 hour 45 minutes during the previous five sectors.

2.2 Flight crew rostering

2.2.1 The aircraft operator's flight schedule did not allocate the roles of the PF, PM and AFCM to the flight crew. The flight crew decided among themselves on how to share the PF/PM/AFCM duties for the six sectors.

2.2.2 This resulted in an arrangement whereby Captain 1 and Captain 2 each operated three sectors and rested on three sectors, whereas the FO operated five sectors and only rested on one sector. This imbalance in rostering also resulted in the FO having had the least rest (only about 1 hour 45 minutes).

2.2.3 It may be desirable for a rostering system to allocate flight duties and rest periods more equitably to ensure that no flight crew member will be overly tired.

2.3 Resting arrangement in the aircraft

2.3.1 According to the State of the Operator's regulations, one of the conditions for the extension of maximum duty time with an AFCM is the availability of a passenger seat for the pilot in the role of AFCM, when not required to be in the cockpit, to rest in. However, there was no passenger seat on TMG019. Instead, sleeping bags were issued by the aircraft operator to the pilots so that they could rest in them on the galley floor.

2.3.2 While some pilots do find that it is more comfortable to rest on the floor than to rest on the observer seat or the two-man seat, the investigation team believes that the practice of resting on the galley floor is not safe as there is no restraint system of any form to mitigate the likelihood of injuries during an air turbulence. The aircraft operator ought to review the appropriateness of its practice of allowing its flight crew to rest in a sleeping bag on the galley floor.

2.3.3 There is no evidence that this resting arrangement was acceptable to the State of the Operator. It would be desirable for the State of the Operator to review the appropriateness of the aircraft operator's practice of allowing its flight crew to rest in a sleeping bag on the galley floor.

2.4 Crew resource management

2.4.1 A good CRM practice is the emphasis of situational awareness among the crew members. It is important that all flight crew members identify and communicate any situation that appears unsafe or out of the ordinary. In this respect, the role of the PM is important in monitoring and cross-checking what the other flight crew member is doing, as well as adhering to recommended callouts to ensure shared crew situational awareness.

2.4.2 There were instances in this incident where the flight crew's performance in terms of CRM had not been optimal:

- (a) After receiving the Runway Controller's clearance, the PM did not communicate clearly to the PF that they had to hold TMG019 at the runway holding point at Taxiway E11. The PF, who did not pay attention to the PM's radio communication with the ATC although he should have been monitoring such radio communication, assumed that there was clearance to enter runway and did not elicit a confirmation from the PM.
- (b) The AFCM was not assigned any duty in the cockpit. Thus, a valuable crew resource went unutilised. Notwithstanding the fact that he was not assigned a duty role, he could have helped monitor the actions of the PF and PM, listen in to the radio communication with the ATC, and intervene as necessary.
- (c) The execution of a checklist requires one pilot to read out the check items in the checklist and the other pilot to perform the items in the checklist. The PF called for the PM to carry out the BTO Checklist but did not wait for him to announce "Checklist completed". Given that the checklist consisted of only two check items, he should have expected the PM not to take too much time to report "Checklist completed" or should prompt the PM of the status of his checklist execution before crossing the runway holding point at Taxiway E11.
- (d) The PF and PM did not conduct a cross-checking regarding ATC clearance to enter the runway as required by the FCTM.

- 2.5 Standard operating procedures
 - 2.5.1 The aircraft operator adopted the BTO Checklist of the aircraft manufacturer, which consisted of only two check items. The aircraft manufacturer left it to aircraft operators to expand the checklist as necessary. The aircraft operator did not expand the checklist.
 - 2.5.2 The cross-checking on whether clearance had been obtained before entering the runway is a memory item. Relying on memory to initiate an important action is not ideal, as there is a possibility for one's memory to fail. While there is no evidence that this aspect is a contributing factor to this incident, the investigation team is aware that some other operators have included such memory items in the BTO Checklist. It is desirable that the aircraft operator consider minimising the flight crew's reliance on memory when it comes to important tasks that they have to carry out.
 - 2.5.3 As regards the role of the AFCM and as mentioned in 2.4.2(b), the AFCM was unutilised as a valuable crew resource in the cockpit. There is scope for the aircraft operator to consider a better utilisation of the AFCM and embody this in its standard operating procedures.
- 2.6 Duty time limitation
 - 2.6.1 The ICAO Document 9966 suggests that the number of sectors in a flight should be taken into consideration when setting the maximum duty time.
 - 2.6.2 There is no evidence that the aircraft operator has considered including the number of sectors to be flown in a flight as a planning parameter when setting the maximum duty time. The State of the Operator apparently also does not require the number of sectors for short haul flights to be considered by the aircraft operator in flight planning.
 - 2.6.3 Given that a flight crew's workload is usually the highest during take-off and landing and that a multi-sector flight, with the multiple take-offs and landings, would cause a higher level of tiredness for the flight crew, it appears that there is merit in factoring in the number of sectors when setting the maximum duty time.
- 2.7 ATC apprising departing flight crew of the departure sequence
 - 2.7.1 Aircraft traffic was low and the flight crew did not hear any transmissions over the runway frequency after they were transferred from the Ground Controller to the Runway Controller. This may have influenced the PF to believe that TMG019 was the only aircraft operating in the vicinity of the airport. This

absence of radio transmissions could lead to a reduced awareness and alertness on the part of the flight crew.

