

FINAL REPORT

BOEING B777, REGISTRATION 9V-SWH LOSS OF SEPARATION EVENT

3 JULY 2014

AIB/AAI/CAS.109

Air Accident Investigation Bureau of Singapore
Ministry of Transport
Singapore

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The Air Accident Investigation Bureau of Singapore

The Air Accident Investigation Bureau (AAIB) is the air accidents and incidents investigation authority in Singapore responsible to the Ministry of Transport. Its mission is to promote aviation safety through the conduct of independent and objective investigations into air accidents and incidents.

The AAIB conducts the 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.

In carrying out the investigations, the AAIB will adhere to ICAO's stated objective, which is as follows:

"The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability."

Accordingly, it is inappropriate that AAIB Reports should be used to assign fault or blame or determine liability, since neither the safety investigation nor the reporting process has been undertaken for that purpose.

CONTENTS

	Page
GLOSSARY OF ABBREVIATIONS	3
SYNOPSIS	4
1 FACTUAL INFORMATION	5
1.1 History of flight	5
1.2 'Climb Via SID' clearances	7
2 DISCUSSION	8
3 SAFETY ACTIONS	9
5 SAFETY RECOMMENDATIONS	10

GLOSSARY OF ABBREVIATIONS

ATC	:	Air Traffic Control
FAA	:	Federal Aviation Administration
FCOM	:	Flight Crew Operations Manual
FCTM	:	Flight Crew Training Manual
MCP	:	Mode Control Panel
PF	:	Pilot Flying
PM	:	Pilot Monitoring
RNAV	:	Area Navigation
SID	:	Standard Instrument Departure
TCAS	:	Traffic Alert and Collision Avoidance System

SYNOPSIS

On 3 July 2014 at 1815 hours (local time), a Boeing B777 aircraft departed Houston in Texas, USA via the INDIE ONE Standard Instrument Departure (SID). The INDIE ONE required the aircraft to maintain 4,000ft or other altitudes as assigned by ATC. However, after departure the B777 climbed above 4,000ft, thus conflicting with another aircraft which was descending to 6,000ft. An air traffic controller noticed the potential conflict and instructed the B777 to descend to 5,000ft. It was estimated that, at their closest, the aircraft were 0.61NM and 200ft apart.

The US National Transportation Safety Board (NTSB) did not formally investigate into the occurrence, which was regarded as a pilot deviation from an ATC clearance, but reviewed the circumstances with the Federal Aviation Administration (FAA) and provided information relating to this occurrence to the AAIB, including an initial report on the occurrence by FAA.

However, the AAIB regarded the occurrence as being significant enough to merit a report to highlight the safety lessons. The factual information in the report is largely based on the inputs of the NTSB, FAA and the operator.

AIRCRAFT DETAILS

Aircraft type:	Boeing B777-300ER
Operator:	Singapore Airlines
Registration:	9V-SWH
Numbers and type of engines:	2 x GE90-115B
Type of flight:	Scheduled passenger flight

1 FACTUAL INFORMATION

All times used in this report are Houston times. Houston time is five hours behind the Coordinated Universal Time (UTC).

1.1 History of the flight

1.1.1 On 3 July 2014, at 1812 hours, the crew of the Boeing 777 aircraft was preparing for a flight from the George Bush Intercontinental Airport in Houston in Texas, USA to Moscow. The flight crew comprised a Captain (C1), a Senior First Officer (SFO) and a second Captain (C2). The crew had earlier arrived in Houston from Moscow on 1 July 2014.

1.1.2 C1 was the pilot flying (PF) and the SFO the pilot monitoring (PM). The flight was to depart from runway 15L, and the ATC clearance given to the crew included the INDIE ONE RNAV¹ SID².

1.1.3 The PF conducted a departure briefing with the PM. C2 followed the briefing. The pilots each used a copy of a Jeppesen chart from their respective Electronic Flight Bag (EFB)³.

1.1.4 This was the first time the flight crew flew the INDIE ONE RNAV Departure and used the corresponding Jeppesen chart for the departure briefing.

