Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A08C0164

AIRSPEED DECAY — UNCOMMANDED DESCENT

AIR CANADA JAZZ
BOMBARDIER CRJ 705, C-FNJZ
WINNIPEG, MANITOBA, 180 nm SE
01 AUGUST 2008

Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

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Summary

The Air Canada Jazz Bombardier CL-600-2D15 (CRJ 705), registration C-FNJZ, serial number 15046, operating as JZA 8491, departed Toronto, Ontario, at 2315 eastern daylight time on 31 July 2008 for Winnipeg, Manitoba, with 75 passengers and 4 crew on board. After passing Thunder Bay, Ontario, JZA 8491 climbed to the planned flight level of 380. After levelling-off, the captain reduced the engine power. About 17 minutes later, the crew noted a rumbling sound and the aircraft began an uncommanded descent. Control was re-established and the aircraft levelled-off after an altitude loss of about 4600 feet. During the recovery, the engines experienced an uncommanded power reduction but recovered without action by the crew. One passenger sustained minor injuries as a result of the uncommanded descent. JZA 8491 landed at Winnipeg on 01 August 2008 at 0052 central daylight time without further incident.

Ce rapport est également disponible en français.

Other Factual Information

The forecast conditions for flight level (FL) 380 were: winds 280 degrees true at 75 knots; temperature -51° C. JZA 8491 experienced smooth atmospheric conditions in cruise at both FL 360 and FL 380 in predominately clear skies. Sigmet S4, a report of significant meteorological conditions issued at 2346 central daylight time [1] on 31 July 2008, indicated a line of thunderstorms near Dryden, Ontario, topped at FL 330 about 30 miles north of the intended route of flight. Air traffic control provided JZA 8491 with a small deviation from the flight planned route to avoid these thunderstorms. The crew observed them on the cockpit weather radar and visually watched the intense and spectacular display.

The aircraft captain, the pilot flying (PF), used a power setting of 86 per cent engine fan speed (N1) to maintain an airspeed of Mach .77 at FL 360 until Thunder Bay. After passing Thunder Bay, the PF climbed to FL 380 at climb thrust, levelling off utilizing the autopilot. This was a planned climb and the conditions at the flight level were suitable for the aircraft weight. While the autopilot could capture and maintain altitude and track, it did not have an auto thrust feature and required the PF to manually set the thrust for the desired cruising speed of Mach .77. The thrust setting is selected by the PF based on experience.

After levelling at FL 380 the thrust was left at climb thrust to accelerate to the programmed cruise speed of Mach .77. The programmed speed was exceeded and the PF reduced the engine thrust to approximately 86 per cent N1 to allow it to slowly decelerate to the desired Mach. The intention was to monitor the speed and adjust the power when Mach .77 was attained. The aircraft flight planning and cruise control manual, not normally referenced in flight, indicated that the thrust setting required to maintain Mach .77 for the actual conditions at FL 380 was approximately 87.3 per cent N1. Moreover, the aircraft manufacturer assessed the selected power setting to be below that required to maintain minimum drag speed.

About two minutes after the power was set, an airspeed of Mach.77 had been reached and, as shown by the airspeed trend line indicator [2], was stabilized and confirmed as such by the crew. The power setting was not, however, readjusted.

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1 All times in the report are central daylight time (Coordinated Universal Time [UTC] minus six hours) unless otherwise stated. Times in the appendices are in UTC.

2 Airspeed is displayed on a moving vertical tape on the primary flight display. An arrow points to the current airspeed. The pilot can set a magenta reference marker or bug to the desired airspeed. When the head of the arrow is in the notch of the airspeed bug, the aircraft is at the desired airspeed. The trend line is a magenta line originating from the tail of the arrow pointer. The line is upward for increasing speed and vice versa. The end of the trend vector indicates the airspeed value in 10 seconds at the current rate of acceleration. The parameter resolution is one knot change in 10 seconds.

Once established at Mach .77 at FL 380, the crew engaged in several activities for about the next 17 minutes. Because the cockpit voice recorder (CVR) was overwritten after the aircraft landed at Winnipeg, the sequence and extent of these activities could not be rigorously established. During this time, the crew re-programmed the flight management system (FMS) for the weather deviation. They discussed the approach to land in Winnipeg and reprogrammed the FMS again for the approach. There were at least three visits to the flight deck by members of the cabin crew. The captain was served a meal and coffee was provided for the first officer. During these visits to the flight deck, the lightning display was the subject of some discussion. Both the captain and first officer monitored the storm cells on the radar display and manipulated the radar controls to identify cells. The crew also monitored the traffic collision avoidance display and were aware of several flights that were operating in its vicinity.

