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ATSB TRANSPORT SAFETY REPORT
Aviation Occurrence Investigation AO-2011-036
Final

Stall warning device event, VH-TQL Sydney Airport, New South Wales 1 March 2011

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Abstract

On 1 March 2011, a QantasLink Bombardier Inc DHC-8-315, registered VH-TQL, was conducting a regular public transport flight from Tamworth Airport to Sydney Airport, New South Wales. The crew were conducting a Sydney runway 16 left (16L) area navigation global navigation satellite system (RNAV(GNSS)) approach in Vertical Speed (VS) mode. The aircraft's stickshaker stall warning was activated at about the final approach fix (FAF). The crew continued the approach and landed on runway 16L.

The stickshaker activated at a speed 10 kts higher than was normal for the conditions. The stall warning system had computed a potential stall on the incorrect basis that the aircraft was in icing conditions. The use of VS mode, as part of a line training exercise for the first officer, meant that the crew had to make various changes to the aircraft's rate of descent to maintain a normal approach profile.

On a number of occasions during the approach the autopilot pitched the aircraft nose up to capture an assigned altitude set by the pilot flying. The last recorded altitude capture occurred at about the FAF, which coincided with the aircraft not being configured, the propeller control levers being at maximum RPM, and the power levers at a low power setting. This resulted in a continued speed reduction in the lead-up to the stickshaker activation.

Each factor that contributed to the occurrence resulted from individual actions or was specific to the occurrence. The Australian Transport Safety Bureau is satisfied that none of these safety factors indicate a need for systemic action to change existing risk controls. Nevertheless, the operator undertook a number of safety actions to minimise the risk of a recurrence.

In addition, the occurrence highlights the importance of effective crew resource management and of the option of conducting a go-around should there be any doubt as to the safety of the aircraft. Transport Canada, which regulates the aircraft manufacturer, advised that it will publish a summary of this occurrence and recommend that operators consider using it in their scenario-based crew resource management training programs.

FACTUAL INFORMATION

Sequence of events

At about 1810 Eastern Daylight-saving Time[1] on 1 March 2011, the flight crew of a Bombardier Inc DHC-8-315 (DHC8), registered VH-TQL and operating as QantasLink Flight 2007, was conducting a regular public transport flight from Tamworth Airport to Sydney Airport, New South Wales. The captain, who was pilot not flying (PNF), and the first officer, who was the pilot flying (PF) conducted an approach to land at Sydney using the runway 16 left (16L) area navigation global navigation satellite system (RNAV(GNSS)) approach. The instrument landing system (ILS) approach that was normally used for an approach and landing on this runway was not operative at the time.

1 Eastern Daylight-saving Time was Coordinated Universal Time (UTC) + 11 hours.

Both pilots stated that an approach brief was completed and that the brief included an overview of the approach chart procedure, the missed approach procedure and the identification of any additional restrictions or requirements. The approach was conducted with the autopilot engaged and using the flight director in Vertical Speed (VS) mode, rather than the Vertical Navigation (VNAV) mode. The VNAV mode uses a higher level of automation than the VS mode, which maintains a constant descent profile to an assigned altitude entered by the crew. When the assigned altitude is reached, the aircraft flight director and autopilot automatically levels the aircraft off unless another, lower altitude has already been entered.

The flight crew reported that the approach was commenced in instrument meteorological conditions (IMC) but as it progressed they became 'visual' and operated in visual meteorological conditions (VMC)[2] until landing.

The captain stated that, approaching the initial approach fix (IAF[3] - see Appendix A), the crew had started to feel some time pressure to complete all of the necessary checklist items and actions for the approach. It was at this point that the captain identified that the aircraft was no longer in icing conditions and so turned off the ice protection switch, without informing the first officer. During this action, the captain did not turn off the increased reference speed switch. That switch is selected ON for flight in icing conditions and sets the stall warning to activate at a lower angle of attack (thus raising the speed at which the stall warning activates).

