

Final Report

Boeing 787-9 Registration HL-7209 Taxi Incident

24 February 2023

TIB/AAI/CAS.215

Transport Safety Investigation Bureau
Ministry of Transport
Singapore

21 September 2023

The Transport Safety Investigation Bureau of Singapore

The Transport Safety Investigation Bureau (TSIB) is the air, marine and rail accidents and incidents investigation authority in Singapore. Its mission is to promote transport safety through the conduct of independent investigations into air, marine and rail accidents and incidents.

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

The sole objective of TSIB's air safety investigations is the prevention of aviation accidents and incidents. The safety investigations do not seek to apportion blame or liability. Accordingly, TSIB reports should not be used to assign blame or determine liability.

Table of Contents

ABBREVIATIONS	iv
SYNOPSIS	1
1 Factual information	2
1.1 History of the flight	2
1.2 Injuries to persons	6
1.3 Damage to aircraft	6
1.4 Other damage	6
1.5 Personnel information	7
1.6 Meteorological information	8
1.7 Communication	8
1.8 Aerodrome information	8
1.9 Recorded data	10
1.10 Tests and research	11
2 Analysis	12
2.1 Flight crew's readback of ATC's taxi instruction	12
2.2 Recognising the marker board on Taxiway T	12
2.3 Familiarity with taxiway layout	13
2.4 Crew resource management (CRM)	13
3 Conclusions	15
4 Safety actions	16
5 Safety recommendation	17

ABBREVIATIONS

ATC	Air Traffic Control
CAAS	Civil Aviation Authority of Singapore
CCTV	Closed Circuit Television
CRM	Crew Resource Management
EAFR	Enhanced Airborne Flight Recorder
FO	First Officer
GMC	Ground Movement Controller
PIC	Pilot-In-Command
PF	Pilot Flying
PM	Pilot Monitoring
NOTAM	Notice to Airmen
UTC	Coordinated Universal Time

SYNOPSIS

On 24 February 2023, a B787-9 passenger aircraft was scheduled for departure from Runway 02R of Changi Airport, Singapore. While taxiing to Runway 02R, the aircraft taxied into a closed section of a taxiway. The aircraft's nose landing gear tyres hit and damaged a marker board of about 3m in length that demarcated the boundary of the taxiway closure area and came to a stop about 100m beyond the marker board. There was no injury and no damage to the aircraft other than some scuff marks on the nose landing gear tyres.

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

AIRCRAFT DETAILS

Aircraft type	:	Boeing 787-9
Operator	:	Korean Air
Aircraft registration	:	HL-7209
Numbers and type of engines	:	Two engines / GENX-1B74/75/P2
Engine hours/cycles since new	:	2,257 Flight Cycles since new
Date and time of incident	:	24 February 2023 / 11:02 Singapore Local Time
Location of occurrence	:	Changi Airport
Type of flight	:	Scheduled
Persons on board	:	273 (261 passengers, 2 pilots, 10 cabin Crew members)

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 24 February 2023, a B787-9 aircraft, parked at Bay G18 at Terminal 4 of Changi Airport, was scheduled for departure from Runway 02R. While travelling to the airport from the hotel, the flight crew, comprising a Pilot-in-Command (PIC) and a First Officer (FO), reviewed all Notices to Airmen¹ (NOTAMs) and concluded that there was no NOTAM applicable to taxiing the aircraft for their impending departure. At the aircraft, the PIC briefed the FO that the planned taxi route from Terminal 4 to Runway 02R would likely be via Taxiways U1, U3, S and T or via U1, R7, S and T, and then via K or J. They were satisfied that there was no NOTAM applicable to the planned taxi route.

1.1.2 After the completion of all pre-flight duties at 10:48:48, the aircraft was cleared for pushback onto Taxiway U1 by the Ground Movement Controller 2 (GMC2) on 121.725MHz. At 10:55:01, GMC2 cleared the aircraft to taxi via Taxiways U1, U3 and S, and to hold short of Taxiway T. The PIC was the Pilot Flying (PF) and was taxiing the aircraft and the FO the Pilot Monitoring (PM).

1.1.3 At 10:55:53 while the aircraft was taxiing along Taxiway U1, GMC2 cleared the aircraft to taxi via Taxiways S and T, and to hold short of Taxiway P5 (see **Figure 1**).