- 2.7.2 It may be useful if the ATC could provide additional information to make the flight crew of departing aircraft aware of arrival traffic. In this incident, it would have been useful to the flight crew of TMG019 if the Runway Controller had informed them that they were to expect departure after one landing. Such information can help manage the flight crew's expectation as to their turn for departure and can also be beneficial to the flight crew in terms of situation awareness.

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 was a result of the PF assuming that ATC clearance had been given for TMG019 to enter the runway. The PF did not notice that the red stop bar lights were illuminated, indicating that TMG019 was to stop at the holding point at Taxiway E11.
- 3.2 The investigation team suspects that the PF and PM might have suffered from some degree of tiredness, considering that they had been on duty for more than 13 hours at the time of the incident.
- 3.3 The aircraft operator's flight schedule did not allocate the roles of the PF, PM and AFCM to the flight crew. The flight crew decided among themselves on how to share the PF/PM/AFCM duties for the six sectors of the flight. This resulted in an arrangement whereby Captain 1 and Captain 2 operated three sectors and rest on three sectors, whereas the FO operated five sectors and rested on only one sector.
- 3.4 The aircraft operator did not include the cross-checking of line-up/take-off clearance in the BTO Checklist as the cross-checking was treated as a memory item. In this incident, the cross-checking for line-up clearance was not carried out by the flight crew.
- 3.5 There were a number of instances in this incident where the flight crew's performance in terms of CRM had not been optimal.
- 3.6 The AFCM was available as a crew resource in the cockpit. However, he was not assigned any duties.
- 3.7 The State of the Operator's regulations require the availability of a passenger seat as a condition for the extension of maximum duty time with an AFCM for the execution of the flight. However, there was no passenger seat in TMG019.
- 3.8 The aircraft operator issued sleeping bags to the flight crew members so that they could rest in them on the galley floor when they were not required to be in the cockpit. However, there was no restraint system for the person resting in such a sleeping bag and there was no evidence that this resting arrangement was acceptable to the State of the Operator.
- 3.9 In the determination of the maximum duty time, the aircraft operator did not include the number of sectors as a planning parameter. The State of the

Operator also did not have a requirement for the aircraft operator to include the number of sectors for short haul flights as a planning parameter when determining the duty time limits.

4 **SAFETY ACTIONS**

Arising from discussions with the investigation team, the (organisation(s)) has/have taken the following safety action.

- 4.1 The ATC service provider has conducted a safety briefing to all its controllers in August 2021, with discussions focusing on how ATC can provide information to improve pilots' awareness of traffic. The safety briefing also provided information on how human performance might be affected by very low traffic volume situations as a result of COVID-19 which pilots and air traffic controllers are unaccustomed to.

5 SAFETY RECOMMENDATIONS

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

5.1 The State of the Operator:

- (a) consider requiring its aircraft operators to include the number of sectors as a planning parameter when determining the maximum duty time for short haul flights [TSIB Recommendation RA-2021-003]; and
- (b) review the appropriateness of the aircraft operator's practice of allowing its flight crew to rest in a sleeping bag on the galley floor [TSIB Recommendation RA-2021-004].

5.2 The aircraft operator:

- (a) remind its flight crew to be alert when approaching the active runway and to never cross illuminated red stop bar lights without authorisation from the Air Traffic Control [TSIB Recommendation RA-2021-005];
- (b) assess the need to include in its Before Take-off Checklist a check item on line-up/take-off clearance before entering a runway [TSIB Recommendation RA-2021-006];
- (c) consider including the number of sectors as a planning parameter when determining the maximum duty time [TSIB Recommendation RA-2021-007];
- (d) review its practice of allowing its flight crew to rest in a sleeping bag on the galley floor [TSIB Recommendation RA-2021-008];
- (e) consider assigning duties to an augmented flight crew member to better utilise crew resource [TSIB Recommendation RA-2021-009]; and
- (f) review its flight crew rostering system with a view to ensuring a more even distribution of flight duties and rest period [TSIB Recommendation RA-2021-010].