Australian Government
Australian Transport Safety Bureau

Tailstrike involving Boeing 737-800, VH-YIR

Auckland Airport, New Zealand, on 17 January 2018

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Aviation Occurrence Investigation
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Addendum

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Tailstrike involving B737, VH-YIR

What happened

On 17 January 2018, at about 1700 New Zealand Daylight Time,[1] a Boeing 737-800, registered VH-YIR and operated by Virgin Australia Airlines (Virgin), prepared to depart Auckland, New Zealand. The aircraft was operating scheduled passenger flight VA91 to Rarotonga, Cook Islands, with two flight crew, four cabin crewmembers and 135 passengers on board. Runway 05 right was in use and the wind direction and strength was from 040° true at 25 knots gusting to 38 knots. The captain was the pilot flying (PF) and the first officer was the pilot monitoring (PM).[2]

The flight crew prepared the take-off performance calculations and determined the take-off limit weight to be 76.7 t with an actual take-off weight of 75.0 t. The flight crew elected to use the 24,000 pound thrust rating for the reported weather conditions.

At about 1715, the PF commenced the take-off. During the take-off, the PF maintained a small amount of left aileron input for the crosswind. The aircraft accelerated to V_1[3] and the automated V_1 announcement sounded, shortly followed by the PM making the 'rotate' call at the rotation speed of 149 knots. During rotation, the PF felt a slight side-to-side movement of the aircraft's tail, which he corrected with minor rudder input, and observed some fluctuation of the airspeed. The PF did not recall the PM announcing any variation in airspeed during the rotation. Just before the aircraft became airborne, the PF noticed the nose-up attitude of the aircraft was slightly higher than the target 8° pitch angle. The PM also recognised this and called out that the pitch attitude was high. As the main wheels left the ground, the flight crew felt a bump from the rear of the aircraft.

After the initial climb, the flight crew discussed the sequence of events and concluded that their observations were most likely the result of a tailstrike. The captain handed control of the aircraft to the first officer and called the cabin supervisor to verify their suspicion. The cabin crewmembers reported that there had been a very loud noise from the rear of the aircraft during take-off.

The captain then contacted air traffic control (ATC), informed them of the suspected tailstrike, requested a runway inspection and asked for the tower's observations of the take-off.

The flight crew elected to stop the climb at 12,000 ft. Shortly after stopping the climb, ATC confirmed that the tower had not observed any abnormalities, and the runway inspection had identified no debris or damage to the runway.

The captain then called the Virgin ground operations duty manager to report the situation and seek input on whether an overweight landing be conducted or to continue a holding pattern to burn off fuel prior to return to Auckland. Subsequently, the captain elected to return to Auckland for an overweight landing. He then updated the cabin crew and made a passenger announcement advising of the intention to return to Auckland.

The aircraft returned to the airport where an overweight landing was conducted without further incident.

After shut-down, the captain monitored the off-loading of the bags and freight. The captain found that there were 10 fewer bags in the forward compartment of the cargo hold than detailed on the load sheet.

No persons were injured and the aircraft sustained minor damage in the incident.

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1 New Zealand Daylight Time (NZDT): Coordinated Universal Time (UTC) + 13 hours

2 Pilot Flying (PF) and Pilot Monitoring (PM): procedurally assigned roles with specifically assigned duties at specific stages of a flight. The PF does most of the flying, except in defined circumstances such as planning for descent, approach and landing. The PM carries out support duties and monitors the PF's actions and the aircraft's flight path.

3 V_1: the critical engine failure speed or decision speed required for take-off. Engine failure below V1 should result in a rejected take-off; above this speed the take-off should be continued.

