National Transportation Safety Board
Washington, D.C. 20594

Aircraft Accident Investigative Update

On February 20, 2021, about 1309 mountain standard time (MST), United Airlines flight 328, a Boeing 777-222, N772UA, experienced a failure of the right engine, a Pratt & Whitney PW4077, while climbing through an altitude of about 12,500 feet mean sea level (msl) shortly after takeoff from Denver International Airport (DEN), Denver, Colorado. There were no injuries to the 239 passengers and crew onboard, and the airplane sustained minor damage. The regularly scheduled domestic passenger flight was operating under the provisions of Title 14 Code of Federal Regulations (CFR) Part 121 from DEN to Daniel K. Inouye International Airport (HNL), Honolulu, Hawaii.

Upon notification, the NTSB launched a go-team led by an investigator-in-charge and specialists in structures and powerplants. Specialists in metallurgy, flight crew operations, air traffic control, maintenance records, and flight recorders supported the investigation from other locations. The flight data recorder (FDR) and cockpit voice recorder (CVR) were sent to the NTSB Recorders Laboratory in Washington, DC, for download and analysis.

Parties to the investigation include The Boeing Company, Pratt &Whitney, the Federal Aviation Administration (FAA), United Airlines, the Air Line Pilots Association, and the International Brotherhood of Teamsters. Numerous local law enforcement and public safety agencies also assisted with the initial response and recovery.

The following groups have been formed to investigate this incident: structures, powerplants, metallurgy, maintenance records, flight crew operations, FDR, and CVR. Additional groups may be formed as the investigation progresses.

The airplane departed at approximately 1304 MST from runway 25 at DEN. The captain was the pilot flying, and the first officer was the pilot monitoring. According to FDR data and flight crew interviews, about 4 minutes after takeoff, the airplane was climbing through an altitude of about 12,500 feet msl with an airspeed of about 280 knots. The flight crew indicated they advanced power at that time to minimize time in expected turbulence during their climb up to their assigned altitude of flight level 230. Immediately after the throttles were advanced a loud bang was recorded on the CVR. FDR data indicate the engine made an uncommanded shutdown and the engine fire warning activated shortly after. The flight crew declared an emergency with ATC and stated their intention to return to DEN for an emergency landing. The flight crew began to complete checklists, including the engine fire checklist. As part of the checklist, the flight crew discharged both fire bottles into the engine, but the engine fire warning did not extinguish until the airplane was on an extended downwind for landing.

The flight crew continued to prepare for the emergency landing by completing additional critical checklists and verifying airplane performance for landing. They elected not to dump fuel for safety and time reasons and determined that the magnitude of the overweight landing was not significant enough to outweigh other considerations. The captain accomplished a one-engine-inoperative approach and

landing to runway 26 without further incident. Airport Rescue and Firefighting (ARFF) met the airplane as soon as it stopped on the runway and applied water and foaming agent to the right engine. The base of the engine experienced a flare up, which was quickly extinguished. Once cleared by ARFF, the airplane was towed off the runway where the passengers disembarked via air stairs and were bussed to the terminal.

An NTSB structures engineer and two investigators from the NTSB's Denver office collected fallen debris with local law enforcement and safety agencies over the next several days. Most of the structure from the inlet cowl and fan cowl doors was recovered and identified. Recovered portions of the inlet cowl, fan cowl door structure, and inlet cowl attach ring were laid out in a hangar, as shown in figure 1. The inlet cowl, fan cowl doors, and thrust reversers will be examined further to map damage and cowl failure patterns after the fan blade failure, and to examine the subsequent progression of fire in the thrust reversers.

Figure 1. Inlet cowl and cowling debris laid out in hangar

Initial examination of the right engine fire damage, as shown in figures 2 and 3, found it was primarily contained to the engine's accessory components, thrust reverser skin, and composite honeycomb structure of the inboard and outboard thrust reversers. Both halves of the aft cowl appeared to be intact and undamaged, and all four pressure relief doors were found in the open position. The spar valve, which stops fuel flow to the engine when the fire switch is pulled in the cockpit, was found closed; there was no evidence of a fuel-fed fire. Examination of the engine accessories showed multiple broken fuel, oil, and hydraulic lines and the gearbox was fractured.

