NOTE: Below are the NTSB Findings contained in Volume 1 of the NTSB Report as revised on September 13,2002. The Board adopted changes to findings 21, 23, 24, 25, 26, 35, and 36 on that date. The revised findings are contained on pages a-1 and a-2 of the report. The full text of the findings begin on page 203 of the report, but do not reflect the September 13, 2002 revisions.

3. CONCLUSIONS

3.1 Findings

1. The flightcrew was properly certified and qualified in accordance with applicable regulations to conduct the flight.
2. The Chicago air route traffic control center (ARTCC) sector controllers were properly certified and trained to perform their duties.
3. The ATR 72 was certificated, equipped, and maintained in accordance with Federal regulations and approved procedures.
4. There was no evidence of an aircraft structural or system failure that would have either been causal or contributing to the accident.
5. Flight 4184 encountered a mixture of rime and clear airframe icing in supercooled cloud and drizzle/rain drops. Some drops were estimated to be greater than 100 microns in diameter, and some were as large as 2,000 microns.
6. The forecasts produced by the National Weather Service (NWS) were substantially correct, and the actions of the forecasters at the National Aviation Weather Advisory Unit (NAWAU) and the meteorologists at the Chicago ARTCC's Center Weather Service Unit (CWSU) were in accordance with NWS guidelines and procedures.
7. Safety would be enhanced if the hazardous in-flight weather advisory service (HIWAS) information were presented more consistently and had 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 (e.g. in clouds and precipitation).
8. The flightcrew's actions would not have been significantly different even if they had received the available AIRMETs.
9. The flightcrew’s actions were consistent with their training and knowledge.
10. PIREPs [pilot reports] of icing conditions, based on the current icing severity definitions, may often be misleading to pilots, especially to pilots in aircraft that may be more vulnerable to the effects of icing than other aircraft.
11. The aviation community's general understanding of the phrase "icing in precipitation," which is used by the NWS and is often contained in inflight weather advisories, does not typically specify types of precipitation. The provision of a definition in aviation publications, such as the Aeronautical Information Manual (AIM) or Part 1 of the Federal Aviation Regulations, would make pilots and

dispatchers more aware of the types of precipitation and icing conditions that are implied by this phrase.

12. Continued development of equipment and computer programs to measure and monitor the atmosphere could permit forecasters to produce real-time warnings that define specific locations of potentially hazardous atmospheric icing conditions (including freezing drizzle and freezing rain) and short range forecasts ("nowcasts") that identify icing conditions for a specific geographic area with a valid time of 2 hours or less.
13. The 14 Code of Federal Regulations (CFR) Part 25, Appendix C, envelope is limited and does not include conditions of freezing drizzle or freezing rain; thus, 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 in all the possible icing conditions that can, and do, occur in nature.
14. 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.
15. If the FAA had acted more positively upon the Safety Board's aircraft icing recommendations issued in 1981, this accident may not have occurred.
16. ATR 42 and 72 ice-induced aileron hinge moment reversals, autopilot disconnects, and rapid, uncommanded rolls could occur if the airplanes are operated in near freezing temperatures and water droplet median volume diameter (MVDs) typical of freezing drizzle.
17. At the initiation of the aileron hinge moment reversal affecting flight 4184, the 60 pounds of force on the control wheel required to maintain a wings-level-attitude were within the standards set forth by the Federal Aviation Regulations. However, rapid, uncommanded rolls and the sudden onset of 60 pounds of control wheel force without any warning to the pilot, or training for such unusual events, would most likely preclude a flightcrew from making a timely recovery.
18. ATR is considering design changes to the lateral control system for current and future ATR airplanes that will reduce the susceptibility to flow separation-induced aileron hinge moment reversals. Such design changes could minimize the reliance on the changes to flight operations and pilot training that have already been mandated.
19. The French Directorate General for Civil Aviation (DGAC) and the Federal Aviation Administration (FAA) failed to require the manufacturer to provide documentation of known undesirable post-SPS [stall protection system] flight characteristics, which 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.
20. The addition of a test procedure, similar to the "zero G" flight test maneuver (pushover) designed to identify ice-induced elevator hinge moment reversals, could determine the susceptibility of an aircraft to aileron hinge moment reversals in both the clean and iced-wing conditions and could help prevent accidents such as the one involving flight 4184.
21. Before the Roselawn accident, previous incidents demonstrated that ice accumulation behind the deice boots, at an [angle of attack] sufficient to cause an airflow separation, would cause the ailerons to become unstable. Therefore, it would have

been prudent for ATR to examine the combinations of icing conditions and airplane configurations that could produce the performance, stability, and control characteristics (including aileron hinge moment shifts) exhibited in the prior incidents, and the possible repercussions of such aileron hinge moment shifts.

