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Aviation Safety: Icing and Winter Weather-Related Recommendations That NTSB Has Issued Since 1996 **(GAO-10-679SP), an E-supplement to (GAO-10-678)**

Read the Full Report: Aviation Safety: Improved Planning Could Help FAA Address Challenges Related to Winter Weather Operations (GAO-10-678)

Background Information

Introduction

Ice formation on aircraft can disrupt the smooth flow of air over the wings and prevent the aircraft from taking off or decrease the pilot's ability to maintain control of the aircraft. Taxi and landing operations can also be risky in winter weather. Despite a variety of technologies designed to prevent ice from forming on planes and to remove ice that has formed, as well as persistent efforts by the Federal Aviation Administration (FAA) and other stakeholders to mitigate icing risks, icing remains a serious concern.

Since 1996, the National Transportation Safety Board (NTSB) has issued 89 recommendations aimed at reducing risks from in-flight structural icing, engine and aircraft component icing, runway condition and contamination, ground icing, and winter weather operations. Eighty-two of the recommendations were addressed to FAA, four were addressed to air carriers, one was addressed to the National Oceanic and Atmospheric Administration (NOAA), and one was addressed to the National Atmospheric and Space Administration (NASA). This e-supplement lists icing and winter weather-related recommendations that NTSB has issued since 1996, including the number, issue date, close data, most-wanted status, and description of each recommendation.

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Background

A safety recommendation originates from NTSB's accident investigation reports, safety studies, or special investigations. NTSB tracks a safety recommendation from the date of issue until it is closed; safety recommendations are closed only by vote of the Safety Board. NTSB assigns a status to each recommendation, descriptions of which are listed below in table 1.

Table 1: Definitions of NTSB's Recommendation Status Categories

Status category	Definition of status category
Closed—exceeds recommended action	Response by recipient indicates action on the safety recommendation has been completed. The action taken surpasses what the Safety Board envisioned.
Closed—acceptable action	Response by the recipient indicates action on the safety recommendation has been completed. The action complies with the safety recommendation.
Closed—acceptable alternate action	Response by the recipient indicates an alternate course of action has been completed that meets the objective of the safety recommendation.
Closed—unacceptable action	Response by recipient expresses disagreement with the need outlined in the recommendation. There is no further evidence to offer, and the Safety Board concludes that further correspondence on, or discussion of, the matter would not change the recipient's position. This status can also be used when the time frame goals outlined in this order have not been met.
Closed—unacceptable action/no response received	No response to the recommendation was ever received.
Closed—reconsidered	Recipient rejects the safety recommendation and supports this rejection with a rationale with which the board concurs. Reasons for the "reconsidered" status would include situations where the recipient is able to convince the board that the proposed action would not be effective or that it might create other problems. This status is also assigned when the recipient of a recommendation was in compliance before the recommendation was issued or when the recipient was incorrectly chosen and cannot perform the recommended action.
Closed—no longer applicable	The recommended action has been overtaken by events. For example, if technology and/or regulatory action have eliminated the reason for the recommendation or if a company has gone out of business.
Closed—superseded	Applied to recommendations held in an open status when a new, more appropriate safety recommendation is issued that includes the necessary elements of the recommendation to be closed.
Closed—acceptable/acceptable alternate/unacceptable action superseded	Applied to recommendations held in an open status when a new, more appropriate safety recommendation is issued that includes the necessary elements of the recommendation to be closed. The board determines the acceptable/acceptable alternate/unacceptable status based on the criteria defined above prior to superseding the recommendation.
Open—acceptable response	Response by recipient indicates a planned action that would comply with the safety recommendation when completed.
Open—acceptable alternate response	Response by recipient indicates an alternate plan or implementation program that would satisfy the objective of the safety recommendation when implemented.
Open—unacceptable	Response by recipient expresses disagreement with the need outlined in the recommendation or attempts to convince the board (unsuccessfully) that an alternative course of action is acceptable. The board believes,

Status category	Definition of status category
response	however, that there is enough supporting evidence to ask the recipient to reconsider its position. This status can also be used when the board believes that action is not being taken in a timely manner.
Open—response received	Response has been received from recipient, but staff evaluation of the response has not been approved by the board members.
Open—await response	When a safety recommendation is issued, the status "open-await response" is automatically assigned.

Source: NTSB.

Of the 82 recommendations addressed to FAA, NTSB has closed 41 (50 percent) as implemented, and has classified another 22 (27 percent) as FAA having made acceptable progress.[1] This combined 77 percent acceptance rate is similar to the rate for all of NTSB's aviation recommendations. Of the 7 recommendations addressed to other stakeholders, NTSB closed 6 as implemented and the remaining recommendation remains open, with an acceptable response provided by the recipient.