1.1.5 According to the PF, after reading the first line in the 'Routing' section of the text box at the bottom left corner of the chart, he scrolled to the pictorial portion at the right of the chart and zoomed in to check on the track and distances. He ended his briefing on the chart without returning to the 'Routing' section of the chart, which contained an altitude restriction of 4,000ft (see **Figure 1**).

RWY	INITIAL CLIMB
8L/R, 9	Climb heading 087° to 600', EXPECT RADAR vectors to RENNK.
15L/R	Climb heading 149° to 600', EXPECT RADAR vectors to RENNK
26L/R, 27	Climb heading 267° to 600', EXPECT RADAR vectors to RENNK.
33L/R	Climb heading 329° to 600', EXPECT RADAR vectors to RENNK
ROUTING	
From RENNK on track 016° to COLET, then on track 025° to SUSHI, then on track 026° to INDIE, then on transition. MAINTAIN 4000' or as assigned by ATC. EXPECT filed altitude 10 minutes after departure.	

Figure 1: Published altitude restriction included in the SID route description

¹ Area Navigation (RNAV) is based on the use of GPS technology to fly a particular route.

² A Standard Instrument Departure Route (SID) is a pre-identified air traffic route whereby an aircraft may proceed from the take-off phase to the en-route phase.

³ EFB is an electronic information management device that helps flight crews perform flight management tasks with less paper.

- 1.1.6 The PF concluded to the PM and C2 that there were no altitude restrictions, and proceeded to set FL310 on the Mode Control Panel⁴ (MCP) altitude window (see **Figure 2**). FL310 was the flight plan's initial cruising altitude.



Figure 2: Altitude window on the MCP

- 1.1.7 In the interview by the airline operator, the flight crew stated that they expected some intermediate altitude to level off before being cleared to the final cruising altitude. The PF shared that when he did not see any intermediate altitude on the SID chart, he thought that it would be given to him by ATC later. His plan was to ask ATC for it if not volunteered by ATC. However, the PF did not communicate his 'plan to ask ATC' to the PM who could have reminded him to ask ATC later.
- 1.1.8 The PF then chose to set the final cruise altitude in the MCP which he stated in his interview as the 'next best thing as there was no other altitude to set'⁵.
- 1.1.9 Later, the PM obtained an ATC departure clearance to Moscow "via INDIE ONE RNAV Departure, TPAKK transition, climb via SID". ATC did not mention the altitude restriction of 4,000ft since it was already published in the SID route description. The PF, however, did not ask ATC regarding the initial altitude to climb to on departure.
- 1.1.10 After departure, the PM while making his initial contact with ATC reported "Singapore 61 take up heading of 020 passing 2,500ft". The PM did not report the altitude that the aircraft was climbing to.
- 1.1.11 At about 5,600ft when the aircraft was still climbing, the Traffic Alert and Collision Avoidance System⁶ (TCAS) generated a Traffic Advisory⁷ (TA) "Traffic, Traffic" aural alert⁸. Shortly after, the ATC instructed the aircraft to descend to 5,000ft in an urgent tone. The PF complied with the instruction by disconnecting the autopilot and

⁴ MCP provides control of the Autopilot, Flight Director, Altitude Alert and Autothrottle System. The MCP is used to select and activate Autopilot Flight Director System modes and establish altitudes, speeds and climb/descent profiles.

⁵ Such action is not in accordance with the operator's Flight Crew Operations Manual (FCOM) on "Flight Deck Preparation – Before Start" checklist. The checklist called for the assigned or SID limit altitude to be set in altitude window on the MCP.

⁶ Traffic alert and Collision Avoidance System (TCAS) is designed to prevent mid-air collisions between aircraft. The TCAS on an aircraft monitors the airspace around the aircraft and warns the pilots of the presence of other aircraft that may present a collision threat.

⁷ TA alerts the pilot of the presence of another aircraft that may be a threat.

