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Australian Transport Safety Bureau

Obstacle proximity warning involving Bombardier DHC-8, VH-TQM

near Adelaide Airport, South Australia | 24 April 2015

Investigation

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Addendum

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Safety summary

What happened

On 24 April 2015, a Bombardier DHC-8 aircraft, registered VH-TQM, was operating QantasLink flight QF2274 from Port Lincoln to Adelaide, South Australia.

During the approach to runway 30, in instrument meteorological conditions and with vertical navigation (VNAV) flight director mode engaged, the airspeed reduced. As the flight crew responded, an uncommanded disengagement of the aircraft's flight director occurred. The flight crew re-engaged the flight director and selected vertical speed mode. That mode resulted in the aircraft descending below the approach profile and 100 ft below a segment minimum safe altitude.

As the aircraft drew nearer to the runway, the flight crew received an obstacle proximity warning, since their projected approach path would bring them too close to a tower. In response, the crew conducted a missed approach and instead landed the aircraft on runway 05. No damage or injuries were sustained.

What the ATSB found

Flight director dropouts had occurred previously – including on that aircraft and on that day. On those occasions the flight director had automatically re-engaged in the same mode it had dropped out in. As the flight crew expected this would happen again, they continued the approach. The reason for the uncommanded disengagement of the aircraft's flight director was not established. The previous flight director dropouts had not been reported by company flight crew, affecting the operator's ability to resolve the issue and to educate flight crew about it.

The manual re-engagement of the flight director was done during a period of high workload and focus on other tasks and the flight crew did not identify the incorrect active mode. The captured vertical speed resulted in the aircraft descending too fast for the approach profile. Without the protection provided by VNAV mode, the aircraft descended below a segment minimum safe altitude. The altitude and vertical speed resulted in the activation of an obstacle proximity warning.

The elevation of the tower was incorrect on the published approach chart and in the terrain database, and there had been previous occurrences of obstacle warnings on that approach. There were also deficiencies in the induction and route information provided to flight crew about the instrument approach.

What has been done as a result

Following this occurrence, QantasLink immediately prohibited use of the GNSS RWY 30 approach and has since undertaken a range of education, training and operational safety actions.

Airservices Australia amended the approach chart with the correct height of the tower. While safe obstacle clearance existed on the approach profile, they also amended the approach procedure to increase the clearance above the obstacle, with the aim of eliminating proximity alerts to aircraft on the approach profile.

Safety message

This incident highlights the importance of auto-flight system mode awareness and the adverse effects of flight crew expectation and high workload. It also demonstrates the value of operators conducting a thorough risk assessment and making flight crew aware of hazards associated with airport approaches.

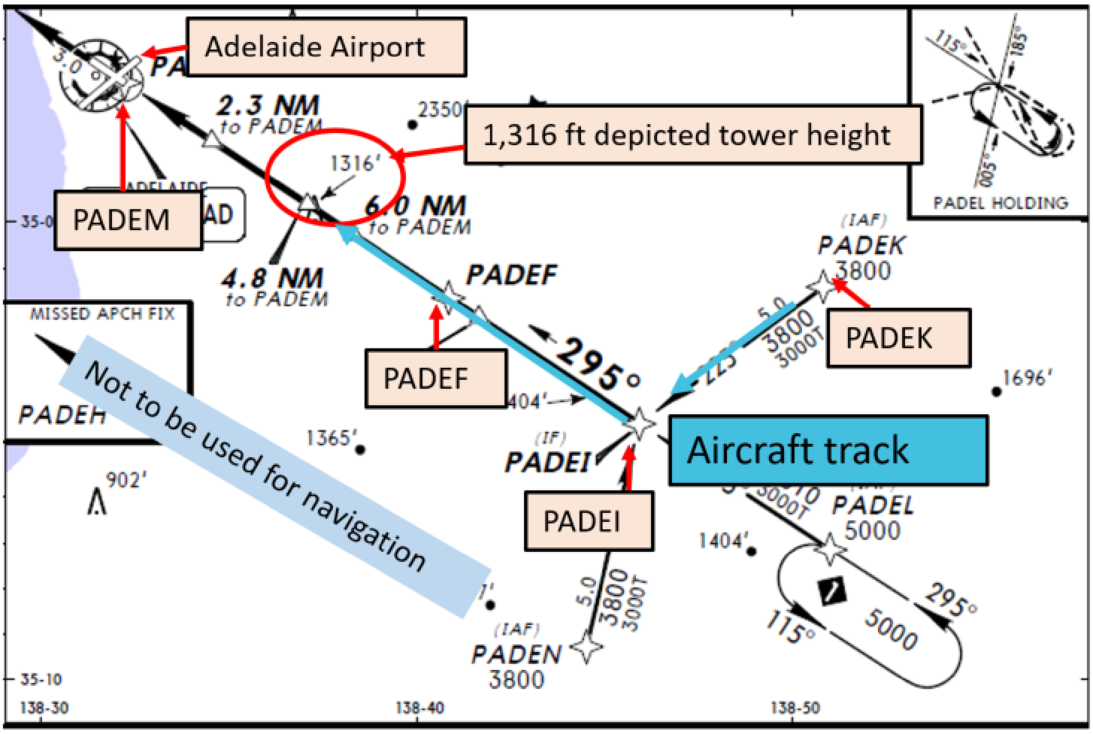
Reporting of technical faults, even those that occur momentarily and resolve quickly, is important as it enables the operator to resolve the issue and educate flight crew.

