Australian Government
Australian Transport Safety Bureau

Severe turbulence involving Bombardier DHC-8, VH-LQM

30 km south of Canberra Airport, Australian Capital Territory, 10 October 2016

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Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office: 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
Telephone: 1800 020 616, from overseas +61 2 6257 4150 (24 hours)
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117, from overseas +61 2 6247 3117
Email: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

Addendum

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Severe turbulence involving Bombardier DHC-8, VH-LQM

What happened

On 10 October 2016, a QantasLink Bombardier DHC-8-402, registered VH-LQM, conducted a scheduled passenger flight from Melbourne, Victoria, to Canberra, Australian Capital Territory. On board the aircraft were two flight crew, two cabin crew and 70 passengers. The captain was the pilot flying (PF) and the first officer was the pilot monitoring (PM).[1]

During the pre-flight briefing at Melbourne Airport, the flight crew noted there was severe turbulence and severe mountain wave turbulence in the area forecast[2] and SIGMET[3] for their descent and approach to Canberra. They briefed the cabin crew to be prepared for a quick cabin service and that the seat belt sign would be activated early on the approach due to the forecast turbulence.

The aircraft departed from Melbourne at about 1158 Eastern Daylight-saving Time (EDT) and climbed to a cruising level of FL 210.[4] The flying conditions were smooth at FL 210 and the flight was issued with the POLLI FOUR ALPHA standard arrival route into Canberra, which started at waypoint POLLI, to the south west of Canberra (Figure 1). The flight crew instructed the cabin crew to prepare the cabin for landing several minutes before the top of descent. However, the flying conditions continued to be smooth during the descent, so the flight crew waited until about FL 130 before activating the seatbelt sign. This was shortly after passing waypoint POLLI.

Between waypoints GOMAN and HONEY, the aircraft descended below FL 110 and the PF reduced the aircraft speed to 210 kt, which is the best speed for turbulence penetration. The PM estimated that the tailwind component reduced from about 70 kt to about 40 kt after the descent below FL 110. At this point, the aircraft was tracking about 060° and passing in and out of cloud over the Brindabella Ranges, which has ridgelines orientated north-south to the south-west of Canberra.

During the descent, the flight crew did not observe any weather radar indications of potential turbulence or visible indications from the shape or movement of the clouds. Between waypoints HONEY and DALEY at about 7,000 ft AMSL, while passing through a small cloud, the aircraft dropped abruptly. The flight crew reported that everything in the flight deck became airborne, the autopilot disengaged and the PF struck the left side of their head on the overhead air-vent and light, which dislodged their headset. The captain handed control over to the first officer while they refitted their headset and re-established communications, then resumed their flying pilot role and reset the auto-pilot.

The flight crew continued the approach to land at Canberra without further incident and notified Canberra air traffic control of their severe turbulence encounter on the approach. After the aircraft landed, the PM contacted the cabin crew to check if there were any cabin injures to report. The cabin crew indicated they were uninjured and made a public address to the passengers to check

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1 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.

2 Area forecast (ARFOR): routine forecasts for designated areas and amendments when prescribed criteria are satisfied. Australia is subdivided into a number of forecast areas.

