INCIDENT

Aircraft Type and Registration:	De Havilland Canada DHC-8 Series 311, G-NVSB
No & Type of Engines:	2 Pratt & Whitney Canada PW123 turboprop engines
Year of Manufacture:	1998
Date & Time (UTC):	9 August 2005 at 0830 hrs
Location:	On departure from Manchester Airport
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 33
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to right engine and propeller assembly
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience:	15,735 hours (of which 3,634 were on type) Last 90 days - 205 hours Last 28 days - 81 hours
Information Source:	AAIB Field Investigation

Synopsis

Shortly after takeoff from Manchester the No 2 (right) engine failed and subsequent attempts to feather the propeller were unsuccessful. The aircraft returned to Manchester where it made an uneventful landing. The No 1 propeller blade support bearing of the right propeller assembly had failed catastrophically, resulting in large imbalance loads through the engine. This led to the fracture of the Power Turbine (PT) shaft, and a consequent overspeed of the PTs, leading to the loss of the PT blades and an exhaust baffle plate from the rear of the engine. The failure of the propeller to feather was due to a ball from the failed bearing becoming jammed between the propeller blade root and the propeller hub. The origin of the bearing failure was not determined although metallurgic examination revealed that cracking had been occurring for a period of time. Six days prior to the incident, heavy vibration was reported but, as vibration survey equipment was not available at the time, the defect was deferred in accordance with the aircraft operator's technical instruction. When vibration survey equipment was fitted, it was set up incorrectly and a full vibration survey was not carried out prior to the incident flight. Two safety recommendations are made.

History of the flight

The aircraft was on a scheduled passenger flight from Manchester to Aberdeen. Prior to the flight the commander and co-pilot had been informed by the company operations department that a propeller vibration survey was required during the flight. The commander had flown the aircraft the previous day, during which he was due to take readings using a monitoring kit that had been fitted specifically for the measurement of reported propeller vibration. During this flight, the commander felt that the vibration levels peaked during propeller speeds of between 900 rpm and 1200 rpm and that this was worse than normal. However, the vibration monitoring equipment was not working correctly so the commander was unable to take any meaningful readings.

The co-pilot was the pilot flying (PF) on the incident flight; the commander was the pilot not flying (PNF). After the engines were started normal checks were carried out with no reported problems, except that during the de-icing checks, airframe vibration was felt with the propellers at 900 rpm. When the aircraft lined up on the runway, a check of the autofeather system was carried out, again with no problems. However, during the takeoff the commander felt the airframe vibration again and thought it had worsened compared with the flight he had carried out the previous day. As the flaps were retracted the crew discussed the vibration level and considered a possible return to Manchester.

In accordance with standard procedure, the autofeather system was deselected and engine power was reduced, at which point there was a 'pop' and a 'bang', heavy vibration was felt and the aircraft yawed to the right. The PF noticed that the torque indicator for engine No 2 was showing 0% and therefore he called for the engine shutdown drill to be carried out. The PNF completed the shutdown drill but the propeller did not feather when the condition lever was selected to START & FEATHER. ALTERNATE FEATHER was selected, but the propeller would still not feather. The propeller speed indication remained at about 500 rpm for the remainder of the flight.

A MAYDAY call was made and ATC gave the crew a priority visual circuit for an approach to runway 24R. The flight crew briefed the cabin crew about the problem and instructed them to prepare for an emergency landing. At about four miles from touchdown the landing gear was selected down, but only the main landing gears indicated as 'down and locked'; the nose landing gear indicated 'unsafe'. The alternate landing gear release was used, successfully, and the approach continued to an uneventful landing. The aircraft vacated the runway and was met by the airfield Rescue and Fire Fighting Service (RFFS), who reported that there were signs of overheating on the left main gear wheels. A precautionary evacuation of the passengers was carried out using the integral airstairs on the forward left door. The co-pilot had remained as PF during the incident, as the commander felt that there was not an appropriate opportunity for him to have safely taken control.

On the day of the incident, a member of the public had been riding a horse in a field to the south of Manchester airport, and had seen a "sizzling hot" object the size and shape of a dinner plate fall from an aircraft and land nearby. The time at which this object had fallen was concurrent with the overflight of G-NVSB and it was later confirmed that the object was a baffle from the rear exhaust section of the aircraft's No 2 engine.

Weather

The weather at the time was reported as being good with a wind of 150°/5 kt, visibility 9 km and broken cloud at 8,800 ft.

Aircraft Description

General

The Dash 8-300 aircraft is powered by two Pratt and Whitney PW123 turboprop engines, each driving a four-bladed Hamilton Sundstrand constant speed propeller, which can be feathered and reversed. G-NVSB was fitted with Type 14SF-15 propeller blades.

Engine

The PW123 engine gas generator is comprised of two spools. The first spool is a single Low Pressure (LP) centrifugal compressor which is shaft driven by a single LP turbine. The second spool is a high pressure (HP) centrifugal compressor, also shaft driven, by a single HP turbine. Power is provided to the propeller, via a reduction gear box, by a two stage free PT located at the rear of the engine. This shaft rotates clockwise and runs internally within the LP shaft, which in turn rotates anticlockwise within the clockwise rotating HP shaft. Each shaft is supported by various bearings throughout the engine.

