National Transportation Safety Board

Washington D.C. 20594

Safety Recommendation

Date: August 15, 1996

In reply refer to: A-96-48 through -69

Honorable David R. Hinson
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On October 31, 1994, at 1559 Central Standard Time, an Avions de Transport Regional, model 72-212 (ATR 72), registration number N401AM, leased to and operated by Simmons Airlines, Incorporated, and doing business as (d.b.a.) American Eagle flight 4184, crashed during a rapid descent after an uncommanded roll excursion. The airplane was in a holding pattern and was descending to a newly assigned altitude of 8,000 feet when the initial roll excursion occurred. The airplane was destroyed by impact forces; and the captain, first officer, 2 flight attendants and 64 passengers received fatal injuries. Flight 4184 was a regularly scheduled passenger flight being conducted under 14 Code of Federal Regulations (CFR) Part 121; and an instrument flight rules flight plan had been filed.[1]

[1]For more detailed information, read Aircraft Accident Report--"In-flight Icing Encounter and Loss of Control, Simmons Airlines, d.b.a. American Eagle Flight 4184, Avions de Transport Regional (ATR), Model 72-212, N401AM, Roselawn, Indiana, October 31, 1994" (NTSB/AAR-96/01)

The National Transportation Safety Board has determined that the probable causes of this accident were the loss of control, attributed to a sudden and unexpected aileron hinge moment reversal that occurred after a ridge of ice accreted beyond the deice boots because: 1) ATR failed to completely disclose to operators, and incorporate in the ATR 72 airplane flight manual, flightcrew operating manual and flightcrew training programs, adequate information concerning previously known effects of freezing precipitation on the stability and control characteristics, autopilot and related operational procedures when the ATR 72 was operated in such conditions; 2) the French Directorate General for Civil Aviation's (DGAC's) inadequate oversight of the ATR 42 and 72, and its failure to take the necessary corrective action to ensure continued airworthiness in icing conditions; and 3) the DGAC's failure to provide the Federal Aviation Administration (FAA) with timely airworthiness information developed from previous ATR incidents and accidents in icing conditions, as specified under the Bilateral Airworthiness Agreement and Annex 8 of the International Civil Aviation Organization.

Contributing to the accident were: 1) the FAA's failure to ensure that aircraft icing certification requirements, operational requirements for flight into icing conditions, and FAA published aircraft icing information, adequately accounted for the hazards that can result from flight in freezing rain and other icing conditions not specified in 14 CFR Part 25, Appendix C; and 2) the FAA's inadequate oversight of the ATR 42 and 72 to ensure continued airworthiness in icing conditions.

As a result of the investigation of this accident, the Safety Board has concluded that the weather forecasts produced by the National Weather Service (NWS) were correct based on the available information, and that the actions of the forecasters at the National Aviation Weather Advisory Unit, Kansas City, and the Center Weather Service Unit meteorologists at the Chicago air route traffic control center were in accordance with NWS guidelines and procedures.

Nonetheless, the Safety Board has some concerns about the lack of weather information disseminated to the crew of flight 4184. Specifically, the information contained in AIRMETs [airman's meteorological information] "Zulu," "Sierra" and "Tango," and Update 2, was available well in advance of

flight 4184's departure, and was pertinent to the airplane's route of flight. This information was not, and typically would not be, included in the weather portion of the flight release provided by Simmons Airlines/AMR Eagle. Further, it could not be determined if the flightcrew had obtained the updated weather information via the hazardous in-flight weather advisory service (HIWAS) while en route or prior to the recorded conversations on the cockpit voice recorder (CVR).

14 CFR Part 121.601 (b) and (c) state, in part, respectively, "before beginning a flight the aircraft dispatcher shall provide the pilot in command with all available weather reports and forecasts of weather phenomena that may affect the safety of flight" and that during a flight the dispatcher shall provide "any additional available information of meteorological conditions including adverse weather phenomena." FAA Order 8400.10, paragraph 1423, (Operational Requirements - Flightcrews) requires that AIRMET information be considered in the preflight planning process; however, Center Weather Advisories (CWAs) are not required to be included or considered. Simmons Airlines dispatchers review the AIRMETs, but they do not typically include them in the flight release package. CWAs are not included in the release packages because they are not required. The Safety Board is concerned that because Simmons Airlines dispatchers do not include AIRMETs (which include information regarding moderate icing) and CWA information, flightcrews may not be provided "all available weather reports and forecasts of weather phenomena" necessary to make informed decisions.

