May 24, 2022 AIR-22-07

Provide Graphical Forecast of Potential Supercooled Large Droplet Icing Conditions in Alaska

Introduction

The National Transportation Safety Board (NTSB) is providing the following information to urge the Federal Aviation Administration (FAA) and the National Weather Service (NWS) to take action on the safety recommendations in this report. We identified a safety issue during our ongoing investigation of an accident involving a Cessna 208B airplane that was substantially damaged after an in-flight upset resulting from an inadvertent encounter with supercooled large droplet (SLD) icing conditions after takeoff from Fairbanks, Alaska. The NTSB is issuing one safety recommendation to the FAA and one safety recommendation to the NWS; the US aviation weather service program includes the joint efforts of these civilian agencies.

Background and Analysis

On August 16, 2021, a Cessna 208B, N97HA, was substantially damaged when it was involved in an accident near Fairbanks, Alaska. The pilot and eight passengers were not injured. The airplane was operated by Wright Air Service as flight 440, and the flight was operating under Title 14 *Code of Federal Regulations* (*CFR*) Part 135 as a scheduled commuter flight.[1]

The airplane departed from Fairbanks International Airport (FAI), Fairbanks, Alaska, for Huslia Airport, Huslia, Alaska, which is located about 220 miles west-northwest of FAI. According to the pilot, the airplane climbed to the assigned altitude of 10,000 ft mean sea level with the autopilot engaged and encountered light

[1] Visit ntsb.gov to find additional information in the public docket for this ongoing NTSB investigation (case no. ANC21LA073).

rime icing conditions.[2] The pilot stated that the airplane's deice boots and propeller heat were operating and removing accumulated ice. To exit the icing conditions, the pilot requested and was assigned a block altitude from 10,000 to 12,000 ft. The pilot then climbed the airplane to an altitude of about 10,500 ft but still encountered the icing conditions. As a result, the pilot began a gradual descent back to 10,000 ft. During the descent, the autopilot "suddenly" disengaged, and the airplane entered an abrupt uncommanded right bank followed by a steep nose-down spiraling descent.

The pilot stated that she was "fighting" to regain control of the airplane because the aileron controls were "jammed." FAA automatic dependent surveillance-broadcast data showed that the pilot regained control at an altitude of about 3,100 ft. Afterward, the pilot declared an in-flight emergency and made an emergency landing at FAI. A postaccident examination of the airplane found that the right aileron sustained substantial damage during the upset.

During the ongoing investigation, the NTSB found that the accident flight had encountered SLD icing conditions. (This determination was based on the meteorological information supporting the investigation, including weather radar data, observations of in-flight conditions, and weather model data.) According to FAA Advisory Circular (AC) 00-45H, "Aviation Weather Services" (dated March 6, 2019), SLD icing conditions comprise supercooled water droplets, such as freezing drizzle and/or freezing rain, that measure 0.05 mm in diameter or larger. The AC also states that SLD icing conditions are outside the envelopes used for aircraft icing certification (contained in Appendix C of 14 *CFR* Part 25) and that SLD icing conditions "can be particularly hazardous" to some aircraft.[3]

In addition, in November 2014, 14 *CFR* 25.1420 and Part 25, Appendix O, were revised to include SLD certification requirements for new transport-category airplanes. However, AC 91-74B, "Pilot Guide: Flight in Icing Conditions" (dated October 8, 2015), pointed out that similar SLD certification requirements have not been implemented for other aircraft types.

In-flight encounters with SLD icing can have catastrophic consequences, as demonstrated by the October 31, 1994, accident involving an Avions de Transport Regional 72-212 airplane operated as American Eagle flight 4184. The airplane

[2] (a) All altitudes in this report are expressed as mean sea level. (b) Rime ice is a type of ice that is opaque, granular, and rough. Rime ice usually forms on airplane surfaces such as a wing leading edge, the horizontal stabilizer, and an engine inlet.

