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National Transportation Safety Board

Washington, D C 20594

Safety Recommendation

Date May 21, 1997

In reply refer to A-97-31 through -34

Mr Barry Valentine
Acting Administrator
Federal Aviation Administration
Washington, DC 20591

On January 9, 1997, an Embraer EMB-120, operating as Comair flight 3272, crashed in Monroe, Michigan, while being vectored for the approach to runway 3R at the Detroit Metropolitan Wayne County Airport (DTW) The flight was operated under Title 14 Code of Federal Regulations Part 135 All 26 passengers and 3 crewmembers were killed, and the airplane was destroyed by impact forces and post-crash fire The Safety Board's investigation of this accident is continuing, and the probable cause has not yet been determined

Information from the flight data recorder (FDR) and cockpit voice recorder (CVR) shows that the airplane was descending from 7,000 feet altitude with the autopilot engaged and wing flaps zero when air traffic control (ATC) issued vectors to the flightcrew to descend and intercept the DTW runway 3R localizer The aircraft leveled at 4,000 feet altitude with flight idle power and flaps zero ATC instructed the flightcrew to reduce speed to 150 knots and then instructed them to turn left To achieve the turn, the autopilot would have initiated a left wing down (LWD) roll angle, to a maximum target of 25° As the left turn commenced, airspeed was decreasing through 164 knots indicated airspeed (KIAS), flaps were zero, and the autopilot's altitude hold mode was engaged As the roll angle reached about 20° LWD, the autopilot control wheel and rudder inputs started moving in a direction to command right wing down (RWD) to slow the LWD rate The left roll angle gradually increased beyond the autopilot target of 25° LWD as the autopilot continued to increase RWD wheel inputs The flightcrew increased engine torque to over 90 percent, but airspeed continued to decrease The airplane remained at an altitude of 4,000 feet FDR data show that the autopilot was commanding airplane nose-up trim at an increasing rate during the turn, although the pitch remained at about 3° nose-up

As the roll angle exceeded 45° LWD, the autopilot disconnected and the stick shaker activated, while this occurred, the airplane reached 145 KIAS and 1 3 Gs load factor Prior to the autopilot disconnect, the control wheel was deflected about 20° to the right, after the autopilot disconnected, the control wheel abruptly deflected at least to 20° to the left, and the aircraft abruptly rolled from 45° LWD to 140° LWD Pitch attitude rapidly decreased from 3° nose-up to 50° nose-down, and the flightcrew reduced engine torque to a level consistent with flight idle After the initial upset, the airplane experienced large oscillations in roll attitude and pitch

oscillations between 20° and 80° nose-down until it impacted the ground in a steep nose-down attitude The flaps and gear remained retracted throughout the entire event

FDR data indicate that before the autopilot disconnected, the airplane roll attitude could not be maintained despite autopilot-commanded aileron and rudder inputs The airspeed continued to decrease despite the flightcrew's application of near maximum engine torque Simulations conducted by Embraer indicate a significant degradation of the airplane's wing lift and drag characteristics

The DTW weather at the time was cloudy with a broken ceiling at 600 and 1,200 feet, overcast above 1,700 feet, temperature of -2° C, and visibility ¾ mile in light snow and mist Trace to severe icing was reported in the area and AIRMET Zulu Update 3, issued for an area that included DTW, forecast occasional light-to-moderate rime icing in clouds below 18,000 feet Information from the CVR indicates that the flightcrew activated the anti-ice equipment for the windshield, propellers, pitot probes, angle-of-attack vanes, sideslip angle vane, and total air temperature probe There is no evidence from the CVR, FDR, performance of the aircraft, or aircraft wreckage to determine if the flightcrew activated the de-icing boots These facts and the airplane's degraded aerodynamic performance strongly suggest that ice had accumulated on the airframe, but may not have been seen or recognized as a hazard by the flightcrew of Comair 3272

The Safety Board participated in a meeting at the Federal Aviation Administration's (FAA's) Atlanta aircraft certification office (ACO) on March 13, 1997 Six prior EMB-120 inflight icing events were reviewed at the meeting, including the accident at Pine Bluff, Arkansas, on April 29, 1993 A summary of these prior icing events follows