Altho the Safety Board concludes that the actions of the flightcrew would not ave been significantly different if they had received the AIRMETs, the Safety Board believes that Simmons Airlines/AMR Eagle should require its dispatchers to include in the flight release AIRMETs and CWAs that are pertinent to the route of flight so that this information can be available for preflight and in-flight decisionmaking. Therefore, the Safety Board believes that the FAA should direct its principal operations inspectors (POIs) to ensure that all air carriers require their dispatchers to provide pertinent information, including AIRMETs and CWAs, to flightcrews for preflight and in-flight planning purposes. Further, the FAA should Revise FAA Order 8400.10, Chapter 7, Section 2, paragraph 1423 to specify that CWAs be included and considered in the flightcrew's preflight planning process.

With regard to the availability of in-flight weather information, the Safety Board notes that the HIWAS broadcast generated by the Kankakee (AFSS) included all of the icing information contained in AIRMET "Zulu," Update 3. Although the HIWAS broadcast generated by the Terre Haute AFSS indicated that icing was forecast above the freezing level, it did not indicate the icing levels, the intensity and type of icing, or the existence of icing conditions in clouds and precipitation included in AIRMET "Zulu," Update 3. The Safety Board understands that the HIWAS broadcasts are intended to provide hazardous weather information in a short format that will facilitate the pilot's understanding of the potentially hazardous conditions. However, the Safety Board concludes that safety would be enhanced if the information were presented more consistently among HIWAS stations and if those broadcasts included all of the information pertinent to the safety of flight, such as the altitudes of the icing conditions, the intensity and type of icing, and the location of the actual or expected icing conditions (i.e. in clouds and precipitation). Therefore, the Safety Board believes that the FAA should require that HIWAS broadcasts consistently include all pertinent information contained in weather reports and forecasts, including in-flight weather advisories (AIRMETs, SIGMETs, and CWAs). The Safety Board also believes that the FAA and air carriers should reemphasize to pilots that HIWAS is a source of timely weather information and that it should be used whenever aircraft are operating in or near areas of potentially hazardous weather conditions.

Air traffic controllers are required by FAA Order 7110.65 to solicit a pilot report (PIREP) when certain weather conditions that are specified in the order are either forecast or reported for the area of jurisdiction. "Lighter or greater..." icing conditions, which include freezing rain, are one of the five conditions specified by the order for which a controller will solicit a PIREP. When the BOONE sector controller assumed control of the position and received a briefing by the departing controller, he was told, "...no one was complaining about the weather." This included flight 4184 which had been on the radio frequency for approximately 3 minutes when the BOONE controller assumed control. Because there were no PIREPs provided to the previous controller, and the crew of flight 4184 did not provide a PIREP of icing conditions at the LUCIT intersection, it was reasonable for the controller to assume that there were no significant weather events in that area, and that the crew of flight 4184 was not experiencing any problems that

would have required the controller to take alternative actions. Nonetheless, the Safety Board believes that the FAA should revise FAA Order 7110.65, "Air Traffic Control," Chapter 2, "General Control," Section 6, "Weather Information," paragraph 2-6-3, "PIREP" Information, to include freezing drizzle and freezing rain. These conditions should also be clearly defined in the Pilot/Controller Glossary.

The investigation revealed that although the icing definitions in the Aeronautical Information Manual (AIM) provide some basis for assessing ice accumulation in PIREPs, they are subjective and of limited use to pilots of different aircraft types. For example, using these definitions, "light" icing for a B-727 could be "severe" icing for an ATR 72 or a Piper Malibu. The icing report provided by the captain of the A-320 Airbus that was holding at the HALIE intersection near Roselawn indicated that he observed about 1 inch of ice accumulate rapidly on his aircraft's icing probe. The captain provided a PIREP to air traffic control (ATC) and reported the icing as "light rime." After the accident, he stated that the anti-ice equipment on the airplane "handled the icing adequately," and that he believed the icing intensity to have been "light to moderate."

The Safety Board concludes that icing reports based on the current icing severity definitions may often be misleading to pilots, especially to pilots of aircraft that may be more vulnerable to the effects of icing conditions than others. Therefore, the Safety Board believes that the FAA should develop new aircraft icing intensity reporting criteria that are not subjective and are related to specific types of aircraft.

In addition, the investigation revealed a problem with the aviation community's general understanding of the phrase "icing in precipitation," which is used by the NWS but is not defined in any aeronautical publications, including advisory circulars, Part 1 of the Federal Aviation Regulations or the AIM. This phrase is often contained in in-flight weather advisories; however, it does not typically specify types of precipitation. According to the NWS, this phrase is intended to include freezing drizzle and freezing rain. Therefore, the Safety Board concludes that defining "icing in precipitation" in these publications would make pilots and dispatchers more aware of the types of precipitation and icing conditions that are implied by this phrase. Accordingly, the Safety Board believes that the FAA should provide a

definition of the phrase "icing in precipitation" in the appropriate aeronautical publications. Further, the Safety Board believes the FAA should require all POIs of 14 CFR Part 121 and 135 operators to ensure that training programs include information about all icing conditions, including flight into freezing drizzle/freezing rain.

