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Mr. Richard Rodriguez
Investigator-In-Charge
Major Investigations Division
National Transportation Safety Board
AS-10, Room 5305
490 L'Enfant Plaza East, S.W.
Washington, D.C. 20594-2000

Dear Mr. Rodriguez:

In accordance with the Board's rules, the Air Line Pilots Association submits the following comments concerning the accident involving Comair Airlines Flight 3272, which occurred on January 9, 1997 in Monroe, Michigan.

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 being 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.

ACCIDENT DISCUSSION

ALPA believes that this accident was avoidable and was caused by the actions (or inaction's) of many organizations. There were several significant warnings during the history of EMB-120 operations that should have resulted in proactive actions to preclude an accident. The attached submission contains ALPA's analysis of the facts surrounding the accident based upon information obtained through the NTSB's investigation. Also included are ALPA's Safety Recommendations aimed at preventing future accidents of this nature.

Eighteen years ago, BFGoodrich conducted an icing impingement study for the EMB-120 airfoils to determine the extent of the pneumatic boot coverage. The results of this study indicated that the pneumatic boot coverage on the EMB-120 did not meet the requirements of the Federal Aviation Regulations (FAR's) in providing protection against FAR 25, Appendix C icing conditions. Seventeen years later, subsequent to the accident, NASA Lewis Icing Research Tunnel tested an EMB-120 airfoil and obtained similar results; the current pneumatic boot coverage does not provide protection of the airfoil against FAR 25, Appendix C icing conditions. Yet, this issue was not addressed by either BFGoodrich, Embraer, CTA or the FAA when it initially was discovered 19 years ago.

Approximately three years after the 1980 BFGoodrich study, Embraer conducted dry-air, high angle-of-attack flight testing in which the EMB-120 exhibited high roll rate tendencies at high angles-of-attack. These tests resulted in the incorporation of a stall avoidance system on the aircraft. Although the FAA was not involved in this initial BFGoodrich and Embraer testing, an EMB-120 ice induced roll upset incident history which began in 1989 and continued until this accident in 1997, should have provided the FAA with clear indications that this aircraft exhibited adverse handling qualities while operating in icing conditions. However, throughout the incident history and as part of the Certification and ongoing Airworthiness Review of the aircraft, no action was taken on the part of either Embraer, CTA or the FAA to correct these problems.

Another opportunity presented itself to take action to address the EMB-120's handling qualities when, subsequent to the ATR-72 accident over Roselawn, Indiana, the FAA identified the EMB-120 as another aircraft type that exhibits handling qualities problems in icing conditions. The FAA requested that Embraer conduct additional flight testing to determine if such problems do exist. The conclusions of this series of tests resulted in procedural and operational change recommendations by Embraer. However, these recommended changes were not acted upon by the FAA until after the Comair 3272 accident.

It would appear that the industry still has not taken adequate steps to preclude another event such as Comair 3272. In March of 1998, another EMB-120 experienced an ice induced roll upset. The aircraft performance and handling qualities experienced in this incident were very similar to all of the other EMB-120 upsets as well as the Comair 3272 accident aircraft. Accident factors have been described as "links in a chain", however, due to the inaction on the part of industry to address and correct known deficiencies in the EMB-120 aircraft, the flightcrew remains the only link available to preclude an accident.

Early Testing and Analysis

In 1980, BFGoodrich conducted an icing impingement study on the EMB-120 airfoil to determine the extent of pneumatic boot coverage required to protect the airfoil from FAR Part 25, Appendix C (current certification requirement) icing conditions. The cloud physics used in this study consisted of 20-micron mean (average) droplet diameters with a maximum diameter of 40-microns. BFGoodrich indicated that since most of the ice collected will be within the 20-micron impingement limit, the 40-micron limits will be calculated. Calculations of the 40-micron limits resulted in icing impingements and accretions aft of the pneumatic boot surface on the underside of the wing.

During the initial design testing of the EMB-120 aircraft, the aircraft exhibited uncommanded left rolling tendencies at high angles of attack. This testing was conducted on a clean aircraft in dry air. Flight test pilots also made statements regarding high roll rates and high control wheel / column forces. These inherent rolling tendencies resulted in Embraer incorporating a stall avoidance system (stick shaker and stick pusher) on the aircraft. The intent of the stall avoidance system was to preclude operation of the aircraft in these areas of the flight envelope (high AOA).

