



National Transportation Safety Board Aviation Accident Final Report

Location:	West Palm Beach, FL	Accident Number:	DCA01MA031
Date & Time:	03/19/2001, 1830 EST	Registration:	N266CA
Aircraft:	Embraer EMB-120	Aircraft Damage:	Substantial
Defining Event:		Injuries:	28 None
Flight Conducted Under:	Part 121: Air Carrier - Scheduled		

Analysis

On March 19, 2001, about 1825 eastern standard time, an Empresa Brasileira de Aeronautica, S/A (Embraer) EMB-120, N266CA, operated by Comair Airlines, Inc., as flight 5054, encountered icing conditions while in cruise flight at 17,000 feet mean sea level (msl) and departed controlled flight, descending to an altitude of about 10,000 feet. The pilots recovered control of the airplane and diverted to West Palm Beach, Florida, where they landed without further incident. The 2 flight crewmembers, 1 flight attendant, and 25 passengers were uninjured, and the airplane sustained substantial damage to the elevators and the horizontal stabilizer. Flight 5054 was operating under 14 Code of Federal Regulations Part 121 as a scheduled international passenger flight from Nassau International Airport, Bahamas, to Orlando International Airport, Florida.

The flight departed in visual meteorological conditions (VMC). In postaccident interviews, the captain stated that while in VMC, the airplane flew normally. Flight data recorder (FDR) data indicate that about 7 minutes before the upset occurred, the airplane was at about 17,000 feet msl, with the autopilot engaged and airspeed stabilized near 200 knots indicated airspeed (KIAS). These data indicate that beginning about 1818, the airspeed slowed to 185 KIAS over a 1-minute period as the autopilot began trimming airplane nose-up (ANU) to maintain altitude. The airspeed then decreased to about 137 KIAS over the next 3 minutes. The airplane continued to maintain a constant altitude as the autopilot trimmed the airplane from about 0 to about 7 degrees ANU. The first officer stated that immediately before the upset occurred, he switched the leading-edge deicing system inflation cycles switch from "light" to "heavy" and the propeller deicing system cycles switch from "norm" to "cold" because he saw "more ice accumulation than he had ever seen" on the wing and spinner. FDR data indicate that when torque indications for both engines were about 55 percent and the airspeed was about 141 KIAS, the autopilot was disengaged. The airplane then pitched down and rolled about 80 degrees to the left, then rolled back to near level. During the next 20 seconds, engine torque increased to about 98 percent on both engines, the airplane rolled about 110 degrees to the left, returned to level flight, rolled about 130 degrees to the right, returned to level flight, then rolled 360 degrees to the right before returning to near wings level, with torque on both engines stabilized at about 22 percent. The airplane's behavior during the upset is consistent

with an ice-induced stall event. The first officer stated in postaccident interviews that the stick shaker and aural stall warning, which is part of the airplane's stall warning/protection system, activated but did not indicate whether it was before, during, or after the upset. The Safety Board's investigation could not precisely determine whether or when the stick shaker and aural stall warning activated.

Meteorological data at the time of the accident indicate that Comair flight 5054 may have encountered an area of icing conducive to the formation of super-cooled large droplets (SLD). The EMB-120 is not certified for flight in SLD conditions. FDR data indicate that airspeed had decreased to only about 137 KIAS before control of the airplane became difficult and altitude was no longer maintained. However, according to the Embraer EMB-120 Airplane Flight Manual (AFM) performance section, the airplane stalling speed is about 115 knots calibrated airspeed for an airplane at the accident airplane's approximate gross weight at the time of the event (23,800 pounds).

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: the failure of the flight crew to maintain airspeed during an encounter with severe icing conditions, which resulted in an inadvertent stall, loss of control, and structural damage to the airplane.

