INCIDENT

Aircraft Type and Registration:	Bombardier DHC-8-311 Dash 8, G-WOWC
No & Type of Engines:	2 Pratt & Whitney Canada PW123 turboprop engines
Year of Manufacture:	1991
Date & Time (UTC):	11 April 2006 at 1250 hrs
Location:	Plymouth Airport, Devon
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 42
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to tail strike sensor and its fibreglass cover
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	41 years
Commander's Flying Experience:	8,947 hours (of which 2,349 were on type) Last 90 days - 97 hours Last 28 days - 20 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

After a turbulent ILS approach to Runway 31 at Plymouth Airport the aircraft landed firmly and bounced. During the landing the aircraft's TOUCH RUNWAY warning light illuminated, indicating that the aircraft's tail had made contact with the runway. There was no structural damage to the aircraft. The incident occurred through a combination of turbulence, windshear and the pilot's inappropriate response to reducing airspeed throughout the final 10 seconds of the approach.

History of the flight

The aircraft was operating from London Gatwick Airport to Plymouth Airport. Before departing from Gatwick the flight crew noted that the wind at Plymouth was forecast to be strong and gusty from the south-west.

The TAF for the period 1000 hrs to 1900 hrs forecast a wind from 240º at 15 kt gusting to 25 kt. The weather recorded at the time of the incident indicated that the wind was predominately from 230º, but varying in direction between 200º and 280º, at 16 kt gusting to 27 kt. The visibility was 5,000 m in moderate rain and mist, with scattered cloud at 400 ft agl and broken cloud at 800 ft agl.

The departure and cruise phases of the flight progressed uneventfully. Before descent the flight crew obtained the actual weather for Plymouth Airport from ATC; it was similar to the forecast obtained at Gatwick. As a result the commander, who was PF, briefed the co-pilot about the possibility of windshear and asked him to monitor

carefully the aircraft's IAS and vertical speed during the approach. He added that in accordance with company's Standard Operating Procedures, he would add a "pad" to the V_{REF} speed due to the strong and gusty wind. These procedures specify that an increment of half the wind speed and the entire gust factor should be added to V_{REF} subject to a minimum increment of 5 kt and a maximum increment of 20 kt**.** The additional speed is to guard against sudden drops in airspeed due to wind shear. The commander also decided to use the normal landing configuration of Flap 15 because this setting permitted a higher crosswind limit than Flap 35.

The landing weight of the aircraft was 39,000 lb. As a result, the operating crew would have used the speeds listed on the 40,000 lb landing card. The V_{REF}**,** with Flap 15, would have been 107 kt. Given the wind conditions, the commander would have been expected to fly a V_{APP} of approximately 125 kt; the aircraft should have touched down approximately 6 kt less, at 119 kt. The centre of gravity of the aircraft was in the middle of the allowable range.

The ILS progressed normally despite conditions being very turbulent. The commander reported that he became visual with the runway at approximately 300 ft aal, 100 ft above Decision Height, and he disconnected the autopilot. He then lowered the nose in order to bring the touchdown point closer to the threshold than the touchdown markers 1,000 ft from the threshold. As the aircraft crossed the runway threshold, at approximately 15 ft aal, just as the commander commenced the landing flare, both he and the co-pilot reported sensing a "sinking feeling". The commander applied a small amount of power and pulled the control column back slightly in an attempt to arrest the rate of descent. There was no GPWS sink rate warning.

The aircraft landed firmly and the operating crew perceived that it "bounced slightly". At this point the co-pilot reported that he noticed the TOUCHED RUNWAY warning light had illuminated. The commander stated that he could not recall if the warning illuminated as a result of the first or second touchdown.

The aircraft was then taxied onto its stand where the commander reported the warning light to the engineers and the awaiting operating crew. Upon inspection, the only damage found was to the 'touched runway' sensor and its fairing; there was no structural damage to the aircraft.

Plymouth Airport

The UK Aeronautical Information Package (AIP) contains the following warnings in the section for Plymouth Airport:

> *'In strong wind conditions windshear and turbulence may be experienced on the approach to or climb out from any runway. Downdraught effect and sudden changes in wind velocity are possible in light wind conditions.'*
>
> *'Significant differences may occur between the surface wind velocity reported by ATC and the actual wind at approximately 100 ft aal.'*

These warnings are also printed on the airfield charts for Plymouth used by the operator's flight crew.

