Australian Government

Australian Transport Safety Bureau

Flight path management occurrence involving Boeing 737, VH-VZZ

near Canberra Airport, Australian Capital Territory, 13 March 2017

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Addendum

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Flight path management occurrence involving Boeing 737, VH-VZZ

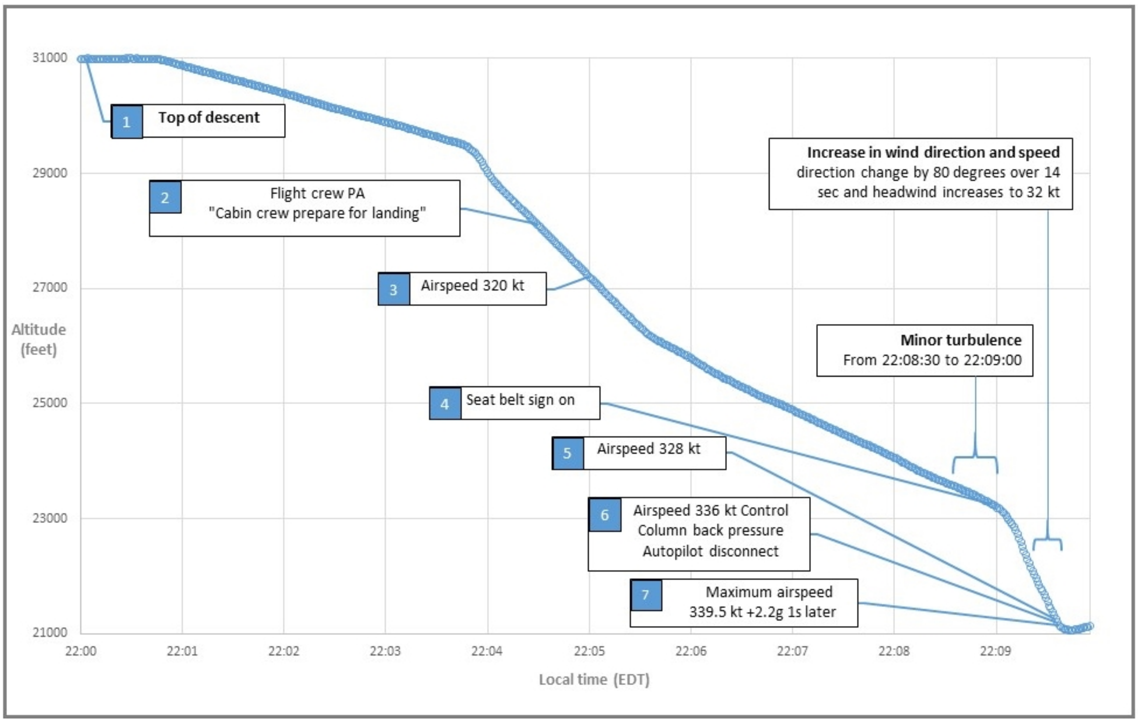
What happened

At about 2155 Eastern Daylight-saving Time[1] on 13 March 2017, a Qantas Airways (Qantas) Boeing 737-838 aircraft (B737), registered VH-VZZ (VZZ), was about to start its descent in to Canberra Airport, Australian Capital Territory. The aircraft was on a scheduled passenger flight from Perth Airport, Western Australia, and had two flight crew, five cabin crew, and 177 passengers on board. The first officer was the Pilot Flying (PF) and the Captain was performing the role of the Pilot Monitoring (PM).[2]

Air traffic control (ATC) cleared VZZ to descend and advised its flight crew to expect an arrival on runway 17. The controller also requested that the crew maintain maximum speed. In response, a descent speed of 320 kt was selected, 40 kt above the standard descent speed of 280 kt. The aircraft's maximum allowable operating speed (V_{MO}) was 340 kt.

At about 2200, the flight crew informed ATC that descent from flight level (FL) 310[3] had commenced and reported some light to moderate turbulence (Figure 1). Shortly after, ATC informed the flight crew that there would be a runway change to 35.

Figure 1: Diagram showing actions, conditions, and events during the aircraft's descent



Source: ATSB

At about 2204, VZZ was descending past FL 280 when the flight crew made an announcement over the aircraft's public address system advising the cabin crew to prepare for landing. That

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1 Eastern Daylight-saving Time (EDT): Coordinated Universal Time (UTC) + 11 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.