The occurrence

On 24 April 2015, at about 1900 Central Standard Time,[1] a QantasLink Bombardier DHC-8-300 aircraft, registered VH-TQM (TQM), departed Port Lincoln, South Australia (SA) on a scheduled passenger flight (QF2274) to Adelaide, SA. On board were the flight crew, comprising a captain and first officer, two cabin crewmembers and 40 passengers. The captain was pilot flying (PF) and the first officer pilot monitoring (PM) for the departure.[2]

After passing the transition altitude of 10,000 ft above mean sea level (AMSL), the crew switched roles so the first officer became pilot flying (PF). The flight crew planned to conduct the area navigation (RNAV) '-Z' global navigation satellite system (GNSS) approach to runway 30 on arrival in Adelaide (Figure 1).

Figure 1: Extract of RNAV-Z (GNSS) Runway 30 approach



Note the 1,316 ft tower on the approach path

Source: Jeppesen – annotated by ATSB

After reaching their cruising altitude of flight level (FL) 150,[3] the PM contacted air traffic control (ATC) who confirmed they could expect the runway 30 RNAV-Z approach. The flight crew then briefed for that approach, including highlighting that the approach was steeper than normal and had a long final segment. The captain reported that the briefing was broken by air traffic control instructions, and that they did not identify that there was an obstacle on the approach path.

After clearing the flight crew to descend to 9,000 ft, ATC advised them to expect radar vectors for a right circuit via initial approach fix (IAF) PADEK, which the PM entered into the flight management system (FMS).

1 Central Standard Time (CST) was Universal Coordinated Time (UTC) + 9.5 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 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 150 equates to 15,000 ft.

Air traffic control subsequently issued radar vectors, cleared the aircraft to descend to 6,000 ft, and requested the crew to reduce aircraft speed. The aircraft descended to 6,000 ft and then remained level for about 7 NM.

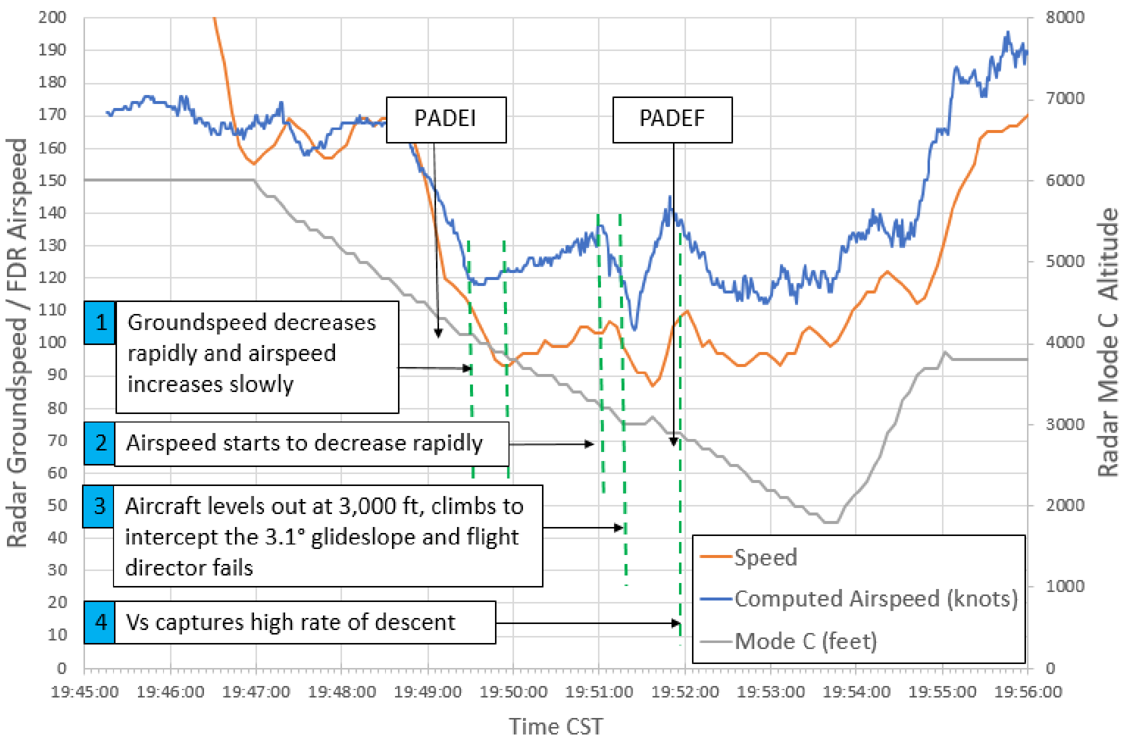
At about 1945, the aircraft was 3.5 NM north of PADEK and ATC cleared the crew to track direct to PADEK for the RNAV-Z approach and to descend to 4,000 ft. Passing 4,770 ft, the flight crew selected an alerting altitude of 680 ft in the assigned altitude selector (AAS) in accordance with standard procedures for the RNAV approach.

As the aircraft passed PADEK, the PM selected the vertical speed (VS) mode on the flight guidance controller, and then armed the lateral (LNAV) and vertical navigation (VNAV) mode (see the section titled *Auto-flight modes*). The autopilot captured the approach and the aircraft descended in VNAV and LNAV mode from PADEK to PADEI. The aircraft turned at PADEI passing about 4,500 ft. The PF then elected to configure the aircraft for landing, which was slightly earlier than normal.

The flight crew lowered the landing gear, set the reference bug on the airspeed indicator to the (calculated) minimum reference speed of 115 kt and selected flap 15 to configure the aircraft for landing. These actions were completed by 4,200 ft.

