Australian Government

Australian Transport Safety Bureau

Engine failure during take-off involving Bombardier Dash 8, VH-ZZE

Darwin Airport, Northern Territory, on 11 November 2019

ATSB Transport Safety Report

Aviation Occurrence Investigation (Defined)

AO-2019-060

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Addendum

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Safety summary

What happened

On 11 November 2019, at about 1510 Central Standard Time, a Bombardier DHC-8-315 aircraft, registered VH-ZZE and operated by Surveillance Australia, was about to start the take-off roll from Darwin Airport, Northern Territory, on a surveillance flight. There were four crew on board.

The aircraft was on the departure runway with the brakes on. Power was applied to both engines, but when take-off power was reached, and prior to the release of the brakes, the crew heard a loud bang. The take-off was aborted, and air traffic control advised the crew of smoke from the right engine. After reviewing the engine instrumentation, the crew shut down the engine and returned the aircraft to the maintenance hangar.

A subsequent inspection of the runway identified metal fragments behind the aircraft's take-off position. An external inspection of the right engine revealed significant damage to the power turbine (PT) assembly.

What the ATSB found

The PT shaft of the aircraft's right engine fractured due to fatigue cracking, resulting in secondary damage and engine failure. The fatigue cracking initiated at corrosion pitting, which was probably associated with prolonged low-altitude operation in a marine environment.

The PT shaft originally installed in the engine was replaced during its first overhaul in 2011 due to excessive corrosion pitting. However, the finding of corrosion was not escalated by the maintenance organisation to Pratt & Whitney Canada (P&WC), possibly due to the informal reporting process at the time (this process was replaced in 2018 with formal guidance and criteria for reporting such findings).

The ATSB investigation also identified that the PT shaft in Pratt & Whitney Canada PW100 series engines operating in certain marine environments is susceptible to corrosion pitting, which can grow undetected between scheduled inspections, increasing the risk of shaft fracture and engine failure.

What has been done as a result

Pratt & Whitney Canada advised the ATSB that it had commenced a review of historical overhaul experience of the PT shaft in an effort to identify which engines and operators are potentially exposed to an increased risk of PT shaft corrosion.

In addition, P&WC has proposed a range of safety action to address the safety issue concerning corrosion-related fracture of PT shafts in PW100 series engines that should complement its formalised reporting. This includes considering a borescope inspection of the PT shaft between overhauls during hot section inspections (HSI) with defined corrosion inspection criteria. A method to remove contaminants from inside the shaft during service is also being investigated. Additional mitigating action for engines within the PW100 engine fleet that have completed an HSI, but are potentially exposed to the risk of PT shaft corrosion, is also being assessed.

While the proposed actions should address the safety issue, no timeline for their implementation was provided. As such, the ATSB has issued a safety recommendation to P&WC to support the proposed action.

Safety message

The corrosion-related fracture of the power turbine shaft of the aircraft's engine in this occurrence highlights that corrosion pitting that exceeds repair limits on safety-critical components should be a warning sign to manufacturers, maintainers, and operators that the existing maintenance strategy may not be effective.

Additionally, manufacturers should provide guidance and criteria to maintenance organisations for assessing and reporting corrosion on safety-critical components. This enables identification of whether the maintenance strategy is effective or if changes are required to reduce the risk of in-service failures.

Contents

The occurrence

On 11 November 2019, at about 1510 Central Standard Time,[1] a Bombardier DHC-8-315 aircraft, registered VH-ZZE (ZZE) and operated by Surveillance Australia,[2] was about to start the take-off roll from Darwin Airport, Northern Territory, on a surveillance flight. There were four crew on board – the captain (pilot monitoring), the first officer (FO) who was the pilot flying, and two system operators.[3]

The aircraft was on the departure runway with the brakes on. Power was applied to both engines, but when take-off power was reached, and prior to the release of the brakes, the crew heard a loud bang. In response, the captain aborted the take-off, reduced both power levers to flight idle, and instructed the FO to contact air traffic control (ATC) to advise they were aborting the take-off and had an engine issue. Air traffic control acknowledged the advice and reported sighting smoke from the right engine before informing emergency services. The captain checked the right engine instrumentation and advised the crew that the torque gauge had failed, and the propeller RPM gauge indicated zero. Other indications for the gas core of the engine, such as fuel flow, appeared normal. The captain instructed the FO to shut down the engine.

After confirming the aircraft brake, hydraulic and electrical systems were functioning, the crew returned the aircraft to the maintenance hangar. A subsequent inspection of the runway by a safety car identified metal fragments behind the take-off position of ZZE.