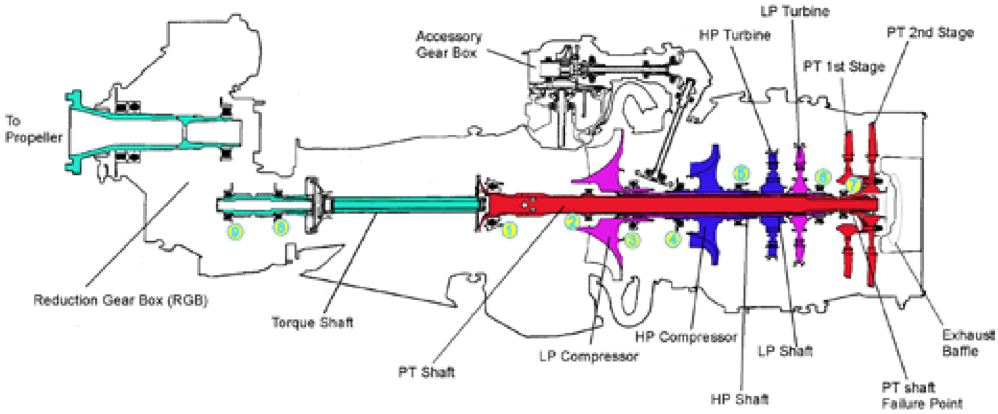

Figure 1

PW123 Engine Shaft Layout and Bearing Locations

The engine contains a wet sump oil lubrication system, pressurised by a pump driven by the accessory gear box (AGB). Scavenge pumps, also driven by the AGB, return used oil to the sump. An auxiliary oil tank is located within the reduction gearbox and this is kept full, being replenished with pressurised oil whenever the engine is running.

To the rear of the engine, aft of the PT stage, is an exhaust assembly, the centre of which contains a baffle plate.

Engine Control and Indication

Two engine power levers control the engine speed in the forward power range, and propeller blade pitch angle in idle and reverse 'beta' range. Two condition levers, located to the right of the engine power levers, provide control over propeller speed between 1,200 rpm (MAX) and 900 rpm (MIN), by altering the propeller blade pitch over a range of +26° to +86°. Moving the condition lever aft to START&FEATHER causes the propeller blade angle to be manually commanded into the feather setting. The full aft position is FUEL OFF, which cuts off fuel supply to the engine.

Engine torque for each engine is indicated as a percentage and is displayed to the flight crew on the centre instrument panel. The torque signal is taken from a sensor located on the front inlet case of the engine and this senses the passing of teeth on the PT torque shaft as it rotates. A similar set of teeth are mounted on an unloaded reference tube and it is the phase difference between the passing of the teeth on the torque shaft and the reference tube which determines the torque output indication of the engine. The passing frequency of the teeth on the torque shaft also determines the PT speed (N_{PT}).

The speed of each propeller is also indicated to the flight crew and is generated by a speed sensor located within the reduction gear box.

Propeller

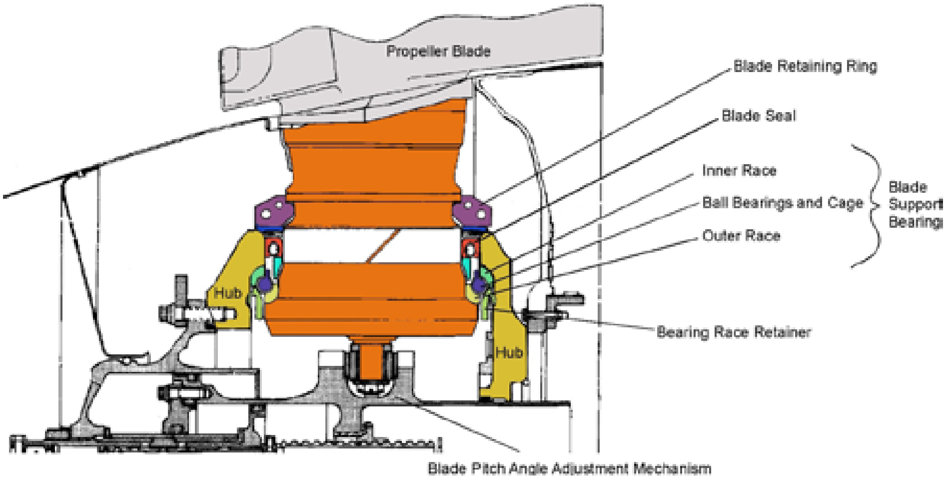

Figure 2

Cross section of a typical propeller blade to hub installation

The propeller assembly consists of four propeller blades retained within a hub, which contains the blade pitch change mechanism. Each blade is retained and supported by bearings which consist of a single piece outer race, a single or split inner race, and steel balls separated by a nylon cage. A nylon bearing race retainer ring holds the outer bearing race in position. Spring blade seals, kept in place with a seal support ring and spacer, seal the blade to the hub and are retained statically by an aluminum retaining ring.