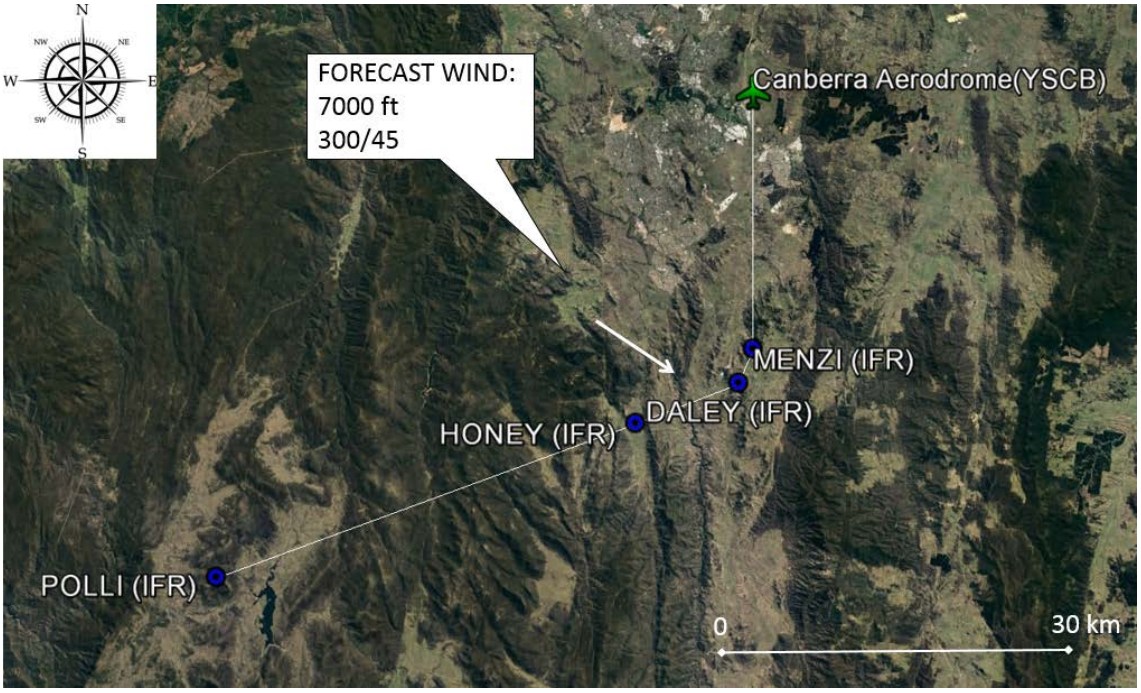
3 Significant meteorological information (SIGMET): a weather advisory service that provides the location, extent, expected movement and change in intensity of potentially hazardous (significant) or extreme meteorological conditions that are dangerous to most aircraft, such as thunderstorms or severe turbulence.

4 Flight level: 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 210 equates to 21,000 ft.

for injuries. The PM then called their company to inform them the aircraft was unserviceable after a severe turbulence incident, and also noticed the captain's minor injuries.

During the disembarkation of the passengers, the cabin crew informed the first officer that one passenger had hit their head on the overhead baggage locker. The first officer then asked a company ground agent to contact the emergency services so the passenger could be checked. However, the passenger declined treatment. The emergency services arrived and checked the captain. The captain was then advised by the company to visit a doctor where they were diagnosed with minor injuries.

Figure 1: POLLI FOUR ALPHA arrival track of VH-LQM



Source: Google earth, annotated by ATSB

Flight data recorder

The flight data recorder showed that as the aircraft descended through about 7,800 ft the aircraft was in a stable descent maintaining 210 kt and heading 042°. As the aircraft descended through about 7,300 ft the airspeed peaked at about 240 kt and the vertical acceleration oscillated rapidly between a maximum of +1.6G,[5] minimum of -1G, then maximum of +1.6G before returning to +1G.

Maintenance inspection

After landing, the captain raised a defect report in the maintenance technical log for the severe turbulence encounter. Inspections were then conducted for the severe turbulence assessment. No defects were found and the aircraft returned to service on 12 October 2016.

Weather forecast

The weather forecast for the Canberra area, issued for the period from 0840 to 2200 EDT on 10 October 2016 included severe turbulence below 12,000 ft and severe mountain wave turbulence above 5,000 ft. The wind was forecast as follows:

- 10,000 ft, from 300° at 60 kt
- 7,000 ft, from 300° at 45 kt

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

- 5,000 ft, from 290° at 30 kt.

Mountain waves

Mountain waves may be experienced on the lee-side of mountain ranges as smooth undulating airflow or may contain turbulence in the form of breaking waves and rotors (Figure 2). They typically form when the wind direction is close to perpendicular to a ridge line (+/-30°), the wind speed is at least 15 kt[6] and increases with height, and there is stable air above the crest of the ridge with less stable air above that and a stable layer below the ridge. The formation of clouds on the lee-side may indicate turbulent flying conditions. Further information can be found in the ATSB website safety publications: *Mountain wave turbulence*.