Findings

Occurrence #1: ALTITUDE DEVIATION, UNCONTROLLED
Phase of Operation: CRUISE

Findings

1. (C) AIRSPEED - NOT MAINTAINED - FLIGHTCREW
2. STALL - INADVERTENT
3. (C) AIRCRAFT CONTROL - NOT MAINTAINED - FLIGHTCREW

Factual Information

HISTORY OF FLIGHT

On March 19, 2001, about 1825 eastern standard time, an Empresa Brasileira de Aeronautica, S/A (Embraer) EMB-120, N266CA, operated by Comair Airlines, Inc., as flight 5054, encountered icing conditions while in cruise flight at 17,000 feet mean sea level (msl) and departed controlled flight, descending to an altitude of about 10,000 feet. The pilots recovered control of the airplane and diverted to West Palm Beach, Florida, where they landed without further incident. The 2 flight crewmembers, 1 flight attendant, and 25 passengers were uninjured, and the airplane sustained substantial damage to the elevators and the horizontal stabilizer. Flight 5054 was operating under 14 Code of Federal Regulations Part 121 as a scheduled international passenger flight from Nassau International Airport, Bahamas, to Orlando International Airport, Florida.

Comair flight 5054 departed Nassau about 1741 in visual meteorological conditions (VMC). In postaccident interviews, the captain stated that before the upset, the airplane flew normally. Flight data recorder (FDR) data indicate that about 7 minutes before the upset occurred, the airplane was at about 17,000 feet msl, with the autopilot engaged and airspeed stabilized near 200 knots indicated airspeed (KIAS). According to both pilots, shortly after cruise flight was established at 17,000 feet (about 1822), the airplane entered a cloud and that, shortly thereafter, the windshield frosted over with pebble-like rime ice. The captain stated that he then instructed the first officer to activate the anti-icing and deicing systems and that once these systems were activated, ice on the windshield started to melt within a couple of seconds. The captain stated that the ice detection light illuminated and, about 1 minute later, went out. He also stated that he looked outside and saw remnants of light ice between the ribs on the wing deicing boots but that there was no buildup of ice on the post where the windshield wiper arm attaches to the fuselage.

FDR data indicate that beginning about 1818, the airspeed slowed to 185 KIAS over a 1-minute period as the autopilot began trimming airplane nose-up (ANU) to maintain altitude. The altitude and speed remained constant for the next 3 minutes. According to FDR data, beginning about 1822, the airspeed decreased to about 183 KIAS then decreased to 137 KIAS over the next 3 minutes. The airplane continued to maintain a constant altitude as the autopilot trimmed the airplane from about 0 to about 7 degrees ANU. The first officer stated that immediately before the upset occurred, he switched the leading-edge deicing system inflation cycles switch from "light" to "heavy" and the propeller deicing system cycles switch from "norm" to "cold" because he saw "more ice accumulation than he had ever seen" on the wing and spinner.

FDR data indicate that about 1825, when torque indications for both engines were about 55 percent and the airspeed was about 141 KIAS, the autopilot was disengaged. The airplane then pitched down and rolled about 80 degrees to the left, then rolled back to near level. During the next 20 seconds, engine torque increased to about 98 percent on both engines, the airplane rolled about 110 degrees to the left, returned to level flight, rolled about 130 degrees to the right, returned to level flight, then rolled 360 degrees to the right before returning to near wings level, with torque on both engines stabilized at about 22 percent. The maximum nose-down pitch attitude was 60 degrees; the maximum recorded airspeed was about 240 KIAS, and the maximum vertical acceleration during recovery was about +3.6 G.

FDR data indicate that airspeed had decreased to about 137 KIAS before control of the airplane became difficult and altitude was no longer maintained. According to the Embraer EMB-120 Airplane Flight Manual performance section, the airplane stalling speed is about 115 knots calibrated airspeed for an airplane at the accident airplane's approximate gross weight at the time of the event (23,800 pounds.) The airplane's behavior during the upset is consistent with an ice-induced stall event. The first officer stated in postaccident interviews that the stick shaker and aural stall warning, which is part of the airplane's stall warning/protection system, activated but did not indicate whether it was before, during, or after the upset. The Safety Board's investigation could not precisely determine whether or when the stick shaker and aural stall warning activated.

Interviews with the flight crew indicated that during the event, both of the electronic attitude display indicators (EADI) in the cockpit blacked out and that red flags appeared on the screens. The EADIs displays reappeared after the aircraft came out of the clouds and recovered from the event.

