Aviation Investigation Final Report

Location:	Atlantic City, New Jersey	**Incident Number:**	ENG22LA002
Date & Time:	October 2, 2021, 17:14 Local	**Registration:**	N922NK
Aircraft:	Airbus A320-271N	**Aircraft Damage:**	Minor
Defining Event:	Birdstrike	**Injuries:**	4 Minor, 108 None
Flight Conducted Under:	Part 121: Air carrier - Scheduled		

Analysis

Based on the bird remains and feathers collected and identified by Smithsonian Institution *National Museum of Nature History* Division of Birds - Feather Identification Laboratory, a male immature Blade Eagle was ingested into the right engine striking the fan and causing a single fan blade to fracture near the blade root; the fractured fan blade was contained by the fan case and the remaining fan blades exhibited a combination of leading and trailing edge, as well as blade tip, impact damage, tearing, missing material and bending in the direction opposite rotation. Upon further examination of the engine, it was discovered that two of the thermal management system (TMS) manifold lower aft mounting bracket securing bolts had fractured in shear overstress allowing the bracket to swivel/rotate radially outward. This is one of three mounting brackets that secure the TMS manifold to the engine and prevents excessive moment of the TMS manifold during operation. Along with the broken/sheared TMS lower aft bracket bolts, a crack was visible on the CP-09 fuel line that initiated in fatigue; the CP-09 fuel line is attached to the TMS and contains high pressure fuel. The crack in the CP-09 fuel line was due to necking down of the material as the fuel tube bent and stretched (elongated) under the vibration/cyclic loads after the bird strike and not as a manufacturing issue.

The TMS manifold lower aft mounting bracket securing bolts fractured due to the high impact and vibration loads because of the fan blade release after the bird strike. Subsequently the TMS manifold was allowed to move radially back and forward from the engine in response to the engine vibrations that were recorded on the flight data recorder to be in excess of the 10 cockpit units which is the highest value that the flight data recorder will record. The CP-09 fuel line flexed, bent, and stretched under the cyclical radial motion of the TMS manifold until it cracked due to fatigue spraying high pressure fuel onto the hot engine cases igniting an undercowl fire.

An immature male Bald Eagle has a mean mass of about 4,130 grams (g) (9.1 lbs.). The Federal Aviation Administration large bird ingestion certification test bird weight requirement was 2.75

kilograms (6.05 pounds) for the size of the inlet throat area on the PW1127G-JM geared turbofan engine; thus, the incident ingested bird was larger than the certification basis for the engine.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be:

The ingestion of a bird into the right engine during the takeoff roll caused a fan blade to fracture near the blade platform resulting in high fan blade off loads and engine vibrations sufficient to result in an eventual failure of a fuel tube in the right engine that sprayed fuel onto hot engine cases, igniting an undercowl engine fire and triggering a rejected takeoff.

Findings

Environmental issues	Animal(s)/bird(s) - Effect on equipment
Aircraft	Compressor section - Damaged/degraded
Aircraft	Compressor section - Capability exceeded

Factual Information

History of Flight

Takeoff	Birdstrike (Defining event)
Takeoff-rejected takeoff	Fire/smoke (non-impact)
Takeoff-rejected takeoff	Powerplant sys/comp malf/fail
Takeoff-rejected takeoff	Loss of engine power (partial)
Takeoff-rejected takeoff	Engine shutdown

On October 2, 2021, about 17:44 eastern standard time, an Airbus A320-271N neo, registration number N922NK, operated by Spirit Airlines as flight number 3044, and powered by two International Aero Engines (IAE) PW1127G-JM geared turbofan engines experienced a right (No. 2) engine bird strike and subsequent engine fire during takeoff roll from the Atlantic City International Airport (ACY), Atlantic City, New Jersey. The flightcrew reported receiving a No. 2 engine fire warning, discharged both fire bottles, aborted the takeoff at a groundspeed of about 100 knots and stopped the airplane on the runway. The airplane's slides were deployed, and the passengers egressed via the slides onto the runway. The airport's Aircraft Rescue and Firefighting (ARFF) met the airplane. Of the 102 passengers, 6 crew members, and one dead-heading crew member onboard the flight, four minor injuries were reported during the airplane evacuation. The incident flight was a 14 *Code of Federal Regulations* (*CFR)* Part 121 passenger flight from ACY to Fort Lauderdale-Hollywood International Airport (FLL), Fort Lauderdale, Florida.