- In April of 1995, both crewmembers in an EMB-120 near Tallahassee, Florida, noticed trace icing on the outboard leading edge of the wing The crew also observed an airspeed reduction from 180 KIAS to 140 KIAS, a pitch increase to 5° nose-up, and no apparent increase of trace icing on the leading edge of the wing The crew activated the de-ice boots, after which the airspeed increased and pitch decreased Information about the use of the autopilot was unavailable (This information was obtained from Aviation Safety Reporting System (ASRS) report 302910)

- On October 16, 1994, near Elko, Nevada, an EMB-120 stabilized at 160 KIAS at 13,000 feet Both pilots checked for ice on the wings and spinner, but they did not see a significant amount With the aircraft on autopilot, the flightcrew initiated a heading change to the right, and the aircraft began a right wing down (RWD) roll attitude During the turn, at about 20° RWD, the stick shaker and pusher activated almost simultaneously The aircraft rolled nearly 90° to the right and pitched over The pilot took manual control of the airplane and recovered Post-flight inspection of the aircraft revealed clear ice on the wing leading edge and propeller spinners The de-ice boots were not activated during the flight because the crew did not believe the ice was of sufficient thickness to cause concern Data from the FDR were extracted by the air carrier and forwarded to the FAA and Embraer; analysis showed a minimum airspeed of 138 KIAS before the stick shaker activated The stick shaker activated about 10 knots above the calculated accelerated stick shaker speed The Safety Board was

not notified of this incident until after the Comair flight 3272 accident, however, regulations do not require this type of incident to be reported to the Safety Board (This incident was described in ASRS report 286127)

- On April 29, 1993, at Pine Bluff, Arkansas, an EMB-120 was climbing on autopilot when it stalled and entered a steep descent Three of the four propeller blades subsequently separated from the left engine The airplane's airspeed had decreased to 138 knots before the stick shaker activated and the autopilot disconnected The aircraft experienced an extreme roll upset during the stall Occasional moderate icing in clouds and precipitation were forecast for the area and for the altitude traversed by the airplane The Safety Board concluded that an accretion of ice on the wing was the only reasonable explanation for activation of the stick shaker and loss of roll control at higher-than-expected airspeeds There was no evidence that any ice protection systems were activated before, during, or after the upset, and the aircrew did not recall seeing evidence of icing before the loss of control A passenger, however, recalled seeing a "whitish" substance that appeared to be snow about 8 to 10 inches above the windshield wipers

- On November 22, 1991, in Clermont-Ferrand, France, an EMB-120 was descending with autopilot engaged The captain considered the descent rate too high and disconnected the autopilot manually, leveling the aircraft at 4,500 feet As the airspeed decreased through 150 KIAS, the stick shaker activated The airplane then rolled 60° to the right three times and lost 1,000 feet of altitude During recovery, the flightcrew increased engine power and cycled the de-ice boots Post-flight inspection revealed some residual clear ice on the aircraft The French Bureau Enquettes Accidents (BEA) obtained the FDR data and forwarded them to Embraer Avions de Transport Regional (ATR) informed the Safety Board staff of this incident during the Safety Board's investigation of the October 31, 1994, ATR-72 icing accident at Roselawn, Indiana

- In September, 1991, at Fort Smith, Arkansas, an unspecified aircraft type (assumed to be an EMB-120 based on systems descriptions) was in level flight at 19,000 feet with the autopilot engaged Both pilots felt vibration through the floorboards The pilots inspected the wings, propeller spinners, and engine inlets, which did not appear to have excessive amounts of ice Thirty seconds after the first vibration, the stick shaker activated, the captain took manual control of the aircraft and called for all anti-ice equipment on The aircraft did not immediately respond to rudder/elevator inputs and it entered a right bank, nose-down descent of 1,000 feet per minute The pilots regained control at 16,000 feet (This incident was described in ASRS report 189745)

- On June 28, 1989, at Klamath Falls, Oregon, an EMB-120 was flying on autopilot at 16,000 feet in light icing and turbulence The flight descended to 15,000 feet and the flightcrew observed light mixed rime and clear ice The airspeed decreased rapidly, from 180 to 160 KIAS, and was followed by activation of the stick shaker The pilot took control of the aircraft and applied maximum power as the aircraft rolled 30° to the left one time then 40° to the right two times The aircraft stabilized at 12,000 feet There was no indication that any ice protection equipment was used (This incident was described in ASRS report 115422)