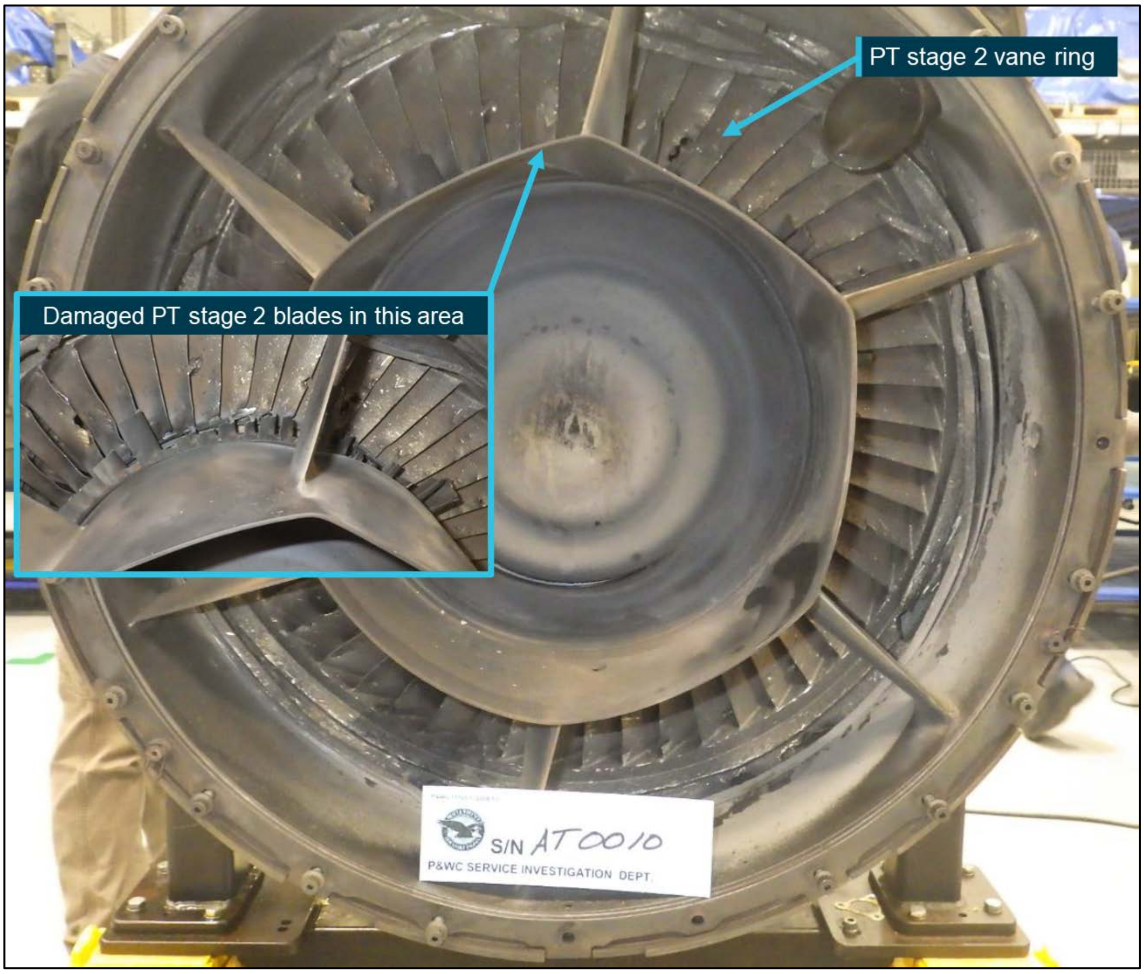
The right engine was subsequently removed from the aircraft with an external inspection revealing that all of the second-stage power turbine (PT) blades had separated from the disk (Figure 1). The PT assembly could not be rotated but the propeller shaft turned freely.

[1] Central Standard Time (CST): Coordinated Universal Time (UTC) + 9.5 hours.

[2] Surveillance Australia is a subsidiary of Cobham Aviation Services which provides a range of contract aviation services in Australia.

[3] 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.

Figure 1: Rear-view of engine showing second-stage PT damage



Source: P&WC, annotated by ATSB

Context

Operator

The aircraft, registered VH-ZZE (ZZE), formed part of the operator's fleet of 10 DHC-8 aircraft, which provided aerial surveillance operations for the Australian Border Force. Some of the aircraft began these operations in 1996 and all were fitted with Pratt & Whitney Canada (P&WC) PW100 series engines.

Operating environment

These aircraft were used for maritime surveillance activities, which required extensive flying at low level over the sea. The elevated moisture and salt content in the air at those levels created a corrosive operating environment. The fleet accumulated approximately 15,000 hours per year, with all aircraft and engines being exposed to a marine environment for a similar amount of time.

According to P&WC, there are other PW100 series operators within the global fleet that also conducted maritime surveillance activities.

Aircraft and engine information

The aircraft was a Bombardier DHC-8-315, manufactured in 2007 and operated by Surveillance Australia since March 2008. The aircraft was fitted with two P&WC PW123E turboprop engines, which form part of the PW100 series engine family.