The propeller control unit (PCU) uses high pressure oil supplied from the engine oil system to control the propeller blades pitch angle. This is determined from propeller speed, engine speed and condition lever position. The PCU controls the supply of oil to the pitch change mechanism piston, which then drives yokes connected to rollers on the bottom of each of the propeller blades. The fore and aft motion of the yokes imparts a rotational movement to each blade, thereby changing the pitch angle.

Propeller feathering

Propeller feathering on the DHC Dash-8-300 can be either automatic, when the system is armed, or manually commanded by the flight crew. There is also an alternate feather system, to be used should either the automatic feather system not operate or there is a loss of engine oil pressure.

Automatic feathering is only armed during takeoff and is disarmed by the crew once established in the climb. Should the engine torque drop below 28% during takeoff or the initial climb, the PCU is commanded to move the propeller blades of the affected engine into feather and the remaining engine is then commanded, via its engine control unit (ECU), to increase power (up-trim).

The manual command to feather a propeller, whilst the engine is running, is accomplished by selection of the condition lever into START&FEATHER position but there is no associated 'up-trim' of the remaining engine.

An 'alternate feather' system is provided so that a propeller may be feathered, via the PCU, but using the auxiliary oil supply and separate oil pump. This system is designed so that it can provide feathering oil pressure to the PCU in the event of a loss of engine oil pressure. 'Alternate feather' is actuated by a switch on the centre console in the cockpit, and requires the engine power lever to be in a position at, or greater than, flight idle and the condition lever to be below the MIN setting.

Flight Data Recorder

Data from the aircraft's flight data recorder covering the incident flight is presented in Figures 3 and 4.

Aircraft examination

The aircraft was inspected by the aircraft operator's maintenance organisation. Externally, there was evidence of a significant oil loss from the No 2 engine propeller hub with oil staining evident on the outside of the engine cowls. On their removal, and after further inspection of the propeller assembly, it was revealed that one of the propeller blade support bearings had failed catastrophically. The remains of the bearing inner race, ball and ball race support cage had been retained within the propeller hub. All four propeller blades had remained attached to the hub.

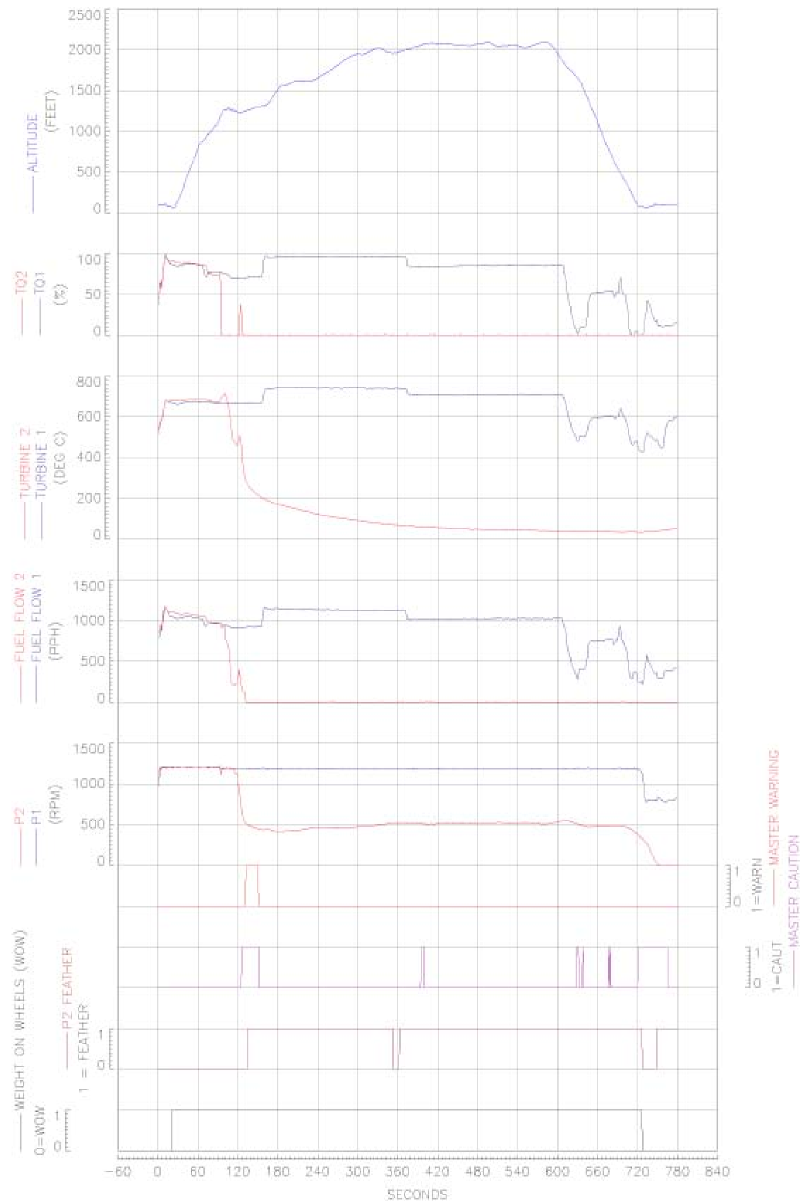

Figure 3

Salient FDR Parameters
(Incident to G-NVSB on 9 August 2005)

