National Transportation Safety Board
Washington, D.C. 20594

Safety Recommendation Report

Preventing Catastrophic Failure of Pratt & Whitney Canada JT15D-5 Engines Following Birdstrike or Foreign Object Ingestion

Accident Number:	ENG14IA013, ENG14IA011, and CEN09IA481
Operator/Flight Number:	Multiple
Aircraft and Registration:	Multiple
Location:	Multiple
Date:	Multiple
Adopted:	February 28, 2017

The National Transportation Safety Board (NTSB) is providing the following information to urge Transport Canada to take action on the safety recommendation in this report. This recommendation is intended to prevent catastrophic failure of Pratt & Whitney Canada (PWC) JT15D-5 engines installed on Beechcraft Beechjet 400A airplanes following a birdstrike or foreign object ingestion.[1] It is derived from three NTSB investigations of incidents in which liberated fan blades breached engine cases and cowlings after bird species well below the weight required for certification testing were ingested. Subsequent testing and analysis identified a failure mode in the event of a birdstrike or foreign object ingestion at a certain engine speed. As a result of these investigations, the NTSB is issuing one safety recommendation to Transport Canada.

Background and Analysis

On May 13, 2014, about 1511 central daylight time, a Beechcraft Beechjet 400A, registration number N412GJ, equipped with two PWC JT15D-5 engines, experienced a fire in the No. 2 (right) engine following a birdstrike during takeoff roll at Sugar Land Regional Airport (SGR), Sugar Land, Texas. The flight crew successfully rejected the takeoff and discharged both fire bottles, which extinguished the fire. During an examination of the airplane, fuel was found leaking from the No. 2 engine cowling and from a puncture in the right wing fuel tank. The No. 2 engine fan blades were all fractured near the root. The No. 2 engine cowling had multiple penetrations and there was evidence of blade fragments impacting the inlet cowl forward of the fan (see figure 1).[2]

[1] Due to manufacturer mergers and reorganizations, these airplane models have been branded under various manufacturer names, such as the Hawker 400 and the Raytheon Beechjet 400A. A version developed for the US Air Force is known as the Raytheon T-1A Jayhawk trainer. In this report, they are identified as Beechcraft Beechjet 400As.

[2] Additional information about this incident, NTSB case number ENG14IA013, can be accessed at the NTSB's Aviation Information Resources web page (http://www.ntsb.gov/air).

Figure 1. Photograph showing damage to the inlet cowl of the No. 2 engine on N412GJ.

A similar event occurred at SGR in July 2009. In that incident, the No. 2 (right) PWC JT15D-5 engine on a Beechjet 400A, N679SJ, sustained damage and immediately lost all power after ingesting at least one bird during takeoff.[3] The pilots successfully rejected the takeoff. Postincident examination of the airplane found all but one of the right engine fan blades fractured and that the inlet duct separated from the front of the engine (see figure 2). [4]

On March 13, 2014, about 1020 eastern daylight time, the No. 2 (right) PWC JT15D-5 engine of a Beechjet 400A, N193BJ, was damaged following a birdstrike shortly after takeoff from Greater Rochester International Airport, Rochester, New York.[5] The flight crew declared an emergency and returned to the airport where they performed an uneventful landing. During an examination of the airplane, extensive damage to the No. 2 engine fan and inlet cowl was observed (see figure 3). The compressor cowl had multiple holes and the right wing had an impact mark forward of the engine fan case. Several weeks after the event, a blade fragment was found lodged in the roof of a building below the flightpath.[6]

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[3] The pilot reported seeing one large and two smaller birds fly across the airplane's path. He described the two smaller birds as "sparrow"-sized and the larger bird as a heron. Bird remains recovered from the runway were individually submitted to the Smithsonian Institution Feather Identification Laboratory, which identified each sample as belonging to a juvenile yellow-crowned night heron. The laboratory estimated that this species of heron can weigh 1.5 to 2 pounds.

[4] Additional information about this incident, NTSB case number CEN09IA481, can be accessed at the NTSB's Aviation Information Resources web page (http://www.ntsb.gov/air).

[5] In an incident report, the pilot reported that after a normal takeoff, "a large bird" was ingested in the right engine.

[6] Additional information about this incident, NTSB case number ENG14IA011, can be accessed at the NTSB's Aviation Information Resources web page (http://www.ntsb.gov/air).

Figure 2. Photograph showing the inlet duct separated from the No. 2 engine on N679SJ.

