Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A05W0109

INADVERTENT STICK SHAKER AT HIGH ALTITUDE

AIR CANADA JAZZ
BOMBARDIER CRJ705 C-FBJZ
LETHBRIDGE, ALBERTA, 41 nm SE (COUTS INTERSECTION)
10 JUNE 2005

Canada

Aviation Investigation Report

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Summary

The Air Canada Jazz Bombardier CRJ705 aircraft (registration C-FBJZ, serial number 15037) was operating as JZA8105 from Houston, Texas, to Calgary, Alberta, with 64 passengers and 4 crew members on board. The aircraft entered Canadian airspace in the vicinity of COUTS intersection, while in cruise at flight level 400. Shortly thereafter, at 2046 mountain daylight time, the crew contacted Edmonton Centre and was advised that traffic was being metered into Calgary. The controller gave the crew a crossing time for the VUCAN intersection of 2121 and offered the option of slowing at pilot's discretion. This crossing time was 18 minutes later than planned.

The crew was concerned about fuel reserves as the flight had already been diverted west of its planned route in the United States due to weather and air traffic control requirements. The pilot reduced power to slow the aircraft in response to the anticipated metering of traffic. While the crew was occupied with the fuel calculations for a possible hold, the airspeed deteriorated to the point of stick shaker activation. The aircraft speed was recovered by applying power and initiating a descent. There was no damage to the aircraft or injuries to passengers or crew. The flight landed at Calgary without further incident.

Ce rapport est également disponible en français.

Other Factual Information

At the time of the occurrence, the aircraft's weight of about 68 000 pounds and its centre of gravity were within approved limits. There were no known defects that might have influenced the aircraft's performance.

The aircraft was clear of cloud at the time of the occurrence, and there was little or no turbulence. Forecast upper winds at flight level (FL) 400 were 260° True (T) at 18 knots and temperature -55°C.

The incident occurred during the inaugural week of the company's scheduled CRJ705 operation. Both pilots had previous experience in the CRJ200 model (CL-600-2B19), and had completed a conversion course for the CRJ705 (CL-600-2D15). The conversion course consisted of ground instruction, simulator training, and a pilot proficiency check (PPC). The captain completed initial CRJ200 series training in September 2004 and the CRJ705 conversion training in March 2005. His last recurrent CRJ200 PPC was in February 2005. The first officer received his CRJ200 type endorsement in October 2004, and his CRJ705 conversion in May 2005. His last recurrent PPC was in February 2005.

Both crew members arrived in Houston earlier the same day on JZA8106 at approximately 0200 mountain daylight time (MDT).[1] The captain flew the aircraft with a different pilot acting as first officer, with the occurrence first officer deadheading on the aircraft. The crew arrived at their hotel at 0300. The captain slept fitfully for 3.5 hours before rising at 0830 and was not well rested before the flight to Calgary. Take-off for the return flight (JZA8105) to Calgary was at 1725.

Fatigue impairs alertness and performance, and fatigued persons may fix their focus on minor problems, fail to anticipate danger, display flawed logic, or apply inappropriate corrective actions.[2] Fatigue can significantly impair performance on safety-critical tasks. Included among the common effects of fatigue are the following:

- reduced attention;
- preoccupation with single tasks or elements of a task; and
- overlooked or misplaced sequential task elements.