Figure 2: Mountain wave turbulence

Source: US Federal Aviation Administration

Flight crew harnesses

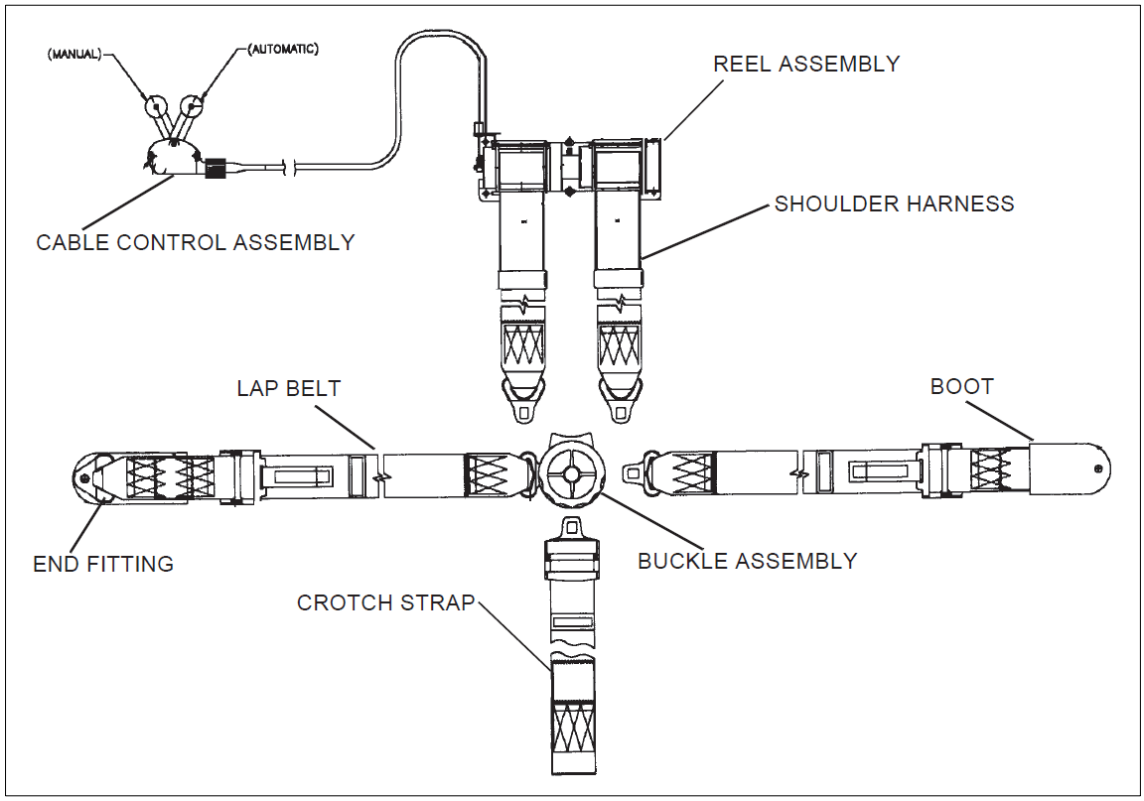
The aircraft's flight crew seats are fitted with five point harnesses. The harness consists of a lap belt, a rotary buckle, a crotch strap, two shoulder straps and inertia-reel assembly with emergency locking retractors and cable control assembly (Figure 3). At the time of the turbulence, both flight crewmembers had the five points of their harnesses fitted, but with their shoulder harnesses in the AUTOMATIC position. In the AUTOMATIC position, the shoulder harness inertia-reel permits the occupant to move forward slowly, but locks when the straps are pulled at 1.5G and remains locked until the force is removed. In the MANUAL position, the shoulder straps are locked. The shoulder harness is primarily intended to mitigate forward movement of the torso and head.