Figure 2. Fire damage on the outboard side of the right engine.

Figure 3. Fire damage on the inboard side of the right engine.

Examination of the cockpit found that the right engine fire switch had been pulled and turned to the "DISCH 1" position, and both fire bottle discharge lights were illuminated, as shown in figure 4.

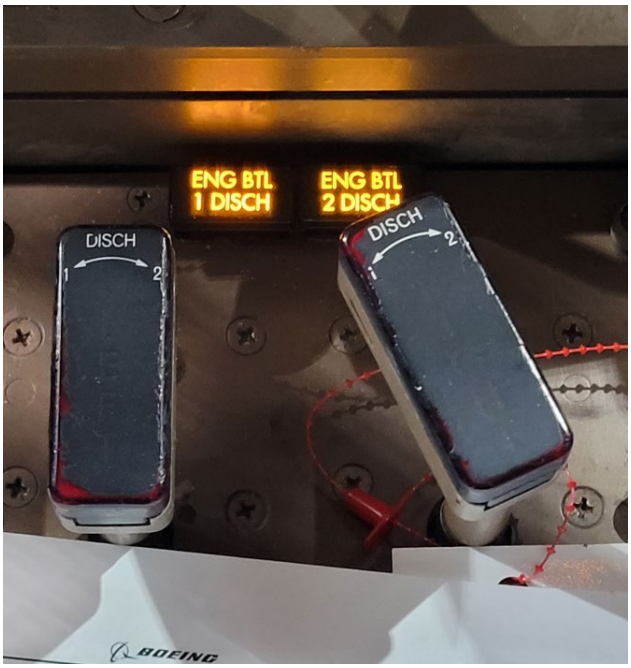

Figure 4. Right engine fire switch and fire bottle status lights.

Initial examination of the right engine fan revealed that the spinner and spinner cap were in place and appeared to be undamaged (see figure 5). The fan hub was intact but could not be rotated by hand. All fan blade roots were in place in the fan hub, and two blades were fractured. One fan blade was fractured transversely across the airfoil about 5 inches above the base of the blade at the leading edge and about 7.5 inches above the base of the blade at the trailing edge. The blade's fracture surface was consistent with fatigue. A second fan blade was fractured transversely across the airfoil about 26 inches above the base of the blade at the leading edge and about 24 inches above the base of the blade at the trailing edge (see figure 6). The second blades fracture surfaces had shear lips consistent with an overload failure. The remaining fan blades were full length but all had varying degrees of impact damage to the airfoils.

Figure 5. The right engine fan, as viewed from the front.

Figure 6. The two fractured blades on the right engine.

The right engine fan blades were removed from the hub, and the blade that exhibited fractures consistent with fatigue was sent to the metallurgical laboratory at Pratt & Whitney for further examinations led by a senior NTSB metallurgist. Preliminary findings from the scanning electron microscope (SEM) examination have identified multiple fatigue fracture origins on the interior surface of a cavity within the blade (see figure 7). Efforts to further characterize the fracture surface, including identifying the primary origin and counting striations, are ongoing.

