Aviation Investigation Final Report

Location:	St. Louis, Missouri	**Incident Number:**	ENG14IA005
Date & Time:	December 23, 2013, 16:15 Local	**Registration:**	N360SW
Aircraft:	Boeing 737 3H4	**Aircraft Damage:**	Minor
Defining Event:	Birdstrike	**Injuries:**	107 None
Flight Conducted Under:	Part 121: Air carrier - Scheduled		

Analysis

On December 23, 2013, at approximately 1615 central standard time a Boeing 737-344, registration number N360SW, operated by SWA as flight 1091, and powered by two CFM56-3 turbofan engines, experienced a bird strike and ingestion on the No. 2 or right-hand engine (RHE) after takeoff from Lambert-St. Louis International Airport (STL), Missouri. As the airplane climbed through 1,700 feet, it impacted multiple birds causing damage to the RHE and wing. The pilot declared an emergency and returned to STL for an uneventful landing. There were no injuries reported to the 110 passengers, 2 flight crew and 3 flight attendants. The incident flight was a 14 CFR Part 121 domestic passenger flight from STL to Kansas City International Airport, Kansas City, Missouri (MCI). Day visual meteorological conditions prevailed at the time and an instrument flight rules flight plan was filed.

Examination of the airplane revealed no damage to the fuselage. Examination of the engine revealed no penetration or breaches of the cases; however, the fan case exhibited several bulges that corresponded to hard impacts and missing fan blade rub strip material exposing the parent material below.

Examination of the RHE revealed that all the fan blades were extensively damaged exhibiting hard-body impact damage with significant material loss along the length of the leading edge. Two adjacent fan blades were fractured transversely across the airfoil near the one-third span, and exhibited leading edge soft-body impact damage. The remains of the two birds were identified as one male and one female mallard duck. The average weight of the male mallard is 1246 grams or 2.75 pounds; the average weight of the female mallard is 1095 grams or 2.4 pounds.

Comparing the airplane and engine damage to the requirements for bird ingestion and engine debris containment at the time the engine and airplane were both certificated revealed that the engine complied with the bird ingestion and containment requirements set forth in Parts 33.77 and 33.19 and the airplane complied with the containment requirements set forth in Parts 25.903.

Probable Cause and Findings

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

The initial damage to the fan blades was caused by the ingestion of two mallard ducks that caused one or more fan blades to fracture, striking the fan shroud, as well as other passing fan blades, producing various sized blades fragments that created a cascading effect of collateral impact damage to the other fan blades, the fan case, and the inlet cowl. One large blade fragment was deflected out of the fan containment plane, which pierced and exited the inlet cowl in a benign direction.

The engine and airplane met the applicable bird and containment design standards since the engine did not catch on fire, no engine cases exhibited any penetrations, the engine was able to be shutdown normally, and the airplane damage did not impact the safe operation of the airplane or create a hazard to the persons on board.

Findings

Environmental issues	Animal(s)/bird(s) - Effect on equipment

Factual Information

History of Flight

Takeoff	Birdstrike (Defining event)

HISTORY OF FLIGHT

On December 23, 2013, at approximately 1615 central standard time a Boeing 737-344, registration number N360SW, operated by SWA as flight 1091, and powered by two CFM56-3 turbofan engines, experienced a bird strike and ingestion on the No. 2 or right-hand engine (RHE) after takeoff from Lambert-St. Louis International Airport (STL), Missouri. As the airplane climbed through 1,700 feet, it impacted multiple birds causing damage to the RHE and wing. The pilot declared an emergency and returned to STL for an uneventful landing. There were no injuries reported to the 110 passengers, 2 flight crew and 3 flight attendants. The incident flight was a 14 CFR Part 121 domestic passenger flight from STL to Kansas City International Airport, Kansas City, Missouri (MCI). Day visual meteorological conditions prevailed at the time and an instrument flight rules flight plan was filed.

ENGINE AND NACELLE DAMAGE EXAMINATION

On site examination of the airplane revealed a hole in the leading edge of the wing with its immediate surroundings splattered with red colored organic debris. The inner barrel of the RHE inlet cowl exhibited multiple impacts, gouges, and through-holes. There was no evidence of fuel or oil leaks from the engine. The engine and nacelle were removed from the airplane and sent to the Southwest Airlines Maintenance Training Building in Dallas, Texas for detailed examination.

Examination of the nacelle revealed that the inlet nose cowl had a dent at 5:30 o'clock location on the outer surface of the inlet lip, approximately 8 inches x 4 inches x 0.5 inches deep. The inlet inner barrel had multiple small punctures on the inner skin (airflow) side and two large thru-holes; the one at 2:30 o'clock location was approximately 3 inches x 2 inches in size and the other at 3:00 o'clock was approximately 5 inches x 4 inches in size. One fan blade fragment penetrated the outer skin of the inlet at the 3 o'clock location, creating a 7-inch long tear, in the shape of a fan blade chord, consistent with a piece of fan blade passing thru edgewise. The exiting direction of the uncontained fan blade particle was outboard, causing no damage to the fuselage.