[3] Aircraft that are certificated for operations in icing conditions have specifications that include approval for flight into known icing. Even for aircraft that are certificated for flight in icing conditions, flight into SLD icing conditions poses a structural icing hazard.

entered an uncommanded roll excursion and rapid descent and crashed in Roselawn, Indiana. The 2 flight crewmembers, 2 flight attendants, and 64 passengers sustained fatal injuries, and the airplane was destroyed by impact forces. The NTSB's investigation found that the airplane, while in a holding pattern, "intermittently encountered supercooled cloud and drizzle/rain drops [SLD], the size and water content of which exceeded those described in the icing certification envelope." While the airplane was in the holding pattern, a ridge of ice accreted beyond the airplane's deice boots, causing "a sudden and unexpected aileron hinge moment reversal." [4]

Further, on February 16, 2005, a Cessna Citation 560 was involved in a loss-of-control accident near Pueblo Memorial Airport, Pueblo, Colorado, after an SLD icing encounter. The two pilots and six passengers sustained fatal injuries, and the airplane was destroyed by impact forces and postcrash fire. The NTSB's investigation of this accident determined that the airplane likely encountered SLD icing conditions while descending from 9,400 ft and that the airplane entered a substantial roll to the left along with a rapid decrease in pitch, consistent with an aerodynamic stall, at 6,100 ft.

The NTSB's accident report stated that, while the airplane was in SLD icing conditions, about 1 to 4 mm (0.039 to 0.156 inch) of ice could have accumulated on the wings' leading edges. The NTSB concluded that the airplane's wings had residual ice after the deice boots were activated earlier in the flight (after the airplane descended through an altitude of 18,000 ft) and that this ice would have affected the overall thickness, roughness, and distribution of the ice accumulation.[5]

The NTSB's report on the Pueblo accident also stated that "SLD conditions are most conducive to the formation of thin, rough ice on or aft of the protected surfaces" (that is, those surfaces with deice boots) and that such ice "can severely degrade an airplane's performance."[6] In addition, the report stated that SLD icing conditions could cause ice accretions that are more "aerodynamically detrimental" than those considered during the initial certification of many existing airplanes for flight in icing conditions.

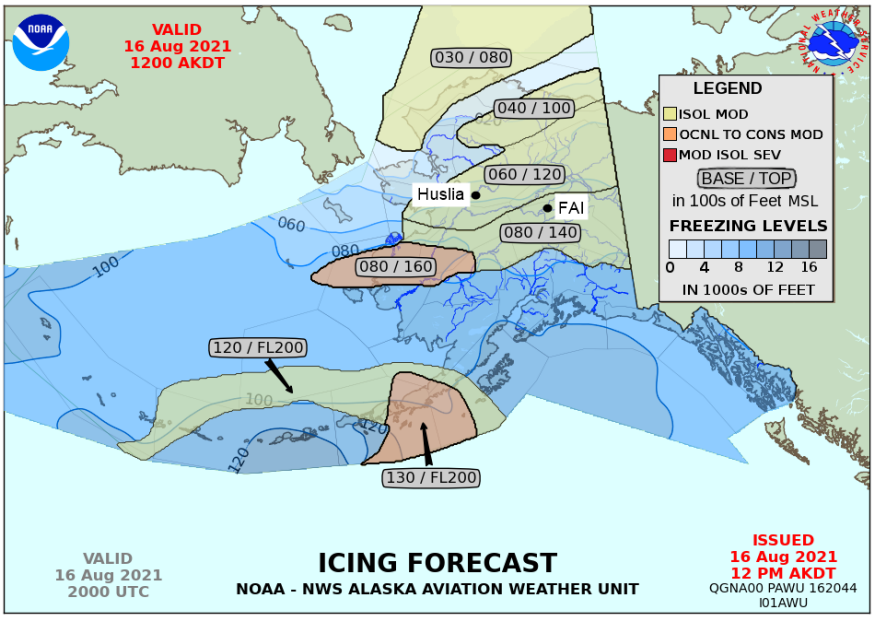
[4] For more information, see *In-flight Icing Encounter and Loss of Control, Simmons Airlines, d.b.a. American Eagle Flight 4184, Avions de Transport Regional (ATR), Model 72-212, N401AM, Roselawn, Indiana, October 31, 1994* (NTSB/AAR-96/01).

[5] For more information, see *Crash During Approach to Landing, Circuit City Stores, Inc., Cessna Citation 560, N500AT, Pueblo, Colorado, February 16, 2005* (NTSB/AAR-07/02).

[6] FAA AC 91-74B states that the surfaces behind the protected area of leading edges "may be very effective ice collectors, and ice accumulations may persist as long as the aircraft remains in icing conditions."

During a postaccident interview, the pilot involved in the recent Fairbanks accident stated that she knew about the potential for icing conditions but that she did not expect the airplane to encounter SLD icing. The pilot also stated that, before the accident flight, she reviewed weather information from several sources, including "multiple pages" on the NWS Alaska Aviation Weather Unit (AAWU) website.[7]

Figure 1 shows one of the graphical weather products that the accident pilot reviewed: the AAWU icing forecast graphic. That forecast, which was valid starting at 1200 Alaska daylight time on the day of the accident, showed isolated moderate icing conditions between 8,000 and 14,000 ft (labeled as flight levels "080/140" in the figure) for the departure and accident locations. The AAWU developed such icing forecasts to supplement text-based area forecast and AIRMET information for Alaska by graphically depicting information about freezing levels and the potential for significant icing.