According to the digital flight data recorder (DFDR), approximately two minutes after levelling off, a stable airspeed of Mach .77or 243 knots indicated airspeed (KIAS) was maintained for several seconds only, after which it began to decrease. Gradually, over a period of about 17 minutes, the airspeed decreased to 180 KIAS [3] as the angle of attack (AOA) gradually increased while the autopilot attempted to maintain altitude. Engine N1's and fuel flows also decreased about one per cent and 200 pounds per hour respectively as the aircraft decelerated. The aircraft was not equipped with auto thrust capability to maintain a selected speed or Mach number and the DFDR showed that the power levers were not adjusted in this timeframe.

The aircraft does not have an early speed decay audio or visual warning other than low-speed visual cues on the airspeed indicator itself; monitoring of the airspeed and engine performance was an essential crew function. The gradual decrease in airspeed and engine indications was not observed by the crew. At approximately 0010, a rumbling sound was heard and a vibration was felt throughout the aircraft. The crew believed that an engine anomaly was occurring, analyzed the engine display, but found no indication of engine abnormality. The autopilot then disengaged and the stick shaker activated. The captain took control and advanced the power levers within two seconds. The stall light illuminated and the warbler tone associated with the stall protection system (SPS) sounded. The stick pusher activated and re-activated a further four times over a period of about 32 seconds as the captain attempted to recover with minimum altitude loss. Control of the aircraft was re-established and the aircraft levelled off after an altitude loss of approximately 4600 feet.

The crew was unaware that the airspeed had decreased and did not identify the cause of the rumbling. Analysis of the DFDR and the memory of the full authority digital engine control (FADEC) indicated that, when the power levers were advanced in response to the stick shaker and pusher activation, the engines (General Electric CF-34-8C5) responded but then spooled down to 49 per cent N1 and then recovered without input from the crew. The crew did not observe this rundown during the event. The SPS performed as designed. Movement of the control column and changes in the pitch angle of the aircraft were indicative of a pilot-induced oscillation. The SPS automatically activated the engine igniters as soon as the AOA exceeded the auto ignition firing angle. This occurred just prior to stick shaker activation.

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3 See *Appendix A – FDR Plot – Event Overview* and *Appendix B - Event Close-up*

The non-volatile memories from both engine FADEC's were downloaded by the operator and forwarded to the manufacturer, GE Aviation, for analysis. DFDR data shows both engine fuel flows dropped significantly on both engines eight seconds after the stick pusher activated in response to the high angle of attack and the resultant lack of airflow. The right engine FADEC registered an indication that the FADEC parameters for engine flameout had been reached 19 seconds after the stick shaker was activated. The left engine FADEC did not register such an indication. The SPS had already energized the igniters of both engines in the stall condition to prevent engine flameout. Thirty-four seconds after the uncommanded power reduction, both engines responded to the power lever positions set by the PF in response to the shaker and pusher activation.

Both crew were licensed and qualified in accordance with existing regulations. The captain had about 8000 hours of total flying time with approximately 2000 hours on the CRJ series aircraft. The first officer had approximately 13 000 hours of total flying time with about 1600 hours on the CRJ series aircraft.

During the 15-day period prior to the incident flight, the captain worked a series of irregular shifts, with start times ranging from 1715 to 2145. Finishing times ranged from 0700 to 2315. In this time period, the captain experienced some difficulty maintaining a regular sleep pattern. When the captain's work schedule permitted him to sleep at home, he would sleep either from 0200 to 1000 or from approximately 1100 to 1500, depending on the schedule. The captain did not work from July 19 to 21 inclusive or from July 24 to 27 inclusive. On the day of the occurrence, 30 July 2008, the captain woke up at 1215 after sleeping for about nine hours and reported for duty at 1730. At the time of the occurrence, he had been on duty for about eight hours and his work schedule conformed to flight duty time limitations established in subsection 700.16(1) of the *Canadian Aviation Regulations*.

During the period of July 24 to 26, the first officer worked during the day and was able to sleep from about 2300 to 0800. The first officer did not work from July 27 to 30 and was able to sleep during the night. He awoke at approximately 0800 on July 31 and remained awake throughout that day. He reported for duty at 1730 on 31 July 2008. At the time of the occurrence, he had been on duty for about eight hours.