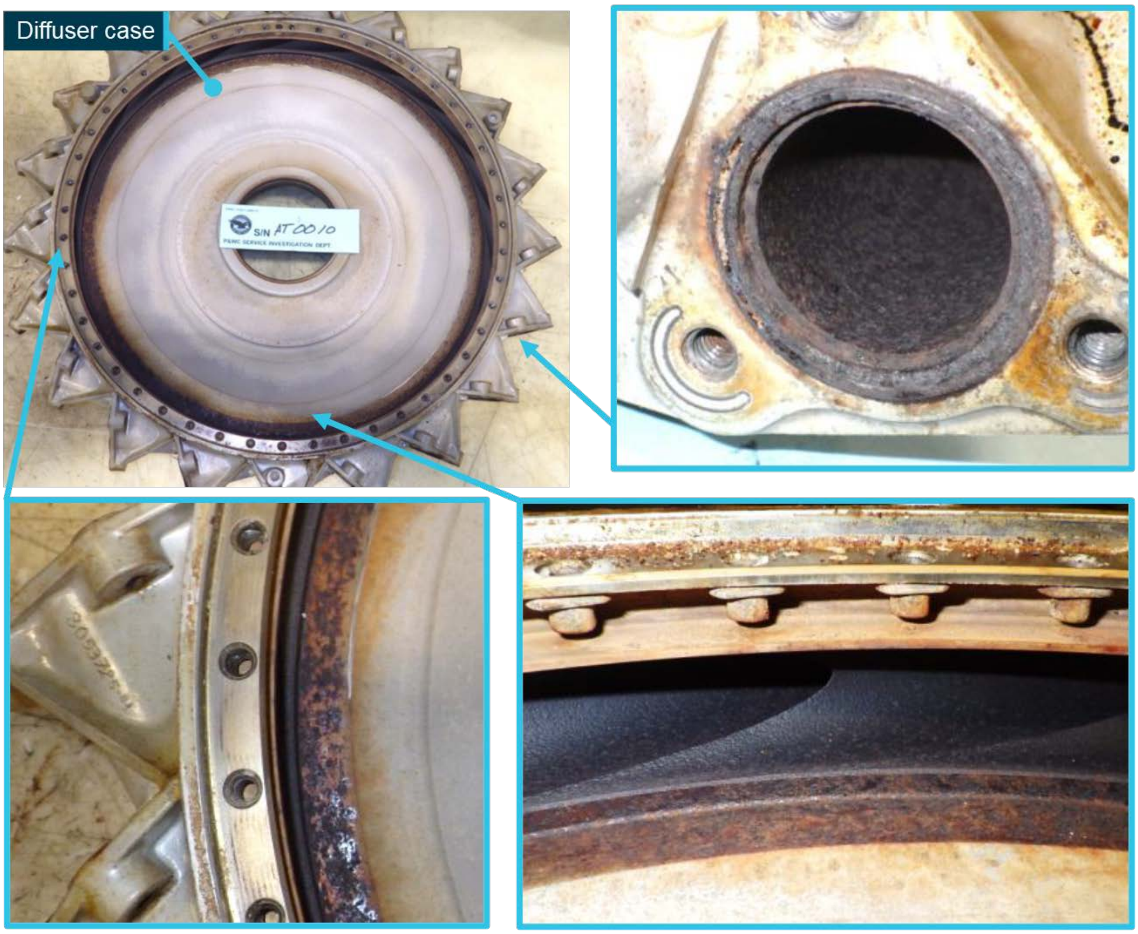
The PW123E engine has a compressor comprising a low pressure (LP) and a high pressure centrifugal impeller, each driven by an independent axial turbine. In addition, there is a reverse flow annular combustor and a two-stage power turbine (PT) that provides the drive for the reduction gearbox and propeller shaft. At the time of the incident, the right engine, serial number AT0010, had accumulated 25,801.51 hours in service and 12,254.21 hours since its last overhaul.

Engine examination

The damaged engine was transported to a P&WC maintenance facility in Canada for a detailed technical examination, supervised by the Transportation Safety Board of Canada. The following is a summary of the examination's findings.