According to the flight and radar data, as the aircraft descended through about 4,200 ft (at 1949:34), the groundspeed decreased over the next 18 seconds from about 114 kt to 93 kt, while the airspeed increased gradually from 118 kt to 121 kt over the same period ('1' in Figure 2). That indicated an increase in headwind component of about 24 kt. Both ground and airspeed then increased at similar rate until just after 19:51:02.

Figure 2: VH-TQM approach to Adelaide showing airspeed, groundspeed and altitude



Source: ATSB

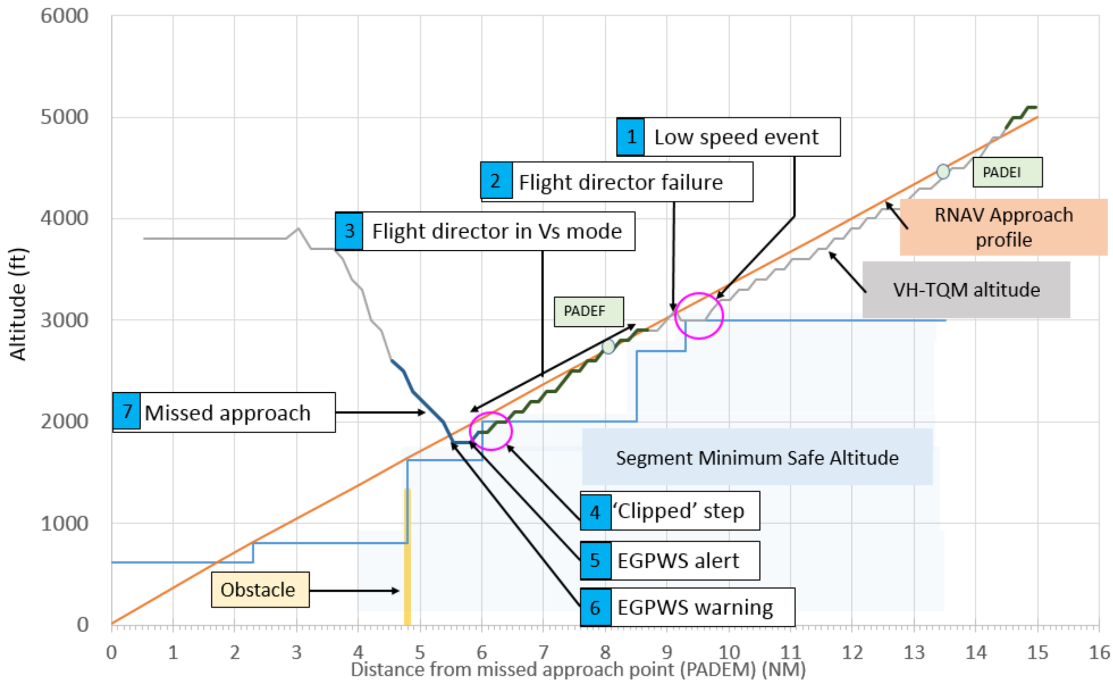
Passing about 3,400 ft, the PM observed a decay in airspeed, with the speed trending towards the minimum reference speed ('2' in Figure 2). The PM called 'speed' and the PF responded by increasing the thrust. The speed continued to decay, so the PM again called 'speed' and the PF further increased the thrust, and the speed soon returned into the normal range (see the section titled *Speed decay*).

Passing about 3,200 ft and 8.5 NM from the threshold, uncommanded disengagement of the flight director lateral and vertical navigation modes occurred ('3' in Figure 2). The 'FD NAV DATA INVALID'[4] message appeared on the advisory display panel (ID-802) and the flight director bars dropped out on the electronic attitude direction indicator (EADI) display, but the autopilot remained engaged.

The PF noticed the message and called for a go-around. The PM hesitated, assuming that the flight director modes would re-engage quickly and automatically, as it had on two flights earlier that day. That did not occur, so the PM re-engaged the flight director in VS mode first, then LNAV, but did not then engage VNAV mode (which was the normal sequence of mode activation). Consequently, the aircraft descended on the lateral approach path, at the vertical speed that existed at the time the VS mode was engaged and therefore not necessarily on the published approach profile ('4' in Figure 2). Both flight crewmembers reported that they thought VNAV mode was set and therefore they did not crosscheck the navigation modes at that time.

The aircraft deviated below the published approach path and, at about 6.1 NM prior to PADEM, descended 100 ft below the segment minimum safe altitude of 2,000 ft, by 'clipping' the step in the minimum safe altitude profile ('4' in Figure 3).

Figure 3: Plot of radar data showing vertical profile of runway 30 RNAV approach and aircraft descent



Source: ATSB

At 6 NM to PADEM, the segment minimum altitude decreased to 1,620 ft and although the aircraft was below the approach profile, it did not descend below that altitude restriction.

At 1,864 ft, about 5.7 NM prior to PADEM and descending at about 660 ft per minute, the crew received an enhanced ground proximity warning system (EGPWS) 'CAUTION OBSTACLE' alert, due to a tower located about 4.8 NM from PADEM (Figure 1). The flight crew initially did not take any action as they believed the caution was spurious. Six seconds later, at 1,798 ft (100 ft below the approach path) and descending at 590 ft per minute, the crew received an EGPWS 'OBSTACLE, OBSTACLE, PULL UP' warning. In response, the PF initiated a missed approach.

4 This amber message appears for loss of valid NAV data on the selected side.

According to the radar data, the aircraft descended to a minimum altitude of about 1,745 ft AMSL,[5] when 5.6 NM from the runway threshold, which was above the segment minimum safe altitude of 1,620 ft.