To develop this complete listing of and information on NTSB's icing-related recommendations made since 1996, we obtained data from NTSB and summarized it in the tables below. A more detailed discussion of aviation safety in icing and winter weather operating conditions is contained in our report (GAO-10-678). We conducted our review from August 2009 to July 2010 in accordance with generally accepted government auditing standards. We provided a draft of this e-supplement to NTSB officials to obtain their comments and incorporated their comments where appropriate.

Aircraft Icing and Winter Weather-Related NTSB Recommendations Issued Since 1996

American Eagle Flight #4184

On October 31, 1994, American Eagle Flight #4184, an Avions de Transport Regional model 72-212 (ATR 72), crashed in Roselawn, Ind. All 68 passengers and crewmembers were killed. NTSB determined that accident was caused by loss of control, which occurred after a ridge of ice built up beyond deicing equipment. The aircraft was flying in icing conditions beyond its certification criteria. Additionally, NTSB found that FAA's requirements did not adequately account for the hazards of flight in freezing rain.

Table 2: Recommendations Resulting from the Crash of American Eagle Flight #4184

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-96-51 Issued 8/15/1996 Closed 4/28/2010	FAA	Revise the criteria used to report icing conditions so that it relates to specific types of aircraft and is consistent with existing regulations.	Closed—acceptable action
A-96-52 Issued 8/15/1996 Closed 5/31/2005	FAA	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.	Closed—acceptable action

[1]NTSB has closed 8 of these recommendations as "unacceptable response" by FAA; has classified 7 of the open recommendations as "unacceptable response" by FAA; has closed 3 of these recommendations after concurring with FAA's rationales for disagreeing with the recommendations; and is awaiting FAA's response on 1 of these recommendations.

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-96-53 Issued 8/15/1996 Closed 8/20/1997	FAA	Continue to sponsor the development of weather forecast production methods that both define specific locations of icing conditions and identify icing conditions for a specific time frame within a specific area.	Closed—acceptable action
A-96-54 (Most Wanted recommendation)[a] Issued 8/15/1996	FAA	Revise aircraft certification criteria to reflect research on aircraft ice buildup under various atmospheric conditions and changes in aircraft design and use. Also, expand aircraft certification criteria to include a wider range of atmospheric conditions.	Open—unacceptable response Supersedes A-81-116 and A-81-118.
A-96-55 Issued 8/15/1996 Closed 2/16/2000	FAA	Revise icing certification requirements and advisory material to specify methods for icing certification testing.	Closed—acceptable alternate action
A-96-56 **Most Wanted** Issued 8/15/1996	FAA	Revise certification criteria to ensure that aircraft are tested for all conditions in which they are authorized to operate, or are otherwise shown to be capable of safe flight into such conditions. FAA should prohibit operation in conditions beyond the capability of an aircraft and flight crews should be given the means to determine when they are in such conditions.	Open—unacceptable response
A-96-57 Issued 8/15/1996 Closed 2/5/2003	FAA	Require aircraft manufacturers to provide information to FAA and operators about any known undesirable characteristics of flight beyond the protected flight regime.	Closed—unacceptable action
A-96-58 Issued 8/15/1996	FAA	Develop an icing certification test procedure to determine the susceptibility of airplanes to control anomalies with and without ice on the wing. Revise icing certification requirements to include such a test.	Open—acceptable response
A-96-59 Issued 8/15/1996 Closed 2/5/2003	FAA	Encourage ATR (a manufacturer of airplanes) to test the newly developed stabilization system design changes. When design changes show that the stabilization problem has been corrected, require these changes on all new and existing ATR airplanes.	Closed—unacceptable action
A-96-60 Issued 8/15/1996 Closed 11/20/2009	FAA	Ensure that regulations governing small commercial and noncommercial airplanes are compatible with the published definition of severe icing and eliminate the implied authorization of flight into severe icing conditions.[b]	Closed—acceptable alternate action
A-96-61 Issued 8/15/1996 Closed 8/20/1997	FAA	Require FAA inspectors to ensure that training programs for large commercial and small commercial airplane operators include information about all icing conditions, including freezing rain and freezing drizzle.[c]	Closed—acceptable action
A-96-65 Issued 8/15/1996 Closed 8/20/1997	FAA	Evaluate the need to prohibit nonessential activities in the cockpit for airplanes holding in weather conditions such as icing, hail, and thunderstorms.	Closed—acceptable action
A-96-68 Issued 8/15/1996 Closed 8/20/1997	FAA	Revise an FAA order governing pilot reporting of weather information to include freezing drizzle and freezing rain and clearly define these conditions in the pilot/controller glossary.	Closed—acceptable action
A-96-69 Issued 8/15/1996 Closed 1/27/2003	FAA	Conduct or sponsor research and development of systems which would alert flight crews when the airplane is encountering freezing drizzle and freezing rain and accumulating resultant ice.	Closed—acceptable alternate action