Engineering inspection

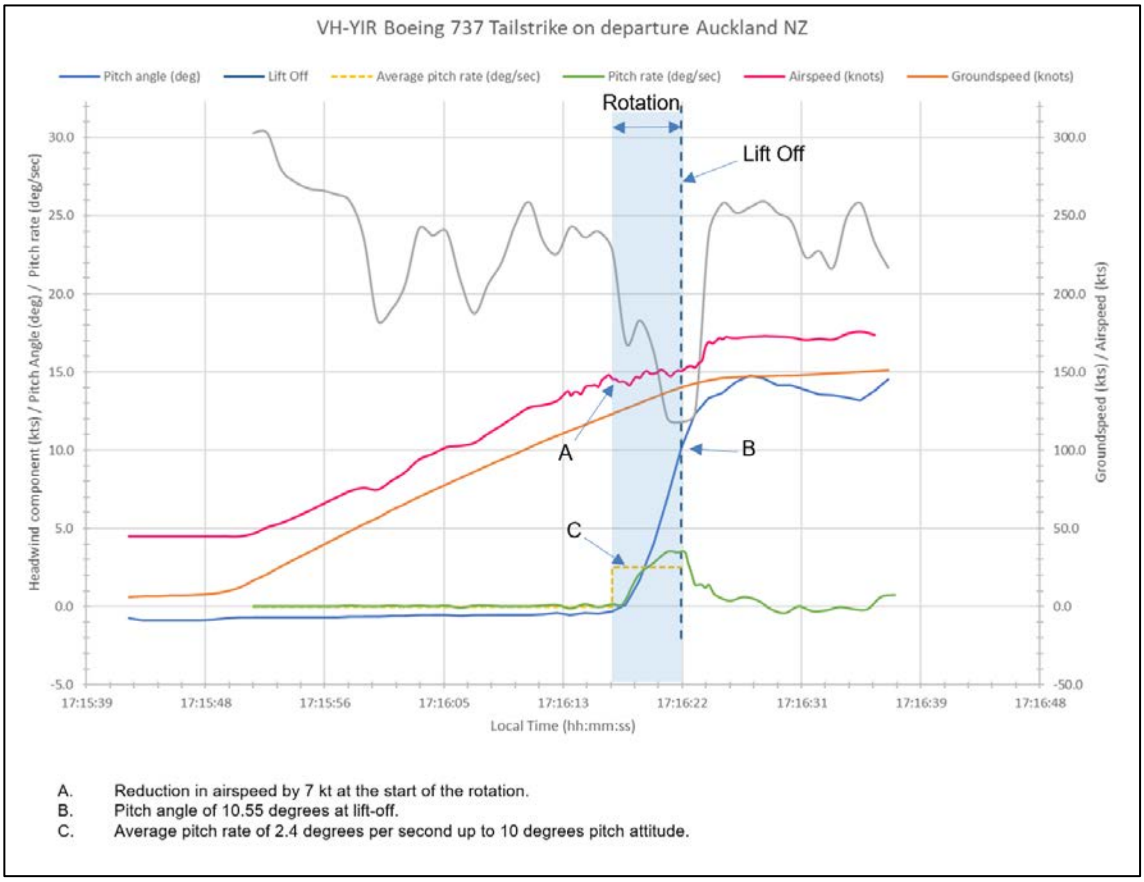
An engineering inspection confirmed that the aircraft had sustained a tailstrike during the take-off. The damage was limited to a scratch on the tailskid shoe that was found to be within the allowable limits. An overweight landing check was completed and the aircraft was determined to be serviceable.

Recorded flight data

Analysis of flight data from the aircraft's digital flight data recorder indicated the rotation occurred in gusty conditions with aircraft speed reducing during rotation. The data showed:

- a reduction in airspeed of 7 knots (Figure 1), followed by a stagnation in airspeed (the groundspeed continued to increase over this period, indicating the change in airspeed was a result of the variation in headwind component, which reduced by up to 11 knots during rotation)
- at lift-off, the pitch attitude of the aircraft was 10.55°
- maximum pitch rate during the rotation was 3.5° per second
- the average pitch rate during rotation was 2.4° per second
- the aircraft was slow to lift-off the runway (6 seconds from the point of initial rotation).

Figure 1: VH-YIR take-off data



Source: ATSB

Flight crew training manual and Boeing guidelines

The operator's *737 Flight Crew Training Manual* provided the following guidance:

- With a consistent rotation technique, where the pilot uses approximately equal control forces and similar visual cues, lift-off attitude is achieved in approximately 3 to 4 seconds.
- A rotation rate of 2 to 3° per second is required to ensure adequate tail clearance is achieved on take-off.

- At flaps 5 setting, the target attitude to achieve a 51 cm tail clearance to the runway is 8°.
- Under gusty wind and strong crosswind conditions, do not rotate early or use a higher than normal rotation rate in an attempt to clear the ground and reduce the gust effect because this reduces the tail clearance margins (tail clearance).
- The PM makes callouts based on instrument indications or observations for the appropriate condition. The PM should monitor engine instruments and airspeed indications during the takeoff roll and announce any abnormalities.

Guidelines that relate to Boeing aircraft show that the following factors contribute to reduced tail clearance:

- lateral control deflection
  - activation of flight spoilers, which reduces the amount of lift on the aircraft
- average pitch rate above 2.5° per second
- maximum pitch rate in excess of 4° per second.

Pilot's comments

The captain stated that the runway in use had slowly rising terrain along the departure path, which created the visual illusion that the pitch attitude of the aircraft was lower than it actually was. He advised that this delayed his appreciation that the aircraft was approaching the pitch attitude where a tailstrike could occur.

The captain stated that during his initial training with the operator in 2012, a training captain had advised that he needed to increase the rotation rate on take-off. The captain advised that, because of this tail-strike, he has reduced his take-off rotation rate to ensure it is within the manufacturer's recommended limits of 2 to 3° per second.

The captain also advised that, due to the crosswind conditions, significant control wheel input was required to keep the wings level. Even so, the aircraft became airborne with the right wing slightly lower than the left. The captain noted that in strong crosswind conditions, flight crews are required to make a quick decision on the compromise between keeping wings level and avoiding raising a spoiler, which has a corresponding loss of performance.