PERSONNEL INFORMATION

Both flight crewmembers were properly certificated in accordance with Federal Aviation Administration (FAA) regulations. The captain, who was also the pilot flying at the time of the accident, had about 16,000 hours total flight time, including about 9,000 hours in the EMB-120. The first officer had about 1,350 hours total flight time with about 250 hours in the EMB-120.

AIRCRAFT INFORMATION

The EMB-120 anti-icing system includes electrically heated windshields, angle of attack and sideslip sensors, pitot/static and outflow valve static ports, and the total air temperature sensor. The deicing system includes inflatable rubber boots installed over appropriate regions of the wing and tail leading-edge surfaces and over the engine air inlet lips and engine air bypass ducts. The propeller deicing system consists of electrical heaters directly bonded onto the blade leading edge over a length of 20 inches.

When the inflation cycles switch is selected to "heavy," each ejector flow control valve is energized for 6 seconds and automatically cycles every minute. When the inflation cycles switch is selected to "light," each ejector flow control valve is energized for 6 seconds and automatically cycles every 3 minutes.

The EMB-120 propeller blade leading edge incorporates imbedded electrical resistances for ice protection. The system incorporates two dual-cycle electronic timers that provide selectable cycles; the "cold" cycle is 20 seconds on and 60 seconds off, and the "norm" cycle is 10 seconds on and 60 seconds off.

The EMB-120 stall warning/protection system consists of a three-stage process: first, the control column vibrates (also known as the stick shaker function), second, an aural warning sounds, and, finally, the control column is pushed forward (also known as the stick pusher function).

METEOROLOGICAL INFORMATION

Comair flight 5054 was in VMC until about 1818 when it entered an overcast cloud layer with cloud tops around 23,000 feet. Radar data showed that, between 1820 and 1822, flight 5054 penetrated the core of a level 3 convective cell with tops to about 33,000 feet. The temperature

at flight 5054's flight altitude was about -3 degrees Celsius. The airplane exited the cell core around 1822 but remained in instrument meteorological conditions through the upset sequence.

Flight 5054 encountered severe mixed icing as the airplane exited the north side of the cell. The Miami Weather Surveillance Radar-1988, Doppler indicated that a strong convective cell was present beneath flight 5054 about the time that the airplane was experiencing icing. Meteorological data at the time of the accident indicate that Comair flight 5054 may have encountered an area of icing conducive to the formation of super-cooled large droplets (SLD). The EMB-120 is not certified for flight in SLD conditions.

WRECKAGE AND IMPACT INFORMATION

Initial examination of the airplane at Palm Beach International Airport showed no evidence of hail damage to the leading edges of either wing or the horizontal stabilizer. The damage to the right horizontal stabilizer and elevator was noted to be greater than the damage to the left horizontal stabilizer and elevator. The upper skin of the right horizontal stabilizer was buckled between horizontal stabilizer station (HS) 2965 and 1950. The upper skin of the stabilizer at HS 2965 was rolled up from the aft spar to the skin tear location; there was a corresponding mark on the interior skin surface adjacent to that location. The stabilizer hinge fitting at HS 992.1 had contact marks associated with the elevator on both the inboard and outboard sides at the aft end of the fitting. The sealing retention rings of the hinge fitting bearings on the inboard and outboard portions were displaced away from the bearing center. The upper spar cap of the rear spar of the stabilizer was buckled in a downward direction 2.5 inches outboard of HS 2590. There were 13 pulled rivets on the upper skin at the aft spar between HS 2590 and 2965; examination of these rivets showed that the third rivet inboard from HS 2965 had an internal mark on the forward edge of the hole, which was in-line with the skin buckle. The stabilizer rib at HS 2965 was torn fully from the top to the bottom flange, 7.25 inches aft of the auxiliary rear spar. The elevator rib at elevator station (ES) 3016.5 was dented outboard 8.375 inches aft of the leading edge skin splice. The rib at ES 3016.5 exhibited evidence of contact from the top to the bottom of the rib. The skin edge of the elevator horn at ES 3016.5 was found rolled down 4.25 inches from the leading edge in an aft direction. The skin edge was also found rolled down at the contour change. The upper skin of the elevator at ES 2600 exhibited a buckle, which traveled aft to the elevator auxiliary spar. The leading-edge skin of the elevator at the hinge fitting (ES 2590) exhibited evidence of contact with the outboard hinge location. A buckle and 4.5-inch tear were observed on the leading-edge skin of the elevator starting 2.5 inches inboard of ES 2241. There was evidence of contact between the outboard lower edge of the hinge fitting (HS 2590) and the outboard lower skin cutout edge of the elevator at ES 2616.5. The upper spar cap of the forward spar of the elevator was fractured and buckled; the damage was centered 2.5 inches inboard of ES 2241. The lower spar cap of the forward elevator spar fractured and buckled. The trailing edge of the elevator was displaced downwards and buckled 0.75 inch. The upper skin on the stabilizer at HS 2965 was buckled. The stabilizer rib at HS 2965 was cracked, starting from the top of the rib and continuing downwards for 2.25 inches.