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-96-70 Issued 8/15/1996 Closed 3/20/1997	NOAA	Develop methods to produce weather forecasts that define specific locations of atmospheric icing conditions and produce forecasts for a specific time frame and location.	Closed—acceptable action
A-96-71 Issued 8/15/1996 Closed 1/30/2001	American Eagle	Require dispatchers to provide flight crews with weather information pertinent to the route of flight to aid in preflight and in-flight decisions.	Closed—acceptable action
A-96-72 Issued 8/15/1996 Closed 1/30/2001	American Eagle	Encourage captains to forgo unnecessary activity and conversation in the cockpit when an airplane is holding in weather conditions such as icing, hail, or thunderstorms.	Closed—acceptable action
A-96-73 Issued 8/15/1996 Closed 1/30/2001	American Eagle	Audit aircraft flight manuals, flight operations manuals, and other published material to eliminate conflicts in guidance and procedures.	Closed—acceptable action

Source: NTSB.

[a]NTSB's Most Wanted list includes important safety recommendations identified for special attention and intensive follow-up. NTSB established the list in 1990 and annually updates it.

[b]By small commercial airplanes, we mean those airplanes operating under part 135 of title 14. Among other things, part 135 covers commuter operations on airplanes, other than turbojet powered airplanes, with nine passenger seats or less, and a payload capacity of 7,500 pounds or less. Most commuter, air tour, and air taxi operators and medical services (when a patient is on board) fall under the purview of part 135. By noncommercial airplanes, we mean airplanes that are privately operated under part 91 of title 14. These types of operations are often referred to as "general aviation" and include flights for recreation and training. Although noncommercial flights usually involve small aircraft, the definition depends on the nature of the operation not the size of the aircraft.

[c]By large commercial airplanes, we mean those airplanes operating under part 121 of title 14 C.F.R. part 121. Among other things, part 121 applies to air carrier operations involving turbojet airplanes or any airplane with a seating capacity of more than nine passenger seats or a maximum payload capacity of more than 7,500 pounds, as defined under 14 C.F.R. § 119.3. See 14 C.F.R. § 121.1.

Tower Air Inc. Flight #41

On December 20, 1995, Tower Air Flight #41, a Boeing B-747, veered off the side of the runway during an attempted takeoff at John F. Kennedy International Airport. Twenty-four of the 468 people on board sustained minor injuries, one person received serious injuries, and the airplane sustained substantial damage. NTSB found that the probable cause of the accident was the captain's failure to reject takeoff in a timely manner when the airplane lost control on a slippery runway. Inadequate operating procedures by Boeing and Tower Air also contributed to the accident.

Table 3: Recommendations Resulting from the Accident Involving Tower Air Inc. Flight #41

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-96-150 Issued 12/20/1996 Closed 5/13/1998	FAA	Require Boeing to revise its operating procedures to warn flight crews against using the tiller during slippery runway operations and to provide appropriate limitations on tiller use during these operations.	Closed—acceptable action
A-96-151 Issued 12/20/1996 Closed 10/6/1998	FAA	Inform FAA inspectors of the circumstances of this accident. Require the review, and modification as required, of each air carrier's takeoff procedure regarding pilot hand position with respect to the tiller.	Closed—acceptable action

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-96-152 Issued 12/20/1996 Closed 10/6/1998	FAA	Require Boeing to develop criteria for making a rapid and accurate decision to reject a takeoff under slippery runway conditions; then require that B-747 flight, operating, and training manuals be revised accordingly.	Closed—acceptable action
A-96-153 Issued 12/20/1996 Closed 12/26/2001	FAA	Ensure that Boeing 747 air carrier flight crew training simulators accurately simulate the aircraft's slippery runway handling characteristics.	Closed—acceptable action
A-96-154 Issued 12/20/1996 Closed 12/26/2001	FAA	Direct FAA inspectors assigned to Boeing 747 operators to enhance simulator training for slippery runway operations.	Closed—acceptable action
A-96-164 Issued 12/20/1996 Closed 6/14/2002	FAA	Require a rulemaking advisory group to establish runway friction measurements that are useful to pilots and air carriers during slippery runway operations.	Closed—reconsidered

Source: NTSB.

ValuJet Airlines Flight #558

On January 7, 1996, ValuJet Airlines Flight #558 touched down short of the runway at the Nashville International Airport. Of the 93 people on board, 5 received minor injuries. The airplane sustained substantial damage. NTSB found that this accident was caused by flight crew error and that ValuJet's incomplete manuals and guidance contributed to the accident.

Table 4: Recommendations Resulting from the Accident Involving ValuJet Flight #558

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-96-166 Issued 12/20/1996 Closed 12/19/1997	FAA	Require all airlines to review their operations and maintenance manuals and, if necessary, adjust or expand these manuals to reflect the manufacturer's recommended cold weather nosegear servicing procedures.	Closed—acceptable action
A-96-172 Issued 12/20/1996 Closed 7/25/2001	ValuJet	Develop, immediately, a more extensive and accurate winter operations manual, with corresponding adjustments to maintenance procedures, to reflect the manufacturer's cold weather nosegear servicing procedures.	Closed—acceptable action

Source: NTSB.