Figure 3. Photograph showing damage to the inlet cowl of the No. 2 engine on N193BJ.

The degree of damage documented during these investigations exceeded what has historically been observed following birdstrike events. Forensic analysis done by the Smithsonian Institution Feather Identification Laboratory was conducted to identify the different bird species involved in each of the three incidents. Of the various bird species identified, all had an average weight below 4 pounds.[7] At the time the JT15D-5 engine was certificated, it had to be capable of ingesting a 4-pound bird without catching fire (as occurred in ENG14IA013), generating loads greater than ultimate loads (as occurred in all three events), experiencing an engine burst, or losing the ability to be shutdown (neither of which was an issue in any of the events).[8] Although forensic analysis could not confirm that only one bird was ingested in each of these events, the pilots' statements for two of the events support the likelihood that this was the case.

To understand the cause of the failure mode, PWC completed dynamic testing using a shaker table, vibration tap hammer, and computer model simulation. The testing identified a natural frequency (resonance) between the fan and fan case while the JT15D-5 engine is operating near 72% N_1.[9,10] If sufficient energy is imparted to the fan (such as during a birdstrike) near the identified rotational speed, it may result in a rub-induced excitation between the rotating fan blades and the fan case. This excitation, in turn, can lead to fan blade separation and release that could hit critical structures, severe engine vibration, engine case flange separation, engine case fracture, radial uncontainment, high pressure turbine shaft fracture, inlet cowl separation, or engine fire. Engine speed passes through 72% N_1 during takeoff roll, which is a phase of flight during which birdstrikes commonly occur.[11] The natural resonance identified during PWC's testing only occurs in JT15D-5 engines installed on Beechjet 400A airplanes.[12]

The NTSB notes that, in response to the dynamic testing findings, PWC is in the process of evaluating design options for the JT15D-5 engine model to dampen the identified natural resonance shared by the fan and fan case when the engine is operating near 72% N_1 and plans to release a service bulletin when the design change is available.[13] However, a service bulletin does not mandate corrective action. To date, the NTSB is not aware of any accidents (as defined in 49 *CFR* 830.2) that have been caused by the identified dynamic response between the engine fan

[7] The US Air Force provided information to the NTSB about a similar event involving a T-1A trainer. In that event, engine damage and failure similar to that documented during the NTSB's investigations occurred after ingestion of a mourning dove (a species with an average weight of about 4 ounces according to the Smithsonian Institution Feather Identification Laboratory).

[8] The Transport Canada-defined certification basis for the JT15D-5 is 14 *Code of Federal Regulations* (*CFR*) 33.76, "Bird Ingestion."

[9] The resonant frequency of any vibration is the naturally occurring frequency at which a blade will vibrate when excited.

[10] N_1 is the rotational speed of the low pressure spool of the engine, which consists of the fan, low pressure compressor, and low pressure turbine.

[11] According to the FAA's frequently asked questions concerning wildlife mitigation at airports (http://www.faa.gov/airports/airport_safety/wildlife/faq/ [accessed March 1, 2017]), 37% of birdstrikes occur during takeoff.

[12] As of 2015, there were 1,742 JT15D-5 engines in the fleet.

[13] Engine frequency damping is a common design practice to move dynamic modes out of the operating range.

and fan case during a birdstrike.[14] We are nonetheless concerned about the potential for catastrophic engine failure resulting in blade fragments that impact critical structure or lead to engine fire and believe that this risk warrants required corrective action. Therefore, the NTSB recommends that Transport Canada require that all JT15D-5 engines installed on Raytheon/Hawker Beechjet 400A airplanes be modified to dampen the rub-induced excitation that can occur between the engine fan and fan case during birdstrike or foreign object ingestion events.

Recommendation

To Transport Canada:

Require that all JT15D-5 engines installed on Raytheon/Hawker Beechjet 400A airplanes be modified to dampen the rub-induced excitation that can occur between the engine fan and fan case during birdstrike or foreign object ingestion events. (A-17-7)

[14] Section 830.2 defines an aircraft accident as "an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage" Substantial damage is defined, in part, as "damage or failure which adversely affects the structural strength, performance, or flight characteristics of the aircraft, and which would normally require major repair or replacement of the affected component. Engine failure or damage limited to an engine if only one engine fails or is damaged…[is] not considered substantial damage for the purpose of this part." The incidents described above did not meet the definition of an accident.