Examination of the RHE revealed that all the fan blades were extensively damaged with two adjacent engine fan blades fractured transversely across the airfoil below the mid span shrouds. No penetration or breaches were observed in any of the engine cases, but the fan case exhibited several bulges that corresponded to hard impacts and missing fan blade rub strip material exposing the parent material below.

TESTS AND RESEARCH

A United States Department of Agriculture Wildlife Biologist collected tissue and feathers from the leading edge of the wing and sent them to the Smithsonian Institution National Museum of Natural History Division of Birds - Feather Identification Laboratory in Washington, D.C. for analysis. The analysis of the remains identified it as both male and female mallard ducks. The average weight of the male mallard is 1246 grams or 2.75 pounds; the average weight of the female mallard is 1095 grams or 2.4 pounds. No damage to the fuselage was reported.

ADDITIONAL INFORMATION

Bird Ingestion Requirements

The CFM56-3 was certified under Part 33, effective February 1, 1965, with Amendments 33-1 through 33-6. The bird ingestion requirement at that time in Part 33.77 Foreign Object Ingestion was for a 4-pound bird.

Under Part 33.77, the ingestion of a 4-pound bird that may not cause the engine to -

i Catch Fire;

ii. Burst (penetrate its case);

iii. Generate loads greater than those specified in Part 33.23; or

iv. Loss of capability of being shut down.

Examination of the engine revealed that the engine did not catch fire, there were no engine case penetrations, the pilot was able to shutdown the engine normally, and the calculated imbalance loads based on the loss of fan blade material were less than those the engine was certified.

Engine and Airplane Containment Requirements

The engine containment standards are found in Part 33.19 Durability, and require engine manufacturers to design compressor and turbine rotor cases that must provide for the containment of damage from rotor blade failure. Examination of the engine revealed that the fan case sustained some bulging but no exit holes, penetrations, or uncontainments were noted.

No containment requirements exist that call for airplane manufacturers to design inlets or nacelles to contain engine debris. Therefore, the requirement for containment of fan blades stops are the interface between the engine structure and the airplane inlet structure. Although the airplane manufacturers are not required to design structure to contain engine debris, they are responsible for the overall safety of the airplane and do have some engine debris
uncontainment responsibility. Engine debris containment requirements for transport category airplanes are addressed in Part 25.903 Engines subsection (d)(1) and require airplane manufacturers to incorporate design precautions to minimize the hazards to the airplane in the event of an engine rotor failure or of a fire originating inside the engine which burns through the engine case. FAA Advisory Circular (AC) 20-128A, "Design Considerations for Minimizing Hazards Caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failure" describes how to best mitigate the threat of the debris causing a potential hazardous or catastrophic condition to the airplane or harm to the occupants on board by

requiring design precautions based on service experience and tests. Examination of the airplane revealed minor superficial gouging of the fuselage, the left-hand wing, and one passenger window, none of which posed a hazard to the airplane or passengers.

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:	Boeing	**Registration:**	N360SW
Model/Series:	737 3H4 3H4	**Aircraft Category:**	Airplane
Year of Manufacture:	1992	**Amateur Built:**	
Airworthiness Certificate:	Transport	**Serial Number:**	26571
Landing Gear Type:	Tricycle	**Seats:**	
Date/Type of Last Inspection:		**Certified Max Gross Wt.:**	138499 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo fan
Airframe Total Time:		**Engine Manufacturer:**	CFM INTL.
ELT:		**Engine Model/Series:**	CFM56 SERIES
Registered Owner:	U S BANK NA TRUSTEE	**Rated Power:**	
Operator:	SOUTHWEST AIRLINES CO	**Operating Certificate(s) Held:**	Flag carrier (121)
Operator Does Business As:		**Operator Designator Code:**	SWAA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Unknown	**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:	ST LOUIS, MO (STL)	**Type of Flight Plan Filed:**	
Destination:	KANSAS CITY, MO (MCI)	**Type of Clearance:**	Unknown
Departure Time:		**Type of Airspace:**	

Airport Information

Airport:	ST LOUIS LAMBERT INTL STL	**Runway Surface Type:**	
Airport Elevation:	618 ft msl	**Runway Surface Condition:**	
Runway Used:		**IFR Approach:**	Unknown
Runway Length/Width:		**VFR Approach/Landing:**	

Wreckage and Impact Information

Crew Injuries:	5 None	**Aircraft Damage:**	Minor
Passenger Injuries:	102 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	107 None	**Latitude, Longitude:**	38.750278,-90.375556(est)

Administrative Information

Investigator In Charge (IIC):	Reichel, Harald
Additional Participating Persons:	
Original Publish Date:	January 12, 2018
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB did not travel to the scene of this incident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=88584