Irregular sleep patterns are known to result in circadian rhythm disturbances that can lead to fatigue [4]. The risk of fatigue and fatigue-related performance decrements is increased when circadian rhythm disruptions are coupled with variable sleep patterns and sleep deprivation, which often result from an irregular and extended work schedule. This type of schedule can, therefore, result in fatigued flight crews.

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4 A. K. Pati, A. Chandrawanshi, and A. Reinberg, *Shift work: Consequences and management*, Current Science, 2001, 81(1), pages 32-52

Forgetting to adequately monitor for the appropriate moment to perform an action is a common phenomenon [5]. This phenomenon is more prevalent when a distraction occurs in the middle of a task [6], such as monitoring, and no overt cues, such as alarms, are in place to remind pilots to return to the monitoring task.

A review of the radar tapes indicated that the wake turbulence of other traffic in the vicinity of JZA 8491 would not have affected the flight.

For an aircraft similarly configured, the CRJ 705 SPS provides a minimum five per cent margin between stall warning and stall identification. In this context, stall warning is provided in all configurations by the stick shaker and was considered clear and distinctive [7]. Stall identification is considered to be by means of the stick pusher. Certification testing reports indicate that, in the configuration of the aircraft during the occurrence, light airframe buffet was present at low altitudes just before pusher activation, but was present earlier at higher altitudes and, in some cases, prior to stick shaker activation.

The manufacturer does not consider airframe vibration/buffeting to provide either stall warning or stall identification on the CRJ 705. Although buffeting is characteristic of the stalling behaviour of the aircraft, it is not considered to be significant in terms of SPS design or operation. The manufacturer does not provide any information with respect to the vibration/buffeting characteristic in either the airplane flight manual (AFM) or the flight crew operating manual (FCOM).

Since the Air Canada Jazz aircraft operating manual (AOM) is based on information extracted from the AFM and FCOM, it does not provide information with respect to the vibration/buffeting characteristic. The Air Canada Jazz AOM, Volume 2, indicates that, in the event of a stall warning at high altitude, it may be necessary to reduce pitch angle slightly to achieve a suitable acceleration. It also notes that if a full stall occurs, the nose must be lowered and some altitude lost for recovery. The Air Canada Jazz AOM, Volume 1, indicates that the SPS will activate the stick pusher before the angle of attack reaches the critical stall point. If the SPS detects a rapid increase in angle of attack, it will lower the point at which the stick shaker and stick pusher will activate.

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5 J. Nowinski, J. Holbrook, and R. Dismukes, *Human memory and cockpit operations: An ASRS* [aviation safety reporting system] *Study*, in Proceedings of the 12th International Symposium on Aviation Psychology, 2003, pages 888-893. Dayton, OH: The Wright State University

6 M. Botvinick, and L. Bylsma, *Distraction and action slips in an everyday task: Evidence for a dynamic representation of task context*. Psychonomic Bulletin & Review, 2005, 12(6), pages 1011-1017

7 In accordance with United States Federal Aviation Regulation/Joint Aviation Requirement 25.207 Air Worthiness Standards: Transport Category Airplanes.

Transport Canada Commercial and Business Aviation Advisory Circular (CBAAC) No. 0247, Training and Checking Practices for Stall Recovery, has the stated goal of ensuring 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. The circular recommends ground training in stall and low-speed buffet characteristics specific to the aeroplane type, as well as simulator training.

Information provided by the operator indicated that, prior to this incident, stall training for the CRJ 705 was provided on the initial type rating course and bi-annually during recurrent simulator training [8]. The initial training focused mainly on stall characteristics at 10 000 feet, although one demonstration was performed at high altitude on the CRJ 200 only. The CRJ 200 does not have the same stall characteristics as the CRJ 705 at altitude. During recurrent simulator sessions, the stall training focused on low-altitude operations, with the occasional demonstration at a simulated high altitude. No discussion occurred about airframe buffet occurring before activation of the stick shaker. Engine vibration scenarios were included in simulator sessions, which produced an airframe vibration similar to the airframe buffeting experienced by the crew during the occurrence.