The captain reported initially being high on profile during the approach, however by the 'SYDLI' intermediate fix (Figure 1), the aircraft was back on profile but as a result needed to slow down. In response, the captain selected the propeller control levers to maximum RPM, which changed the pitch of the propellers and effected a significant slowing of the aircraft. In addition, the first officer reported that the power levers were retarded to flight idle from about the SYDLI position fix until the final approach fix (FAF)[4]. The use of maximum RPM at this point in the approach, rather than at the FAF, was not considered normal practice by the operator.

The first officer reported that, despite approaching the FAF, they had not yet configured the aircraft for landing with flap extended or the landing gear down. In contrast, the captain stated that the landing gear was down prior to the FAF but the flaps were not extended.

The first officer adjusted the assigned altitude in the flight director system during the approach; however, the captain indicated that these adjustments were not happening fast enough to allow a continuous descent, and that the autopilot kept capturing the assigned altitude and levelling off.

Prior to the FAF, the captain noticed the airspeed was decreasing through 130 kts and called 'airspeed'. The recorded flight data showed that at about this time the autopilot commenced pitching the aircraft up in anticipation of capturing the preselected altitude set by the first officer. This further reduced the airspeed to around 114 kts, the stickshaker activated and the autopilot disconnected.

The captain called 'stickshaker', took over as PF and momentarily advanced the power levers before continuing the descent. The first officer reported assuming the role of PNF and conducted the checklist items in preparation for landing, including selecting flap 15.

The aircraft continued on the RNAV(GNSS) approach and the crew reported they were stable by 500 ft, in accordance with the operator's stable approach procedure. They then conducted a landing on runway 16L. After landing the first officer noticed the increased reference speed switch was still in the ON position.

2 Visual Meteorological Conditions is an aviation flight category in which visual flight rules (VFR) flight is permitted—that is, conditions in which pilots have sufficient visibility to fly the aircraft maintaining visual separation from terrain and other aircraft.

3 The initial approach fix was a published position on an instrument approach chart that indicated the start of the initial approach segment.

4 The final approach fix was a published position on an instrument approach chart that indicated the start of the final approach segment.

Pilot information

Captain

The captain held an Air Transport Pilot (Aeroplane) Licence (ATPL(A)) that was issued in 1995. The captain had accumulated a total aeronautical experience of about 11,195 flying hours, with about 6,666 hours on the DHC8. Of those hours on type, 126 hours were accumulated in the last 3 months. The captain was appropriately endorsed and held a valid Class 1 Medical Certificate and Multi Engine Command Instrument Rating (MECIR).

First officer

The first officer held an ATPL(A) that was issued in 2005. The first officer had accumulated a total aeronautical experience of about 3,250 hours, with about 26 hours on the DHC8. All of the hours on the DHC8 were line training and had occurred within the last 2 weeks.. The first officer was appropriately endorsed and held a valid Class 1 Medical Certificate and MECIR.

The first officer had recently received an endorsement and commenced line training in the DHC-8 on 16 February 2011. The training notes from the first officer's endorsement indicated there had been a recurring issue with speed, descent and power management during approaches, which resulted in an unsatisfactory rating for these areas in two simulator exercises. The training notes showed the first officer had successfully repeated these exercises before undertaking the next training session.

According to the training file, the first officer satisfactorily completed the endorsement training program.

General

As part of the company training program, all pilots initially completed Crew Resource Management (CRM) and Threat and Error Management (TEM) training as part of the induction program. CRM/TEM training then formed part of flight crew's annual recurrent training.

Crew resource management is a strategy for pilots to effectively use all available resources (including other crew, ATC, equipment and information).[5]

Approach Procedures

The operator's standard operating procedures (SOP) required that, when conducting an instrument approach, the relevant aircraft speed and configuration[6] should be accomplished prior to a defined position in the approach. For an RNAV (GNSS) approach, the crew was required to achieve a speed reduction to 180 kts by the IAF. From the IAF, the aircraft was to be slowed further to a speed below 163 kts and then to 150 kts, with the PF expected to achieve a target speed of 120 to 130 kts by the FAF.

Before the aircraft passed the FAF, the operator's SOP required that the PF would request the PNF to select the gear down, set the flaps to 15 and initiate the landing checklist. The crew reported that the aircraft's speed was not stable and the configuration was not finalised prior to reaching the FAF.