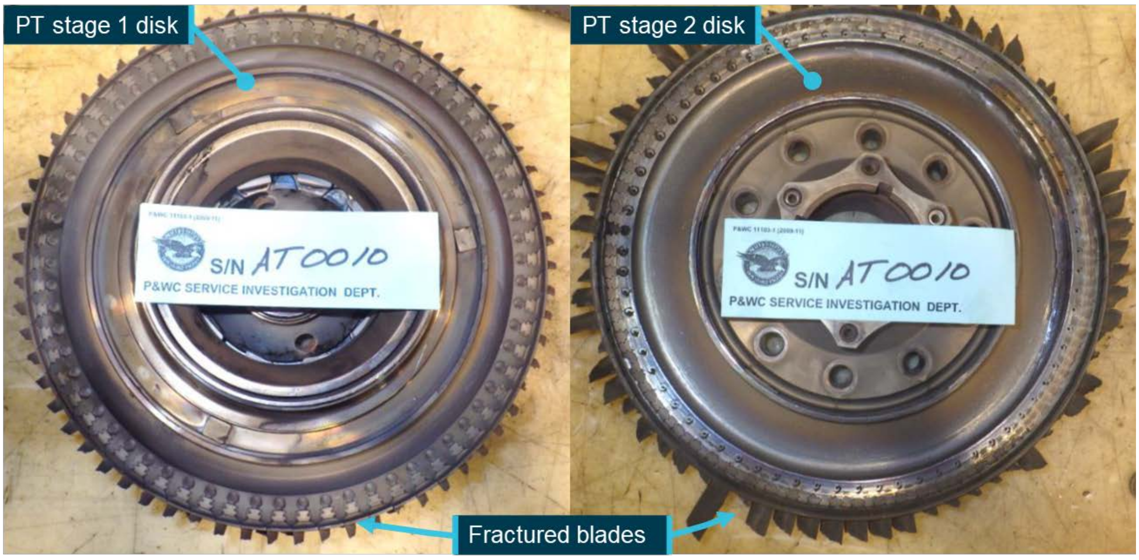
- Visual examination of the diffuser case, which contained the LP centrifugal impeller, showed corrosion at several locations (Figure 2). The LP impeller blades showed leading edge erosion.
- All PT stage 1 and stage 2 blades had fractured through tensile overload (Figure 3).
- The PT shaft (serial number A0030D9A) had fractured in two locations, referred to as surface 'A' and 'B' (Figure 4). Visual examination of the inner diameter next to surface A indicated corrosion pitting (Figure 5).
- No. 6 and No. 7 bearing oil transfer tubes had evidence of impact damage, and the vent transfer tube was fractured.
- The turbine interstage baffle was found buckled.
- The LP turbine disk assembly showed rubbing and cracks at the blade tips.
- The PT stator and vane ring exhibited impact damage.
- The exhaust case was deformed.

Figure 2: Diffuser case showing areas of corrosion



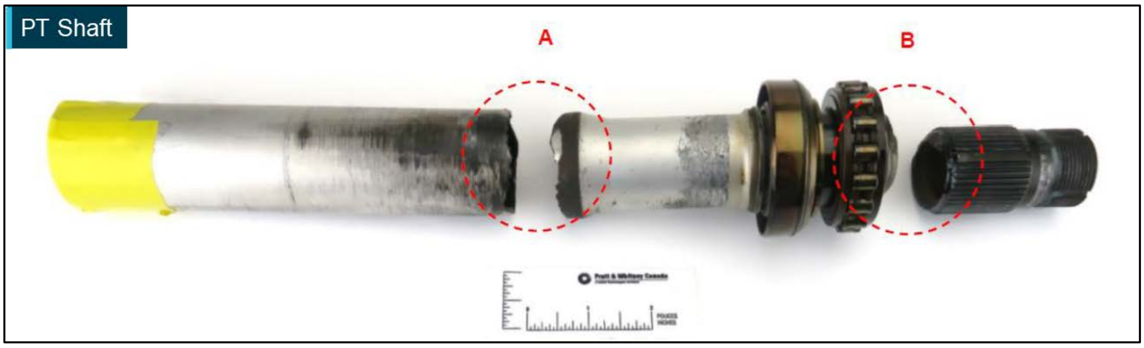
Source: P&WC, annotated by ATSB

Figure 3: Power turbine disk assemblies with all blades fractured



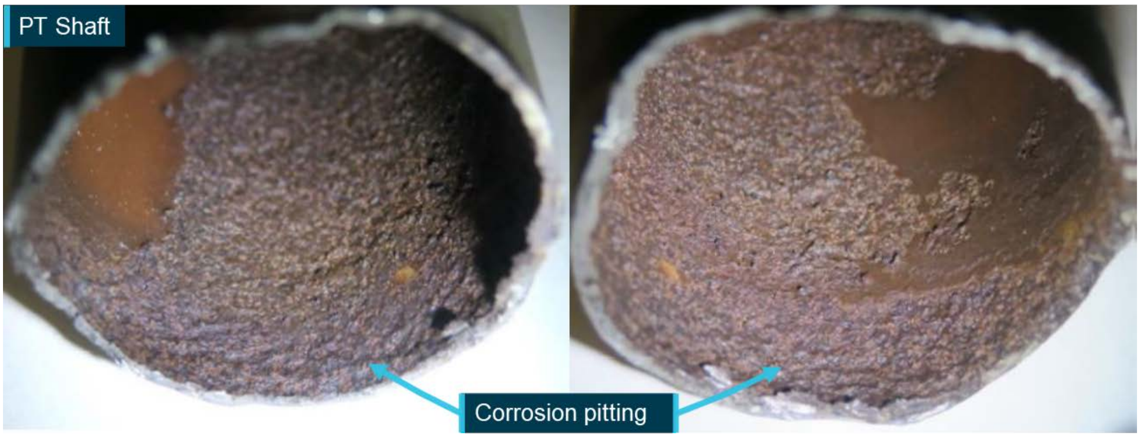
Source: P&WC, annotated by ATSB

Figure 4: Fractured PT shaft



Circled locations A and B refer to the two different fracture surfaces
Source: P&WC

