FINAL REPORT

RUNWAY INCURSION INVOLVING B777 AND TWO DEPARTURES IN CHANGI AIRPORT 29 JUNE 2017

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Transport Safety Investigation Bureau
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The Transport Safety Investigation Bureau

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SYNOPSIS

On 29 June 2017, at about 1526LT, a runway incursion occurred at Runway 20C, Changi Airport, when two aircraft were allowed to take off while an arriving B777 aircraft remained at Rapid Exit Taxiway E6 after landing and was not clear of the runway holding position of Runway 20C[1].

The Transport Safety Investigation Bureau classified this occurrence as an incident and investigated this incident for learning safety lessons, even though it was assessed that there was no risk of collision as the B777 was already a distance away from the runway.

AIRCRAFT DETAILS

Aircraft type	: Boeing B777-300
Operator	: Singapore Airlines
Registration	: 9V-SYF
Number and type of engines	: 2 x Rolls Royce Trent 892 engines
Date and Time of occurrence	: 29 June 2017, 1526 hours (local)
Location of occurrence	: Singapore Changi Airport
Type of flight	: Scheduled Passenger
Persons on board	: 259

[1] The Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM, Doc 4444) issued by the International Civil Aviation Organisation defines a runway incursion as: "Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft."

1 FACTUAL INFORMATION

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

1.1 Sequence of events

1.1.1 In the afternoon of 29 June 2017, at about 1524LT, a B777 aircraft landed on Runway 20C in Changi Airport. After the aircraft had landed, the Runway Controller (RWC) instructed a departing A320 to line up on Runway 20C. The RWC then instructed the B777 to vacate the runway via Rapid Exit Taxiway E6 and South Cross 1 (SC1) and to contact the Ground Movement Controller (GMC) on frequency 124.3 MHz.

1.1.2 The RWC monitored the movement of the arriving B777. He saw that it had vacated the runway and was moving on E6. Assessing that the aircraft would soon be clear of the runway holding position marking while on E6[2], the RWC issued a departure clearance to the A320 that had lined up on the threshold of Runway 20C. He also cleared an A330 to line up behind the A320. **Figure 1** shows the positions of the three aircraft.

Figure 1. Positions of A320 and A330 as the B777 vacated Runway 20C

1.1.3 As the B777 was moving towards the runway holding position on E6 (see **Figure 2**), the aircraft's Pilot Monitoring (PM) called the GMC and reported, "Good afternoon, vacated runway for South Cross 1 (SC1)". Proceeding from E6 to SC1 would involve turning the aircraft about 50-60° to the right after the runway holding position on E6.

[2] Aircraft vacating a runway-in-use should not stop on a rapid exit taxiway until the entire aircraft has passed the runway holding position marking.

Figure 2. Holding Position at E6 and taxi route for B777

1.1.4 The Pilot Flying (PF) used the tiller to effectuate the turning. The PF felt that the aircraft was not responding to his tiller input. He applied more tiller input but this resulted in the aircraft turning more than the desired angle. Sensing that the steering control was lost, the PF stopped the aircraft on E6. The aircraft ended up with its nose pointing more or less in the direction of the Control Tower which was about 1,700m away (see **Figures 3** and **4**).