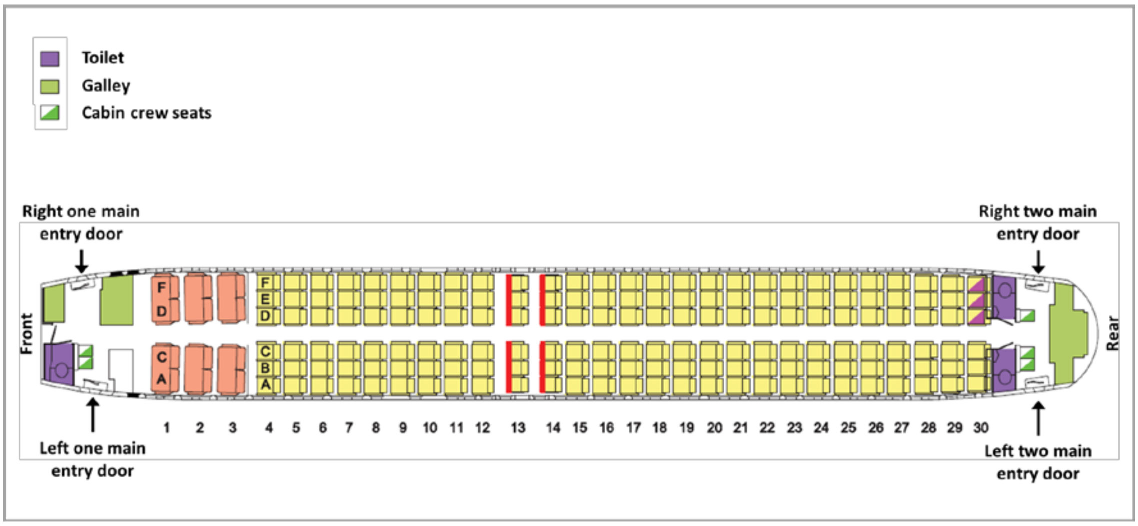
3 At altitudes above 10,000 ft in Australia, an aircraft's height above mean sea level is referred to as a flight level (FL). FL 310 equates to 31,000 ft.

announcement provided a cue to the cabin crew that they had about 10 minutes to secure all loose items in the cabin before illumination of the ‘fasten seat belt’ sign. By the time the aircraft passed FL 270, it had accelerated to the flight crew selected speed of 320 kt.

At about 2209, the turbulence began to increase. In response, the flight crew switched on the ‘fasten seat belt’ sign and advised the passengers and crew to be seated with seat belts fastened. The operator’s procedures required cabin crew members to be seated within 1 minute of that announcement.

At that time, a cabin crew member was passing row 22 on her way back to the rear of the cabin (Figure 2). The aircraft’s movement due to the turbulence was such that she needed to hold onto the overhead lockers as she walked along the aisle. About 15 seconds later, she reached the rear galley, closed a stowage latch, and secured a rubbish bin in preparation to be seated in the left cabin crew seat.

Figure 2: Boeing 737-800 VH-VZZ aircraft seat map



Source: Qantas (annotated by the ATSB)

When VZZ descended through FL 220 (about 30 seconds after the ‘fasten seat belt’ sign was switched on), the wind direction changed by about 80 degrees, resulting in a head wind increase from 15 kt to 32 kt. That in turn led to the airspeed increasing through 325 kt, and the PF applying control column backpressure to avoid exceeding V_{MO}. About 1 second after the maximum control column force was applied, the autopilot disengaged and the G-Load[4] peaked at 2.2 g. The pilot monitoring reported that they were checking the instrument approach, as a result of the change to runway 35, when they heard the autopilot disengage tone and saw the speed of the aircraft increasing toward V_{MO}.

The aircraft’s pitch angle changed by 3.87 degrees in 1 second, and its airspeed reached a maximum of 339.5 kt.

The cabin crew member recalled that, while standing in the rear galley and preparing for arrival, she felt the cabin floor drop and then quickly come up. The force due to the aircraft’s movement resulted in the cabin crew member fracturing her leg. The cabin crew member seated in the right rear seat assisted the injured cabin crew member.