MAINTENANCE RECORDS

According to Comair records, the airplane had accumulated 22,154.8 flight hours and 23,115 cycles at the time of the event. The airplane was being maintained in accordance with a FAA-approved maintenance program consisting of service checks and periodic inspection checks, as well as unscheduled maintenance items. A review of the airplane's maintenance records did

not reveal outstanding discrepancies or recurring problems with any of the systems cited above.

TESTS AND RESEARCH

The two attitude heading computers (AHC) were benchtested at Rockwell Collins on May 31, 2001 in accordance with the Production Test Requirement. The purpose of the testing was to check the roll rate outputs of the boxes at high roll rates and to verify the expected outputs to the displays.

The computers are designed to provide valid outputs for pitch, roll, and yaw rates of 128 degrees/second. The captain's AHC was tested under simulated roll conditions. During the test for an invalid flag in the roll axis, the unit flagged at approximately 40 degrees/second in the clockwise direction and in the range of 40 to 50 degrees/second in the counterclockwise direction. The first officer's AHC would not initialize properly due to excessive pitch error. The unit generated erratic pitch and yaw rate readings even when sitting still on the bench.

Testing confirmed that when the flag appeared during the high roll rate, the sky and pitch tape were removed from the display. The result was a dark background with a red "ATT" displayed in a box. The display remained black until a reset occurred, which was approximately 40 seconds after controlled conditions (that is, rates within the range of the AHC) were restored. Even in uncontrolled flight, the display de-cluttered and the stroke writing around the perimeter of the display was removed. In such situations, the text may alternately appear, be removed, and reappear while the raster is still dark. A review of the output from the accident FDR revealed several points at which the display would have been cluttered, de-cluttered, then cluttered again.

ADDITIONAL INFORMATION

During postaccident interviews, the captain of flight 5054 stated that he routinely placed his knee against the trim wheel so that he can feel it move as automatic trim is applied by the autopilot and that he did this during the accident flight. He also stated that, although he had his right leg against the trim wheel before the upset event occurred, he did not feel the trim wheel move. However, FDR data indicate that the pitch trim increased from about 0 to about 7 degrees ANU as the autopilot called for increased pitch trim during the 3-minute period before the upset event. To accomplish this change in trim, the trim wheel would have had to rotate about 1.3 revolutions. Safety Board investigators interviewed other Comair EMB-120 pilots about this practice and learned that is a common technique among this group for monitoring automatic trim changes.

As a result of the accident involving flight 5054, Embraer issued several service bulletins (SB). SB 120-25-0258 reminded flight crews of the necessity to monitor aircraft performance and suggested that a placard be installed directing flight crews to activate the de-icing boots and disengage the autopilot whenever they visually detect ice or the ice detector light illuminates. SB 120-30-0032 called for modifications to the inflation cycles switch on the leading-edge deicing system to automatically switch to the heavy mode cycle when the de-ice boots are activated. Embraer also issued SB 120-30-0033, which recommended that an icing condition low speed alarm be installed to activate if a flight crews does not observe the minimum recommended speed in icing conditions when in cruise configuration. The Federal Aviation Administration issued airworthiness directives enforcing these SBs. In addition, Embraer revised its icing video training tool to include instruction on the ice condition low speed alarm

and to review and reinforce safe operating procedures in icing conditions.