Note: The accident airplane departed FAI about 1424 Alaska daylight time, and the in-flight upset occurred about 28 minutes later. The locations of FAI and Huslia Airport (the destination airport) were added to the image.

Figure 1. Icing forecast valid at the time of the accident (Source: AAWU).

[7] According to FAA AC 00-45H, the NWS provides weather data, forecasts, and warnings for the United States, its territories, adjacent waters, and ocean areas. Within the NWS is the AAWU in Anchorage, Alaska, which issues aviation weather products for the airspace over Alaska and the adjacent coastal waters. The NWS Aviation Weather Center in Kansas City, Missouri, issues aviation weather forecasts for the 48 contiguous states. The NWS Honolulu, Hawaii, weather forecast office provides aviation-related products for Hawaii and the adjacent waters.

In addition, the NWS Aviation Weather Center (AWC) produces graphical forecast products—the current icing product (CIP) and the forecast icing product (FIP)—that depict the potential for significant icing, including SLD conditions, for the contiguous United States. The AWC's CIP, shown in figure 2, depicts potential areas of SLD icing conditions using red hatched marks. Further, the AWC generates a FIP to show potential areas of SLD icing conditions (also using red hatched marks) during the next 1 to 18 hours.[8] According to the AWC's website, these graphics are determined from observational data, including Weather Surveillance Radar-1988 Doppler radar; satellite data; pilot weather reports; surface weather reports; lightning network data; and computer model output.[9]

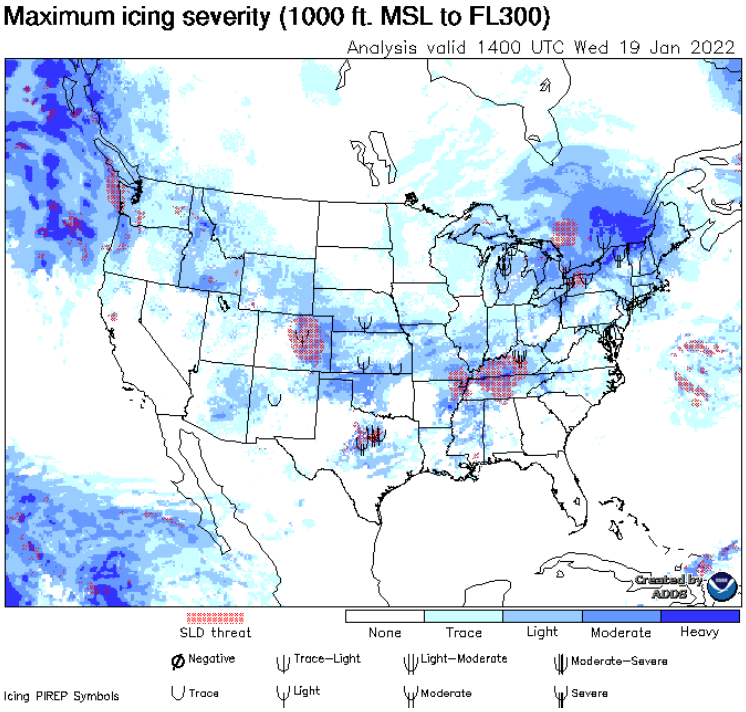


Figure 2. Example of CIP showing potential SLD icing in areas with red hatched marks (Source: AWC).

[8] According to FAA AC 91-74B, a CIP is "a graphical planning product that combines sensor and numerical model data to provide a three-dimensional diagnosis of the probability and severity of icing, plus the potential for the presence of supercooled large drops (SLD)." An FIP "examines numerical weather prediction model output to calculate the probability and severity of icing conditions, plus SLD potential." According to AC 00-45H, the CIP and FIP include graphical information about icing probability, icing severity, and SLD potential for altitudes from 1,000 ft to flight level 300 at 1,000-ft intervals.

[9] For more information, see https://www.aviationweather.gov/icing/help, accessed April 18, 2022.