In anticipation of traffic metering into Calgary, the captain, who was the pilot flying, reduced power to slow from the cruise speed of 0.77M[3] to the long range cruise speed of 0.70M. The flight director was set to altitude track mode with the autopilot engaged. The captain then focused attention to the flight management system (FMS) on the centre console to help the first officer determine fuel reserves for a possible hold. About 90 seconds later, the first officer

1 All times are MDT (Coordinated Universal Time minus six hours).

2 Reference: *A Guide for Investigation for Fatigue* – TSB, August 1997

3 M is Mach number, which is the ratio between the aircraft's true airspeed and the speed of sound at a particular temperature.

noticed the speed dropping below 0.70M and warned the captain. The captain responded by advancing the thrust levers. The aircraft continued to decelerate with increasing nose-up pitch attitude while maintaining FL 400. The captain then began programming a descent in the flight control computer (FCC) vertical speed mode. Immediately thereafter, as the airspeed decreased to 0.61M (180 knots indicated airspeed (KIAS)), the stick shaker activated and the autopilot disengaged. Both pilots pushed the control yoke forward to reduce the pitch attitude, which resulted in a descent and an increase in airspeed. This was followed by the crew returning the aircraft to a pitch-up attitude, with an increase in body angle of attack and G.[4] A second stick shaker activation occurred 11 seconds after the first. Buffeting and roll oscillations of about 10 degrees accompanied the stick shaker events. The pitch attitude was further reduced and the airspeed recovered to 0.82M (250 KIAS). The altitude stabilized briefly at FL 386 before the crew coordinated with ATC, a further descent to FL 380 due to conflicting traffic. (See Appendices A and B for digital flight data recorder plots.)

Minimum drag speed (V_{md}) is defined as the speed at which aircraft total drag is at a minimum, requiring minimum thrust for level flight. This speed is associated with the endurance speed. At a constant altitude, progressive reduction in true airspeed below V_{md} results in a concomitant increase in total drag, which results in a further deterioration of airspeed. Therefore, airspeed values below V_{md} can result in negative stability (see Figure 1). Should cruise airspeed become less than V_{md}, speed restoration can be accomplished by increasing engine power, by initiating a descent, or a combination of both.

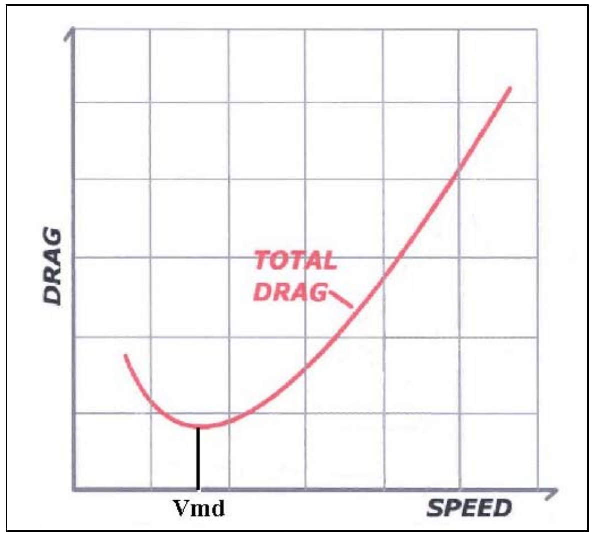

Figure 1. Drag versus speed (adapted from Air Canada Jazz training module)

The power required to maintain V_{md} increases as altitude and/or aircraft weight increases. At high altitudes, the power required to maintain V_{md} may be only marginally lower than that required for cruise. Delaying a descent in favour of applying power may result in the aircraft speed decelerating to the point of stick shaker activation and disengagement of the autopilot. Data supplied by Bombardier Aerospace indicated that, under the conditions JZA8105 was operating at the time of the occurrence, V_{md} was 0.75M, which was near the cruise speed of 0.77M. In the CRJ200, V_{md} was below the published long range cruise speed under all normal flight conditions, whereas in the CRJ705, under certain altitudes and aircraft weights, V_{md} could be above the long range cruise speed.