Prior to the arrival of the Powerplant Group, the Wildlife Biologist District Supervisor for the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) assigned to the Atlantic City International Airport collected bird remains (snarge) and feather samples from the event engine and sent them to the Smithsonian Institute Feather Identification Laboratory in Washington DC for analysis.

On scene examination of the airplane and engine was conducted by the Powerplant Group comprised of members from Spirt Airlines, Federal Aviation Administration, International Aero Engines, and the National Transportation Safety Board. No visible impact damage to the airplane or wing from exiting engine debris was noted. The only significant airframe damage was to the No. 2 engine (right) outboard thrust reverse translating sleeve that exhibited thermal distress longitudinally from just aft of the fan cowl-to-outer translating sleeve interface and circumferentially from about the 4:00 o'clock position aft looking forward down to the latch beam at the bottom of the engine (6:00 o'clock position). The thermal distress to the No. 2 engine outboard translating sleeve consisted of

blistered and consumed paint, and slight damage to the sleeve skin panel; no burn-thru holes were observed. Minor discoloration of the thermal blankets was noted on the No. 2 engine inboard and outboard thrust reverser inner fixed structure as well as bifurcation panel.

On scene examination of the engine revealed one fan blade was fractured above the blade platform near the root (essentially a complete fan blade airfoil release) (**PHOTO 1**) and a portion of the fractured fan blade airfoil was found wedged in the fan case fan blade rub strip thermally conforming liner at about the 9:00 o'clock position aft looking forward; there were no uncontainments, breaches, tears, or holes through the fan case assembly. The root portion of the fractured fan blade stayed slotted in the fan disk hub and the fracture surface had a shiny and clean appearance. Several fan blades in both the leading and trailing directions from the fractured blade exhibited pronounced and considerable airfoil bending from about 50% span to the tip creating an "S"-shaped bend; all fan blade airfoils exhibited a combination of impact damage, tears, missing material and bending in the direction opposite rotation (**PHOTO 2**). A large quantity of snarge remained on the forward acoustic liner predominantly at the bottom of the fan case assembly and at multiple locations on the fan exit guide vanes. Additional samples were taken and sent to the Smithsonian Institute Feather Identification Laboratory in Washington DC for analysis.

Photo 1: Fractured Fan Blade at Platform

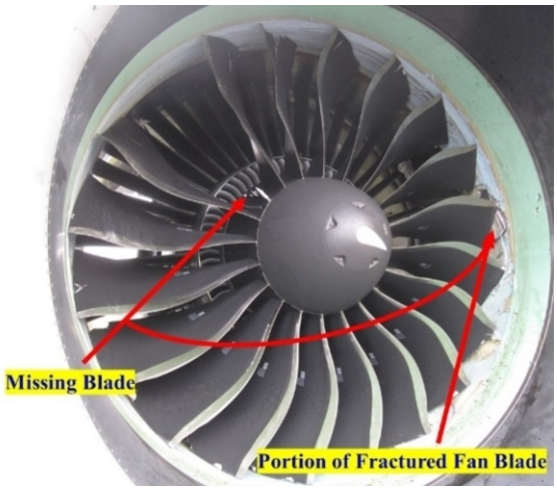

Photo 2: Additional Fan Blade Damage

No obvious flammable fluid leak locations were noted during the initial engine exam; therefore, an on-wing fuel leak test was conducted using the aircraft right wing tank boost pumps. No engine start cart or hand cranking of the No. 2 engine was performed; thus, the engine-driven fuel pump was not engaged. With the wing tank boost pumps providing fuel pressure, fuel was observed coming from behind the fuel-oil heat exchanger (FOHE) and the fuel-oil cooler generator located on the left side of the engine at about the 9:00 o'clock position. Due to the tubing and components obstructing the source of the fuel leak and the large quantity of fuel that was leaking, it was determined to terminate any further

on-wing leak testing on the airplane and to send the engine to the Pratt &Whitney Columbus Engine Center in Columbus Georgia for further evaluation.

During the engine exam at Columbus Engine Center, it was discovered that two bolts on the TMS manifold lower aft link (support bracket) had fractured (**PHOTO 3**) allowing the manifold to move relative to the engine. Also discovered was a cracked CP-09 fuel tube which runs along the underside of the engine from the fuel manifold on the engine right side to the TMS manifold at approximately the engine 9:00 o'clock position (**PHOTO 4**). The CP-09 fuel tube, along with the three TMS manifold mount support brackets/links, and their associated bolts were shipped to the Pratt & Whitney materials laboratory in East Hartford, Connecticut for evaluation.