At the FAF, the propeller control levers were to be advanced to provide maximum RPM, the landing checklist was to be completed and the speed reduced to Vref[7]+5 to Vref+20 kts by 500 ft above ground level (AGL). If these conditions were not met by 500 ft AGL, a go-around was to be conducted. Additionally, according to the operator's flight administration manual (FAM):

> Flight Crew are encouraged to perform a missed approach whenever any doubt exists as to the safe continuation of an approach and landing.

Previous stickshaker occurrences prompted the operator to issue a safety alert and safety investigation bulletins to all operating crew. These

5 Salas E., Wilson, K.A. & Burke C.S (2006). Does Crew Resource Management Training Work? An Update, an Extension, and Some Critical Needs. *Human Factors*, 48(2) 392-412.

6 The position of the aerodynamic elements of an aircraft that are variable by the pilot (principally control surfaces and landing gear).

7 Vref. Reference speed that is commonly used to determine an aircraft's approach speed. Vref is Vs multiplied by a factor of 1.3. Vs is the minimum indicated airspeed at which the aeroplane exhibits the characteristics of an aerodynamic stall.

notices highlighted the importance of crews following SOPs and monitoring all stages of the approach. They also highlighted the need for crews to adhere to the SOPs for ceasing the use of all ice protection systems after exiting icing conditions. In addition, the safety alert detailed strategies for profile management and aids for maintaining situation awareness.

With regard to the use of automation, the company's DHC8 Flight Crew Operating Manual (FCOM) stated:

> Use of the autopilot is encouraged for all RNAV (GNSS) approaches to reduce workload…

The autopilot can be used with the flight director in either VNAV or VS mode for an RNAV approach.

Stall warning system

Based on the aircraft's weight and using data available in the operator's FCOM, the flap 15 stalling speed of the aircraft at the time of the occurrence was 81 kts. In contrast, the flap 0° stalling speed was 99 kts.

The aircraft's stall warning system consisted of two stall warning computers, an angle of attack (AOA) vane on each side of the forward fuselage, a stickshaker on each control column, and a stick push actuator.

The aircraft's two stall warning computers received AOA data from the respective AOA vanes, as well as true airspeed, flap angle and pitch rate information. The computers used that information to determine a compensated angle which, if greater than the stall warning threshold angle, would activate the stickshaker. That activation occurred at a speed of 6 to 8 kts above the computed stall speed.

If action was not taken by the flight crew in response to the stickshaker, and an aerodynamic stall was encountered, the stall warning computer would activate a stick push actuator to drive the control column forward. This would decrease the aircraft's AOA to aid in the recovery from the stall.

According to the operator's SOPs, the recovery action following a stickshaker was to simultaneously:

- Call stickshaker
- Advance power levers to within 10% of MTOP[8] then adjust for maximum power
- Select flap 15 if flap 35 is extended
- Gear up with positive rate of climb
- Select flap zero when IAS[9] is above flap retraction speed

The aircraft manufacturer advised that recent updates to the aircraft flight manual include an immediate reduction in pitch attitude in response to a stickshaker activation, as well as stating that no configuration changes should be made.

Human factors

The first officer reported that, after passing the IAF, there was an increase in workload, predominantly due to conducting an unfamiliar approach as PF and commencing the approach in IMC. In addition, the approach was being conducted in VS mode, which the first officer had reportedly not used for an approach during line flying. Use of the VS mode required more mental calculations and data entry inputs by the PF to meet the descent profile targets than would be necessary using VNAV mode (where data entry is done before descent and the autopilot flies the required descent path).

The captain reported that the use of VS mode was to increase the first officer's awareness of groundspeed and vertical speed. The aim was to increase the first officer's skill at maintaining a vertical profile without the use of VNAV mode.

The captain also stated that, as a result of previous flights with the first officer, he anticipated an increase in his own workload due to the need to monitor the approach and the actions of the first officer. Both flight crew reported that the clearance to conduct an RNAV(GNSS) approach caught them by surprise as they were expecting another approach type. They both commented that this increased the time pressure, as they had to unexpectedly re-brief for the RNAV(GNSS) approach.