As they conducted the missed approach, the PM advised ATC that they were going around due to spurious instrument indications. The aircraft passed over the tower climbing (in the missed approach) through about 2,200 ft and climbed to 3,800 ft in accordance with the missed approach procedure. The aircraft was subsequently repositioned and landed on runway 05 at about 2022.

Flight crew experience and approach familiarity

The captain held an Air Transport Pilot (Aeroplane) Licence and had a total flying experience of 3,885 hours, of which 1,132 hours were on the DHC-8-300 (Q300) aircraft. The captain joined QantasLink in 2013, and was transferred from Cairns to QantasLink's Adelaide base about 2 months before the incident to support the Q300 operations.

The FO held an Air Transport Pilot (Aeroplane) Licence and had a total flying experience of 2,664 hours, of which 32 hours were on the Q300 aircraft. The FO was transferred to Adelaide from Brisbane, where they had been operating the DHC-8-400 (Q400) since joining QantasLink in 2014. This was the FO's second flight after being checked to line on the Q300. As the FO had not yet completed one year with QantasLink, a crosswind limitation of 15 kt was mandated by the operator for take-off and landing.

In establishing a flight crew base in Adelaide, and as part of the QantasLink Management System Airport Assessment, all approaches into Adelaide were reviewed. That review did not identify any increased operational risk.

The route qualification training package for Adelaide operations did not include information on the RNAV runway 30 approach. In addition, the route manual did not detail the obstacle and its proximity to the approach. Neither of the pilots had previously conducted the runway 30 RNAV approach.

The flight crew commented that they were unfamiliar with that approach and were not aware of the obstacle or its proximity to the flight path prior to the incident. They further reported that, had they known there was an obstacle, they would have highlighted it as a threat when briefing for the approach.

QantasLink reported that the GNSS RWY30 approach was used infrequently due to prevailing winds and ATC sequencing onto the primary runway 05/23 but strong north-westerly winds led the crew to conduct this approach.

The QantasLink investigation of this occurrence found that another operator within the Qantas Group had previously experienced EGPWS alerts on approaches to Adelaide runway 30. This had resulted in action to redesign the RNAV–P required navigation performance (RNP) approach to avoid tracking over the obstacle.

At the time of the incident, the ATSB had been notified of eight other EGPWS alerts at Adelaide runway 30 since 2004. These included one event involving a Qantas Boeing 737 aircraft on 16 September 2007, in which the crew conducted a missed approach before landing on runway 05.

There was no established method of sharing information on safety matters with other Qantas Group airlines at the time of the incident. The operator, however, provided the results of their investigation of this incident to other Qantas Group airlines. They also advised that formal ways of sharing safety information within the group were being considered.

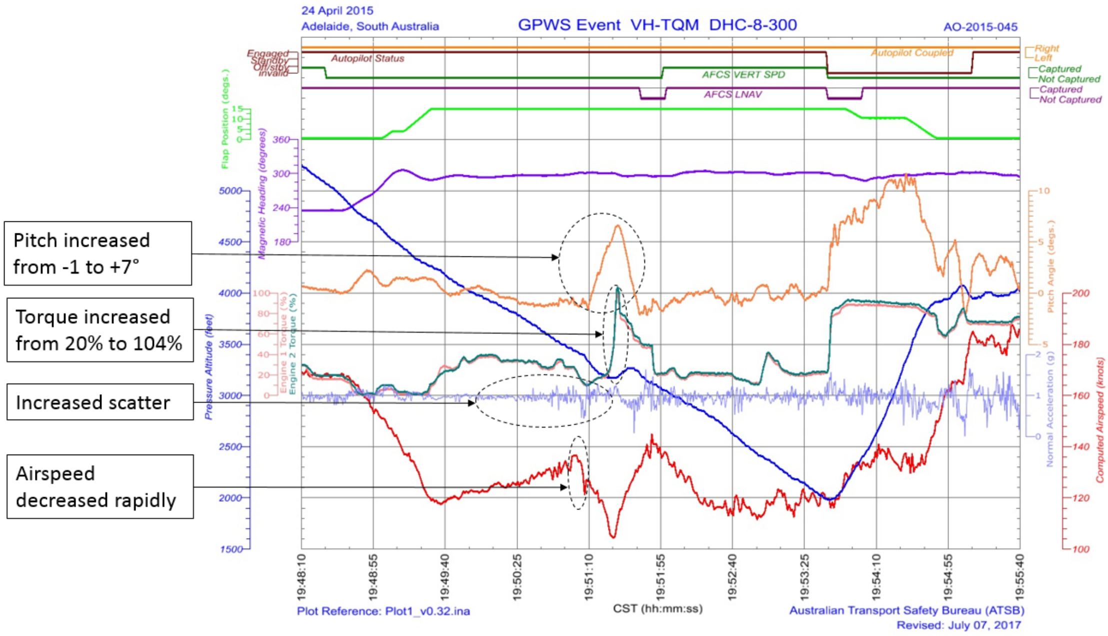
[5] The aircraft descended to a recorded pressure altitude of 1,985 ft during the go-around. The pressure height recorded was about 240 ft higher than AMSL.

Speed reduction and pitch change

Recorded flight data (Figure 4) showed a reduction in engine torque concurrent with a decrease in airspeed (red) from 136 kt to 121 kt over 6 seconds from 1951:00, and then to 104 kt over the next 19 seconds. The airspeed reduction occurred following a reduction in torque with the aircraft configured for landing (landing gear and flaps extended). The change in torque over that period was likely due to pilot input.