Figure 5: Corrosion pitting of PT shaft internal diameter next to fracture surface A



Source: P&WC, annotated by ATSB

Metallurgical analysis

Following the engine examination, P&WC conducted a metallurgical analysis on the PT shaft which found that:

- Fatigue cracks had initiated from corrosion pits on fracture surface A. Due to the corrosion, the material thickness was 25 per cent below the minimum thickness requirement.
- The base material (steel alloy) and its hardness were consistent with the design specification.
- The corroded layer near the fracture origin showed the presence of sodium, phosphorus, sulphur, and chlorine.
- Fracture surface B showed evidence of bending (as opposed to torsional) overload fracture.

The analysis concluded that the PT shaft had fractured from fatigue cracking, which initiated at the internal corrosion pitting at surface A. The fracture of the shaft at surface B was considered secondary. After the shaft fractured, the PT stage 1 and stage 2 disks moved backwards. The stage 1 disk subsequently went into an overspeed condition, which caused the blades to fracture by tensile overload near each blade platform as designed.[4] The stage 2 disk contacted the exhaust duct, resulting in the blades fracturing through tensile overload, at various heights above the blade platforms, from impact and overspeed.

The damage to the bearing oil transfer tubes, turbine interstage baffle, PT stator, PT vane ring, exhaust case and LP turbine disk assembly were consistent with secondary damage due to the

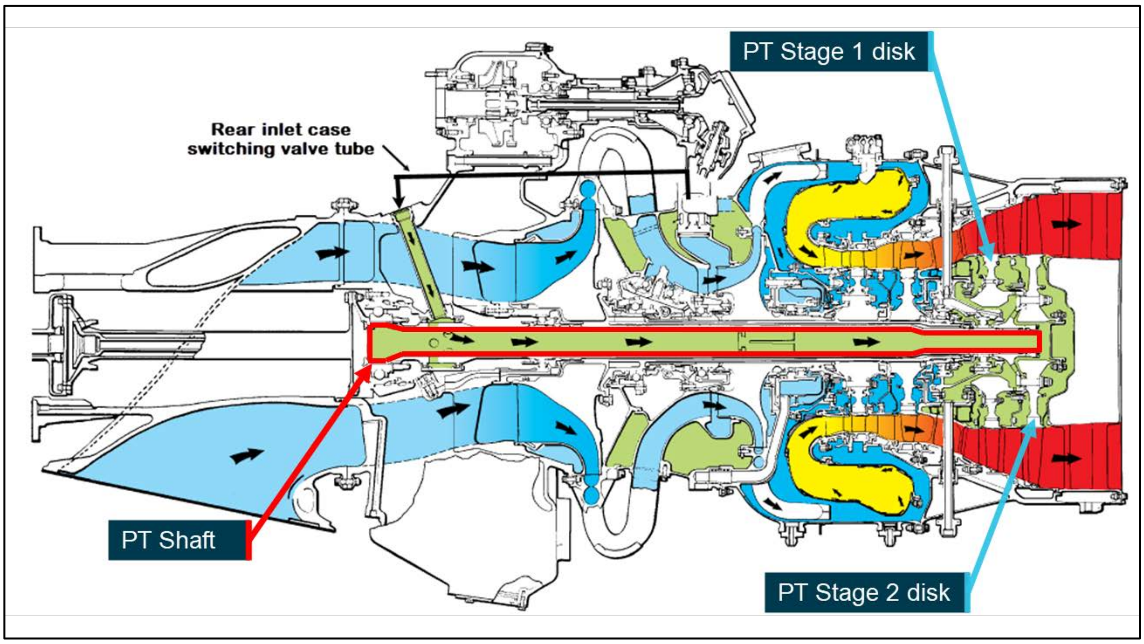
[4] The blades on both PT disks are designed to fracture in tensile overload near the blade platform when the disk is in overspeed. This is to prevent a disk burst that could result in an uncontained engine failure.

PT shaft fracture. According to P&WC, the LP impeller leading edge erosion, diffuser corrosion and PT shaft corrosion was due the engine's operational environment.

Power turbine air system and corrosion protection

During normal engine operation, some of the air flowing through the compressor is delivered to the inside of the PT shaft via internal and external tubes. This air is used to seal bearings and cool the PT stage 1 and stage 2 disks (Figure 6).

Figure 6: PW100 series air system



The black arrows show the direction of air flow. The green colour denotes PT shaft related air flow
Source: P&WC, annotated by ATSB

Internal corrosion resistance is provided by an aluminium coating applied to the inside of the shaft during manufacture. P&WC stated that during the metallurgical analysis, it was not possible to evaluate the coating near the surface fractures. However, there were no other indications, such as delamination, which would suggest the coating had been incorrectly applied. P&WC also indicated that based on in-service experience, the aluminium coating had historically provided good corrosion protection.