The first officer and captain both reported inter-personal communication issues with the other pilot prior to the commencement of the

8 Maximum take-off power.

9 Indicated airspeed.

approach. The first officer reported not feeling comfortable speaking up in the line training environment. As a result, the first officer had been scheduled to fly with another line training captain, which was to take effect in the days following the occurrence.

Both of the flight crew also reported issues during the approach. The use of non-standard phraseologies by the first officer, and that the captain was not aware the first officer was feeling overloaded, affected the conduct of the approach.

When learning a new skill, individuals move from what is known as knowledge-based performance to skill-based performance.[10] Skill-based actions are possible once an individual is very familiar with a task and they have repeated it to an extent that the actions become predominantly automatic and do not need conscious oversight. Knowledge-based performance is typical during unfamiliar or novel situations and, by contrast to skill-based performance, requires more conscious oversight and typically uses greater mental resources, increasing mental workload.

ANALYSIS

The stickshaker activation was because the aircraft's speed had slowed to the computed stall reference speed. In this case, due to the increased reference speed switch being left on, the stickshaker activated 10 kts higher than normal for the aircraft's configuration. The aircraft was not configured in accordance with the operator's standard operating procedures (SOP) for the approach. This also contributed to the stickshaker activating at a higher reference speed than if the aircraft was appropriately configured.

In addition, the target airspeed range of 120 to 130 kts for this stage of flight was not met and the action of the autoflight system's altitude capture feature, which raised the aircraft's nose to maintain altitude and resulted in a further decrease in airspeed. This speed reduction also contributed to the stickshaker activating.

Following the stickshaker activation at around the final approach fix (FAF), the aircraft was not configured for landing and the speed was not stable. According to the operator's SOPs, if the safe continuation of the flight is in doubt, a go-around is to be conducted. Given a stickshaker activation is an indicator of an impending stall, which could affect the safety of the flight, a lower risk option for the crew was to have conducted a go-around.

The first officer's training in the simulator had identified performance issues with speed, descent and power management during the approach and landing phase. While the first officer was successfully re-trained in the simulator during the endorsement, some of these issues reappeared during the RNAV(GNSS) approach to Sydney.

The use of VS mode for the approach was a deliberate decision by the captain to make the first officer consider the vertical profile and power management. While this technique had reportedly helped other first officers in this situation, it would appear that for the first officer's level of training and experience, the use of VS mode was not appropriate and unnecessarily increased the workload of both flight crew.

The flight crew reported feeling time pressured during the approach, which increased their workload. As a result the captain turned off the ice protection system without informing the first officer. While this action was done as a result of the captain identifying and completing a required action, it was not conducive to a shared understanding of the system state by both crew. There is a need for clarity in operating roles and close adherence to SOPs during normal operations and this is particularly important in the line training environment, given the first officer's level of experience.

Despite the mismanagement of the speed and power during the approach by the first officer, which necessitated the selection of maximum RPM by the captain in order to slow down, the captain did not take over prior to the stickshaker activation, nor was a go-around initiated when the activation occurred. Although the decision of the captain to continue with the approach did not result in a further incident, the lower risk option is for flight crew to discontinue an approach or landing if at any stage there is any doubt as to the safe continuation of the flight.

10 Rasmussen, J. (1983). Skills, Rules, and Knowledge; Signals, Signs, and Symbols, and Other Distinctions in Human Performance Models. *IEEE Transactions on Systems, Man & Cybernetics, SMC;* 13(3).

The inter-personal communication issues reported by both crew appears to have affected their interactions and the learning opportunities for the first officer in the line training environment. This was supported by the fact that despite having completed crew resource management (CRM) training, the first officer reported feeling unable to report feeling overloaded to the captain at the beginning of the approach. The first officer's performance during the approach may have affected the captain's decision to continue following the stickshaker activation, as conducting a missed approach or go-around with the first officer overloaded may have further increased the workload of both flight crew.