⁸ There was a conflicting aircraft that had been cleared by ATC to descend to 6,000ft.

initiating the descent. Soon after, a TCAS Resolution Advisory⁹ (RA) “Climb, Crossing Climb” came on. However, the PF did not carry out the climb command. When a second RA of “Level off” came on 19 seconds after the first RA, the aircraft was still descending.

1.1.12 The TCAS “Clear of Conflict¹⁰” came on 8 seconds after the second TCAS RA, after which the aircraft started to level off at about 5,000ft. The crew reported to the ATC that they were cleared of traffic. The entire RA episode lasted 27 seconds in total and standard vertical separation of 1000ft was restored in less than 10 seconds.

1.1.13 The aircraft then started to climb above 5,000ft because FL310 was still set on the MCP altitude window. It was only when the ATC queried the crew on their climb that C2 noticed the FL310 setting. The PM then changed the setting to 5,000ft and the aircraft returned to and maintained the assigned altitude of 5,000ft.

1.1.14 After the TCAS event, C2 queried the PM if there was any assigned altitude given by ATC when the departure clearance was given. The PM recalled that there was none, and that the clearance was to climb via SID. C2 then reviewed his copy of Jeppesen chart and noticed that there was a requirement to “MAINTAIN 4,000FT or as assigned by ATC”. He highlighted this to the PF and PM. All of them had missed the 4,000ft altitude restriction on the chart during the departure briefing.

1.2 ‘Climb via SID’ clearance

1.2.1 The “climb via SID” clearance (see paragraph 1.1.9) is a new phraseology and procedures introduced by the Federal Aviation Administration (FAA), the US ATC authority, on 3 April 2014.

1.2.2 The operator had informed its flight crews of the new phraseology and related procedures and had also highlighted and discussed the procedure with the flight crews during their simulator sessions.

1.2.3 A clearance for a SID which contains published altitude restrictions or ‘top altitude’ is issued using the phraseology “climb via”. The “climb via” is an abbreviated ATC clearance that requires compliance with the procedure lateral path, associated speed restrictions, and altitude restrictions along the cleared route or procedure. When the top altitude is included in the SID route description, controller will instruct aircraft to “climb via SID”. The top altitude is the charted “maintain” altitude contained in the procedure description or assigned by ATC. The filed flight plan

⁹ RA provides the pilot voice instructions to avoid danger. Pilots must comply with the RA instructions, even if the RA is not in line with ATC instructions.

¹⁰ When a threat has passed, the TCAS announces “Clear of conflict”.

altitude is not relevant, and has no bearing on the SID unless communications are lost between the pilot and ATC.

2 DISCUSSION

2.1 The TCAS TA/RAs were the result of the flight crew not noticing the altitude restriction of 4,000ft in the Jeppesen chart for the INDIE ONE RNAV SID.

2.2 On the one hand, the pilots were not being systematic in the way they conducted the departure briefing and read the Jeppesen chart. After reading the first line in the 'Routing' section of the text box at the bottom left corner of the chart, the PF scrolled to the pictorial portion at the right of the chart and zoomed in to check on the track and distances. He ended his briefing on the chart without returning to the 'Routing' section of the chart, which contained an altitude restriction of 4,000ft. This omission was not picked up by the PM and C2. This suggests ineffectiveness of the monitoring action on the part of the PM and that there is room for improvement in crew resource management (CRM) training.

2.3 On the other hand, had the altitude restriction of 4,000ft appeared more prominently in the Jeppesen chart, the flight crew might have been able to notice such a piece of information. As it was, the SID's altitude restriction was not found in the 'Initial Climb' section, but was in SID's text box under the 'Routing' section. It is not intuitive to look for information on altitude restriction for the Initial Climb phase in the 'Routing' section.