Comair Airlines Flight #3272

On January 9, 1997, Comair Flight #3272 (an Embraer EMB-120 aircraft) crashed near Monroe, Michigan. All 29 people on board were killed. The airplane was destroyed by impact forces and postcrash fire. NTSB found that the airplane lost control when it accumulated a layer of ice on its lifting surfaces and failed to maintain sufficient airspeed.

Table 5: Recommendations Resulting from the Crash of Comair Airlines Flight #3272

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-97-31 Issued 5/21/1997 Closed 8/20/1999	FAA	Require air carriers to reflect FAA-approved minimum airspeeds, including those for flight in icing conditions, in their EMB-120 operating manuals.	Closed—acceptable action
A-97-32 Issued 5/21/1997 Closed 8/20/1999	FAA	Ensure that the deicing information and procedures in air carrier's EMB-120 operating manuals and training programs are consistent with the revised Embraer EMB-120 airplane flight manual.	Closed—acceptable action
A-97-33 Issued 5/21/1997 Closed 8/20/1999	FAA	Direct FAA inspectors to ensure that EMB-120 operators train flight crews to recognize icing conditions and emphasize the need to adhere to the flight manual's procedure for using deicing equipment.	Closed—acceptable action
A-97-34 Issued 5/21/1997 Closed 7/8/1998	FAA	Require that all EMB-120 aircraft be equipped with automated ice detection and crew alerting systems for structural ice buildup.	Closed—acceptable action
A-98-88 Issued 11/30/1998 Closed 3/9/2000	FAA	Amend the definition of trace ice in FAA documents so that they do not indicate that trace icing is not hazardous.	Closed—acceptable action
A-98-89 Issued 11/30/1998	FAA	Require FAA inspectors to discuss airplane flight manual revisions or manufacturers' operational bulletins with affected air carrier operators. Encourage air carriers to share the information with pilots.	Open—acceptable response
A-98-90 Issued 11/30/1998 Closed 1/3/2002	FAA	Educate manufacturers, operators, and pilots of turboprop airplanes in which ice bridging is not a concern on the dangers of accumulating thin, rough ice; the importance of activating deice boots as soon as the airplane enters icing conditions; and the importance of maintaining minimum airspeeds in icing conditions.[a]	Closed—acceptable action
A-98-91 Issued 11/30/1998 Closed 2/27/2007	FAA	Require manufacturers and operators of turboprop airplanes in which ice bridging is not a concern to review and revise their manuals and training programs to emphasize that deicing equipment as soon as the airplane enters icing conditions.	Closed—unacceptable action/superseded Superseded by A-07-14.
A-98-92 Issued 11/30/1998 Closed 10/16/2008	FAA	Conduct research to identify realistic ice accumulations and determine the effects and dangers of such ice accumulations. The information developed through such research should be incorporated into aircraft certification requirements and pilot training programs.	Closed—acceptable action
A-98-93 Issued 11/30/1998 Closed 3/12/2001	FAA	Work with industry to develop effective ice detection and protection systems that will keep aircraft surfaces free of ice. Then, require installation of such systems on aircraft certified for flight in icing conditions.	Closed—unacceptable action
A-98-94 Issued 11/30/1998 Closed 1/19/2006	FAA	Require jet engine aircraft manufacturers to provide minimum airspeed information, with consideration of various types, amounts, and locations of ice accumulation.	Closed—acceptable action
A-98-95 Issued 11/30/1998 Closed 9/15/2003	FAA	Require jet engine aircraft operators to incorporate the manufacturer's minimum airspeeds in their operating manuals and pilot training programs, with emphasis on maintaining minimum safe airspeeds while operating in icing conditions.	Closed—acceptable alternate action