The lap belt combined with the crotch strap are the primary means of restraint for turbulence encounters and exposure to negative-G forces. The crotch strap is also referred to as the 'negative-G strap' and its purpose is to reduce upward movement of the lap belt during negative-G aircraft motion. The length of the crotch strap should be adjusted such that no slack exists in the strap when the lap belt is properly positioned in the pelvic region. In this position, the crotch strap will resist the upward pull from the shoulder harness in negative-G.

When the aircraft encountered the negative-G turbulence, the captain felt the aircraft drop from underneath them and struck their head on the overhead air-vent and light. The captain and first officer reported that they had their lap belts tightened to 'firm but comfortable'. The first officer reported that they may have hit their head on the ceiling of the flight deck, but received no injuries. The captain reported that some crotch straps do loosen during flight. The captain also advised that they had set their seat height so their eyes were lined up with height bar markers on the screen. They estimated that provided them with about 20-25 cm head clearance.

[6] This number varies between references with a lower limit of 15 kt and upper limit of 25 kt cited.

Figure 3: Aircraft flight crew harness



Source: Operator

Safety analysis

The flight crew had briefed and prepared the aircraft for flight in forecast severe turbulence.

As the aircraft tracked from waypoint HONEY to DALEY, it entered the lee-side of the Brindabella Ranges, tracking towards the north-east with a strong tailwind component. The wind was forecast to be 30 kt at 5,000 ft, increasing to 45 kt at 7,000 ft and within 30° of perpendicular to the ridgeline, at this location. Therefore, the abrupt encounter with turbulence was probably the result of mountain wave activity.

During the encounter, the flight crew described their movement relative to the aircraft as vertical when the aircraft dropped from underneath them. The primary method of restraint for negative-G is the lap belt supported by the crotch strap. If there is slack in the lap belt, this will permit the body to move up relative to the lap belt, and if there is slack in the crotch strap, this will permit the lap belt to move up if it is pulled upwards by the shoulder harness. The captain reported that the crotch strap can loosen with occupant movement and the aircraft was subject to minor fluctuations in G before the turbulence incident. Therefore, the captain's injury was probably the result of some measure of slackness in their crotch strap.

Findings

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

- The severe turbulence incident was probably an encounter with mountain wave activity in the lee-side of the Brindabella Ranges.
- The captain was probably insufficiently restrained by their crotch strap to prevent them striking their head during the encounter with turbulence.

- The flight crew were prepared for the risk of an encounter with severe turbulence during the descent and approach to Canberra.

Safety message

This incident highlights the importance of flight crew preparation for entry into an area of forecast turbulence and the importance of ensuring the correct adjustment of all harness straps. The captain planned to activate the seat belt sign early on the descent into Canberra and briefed the cabin crew accordingly. On descent into Canberra, all personnel were seated, the seat belt sign was activated and the aircraft speed reduced to turbulence penetration speed before the encounter with severe turbulence, which minimised the risk of injury to personnel and damage to the aircraft. However, despite the precautions taken by the crew, the captain received minor injuries.

Further information on flight crew harnesses can be found in United States Federal Aviation Administration Advisory Circular 21-34: *Shoulder harness – safety belt installations*.

General details

Occurrence details

Date and time:	10 October 2016 – 1240 EDT	
Occurrence category:	Serious incident	
Primary occurrence type:	Weather – turbulence / windshear / microburst	
Location:	30 km south of Canberra Airport, Australian Capital Territory	
	Latitude: 35° 34.27' S	Longitude: 149° 7.43' E

Aircraft details

Manufacturer and model:	Bombardier Incorporated DHC-8-402	
Registration:	VH-LQM	
Operator:	Sunstate Airlines (QLD) PTY LTD (Operating as QantasLink)	
Serial number:	4450	
Type of operation:	Air transport high capacity - Passenger	
Persons on board:	Crew – 4	Passengers – 74
Injuries:	Crew – 1 (minor)	Passengers – 0
Aircraft damage:	Nil	

About the ATSB

The Australian Transport Safety Bureau (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.