Engine washes

P&WC advised that engine desalination washes,[5] which are commonly used to clean and remove corrosive contaminants from the compressor and turbine sections, are not intended to perform a similar function for the PT shaft. As the shaft is part of the air system, water and washing fluid can enter the shaft during an engine wash, but not for the purpose of cleaning or removing contaminants. Any residual fluid inside the shaft is expected to evaporate when a post-wash engine run is performed in accordance with the engine maintenance manual (EMM). At the time of the occurrence, there were no maintenance procedures to clean the internal surface of the PT shaft.

Power turbine shaft maintenance

The PT shaft did not have an operational service life and was maintained 'on condition'. It was subject to maintenance at each overhaul which included cleaning, inspections and, if applicable,

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[5] Engine desalination washes, commonly referred to 'compressor washes' and 'turbine washes', are performed to remove harmful contaminants that can build-up on engine components and reduce the rate of deterioration. This is especially important for engines operated in salt-laden environments where there is an increased risk of corrosion.

repairs.[6] The aluminium coating was removed as part of the cleaning process and then re-applied after inspection or after any repairs. Any corrosion on the shaft (if observed) was evaluated against the repair limits. If within limits, the shaft was repaired, otherwise it was replaced.

The time between overhaul (TBO) depended on whether the operator's engine maintenance regime was hard-time or soft-time (on-condition). Engines maintained on hard-time maintenance were overhauled every 8,000 hours. Engines maintained on-condition, using P&WC's on-condition Maintenance Program (OCP), were overhauled based on the condition of the engine, which could extend the TBO beyond 8,000 hours. To be eligible for the OCP, an operator was required to conduct additional inspections and checks between overhauls, but there were no additional tasks required for the PT shaft. The operator was utilising an OCP for its DHC-8 engine fleet.

Engine maintenance history and management of findings

Engine AT0010 was manufactured in 2000 and was fitted to various other DHC-8 aircraft in the operator's aerial surveillance fleet throughout its life. The original PT shaft (serial number A000547M) was removed for the engine's first overhaul at 13,547.3 hours in March 2011 due to 'deep corrosion pitting' on the inner diameter of the shaft, beyond the repair limits. Corrosion was also observed on various components throughout the engine's gas path. The shaft was replaced with the subject PT shaft (serial number A0030D9A) that was new from manufacture, which then accumulated 12,254.21 hours in service before fracturing.

The operator advised that post wash engine runs were being performed on its DHC-8 fleet after every engine wash in accordance with the EMM. In addition, engine AT0010 had not experienced any extended periods of inactivity, so had not undergone any preservation[7] since its last overhaul.

P&WC managed in-service findings by categorising them into one of five categories. This process was to ensure the communication of in-service findings which had affected, or had the potential to affect, flight safety or aircraft availability. Category 5 (CAT 5) was introduced in 2018 and covered unusual or unexpected findings discovered by maintenance organisation's during scheduled engine maintenance.[8] It was intended to provide P&WC with visibility of potential warning signs that might need assessment.

P&WC stated that the reporting process at the time of the engine's first overhaul in 2011 was informal and relied primarily on the maintenance organisation's judgement of what constituted an unusual finding worth reporting. Historical P&WC records indicated that the P&WC overhaul facility did not raise the PT shaft corrosion finding during the engine's first overhaul. Although the introduction of the CAT 5 process provided procedural guidance for maintenance organisations to raise unusual findings, P&WC further stated that engineering judgement, rather than specific criteria, would still be exercised when raising a CAT 5.

Other occurrences

P&WC advised that this PT shaft fracture was the first confirmed to have occurred due to corrosion. P&WC had previously received images of a similar looking fracture, but the parts were not in a condition that allowed for detailed examination. Therefore, the cause of that fracture could not be determined.

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6 The inspections involved the following – non-destructive inspection for cracks, hardness check, dimensional checks, and a visual inspection, which includes an assessment of any damage against repair limits.

7 Engine preservation refers to procedures implemented to protect an engine from corrosion during extended periods of inactivity.

8 As outlined in P&WC procedures, CAT 5 is used when the condition; has the potential to lead to a hazardous or significant event such as an uncontained engine failure or in-flight shut-down, presents a new or uncharacterised risk to flight safety or reliability of the fleet, or includes damage or wear affecting a critical component exceeding repair criteria.

Since this occurrence, corrosion on the inside of a PT shaft was discovered during a hot section inspection (HSI)[9] of another engine in the operator's DHC-8 fleet. While a PT shaft inspection is not normally carried out during an HSI, P&WC elected to conduct an unscheduled visual inspection of the shaft as a result of this occurrence. The shaft was subsequently sent to its maintenance facility in Canada for further analysis.

9 A scheduled inspection of components subject to high temperatures such as the turbine blades, turbine disks and the combustion chamber. HSI's are performed between overhauls.