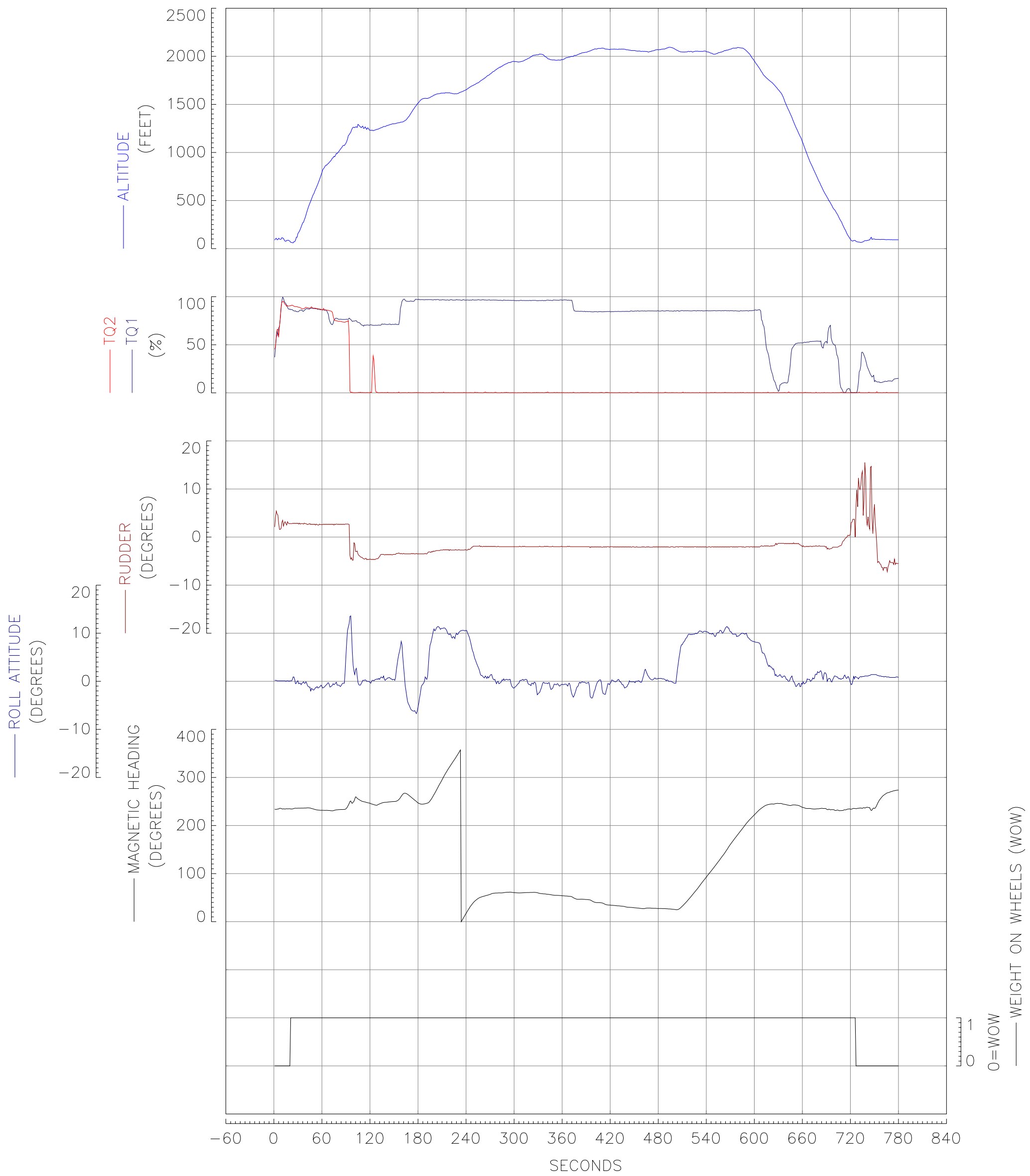

Figure 4

Salient FDR Parameters
(Incident to G-NVSB on 9 August 2005)

Additional inspection of the No 2 engine revealed that the PT had been damaged significantly, with most of the turbine blades on the first and second stage missing. A large section of the rear exhaust baffle was also missing. There was no evidence of an uncontained engine failure, all debris having exited the engine through the exhaust duct.

Both the No 2 propeller assembly and engine were removed from the aircraft and taken to specialist organisations for further detailed examination.