¹ According to Annex 15 to the Convention on International Civil Aviation, a NOTAM is a notice distributed by means of telecommunications containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.

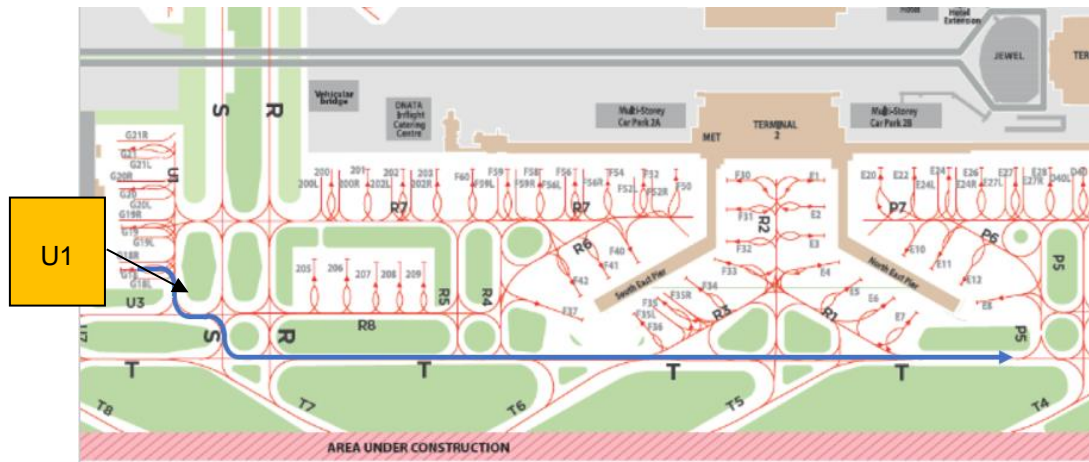


Figure 1: Taxi route from U1 to P5

- 1.1.4 At 10:59:08, while the aircraft was taxiing on Taxiway T, GMC2 informed the PM to contact the Ground Movement Controller 1 (GMC1) on 121.85 MHz and the PM did so. At 10:59:33, GMC1 instructed the PM to continue taxiing on Taxiway T and to hold short of Taxiway P3. GMC1 also informed the PM to expect to be number one to an aircraft that was on tow² on Taxiway P5 (Taxiway P5 was to the left of and perpendicular to Taxiway T and was about 900m away from the flight crew, see **Figure 2**). As the PM was unsure whether his aircraft was given priority to taxi on Taxiway T over the aircraft on tow, he queried GMC1 and GMC1 confirmed that his aircraft was number one to the aircraft on tow. At this point, the PF saw at a distance on Taxiway T what appeared to him faintly as a painted red and white marking on the ground and he continued to taxi the aircraft on Taxiway T. The PM also mentioned that he viewed the similar faint red and white marking and planned to verify it as the aircraft was getting closer to it.

² This means that the aircraft on tow would only be allowed to enter Taxiway T after the passage of the taxiing aircraft.