Based on the evidence uncovered in this accident, the Safety Board believes that the current methods of forecasting icing conditions are of limited value because they typically cover very large geographic areas, do not provide specific information about liquid water content (LWC) or water drop sizes, and use only relative humidity and temperature. According to testimony from a scientist from the National Center for Atmospheric Research (NCAR), it is not possible to infer the severity of icing using only temperature and humidity. Rather, the severity of the icing also depends on the LWC and the size of the water droplets, information which is not currently identified and forecasted.

The Safety Board is concerned that there are no reliable methods for flightcrews to differentiate, in flight, between water drop sizes that are outside the 14 CFR Part 25, Appendix C, icing envelope and those within the envelope. Further, although side window icing was recognized as an indicator of ice accretions from freezing drizzle during flight tests of an ATR 72 after the accident, the crew of flight 4184 could not have been expected to know this visual cue because its significance was unknown to the ATR pilot community at the time. Moreover, in-service ATR incidents and pilot reports have shown that side window icing does not always accompany ice accretions aft of the deice boots, which ATR has stated only occurs in freezing drizzle and/or freezing rain.

The Safety Board acknowledges the efforts of atmospheric research in the meteorological community and hopes that its important findings will eventually provide the aviation industry with a better understanding of the freezing drizzle/rain phenomenon. The Safety Board concludes that the continued development of atmospheric measuring and monitoring equipment, such as atmospheric profilers, use of the WSR-88D [weather surveillance radar] and terminal Doppler weather radars, multispectral satellite data, aircraft-transmitted atmospheric reports, and sophisticated mesoscale models, and the development of computer algorithms, such as those contained in the

FAA's Advanced Weather Products Generator program to provide comprehensive aviation weather warnings, could permit forecasters to refine the data sufficiently to produce more accurate icing forecasts and real-time warnings. Therefore, the Safety Board believes that the FAA should continue to sponsor the development of methods to produce weather forecasts that define very specific locations of potentially hazardous atmospheric icing conditions (including freezing drizzle and freezing rain) and to produce short-range forecasts ("nowcasts") that identify icing conditions for a specific geographic area with a valid time of 2 hours or less.

Although the Safety Board has found no evidence that the ATR 42 and 72 were not properly certificated for flight into icing conditions, the investigation has raised a number of concerns relating to the process for certifying an airplane for flight into icing conditions. Among these concerns are the acceptance by regulatory authorities of a limited number of icing test data points, most of which are not near the boundaries of the envelope; the limited range of conditions (LWC and MVD [median volumetric diameter] size) provided by the Appendix C icing certification envelope; the lack of standardized methods for processing LWC and MVD data; the implied authorization of flight into conditions beyond the envelope; and the certification of stall protection systems that are intended to prevent exposure to undesirable (even dangerous) characteristics of the airplane without a requirement for the manufacturer to advise the FAA, operators, and pilots of such characteristics.

This investigation has revealed that the ATR 42 and 72 were not required to be tested throughout a significant portion of the icing conditions that are specified in the Appendix C icing envelope. The limited number of test points accepted by the FAA as sufficiently comprehensive were well within the boundaries of the envelope and did not include the warmer, near freezing conditions at the upper boundary of the Appendix C envelope in which run-back icing and asymmetric sliding/shedding are likely to occur. Thus, by allowing limited data well within the envelope to suffice for certification purposes, the FAA effectively precluded any chance of identifying the phenomena that led to flight 4184's ice ridge buildup, uncommanded aileron deflection and loss of control.

The Safety Board's concern about the adequacy of Appendix C criteria was heightened by the results of one December 1994 ATR icing tanker test in which ice accumulated behind the active portion of the ATR 72's deice boots during exposure to water droplet sizes of only 57 microns MVD, which is only slightly outside the Appendix C envelope. Further, data developed by NACA, the NASA predecessor, indicated in the 1950s that MVDs of 70 microns or more could be encountered in layer clouds. Flight in layer clouds is not an unusual event in this country, but flight into layer clouds can result in encounters with icing conditions beyond those set forth in 14 CFR Part 25, Appendix C. Several ATR 42 icing incidents with ice aft of the boots occurred in layer clouds, which supports the conclusion that icing encounters in high altitude layer clouds can exceed the capabilities of aircraft certified to the Appendix C envelope.