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-98-96 Issued 11/30/1998	FAA	Require the manufacturers and operators of aircraft certified to operate in icing conditions to install systems that provide a cockpit warning before the onset of a stall when the aircraft is operating in icing conditions.	Open—unacceptable response
A-98-97 Issued 11/30/1998 Closed 1/12/2001	FAA	Require operators of turboprop aircraft to require pilots to disengage the autopilot and fly the aircraft manually when anti-ice systems are activated.	Closed—unacceptable action
A-98-98 Issued 11/30/1998 Closed 7/8/2009	FAA	Require all manufacturers of transport-category airplanes with autopilot to provide a cockpit aural warning to alert pilots when the airplane's pitch or roll angle increases beyond the autopilot's maximum limits.[b]	Closed—unacceptable action
A-98-99 Issued 11/30/1998 Closed 3/9/2000	FAA	Ensure that airplanes are adequately tested for the conditions in which they are certified to operate. This should include identifying ice shapes that form on aircraft surfaces, determining the effects of these ice shapes on flight performance, and incorporating this information into certification requirements.	Closed—unacceptable action
A-98-100 Issued 11/30/1998 Closed 2/27/2007	FAA	When the revised icing certification standards are complete, ensure that all turboprop airplanes that are currently certified to fly in icing conditions meet the requirements of the revised standards.	Closed—unacceptable action/superseded Superseded by A-07-16
A-98-101 Issued 11/30/1998 Closed 5/10/2006	FAA	Review turboprop airplane manufacturers' flight manuals and air carrier operating manuals to ensure that they provide operational procedures for flight in icing conditions.	Closed—acceptable action
A-98-102 Issued 11/30/1998	FAA	Require air carriers to adopt the operating procedures in the manufacturer's flight manual or provide written justification that an alternative procedure is equally safe.	Open—acceptable response
A-98-105 Issued 11/30/1998 Closed 5/6/2003	FAA	Periodically remind pilots of their responsibility to report weather conditions that could affect the safety of other flights.	Closed—acceptable action
A-98-106 Issued 11/30/1998 Closed 3/23/2000	FAA	Require that information provided to arriving and departing aircraft includes information on pilot reports of icing conditions.	Closed—reconsidered
A-98-107 Issued 11/30/1998 Closed 8/19/2004	NASA	Educate manufacturers, operators, and pilots of turboprop airplanes on the hazards of thin, rough ice buildup; the importance of activating deicing boots as soon as the airplane enters icing conditions (for those airplanes in which ice bridging is not a concern); and the importance of maintaining minimum airspeeds in icing conditions.	Closed—acceptable action
A-98-108 Issued 11/30/1998	NASA	Identify realistic ice accumulation configurations and determine their effect on aircraft performance. Incorporate this information into aircraft certification requirements and pilot training programs.	Open—acceptable response

Source: NTSB.

[a]A turboprop airplane is an airplane with a turboprop engine, which is a hybrid engine that provides jet thrust and also drives a propeller.

[b]In general, a transport category airplane is an airplane with maximum takeoff weight (MTOW) greater than 12,500 pounds or with 10 or more passenger seats, except for propeller-driven, multi-engine airplanes, in which case the transport category airplanes are those with MTOW greater than 19,000 pounds or with 20 or more passenger seats. FAA certifies the design of transport category airplanes under 14 CFR part 25.

Reno Air Flight #153

On March 14, 1997, Reno Air Flight #153, a McDonnell Douglas MD-87 airplane experienced a partial power loss in both engines during takeoff from Detroit, Michigan. The airplane returned to Detroit and landed without further incident. NTSB found that ice was present on the wings at takeoff, despite tactile wing inspections by the flight crew. The wing ice was ingested by the engines, blocking engine airflow.

Table 6: Recommendations Resulting from the Incident Involving Reno Air Flight #153

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-97-121 Issued: 12/22/1997 Closed: 7/20/1998	FAA	Alert FAA inspectors, and through them all affected air carrier flight crews, of the details of the Reno Air incident and the need to reduce power when engine airflow is blocked to minimize engine damage and ensure safe landing.	Closed—acceptable action
A-97-122 Issued 12/22/1997 Closed 7/25/2001	FAA	Require MD-80 and MD-90 airplanes to have more reliable equipment for preventing or detecting wing ice before every flight in lieu of tactile inspection.	Closed—acceptable action

Source: NTSB.

Garuda Indonesia Airlines Flight #421

On January 16, 2002, Garuda Indonesia Airlines Flight #421 lost power in both engines when approaching the city of Yogyakrta on Java Island in Indonesia. After several unsuccessful attempts to restart the engines, the flight crew made an emergency water landing. Of the 60 people on board, 1 was killed, 12 received serious injuries, and 10 received minor injuries. The airplane was substantially damaged. Based on weather data and the cockpit recording, NTSB suspects that rain and hail ingestion may have caused the engine failure.

Table 7: Recommendations Resulting from the Accident Involving Garuda Indonesia Airlines Flight #4184

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-05-019 Issued 8/31/2005	FAA	Complete the review of the current turbofan engine certification standards for rain and hail intake and revise these standards if necessary.[a]	Open—acceptable response

Source: NTSB.

[a]A turbofan engine is a type of jet engine in which the core engine is surrounded by a fan in the front and an additional turbine in the rear.

Spirit Airlines Flight #970

On June 4, 2002, Spirit Airlines Flight #970 experienced a gradual power loss in both engines and a stall warning while in flight near Wichita, Kansas. Pilots disengaged autopilot, turned on engine ignition, activated the engine anti-ice system, and initiated a descent. The flight landed safely and there were no injuries.

Table 8: Recommendations Resulting from the Incident Involving Spirit Airlines Flight #970

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-04-34 Issued 4/29/2004 Closed 10/21/2004	FAA	Have FAA inspectors alert affected air carrier flight crews about the Spirit Airlines Flight #970 encounter with icing conditions. Emphasize the need to be alert to the signs of high-altitude icing conditions, the effect of these conditions on airplane and engine performance, and the need for appropriate use of engine icing protection equipment.	Closed—acceptable action
A-04-35 Issued 4/29/2004	FAA	Pursue research to develop an ice detector that would alert pilots to icing of certain aircraft equipment and require that the ice detector be installed on new production turbojet airplanes and retrofitted to existing turbojet airplanes.	Open—acceptable response

Source: NTSB.