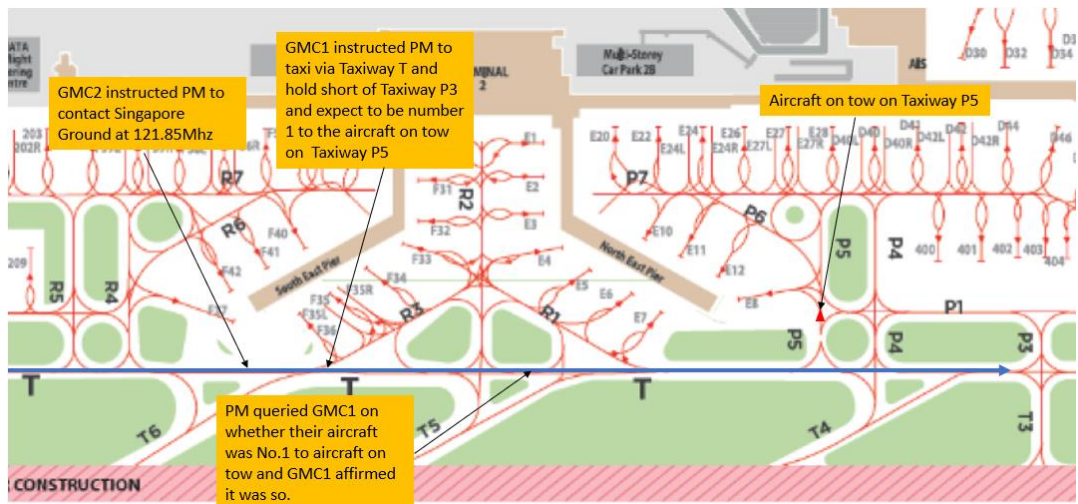


Figure 2: Updated taxi route after instruction by GMC1

- 1.1.5 At 11:01:23, when the aircraft was on Taxiway T approaching Taxiway P5, GMC1 instructed the aircraft to taxi via Taxiways P3³, P1⁴ and K, and to hold short of Taxiway K1 (see **Figure 3**). The PM read back the taxi instruction correctly. At this moment, according to the PF, he still could not recognise what the faint red and white marking was and he continued to taxi the aircraft forward.

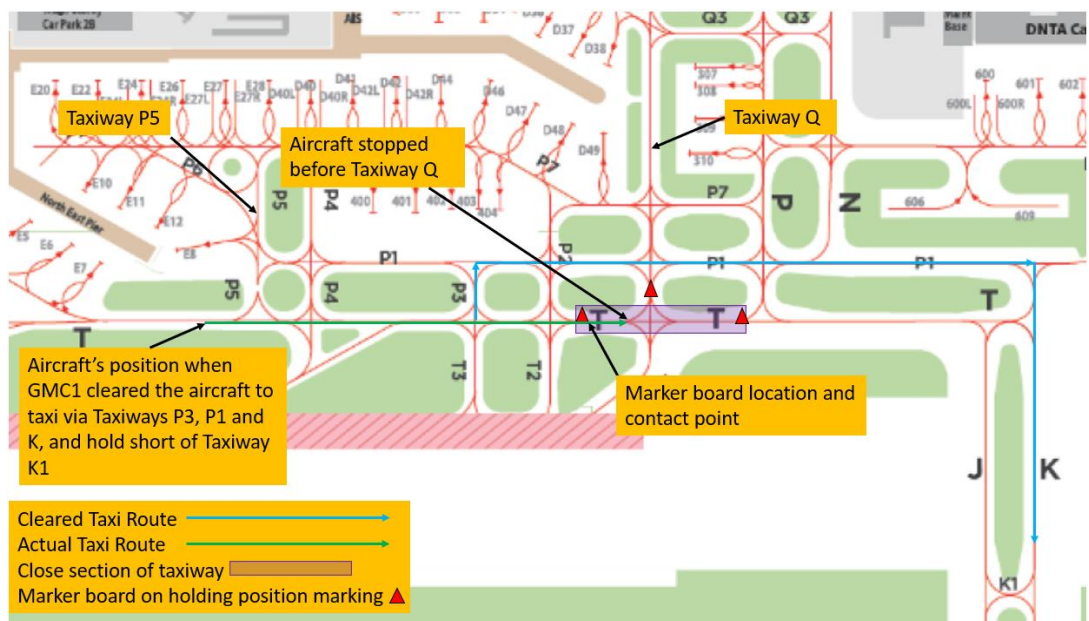


Figure 3: Remaining taxi route from P5

- 1.1.6 At the time of the PM's reading back to GMC1, the aircraft was

³ Taxiway P3 is perpendicular to Taxiway T and is about 400m away from Taxiway P5.

⁴ Taxiway P1 is parallel to Taxiway T. GMC1's taxi instruction would require the aircraft to turn left onto Taxiway P3 and then turn right onto Taxiway P1.

approaching the junction of Taxiways T and P5. According to the flight crew, they looked left momentarily at the aircraft on tow on Taxiway P5. When the PF turned his head back towards the front to continue taxiing the aircraft, he saw the red and white marking near the junction of Taxiways T and Q⁵ (Taxiway Q is about 700m from the junction of Taxiways T and P5) but still could not discern what it was.