An Operational Evaluation Board Report (OEBR) prepared by Transport Canada in 2002, and revised in 2004, established master differences in training, pilot checking, and currency requirements for pilots operating CL-65 series aircraft. Operator aircraft differences requirement (ODR) tables in the OEBR contained detailed model/variant differences and training

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[4] For bodies undergoing acceleration and deceleration, G is used as a unit of load measurement.

requirements. Canadian commercial operators, including Air Canada Jazz, could use the report to develop flight crew training programs and checks in accordance with the *Canadian Aviation Regulations* (CARs). Flight characteristics relating to aircraft aerodynamic responses to airspeed changes were included in definitions. However, because the flight characteristics were considered to be similar, the ODR tables did not include differences between the CRJ200 and CRJ705/900 related to V_{md}.

The Air Canada Jazz pilot training syllabus included sections devoted to high altitude physiology and depressurization in accordance with CARs. During the initial type training on the CRJ200, company pilots received training in high-altitude/high-speed aerodynamics specific to the type. Approach to stall recognition and recovery training was limited to 10 000 feet above sea level (asl) and did not cover the significant differences in techniques between low-altitude and high-altitude speed recovery. In June 2005, simulator training in airspeed recovery at high altitude, which emphasized timely pitch reduction, was added to the CRJ recurrent training syllabus. Both occurrence pilots had completed their recurrent training before that time and therefore had not received this training.

Before the incident, the company's CRJ705 Aircraft Operating Manual included a recommended normal holding speed of 225 KIAS for altitudes above 14 000 feet. There was no reference to the fact that this speed could be substantially below V_{md} at altitudes near the maximum cruising altitudes. Although data related to V_{md} was included in the Bombardier Flight Planning and Cruise Control Manual, the information was not readily available to flight crews in the cockpit. It was not included in quick reference material or aircraft operating manuals.

Due to the length of the flight remaining, the cockpit voice recorder information pertaining to the incident had been overwritten. The digital flight data recorder (DFDR) was removed and analysed by the TSB Engineering Laboratory. It was determined that, during the occurrence flight, the offset between the recorded DFDR time and the GPS-based Coordinated Universal Time (UTC) changed by one second about every 10 minutes. At the time of the incident, the time recorded by the DFDR was 23 seconds longer than the recorded UTC time. This corresponded to a difference between timing parameters of 0.16 per cent. Section 625.33 of the CARs stipulates that the accuracy limits for recorded time drift be within ± 0.125 per cent per hour. The observed drift suggested that the stability requirements as set out by the CARs were exceeded. Since the GPS-based UTC time stamp would have been very accurate, it is likely that the time drift originated in the data concentrator unit (DCU) (part number DCU-4004) of the DFDR. This information was communicated to the aircraft manufacturer and the component supplier for evaluation.

Analysis

Neither the weather conditions nor aircraft serviceability were factors in the occurrence. The analysis will therefore focus on crew actions and company training programs.

The crew of JZA8105 had been initially trained on the CRJ200, which included aeroplane performance and limitations training. The crew had experience flying the CRJ200 before completing the CRJ705 conversion training. The Air Canada Jazz CRJ705 conversion training was based on the Transport Canada OEBR, which outlined aircraft difference requirements for conversion training between the CL-65 variants. Neither the OEBR nor the Air Canada Jazz CRJ705 conversion training program covered flight characteristics at high-altitude cruise. Also, Air Canada Jazz CRJ705 cockpit reference material did not include information on V_{md} limitations. Therefore, the crew of JZA8105 was not aware that, unlike in the CRJ200, long-range cruise speed in the CRJ705 could be less than V_{md} at altitudes near the aircraft service ceiling. Consequently, the decision to slow the aircraft to 0.70M, which was below the V_{md} of 0.75M, while attempting to maintain a constant altitude, was not an appropriate course of action**.**

When the captain was alerted to the airspeed falling below the targeted 0.70M, the viable speed-recovery options in order of effectiveness were to begin a descent, and to increase power. When he advanced the power levers, the engine power available at FL 400 was only slightly more than that required for cruise, and the aircraft could not accelerate beyond V_{md} in level flight. When the airspeed continued to decrease, the captain selected the FCC vertical speed mode. With stick shaker activation imminent, the best course of action would have been to disconnect the autopilot and manually reduce pitch. The second stick shaker event was likely due to the crew introducing a pitch-up with a resultant increase in angle of attack and G loading. Speed recovery was eventually established by a more aggressive and sustained reduction in pitch attitude.