Safety analysis

Engine failure

Examination of the power turbine (PT) shaft by the engine manufacturer, Pratt & Whitney Canada (P&WC), identified conclusively that it fractured due to fatigue cracking that originated from corrosion pitting. Excluding the low pressure impeller leading edge erosion and diffuser corrosion, the observed damage to other engine components, including the second PT shaft fracture location, was consistent with secondary damage due to the initial fatigue fracture.

Although the gas core of the engine continued to operate after the PT shaft fracture, no power could be transmitted to turn the section of the PT shaft still connected to the gearbox and propeller. As a result, no engine power was available, and the crew shut down the engine.

Power turbine shaft corrosion

The corrosion products identified at the PT shaft fracture origin indicated that the corrosion was probably caused by salt-laden air. Since air from the compressor entered the PT shaft during normal engine operation, corrosion causing contaminants (for example, salt) and moisture within the ambient air probably built up on the inside of the shaft, allowing corrosion to occur.

The engine had been operated at low altitude over the sea throughout its life, with PT shaft and air system corrosion evident at its first overhaul and subsequent engine examination. These observations supported P&WC's conclusion that the PT shaft corrosion was caused by the engine's operational environment.

As a result of the operator utilising an engine on-condition maintenance program, the engine operated significantly beyond the hard-time overhaul of 8,000 hours, with no additional maintenance of the PT shaft. Coupled with the absence of a cleaning process to remove contaminants from the shaft during inactivity, meant an increased operational time and calendar time between PT shaft inspections, both of which probably contributed to corrosion formation and growth.

Since post wash engine runs were being performed and the engine had not undergone any preservation, it was unlikely that any fluid or moisture would have remained in contact with the shaft surface for any extended period while the engine was inactive. There were also no indications that the shaft's protective aluminium coating had been incorrectly applied. Therefore, it was unlikely that any of these factors contributed to the observed PT shaft corrosion.

Corrosion management

The information obtained by the ATSB during this investigation indicated three instances of corrosion forming within the PT shaft of PW100 series engines that grew undetected between the scheduled overhaul inspections. All three occurred within the operator's engine fleet which have been used primarily in a marine environment, with one resulting in a fracture of the shaft.

The PT shaft fracture due to marine environment exposure demonstrated that the existing protective coating and maintenance requirements were not sufficient to prevent progression to corrosion-related fatigue fracture. Although corrosion pitting may not always lead to a fracture before overhaul, it provides sites for fatigue crack initiation, presenting an increased risk of premature fatigue fracture.

Given the power turbine shaft design and function is the same across all PW100 series engines, and there are other PW100 series operators conducting maritime surveillance activities, there is potential for this risk exposure to extend to other operators within the global fleet.

While P&WC indicated that based on its experience the PT shaft coating provided good corrosion protection, corrosion pitting outside of repair limits might not necessarily have been reported by maintenance organisations during overhaul. Reporting such findings was probably less likely prior to the introduction of the additional guidance through the CAT 5 process in 2018. Therefore, P&WC may have had limited visibility on engines exposed to an increased risk of PT shaft corrosion.

Although engine AT0010 exhibited ‘deep corrosion pitting’ of the PT shaft outside of repair limits at the engine’s first overhaul, the finding was not escalated by the maintenance organisation to P&WC for further assessment, possibly due to the informal reporting process in place at the time. Additionally, it does not appear that the location, extent, size, and depth of the corrosion was recorded. Furthermore, there was no recorded information available regarding an assessment of the finding. Therefore, there was insufficient information to determine whether that specific finding should or should not have been escalated.

Nevertheless, the circumstances of this occurrence illustrate the importance of specific guidance and criteria on how to assess corrosion. In this instance, this would probably have provided P&WC with greater visibility of engines in the global fleet that are exposed to an increased risk of corrosion-related failure.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

Safety issues are highlighted in bold to emphasise their importance. A safety issue is a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operating environment at a specific point in time.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect to the engine failure during take-off involving a Bombardier Dash 8, registered VH-ZZE, which occurred at Darwin Airport, Northern Territory, on 11 November 2019.

Contributing factors

- The power turbine shaft of the aircraft's right engine fractured due to fatigue cracking, resulting in secondary damage and engine failure.
- The fatigue cracking in the engine's power turbine shaft initiated at corrosion pitting, which probably resulted from prolonged low-altitude operation in a marine environment.
- **The power turbine shaft in Pratt & Whitney Canada PW100 series engines operating in certain marine environments is susceptible to corrosion pitting, which can grow undetected between scheduled inspections. This increases the risk of shaft fracture resulting in engine failure. [Safety issue]**

Safety issues and actions

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues. The ATSB expects relevant organisations will address all safety issues an investigation identifies.

Depending on the level of risk of a safety issue, the extent of corrective action taken by the relevant organisation(s), or the desirability of directing a broad safety message to the aviation industry, the ATSB may issue a formal safety recommendation or safety advisory notice as part of the final report.