Thus, because the Appendix C envelope is limited and does not include larger water drop conditions, such as freezing drizzle or freezing rain (conditions that can be routinely encountered in winter operations throughout much of the northern United States, and were most likely encountered by flight 4184), the Safety Board concludes that the current process by which aircraft are certified using the Appendix C icing envelope is inadequate and does not require manufacturers to sufficiently demonstrate the airplane's capabilities under a sufficiently realistic range of icing conditions.

In addition, the lack of standardized methods for processing icing data to determine MVDs raises concern that certification icing tests may be conducted at actual MVDs below the calculated values. For example, during the series of icing tanker tests at Edwards Air Force Base, it was determined that two generally accepted methods of calculating MVD and LWC provided significantly different results. Therefore, it is possible that airplanes certificated in accordance with Appendix C criteria may not actually have been tested in the icing conditions described in the certification documentation. Thus, the Safety Board believes that the FAA should revise the icing certification requirements and advisory material to specify the numerical methods to be used in determining MVD and LWC during certification tests.

A significant Safety Board finding in this investigation is that no airplane should be authorized or certified for flight into icing conditions more

severe than those to which the airplane was subjected in certification testing, unless the manufacturer can otherwise demonstrate the safety of flight in such conditions. Although no aircraft are certified for flight into freezing drizzle or freezing rain, the ATR 72 flight manual did not specify the operational limits and capabilities of the airplane in conditions such as freezing drizzle and freezing rain.

Currently, FAA ground deice and anti-ice programs permit operators to dispatch aircraft into freezing drizzle and light freezing rain[2] provided they use Type II anti-ice fluid and respect the specified holdover timetables. Specifically, Flight Standards Information Bulletin (FSIB) for Air Transport (FSAT), 95-29, dated October 25, 1995, states that Type II deicing fluid will be used when "operating during light freezing rain and freezing drizzle weather conditions" and that the "use of special procedures (i.e. visual inspections, remote deice capability) is required." The Safety Board recognizes that the FAA's intent of this FSAT is to provide operators with the means to dispatch airplanes that will quickly depart and climb through the freezing drizzle or light freezing rain conditions and that the FAA's permission of limited operations in freezing drizzle and light freezing rain is apparently based on the assumption that the airplane will depart within the prescribed "holdover" time of the anti-ice fluid, and transit through the freezing drizzle/light freezing rain conditions with minimal exposure. However, FSAT 95-29 does not specifically state that continued flight in such conditions is prohibited. The Safety Board is concerned that in some situations it may be necessary to operate in such conditions for an extended period of time. One such situation is the failure of an engine shortly after takeoff, a situation that could require maneuvering for an indeterminate period of time while returning to the departure airport where freezing drizzle or light freezing rain conditions are known to exist.

Further, although it is known by many in the aviation community that flight into freezing drizzle or freezing rain is not safe, the Safety Board is unaware of an explicit provision in the Federal Aviation Regulations that

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[2]The NCAR definition for light freezing rain is: "measured intensity up to 0.10 in/hr (2.5 mm or 25 gr/dm^2/hr); Maximum 0.01 inch in 6 minutes from scattered drops that, regardless of duration, do not completely wet an exposed surface up to a condition where individual drops are easily seen."

prohibits flight into freezing drizzle and freezing rain. Additionally, as was noted in the Safety Board's 1981 study on aircraft icing, airplanes certificated for flight into known icing are authorized to fly into weather conditions that produce "severe" icing under 14 CFR Parts 91, 135 and 121. However, by definition, severe icing conditions result in a rate of ice accumulation that exceeds the capabilities of the airplane deice/anti-icing system or that require immediate diversion from the planned route of flight.

The Safety Board is concerned that these unclear and inconsistent messages to pilots about the operation of aircraft that are certified for flight in icing conditions may create the misconception that flight in freezing drizzle and/or freezing rain is acceptable when it is not. Such confusing and apparently contradictory information could have contributed to the belief by Simmons Airlines/AMR Eagle management that it was permissible for ATR 42 and 72 airplanes to be dispatched and flown into conditions of freezing drizzle and light freezing rain when it disseminated a memorandum to its pilots in 1991 setting forth the conditions for such flights.

The Safety Board concludes that no airplane should be authorized or certified for flight into icing conditions more severe than those to which the airplane was subjected in certification testing unless the manufacturer can otherwise demonstrate the safety of flight in such conditions. Thus, the Safety Board believes that the FAA should revise its certification regulations to ensure that airplanes are properly tested for all conditions in which they are authorized to operate, or are otherwise shown to be capable of safe flight into such conditions. If safe operation cannot be demonstrated by the manufacturer, operational limitations should be imposed to prohibit flight in such conditions, and flightcrews should be provided with the means to positively determine when they are in icing conditions that exceed the limits for aircraft certification.