The captain had obtained a limited quantity of fitful sleep the night before the incident flight, despite being afforded adequate time to obtain the required rest. His preoccupation with the FMS after reducing power, at the expense of the more critical task of monitoring the airspeed, was consistent with a type of performance decrement associated with fatigue.

The following TSB Engineering Laboratory report was completed:

LP 058/2005 — DFDR Examination.

This report is available from the Transportation Safety Board of Canada upon request.

Findings as to Causes and Contributing Factors

1. The pilots were not familiar with the relationship between cruise speed and minimum drag speed (V_{md}) at high altitudes in the CRJ705. The Air Canada Jazz CRJ705 conversion training, which was based on the Transport Canada evaluation of CL-65 variants in an Operational Evaluation Board Report (OEBR), did not include differences in flight characteristics pertaining to V_{md}.

2. The flight crew of JZA8105 were not aware that, under their flight conditions, a low margin of power was available to sustain level flight at cruise altitude at a speed below V_{md}. As a result, the crew initiated an airspeed reduction to below V_{md}, from which the aircraft was unable to accelerate without loss of altitude.

3. The captain was not well rested before the flight. The effects of fatigue likely resulted in a degradation of his concentration and prolonged diversion of attention from monitoring of airspeed after power reduction. The airspeed was therefore allowed to fall below the targeted value.

4. The company's speed recovery training in the CRJ was limited to 10 000 feet above sea level (asl), and did not cover the differences in techniques between airspeed recovery at low altitude and at high altitude. Without the benefit of this training, the captain's initial response for airspeed recovery was ineffective, which eventually resulted in stick shaker activation.

Other Finding

1. A time drift originating in the digital flight data recorder (DFDR) introduced an inaccuracy of 0.16 per cent where the required standard was 0.125 per cent. Although the drift did not have an impact on this investigation, the resulting inaccuracy of time synchronization could reduce the value of flight data recorder information as it applies to establishing an accurate sequence of events in other occurrences.

Safety Action Taken

Following this occurrence, Bombardier Aerospace issued a message to all operators of the CRJ705/900 variants of the CL-65. It emphasized that operators may not be aware that, under certain flight conditions, climb speeds may be below minimum drag speed (V_{md}). It was recommended that flight operations should not be conducted below V_{md} as defined in the General Speed Section of the Flight Planning Cruise Control Manual for the aircraft type. In addition, Bombardier Aerospace will add V_{md} tables to the aircraft Quick Reference Handbook (QRH) to provide flight crews with readily available information on speed limitations.

Air Canada Jazz introduced a nine-module "High Altitude and High Speed Training" program for all CRJ705 pilots. Company operations on the type were limited to FL 350 until all pilots completed the training. Air Canada Jazz also developed a Quick Reference chart for pilot use in plotting V_{md} versus aircraft weight, altitude, and air temperature. Amendments were made to the company Aircraft Operations Manual warning crews of the importance of adhering to published climb schedules. It also emphasized that the CRJ705 may not accelerate or maintain cruise altitude if speed is allowed to deteriorate below V_{md}. Minimum recommended holding and manoeuvring speeds were charted as a function of altitude.

In August 2005, Transport Canada published Commercial and Business Aviation Advisory Circular No. 0247. This circular provided guidance and recommendations to operators for stall recovery training and checking, with the goal of ensuring that flight crews recognize early indications of an approach to a stall and apply the appropriate recovery actions to prevent an aeroplane from entering a stall or upset.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 27 July 2006.