- 1.1.7 According to the PM, he had observed that Taxiways P5, P4, P3 and P2 were all perpendicular to Taxiway T and he was expecting Taxiway P1 to be perpendicular to Taxiway T and located after Taxiway P2⁶. As the aircraft was proceeding on Taxiway T, he was looking out to the left for Taxiway P1.
- 1.1.8 The flight crew did not turn the aircraft onto Taxiway P3 as instructed by GMC 1 (see paragraph 1.1.5) and instead continued to taxi on Taxiway T towards Taxiway P2⁷. At 11:02:42 when the aircraft was taxiing past Taxiway P2, the PM noticed a marker board⁸ on the taxiway below the aircraft. He immediately told the PF to stop the aircraft. At the same time, GMC1 instructed the PM to stop when he saw the aircraft entering the closed section of Taxiway T between Taxiways P2 and P (see Figure 3). In response, the PF applied brakes to stop the aircraft. The aircraft eventually came to a stop on Taxiway T about 160m from the junction of Taxiways T and P2 and about 680m from the junction of Taxiways T and P5. The marker board was at about 100m away from the aircraft's stop position.
- 1.1.9 At 11:04:16, GMC1 informed the flight crew that they had entered the taxiway closure area. The PF replied that the instruction was to taxi via Taxiway T to Taxiway K. GMC1 repeated to the PF that the aircraft was instructed to taxi via Taxiways P3, P1 and K, and to hold short of K1⁹. GMC1 then queried the PF whether the flight crew had noticed any marker board along Taxiway T on their way to the current position, and the PF replied that they saw what looked like ground markings on Taxiway T in front of their aircraft. GMC1 further queried the PF whether

⁵ There was no marker board near the junction of Taxiway T and Q. The investigation team believed that the PF could be referring the red and white marking to the marker board placed either near the junction of Taxiways T and P2 or Taxiways T and P.

⁶ The sequence of taxiways perpendicular to Taxiway T from south to north in the area of concern is: Taxiways P5, P4, P3, P2, Q and P. According to the PM, he was trying to locate Taxiway P1 while referring to the Air Moving Map on the Navigation Display, the Jeppesen chart (an aerodrome layout map) on the portable tablet and the view outside of the aircraft.

⁷ The junction of Taxiways T and P2 is about 500m away from the junction of Taxiways T and P5.

⁸ At this point, the PM realised that it was an object and not a marking. More on marker board in paragraph 1.1.8.2.

⁹ According to the PM, he recalled that GMC1's instruction (paragraph 1.1.5) was to taxi via Taxiways P1 and K, and to hold short of Taxiway K1. He did not recall hearing GMC1 mention Taxiway P3.

the flight crew had noticed any marker board at the junction of Taxiways T and P2, and the PF replied that, before reaching Taxiway P2, he saw a marker board¹⁰ at the junction of Taxiways T and P2. Thereafter, GMC1 sent an inspection team to assess the situation and the team informed GMC1 that the marker board was damaged by the nose wheels of the aircraft.

1.2 Injuries to persons

1.2.1 There were no injuries to any persons.

1.3 Damage to aircraft

1.3.1 There were scuff marks on the nose wheels (see **Figure 4**) as well as red paint marks from the marker board placed near the junction of Taxiways T and P2.



Figure 4: Damage on each nose wheel

1.4 Other damage

1.4.1 The marker board near the junction of Taxiways T and P2 was broken owing to the impact with the aircraft's nose wheels (see **Figure 5**).

¹⁰ While the PF's reply to GMC1 that he saw a marker board, the PF described to the investigation team that he viewed the marker board as a ground marking and did not recognise the significance of it.



Figure 5: The damaged marker board

1.5 Personnel information

1.5.1 PIC (the PF)

Age	49
Licence type	Airline Transport Pilot Licence
Issuing authority	Korea Transportation Safety Authority
Licence validity date	31 July 2023
Medical certificate	Class 1
Medical certificate validity	31 July 2023
Medical operational proviso	Must wear corrective glasses of lenses and have spare glasses on duty
Last Base Check date	7 October 2022
Last Line Check date	7 January 2023
Total flying hours	9,740
Aircraft types flown	A310/A300-600, B737, B747-400, B787, CE500/CE560
Total hours on B787 type	1,714 hours
Flying in last 90 days	200 hours
Flying in last 7 days	8 hours
Flying in last 24 hours	0 hour
Duty time in last 48 hours	0 hour (It was the first flight duty)
Rest period in last 48 hours	48 hours

1.5.2 FO (the PM)

Age	37
-----	----

Licence type	Commercial Pilot Licence
Issuing authority	Korea Transportation Safety Authority
Licence validity date	31 October 2023
Medical certificate	Class 1
Medical certificate validity	31 October 2023
Medical operational proviso	Nil
Last Base Check date	14 November 2022
Last Line Check date	29 April 2022
Total flying hours	727
Aircraft types flown	B737, B787, C525
Total hours on B787 type	243 hours
Flying in last 90 days	114 hours
Flying in last 7 days	8 hours
Flying in last 24 hours	0 hour
Duty time in last 48 hours	0 hour (It was the first flight duty)
Rest period in last 48 hours	48 hours