Icing Accidents and Incidents Involving Cessna 208 Series Airplanes

From 1987 to 2003, there were 26 icing-related accidents and incidents involving Cessna 208 series airplanes, resulting in at least 36 fatalities. NTSB's findings raised concerns about possible deficiencies the certification standards applicable to Cessna 208 series airplanes, the cold weather operational procedures used by Cessna 208 pilots, or the design of the airplane and its deicing and anti-icing systems.

Table 9: Recommendations Made to Address Accidents and Incidents Involving Cessna 208 Series Airplanes

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-04-64 Issued 12/15/2004 Closed 1/29/2009	FAA	Require all pilots and operators of those Cessna 208 series airplanes equipped for flight in icing conditions to undergo annual training for ground deicing and flight into icing conditions.	Closed—acceptable action
A-04-65 Issued 12/15/2004 Closed 1/7/2009	FAA	Require the Cessna Aircraft Company to develop effective procedures and guidance to minimize the chance of ground and in-flight icing accidents and incidents for Cessna 208 series aircraft. FAA should then verify that these procedures and guidance materials are incorporated into Cessna 208 operator manuals and training programs.	Closed—acceptable action
A-04-66 Issued 12/15/2004 Closed 1/7/2009	FAA	Require pilots and operators of Cessna 208 series airplanes to examine the wing and other surfaces to ensure that they are free of ice, snow, or both before any flight from a location where temperatures are conducive to frost and ground icing.	Closed—acceptable action

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-04-67 Issued 12/15/2004	FAA	Evaluate FAA's current surveillance procedures for operators of Cessna 208 series airplanes equipped for flight into icing conditions to determine whether the surveillance effectively ensures that these operators are in compliance with federal deicing requirements. If necessary, modify the surveillance procedures to ensure such compliance.	Open—acceptable response

Source: NTSB.

Engine Power Loss in Raytheon Beechjet 400 Series Airplanes

From 2004 to 2006, three incidents occurred in the United States in which Raytheon Beechjet airplanes lost power in both Pratt & Whitney JT15D engines. A similar incident occurred in Brazil in 2000. NTSB is concerned about this recent onset of dual-engine failures and the sustained loss of power that occurred in each event after several attempts to restart the engine. A study by Pratt & Whitey Canada (the engine manufacturer) found that with the engine anti-ice turned off, it was possible for ice crystals to build up in the engines and that the buildup could lead to airflow disruption, engine failure, or both.

Table 10: Recommendations Resulting from Power Loss in Raytheon Beechjet 400 Series Airplanes

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-06-56 Issued 8/25/2006 Closed 5/18/2007	FAA	Immediately require Beechjet 400 pilots to activate engine ice protection systems in weather conditions conducive to engine icing or before a power reduction in certain weather conditions.	Closed—exceeds recommended action
A-06-57 Issued 8/25/2006 Closed 5/18/2007	FAA	Require Raytheon to incorporate information on ice protection system operation and ice formation into the Beechjet 400 airplane flight manual.	Closed—exceeds recommended action
A-06-58 Issued 8/25/2006 Closed 2/29/2008	FAA	Incorporate information on ice protection system operation and ice formation into the flight manuals of aircraft with JT15D engines.	Closed—acceptable action
A-06-59 Issued 8/25/2006	FAA	Pursue research to develop an ice detector that would alert pilots of engine icing. Require that such an ice detector be installed on new turbojet engines and retrofitted to existing turbojet engines.	Open—acceptable alternate response

Source: NTSB.

Glo-Air Flight #73

On November 28, 2004, Glo-Air Flight #73 crashed during an attempted takeoff in snowing conditions. Before the accident flight, the airplane was parked for 45 minutes while wet snow fell, and the airplane was not deiced before takeoff. Three people on board were killed, and three received serious injuries. The airplane was destroyed by impact forces and postcrash fire. NTSB found that the

accident was caused by the flight crew's failure to ensure that the airplane's wings were free of ice and snow prior to takeoff.

Table 11: Recommendations Resulting from the Crash of Glo-Air Flight #73

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-06-042 Issued 8/4/2006	FAA	Develop training aids to accurately depict small amounts of wing ice buildup and require all commercial airplane operators to use them in their initial and recurrent training.	Open—unacceptable response

Source: NTSB.

Martinair Circuit City Accident in Pueblo, Colorado

On February 16, 2005, a Cessna Citation 560, operated by Martinair for Circuit City Stores, crashed near Pueblo, Colorado. Eight people were killed, and the airplane was destroyed by impact forces and postcrash fire. NTSB found that this accident was caused by the flight crew's failure to monitor and maintain airspeed and comply with deicing system activation procedures. NTSB also found that FAA's failure to establish adequate icing certification requirements contributed to the accident.