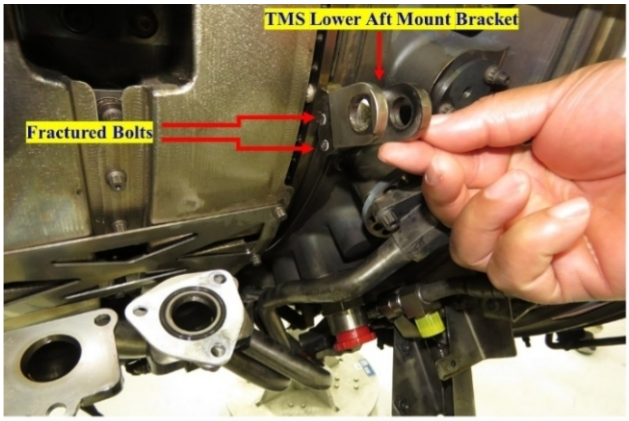

Photo 3: TMS Manifold Lower Aft Bracket with Fractured Bolts

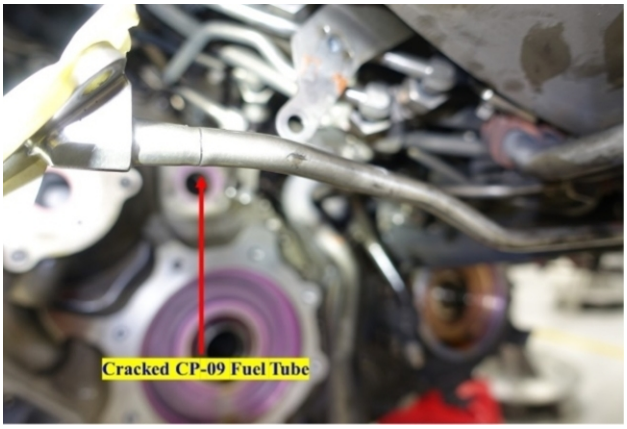

Photo 4: Cracked CP-09 Fuel Tube (installed)

Metallurgical evaluation of the CP-09 fuel tube found the material composition to be consistent with the manufacturing print. The fuel tube also exhibited a transgranular fatigue region that progressed through the wall thickness from the outer diameter, with multiple fatigue origins along the outer diameter, and necked down/reduced cross-section wall thickness at the fracture location. According to the P&W materials laboratory, the reduced cross-section wall thickness in the vicinity of the fracture was thought to be due to necking down of the material as the fuel tube bent and stretched (elongated) following the fracture of the TMS mount bolts after the bird strike, and not as a manufacturing issue. Consequently, as the TMS continued to experience vibration/cyclic loading due to the fan blade out, the tube fractured at this yielded location. Metallurgical evaluation of the two fractured bolts from the TMS manifold upper link found the material composition to be consistent with the manufacturing print and the fracture surface exhibited dimple fracture features indicative of over-stress.

The Smithsonian Feather Identification Laboratory identified the bird remains as coming from a male immature Bald Eagle with a mean mass of about 4,130 grams (g) (9.1 lbs.). The Federal Aviation

Administration large bird ingestion certification test bird weight requirement was 2.75 kilograms (6.05 pounds) for the size of the inlet throat area on the PW1127G-JM; thus, the incident ingested bird was larger than what the engine was certificated for. Review of the large bird ingestion certification test results revealed that only portions of fan blade airfoil material were released on several blades with no above-the-blade-platform full blade release like what was observed in this event. Because the large bird ingestion test was conducted on a test rig and not on a complete engine, the TMS manifold and the CP-09 fuel tube were not installed so no comparison could be made with the damage observed on the event engine.

Since the event engine had released a largely full-length fan blade that more closely resembles that of the engine containment fan blade out certification test than a large bird ingestion test, a review of the fan blade out test results was conducted to compare the similarities and differences with what was observed on the event engine. Further, an airfoil release, such as in this event, is enveloped by the successful fan blade out certification test. Post inspection of the fan blade out test engine revealed two fuel leak locations, neither from the CP-09 fuel tube (the CP-09 fuel tube was undamaged) and the fuel leaks did not result in an undercowl fire. Additionally, on the certification test, all the TMS manifold bolts that secure the aft upper and lower aft brackets were fractured/sheared; on the event engine only two of the three lower aft bracket bolts fractured/sheared.