Aircraft handling qualities

Flap 15 is the normal landing configuration for a Dash 8. Flap 35 is available, but normally it is only used when landing distance is a limiting factor. Due to the wind conditions the commander elected to make a Flap 15 approach and landing because the crosswind limit with Flap 15 is 6 kt greater than with Flap 35. With Flap 15 set,

the aircraft had a crosswind limit of 27 kt on a wet runway. Also, the aircraft is more responsive with Flap 15 due to the lower airframe drag.

The operating company commented that during a normal landing, the aircraft should be flared at or just below 10 ft agl and the throttles closed at the same time. Additionally, if the aircraft is flared to a pitch attitude of more than 6º nose up, there is a risk of tail strike.

Flight Data Recorder

The Flight Data Recorder (FDR) was sent by the operator to an approved commercial avionics servicing facility for download and the recovered data was subsequently supplied to the AAIB for analysis.

A time-history of the relevant parameters during the incident landing is shown at Figure 1. The data presented at Figure 1 starts as G-WOWC was established on the glideslope, flaps up, descending through 2,000 ft amsl, with 150 kt airspeed and decelerating. The engine torques were 5% and the propeller speeds were just over 900 rpm. The autopilot was engaged.

The flaps were then lowered, extending to the approach and landing setting of 15º by 1,600 ft amsl as the aircraft continued to descend and slow down (with small adjustments in engine torque and aircraft pitch to maintain this descent profile). As the aircraft passed through 1,450 ft amsl and 117 kt (8 kt below the appropriate V_{APP}), there was an increase in engine torque (to 25%) followed by an increase in propeller speed (to the 1,200 rpm maximum).

Continuous changes to pitch (between -1.5º and +2.5º) and torque (between 18% and 41%) were made for the next 60 seconds as G-WOWC continued to descend at a rate of about 670 ft/min. During this portion of the descent the airspeed slowed to 110 kt (15 kt below the appropriate V_{APP}) before increasing to about 125 kt, the appropriate V_{APP}, as the aircraft passed through 820 ft amsl. At this point, just under 30 seconds before touchdown, the autopilot was disconnected.

Immediately after autopilot disconnect, there was a nosedown elevator input causing the aircraft to pitch down to -6º and accelerate to 131 kt. The descent rate also increased to 750 ft/min and the aircraft descended below the glideslope. The airspeed then began to reduce as the pitch attitude started to increase and the engine torque started to reduce. Ten seconds before touchdown, the airspeed was 125 kt (V_{APP}) and still reducing, the engine torques were 7% and reducing, and the height above ground level was 122 ft over rising terrain towards the airfield. The propeller speed for Engine 2 then reduced, gradually at first then more rapidly together with Engine 1 just before touchdown; these changes were a consequence of the reducing air speed in the landing flare. Coincidentally, there was also a small increase in engine torques. The pitch attitude during the flare was checked at +4º for about one second as the aircraft descended below 20 ft agl.

G-WOWC touched down with a maximum recorded pitch attitude of +8º at 94 kt (31 kt below the appropriate V_{APP} and 13 kt below V_{REF}), with a peak vertical acceleration of +2.3g. The nose gear contacted the ground 1.6 seconds later.

The data sampling rate of one sample/second for both radio height and pressure altitude meant that detecting signs of sink in the final stages of the approach using the recorded data would be unreliable, particularly if the sink was transitory.