Table 12: Recommendations Resulting from the Martinair Circuit City Crash

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-07-12 Issued 2/27/2007	FAA	Require that operational training in the Cessna 560 airplane emphasize that the airplane flight manual requires pilots to increase the airspeed and operate the deice boots in certain phases of flight when ice is present on the wings.	Open—acceptable response
A-07-13 Issued 2/27/2007	FAA	Require that all pilot training programs teach and emphasize monitoring skills and workload management and include opportunities to practice and demonstrate proficiencies in these areas.	Open—unacceptable response
A-07-14 **Most Wanted** Issued 2/27/2007	FAA	Require manufacturers and operators of airplanes with deice boots to revise their manuals and training programs to emphasize that deice boots should be activated as soon as the airplane enters icing conditions.	Open—acceptable response Supersedes A-98-91
A-07-15 Issued 2/27/2007	FAA	Require all airplanes with deice boots that are certified to fly in icing conditions to have a mode that would automatically continue to cycle the deice boots once the system has been activated.	Open—acceptable response
A-07-16 **Most Wanted** Issued 2/27/2007	FAA	When the revised icing certification standards (recommended in Safety Recommendations A-96-54 and A-98-92) are complete, ensure that airplanes with deice boots fulfill the requirements of the revised icing certification standards.	Open—unacceptable response Supersedes A-98-100

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-07-17 Issued 2/27/2007	FAA	Require modification of the Cessna 506 airplane's stall warning system so that it accounts for the size, type, and distribution of ice buildup.	Open—acceptable response

Source: NTSB.

Midwest Airlines Flight #490

On May 12, 2005, Midwest Airlines Flight #490 experienced unreliable airspeed indications during flight in heavy rain and icing conditions. The airplane experienced significant gains and losses in altitude before the crew was able to regain control and divert to Kirksville, Missouri. Results of NTSB's investigation indicate that this incident was caused by the flight crew's failure to activate the air data sensor heating system and that cockpit warnings were ineffective at alerting the crew to the air data sensor problem.

Table 13: Recommendations Resulting from the Crash of Midwest Airlines Flight #490

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-07-55 Issued 9/13/2007	FAA	Require the air data sensor heating systems on new transport category aircraft to automatically activate after engine start.	Open—acceptable response
A-07-56 Issued 9/13/2007	FAA	Require modification of existing transport category aircraft that currently require manual activation of the air data sensor heating system so that this system is activated automatically. For airplanes that cannot be modified, require an upgraded cockpit warning when the heating system fails to activate.	Open—acceptable response

Source: NTSB.

Southwest Airlines Flight #1248

On December 8, 2005, Southwest Airlines Flight #1248 landed on a snow-covered runway in Chicago, Illinois. The airplane departed the end of the runway and rolled through airport fences and then into traffic on an off-airport street. The airplane came to a stop after impacting two cars, which resulted in the death of a child passenger in one of the vehicles. NTSB found that this accident was caused by the pilots' failure to use reverse thrust in a timely manner to safely slow or stop the airplane after landing.

Table 14: Recommendations Resulting from the Accident Involving Southwest Airlines Flight #1248

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-06-16 Issued 1/27/2006 Closed 10/4/2007	FAA	Immediately prohibit large commercial operators from factoring use of the reverse thrust deceleration system into landing performance calculations.	Closed—unacceptable action/ superseded Superseded by A-07-57
A-07-57 Issued 10/4/2007	FAA	Immediately require large commercial, small commercial, and some noncommercial operators to assess the distance needed to land before every landing, incorporating a 15 percent safety margin.	Open—unacceptable response Supersedes A-06-16
A-07-59 Issued 10/16/2007	FAA	Require large commercial and small commercial operators to provide clear guidance and training to pilots and dispatchers on company policy regarding surface condition and braking performance reporting, as well as landing distance calculations.	Open—acceptable response
A-07-61 Issued 10/16/2007	FAA	Require large commercial, small commercial, and some noncommercial operators to make landing distance assessments before every landing based on standardized methodology, using the most conservative interpretation available, and including a 15 percent safety margin.	Open—acceptable response
A-07-62 Issued 10/16/2007	FAA	Develop and issue formal guidance regarding runway surface condition reports.	Open—acceptable response
A-07-63 Issued 10/16/2007	FAA	Establish a minimum standard for large commercial and small commercial operators to use in comparing an airplane's braking ability to runway condition reports.	Open—acceptable response
A-07-64 Issued 10/16/2007	FAA	Show whether it is feasible to outfit transport-category airplanes with the means to track and communicate airplane braking ability needed to stop the airplane during landing. If feasible, require transport category airplane operators to use such equipment and procedures.	Open—acceptable response

Source: NTSB.