All of the directly involved parties were provided with a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

The initial public version of these safety issues and actions are provided separately on the ATSB website, to facilitate monitoring by interested parties. Where relevant, the safety issues and actions will be updated on the ATSB website as further information about safety action comes to hand.

Power turbine shaft corrosion

Safety issue description

The power turbine shaft in Pratt & Whitney Canada PW100 series engines operating in certain marine environments is susceptible to corrosion pitting, which can grow undetected between scheduled inspections. This increases the risk of shaft fracture resulting in engine failure.

Issue number:	AO-2019-060-SI-01
Issue owner:	Pratt & Whitney Canada
Transport function:	Aviation: Maintenance
Current issue status:	Open - Safety action pending
Issue status justification:	To be advised

Proactive safety action taken by Pratt & Whitney Canada

Action number:	AO-2019-060-NSA-01
Action organisation:	Pratt & Whitney Canada
Action status:	Monitor

In September 2020, Pratt & Whitney Canada (P&WC) advised the ATSB that it was 'currently looking at different options' to address this safety issue and 'finding a way to remove the contaminants from inside the shaft is one of them'. In addition, P&WC was 'looking at adding an internal inspection of the shaft during a hot section inspection [HSI] using a borescope' as well as 'evaluating how to define criteria to be used if corrosion or damages are found during that inspection'. It considers these criteria will also assist maintenance organisations in evaluating power turbine (PT) shaft corrosion findings during overhaul inspections.

In February 2021, P&WC advised the ATSB that it had commenced a review of historical overhaul experience of the PT shaft in an effort to identify which engines and operators are potentially exposed to an increased risk of PT shaft corrosion. P&WC also advised that it was assessing the requirement for additional mitigating actions for engines within the PW100 engine fleet that have already completed an HSI, but are potentially exposed to the risk of PT shaft corrosion.

Pratt & Whitney Canada did not provide a timeline for the review and implementation of any related safety action.

ATSB comment

The ATSB acknowledges the safety action taken and proposed by P&WC to address this safety issue and considers that, if implemented, such action will probably address the issue. However, as a timeline for implementation was not provided, the ATSB remains concerned with resolution of the safety issue. Accordingly, the ATSB issues the following safety recommendation to support P&WC's proposed safety action.

Safety recommendation to Pratt & Whitney Canada

The ATSB makes a formal safety recommendation, either during or at the end of an investigation, based on the level of risk associated with a safety issue and the extent of corrective action already undertaken. Rather than being prescriptive about the form of corrective action to be taken, the recommendation focuses on the safety issue of concern. It is a matter for the responsible organisation to assess the costs and benefits of any particular method of addressing a safety issue.

Recommendation number:	AO-2019-060-SR-43
Responsible organisation:	Pratt & Whitney Canada
Recommendation status:	Released

The Australian Transport Safety Bureau recommends that Pratt & Whitney Canada takes safety action to address the risk of corrosion-related fracture of the power turbine shaft in its PW100 series engines.

General details

Occurrence details

Date and time:	11 November 2019 – 1310 CST	
Occurrence category:	Serious Incident	
Primary occurrence type:	Engine failure or malfunction	
Location:	Darwin Airport, Northern Territory	
	Latitude: 12° 24.88' S	Longitude: 130° 52.60' E

Aircraft details

Manufacturer and model:	Bombardier Inc DHC-8	
Registration:	VH-ZZE	
Operator:	Surveillance Australia	
Serial number:	640	
Type of operation:	Aerial Work - Other	
Activity:	General aviation - Aerial work - Other	
Departure:	Darwin, Northern Territory	
Destination:	Darwin, Northern Territory	
Persons on board:	Crew – 4	Passengers – 0
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Nil	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- aircraft operator (Surveillance Australia)
- flight crew
- recorded data (CVR and FDR)
- engine manufacturer (Pratt & Whitney Canada)

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section 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 following directly involved parties:

- the flight crew
- Cobham Aviation Services
- Pratt & Whitney Canada
- De Havilland Aircraft of Canada
- Transportation Safety Board of Canada
- Transport Canada
- Civil Aviation Safety Authority

A submission was received from:

- Pratt & Whitney Canada

The submission was reviewed and, where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. It is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB's purpose is to improve the safety of, and public confidence in, aviation, rail and marine transport through:

- 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, as well as participating in overseas investigations involving Australian-registered aircraft and ships. It prioritises investigations that have the potential to deliver the greatest public benefit through improvements to transport safety.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, international agreements.

Purpose of safety investigations

The objective of a safety investigation is to enhance transport safety. This is done through:

- identifying safety issues and facilitating safety action to address those issues
- providing information about occurrences and their associated safety factors to facilitate learning within the transport industry.

It is not a function of the ATSB to apportion blame or provide a means for determining 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. The ATSB does not investigate for the purpose of taking administrative, regulatory or criminal action.

Terminology

An explanation of terminology used in ATSB investigation reports is available on the ATSB website. This includes terms such as occurrence, contributing factor, other factor that increased risk, and safety issue.