Aircraft Certification / Bilateral Airworthiness Agreement

The EMB-120 aircraft was certificated for operation in the United States through the Bilateral Airworthiness Agreement (BAA) with Brazil. Documentation provided to the NTSB from the FAA in response to several recent NTSB Safety Recommendations indicates that the FAA, during certification of a foreign aircraft, generally focus on areas that are controversial, covered by new regulations, or have shown previous certification or service problems. It does not appear that either as part of the initial certification of the EMB-120 aircraft were the previous two issues of high AOA test results or BFGoodrich ice impingement results adequately reviewed. It also does not appear that, as part of any ongoing Airworthiness Reviews of the EMB-120 aircraft, were the EMB-120 ice induced roll upsets taken into consideration or given ample review.

Incident History

Beginning in 1989, the documented history of EMB-120 ice induced roll upsets began with an event in Klamath Falls, Oregon. Over the next six years, the aircraft experienced five additional ice induced roll upsets. A majority of the events appear to have occurred at approximately 150 to 160 knots with high roll angle excursions and significant drag increases being experienced. Also, a number of the events indicated that the flightcrews felt that the amount of ice they had accreted was not of sufficient thickness to warrant operation of the ice protection systems. Unfortunately, due to the lack of detail on a number of the available documentation, minimal incident information is available.

Manufacturer Testing / Recommendations

Subsequent to the ATR-72 accident of October 1994, the FAA initiated a three phase program to: a) identify and correct any ice induced handling qualities problems on the ATR aircraft; b) identify and correct any ice induced handling qualities problems associated with all other turboprops, and; c) identify and correct any handling qualities problems associated with turbojet aircraft. As part of Phase II (b), the FAA conducted a review of the available information for the above mentioned EMB-120 ice induced roll upsets. The results of this review were presented to all EMB-120 operators at FAA headquarters in November 1995. An FAA internal draft document (dated January 1996) resulted, in which many significant EMB-120 aircraft performance, handling qualities and autopilot usage conclusions were arrived at. Many of these conclusions, had they been acted upon at the time, could have precluded the accident of Comair Flight 3272.

In late 1995, Embraer conducted testing on an EMB-120 aircraft using wood molding (quarter-round) on the upper surface of the wing ahead of the ailerons. This testing was intended to simulate the worst-case conditions of an ice ridge caused by an inadvertent and extended encounter with Supercooled Large Droplet (SLD) icing conditions (conditions outside current icing certification).

Flight testing resulted in high control wheel and control column forces, high roll rates and uncommanded autopilot disconnects due to the autopilots inability to maintain its required bank angle.

In April of 1996, Embraer issued an Operations Bulletin (120-006/96), entitled Operation in Icing Conditions and applicable to the EMB-120 aircraft. This report was generated as a result of icing tanker testing conducted at the request of the FAA as part of the Phase II efforts subsequent to the ATR accident. The subject testing was to evaluate the visual cues and handling qualities of the EMB-120 aircraft in SLD icing conditions. This report identified several highly significant operational recommendations related to the EMB-120 aircraft while operating in icing conditions. These recommendations dealt with minimum operating speeds in all icing conditions, ice protection system operation and autopilot usage restrictions in icing conditions. Again, the implementation of any of these Embraer recommendations may have precluded the accident of Comair Flight 3272.

Manual Guidance

At the time this bulletin was issued, there was no minimum airspeed guidance in icing conditions, there were no autopilot usage restrictions in icing conditions (other than in known SLD conditions), and the ice protection system operation guidance was to wait until ¼" to ½" of ice had accreted on the airframe prior to activation of the system.

Eleven days after the issuance of the Embraer Operations Bulletin, a revision was issued to the EMB-120 Airplane Flight Manual (AFM) modifying the procedure for operation of the ice protection system. This change was to operate the system at the first sign of ice accretion on the airframe. This change, however, was never made to the company manual (Flight Standards Manual (FSM)) which would have been forwarded to the flightcrews operating the EMB-120 aircraft. This change in procedure was never taught to the same flightcrews.

Activities Subsequent to the Comair 3272 Accident

On January 9, 1997, the accident involving Comair Flight 3272 occurred. It is apparent that the upset was icing induced and the aircraft appears to have experienced significant drag increases prior to the upset. Power increases prior to the upset had minimal effect on the aircraft's airspeed. The autopilot was unable to maintain aircraft attitude and disengaged after reaching its bank angle limit. After the initial upset, the aircraft encountered severe roll oscillations.

The Meteorology Group determined that this flight, and several others in the same area, were operating through a thin (~1000 foot) altitude layer of icing. Comair 3272 actually encountered and was exposed to this thin layer for approximately 40 seconds. The Meteorology Group activities determined that this icing layer contained icing conditions primarily within current certification (FAR 25, Appendix C), although SLD conditions may have been possible.