2.4 The flight crew did notice (see paragraph 1.1.7) that there was no intermediate altitude to level off before being cleared to the final cruising altitude, but they did not discuss this among themselves. When the PF set FL310 on the MCP altitude window, the PM and C2 also did not intervene. When the flight was re-cleared to 5000ft by ATC, the flight crew failed to reset the altitude in the MCP to 5,000ft. This resulted in an unauthorised climb again. It took another query from ATC before the flight crew realised their error. Setting FL310 on the MCP altitude window was not in accordance with the operator's procedure. This incident suggests that crew inter-cockpit coordination and communication is an issue that needs to be addressed.

2.5 During the initial radio contact with Houston Departure Control, the PM reported that the aircraft was climbing passing 2,500ft but did not report the altitude that the aircraft was climbing to. There was also no request made to determine the cleared altitude in the departure phase. The Flight Crew Training Manual (FCTM) on standard radio communications phraseology requires pilots to articulate both passing altitude and assigned altitude in their initial

contact with a radar departure frequency, as well as following other frequency changes in a radar environment. ATC would likely have stopped the climb at 4,000ft or 5,000ft if the crew had communicated their intention to climb to FL310.

- 2.6 The flight crew understood that all RA commands must be complied with even if they are in conflict with any ATC instruction. The PF stated that he had experienced TCAS RAs in actual flight before but not a “Climb, Crossing Climb” type. C2 and the PM stated that it was their first TCAS RA in actual flight. This could partially explain the delayed crew responses and incorrect execution of the RA climb command.

3 SAFETY ACTIONS

The following safety actions were initiated by the parties concerned.

The operator

- 3.1 To address the breakdown in CRM, improve the effectiveness of pilot monitoring and enhance CRM training, the operator has incorporated the following in the flight crews’ simulator recurrent training programme:
- (a) More demanding TCAS RA scenarios as mandatory training requirements for pilots in both the roles of PF and PM, particularly the scenarios where there are conflicting ATC instructions and TCAS RA commands; and
 - (b) Scenarios where the PF is not following standard operating procedures and where the PM is expected to challenge the PF promptly or even take over the controls.
- 3.2 The operator shared the following lessons learnt from this occurrence to its flight crews:
- (a) The more demanding TCAS RA scenarios and the critical need for crew to execute the RA commands as Recall Actions.
 - (b) The breakdown in CRM that resulted in the crew not knowing the altitude restriction on the SID chart, and the PF’s incorrect execution of the RA manoeuvre being unchallenged.
 - (c) Inappropriate MCP setting of an altitude that has not been cleared by ATC or as published in the charts.
- 3.3 The operator also issued circulars to remind flight crews to:

- (a) be aware of altitude restrictions as indicated on the SID charts;
- (b) check with ATC if there is any doubt on the clearance given; and
- (c) adhere to the RA command, even when there is a conflict between the RA command and ATC instructions.

FAA

3.4 The FAA has amended their standards for charting RNAV SIDs, including the INDIE ONE procedure, to clearly show the top altitude in a box at the top centre of the chart (see **Figure 3**).

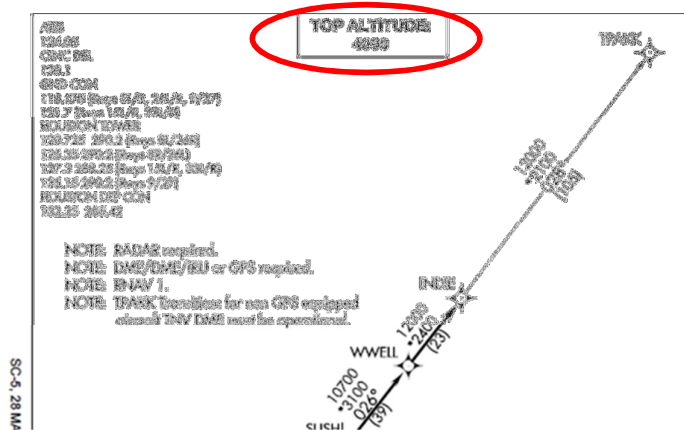


Figure 3: Amended SID with the Top Altitude clearly shown

4 **SAFETY RECOMMENDATION**

4.1 In view of the safety actions taken, no safety recommendation is proposed.