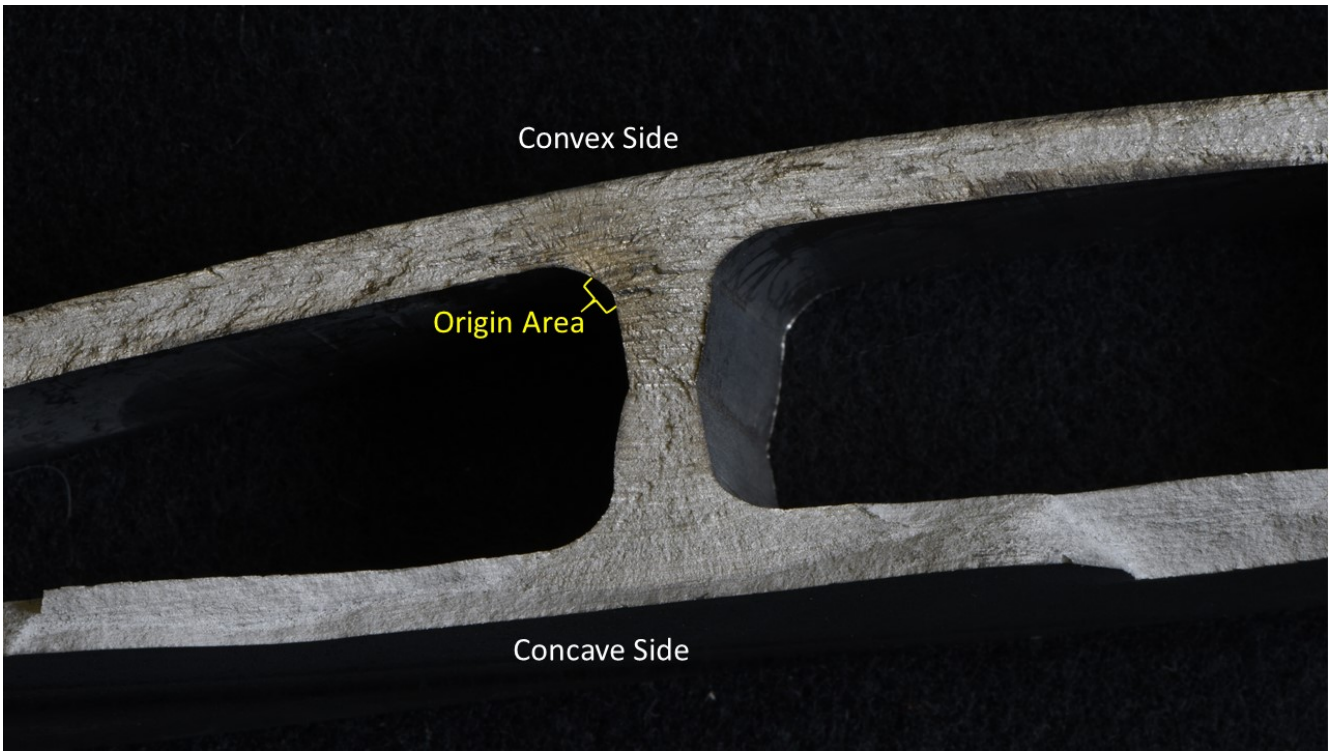

Figure 7. Photo of the fan blade's fracture surface with the origin area identified.

Fluorescent penetrant inspection identified multiple secondary crack indications within an inch of the fracture surface in the same cavity as the fatigue failure origin, and SEM examination confirmed them as potential secondary cracks. Additional work is underway to further characterize the size and depth of the secondary cracks before attempting to open at least two of them for further examination. The NTSB metallurgy group also plans to analyze its chemical composition and the microstructure near the fracture surface.

As a result of this incident, on February 22, 2021, Pratt & Whitney issued Special Instruction 29F-21 providing revised thermal acoustic image (TAI) inspection threshold intervals to 1000 cycles for the first stage low pressure compressor (LPC) blades on the affected engines. On February 23, 2021, the FAA issued Emergency Airworthiness Directive 2021-05-51, which instructs owners and operators of Pratt & Whitney PW4077 and similar type engines to, before further flight, perform a TAI inspection of the first stage LPC blades for cracks and to remove the blade from service if it does not pass the inspection and replace the blade before further flight.

An initial review of maintenance and inspection data for the blade that exhibited factures consistent with fatigue revealed that it had experienced 2,979 cycles since its last inspection. The subject blade underwent TAI inspections in 2014 and 2016. The TAI inspection data collected in 2016 was examined again in 2018 because of a February 13, 2018, incident involving a Boeing 777 with Pratt & Whitney PW4077 engines (DCA18IA092). The maintenance records group and the powerplants group are

reviewing these inspection records to examine the presence and disposition of any anomalies in this TAI data near the fracture initiation point.

Additional information will be released as warranted.