The aircraft movement also resulted in a second cabin crew member in the forward galley falling forward and hitting her head on a trolley. She also received injuries to her knees, back and neck.

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[4] G load: the nominal value for acceleration. In flight, g load represent the combined effects of flight manoeuvring loads and turbulence and can have a positive or negative value.

The flight crew received an interphone call from the cabin reporting the leg fracture injury. The turbulence subsided and the flight crew turned off the 'fasten seat belt' sign and first aid was provided to the injured crew members.

At about 2211, the aircraft's speed decreased and the flight crew re-engaged the autopilot. The flight crew alerted ATC to the turbulence and were informed that no other turbulence had been reported in the area.

Due to her fractured leg, the injured crew member in the rear galley remained lying on the cabin floor for the landing. The aircraft landed at about 2234, and paramedics met the aircraft to attend to the two injured cabin crew members. Both of them were transferred to a hospital for treatment. The cabin crew member injured in the rear galley was admitted to the hospital. The other crew member was treated and discharged without admission. The aircraft was not damaged and none of the other crew or any of the passengers were injured.

Autopilot

The autopilot of VZZ remained engaged until the control column force reached about 25 Ibs.

Qantas advised the ATSB that it was common practice for its B737 flight crews to manage an impending overspeed by applying control column force to override the autopilot. The expected outcome of this action was for the autopilot to revert to 'control wheel steering-pitch' (CWS-P)[5] mode, and raise the aircraft's nose. According to VZZ's first officer, the technique was part of initial B737 type rating training and line training. The captain also confirmed that this technique was commonly practiced.

Following review of the draft investigation report relating to this occurrence, Boeing advised that they were considering a revision to the overspeed guidance in the 737 flight crew training manual. Specifically, they were considering inclusion of the following preferred response to an impending overspeed:

> VMO/MMO is the airplane maximum certified operating speed and should not be exceeded intentionally. However, crews can occasionally experience an inadvertent overspeed. Airplanes have been flight tested beyond VMO/MMO to ensure smooth pilot inputs will return the airplane to the normal flight envelope.
>
> Periodic wind speed or direction changes may lead to overspeed events. Although autothrottle logic provides for more aggressive control of speed as the airplane approaches VMO or MMO, there are some conditions that are beyond the capability of the autothrottle system to prevent short term overspeeds. In these cases, leave the autopilot engaged and deploy partial speedbrakes slowly until a noticeable reduction in airspeed is achieved. Retract speedbrakes slowly when below VMO/MMO.

The autopilot of VZZ had been modified to remove the CWS-P reversion (that is, it would instead disengage when 25 Ibs of control column force was applied). Boeing advised that the modification was introduced due to concern '…that flight crews may not recognise or correctly interpret the autoflight system automatic transition to the Control Wheel Steering mode…'.

A consequence of the modification was that the autopilot disengagement produced a sharper elevator response than reversion to CWS-P, as that mode provided a smoothed resistance as a function of the pitch rate. That is, for the same control force input, the elevator deflection and pitch change were significantly larger when the autopilot disconnected compared to reversion to CWS-P.

5 The CWS-P is the function of the control wheel steering for the autopilot that controls the aircraft pitch angle.

Recorded data

Examination of the relevant flight data showed that:

Minor turbulence occurred from 2208:30 to 2209:00 while the rate of descent was steady and the aircraft's speed was about 320 kt. There were slight variations in the headwind and airspeed in this period.

At 2209:00, 'level change mode'[6] was engaged and, over the next 20 seconds, the rate of descent increased and peaked at 4,725 ft/min.

Between 2209:30 to 2209:44, the wind direction changed about 80 degrees and the headwind increased from 15 kt to 32 kt.

At 2209:36, as the airspeed began increasing above 325 kt, the control column was pulled back and the autopilot disengaged at 2209:40. About 1 second after maximum control column force, the G-load peaked at 2.2 g and the aircraft pitch angle changed from -1.58° to 2.29°. The aircraft reached a maximum speed of 339.5 kt, 0.5 kt below V_{MO}.