The Safety Board understands that as a result of this accident, the FAA is currently planning a review of its icing certification and operational regulations, including the icing severity definitions issue. The Safety Board supports and encourages this action but believes that the FAA should revise 14 CFR Parts 91.527 and 135.227 in a timely manner to ensure that the regulations are compatible with the published definition of severe icing, and

to eliminate the implied authorization of flight into severe icing conditions for aircraft certified for flight in such conditions.

The Safety Board recognizes that the risk of another ATR 42 or 72 accident resulting from an uncommanded aileron excursion in freezing drizzle/freezing rain has been reduced by the addition of extended deice boots, improved operational procedures, extensive crew training, and heightened awareness by pilots. Because wind tunnel and in-flight tanker tests have been performed for only a limited range of icing and flight conditions, the Safety Board remains concerned whether, even with the improvements, the airplane can be controlled under all naturally occurring combinations of conditions of liquid drop size and content, temperature, airplane configuration, load factors, speeds, and time of exposure. Moreover, the Safety Board found that ATR's post-Roselawn brochure entitled, "ATR Icing Conditions Procedures," still does not adequately address or clearly represent the exact nature of the ATR ice-induced aileron hinge moment reversal.

The Safety Board notes that Special Condition B6, developed by the DGAC in the 1980's and initially applied during the ATR 72 certification, includes a "zero G" flight test maneuver (pushover) designed to identify ice-induced elevator hinge moment reversals. The Safety Board understands that at least some manufacturers in the world aviation community (including the United States) are concerned that Special Condition B6 is too demanding, particularly the tailplane icing pushover test. However, the Safety Board concludes that the addition of a test procedure to determine the susceptibility to aileron hinge moment reversals in both the clean and iced-wing conditions could help to prevent accidents such as that involving flight 4184. Thus, the Safety Board believes that the FAA should develop a test procedure similar to the tailplane icing pushover test to determine the susceptibility of airplanes to aileron hinge moment reversals in the clean and iced-wing conditions.

As part of the investigation, the Safety Board reviewed historical accident and incident data of similar turbopropeller aircraft. The data did not show other airplane models to have a similar incident/accident history involving uncommanded aileron excursions in the presence of freezing drizzle/freezing rain. One possible reason for this is that other model aircraft use hydraulically powered ailerons, smaller mechanical ailerons with larger

hydraulically powered spoilers, or different balance/hinge moment control devices to provide adequate roll control with less propensity for aileron hinge moment reversals. The Safety Board understands that ATR is considering design changes to the lateral control system for current and future ATR airplanes that are expected to reduce the susceptibility to flow separation-induced aileron hinge moment reversals and/or uncommanded aileron deflections. The Safety Board concludes that such design changes, if effective, would reduce the need to rely on the changes to flight operations and pilot training that have already been mandated to ensure the safety of flight. Thus, the Safety Board believes that the FAA should encourage ATR to test lateral control system design changes and, if they correct the aileron hinge moment reversal/uncommanded aileron deflection problem, require these design changes on all existing and new ATR airplanes.

In a related area, the Safety Board is concerned that the FAA and other airworthiness authorities still permit airplane manufacturers to use stall protection systems (SPS) to prevent flightcrews from experiencing known undesirable flight characteristics unique to their particular aircraft design without requiring the manufacturers to reveal these characteristics to the airworthiness authorities, operators, and pilots. According to ATR, its use of an SPS to prevent, among other things, aileron hinge moment reversals in the clean and iced configurations was not explained to the airworthiness authorities or the operators because ATR was not required to do so. The Safety Board concludes that the failure of the DGAC and the FAA to require that they be provided with documentation of known undesirable post-SPS flight characteristics contributed to their failure to identify and correct, or otherwise properly address, the abnormal aileron behavior early in the history of the ATR icing incidents. Therefore, the Safety Board believes that the FAA should require aircraft manufacturers to provide, as part of the certification criteria, information to the FAA and operators about any known undesirable flight characteristics beyond the SPS and related shaker/pusher flight regime.

Evidence from the investigation revealed that the FAA's Aircraft Evaluation Group (AEG) does not maintain a data base of incident/accident information. Moreover, a communications deficiency resulted in the failure of the AEG to receive pertinent documentation regarding ATR icing incidents that could have been used to monitor the continued airworthiness of the

airplane. This is not the first time that the Safety Board has identified problems with the timeliness and effectiveness of the FAA's continuing airworthiness oversight of foreign-built aircraft. The Safety Board noted in its 1987 report on the crash of a CASA C-212-CC that the FAA's monitoring of airworthiness issues relating to that aircraft was inadequate. Specifically, that investigation revealed that the FAA delayed for more than 3 years taking actions to correct known issues of noncompliance with 14 CFR Part 25, and that there "was an apparent lack of standardization and coordination" among various offices within the FAA.[3]

Accordingly, the Safety Board concludes that the lack of defined lines of communication and adequate means to retrieve pertinent airworthiness information prevented the AEG from effectively monitoring the continuing airworthiness of aircraft. Therefore, the Safety Board believes that the FAA should develop an organizational structure and communications system that will enable the AEG to obtain and record all domestic and foreign aircraft and parts/systems manufacturers' reports and analyses concerning incidents and accidents involving aircraft types operated in the United States, and ensure that the information is collected in a timely manner for the effective AEG monitoring of the continued airworthiness of aircraft.