Airbus and IAE conducted an analysis of potential ignition sources for the fuel leak coming from the fractured CP-09 fuel tube; the two most likely sources would be hot main landing gear wheel brakes or hot engine cases. It was concluded that: 1) the main landing gear braking temperatures did reach a temperature to ignite fuel, 2) that the drip from the bottom of the nacelle was not sufficiently close to the main landing gear brakes to ignite the fuel vapor, and 3) even if the fuel vapor could reach the brakes, it was unlikely to be at a concentration sufficient for combustion. Therefore, the main landing gear wheel brakes were not considered the ignition source of the engine fire. IAE looked at the various engine case temperatures to determine if any of those would be at temperatures to ignite the leaking fuel from the fractured CP-09 fuel tube. Based on their calculations, IAE estimated that the turbine intermediate case, the low pressure turbine case, and the turbine exhaust case (all downstream of the fractured CP-09 fuel tube) were all at temperatures sufficient to support hot surface ignition of the leaking fuel.

Based on past IAE PW1100 geared turbofan engine bird strike events involving medium flocking birds, IAE has proposed design changes to the fan blade. The redesign will incorporate thickening of the fan blade leading edge root, modifying the fan blade leading edge sheath to account for the thicker leading edge root, increased bonding area for the modified leading edge sheath, and changes to the blade platform geometry. IAE projects that the redesigned fan blade will see fleet incorporation in the third-quarter of 2023. To prevent overload of the TMS mounts in the event of a fan blade out scenario, IAE is in the process of redesigning the TMS mount structure by adding more bolts to both the upper and lower aft mounts and considering modifications to the mount structure itself for improved load distribution. The intent is to mitigate the fire risk, as observed on this event, by preventing movement of the TMS,

and subsequent necking and cyclic loading on the CP-09 fuel tube. Final design details, and timing of incorporation is unknown at the time of this report.

Information

Certificate:	**Age:**
Airplane Rating(s):	**Seat Occupied:**
Other Aircraft Rating(s):	**Restraint Used:**
Instrument Rating(s):	**Second Pilot Present:**
Instructor Rating(s):	**Toxicology Performed:**
Medical Certification:	**Last FAA Medical Exam:**
Occupational Pilot:	**Last Flight Review or Equivalent:**
Flight Time:	

Aircraft and Owner/Operator Information

Aircraft Make:	Airbus	**Registration:**	N922NK
Model/Series:	A320-271N	**Aircraft Category:**	Airplane
Year of Manufacture:	2019	**Amateur Built:**	
Airworthiness Certificate:	Transport	**Serial Number:**	9341
Landing Gear Type:	Retractable - Tandem	**Seats:**	190
Date/Type of Last Inspection:		**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	2 Turbo fan
Airframe Total Time:		**Engine Manufacturer:**	IAE
ELT:		**Engine Model/Series:**	PW1127G-JM
Registered Owner:		**Rated Power:**	26345 Lbs thrust
Operator:		**Operating Certificate(s) Held:**	Flag carrier (121)

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:		**Distance from Accident Site:**	
Observation Time:		**Direction from Accident Site:**	
Lowest Cloud Condition:		**Visibility**	
Lowest Ceiling:		**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:		**Temperature/Dew Point:**	
Precipitation and Obscuration:			
Departure Point:	Atlantic City International Airport, NJ (ACY)	**Type of Flight Plan Filed:**	IFR
Destination:	Ft. Lauderdale-Hollywood International Airport , FL (FLL)	**Type of Clearance:**	Unknown
Departure Time:		**Type of Airspace:**	Unknown

Airport Information

Airport:	Atlantic City International Airport ACY	**Runway Surface Type:**	
Airport Elevation:	75 ft msl	**Runway Surface Condition:**	
Runway Used:		**IFR Approach:**	Unknown
Runway Length/Width:		**VFR Approach/Landing:**	Unknown

Wreckage and Impact Information

Crew Injuries:	1 Minor, 6 None	**Aircraft Damage:**	Minor
Passenger Injuries:	3 Minor, 102 None	**Aircraft Fire:**	On-ground
Ground Injuries:		**Aircraft Explosion:**	None
Total Injuries:	4 Minor, 108 None	**Latitude, Longitude:**	39.358791,-74.458599

Administrative Information

Investigator In Charge (IIC):	Scarfo, Jean-pierre		
Additional Participating Persons:	Patrick Lusch; FAA AVP-100 Richard Ellis ; Spirit Airlines; Mirimar, FL Mike Millat; IAE; East Hartford, CT Doug Zabawa; IAE; East Hartford, CT Arnaud Blanc; BEA Sundeep Gupta; Airbus		
Original Publish Date:	July 5, 2022	**Investigation Class:**	3
Note:			
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=104029		