- 1.5.2.1 The PF's last flight into Singapore Changi Airport was about a year ago on another aircraft type. He had never taxied on the segment of Taxiway T involved in the incident.
- 1.5.2.2 The PM had not operated into Changi Airport before.
- 1.6 Meteorological information
- 1.6.1 There was no precipitation over the aerodrome and visibility was good.
- 1.7 Communication
- 1.7.1 There were no issues with radio communications between the flight crew and GMC1/GMC2.
- 1.8 Aerodrome information
- 1.8.1 Closed section of Taxiway T
- 1.8.1.1 The section of Taxiway T between Taxiways P and P2, including the junction of Taxiways T and Q/T1¹¹ (see **Figure 6**), was temporarily closed for taxiway guidance signage work. The closed section of Taxiway T was demarcated with marker boards and obstacle lights in accordance with the aerodrome operator's standard operating procedure. One marker board was placed on the taxiway centreline at the intermediate holding

¹¹ Taxiways Q and T1 are linked and are on opposite sides of Taxiway T.

position near the junction of Taxiways T and P2 to mark one end of the closed section and another marker board was placed on the taxiway centreline at the intermediate holding position near the junction of Taxiways T and P to mark the other end. Further, one marker board was placed on the taxiway centreline at the intermediate holding position near the junction of Taxiways T and Q to denote the closed section of Taxiway T.

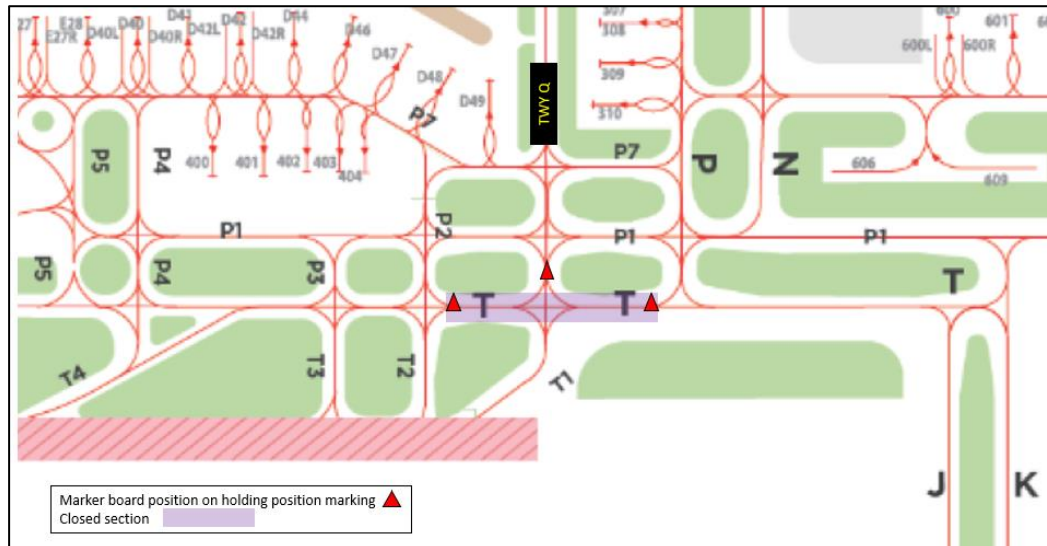


Figure 6: Locations of marker boards

1.8.1.2 NOTAM A0445/23 was published in the Singapore Aeronautical Information Publication on 16 February 2023 to inform all stakeholders about the taxiway closure for the period of 01:00 UTC (09:00 LT) to 09:00 UTC (17:00 LT) on 23, 24, and 27 February 2023. NOTAM A0445/23 was one of the flight documents which the flight crew reviewed prior to the pushback. The flight crew told the investigation team that they had misread the NOTAM's effectivity end time of 09:00 UTC as 09:00 LT.