The investigation has revealed the FAA's limited involvement during the initial certification of the ATR 42 and 72. For example, there were several meetings in which only one person from the FAA reviewed vast amounts of certification documentation and had to resolve problems from many technical disciplines. Further, because FAA personnel were either unavailable, or budget constraints restricted travel, issues involving noncompliance or other concerns were resolved through "issue papers." An issue paper, of which there were more than 90 for the ATR 42 and 17 for the ATR 72, describes the FAA's position on a certification issue and the method(s) necessary to achieve compliance. For the ATR, the FAA delegated the compliance oversight for the issue papers to the DGAC.

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[3]NTSB Accident Report AAR-88-08, Fischer Bros. Aviation, Inc., dba Northwest Airlink, Flight 2268, Construcciones Aeronauticas, S. A. (CASA) C-212-CC, Detroit Metropolitan Wayne County Airport, Romulus, Michigan, March 4, 1987, p.44.

Included in the certification process is the FAA review of test data, including data acquired from flight tests. According to testimony provided by the FAA's ATR certification team leader, the FAA does not flight test the aircraft; rather, it conducts "evaluation" flights for the purpose of "familiarity with airplane... and [to] determine suitability for use in airline service...." The FAA conducted about 10 hours of evaluation flights on the ATR; however, none of these flights duplicated any tests required for certification, and none were conducted in icing conditions.

The Safety Board concludes that the FAA's limited involvement in the ATR 42 certification does not appear to have resulted in an improperly certificated airplane (ATR 42/72). However, such excessive reliance on a foreign airworthiness authority could result in improper certification of an aircraft. Therefore, the Safety Board believes that the FAA should review and revise, as necessary, the manner in which it monitors a foreign airworthiness authority's compliance with U.S. type certification requirements under the Bilateral Airworthiness Agreement (BAA).

The Safety Board is also concerned about the process by which the FAA ensures the continuing airworthiness of airplanes certificated under the BAA. For example, the FAA did not receive pertinent information about the airworthiness of the ATR 42 and 72 series airplanes, including ATR's analyses of the icing-induced aileron hinge moment reversal incidents in 1991, and those in 1993 and 1994. The FAA could have been more aggressive in requesting data from the DGAC following these incidents. However, the DGAC should have, on its own accord, taken actions to make sure that the FAA was provided with all information about the ATR incidents to ensure FAA involvement in the continuing airworthiness of the airplane.

The Safety Board concludes that the FAA's ability to monitor the continued airworthiness of the ATR airplanes has been hampered by an insufficient flow of critical airworthiness information. The DGAC's apparent belief that such information was not required to be provided under the terms of the BAA raises concerns about the scope and effectiveness of the BAA. Thus, the Safety Board believes that the FAA should establish policies and procedures to ensure that all pertinent information is received, including the manufacturer's analysis of incidents, accidents or other airworthiness issues,

from the exporting country's airworthiness authority so that it can monitor and ensure the continued airworthiness of airplanes certified under the BAA.

In this accident, the flightcrew did not indicate that it was concerned about holding in icing conditions, but the Safety Board notes that there were some potentially distracting events during the hold. The cockpit voice recorder (CVR) recorded about 15 minutes of personal conversation between a flight attendant and the captain from 1528:00 to 1542:38. The CVR also recorded music playing for about 18 minutes, as well as the sounds of the captain's departure from the cockpit for about 5 minutes to use the rest room.

According to 14 CFR Part 121.542 (the "sterile cockpit" rule) and FAA staff testimony at the Safety Board's public hearing on this accident, holding at 10,000 feet or above is not considered to be a "critical" phase of flight. Thus, the presence of the flight attendant in the cockpit and the ensuing conversation were not in violation of AMR Eagle policy or Federal regulations.