Operator's comments

With respect to take-offs in strong crosswind conditions, the operator made the following comments:

- The correct technique is as described below in the *Boeing Flight Crew Training Manual*:

  > Limit control wheel input to that required to keep the wings level. Use of excessive control wheel increases spoiler deployment, which has the effect of reducing tail clearance. All of these factors provide maximum energy to accelerate through gusts while maintaining tail clearance margins at lift-off.

- In a swept wing jet aircraft additional momentary aileron input is often required after lift-off to maintain wings level until the control wheel can be neutralised and the aircraft direction controlled with rudder.
- Training on crosswind take-offs is provided to pilots during each simulator session. The simulation is frequently conducted on a 30 m runway, which is more difficult than normal operations on a 45 m runway. Both take-off and landing simulations are conducted at maximum crosswind. Check and training captains assess that the correct procedures are used for the manoeuvres.
- Crosswind technique is further reinforced during the supervised line training components of both intake and command upgrade training.

Safety analysis

Analysis of the flight data determined that, during rotation, as the aircraft continued to accelerate, a reduction in headwind resulted in an initial drop and then stagnation in airspeed until just after lift-off. The airspeed variations were reportedly not identified and called out by the PM, as required in the flight crew training manual. Stagnation in airspeed at rotation had a similar effect to that of rotating too early: reduced lift and an extended the take-off roll, as confirmed by the flight data. The continued rotation with the main landing gear remaining on the runway then resulted in a reduced tail clearance.

The flight crew training manual indicated that the recommended rate of rotation on take-off to achieve sufficient tail clearance is 2 to 3° per second, with a lift-off target attitude of 8°. The maintenance of take-off and initial climb performance is dependent on rotation at the correct airspeed and rate to the target attitude. Boeing data indicated that average rotation rates above 2.5° per second to 10° pitch attitude, impact tail clearance. Analysis of the flight data showed that the aircraft was rotating at an average of 2.4° per second up to lift-off, at a pitch attitude of 10.55°. While the average rotation rate was towards the upper end of the recommended limit, it was not likely to have reduced the available tail clearance. Similarly, the maximum rotation rate of 3.5° was not considered to have contributed to the tailstrike.

Boeing data indicates that lateral control inputs can significantly reduce tail clearance on take-off. The small amount of left aileron input maintained during take-off to compensate for the crosswind was not considered to be sufficient to impact lift and consequently reduce tail clearance.

The minor discrepancy between the actual loading of the cargo hold and the load sheet was not significant and did not contribute to the tailstrike.

Following the occurrence event, the flight crew were proactive in gathering information from all available sources, which enabled them to make a complete assessment of the situation. They were decisive in their actions and kept cabin crew, passengers, ATC and ground staff up to date with clear communications.

Findings

This finding should not be read as apportioning blame or liability to any particular organisation or individual.

- A decrease in the headwind component reduced the airspeed during rotation and extended the time required for VH-YIR to leave the runway, resulting in a reduced tail clearance and subsequent tailstrike.

Safety message

External factors can change flight conditions rapidly. How the crew plans for and mitigates threats can make the difference between an uneventful take-off or landing and one that results in a tailstrike. Boeing guidance shows that airspeed loss, lateral control deflection and a greater than average pitch rate can all contribute to reduced tail clearance. The risk of a tailstrike can be mitigated by using recommended take-off techniques. The Boeing Aero-magazine article *Tail strikes: Prevention* contains a number of useful recommendations on tailstrike prevention, which include stressing the importance of:

- The role of the pilot monitoring to actively monitor and identify airspeed stagnation during the rotation phase to take-off target pitch attitude.
- In gusty conditions, momentarily delay rotation to ensure that the aircraft starts rotation at an average speed above the rotate speed.
- Adherence to the recommended average all-engine take-off rotation rate of 2 to 3° per second.

Following this tailstrike event, the flight crew made good use of resources and were proactive in assessing and resolving the situation. A safe outcome was achieved through the crew's use of effective communication and by following practiced failure management procedures.

General details

Occurrence details

Date and time:	17 January 2018 – 1720 NZDT	
Occurrence category:	Incident	
Primary occurrence type:	Ground strike	
Location:	Auckland International Airport, New Zealand	
	Latitude: 37° 00.48' S	Longitude: 174° 47.50' E

Aircraft details

Manufacturer and model:	The Boeing Company, 787-800	
Registration:	VH-YIR	
Operator:	Virgin Australia International Airlines	
Serial number:	39925	
Type of operation:	Air Transport High Capacity	
Persons on board:	Crew – 6	Passengers – 135
Injuries:	Crew – Nil	Passengers – Nil
Aircraft damage:	Minor	

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; and fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

About this report

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope, fact-gathering investigation was conducted in order to produce a short summary report, and allow for greater industry awareness of potential safety issues and possible safety actions.