Analysis

The initial setting of engine fan speed requires close attention to the airspeed to obtain the target speed. The apparent stabilization of the speed at the target speed for several seconds about two minutes after the adjustment gave the crew the impression that they were stabilized even though the N1 setting was the same as the N1 used at FL 360. At FL 380, a higher setting of about 87.3 per cent N1 was required. Since the power setting was also lower than the power setting to maintain the minimum drag speed, continuous deceleration of the aircraft resulted. The distractions in the cockpit over the period of 17 minutes, the lack of any noticeable change in the behaviour of the aircraft, and the absence of a warning of the airspeed deviation contributed to the prolonged false perception of the crew. These issues likely led the crew to forget to carry out routine cockpit checks and instrument scans that would have revealed the decline in airspeed and permitted timely corrective action.

The crew's initial reaction to the vibration and rumble was to look for and react to an engine problem based on their simulator training. Since they had not been provided with information with respect to the vibration/buffeting characteristic, they did not recognize the impending stall until the stick shaker activated. When it activated, the captain's response was immediate and the power levers were moved within two seconds to maximum thrust. As the captain made pitch inputs to minimize altitude loss, he likely created changes in the angle of attack and the rate of change that likely lowered the trip point of the stick pusher. The activation of the stick pusher indicates that the aircraft was in a stall condition. These pilot-induced oscillations were repeated several times and accounted for most of the altitude lost during the occurrence. Although the rundown and subsequent self-recovery of the engines did not contribute to the stall condition, the altitude loss would likely have been less significant had the engines been developing maximum power during the stall recovery.

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8 All Air Canada Jazz CRJ pilots are dual qualified on the CRJ 200 and CRJ 705 and recurrent training alternates annually between the two aircraft types.

The crew's sleep and wake patterns were examined to determine whether fatigue may have been a contributing factor to the occurrence. Significant performance degradation due to fatigue was determined to have been unlikely at the time of the occurrence. However, several times during the preceding two weeks, the captain's work schedule resulted in irregular sleep patterns that had the potential to increase the risk of fatigue and fatigue-related performance decrements, and the captain had likely flown while fatigued during that time.

Since the CVR was overwritten after the flight arrived at the gate, valuable voice and aural information was lost that was essential to analyzing the crew's actions during the event.

The following TSB Engineering Laboratory report was completed:

LP 104/2008 - FDR/SPS Analysis

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

Findings as to Causes and Contributing Factors

1. After levelling off at flight level 380, the engine N1 settings were set too low and, because the autopilot was set to maintain altitude, a gradual, continuous reduction in airspeed occurred.

2. The crew became distracted and did not carry out routine cockpit checks and instrument scans, causing the slow, gradual, and continuous reduction in airspeed to go undetected.

3. The lack of information concerning the characteristics of high-altitude stalls likely affected the crew's recognition of the impending stall condition and delayed initiation of recovery action.

4. The lack of training in high-altitude stall recovery likely reduced the captain's ability to recover effectively. Pilot-induced oscillations likely caused the stick pusher to activate several times during the occurrence.

5. During the aircraft stall, both engines experienced an uncommanded power reduction, resulting in a greater loss of altitude than if full power had been available.

Findings as to Risk

1. Although it is unlikely that the crew were fatigued at the time of the occurrence, the captain's work schedule resulted in irregular sleep patterns that had the potential to increase the risk of fatigue and fatigue-related performance decrements.

2. A lack of recorded voice and other aural information due to the overwriting of the cockpit voice recorder (CVR) can inhibit safety investigations and delay or prevent the identification of safety deficiencies.

Safety Action Taken

Following this incident, the operator enhanced stall training. During initial training, the course remains largely unchanged and will continue to include multiple low-altitude stall demonstrations and a single high-altitude stall demonstration. Once pilots undergo CRJ 705 differences training (immediately following their CRJ 200 type rating), a detailed review of stalls will occur, including low-altitude and high-altitude stall characteristics, stall protection system (SPS) operation, aircraft buffeting, and flight characteristics and performance. This training will include a ground briefing and at least three demonstrations of stalls at high altitude.

During the recurrent training cycle beginning 01 July 2009, stall training will continue on an annual basis. This training will continue to cover stalls at 10 000 feet, but a discussion/demonstration of high-altitude stalls will occur each time. This training will include a review of low-altitude and high-altitude stall characteristics, including SPS operation, aircraft buffeting, and flight characteristics and performance. This stall training will alternate between the CRJ 200 and CRJ 705 aircraft types.