Figure 3. Nose of B777 facing the Control Tower

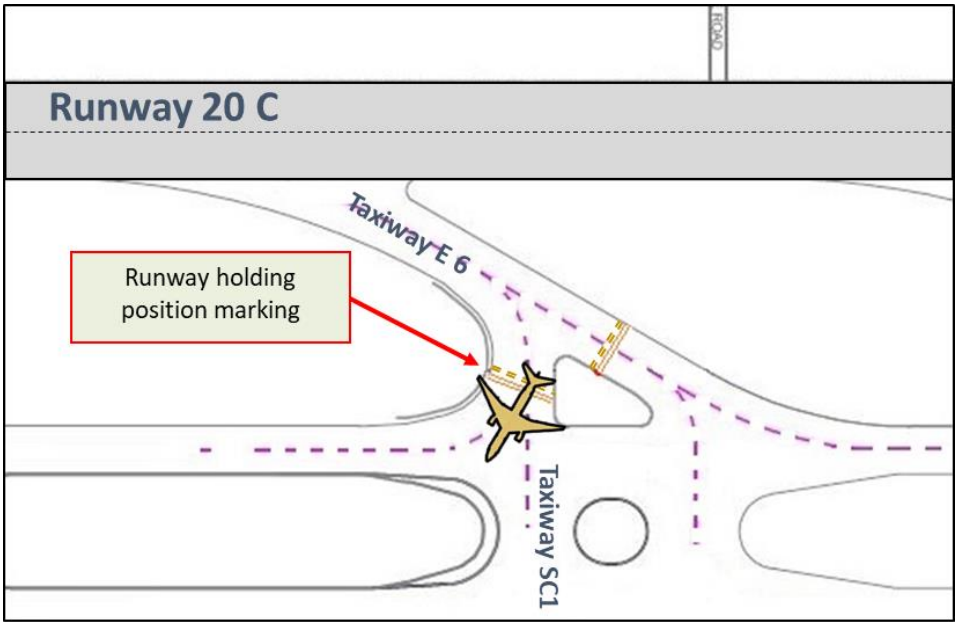

Figure 4. Orientation of B777 at E6

1.1.5 The flight crew informed the GMC that "we got problem with the aircraft", and that they would need to hold their position. At about 1525LT, the GMC made a general broadcast in the Control Tower to alert the other controllers that the B777 was holding its position on E6 due to a technical difficulty. The Tower Watch Manager (WM) heard the broadcast and he immediately alerted the Airport Emergency Service (AES) to stand by. He also called the aerodrome maintenance crew to proceed to the B777 to see if the aircraft needed any assistance[3]. Next, he made an assessment as to whether the aircraft was clear of the runway holding position marking. His quick look at the aircraft made him judge that it was so. Meanwhile, the departing A320 had already commenced its take-off roll.

1.1.6 The RWC also heard GMC's broadcast and observed that the departing A320 had already commenced its take-off roll. He let the A320 continue the take-off run as he assessed that there was sufficient distance separating the B777 and A320. The RWC had considered the option of instructing the A320 to abort the take-off run but assessed that this might entail unanticipated risk. The A320 departed at about 1526LT and the A330 commenced lining up on Runway 20C.

1.1.7 The RWC advised the A330 that there would be some delay to her clearance for take-off. He then asked the WM for his opinion as to whether the position of the B777 on E6 was a threat to the departing A330. The WM looked again at the B777 and again assessed that the aircraft was clear of the runway. He also looked again at the aircraft through a pair of binoculars and saw that the nose and main landing gears of the aircraft had crossed the runway holding

[3] The aerodrome maintenance crew arrived at the B777 at about the same time as Rover 39 (see paragraphs 1.1.8 and 1.1.9).

position marking and that parts of the marking were obscured by the shadow casted by the wings of the aircraft (see **Figure 5**). Nevertheless, he assessed that the B777 was clear of the A330 as the B777 appeared to him to have crossed the marking entirely. The WM indicated to the RWC that it would be all right for the A330 to take off and the RWC issued the take-off clearance for the A330. The A330 departed at about 1528LT.

Figure 5. Reconstructed picture to illustrate the view from the Control Tower of an aircraft vacating a rapid exit taxiway

1.1.8 While the A330 was rolling for take-off, the WM moved closer to the window at the Control Tower and looked at the B777 through the binoculars again. This time, for reason of prudence, he decided to suspend the runway operations on Runway 20C after the A330 departure, and requested for a ground maintenance vehicle, Rover 39 (R39), to proceed to the B777 to check for any fluid leaks from the aircraft and to ascertain whether the entire aircraft had crossed the holding position.

1.1.9 R39 arrived at E6 at about 1534LT and reported to the GMC that there was no fluid leak on the ground and that the tail end of the aircraft was not clear of the runway holding position marking on E6. Runway operations on Runway 20C was suspended until the B777 was towed clear of the runway holding position marking on E6, as arranged by the aerodrome maintenance crew.

1.2 Personnel information

1.2.1 B777 Pilot Monitoring (PM)

Age	60
Appointment	Commander
Qualification	Air Transport Pilot Licence
Total Flying Hours	7853.5 hours
Total Flying Hours on B777	2825.7 hours

1.2.2 B777 Pilot Flying (PF)

Age	46
Appointment	First Officer
Qualification	Air Transport Pilot Licence
Total Flying Hours	2963.3 hours
Total Flying Hours on B777	2963.3 hours

1.2.3 Watch Manager (WM)

Age	47
Qualifications	Licenced air traffic controller, holding Aerodrome Control (Changi) rating issued on 2 April 1994 by the Civil Aviation Authority of Singapore
Working hours	0800 – 1630 hours
Experience as Aerodrome Controller	23 years