For operation in known or forecast icing conditions, the Embraer EMB-120 AFM establishes a minimum flaps zero holding speed of 160 KIAS The Embraer AFM also instructs pilots, "For approach procedures in known or forecast icing conditions, increase the airspeed by 5 up to 10 KIAS until the short final " The Embraer AFM does not establish a minimum maneuver speed for flight in icing conditions

Some air carriers operating EMB-120s required their flightcrews to maintain higher holding speeds in icing conditions after the 1994 ATR accident in Roselawn, Indiana For example, Comair published a bulletin to its FSM establishing a minimum holding speed of 170 KIAS in icing conditions and added 5 knots to the 25° flaps reference speed if residual ice was suspected However, the Comair FSM does not instruct pilots of EMB-120s to add 5 up to 10 knots of airspeed for approach procedures in known or forecast icing conditions, nor does it provide a minimum maneuver speed for flight in icing conditions

In six of the seven icing accidents/incidents examined (including the recent Comair accident), the flightcrews allowed the airspeed to decrease below the Embraer AFM-recommended minimum holding speed in icing conditions; in four of those incidents, the crew was aware of the icing conditions before the upset The history of icing incidents involving EMB-120 airplanes and the circumstances of the Comair 3272 accident highlight the need for the Embraer AFM and the air carrier operating manuals to contain adequate and consistent information relative to the minimum maneuvering, descent, and approach speeds in icing conditions Thus, the Safety Board believes that the FAA should approve minimum EMB-120 airspeeds for all flap settings and phases of flight (holding, descent, approach, etc), including flight in icing conditions Further, the Board believes that the FAA should require air carriers to reflect approved minimum airspeeds in their EMB-120 operating manuals

Until April 1996, the Embraer EMB-120 AFM stated that the wing and tail leading edge ice protection system (de-ice boots) should be turned on when observing ¼ to ½ inch of ice on the leading edges of the wings Previous Safety Board accident investigations have identified the detrimental aerodynamic effect that small amounts of ice, even as little as ¼ inch, can have when accumulating on the leading edge of the wing In its final report on the EMB-120 accident in Pine Bluff, the Safety Board states that even "a small amount of ice on the wing's leading edge could have a significant effect on the aerodynamic performance " An operational bulletin issued by Embraer to all operators of the EMB-120 in April 1996 states the following

> Any contamination as thick and rough as medium sandpaper can significantly reduce handling qualities and stall margins A mirror coating of ice may be sufficient to destroy lift such that performance is significantly degraded Additionally, ice accretion can increase the stall speed and can cause the loss of artificial stall warning

On April 23, 1996, following tanker flight tests on the EMB-120, Embraer issued revision number 43 to its AFM to require activating the de-ice boots "at the first sign of ice formation " The Comair FSM does not contain the revised de-ice boot operating procedures Specifically, the Comair FSM states that flightcrews should "allow ice accumulation to build approximately ½ inch

prior to inflating the wing and engine de-ice boots" and cautions that "premature activation of the surface de-ice boots could result in ice forming the shape of an inflated de-ice boot, making further attempts to de-ice inflight impossible" This phenomenon is referred to as "bridging" According to Embraer, it revised the AFM de-ice boot operating procedures because the bridging phenomenon is rarely (if ever) observed in normal operations and is no longer considered to be an adequate rationale to delay inflating the de-ice boots

As indicated earlier in this letter, there is no evidence from the Comair 3272 accident that the de-ice boots were used Further, the wing and tail de-ice boots were not inflated prior to the six other upsets described Because Comair and several other air carriers continue to instruct their flightcrews to turn on the de-ice boots after ¼ to ½ inch of ice has accumulated, the Safety Board believes that the FAA should ensure that the de-icing information and procedures in the air carriers' EMB-120 operating manuals and training programs are consistent with the revised Embraer AFM

The flightcrews in the described icing incidents either were not aware of ice accretion, or did not believe that ice accretion was severe enough to activate the de-ice boots These circumstances suggest that flightcrews need better information to help them recognize conditions that warrant activating the de-ice boots Thus, the Safety Board believes that the FAA should direct the Principal Operations Inspectors (POIs) to ensure that all EMB-120 operators provide flightcrews with training that emphasizes the recognition of icing conditions and the need to adhere to the procedure for using de-ice boots that is specified in the revised Embraer EMB-120 AFM