Although the presence of the flight attendant and the music could have been a distraction to the flightcrew, both pilots appeared attentive to flight-related duties immediately before, as well as during the roll upset. Thus, the Safety Board concludes that neither the flight attendant's presence in the cockpit nor the flightcrew's conversations with her contributed to the accident. The Safety Board noted, however, that the AMR Eagle ATR 72 flight manual gives the captain the authority to declare "any other phase of a particular flight" a critical phase depending on the circumstances and thus to invoke the sterile cockpit rule. Therefore, the Safety Board concludes that a sterile cockpit environment would have reduced flightcrew distractions and could have heightened the flightcrew's awareness to the potentially hazardous environmental conditions in which the airplane was being operated. However, the sterile cockpit environment would not have increased the flightcrew's understanding of the events that eventually transpired. Nonetheless, the Safety Board believes that the FAA should evaluate the need to require a sterile cockpit environment for all air carriers holding in certain weather conditions, such as icing and convective activity.

In this accident, the Safety Board attempted to determine why the crew of flight 4184 was unable to successfully recover the airplane and prevent the

accident when the flightcrews of the airplanes involved in the prior incidents were able to do so. At the time of the accident, the AMR Eagle pilot training program did not include an "unusual attitude" or "advanced maneuvers" segment (nor was such training required). During simulator training, AMR Eagle pilots were not exposed to aircraft attitudes that were typically beyond those used for normal operations or considered unusual, and they only experienced an abnormal pitch attitude when they practiced emergency descents.

In four separate safety recommendations over the past 27 years, the Safety Board has addressed the issue of unusual attitude training. The FAA's unfavorable responses and failure to require such training have resulted in the Safety Board classifying the FAA's past actions as "Unacceptable" in three of the four cases. In the fourth case, Safety Recommendation A-93-72, the FAA's actions to promulgate rules to bring most 14 CFR Part 135 scheduled passenger operators under 14 CFR 121 training requirements (which include the use of simulators) was classified "Closed—Acceptable Action" on August 29, 1995. However, the Safety Board remains concerned that this does not necessitate a requirement to provide unusual event/attitude training.

Based on the circumstances of this accident, the historical data of similar accidents, and safety recommendations previously issued by the Safety Board, the FAA, in August 1995, in joint cooperation with the aviation industry, issued an FAA Inspector Handbook Bulletin detailing a program that encourages air carriers to implement advanced maneuver/unusual attitude training in their pilot training programs. AMR Eagle implemented an unusual attitude training curriculum into its pilot training syllabus, action that the Safety Board supports. Additionally, the Safety Board is encouraged by the FAA's latest position regarding unusual attitude/events training; however, there remains a concern that the lack of a required program might result in some carriers not providing unusual attitude training, and that their respective training programs might be insufficient to demonstrate the cause for and the recovery from aircraft attitudes that are not considered to be "normal." Therefore, the Safety Board believes that the FAA should amend the Federal Aviation Regulations to require air carriers to provide standardized training that adequately addresses the recovery from unusual events and attitudes, including extreme flight attitudes, in large, transport category airplanes.

Therefore, as a result of its investigation of this accident, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Direct principal operations inspectors (POIs) to ensure that all 14 Code of Federal Regulations (CFR) Part 121 air carriers require their dispatchers to provide all pertinent information, including airman's meteorological information (AIRMETs) and Center Weather Advisories (CWAs), to flightcrews for preflight and in-flight planning purposes. (Class II, Priority Action) (A-96-48)

Require that Hazardous In-flight Weather Advisory Service (HIWAS) broadcasts consistently include all pertinent information contained in weather reports and forecasts, including in-flight weather advisories, airman's meteorological information (AIRMETs), significant meteorological information (SIGMETs), and Center Weather Advisories (CWA's). (Class II, Priority Action) (A-96-49)

Encourage principal operations inspectors (POIs) and operators to reemphasize to pilots that Hazardous In-flight Weather Advisory Service (HIWAS) is a source of timely weather information and should be used whenever they are operating in or near areas of potentially hazardous weather conditions. (Class II, Priority Action) (A-96-50)

Revise the existing aircraft icing intensity reporting criteria (as defined in the Aeronautical Information Manual (AIM) and other Federal Aviation Administration (FAA) literature) by including nomenclature that is related to specific types of aircraft, and that is in logical agreement with existing Federal Aviation Regulations (FARs). (Class II, Priority Action) (A-96-51)

Publish the definition of the phrase "icing in precipitation" in the appropriate aeronautical publications, emphasizing that the condition may exist both near the ground and at altitude. (Class II, Priority Action) (A-96-52)

Continue to sponsor the development of methods to produce weather forecasts that both define specific locations of atmospheric icing conditions (including freezing drizzle and freezing rain) and produce short-range forecasts ("nowcasts") that identify icing conditions for a specific geographic area with a valid time of 2 hours or less. (Class II, Priority Action) (A-96-53)