1.2.4 Runway Controller (RWC)

Age	28
Qualifications	Licenced air traffic controller, holding Aerodrome Control (Changi) rating issued on 2 July 2016 by the Civil Aviation Authority of Singapore
Working hours	0800 – 1630 hours
Experience as Aerodrome Controller	12 months

1.2.5 Ground Movement Controller (GMC)

Age	28
Qualifications	Licenced air traffic controller, holding Aerodrome Control (Changi) rating issued on 7 November 2016 by the Civil Aviation Authority of Singapore
Working hours	0800 – 1630 hours
Experience as Aerodrome Controller	8 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) Recordings of the Airfield Ground Lighting Control and Monitoring System (AGLCMS), from the aerodrome operator

(c) Closed-circuit TV recordings of the area in the vicinity of E6, from the aerodrome operator

1.5 Aircraft information

1.5.1 The aircraft stuck on E6 was a -300 variant of the B777. The length of the aircraft was about 74m (see **Figure 6**). The distance between the nose wheel and the main undercarriage was about 31m. The wing span was about 61m.

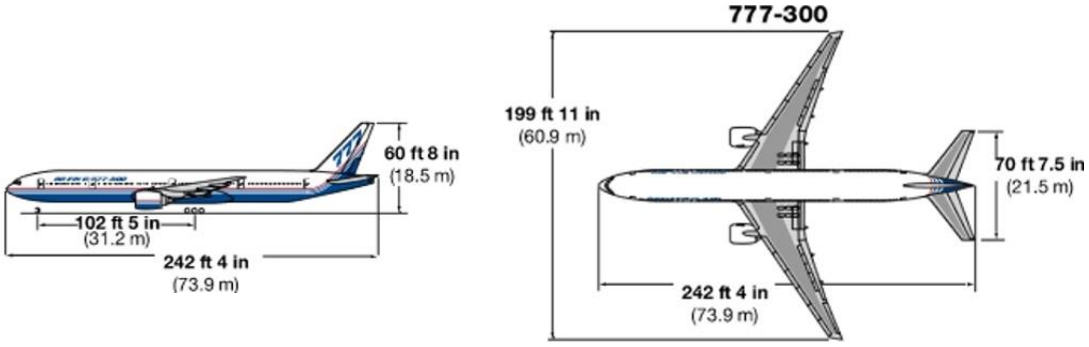

Figure 6. Dimensions of B777

1.5.2 A nose landing gear system functional test was carried out on the B777. The nose gear steering metering valve was found faulty.

1.6 Aerodrome information

1.6.1 The height of the Control Tower was about 81m above ground. The view of E6 from the Control Tower was not obstructed. The line of sight from the Control Tower to the B777 at E6 made an angle of about 3° with the horizontal.

1.6.2 The distance from Runway 20C centreline to the runway holding position marking at E6 was 145m. The minimum distance[4] for large aircraft like B777, A330 and A320 was 90m and for larger aircraft like B747 and A380 was 107.5m (see **Figure 7**).

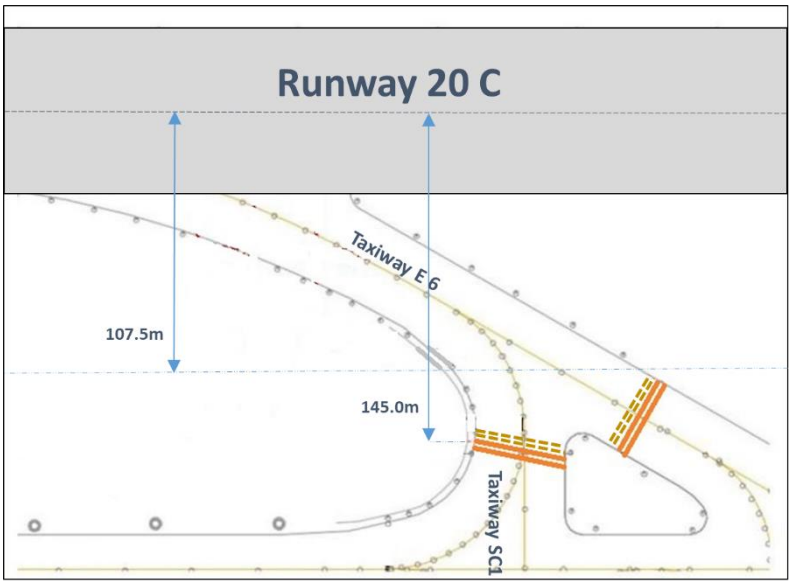

Figure 7. Distance from Runway 20C centreline to E6 runway holding position marking

[4] Paragraph 7.2.12.6 of CAAS Manual of Aerodrome Standards specified the minimum distance from the runway centreline to a runway holding position.