22. The 1989 icing simulation package developed by ATR for the training simulators did not provide training for pilots to recognize the onset of an aileron hinge moment reversal or to execute the appropriate recovery techniques.
23. ATR's proposed post-Mosinee AFM/FCOM changes, which were not adopted by the DGAC and the FAA, would not have provided flightcrews with sufficient information to identify or recover from the type of event that occurred at Roselawn.
24. The 1992 ATR All Weather Operations brochure did not adequately communicate the catastrophic potential of ATR operations in freezing rain.
25. Information provided by to operators after the late 1980s and early 1990s about ice-related incidents did not give adequate warnings and guidance to operators about the adverse characteristics of, and techniques to recover from, ice-induced aileron hinge moment reversal events.
26. Prior to the Roselawn accident, the DGAC failed to require ATR to examine the combinations of icing conditions and airplane configurations that could produce the performance, stability, and control characteristics (including aileron hinge moment shifts) exhibited in the prior incidents, and the possible repercussions of such aileron hinge moment shifts; to issue more specific warnings regarding the aileron hinge moment reversal phenomenon; and to provide specific guidance on the recovery from a hinge moment reversal.
27. The FAA's failure, following the 1994 Continental Express incident at Burlington, Massachusetts, to require that additional actions be taken to alert operators and pilots to the specific icing-related problems affecting the ATRs, and to require action by the manufacturer to remedy the airplane's propensity for aileron hinge moment reversals in certain icing conditions, contributed to this accident.
28. The FAA Aircraft Evaluation Group (AEG) did not receive in a timely manner, from all sources, pertinent documentation (such as the ATR analyses) regarding the previous ATR icing incidents/accidents that could have been used to monitor the continued airworthiness of the airplane.
29. The ability of the FAA's AEG to monitor, on a real-time basis, the continued airworthiness of the ATR airplanes was hampered by the inadequately defined lines of communication, the inadequate means for the AEG to retrieve pertinent airworthiness information, and the DGAC's failure to provide the FAA with critical airworthiness information, because of the DGAC's apparent belief that the information was not required to be provided under the terms of the Bilateral Airworthiness Agreement (BAA). These deficiencies also raise concerns about the scope and effectiveness of the BAA.
30. 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, the FAA's excessive reliance on a foreign airworthiness authority may result in tacit approval of the certification of a foreign-manufactured airplane without sufficient oversight and is not in the best interest of safety.

31. The nearby air traffic control facilities were aware that light icing conditions were forecast for the area of the LUCIT intersection. Nonetheless, the release of flight 4184 from Indianapolis was proper because there were viable options for pilots who chose to avoid holding in icing conditions.
32. Under the circumstances on the day of accident, the controllers acted appropriately in the management of traffic flow into O'Hare International Airport (ORD), which necessitated the holding of flight 4184 in the BOONE sector.
33. The air traffic control (ATC) traffic management coordinator failed to report flight 4184 to the air traffic control system command center (ATCSCC) as an arrival delay, and he failed to alert the ATCSCC that flight 4184 had been holding for more than 15 minutes. However, this lack of information did not affect the operation of the flight and did not contribute to the accident.
34. Because there were no PIREPs [pilot reports] provided to the Boone sector controller by other pilots, and because the crew of flight 4184 did not provide a PIREP of icing conditions at the LUCIT intersection, it was reasonable for the controller to conclude 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 warranted precautionary action by the controller.
35. Because the DGAC did not require ATR to provide to the operators of its airplanes, information that specifically alerted flightcrews to the fact that encounters with freezing rain could result in sudden autopilot disconnects, aileron hinge moment reversals, and rapid roll excursions, or guidance on how to cope with these events, the crew of flight 4184 had no reason to expect that the icing conditions they were encountering would cause the sudden onset of an aileron hinge moment reversal, autopilot disconnect, and loss of aileron control.
36. A sterile cockpit environment would probably have reduced flightcrew distractions and could have promoted a more appropriate level of flightcrew awareness for the conditions in which the airplane was being operated.
37. The flightcrew's failure to increase the propeller RPM to 86 percent and activate the Level III ice protection system in response to the 1533:56 caution alert chime was not a factor in the accident.
38. Had ice accumulated on the wing leading edges so as to burden the ice protection system, or if the crew had been able to observe the ridge of ice building behind the deice boots or otherwise been provided a means of determining that an unsafe condition was developing from holding in those icing conditions, it is probable that the crew would have exited the conditions.
39. The captain's departure from the cockpit to use the rest room while the airplane was in the holding pattern was neither prohibited by Federal regulations nor inconsistent with Simmons Airlines/AMR Eagle policies and procedures and did not contribute to the accident.
40. Although the Simmons Airlines/AMR Eagle policy does require flightcrews to provide a PIREP of icing conditions, and it would have been prudent for the crew of flight 4184 to provide such a report, their failure to do so did not contribute to the accident.
41. Although the crew of flight 4184 received an aural traffic alert and collision avoidance system (TCAS) alert shortly before the roll excursion, this alert was not

perceived by the crew as a conflict, and the proximity of the two airplanes to one another did not contribute to the accident.

42. Both pilots saw the ground, realized their close proximity and high descent rate, and made a nose-up elevator input that, combined with the high airspeed (about 115 KIAS over the certified maximum operating airspeed) resulted in excessive wing loading and structural failure of the outboard sections of the wings.
43. Although both crew members of flight 4184 were certified flight instructors, this was probably the first time they had experienced such unexpected and excessive roll and pitch attitudes in the ATR 72. If the operators had been required to conduct unusual attitude training, the knowledge from this training might have assisted the flightcrew in its recovery efforts and might have prompted the captain to provide useful information to the first officer to facilitate a timely recovery of the airplane.