1.8.2 Marker board

1.8.2.1 The marker board that was destroyed in the incident was about 3m long and 0.9m high¹² with alternate red and white stripes and was made up of two smaller parts placed side-by-side, each 1.5m in length. This type of marker board has one obstacle light mounted on each end and is typically

¹² The marker board complies with the requirements of the Manual of Aerodrome Standards (MOAS) of the Civil Aviation Authority of Singapore (CAAS) which has specified that a marker board should be at least 0.9m in length and 0.5m in height, with alternate red and white (or orange and white) vertical stripes. CAAS' MOAS is in line with the international standards set in Annex 14 to the Convention on International Civil Aviation.

used by the aerodrome operator to demarcate a closed section of a taxiway. **Figure 7** shows a typical marker board.



Figure 7: Typical marker board with an obstacle light on each end

1.8.2.2 **Figure 8** is a picture provided by the aerodrome operator which shows the marker board placed near the junction of Taxiways T and P2 before the incident.



Figure 8: The marker board near the junction of Taxiways T and P2 before the incident

1.9 Recorded data

1.9.1 Flight recorders

1.9.1.1 The aircraft was equipped with two Enhanced Airborne Flight Recorders (EAFRs) manufactured by GE Aviation, which can each record cockpit voices for a minimum of two hours and flight data for a minimum of 25 hours. Both EAFRs were available for readout by the investigation team. The reading out of the recorders was successful.

1.9.1.2 The cockpit voice recording of the taxiing event from the time of aircraft pushback to the time of aircraft contacting the marker board and stopping was overwritten. However, the cockpit voice recording had captured the

post-incident conversation between the flight crew which indicated the following:

- (a) The PF's understanding was to taxi the aircraft via Taxiway T and then to Taxiway K.
- (b) The PM's understanding was to taxi the aircraft via Taxiways P1 and K, and to hold short of Taxiway K1.

1.9.2 Air Traffic Control (ATC) recordings

1.9.2.1 The Air Surface Movement Ground Control System recording and Air Traffic Control (ATC) voice recording of the incident were obtained from the Air Traffic Service provider.

1.9.3 Closed Circuit Television (CCTV) recording

1.9.3.1 The recording of the CCTV of the aerodrome operator showed that the marker board was run over by the aircraft.

1.10 Tests and research

1.10.1 To assess what the flight crew could see from the cockpit, a simulation trial was carried out involving placing marker boards on a taxiway at different distances from a similar B787 aircraft. The conclusion of the trial was that the red/white colour of the marker board could be seen from the cockpit at a distance of about 580m, which was the distance between Taxiway P5 and Taxiway P2.

2 ANALYSIS

The investigation looked into the following:

- (a) Flight crew's readback of ATC's taxi instruction
- (b) Recognising the marker board on Taxiway T
- (c) Familiarity with taxiway layout
- (d) Crew resource management

2.1 Flight crew's readback of ATC's taxi instruction

2.1.1 As mentioned in paragraph 1.1.5, when the aircraft was near the junction of Taxiways T and P5, GMC1 instructed the aircraft to taxi via Taxiways P3, P1 and K, and to hold short of Taxiway K1. While the PM had read back GMC1's taxi instruction correctly, without the information from the CVR, the investigation team is unable to ascertain if the PM had registered the taxi instruction correctly and informed the PF accordingly. As mentioned in paragraph 1.9.1.2(a), on the one hand, the PF's understanding was to taxi the aircraft direct to Taxiway K from Taxiway T. On the other hand, as indicated in 1.9.1.2(b) the PM's understanding was to taxi the aircraft to Taxiway K via Taxiway P1.

2.1.2 The investigation team is inclined to believe that, while the PM had read back GMC1's taxi instruction correctly, he did not register GMC1's taxi instruction as regards the use of Taxiway P3 to reach Taxiway P1. This is evident from the flight crew not turning the aircraft left onto Taxiway P3, and not realising that they had missed the turn onto Taxiway P3.

2.2 Recognising the marker board on Taxiway T

2.2.1 In the simulation trial conducted by the investigation team, it was determined that a marker board would be discernible from a distance of 580m and would become more conspicuous as one got closer to the marker board. The investigation team tried to understand why the flight crew had missed recognising the marker boards placed on Taxiway T between the junctions of Taxiway T and Taxiway P2 and Taxiway T and Taxiway P.

2.2.2 During the post event conversations between the pilots captured in the CVR, the investigation team noted that the PF indicated that his understanding of the

taxi instruction was to taxi to Taxiway K from Taxiway T. It is plausible that the PF had been biased in the interpretation of the taxi instruction and did not expect the red and white marking that he saw was the demarcation of the closed section of Taxiway T.