As the airspeed decreased through 121 kt, the aircraft pitched up (orange) from -1° to +7° over 12 seconds and the aircraft's rate of descent increased from 1,440 ft per minute to 2,280 ft per minute, before again decreasing. The engine torque (green) increased during the same period from about 20 per cent to 104 per cent before decreasing. That was consistent with the PF's recollection that she had momentarily increased torque to maximum because she had been used to flying the Q400 which had a detent on the torque lever, whereas the Q300 did not.

Figure 4: Extract of flight data highlighting the speed, pitch and torque changes



Source: ATSB

Although VNAV mode was not a parameter recorded in the flight data, the flight director and autopilot were engaged immediately prior to the pitch-up and the flight crew reported that VNAV mode was also active at that time.

The aircraft manufacturer advised that, below 5,000 ft, the VNAV mode maintained the vertical profile to within an accuracy of 224 ft, with an additional 30 ft altimetry error. That tolerance was sufficient to allow the observed deviation below the 3.1° approach profile with VNAV mode engaged. Furthermore, engagement of that mode may also have resulted in the aircraft pitching up to maintain the 3,000 ft minimum segment altitude 'step' (see the section titled *Auto-flight modes*) and the flight director dropping out due to an invalid data error. The autopilot remained engaged throughout the change in pitch attitude.

From 1950:14, the normal acceleration parameter (G) showed increasing scatter, consistent with the presence of turbulence (Figure 4). The shorter period fluctuations in airspeed were also indicative of turbulence.

In the hour between the aircraft's departure from Port Lincoln and its arrival at Adelaide, there were six changes to the Adelaide automatic terminal information service (ATIS). This showed the changing weather as a front passed through the area. The ATIS included a forecast of severe turbulence above FL 160, but not at the altitude the aircraft was operating at during the approach.

Windshear avoidance and recovery

The operator's flight crew operating manual (FCOM), defined severe windshear as 'that which produces airspeed changes greater than 15 knots.'

The flight crew did not identify windshear or turbulence as the reason for the speed decay. The PF thought that either the power setting had not been appropriate for the configuration, or the aircraft pitch attitude changed when the flight director was armed in approach mode, causing the speed decay. The flight data, however, showed that the aircraft had completed the turn onto the approach fix and had been configured and armed in approach mode about 3 minutes prior to the rapid decrease in airspeed.

The FCOM detailed that 'If inadvertently caught in a severe undershoot shear and/or intense downdraft: Carry out a missed approach…' The FCOM further stated:

> If preventative action proves unsuccessful and flight path control becomes marginal due to windshear during take-off or approach, conduct the Terrain Avoidance Procedure.
>
> The flight crew must make the determination of flight path control …based on the pilots' experience and judgement of the situation and is to some extent subjective. As a guideline, marginal flight path control may be indicated by uncontrolled changes from normal steady state flight conditions in excess of:
>
> - 15 knots indicated airspeed,
> - 500 feet per minute vertical speed,
> - 5 degrees pitch attitude,
> - 1 dot displacement from the glideslope, or
> - Unusual power lever position for a significant period of time.

The flight data showed that the aircraft encountered speed variations greater than 15 kt, pitch attitude change greater than 5º, and change in vertical speed greater than 500 ft per minute.

The operator's investigation into the incident found that both flight crewmembers had completed appropriate training in windshear recognition and conduct of the terrain avoidance procedure.

Auto-flight modes

In LNAV mode, the auto-flight system guides the aircraft along the FMS-programmed lateral track. During a descent in VNAV mode, the auto-flight system guides the aircraft along the FMS-programmed vertical profile, at the speed computed by the FMS.

The flight crew select VNAV mode by a switch on the flight guidance controller. When selected, the VNAV indicator illuminates on the glare shield.

In accordance with the flight crew operations manual, the crew had to communicate any changes to the flight director mode. The autopilot would normally be engaged or disengaged by the pilot flying, who must advise the pilot monitoring when doing so.

Flight director dropout

The flight crew reported that they experienced two flight director dropouts on flights earlier that day. The first of these was on a different (Q300) aircraft. On both previous occasions the flight director was in LNAV/VNAV modes with the aircraft tracking for the initial approach fix (rather than on the approach). Those dropouts caused momentary loss of lateral and vertical navigational guidance. Unlike the incident approach, however, on both previous occasions the flight director automatically re-engaged with the same autopilot modes.

The flight crew did not recall any failure flags or any associated ID802[6] advisory messages with the earlier dropouts, but on the incident flight, the FD NAV DATA INVALID message displayed.

The aircraft manufacturer stated that it was not clear what had caused the uncommanded disengagement of VNAV/LNAV mode. They advised that it was possible that significant air data variations or accelerations related to windshear may have caused it, however those conditions were not obvious on the flight data traces. Additionally, the autopilot uses the same air data information and it did not automatically disengage in response to the windshear event. They observed that a normal acceleration spike of 0.54 g (1.0 g being unaccelerated flight) was recorded at essentially the same time as the dropout.

The PF commented that if the flight director disengages in the Q400, the autopilot also drops out and the pilot is then hand-flying the aircraft. In TQM (Q300), however, the flight director dropped out but the autopilot remained engaged.

After the event, the PF reported asking the maintenance engineers whether the flight director dropouts were a known issue on the Q300. The maintenance engineers reportedly responded that there was no history of this occurring on the fleet. QantasLink subsequently surveyed other Q300 crew, seven of whom responded that they had experienced flight directors dropping out, but had not recorded them in the maintenance log.