Engine examination

The engine was strip examined at the manufacturer's UK overhaul workshops and from this it was clear that the PT shaft had become disconnected. The two PT discs had been severely damaged and had lost all of their blades. Also, the second stage PT disc had

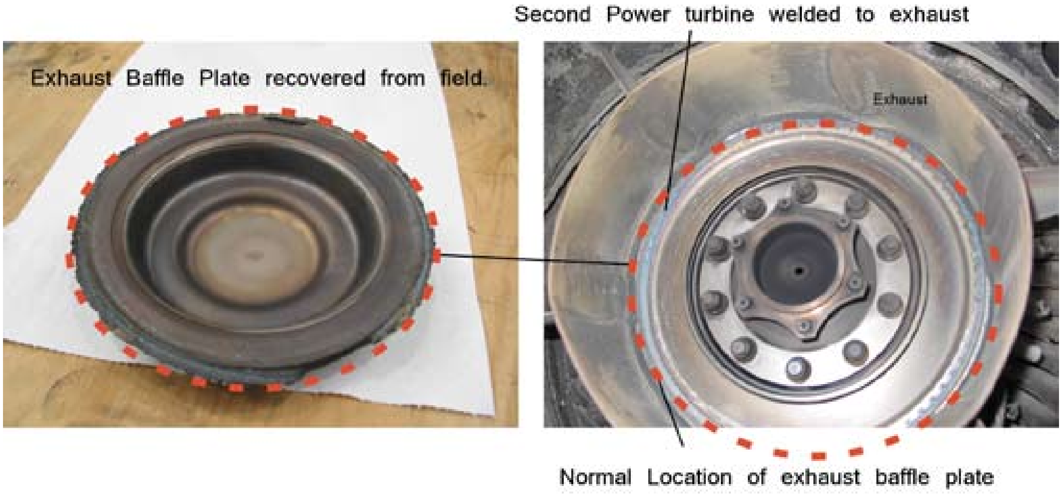

Figure 5

Damage to the exhaust components

come into contact with the exhaust duct and, in the process, had 'machined' into the baffle plate, causing it to depart from the rear of the engine. This disc had then friction welded itself to the remains of the exhaust duct, Figure 5.

The PT shaft had failed just forward of the PT stages and, on its removal, evidence of damage consistent with a torsional failure became apparent, Figure 6. Associated rubbing damage was present on the inner section of the LP shaft. The HP and LP turbine discs were relatively intact with some rubbing evident on the tips of the blades; additionally, there were some light marks evident on the HP and LP centrifugal compressors where they had made contact with the engine caseing.

Propeller examination

The propeller assembly was strip examined at a specialist workshop. This revealed that the failed blade support bearing was that associated with propeller blade No 1. Blade Nos 2, 3 and 4 had been removed from the hub prior to shipping and all appeared to be in a satisfactory condition; the damage associated with blade No 1 precluded its immediate removal. Once removed, it was evident that the inner race, ball race and ball retainer of the blade support bearing had all been significantly damaged and were in many pieces, Figure 7. The outer race remained in one piece in the hub, although it exhibited signs of