Pilot Information

Certificate:	Airline Transport; Commercial; Private	Age:	56, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	Seat Occupied:	Left
Other Aircraft Rating(s):		Restraint Used:	
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	Airplane Multi-engine; Airplane Single-engine	Toxicology Performed:	
Medical Certification:	Class 1 With Waivers/Limitations	Last Medical Exam:	10/19/2000
Occupational Pilot:		Last Flight Review or Equivalent:	
Flight Time:	16000 hours (Total, all aircraft), 8000 hours (Total, this make and model), 9000 hours (Pilot In Command, all aircraft), 166 hours (Last 90 days, all aircraft), 68 hours (Last 30 days, all aircraft), 3 hours (Last 24 hours, all aircraft)		

Co-Pilot Information

Certificate:	Airline Transport; Commercial; Private	Age:	26, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	Seat Occupied:	
Other Aircraft Rating(s):		Restraint Used:	
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	Airplane Multi-engine; Airplane Single-engine; Instrument Airplane	Toxicology Performed:	
Medical Certification:	Class 1 Without Waivers/Limitations	Last Medical Exam:	12/12/2000
Occupational Pilot:		Last Flight Review or Equivalent:	
Flight Time:	1350 hours (Total, all aircraft), 263 hours (Total, this make and model), 1000 hours (Pilot In Command, all aircraft), 116 hours (Last 90 days, all aircraft), 79 hours (Last 30 days, all aircraft), 3 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	Embraer	Registration:	N266CA
Model/Series:	EMB-120	Aircraft Category:	Airplane
Year of Manufacture:		Amateur Built:	No
Airworthiness Certificate:	Transport	Serial Number:	120.258
Landing Gear Type:	Retractable - Tricycle	Seats:	
Date/Type of Last Inspection:	Continuous Airworthiness	Certified Max Gross Wt.:	25353 lbs
Time Since Last Inspection:		Engines:	2 Turbo Prop
Airframe Total Time:	22154.8 Hours	Engine Manufacturer:	Pratt & Whitney
ELT:		Engine Model/Series:	PW118B
Registered Owner:		Rated Power:	1800 hp
Operator:	COMAIR INC	Air Carrier Operating Certificate:	Flag carrier (121)
Operator Does Business As:		Operator Designator Code:	COMR

Meteorological Information and Flight Plan

Conditions at Accident Site:		Condition of Light:	Dusk
Observation Facility, Elevation:		Observation Time:	
Distance from Accident Site:		Direction from Accident Site:	
Lowest Cloud Condition:	Scattered / 800 ft agl	Temperature/Dew Point:	22 °C / 21 °C
Lowest Ceiling:	Broken / 8000 ft agl	Visibility	
Wind Speed/Gusts, Direction:	8 knots, 100°	Visibility (RVR):	
Altimeter Setting:	29.91 inches Hg	Visibility (RVV):	
Precipitation and Obscuration:			
Departure Point:	Nassau (NAS)	Type of Flight Plan Filed:	
Destination:	ORLANDO, FL (MCO)	Type of Clearance:	
Departure Time:		Type of Airspace:	

Wreckage and Impact Information

Crew Injuries:	3 None	Aircraft Damage:	Substantial
Passenger Injuries:	25 None	Aircraft Fire:	None
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	28 None	Latitude, Longitude:	

Administrative Information

Investigator In Charge (IIC):	Al Dickinson	Adopted Date:	12/18/2002
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Additional Participating Persons:

Publish Date:

Investigation Docket: NTSB accident and incident dockets serve as permanent archival information for the NTSB's investigations. Dockets released prior to June 1, 2009 are publicly available from the NTSB's Record Management Division at pubinq@ntsb.gov, or at 800-877-6799. Dockets released after this date are available at <http://dms.nts.gov/pubdms/>.

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