Revise the icing criteria published in 14 Code of Federal Regulations (CFR), Parts 23 and 25, in light of both recent research into aircraft ice accretion under varying conditions of liquid water content, drop size distribution, and temperature, and recent developments in both the design and use of aircraft. Also, expand the Appendix C icing certification envelope to include freezing drizzle/freezing rain and mixed water/ice crystal conditions, as necessary. (Class II, Priority Action)) (A-96-54) (Supersedes A-81-116 and -118)

Revise the Federal Aviation Regulations (FARs) icing certification requirements and advisory material to specify the numerical methods to be used in determining median volumetric diameter (MVD) and liquid water content (LWC) during certification tests. (Class II, Priority Action) (A-96-55)

Revise the icing certification testing regulation to ensure that airplanes are properly tested for all conditions in which they are authorized to operate, or are otherwise shown to be capable of safe flight into such conditions. If safe operations cannot be demonstrated by the manufacturer, operational limitations should be imposed to prohibit flight in such conditions and flightcrews should be provided with the means to positively determine when they are in icing conditions that exceed the limits for aircraft certification. (Class II, Priority Action) (A-96-56)

Require all aircraft manufacturers to provide, as part of the certification criteria, information to the FAA and operators about any known undesirable characteristics of flight beyond the

protected (stall system and related shaker/pusher) flight regime. (Class II, Priority Action) (A-96-57)

Develop an icing certification test procedure similar to the tailplane icing pushover test to determine the susceptibility of airplanes to aileron hinge moment reversals in the clean and iced-wing conditions. Revise 14 CFR Parts 23 and 25 icing certification requirements to include such a test. (Class II, Priority Action) (A-96-58)

Encourage ATR to test the newly developed lateral control system design changes and upon verification of the improved or corrected hinge moment reversal/uncommanded aileron deflection problem, require these design changes on all new and existing ATR airplanes. (Class-II, Priority Action) (A-96-59)

Revise 14 CFR Parts 91.527 and 135.227 to ensure that the regulations are compatible with the published definition of severe icing, and to eliminate the implied authorization of flight into severe icing conditions for aircraft certified for flight in such conditions. (Class II, Priority Action) (A-96-60)

Require all principal operations inspectors (POIs) of 14 CFR Part 121 and 135 operators to ensure that training programs include information about all icing conditions, including flight into freezing drizzle/freezing rain conditions. (Class II, Priority Action) (A-96-61)

Develop an organizational structure and a communications system that will enable the Aircraft Evaluation Group (AEG) to obtain and record all domestic and foreign aircraft and parts/systems manufacturers' reports and analyses concerning incidents and accidents involving aircraft types operated in the United States, and ensure that the information is collected in a timely manner for effective AEG monitoring of the continued airworthiness of aircraft. (Class II, Priority Action) (A-96-62)

Review and revise, as necessary, the manner in which the FAA monitors a foreign airworthiness authority's compliance with U.S. type certification requirements under the Bilateral Airworthiness Agreement (BAA). (Class II, Priority Action) (A-96-63)

Establish policies and procedures to ensure that all pertinent information is received, including the manufacturer's analysis of incidents, accidents or other airworthiness issues, from the exporting country's airworthiness authority so that the FAA can monitor and ensure the continued airworthiness of airplanes certified under the Bilateral Airworthiness Agreement (BAA). (Class II, Priority Action) (A-96-64)

Evaluate the need to require a sterile cockpit environment for airplanes holding in such weather conditions as icing and convective activity, regardless of altitude. (Class II, Priority Action) (A-96-65)

Amend the Federal Aviation Regulations to require operators to provide standardized training that adequately addresses the recovery from unusual events, including extreme flight attitudes in large, transport category airplanes. (Class II, Priority Action) (A-96-66)

Revise FAA Order 8400.10, Chapter 7, Section 2, paragraph 1423 (Operational Requirements - Flightcrews) to specify that Center Weather Advisories (CWAs) be included and considered in the flightcrew's preflight planning process. (Class II, Priority Action) (A-96-67)

Revise FAA Order 7110.65, "Air Traffic Control," Chapter 2, "General Control," Section 6, "Weather Information," paragraph 2-6-3, "PIREP" Information, to include freezing drizzle and freezing rain. Additionally, these conditions should be clearly defined in the Pilot/Controller Glossary. (Class II, Priority Action) (A-96-68)

Conduct or sponsor research and development of on-board aircraft ice protection and detection systems that will detect and alert flightcrews when the airplane is encountering freezing drizzle and freezing rain and accreting resultant ice. (Class II, Priority Action) (A-96-69)

Also, the Safety Board issued Safety Recommendations A-96-70 to the National Oceanic and Atmospheric Administration and A-96-71 through -73 to AMR Eagle.

Chairman HALL, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations. Vice Chairman FRANCIS did not participate.

By: Jim Hall
Chairman