Mode awareness

Ineffective auto-flight system mode awareness has been identified as a contributing factor in many occurrences since the introduction of complex auto-flight systems (Federal Aviation Administration (FAA) 1996). A report into operations of flight path management systems (PARC/CAST Flight Deck Automation Working Group 2013) stated:

> The 1996 FAA report identified insufficient autoflight mode awareness as an important vulnerability area…
>
> Since that report was published, some changes to flight deck equipment design have been made in new aircraft to address this vulnerability area (e.g., only showing selected target values or modes on the PFD, to foster the pilots reviewing the information on the mode annunciator display rather than on the mode selection panel).
>
> In addition, the issue has been addressed in training through increased emphasis on mode awareness and in some operators' flightcrew procedures by having the pilots call out all mode changes. However, other operators find this use of callouts to be too burdensome and a potential distraction.
>
> These mitigations are only partially successful. The data analysis reveals that autoflight mode selection, awareness and understanding continue to be common vulnerabilities…

The FAA report made several broad recommendations to address this and related concerns.

Enhanced ground proximity warning system alert and warning

During the approach, the flight crew received an EGPWS alert CAUTION OBSTACLE, followed 6 seconds later by an EGPWS warning OBSTACLE, OBSTACLE, PULL UP.

When the ground proximity alert and then warning activated, the flight crew reported that they assessed them to be spurious activations. The FCOM stated that the required response to the EGPWS caution was to 'adjust the configuration, flight path or speed of the aircraft to correct the unsafe condition'. There was no indication of any response from the flight crew following the obstacle alert.

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[6] The ID802 advisory display is the primary reference for all flight director mode selections.

When the EGPWS warning activated, the flight crew responded by conducting a missed approach. The FCOM stated that the required response to the warning was to 'immediately conduct the Terrain Avoidance Procedure.'

Although the aircraft was about 100 ft below the 3.1° approach profile when the EGPWS warning triggered, it was not below the 1,620 ft step (which was 255 ft above the tower height). Hence, the aircraft was above the obstacle clearance height required for the approach and within tolerances for approach according to the operations manual. Activation of the warning was due to a combination of the aircraft's rate of descent and deviation below the approach profile.

The terrain database installed on the EGPWS unit had the height of the tower as 1,325 ft, which was the height of 1,316 ft on the approach chart rounded up to the nearest 25 ft. The correct height of the tower was subsequently found to be 1,365 ft and the chart has since been amended. The EGPWS database, however, had not been amended at the time of completion of this report. Had the EGPWS unit had the correct tower height (1,365 ft), it still would have generated the same alert and warning. Airservices Australia advised that the height error was due to corruption of an obstacle database.

Honeywell advised that the database update is on hold pending 'further conversations with Airservices Australia and QantasLink to verify that the amended tower height, combined with any Runway 30 approach angle changes, would not result in nuisance EGPWS obstacle alerts and warnings.'

Missed approach versus terrain avoidance procedure

The operator's missed approach procedure involves setting the thrust to take-off/go-around (TO/GA) setting, which uses 10 per cent less torque than the terrain avoidance procedure (maximum take-off power setting). Despite this, the crew's actions in conducting the missed approach silenced the warning and there were no further EGPWS warnings.

The PF commented that they did not conduct the terrain avoidance procedure although they knew it and had practised it in the simulator. At the time, with the rapid sequence of events, their natural reaction was to 'get out of there'.

The PF further reported having then to prompt the PM for the 'positive rate' callout in the missed approach. The PM commented that they were concerned that, with the flight director dropout, low-speed event and the EGPWS warnings, there may have been an issue with the aircraft's navigation system.

Workload

The flight crew reported that they were operating in a high workload environment during the occurrence sector. That high workload was due to the adverse weather conditions, a high volume of traffic approaching Adelaide, and receiving unexpected tracking vectors from ATC on the approach. They further stated that with the decay in speed and the flight director dropping out, 'it was a high workload… it posed higher stress levels, [they were] under pressure at the time.'

Orlady and Orlady (1999) defined workload as 'reflecting the interaction between a specific individual and the demands imposed by a particular task. It represents the cost incurred by the human operator in achieving a particular level of performance.' A person experiences workload differently, based on their individual capabilities and the local conditions at the time. These conditions can include the following:

- training and experience in the situation at hand
- the operational demands during that phase of flight
- the person is experiencing the effects of fatigue
- the level of automation in use and the mental requirements in interpreting their actions.

Research on unexpected changes in workload during flight has found that pilots who encounter abnormal or emergency situations experience a higher workload with an increase in the number of errors compared to pilots who do not experience these situations (Johannsen and Rouse, 1983).

According to the ATSB research report *Perceived pilot workload and perceived safety of RNAV (GNSS) approaches* (www.atsb.gov.au), survey results showed that, for pilots of category A and B aircraft, the RNAV approach was one of the highest workload approaches in terms of mental workload, physical workload and time pressure.

Safety analysis

Introduction

A combination of the aircraft's high rate of descent and deviation below the approach profile triggered an enhanced ground proximity warning system (EGPWS) warning for an obstacle on the approach path. The flight crew initiated a missed approach in response to the warning, which had the desired effect in mitigating the proximity to the obstacle but was not in accordance with the operator's procedures. The following analysis examines the factors that contributed to the descent below profile and EGPWS warning, as well as the recovery actions taken by the crew.

Speed decay event

The aircraft speed initially decayed due to a reduction in torque with the aircraft configured for landing. At about the same time, the aircraft pitched up, possibly as commanded by the autopilot as the aircraft approached the 3,000 ft minimum safe segment altitude.