International Cessna 208 Series Aircraft Accidents

NTSB participated in two foreign investigations of fatal accidents involving Cessna 208 series airplanes in icing conditions. These accidents occurred in Winnipeg, Manitoba, Canada and Moscow, Russia in 2005. NTSB found the following problems with Cessna 208 series airplanes: in both accidents, the minimum operating airspeed in icing conditions did not provide an adequate safety margin. Specifically, in the Winnipeg accident, the pilot had very little time to escape icing conditions; and in the Moscow accident, the pilots did not have adequate cues of airplane performance degradation.

Table 15: Recommendations Resulting from Two International General Aviation Accidents

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-06-1 Issued 1/17/2006 Closed 11/15/2006	FAA	Require all operators of Cessna 208 series airplanes to maintain sufficient airspeed during flight in icing conditions.	Closed— acceptable action
A-06-2 Issued 1/17/2006 Closed 11/15/2006	FAA	Prohibit operators of Cessna 208 series airplanes from flying into icing conditions more severe than light icing.	Closed— acceptable action
A-06-3 Issued 1/17/2006 Closed 11/15/2006	FAA	Require all operators of Cessna 208 series airplanes to disengage the autopilot and fly the airplane manually when operating in icing conditions.	Closed— acceptable action

Source: NTSB.

American Eagle Flight #3008

On January 2, 2006, American Eagle Flight #3008, a Saab-Scania AB SF340B+, encountered icing conditions in-flight and lost control. After losing altitude, pilots regained control and continued without further incident. NTSB found that the aircraft's performance degradation occurred at airspeeds above the current minimum safe speeds. NTSB also found that the aircraft's stall warning would have activated if the "ice speed" modification to the stall warning system had been used. Furthermore, the airplane did not have an ice detection system, which would have alerted crew to ice buildup, and use of autopilot likely reduced the crew's perception of aircraft performance.

Table 16: Recommendations Resulting from the Incident Involving American Eagle Flight #3008

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-06-48 Issued 7/10/2006 Closed 2/4/2009	FAA	Require operators of Saab SF340 airplanes to instruct pilots to maintain sufficient airspeed in icing conditions and to exit icing conditions as soon as degraded performance prevents the airplane from maintaining sufficient airspeed.	Closed—acceptable action
A-06-49 Issued 7/10/2006	FAA	Require modified stall protection systems in Saab SF340 series airplanes certified to fly in known icing conditions.	Open—acceptable response
A-06-50 Issued 7/10/2006 Closed 2/4/2009	FAA	Require the installation of an icing detection system on Saab SF340 series airplanes.	Closed—acceptable alternate action
A-06-51 Issued 7/10/2006	FAA	Require operators of turboprop airplanes to instruct pilots to disengage the autopilot and fly manually in icing conditions, except during periods of high workload.	Open—await response

Source: NTSB.

Delta Connection Flight #6448

On February 18, 2007, Delta Connection Flight #6448 overran the end of the runway while landing in snowy conditions. The aircraft struck an airport perimeter fence and its nose gear collapsed. Three passengers received minor injuries. NTSB determined that the accident was caused by flight crew errors, including failure to recognize that a safe landing could not be accomplished.

Table 17: Recommendations Resulting from the Crash of Delta Connection Flight #6448

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-08-17 Issued 4/15/2008	FAA	Require large commercial, small commercial, and certain noncommercial operators to include practice for landing on contaminated runways into simulator training for turbojet airplanes.	Open—acceptable alternate response

Source: NTSB.

Pinnacle Airlines Flight #4712

On April 12, 2007, Pinnacle Airlines Flight #4712 ran off the runway after landing in snowy conditions at Traverse City, Michigan. There were no injuries, but the aircraft was substantially damaged. NTSB found that this accident was caused by the pilots' decision to land without performing a landing distance assessment. Airport personnel's use of ambiguous language in providing runway braking information also contributed to the accident.

Table 18: Recommendations Resulting from the Accident Involving Pinnacle Airlines Flight #4712

Recommendation number, date issued, and date closed (where applicable)	Recipient	Summary of recommendation	Status
A-08-41 Issued 6/17/2008	FAA	Address the need for initial training on conducting landing distance assessments before landing on contaminated runways.	Open—acceptable response
A-08-42 Issued 6/17/2008 Closed 6/22/2009	FAA	Alert airports of the circumstances of this accident, urging all airports to ensure that radio communications criteria are met.	Open—acceptable response
A-08-43 Issued 6/17/2008	FAA	Require airport operators to include criteria for runway contamination and runway friction assessments in their airport's snow and ice control plan. Fulfillment of these criteria should trigger closure of the affected runway.	Open—acceptable response

Source: NTSB.

A more detailed discussion of our scope and methodology is contained in our report *Aviation Safety: Improved Planning Could Help FAA Address Challenges Related to Winter Weather Operations*, GAO-10-678. We conducted our work from August 2009 to July 2010 in accordance with generally accepted government auditing standards.

Contact Information

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