2 ANALYSIS

2.1 The investigation looked into the following:

(a) Flight crew's reporting of aircraft vacating runway
(b) RWC's decision to allow two aircraft to depart while B777 remained on E6
(c) WM's judgment that B777 was clear of runway holding position marking
(d) Air traffic service provider's guidelines for air traffic controllers

2.2 Flight crew's reporting of aircraft vacating runway

2.2.1 The B777 exited the runway from E6. The flight crew of the B777 had no intention to stop on E6. After all, as mentioned in Footnote 2 in paragraph 1.1.2, an aircraft was not expected to stop on E6, it being a rapid exit taxiway.

2.2.2 When the flight crew reported to the GMC "Good afternoon, vacated runway for South Cross 1", this was in anticipation of the aircraft's crossing the runway holding position marking in a moment. They would not know at that time that the aircraft's tiller would develop a technical problem.

2.2.3 This incident suggests that pilots might report having vacated a runway before they have actually crossed the critical reference line, in anticipation of their doing so. Nevertheless, it would be desirable for pilots to report having vacated a runway only when they are definite that their aircraft have moved completely past the runway holding position marking, rather than in anticipation of this.

2.3 RWC's decision to allow two aircraft to depart while B777 remained on E6

2.3.1 When the RWC heard GMC's broadcast that the B777 had stopped on E6, the A320 had already commenced its take-off roll. He let the A320 roll on to depart. His considerations were:

(a) There was sufficient distance separating the B777 and A320.

(b) Instructing the A320 to abort the take-off run might entail unanticipated risk.

2.3.2 However, the RWC was prudent in delaying giving clearance for the A330 to take off and in asking for a second opinion from the WM. He only gave the take-off clearance to the A330 after the WM also opined that the B777 was clear of the runway.

2.4 WM's judgment that B777 was clear of runway holding position marking

2.4.1 All together, the WM looked at the position of the B777 four times.

2.4.2 He had the first look, a quick one, after he had alerted the AES to stand by and requested for an aerodrome maintenance crew to proceed to the B777 to see if the aircraft needed assistance. He looked at it again and then a third time (this time with a pair of binoculars) after the RWC had asked for his opinion. He looked at it a fourth time while the A330 was rolling for take-off. Following this, he decided to suspend runway operations on Runway 20C and dispatched a ground maintenance vehicle to check out the situation on E6. It was then confirmed that the B777's tail end of the aircraft was not clear of the runway holding position marking on E6.

2.4.3 Had the B777's nose been pointing in the direction of the centreline of E6, it would not have been difficult for controllers in the Control Tower to decide whether the tail end of the aircraft had crossed the runway holding position marking. However, the aircraft had developed an unexpected problem with its tiller which resulted in the aircraft stopping at the runway holding position with its nose pointing more or less in the direction of the Control Tower, and this nose orientation was such that the nose and main landing gears of the aircraft could be seen as having crossed the runway holding position marking but that parts of the marking were obscured by the shadow casted by the wings of the aircraft. The Control Tower being at a distance of about 1,700m from the aircraft, it might not always be easy to judge whether the tail end of the aircraft was ahead, over or behind the runway holding position marking. This incident suggests that it would be useful to rope in a third party to go the aircraft if there is doubt, to ascertain the position of the aircraft relative to the runway holding position marking, as was done eventually.

2.4.4 Fortuitously, there was an extra margin of safety in the distance between the runway holding position on E6 and Runway 20C. The incomplete crossing by the B777 of the runway holding position marking on E6 did not entail a risk of collision with an aircraft rolling on Runway 20C.

2.5 Air traffic service provider's guidelines for air traffic controllers

2.5.1 The air traffic service provider (ATSP) would consider an aircraft exiting Runway 20C via E6 (or other rapid exit taxiways like E6) be clear of the runway only if the entire aircraft has crossed the runway holding position marking on E6.