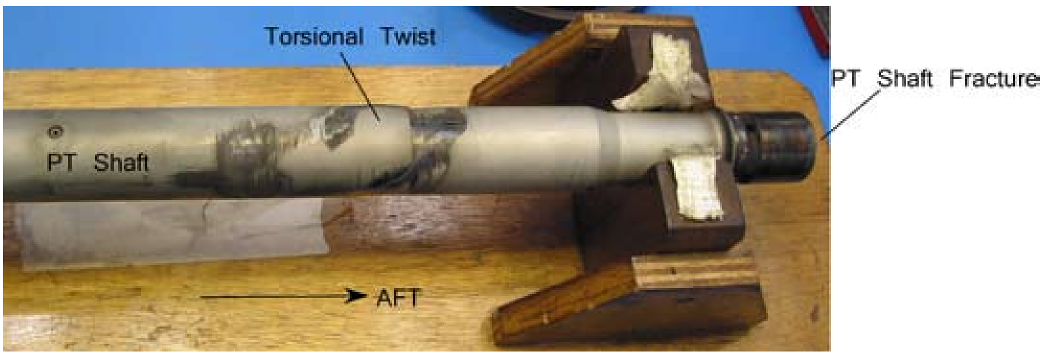

Figure 6

Power Turbine shaft damage

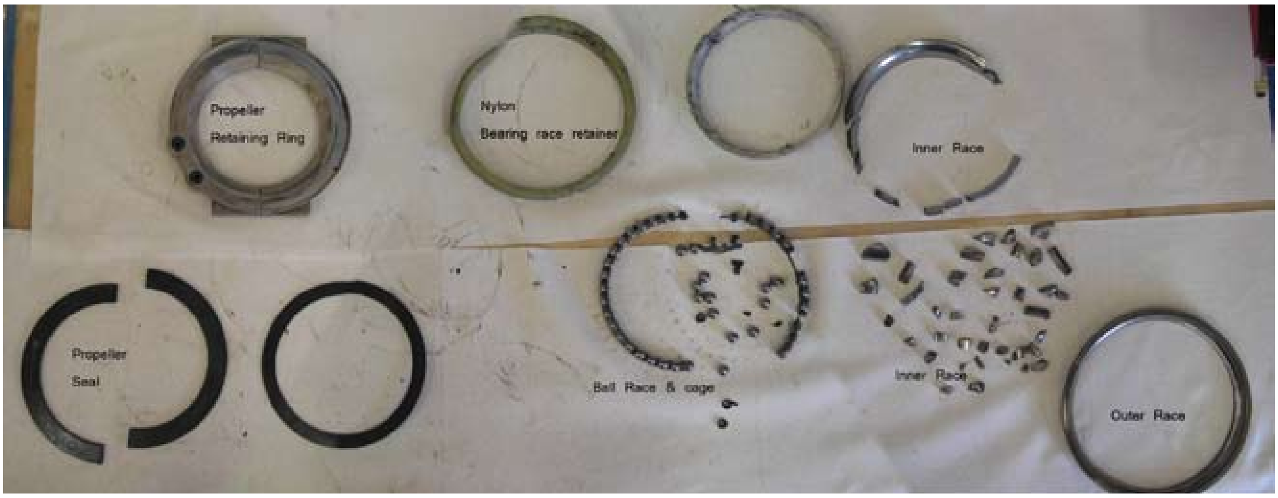

Figure 7

Damaged components of the No 1 propeller blasé support bearing

galling, brinelling and impact damage. The nylon bearing race retainer was also damaged and found in two pieces.

Evidence was found that a ball had become trapped between the blade shank and the hub, with heavy witness marks consistent with the ball having moved with the rotation of the blade toward the feather pitch position, Figure 8. The relative positions of these marks indicated that the blade pitch angle was 31° when the damage occurred. It was evident that the ball had jammed the propeller blade pitch at this position and, consequently, had prevented further movement of all the propeller blades into the feather (86° pitch) position. In addition, the drive roller at the base of the No 1 blade was bent.

No 2 engine propeller assembly history

In the original build, the blade retention bearings used in this hub assembly used a single piece inner race. A split inner race could have been retrofitted whenever the propeller assembly was overhauled or partially disassembled for any reason, if judged necessary.

Figure 8

The propeller pitch change mechanism and the PCU were checked and found to be satisfactory

Bearing histories

Bearing No 1		Overhauled at 10,583 hours on 10.10.01 and fitted to G-NVSB with TSO of 1083.49 hours on 25.08.02. Failed at 16,714 hours. Single piece inner race.
Bearing No 2	24,737 hours TSN	TSO 19,288 hours. Single piece inner race
Bearing No 3	12,010 hours TSN	TSO 2,106 hours. Single piece inner race
Bearing No 4	10,443 hours TSN	TSO 3,083 hours. Split inner race

Metallurgic examinations

Engine

The circumferential scoring on the inside of the LP shaft and the torsional overloading of the PT was as a result of contact with each other. The fracture of the PT shaft occurred at its splined aft end and the fracture exhibited evidence of fatigue cracking, with the final failure due to torsional loading. Neither of the two shafts possessed any pre-existing defects and their material was confirmed as being to design specification.

No 1 propeller blade support bearing

Metallurgic examination of the remains of the No 1 blade retention bearing revealed that its inner race had failed mainly due to overload. Due to the severe nature of the damage, it was not possible to determine the root cause of the failure; however, corrosion of the fracture surfaces indicated that cracks had developed over a relatively long period of time prior to its final failure and break up. Some of these cracks had originated from brinelling of the inner race surface, which was also evident on the outer race, and was consistent with the balls striking, or hammering, the bearing race surface. The irregular pattern of the brinelling suggested that this damage had also been progressive over a period of time. The bearing material conformed to the original design specification.

Bearing life

The propeller blade support bearings do not have a specified life and are considered to be 'on condition'. Due to their location, they cannot be inspected in-situ and can only be inspected if the propeller blade is removed, which normally will only occur during a workshop visit. The time this is likely to occur is during a major overhaul of the propeller assembly, following damage to a propeller blade or following a report of an overtorque on the propeller assembly.

Aircraft vibration history

The technical log for the aircraft revealed that an entry had been made on 3 August 2005 for propeller vibration and it stated:

> *'Prop vibration felt throughout RPM 900 - 1200 particularly bad between 980 - 1080 RPM'*

The action taken was:

> *'Noted with thanks. Due nil test equipment @ MAN ADD[1] P147 raised IAW TI D83-61-02'*

Technical Instruction (TI) D83-61-02, issued in December 2003 by the operator, allowed, at the discretion of the engineer, the deferral of a reported propeller vibration defect for a maximum of 50 flying hours. There were no other entries relating to the propeller vibration until 6 August 2005 when the

Footnote

[1] ADD – Acceptable Deferred Defect, which is a numbered reference to a reported defect that has been deferred for later rectification.

propeller balance test equipment was fitted, with a reference to ADD P147. During the subsequent flight, in which the propeller balance survey was carried out, the results contained a fault code on the equipment, indicating that it had been incorrectly set up. This problem was addressed and a request was made for an additional survey to be carried out on the next sector. However, despite the equipment being fitted, no record was found of any in-flight vibration survey being carried out. Overnight 8/9 August 2005, another request was made, using the technical log, for a vibration survey to be carried out on the next flight. The incident occurred on the first flight following this request.

The commander of the incident flight had flown the aircraft on the previous day and had attempted to carry out a vibration survey, but found the vibration monitoring equipment to be faulty; no record of this was found in the technical log.