Although the flight crew responded to the decay in airspeed, they did not assess that flight path control had become marginal, or identify that the speed reduction was due to windshear or turbulence. Consequently, the flight crew did not carry out the terrain avoidance procedure or missed approach at that time.

Continuation of the approach increased the flight crew's workload as they responded to the variations in speed, thrust and attitude. As a result, their attention was probably focussed on correcting the flight path when the flight director dropped out.

Following the decay in airspeed, increase in torque, and pitch-up, the aircraft developed a higher rate of descent than required for the approach. That vertical speed was subsequently captured by the selection of vertical speed (VS) autopilot mode.

Flight director dropout

The flight director dropout was concurrent with a sudden reduction in normal acceleration, however the exact cause of the dropout was not able to be determined.

The flight director had dropped out on two previous sectors that day, on two different aircraft. On those occasions, it had almost immediately come back in with the same autopilot modes engaged. The flight crew therefore expected it would do so again on the incident sector, but it did not. The flight crew did not recognise the dropout on the incident sector as being different from the earlier dropouts.

The flight crew had not recorded the previous, momentary flight director dropouts on the aircraft's technical log and the operator subsequently found other instances of non-reporting of the same issue. This may have been because it presented as a temporary glitch that resolved itself quickly. The non-reporting, however, indicated that flight director dropouts may have become an accepted fault by flight crew, which reduced the ability of the aircraft operator to address the issue and to educate flight crew on the required responses.

Workload and mode awareness

The flight director dropout occurred shortly after the flight crew responded to the decay in airspeed. At the same time (as the dropout), the aircraft was approaching the final approach fix (PADEF), so the captain was reviewing the approach plate, taking their attention away from re-engaging the flight director. The combination of managing the speed decay while conducting the instrument approach probably resulted in the crew experiencing high workload. That in turn may have impeded confirmation of the autopilot mode when the captain re-engaged the flight director, or discussion of whether a different manifestation of the flight director dropout had occurred.

Consequently, and probably due to their expectations after the earlier dropouts, the crew thought that the vertical navigation (VNAV) mode had re-engaged.

The operator's investigation found that because the VNAV switch light was placed on the glare shield (not on the flight guidance controller), the pilot monitoring was required to alternate their scan between the VNAV switch and the flight guidance controller. Those ergonomics, along with the flight crew's focus on other tasks such as reviewing the approach plate and talking to the cabin crew and passengers, may have led to them not re-engaging the VNAV mode after the flight director dropout.

For the remainder of the approach, neither member of the flight crew detected that VS mode was engaged. The pilot flying recalled seeing the aircraft was not on the glideslope (flight path). While that may have provided a cue that VNAV mode was not engaged, it did not trigger checking of the autopilot mode settings.

In accordance with standard operating procedures, the flight crew were permitted to conduct the area navigation (RNAV) approach without a serviceable flight director. Because the flight crew did not recognise that the aircraft was in VS mode, however, they did not address the glideslope deviation or set the assigned altitude selector to alert them to the segment altitudes. This resulted in the crew not detecting the descent below the approach profile.

Obstacle warning and missed approach

When the aircraft was about 100 ft below the approach path (but above that segment minimum safe altitude, and descending at about 590 ft per minute) the flight crew received a ground proximity warning of a tower 255 ft below the approach profile and about 0.6 NM in front of the aircraft. The flight crew thought the obstacle proximity alert and warning were spurious but the first officer conducted a missed approach in response to the warning.

The operator found that both flight crewmembers were appropriately trained in the terrain avoidance procedure, but that it was infrequently performed, compared with the missed approach procedure. The first officer commented that, at the time, their natural reaction was to initiate a climb and because the flight crew conducted missed approaches more regularly, that also contributed to them conducting that procedure in lieu of the terrain avoidance procedure.

The aircraft operator's investigation also found that 'given the high workload environment and impact of managing multiple threats and errors directly prior to this manoeuvre, it is likely that the flight crew lacked the spare cognitive capacity to retrieve the rarely used terrain avoidance manoeuvre from their long term memory.'

Lack of awareness of the obstacle, combined with the crew experiencing a high workload, may also have contributed to their decision to conduct a missed approach rather than the terrain avoidance procedure.

The flight crew had not previously conducted the RNAV approach to runway 30 at Adelaide and no information about the obstacle or its proximity to the approach path was included in the operator's information provided to the flight crew prior to the flight. This unfamiliarity reduced the likelihood of identifying it as a risk in their approach briefing. The flight crew received air traffic control instructions while conducting that briefing, which may have contributed to not identifying the obstacle on the approach plate.

In addition, the captain commented that the flight director dropout had contributed to their assumption that the ground proximity warning was spurious because there seemed to be a series of abnormalities indicative of a navigation system fault.

Orasanu (2010) explains that flight crew decision-making errors can often occur at the 'situation assessment' phase.

> Situation assessment involves defining the problem, assessing the level of risk associated with it and determining the amount of time available for solving it…If risk is high and time is limited, action may be taken without thorough understanding of the problem.

Orasanu also outlined that situation assessment errors can occur when cues are misinterpreted, such as in this case with the crew’s assumption that the ground proximity warning was spurious. Despite their assessment that the warning was spurious, the flight crew conducted a missed approach in response to the obstacle warning.

In submission to the draft of this report, the Civil Aviation Safety Authority stated that:

> The key purpose of the EGPWS is to provide an independent system to alert the flight crew that their mental model is in error. Therefore, it is not a system that should be open to “interpretation” in the first place. From a regulatory perspective, EGPWS provides a final line of defence and it is to be expected that flight crew are “surprised” by its activation.