The reported workload of the first officer during the approach, combined with the level of unfamiliarity of both the approach and the aircraft's automation, is typical of knowledge-based performance. That is, the first officer's performance was indicative of increased mental effort and workload, as opposed to the predominantly automatic actions used when conducting a highly familiar task.

As set out below, the investigation identified a number of factors that contributed to the occurrence. Each resulted from individual actions or was specific to the occurrence. The ATSB has assessed each of these safety factors and is satisfied that none of them indicated a need for organisational or systemic action to change existing risk controls. However, the investigation did highlight the importance of effective CRM and of the option of conducting a go-around should there be any doubt as to the safety of the aircraft.

FINDINGS

From the evidence available, the following findings are made with respect to the stall warning device event involving Bombardier Inc DHC-8-315 aircraft, registered VH-TQL, at Sydney Airport, New South Wales on 1 March 2011. They should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The stickshaker system activated during the approach as a result of the increased reference speed switch being in the ON position, the associated computed reference speed being reached, and the aircraft not being configured in accordance with standard operating procedures.
- A lack of communication and ineffective crew resource management between the flight crew and non-adherence to the operator's standard operating procedures adversely affected crew actions and coordination.
- Due to time pressure, inadequate crew resource management and the increased workload of both flight crew, the RNAV approach was not flown in accordance with standard operating procedures.

Other safety factors

- Despite being aware that at the Final Approach Fix the aircraft was not appropriately configured, and the resulting stickshaker activation, the crew did not initiate a go-around/missed approach as recommended by the operator's guidance material.
- The conduct of the approach in VS mode rather than VNAV mode increased the workload of the first officer and captain.

SAFETY ACTION

All of the relevant organisations identified during this investigation were given a draft report and invited to provide submissions. Although no safety issues requiring organisational action were identified during this investigation, the following proactive safety action was advised by the aircraft operator.

QantasLink

The operator has advised that, as a result of this incident the following action was taken:

- Relevant sections of the Training and Checking manual have been reviewed and will, subject to Civil Aviation Safety Authority approval, be revised as a result of this incident.
- The aircraft mechanical checklist was amended to include an item known as 'Ice Protection' to confirm the status of the ice protection system.
- A procedure was implemented to identify and heighten flight crew awareness of the minimum speed for the environmental and aircraft configuration state.

- The Standards Department and Procedures Review Group conducted a review of approach workload and submitted the findings to the Flight Standards Review Group. These included: better clarity and role definitions within documented procedures; and expanding the timing and sequencing procedures to aid in management during high periods of workload.
- A group/industry workshop forum was organised to share experiences and best practices in regard to situation awareness on the flight deck. The workshop identified additional human factors competencies that the operator intends to incorporate into its training program.

Transport Canada

Transport Canada advised that:

> [This] report is a good real-life case study for scenario-based contemporary CRM [crew resource management] training. Given our current focus on CRM training for all commercial pilots, once the final report has been released Transport Canada will publish in a future Aviation Safety Letter, a summary of this occurrence with a recommendation for operators to consider using it in their scenario based CRM training programs.

It may be that Australian operators might also benefit from examining this occurrence as part of their CRM programs.

SOURCES AND SUBMISSIONS

Sources of Information

The sources of information during the investigation included the:

- flight crew
- flight recorder data
- the aircraft manufacturer
- operator.

References

Rasmussen, J. (1983). Skills, Rules, and Knowledge; Signals, Signs, and Symbols, and Other Distinctions in Human Performance Models. IEEE Transactions on Systems, Man & Cybernetics, SMC; 13(3).

Salas E., Wilson, K.A. & Burke C.S (2006). Does Crew Resource Management Training Work? An Update, an Extension, and Some Critical Needs. *Human Factors*, 48(2) 392-412.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the flight crew, the aircraft operator, the Civil Aviation Safety Authority (CASA), Transport Canada, the Transportation Safety Board of Canada (TSB) and the aircraft manufacturer.

Submissions were received from the aircraft operator, Transport Canada, CASA and the TSB. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

APPENDIX A: SYDNEY RNAV-Z RUNWAY 16 APPROACH