Vibration monitoring

G-NVSB was not equipped with any form of propeller vibration indication or other monitoring equipment for use in normal operation. The aircraft maintenance manual (MM) provides details on how to conduct propeller vibration measurements on these aircraft. This requires the use of test equipment to be fitted to the aircraft to enable the vibration levels from each propeller to be recorded. The MM specifies the use of the Chadwick-Helmuth CH-8500 series vibration analyzer. However, at the time of the incident, the operator of G-NVSB was using alternative equipment, and its associated operating manual, in lieu of that given in the aircraft MM.

The maintenance manual states:

> *'Note: Propeller dynamic balancing cannot be successfully performed on the ground. Operate aircraft in stable air (nominally 10,000 ft altitude) with no icing conditions. Aircraft should be trimmed for straight and level flight…'*

It also states:

> *'Because of the propeller vibrations produced by both propellers are at the same frequency (same RPMs), one propeller may influence the reading obtained for the other propeller. Therefore an extra data collection flight (or two) may be necessary before an acceptable balance (0.15 IPS or less) is achieved'*

The only limit given with regard to vibration levels is that specified above, ie 0.15 inches per second (IPS). The aircraft manufacturer does not provide vibration limits which would trigger investigation of the propeller or engine prior to a further survey flight.

At the time of the incident, the operator conducted propeller vibration surveys on normal scheduled passenger flights, with the flight crew expected to operate the monitoring equipment to take the readings.

The Dash 8 Q400 series of aircraft is fitted with a propeller vibration and balance monitoring system which is coupled to the active noise cancelling system.

There are permanent on-board propeller vibration and balance monitoring systems that can be fitted to the DHC 8-311. These are not provided by the aircraft manufacturer, but by other component manufacturers and are certificated to be fitted to the aircraft by the issue of an approved supplemental type certificate (STC).

Previous Occurrences

According to the propeller manufacturer, over at least the last twenty years, they know of five previous occurrences in which the propeller blade support bearing has failed. In each of these events the initial symptom was vibration, with a resulting engine shutdown or a reduction in engine power. All propeller blades were retained in the hub in these events.

Analysis

The failure of the No 2 engine, and subsequent failure of the propeller to feather at a critical stage of flight, exposed the flight crew to a situation which they would not normally experience and one for which they were not trained. However, the prompt actions taken by the flight crew enabled a safe return and landing. It was fortunate that despite the propeller not being fully feathered, sufficient rudder authority was available to maintain directional control.

The cause of the incident was due to a catastrophic failure of the No 1 propeller blade support bearing, forming part of the No 2 engine propeller assembly. The bearing appears to have broken up just after takeoff just as engine power was being reduced. The 'pop' and 'bang' reported by the flight crew was likely to have been the propeller blade support bearing failure and the subsequent rapid engine failure; all damage identified in the engine was consistent with being a direct result of the failure of this bearing.

Following the failure, large out of balance loads would have been generated which affected not only the propeller assembly but also the engine's power drive system, in particular, the PT shaft. The out of balance loads caused the PT shaft to 'whip' and come in contact with the inner surface of the contra-rotating LP shaft, resulting in a large torsional load in the PT shaft and its eventual fracture. This disconnected the two PT stages, which very quickly oversped, moving aft in the process, and shedding their blades from the engine exhaust. The 2nd stage PT disc had also come into contact with, and welded itself to, the exhaust assembly, which removed enough material to allow the rear exhaust baffle plate to become detached.

The PT shaft failure removed all torque to the propeller and produced the 0% torque indication in the cockpit. The subsequent shutdown of the engine was successful, however, the feathering of the propeller could not be completed. A ball from the failed bearing prevented complete movement of the propeller blade in pitch, when it had become jammed between the blade shank and the hub. This effectively locked the propeller pitch angle at 31º, causing the propeller assembly to windmill at about 500 rpm.

The cause of the bearing failure was not determined. The bearing had completed 16,714 hours in service so, initially, it was thought that its age was a contributing factor. However, the blade No 2 bearing of the same assembly had completed 24,737 hours and showed no signs of an impending failure. The propeller manufacturer has knowledge of only five previous instances of bearing failures in service and, as such, this failure is considered quite a rare occurrence. Therefore, it is unlikely that the failure was 'time-in-service' related. It was also unlikely that the failure was due to an installation problem as the propeller had been fitted within the hub and had apparently been operating satisfactorily for over 5,000 hours, of the four and had not been disturbed during that time. The brinelling damage to the bearing races indicates that the balls had been free to move within the races, as the marks were generated by the balls striking the races. It is possible that there had either been a failure of the ball cage, or the retaining clip for the ball race had fractured or become detached, as it was not located in the remains recovered from the propeller hub. It was also possible, in the manufacturer's view, that the lubricating oil within the propeller hub could have been contaminated with hard particles, which may have induced fatigue cracking and precipitated the initial failure of the inner bearing race.

As the failure was limited to only one bearing within the propeller assembly, it is unlikely that an overtorque event had precipitated the failure, as this would equally affect all the bearings. Similarly, there was no external damage to the propeller blade or a report of any previous damage that could have induced loads required to initiate the bearing failure.