2.2.3 On the part of the PM, he only saw the marker board at the junction of Taxiways T and P2 just as the aircraft was approaching it. The investigation team could only surmise that the PM could have been focused on locating Taxiway P1, which he believed to be perpendicular to Taxiway T, and lost situation awareness and missed seeing the marker board.

2.3 Familiarity with taxiway layout

2.3.1 The taxiways perpendicular to Taxiway T along the direction of the aircraft taxi route near the area of concern were Taxiways P5, P4, P3, P2 and Q. As mentioned in 1.1.7, the PM was expecting Taxiway P1 to be also perpendicular to Taxiway T after Taxiway P2 and was attempting to locate Taxiway P1 by referring to the Air Moving Map on the Navigation Display, Jeppesen chart and by looking out of the aircraft during the taxi. However, he was not able to locate Taxiway P1 because Taxiway P1 is parallel to Taxiway T. While it is not illogical for the PM to expect that Taxiway P1 to be perpendicular to Taxiway T, a pilot should not rely just on expectation.

2.3.2 The flight crew had misread the NOTAM A0445/23's effectivity end time of 09:00 UTC as 09:00 LT for the closure of the section between Taxiway P2 and Taxiway P and had expected that the taxi route for the day to be direct from Taxiway T to Taxiway K. When the taxi instruction given by GMC1 was not as what the flight crew had expected, it is likely that they became confused and started to look out for the assigned taxi route, such as Taxiway P1.

2.3.3 The incident highlighted the importance of reading the NOTAM diligently and getting familiar with the taxi route before the commencement of taxiing aircraft. Nevertheless, when in doubt, the flight crew should have stopped the aircraft and checked with the ATC.

2.4 Crew resource management (CRM)

2.4.1 CRM is the application of a team management concept and the effective use of all available resources to operate a flight safely. It requires ongoing monitoring, communication, questioning, cross-checking, and refinement of

perception to ensure shared crew situational awareness. Thus, it is important that all flight crew members identify and communicate any situation that appears unsafe or out of the ordinary.

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

- (a) The PF was apparently trying to ascertain the red and white marking on the ground. Given that an alternate red and white colour code is a sign of danger, obstacle or unserviceability of something, one would expect the PF to enlist the help of the PM to resolve this uncertainty. But the PF did not do so.
- (b) The PM was unable to locate Taxiway P1 while consulting the Air Moving Map, Jeppesen chart and seeing outside of the aircraft. Given that it was important to be certain of the correct taxi route, one would expect the PM to alert the PF of his inability to identify Taxiway P1. However, the PM did not do so.

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 Both the PF and the PM misread the effectivity end time of NOTAM A0445/23. This had resulted in the flight crew missing information regarding the closure area along Taxiway T and expected a relatively straightforward taxi route from Taxiway T to Taxiway K.
- 3.2 The expectation of a straightforward taxi route had likely resulted in the flight crew not getting themselves to be familiar with other taxiways along Taxiway T. The PM was expecting Taxiway P1 to be perpendicular to Taxiway T (which was parallel to Taxiway T) and had difficulty in locating Taxiway P1.
- 3.3 Although the PM had read back correctly GMC1's taxi instruction of using Taxiways P3 and P1 to reach Taxiway K, the PM seemed to have missed the part on Taxiway P3 for the taxi instruction.
- 3.4 The PF had mistaken the red and white stripes of a marker board as a ground marking and did not recognise the significance of the red and white marking. This could be due to his preconceived belief that the taxi instruction was straightforward from Taxiway T to Taxiway K and thus missed recognising the marker board.
- 3.5 The PM had likely missed the marker board due to the distraction in locating Taxiway P1.
- 3.6 The flight crew's performance in term of crew resource management had not been optimal.

4 SAFETY ACTIONS

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

4.1 The aircraft operator has taken the following actions after the incident:

- (a) Issued a notice to the aircraft fleet about the incident.
- (b) Included the occurrence as a Discussion Agenda for its twice-a-year Flight Operation Division Safety Meeting which every pilot is required to attend.
- (c) Sent the incident flight crew for a CRM course with emphasis on communication, situational awareness, leadership and teamwork.
- (d) Included the incident as a case study on airmanship in the operator's advanced CRM course.

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.

In view of the safety actions taken by the aircraft operator, no safety recommendation is proposed.