2.5.2 This incident suggests that air traffic controllers could use, and have used, their discretion to give clearance for take-off on a runway like 20C in anticipation of an aircraft's complete crossing of the runway holding position marking on E6

(or similar rapid exit taxiways). To the extent that aircraft on a rapid exit taxiway like E6 are not expected to stop on the taxiway, such exercise of discretion could contribute to operating efficiency of an aerodrome, without necessarily incurring additional risk (as was the case here since there was an extra margin of safety in the distance between the runway holding position on E6 and Runway 20C). One has to bear in mind the dynamic environment that air traffic controllers function in. The tiller problem of the B777 that left it stranded on E6 was not expected. The RWC had to decide whether to instruct the A320 to abort its take-off roll. The WM had concerns for the B777 and the persons on board who may need help. They were mindful that the B777 had to be clear of Runway 20C if they were to allow runway operations on Runway 20C to continue. They needed to make quick decisions, using available visual cues and fix ground references (e.g. marker boards, markings, signage), and determine if the B777 would be clear of the runway.

2.5.3 Nevertheless, it would be desirable for the ATSP to review the practices of its air traffic controllers to decide whether it would continue to allow controllers to exercise such discretion or would prefer that controllers adhere strictly to the requirement that aircraft must have crossed completely the runway holding position marking before they could be considered clear of the runway.

2.5.4 This incident also demonstrates that the air traffic controller was aware that a third party could be roped in to go to the aircraft to check out the situation when there is doubt. However, this approach requires some time. Another option that may be considered is to install additional sensors and cameras, etc., that can help air traffic controllers check out the situation from the Control Tower expediently without involving a third party.

3 CONCLUSIONS

3.1 The runway incursion was a result of the B777 being stranded at Rapid Exit Taxiway E6, that is, not completely past the runway holding position marking when two aircraft (the A320 and A330) were allowed to take off from Runway 20C.

3.2 The incomplete crossing by the B777 of the runway holding position marking on E6 did not entail a risk of collision with an aircraft rolling on Runway 20C as there was an extra margin of safety in the distance between the runway holding position on E6 and Runway 20C.

3.3 This incident suggests that pilots might report having vacated a runway in anticipation of their aircraft's crossing of a rapid exit taxiway's runway holding position marking. Learning from this incident, it would be desirable for pilots to report having vacated a runway only when they are definite that their aircraft have moved completely past the runway holding position marking, rather than in anticipation of this, as mechanical failure might result in aircraft being stranded as was the case here.

3.4 The Runway Controller and Watch Manager's decision to allow the two aircraft to depart were based on their assessment of the position of the aircraft with reference to visual cues and fix ground references (e.g. marker boards, stop bar line, signage). This incident suggests that the existing set of visual cues and fix ground references may not always be enough for air traffic controllers to judge with complete definitiveness as to whether an aircraft is clear of a runway holding position and could be supplemented by verification with the assistance of a third party if there was doubt.

3.5 This incident shows that air traffic controllers would use their discretion to give clearance for take-off in anticipation of an arriving aircraft's complete crossing of a rapid exit taxiway's runway holding position marking. While in this case there was an extra margin of safety in the distance between the runway holding position on E6 and Runway 20C, it would be desirable for the ATSP to review the practices of air traffic controllers to exercise such discretion.

4 SAFETY ACTIONS

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

4.1 Air Traffic Service Provider

4.1.1 The air traffic service provider shared this incident and the following learning points with its controllers:

(a) Priority of safety over efficiency

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

(c) Use of fix ground references, e.g. signboards or runway guard lights, in making judgment as to whether an aircraft is clear of a runway

(d) Good understanding of the limitations of the equipment that they are handling

4.1.2 The air traffic service provider implemented, on 17 January 2018, an improvement to its Advanced-Surface Movement Guidance and Control System (ASMGCS) which consisted of adding a visual reference on the ASMGCS monitors to help air traffic controllers ascertain that there is enough separation between an aircraft departing on a runway and an arriving aircraft vacating the runway via a rapid exit taxiway.

4.2 Airline Operator

4.2.1 The airline operator had reminded, on 26 February 2018, all its pilots to ensure that the aircraft has passed the relevant runway holding position marking before reporting “runway vacated”.

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.

It is recommended that:

5.1 The air traffic service provider review its procedures to decide whether air traffic controllers could exercise their discretion to give clearance for take-off on a runway in anticipation of an arriving aircraft's complete crossing of the runway holding position marking on an associated rapid exit taxiway, or whether air traffic controllers must adhere strictly to the requirement that aircraft must have crossed completely the runway holding position before they can be considered clear of the runway. [TSIB Recommendation RA-2018-015]