Findings

From the evidence available, the following findings are made with respect to an enhanced ground proximity warning system warning involving a Bombardier DHC-8 aircraft, registered VH-TQM, near Adelaide Airport, South Australia on 24 April 2015. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- During approach, for reasons that could not be established, uncommanded disengagement of the aircraft's flight director and vertical navigation mode occurred.
- Contrary to the operator’s procedure, the approach was continued following disengagement of the flight director. That was probably due in part to an expectation that it would automatically re-engage in a similar manner to that experienced on previous flights that day.
- During manual re-engagement of the flight director during a period of high workload and focus on other tasks, vertical speed mode was engaged without the knowledge of the pilot flying. As a result, the vertical flight path protection provided by the vertical navigation mode was removed.
- A combination of the unrecognised vertical speed mode selection and the relatively high captured descent rate resulted in descent below a minimum safe altitude and activation of an obstacle proximity warning.

Other factors that increased risk

- The pilot flying conducted a missed approach instead of a terrain avoidance procedure in response to the obstacle proximity warning, which reduced the obstacle clearance margin of the aircraft's flight path. The use of an incorrect procedure was probably due to high workload at the time.
- Flight director dropouts had occurred previously and not been reported by company flight crew, probably due to acceptance (or normalisation) of the faults. This non-reporting affected the operator's ability to resolve the issue and to educate flight crew about it.
- The Adelaide induction material and route manual provided to the crew did not include information on the hazards of the RNAV-Z runway 30 approach, including its steep flight path and proximity to the obstacle.

Other findings

- The tower height as shown on the approach chart (1,316 ft) was 49 ft lower than its actual height. While the incorrect height was also in the terrain database for the enhanced ground proximity warning system (EGPWS), it did not affect the activation of the EGPWS obstacle warning.

Safety issues and actions

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 safety action in response to this occurrence.

QantasLink

The aircraft operator (QantasLink) took the following safety actions:

- Immediately after the occurrence, QantasLink issued a notice to flight crew immediately following the incident, prohibiting use of the RNAV approach to runway 30 at Adelaide.
- The next simulator cyclic was based in Adelaide and included terrain avoidance procedures.
- A safety information bulletin was published to all flight crew highlighting the key lessons learnt from the event. This included a reminder to pilots about the importance of reporting all system failures, including transient flight director dropouts.
- The port assessment criteria were amended to require specific management consideration of operational and/or training requirements for any approach where the flight path angle is other than 3°.
- The induction package for Adelaide was amended to include the RNAV (GNSS) runway 30 approach.
- New format Jeppesen approach plates have been adopted that highlight tower locations better than the old style in use at the time of the occurrence.

Airservices Australia

Airservices Australia amended the approach chart with the correct height of the tower. While safe obstacle clearance existed on the approach profile, they also amended the approach procedure to increase the clearance above the obstacle, with the aim of eliminating proximity alerts to aircraft on the approach profile.

General details

Occurrence details

Date and time:	24 April 2015 – 1954 CST	
Occurrence category:	Incident	
Primary occurrence type:	Aircraft control	
Location:	near Adelaide Airport, South Australia	
	Latitude: 34° 56.70' S	Latitude 138° 31.83' E

Captain details

Licence details:	Air Transport Pilot (Aeroplane) Licence
Ratings:	Multi engine command instrument rating
Medical certificate:	Class 1
Aeronautical experience:	Total flying hours: 3,885, hours on aircraft type: 1,132
Last flight review:	April 2015

First officer details

Licence details:	Air Transport Pilot (Aeroplane) Licence
Ratings:	Multi engine command instrument rating
Medical certificate:	Class1
Aeronautical experience:	Total flying hours: 2,664, hours on aircraft type: 32
Last flight review:	April 2015

Aircraft details

Manufacturer and model:	Bombardier DHC-8-315	
Year of manufacture:	2004	
Registration:	VH-TQM	
Operator:	QantasLink	
Serial number:	604	
Type of operation:	Air transport high capacity – passenger	
Persons on board:	Crew – 4	Passengers – 40
Injuries:	Crew – 0	Passengers – 0
Damage:	Nil	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- flight crew
- flight data from the aircraft vehicle recorders
- enhanced ground proximity warning system data
- radar data from Airservices Australia
- aircraft operator (QantasLink)
- manufacturer of the aircraft's avionics system (Honeywell)
- aircraft manufacturer (Bombardier)
- Airservices Australia.

References

Johannsen, G & Rouse, WB, 1983. Studies of planning behaviour of aircraft pilots in normal, abnormal, and emergency situations. *Systems, Man and Cybernetics, IEEE Transactions on*, (3), pp.267-278.

Orlady, HW, & Orlady, LM, 1999. *Human factors in multi-crew flight operations.* Ashgate: Aldershot, UK p.203.

Orasanu JM, 2010. Flight crew decision-making. In Kanki, BG, Helmreich, RL, Anca, JM (Eds.), *Crew Resource Management*. Academic Press: Boston, MA, pp.147-179.

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, aircraft operator (QantasLink), avionics manufacturer (Honeywell), aircraft manufacturer (Bombardier), US National Transportation Safety Board (NTSB), Transportation Safety Board of Canada, Airservices Australia and the Civil Aviation Safety Authority (CASA).

Submissions were received from the flight crew, QantasLink, Honeywell, NTSB, Airservices Australia and CASA. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

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; 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.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the 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.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation
Obstacle proximity warning involving Bombardier, DHC-8, VH-TQM
AO-2015-045
Final– 5 February 2018