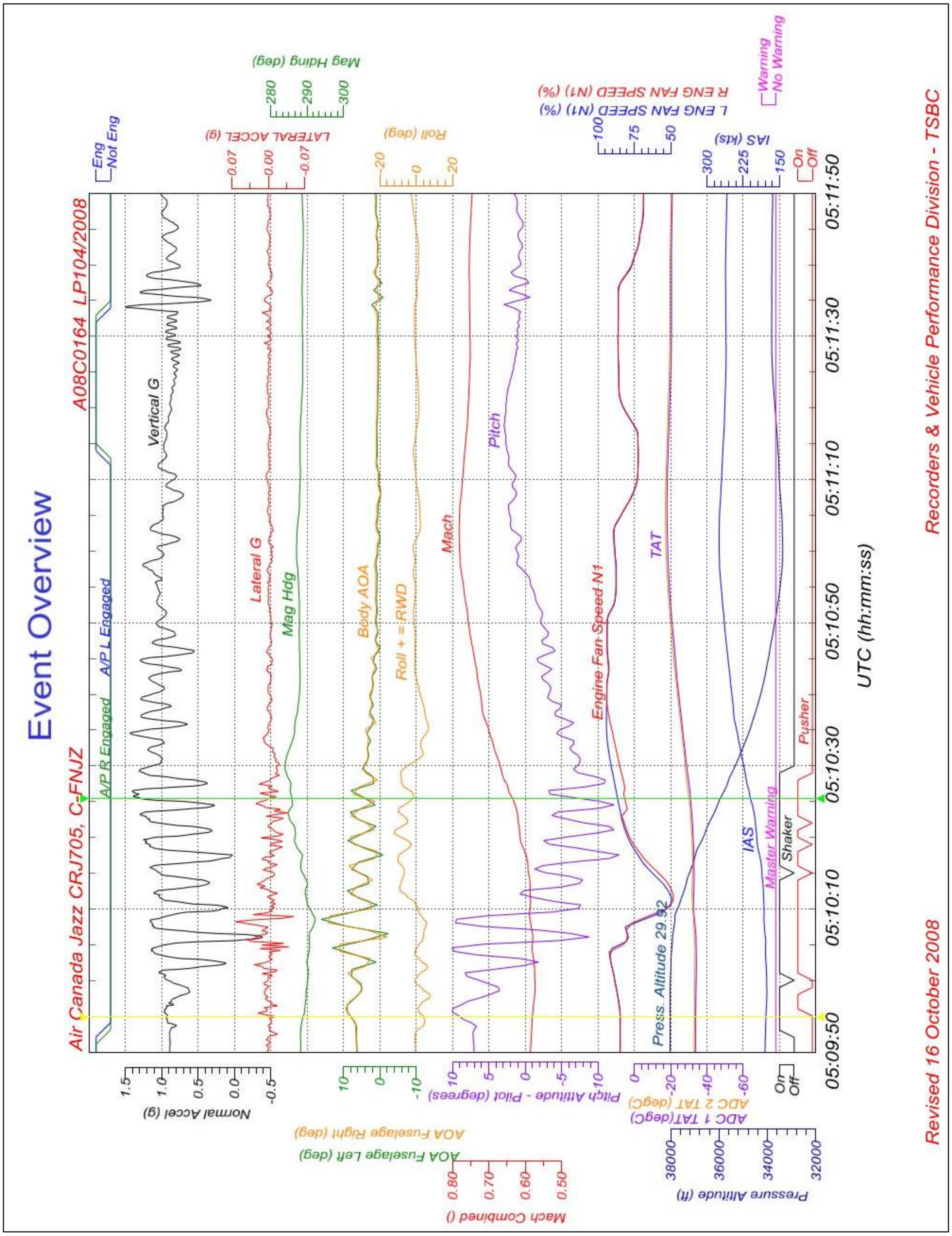
The Air Canada Jazz Corporate Safety and Quality department has used this investigation as an example within the human factors and crew resource management training module of recurrent training beginning in January of 2009.

The TSB issued Aviation Safety Advisory A08C0164-D1 CRJ 705 High-Altitude Stall Characteristics on 18 November 2008 to Transport Canada, stating that other operators of the CRJ 705 and other aircraft of the CRJ series with similar stall characteristics should be aware that buffeting may occur prior to the stall warning of the stick shaker at higher altitudes.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 29 April 2009.

*Visit the Transportation Safety Board's Web site (**www.tsb.gc.ca**) for information about the Transportation Safety Board and its products and services. There you will also find links to other safety organizations and related sites.*

Appendix A – Event Overview



Appendix B – Pre-Event Overview