Although, it was not possible to determine the exact cause of the bearing failure, it appears there were warning signs (vibration) of the impending failure that, if heeded in time, might have prevented the failure. Metallurgic examination has shown that cracks had developed, and been in existence for some time, prior to the break up of the inner race and that some of these cracks originated from brinelling marks. The reports in the technical log indicated that vibration had been evident during a flight on 3 August 2005, some six days prior to the incident. It is considered likely that this vibration was due to the early stages of propeller blade support bearing failure.

At the time of this incident, the operator allowed propeller vibration defects to be deferred, despite having no method to quantify the severity of the vibration or its origin. This operator's aircraft type is not equipped with an on-board vibration monitoring or indication system, so the determination of severity of any vibration is purely a subjective assessment by the crew. The only way to measure vibration is to fit test equipment and conduct a flight on which the vibration level can be ascertained. Indeed, it would appear that the intention of a deferral is to allow the aircraft to continue in service until vibration test equipment becomes available.

In the case of G-NVSB, the raising of a deferred defect in the technical log, was due to the unavailability of test equipment. It was not until 6 August 2005, that the test equipment was finally fitted. Despite this, the subsequent measurements taken were unusable due to a fault in its set up. This included an attempt by the commander of the incident flight, the day before, during which he also found the survey equipment faulty. Finally, a request was made, via the technical log, for a survey flight. Unfortunately, the incident flight was the first flight following this request.

Had a full vibration survey been successfully carried out, it is not known whether the failed bearing would have been immediately identified. The maintenance manual procedure is to, initially rebalance the propeller, based on the survey information, and to continue to do so until the vibration drops to the specified acceptable limit of 0.15 IPS. There is no information in the maintenance manual to guide the operator to look deeper into the propeller assembly for other possible causes, or damage; indeed, there is no upper limit to the vibration level at which it is deemed unacceptable to continue flight without a thorough examination of the assembly.

Therefore the following safety recommendation is made:

Safety Recommendation 2006-067

It is recommended that Transport Canada require the aircraft manufacturer, Bombardier Aerospace, to amend the maintenance manual for the DHC Dash 8-300 aircraft with regard to propeller vibration measurements and to provide instructions when to investigate the propeller and/or engine assembly for possible internal damage, based on measured vibration levels, and to provide specific vibration level limits at which detailed inspections are required.

In a response to this safety recommendation, Transport Canada stated the following:

'Transport Canada agrees with the intent of this recommendation. If appropriate Instructions for Continued Airworthiness (ICA) or other operational limitations for procedures regarding significant or unusual vibration events were in place at the time of the initial event noted in the "Aircraft Vibration History" [page 47 in this Bulletin]*, the bearing failure and subsequent events may have been prevented.'*

In response to this safety recommendation, the aircraft manufacturer have provided the following information:

'We were recently informed by Hamilton Sundstrand that they are planning to incorporate a "Vibration Note" into their maintenance documentation. Bombardier Aerospace will review this note and make a similar change to our Aircraft Maintenance Manual (AMM). At present, there are two independent Supplemental Type Certificates (STCs) available to permantly install propeller vibration monitoring equipment in the Q100, 200 and 300 DHC-8 aircraft………

…..Reporting of abnormal vibrations in flight is very subjective. Flight crew experience and familiarity with the subject aircraft is an important criteria with identifying abnormal aircraft vibration. In our opinion, the investigation of a flight crew noted vibration scenario would highlight potential areas of concern including engine and propeller issues. The response to the reported inflight vibration will confirm either a propeller imbalance or direct maintenance to persue investigation elsewhere.'

As it is not possible to conduct a meaningful vibration survey with the aircraft on the ground, the aircraft has to be flown, but with the risk that an incipient defect may become critical during the flight. It has been a common practice to conduct these vibration surveys on revenue passenger carrying flights, using line pilots, who may not be fully conversant with the monitoring equipment. This practice comes with the attendant risk of a failure occurring, which may necessitate an emergency, as was the case with G-NVSB. It also leads to the possibility of incorrect use of the monitoring equipment and incorrect readings being taken, requiring further survey flights. If a vibration problem has already been identified on an aircraft, it would seem more prudent to conduct the vibration survey using crew members that are experienced in using the test equipment and to fly the aircraft without passengers.

Therefore the following safety recommendation is made:

Safety Recommendation 2006-068

It is recommended that Transport Canada require the aircraft manufacturer, Bombardier Aerospace, to amend the DHC Dash 8-300 maintenance manual with regard to propeller vibration monitoring flights, to ensure that vibration surveys are only conducted on non-revenue flights by appropriately trained crews.

As a direct result of this incident, the operator now carries out all airborne checks of propeller vibration levels using AMM approved equipment which is deployed only during dedicated non-revenue 'function flights'.

In addition, the aircraft manufacturer has stated that they support:

> *'the fact that flight crews must be adequately trained and proficient in the use of the propeller balancing* [vibration measuring] *equipment, prior to undertaking this task.'*

However, they:

> *'believe that mandating of this recommendation* [2006-068] *must remain at regulatory authority level. If it is decided that this task can be performed on a revenue flight, it is mandatory that it be performed during low workload periods (such as cruise flight), by an appropriately trained proficient crew.'*