In March of 1997, the FAA Aircraft Certification Office (ACO) in Atlanta, conducted a second review of the previous EMB-120 ice induced roll upsets. The results of this review were presented to several parties involved in the Comair 3272 accident investigation. This review and presentation was given jointly between FAA and Embraer. The conclusions arrived at based upon this review were significantly different than the January 1996 FAA review and did not identify any aircraft performance, handling quality or autopilot deficiencies associated with the EMB-120 aircraft. This review did recommend several operational changes that the FAA felt should be considered. It was not until December of 1997 that the final Airworthiness Directive (AD) was issued which provided: guidance for the installation of an ice detection system, revised guidance for the operation of the pneumatic ice protection systems and a minimum speed to be used in icing conditions.

An activity requested by the Aircraft Performance Group was an analysis of an EMB-120 airfoil in the NASA Lewis Icing Research Tunnel. Conditions within and outside FAR 25, Appendix C were tested with significant results. 1) While testing within a droplet size range of ~20 – 80 microns, a ½" to ¾" ridge of ice formed on the leading edge of the airfoil after a five minute exposure. 2) While testing within a droplet size range of ~20 – 80 microns, ice always formed aft of the pneumatic boot on the underside of the wing. 3) Five-minute exposures to droplet size ranges of ~20 – 80 microns created significant drag increases on the airfoil (between 74% to 180% over a clean airfoil). 4) For conditions within Appendix C, deicing after two minutes of a five-minute exposure resulted in significant increases in drag over no deicing of the airfoil (136% vs 74%). 5) De-icing after two minutes of a five minute exposure to droplet sizes of 40 microns resulted in minimal drag decreases over no deicing of the airfoil (180% vs 132%).

CONCLUSIONS

Comair Flight 3272 was operating in meteorological conditions that did not cause the flightcrew any concern in terms of the icing environment or the ice accretions they were experiencing. The flight was quite probably experiencing icing conditions and accretions that, based upon the guidance the industry provided them at the time, did not warrant operation of the wing and tail ice protection system.

The airspeed and aircraft configuration which Comair 3272 was operating at the time of the upset was well within company and manufacturer airspeed guidance, as well as the aircraft performance envelope of the EMB-120. The flight, during the descent from 7000', had not reached or maintained a "steady-state" condition where the flightcrew would have noticed that conditions were degrading and that alternate flightcrew actions were necessary. There was absolutely no reason for the flightcrew to question the 150 knot speed restriction given by ATC or to believe that that airspeed was inappropriate.

Based upon the results of the BFGoodrich Icing Impingement Analysis conducted in 1980 and results of the most recent NASA Lewis Icing Tunnel study, it is clear that the ice protection system installed on the EMB-120 aircraft does not meet the icing requirements of FAR 25, Appendix C. Also, it would appear that the ongoing airworthiness review of the EMB-120 aircraft conducted by the FAA was inadequate in identifying and addressing any historical data concerning aircraft performance and handling qualities.

On March 4, 1998, another high-drag, ice induced roll upset occurred on an EMB-120 aircraft. With their pneumatic boot system operating, the flight was operating in conditions that were characterized by the flightcrew as light to moderate rime icing. The flightcrew departed their altitude of 9000' to minimize their exposure and obtain a smoother ride. As the aircraft was entering its second turn in a holding pattern, and as the airspeed approached 150 knots, the flightcrew felt a rumble and increased engine torque. The increase in engine torque had no effect on the airspeed of the aircraft. The flightcrew disconnected the autopilot and the aircraft experienced several uncommanded roll excursions. It would appear that the activities conducted within the industry in terms of aircraft performance and handling qualities fall well short of precluding additional upsets.

ALPA feels that many factors existed which directly contributed to the accident of Comair Flight 3272.

- Failure of CTA to ensure that the ice protection system installed on the EMB-120 aircraft meets the requirements of FAR Part 25, Appendix C.
- Failure of the FAA, through the Bilateral Airworthiness Agreement with Brazil, to ensure that the original pneumatic ice protection system of the EMB-120 aircraft meets the requirements of FAR Part 25, Appendix C.
- Failure of the FAA, through the Bilateral Airworthiness Agreement with Brazil, to ensure that the aircraft performance and handling qualities of the EMB-120 aircraft were not compromised due to operating in icing conditions to the point of eliminating any margin above aerodynamic stall.
- Failure of the FAA, through the Bilateral Airworthiness Agreement with Brazil, to provide adequate certification of the EMB-120 aircraft for operation within the United States.
- Failure of the FAA to provide adequate oversight and act upon the EMB-120 incident history as it relates to aircraft performance and handling qualities issues.
- Failure of the FAA to provide adequate dissemination of "Safety-of-Flight" information from the aircraft manufacturer to the operators and line pilots and ensure that this information was incorporated into all applicable manuals.
- Inadequate airspeed guidance that permitted operation of the aircraft at an airspeed that did not provide adequate margin above aerodynamic stall.