Although the Embraer AFM recommends operation of de-ice equipment at the first sign of ice formation, the accretion of ice is generally only detected and recognized by the flightcrews from visual cues on the wing leading edge, propeller spinners, and windshield Additionally, the Comair FSM states that a 10- to 15-knot loss of airspeed is also an indication of ice accretion However, in the case of flight 3272, the crew was deliberately reducing the airspeed and may not have recognized an airspeed reduction as a cue to ice accretion Some aircraft, such as the ATR-42/72 and others, are equipped with, or have available, optional automated ice detection and alerting systems, most of which utilize the Rosemount ice detector probe or similar technology The EMB-120 has no automated ice detection system, and EMB-120 flightcrews rely on visual or performance cues (and the pilot's awareness of these cues) to prompt the use of ice protection equipment Because the EMB-120 is not equipped with automated ice detection and alerting equipment, the airplane manufacturer, operators, and the FAA rely solely on crew perception and judgment regarding the detection of icing conditions and the accretion of ice on the airframe As the EMB-120 event history demonstrates, in certain conditions the flightcrew may not recognize or act on visual and/or performance cues of ice accretion on the EMB-120 The safety of the EMB-120 would be greatly enhanced by the installation of automated ice detection and alerting equipment The Safety Board thus believes that the FAA should require that all EMB-120 aircraft be equipped with automated ice detection and crew alerting systems for detecting airframe ice accretion

The incident/accident history of the EMB-120 in icing conditions and the recent Comair 3272 accident, which occurred when the aviation community had a heightened awareness of the operational hazards of airframe icing following the Roselawn ATR-72 accident, reinforce the Safety Board's continuing concern about air carrier operations of turboprop airplanes in icing conditions On May 9, 1997, the FAA provided the Safety Board a copy of a Notice of Proposed Rulemaking (NPRM), Docket 97-NM-46-AD, for EMB-120s that was published in the Federal Register on May 13, 1997 The NPRM addresses many of the safety issues discussed in this letter The Safety Board is evaluating whether the proposed 160 KIAS minimum airspeed in icing conditions is appropriate, and if the single speed adequately addresses the intent of what would have been our first recommendation that is, for FAA to approve for inclusion in Embraer's EMB-120 airplane flight manual minimum airspeeds for all flap settings and phases of flight, including flight in icing conditions

Nonetheless, we believe it is advantageous to FAA's rulemaking process for the Safety Board to make known to FAA and industry the full extent of our analysis and proposals, and to put the results in recommendation form The recommendations issued here are in some respects more specific than the FAA proposals The Board would, for instance, wish to guarantee that FAA-approved airspeed requirements and de-icing procedures in the manufacturer's and air carrier's operating manuals are consistent or can be demonstrated to provide the same level of safety The Board seeks specific training in Embraer's new de-icing procedures because many flightcrews will need to unlearn acquired practices We also believe that the more descriptive accounts of the accidents and incidents are useful to focus the attention of the operator and flightcrews on the issues Further, we believe the issuance of Safety Board recommendations will assist FAA in galvanizing industry acceptance for its proposals We are confident that the combined interest of our two agencies in fostering these needed improvements will ensure a timely completion of this project Therefore, the Safety Board recommends that the Federal Aviation Administration

Require air carriers to reflect FAA-approved minimum airspeeds for all flap settings and phases of flight, including flight in icing conditions, in their EMB-120 operating manuals (Urgent) (A-97-31)

Ensure that the de-icing information and procedures in air carriers' EMB-120 operating manuals and training programs are consistent with the revised Embraer EMB-120 airplane flight manual (Urgent) (A-97-32)

Direct Principal Operations Inspectors (POIs) to ensure that all EMB-120 operators provide flightcrews with training that emphasizes the recognition of icing conditions and the need to adhere to the procedure for using de-ice boots that is specified in the revised Embraer EMB-120 airplane flight manual (Urgent) (A-97-33)

Require that all EMB-120 aircraft be equipped with automated ice detection and crew alerting systems for detecting airframe ice accretion (Urgent) (A-97-34)

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHIMDT, GOGLIA, and BLACK concurred in these recommendations.

By: Jim Hall
Chairman