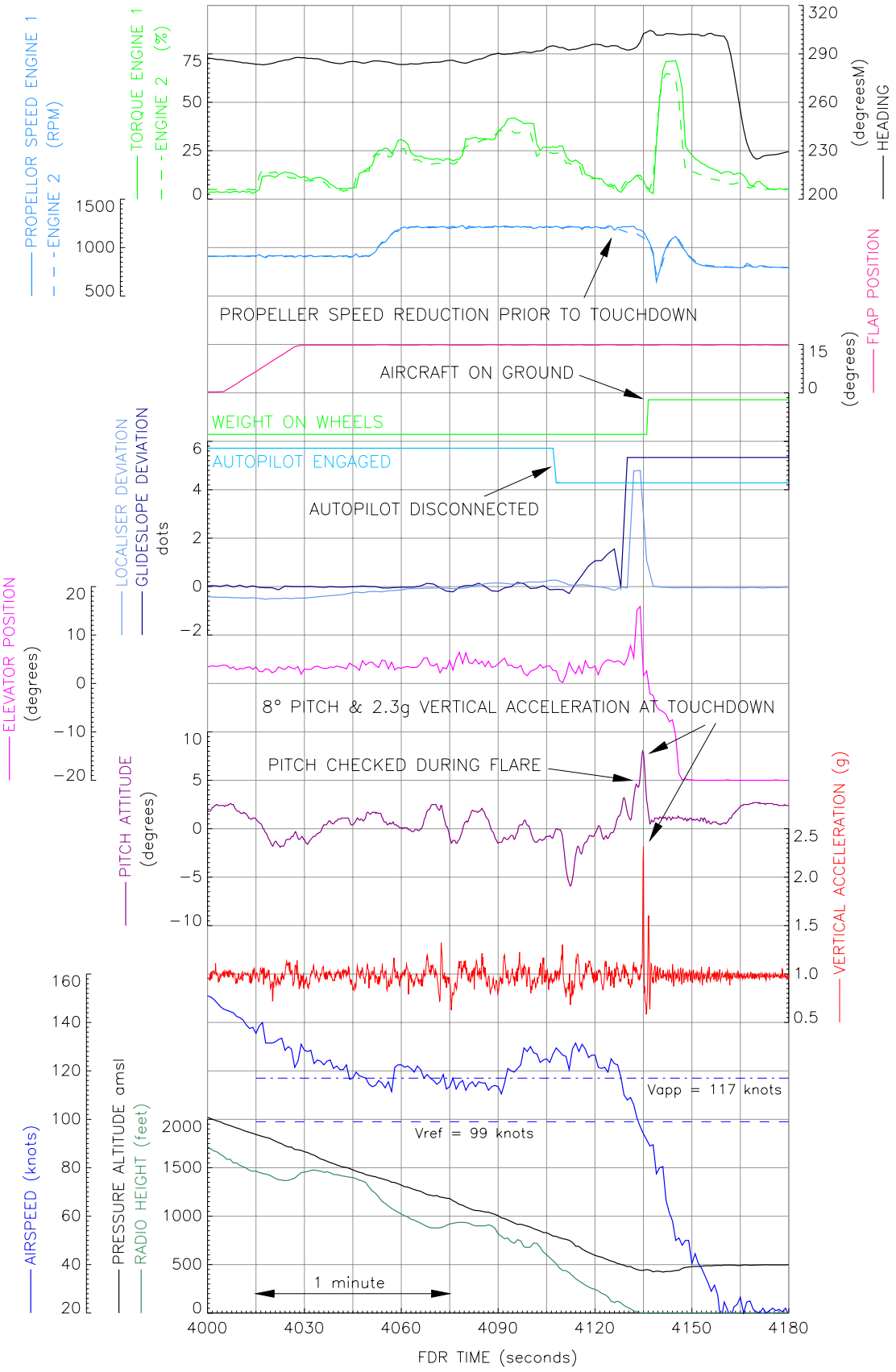

Figure 1

Salient FDR Parameters - Approach and Landing

Analysis

The commander commented he had experienced the conditions mentioned in the AIP when landing on Runway 31 at Plymouth. Given the wind at the time and bearing in mind the AIP warnings, it is likely that some form of windshear reduced the aircraft's IAS during the final stages of the approach.

Soon after the autopilot was disconnected, the aircraft pitched nose down and descended below the glideslope. This happened at about the time the commander became visual with the runway and at the same time the throttles were retarded. The IAS then fluctuated between 120 kt and 130 kt until 7 seconds before touchdown. In turbulent conditions it is common practice for pilots to allow the speed to fluctuate around V_{APP} whilst ensuring that it does not go below V_{REF}.

Next, at about 90 ft aal, the IAS reduced below the appropriate V_{APP} and the throttles were retarded a little further. Because the aircraft was relatively heavy, this closure of the throttles would have increased drag caused by the propellers and reduced lift over the inboard sections of the wings. All of these factors combined would have caused the IAS to continue decreasing and for the aircraft's sink rate to increase. Flaring the aircraft at 20 ft agl, higher than the recommended 10 ft agl, further reduced the aircraft's airspeed.

The reduction in thrust, combined with a slow and heavy aircraft, would have increased the aircraft's rate of descent and may have caused the "sinking feeling" felt by the crew. Any negative wind shear would also have aggravated the reduction in airspeed and wing lift. Just after the "sinking feeling" was perceived, the throttles were advanced slightly, and the commander raised the aircraft's nose to reduce the rate of descent prior to touchdown. This pitch up led to a slight over-rotation of the aircraft at touchdown and the 'touched runway' sensor contacting the runway.

Conclusion

The incident occurred through a combination of turbulence, windshear and the pilot's inappropriate response to reducing airspeed throughout the final 10 seconds of the approach. The handling pilot's control inputs caused the aircraft's pitch attitude to exceed the 6º nose-up limit, beyond which there is a risk of a tail strike. In this incident the consequential damage was limited to the 'touched runway' sensor.