Related occurrence – AO-2015-041[7]

On the 9 May 2015, a Boeing B737-8FE aircraft was making a high-speed descent (320 kt) into Adelaide, South Australia. The crew responded to indications the aircraft was approaching the maximum allowable airspeed by extending the speed brakes. However, the airspeed continued to increase. The autopilot was then overridden by pulling back the control column (the force required was greater than the pilot expected) until the autopilot entered the CWS-P mode. Immediately afterwards, the control column was abruptly released. The subsequent motion of the aircraft resulted in a cabin crew member suffering a minor injury.

Safety analysis

The Qantas internal investigation of this occurrence found that in the past 6 years there had been 47 previous overspeed occurrences involving its Boeing 737-800 aircraft, of which 20 had been managed via manual intervention (that is, overriding the autopilot into CWS-P). The internal investigation also found that it was common practice among its Boeing B737-800 flight crews to descend at 320 kt (20 kt below the V_{MO}) when cleared by ATC to conduct a high-speed descent.

The common practice of flight crews to prevent an overspeed was not a documented Qantas or Boeing procedure. As a result, the potential consequence of this practice was not considered when the autopilot was modified.

Qantas also advised that the flight crew of VZZ had no information that indicated that there would be a risk of turbulence. The wind information provided in the flight plan did not show there would be a significant change in the wind direction during descent. As such, descending at 320 kt was not considered to present an increased risk.

The first officer of VZZ responded to the increase in speed towards the aircraft's V_{MO} consistent with his training, experience, and observations of other crew members. As VZZ had a modified autopilot, it was not possible to override it into CWS-P. Consequently, when sufficient force was applied to the control column, the autopilot disengaged. That resulted in abrupt elevator deflection and pitch change, which in turn led to the cabin crew injuries.

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6 The autopilot level change mode coordinates pitch and thrust commands to make automatic climbs and descents to preselected altitudes at selected airspeeds.

7 Available at www.atsb.gov.au

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The increase in headwind while VH-VZZ was making a routine high speed descent at 320 kt resulted in the airspeed increasing towards the aircraft's maximum allowable speed.
- The pilot flying applied a control column input to prevent an overspeed, which resulted in the autopilot unexpectedly disengaging. The consequent change of pitch and g-loading led to two cabin crew suffering injuries.
- The aircraft's autopilot had been modified such that, if sufficient control column back pressure was applied, the autopilot would disengage rather than revert to the Control Wheel Steering (CWS) mode. Autopilot disengagement resulted in larger elevator and pitch responses than those associated with reversion to CWS mode.

Safety action

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following proactive safety action in response to this occurrence.

Aircraft operator

Qantas advised the ATSB that it has taken the following safety action.

Safety information notice

A safety information notice titled *Pilot responses during high and low airspeed events* has been provided to the flight crew. The notice advised flight crew that:

- during an impending or actual overspeed event, it is preferable to keep the autopilot engaged
- there is a reasonable buffer on V_{MO} before any significant maintenance actions are required. Disengaging (and/or overriding) the autopilot to avoid an overspeed may result in an abrupt pitch change that could lead to more adverse consequences than the overspeed itself.

Safety message

Although there was no expectation of varying wind conditions during the descent on this occasion, this occurrence highlights the increased risk of overspeed when operating with a reduced margin below V_{MO}.

The intervention by the pilot flying to prevent the impending overspeed was understandable, and consistent with previous responses of other flight crew in similar situations. However, as detailed in the Qantas safety information notice, when faced with an impending overspeed, abrupt pitch changes may have more adverse consequences than an overspeed event. The manufacturer's preferred use of speedbrakes to manage increasing airspeed, removes the hazard associated with abrupt pitch changes.

General details

Occurrence details

Date and time:	13 March 2017– 2209 EDT	
Occurrence category:	Accident	
Primary occurrence type:	Operational – Aircraft control – control issues	
Location:	near Canberra Airport, Australian Capital Territory	
	Latitude: 35° 18.42' S	Longitude: 149° 11.70' E

Aircraft details – VH-VZZ

Manufacturer and model:	The Boeing Company 737-838	
Registration:	VH-VZZ	
Operator:	Qantas Airways	
Serial number:	39445	
Type of operation:	Air transport high capacity - passenger	
Persons on board:	Crew – 7	Passengers – 177
Injuries:	Crew – 2	Passengers – 0
Aircraft damage:	Nil	

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.