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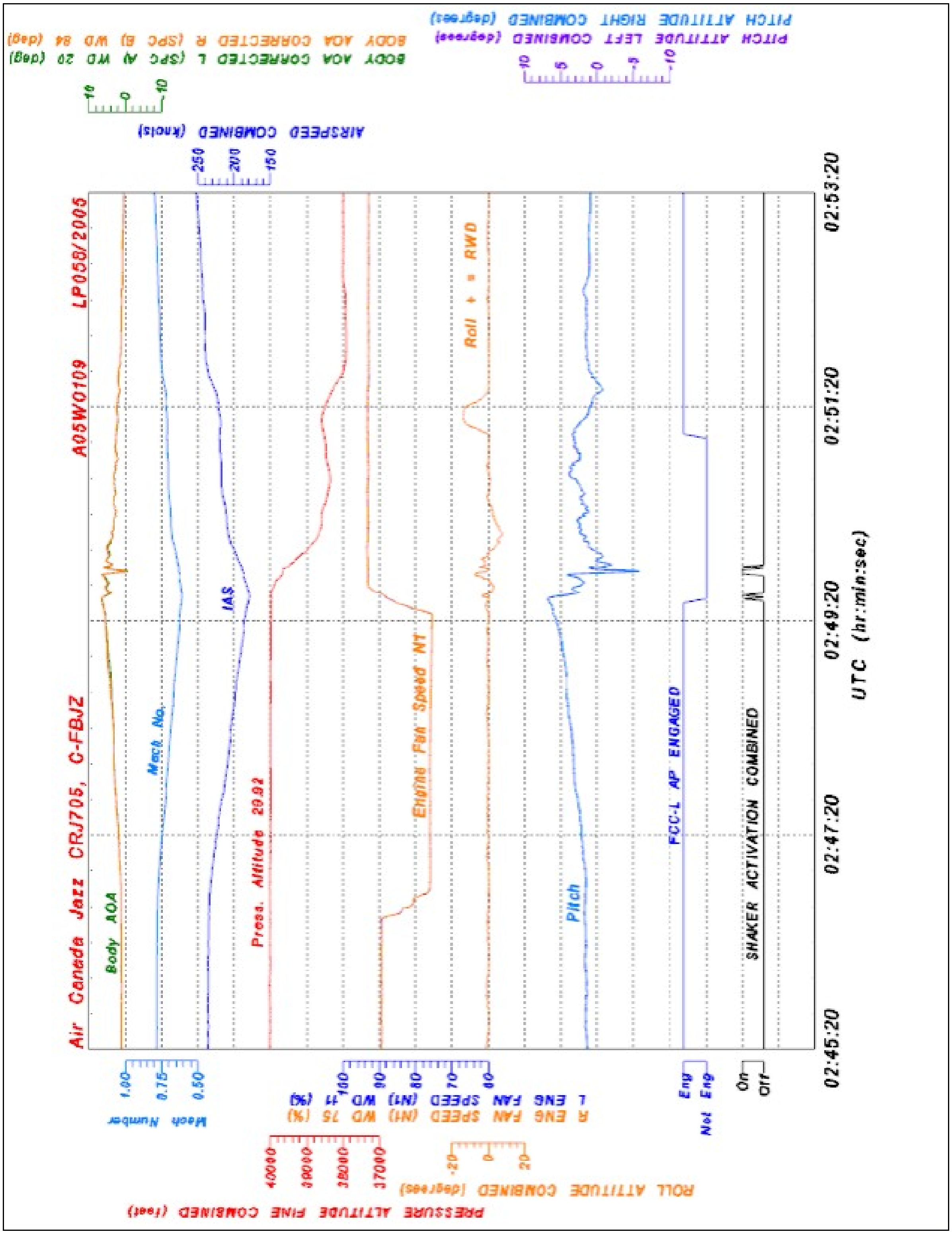
Appendix A – Digital Flight Data Recorder Plot – Event Overview



Appendix B – Digital Flight Data Recorder Plot – Event Close-up