Based on the factual analysis of the accident of Comair Flight 3272, ALPA offers the following safety recommendations in order to address the deficiencies outline above:

1. The Federal Aviation Regulations (FARs) should include guidance for the testing and assessment of aircraft handling qualities in icing conditions.

2. Recommend that all training syllabuses be modified to include aircraft specific handling characteristics in icing conditions as a required item.

3. The FAA must continue its inflight icing research on all aircraft with the intent of further characterizing the icing environment, providing concise methods for flightcrews to identify the environment they are operating.

4. For the EMB-120 and all aircraft with pneumatic de-icing systems and manual controls, revise the Operating Procedures to ensure that flightcrews disengage the autopilot if the aircraft is encountering icing conditions.

5. For the EMB-120 and all aircraft with pneumatic de-icing systems and manual controls, revise the Operating Procedures to ensure that, at the first sign of weather conditions conducive to ice formation, all ice protection systems be turned on and remain on until exiting icing conditions.

6. Revise FAR 121 to ensure that aircraft certificated with ice protection systems have system status information recorded on the Flight Data Recorder.

7. Revise FAR 121 to ensure that aircraft power lever angle information is recorded on the Flight Data Recorder.

8. For aircraft that are not so-equipped, aircraft ice/rain protection systems which are equipped with an automatic feature should be required to complete an entire cycle when selected OFF.

9. For aircraft that are certificated under FAR Part 25 and are not so-equipped, require that their stall warning system activation angles be biased based upon ice protection system status. Essentially the same stall warning and identification margins that were intended in the uncontaminated condition should remain valid with ice accretions resulting from Appendix C icing conditions. This requirement should be retroactive to cover all aircraft engaged in air carrier operations.

10. Ensure that the EMB-120 aircraft meets all applicable requirements of FAR 25.

11. For the EMB-120 and those aircraft that are not so-equipped, install an "aural" trim-in-motion system.

12. All operators of the EMB-120 should revise their training syllabus to ensure that the use of the fast/slow indicator is taught. It should be stressed to flightcrews that the fast/slow indicator is an additional tool to be used to safely operate the aircraft.

13. Recommend to Embraer that the fast slow indicator be calibrated and certified for 1.3_{VS} at all possible aircraft configurations.

14. Autopilot certification standards should be reviewed and changed where necessary to require warning systems to alert the flightcrew in advance of an autopilot disconnect.

15. On the EMB-120 or aircraft that are not so-equipped, provide flightcrews with a "bank angle" warning with a triggering threshold beyond a standard rate turn but well in advance of autopilot disconnect due to excessive bank angle.

16. Ice detector systems should have the capability to detect and notify the flightcrew of an encounter with FAR 25, Appendix C icing conditions and conditions beyond FAR 25, Appendix C. The system should have the ability to differentiate between those conditions and properly enunciate it to the flightcrew.

17. Require operators to provide clear definitions to their flightcrews as to how company bulletin information should be incorporated and utilized.

18. For the EMB-120, and those aircraft not so-equipped, minimum maneuvering speeds for every aircraft configuration should be generated and provided to all flightcrews.

19. Ice protection system manufacturers should determine the proper operation of their system. They should make that information available to all manufacturers that utilize their system and all operators for incorporation into their procedural manuals.

20. Ensure that all pertinent aircraft incident information be compiled and disseminated to the operators of their specific equipment and distributed to the appropriate flightcrews.

21. FAA should develop a formal method to determine if manufacturer Operations Bulletin information requires regulatory action.

22. The FAA should develop a formal method to ensure that all manufacturer Operations Bulletin information is distributed to the appropriate operators and flightcrews.

23. Require all air carrier pilots receive simulator training in both full stall recovery and ice induced roll upsets. Simulators should include contaminated airfoil handling qualities characteristics (e.g. ice induced roll upsets).

24. The FAA should immediately initiate a review of the engineering and certification data used to substantiate the AFM procedures for operating the ice protection system on all aircraft used in air carrier operations. This review should insure that these procedures are substantiated by reliable, repeatable engineering data and that no significant degradations in aircraft safety margins exist at any time during the normal, approved operation of the ice protection system.

25. Review Aircraft Flight Manuals and company standards manuals to ensure that flight critical procedures are consistent between documents and are included in the appropriate procedural sections (i.e. Emergency, Abnormal, Normal, etc.).

ALPA appreciates the opportunity to have participated as a party to the investigation and hopes the attached analysis, conclusions and recommendations will be of assistance as the Board concludes its investigation.

Sincerely,

Mitchell L. Serber

Captain Mitchell L. Serber
Air Line Pilots Association
ALPA Coordinator

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