Before 2002, pilots operating in the contiguous United States did not have access to information about potential SLD icing. The NTSB recognized, during its investigation of the American Eagle flight 4184 accident, that the aviation community needed this information. As a result, on August 15, 1996, the NTSB recommended the following:

> To the FAA: 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. (A-96-53)[10]

> To the National Oceanic and Atmospheric Administration: Develop methods to produce weather forecasts that both define specific locations of atmospheric icing conditions (including freezing drizzle and freezing rain), and that produce short range forecasts ("nowcasts") that identify icing conditions for a specific geographic area with a valid time of 2 hours or less. Ensure the timely dissemination of all significant findings to the aviation community in an appropriate manner. (A-96-70)[11]

The technology that was developed and implemented after these recommendations resulted in the AWC's CIPs and FIPs for the contiguous United States.

In April 2017, the AWC's graphical forecasts for aviation (GFA) became operational.[12] According to the NWS, GFAs "are a set of web-based displays that

[10] On August 20, 1997, the NTSB classified Safety Recommendation A-96-53 "Closed—Acceptable Action" based on the FAA's continuing in-flight icing research efforts, which included an initiative to improve the ability to forecast specific types of in-flight icing, especially freezing rain, freezing drizzle, and SLD aloft.

[11] On March 20, 1997, the NTSB classified Safety Recommendation A-96-70 "Closed—Acceptable Action" because of the NWS' progress in forecasting SLD by using algorithms developed by the National Center for Atmospheric Research. (The NWS is an office within the National Oceanic and Atmospheric Administration. The National Center for Atmospheric Research is a federally funded research and development center sponsored by the National Science Foundation.)

[12] According to the NWS' National Centers for Environmental Prediction newsletter for the second quarter of fiscal year 2017 (accessed April 18, 2022), "addressing a National Transportation Safety Board recommendation from May 2014, the GFA pulls together weather forecasts impacting aviation interests from all National Weather Service offices into one website." The referenced recommendation to the NWS, A-14-17, stated the following: "Modify National Weather Service (NWS) aviation weather products to make them consistent with NWS nonaviation-specific advisory products when applicable, so that they advise of hazardous conditions including aviation hazards less than 3,000 square miles in area that exist outside of terminal aerodrome forecast coverage areas." On

provide observations and forecasts of weather phenomena critical for aviation safety." The GFAs were developed to replace text-based area forecasts (which describe the occurrence or expected occurrence of specific en route weather conditions) for the contiguous United States.[13] Although the GFAs depict general icing forecasts from the surface to flight level 480, the NWS decided not to include SLD icing forecast information in GFAs because those graphical forecasts were intended to replace text-based area forecasts, which did not contain SLD icing information. The GFAs were expanded to Alaska on March 1, 2022.[14]

Even with the switch from area forecasts to GFAs, pilots will continue to have access to SLD icing forecast information for the contiguous United States via the AWC's CIP and FIP website (which is accessible via a link from the GFA website). However, pilots will still not be able to access information about potential SLD icing conditions for Alaska because the CIP and FIP website does not depict that information.

GFA information that shows areas of icing (trace to severe/heavy) is now available in Alaska. However, that information does not depict areas with potential SLD icing. A product that includes the SLD icing information for Alaska could help pilots avoid those areas, which is important because, as previously mentioned, SLD icing is outside the icing certification envelopes of some aircraft types, including those that are routinely operated in Alaska. In addition, areas of SLD icing do not necessarily correspond with areas of severe icing; figure 2 shows that SLD icing can occur in areas with light-to-moderate icing. Without SLD forecast information, pilots in Alaska will remain at risk of inadvertent encounters with SLD icing conditions.

The NTSB concludes that a graphical forecast depicting potential areas of SLD icing conditions in Alaska could help pilots avoid inadvertent flight into those hazardous conditions. Therefore, the NTSB recommends that the FAA, in collaboration with the NWS, develop a graphical forecast showing the potential for SLD icing conditions in Alaska and make this information available to pilots. The NTSB also recommends that the NWS work with the FAA to develop a graphical forecast depicting potential areas of SLD icing conditions in Alaska and make this information available to pilots.

October 21, 2019, the NTSB classified Safety Recommendation A-14-17 "Open—Acceptable Response" pending implementation of digital aviation services at all NWS weather forecast offices.

[13] The NWS newsletter stated that the FAA requested that the NWS discontinue the production of the text-based area forecasts because "given modern advances within NWS…the legacy text FA [area forecast] is no longer the best source of en route flight planning weather information."

[14] Text-based area forecasts will remain in production in Alaska to support flight planning.

Conclusion

Finding

A graphical forecast depicting potential areas of supercooled large droplet icing conditions in Alaska could help pilots avoid inadvertent flight into those hazardous conditions.

Recommendations

To the Federal Aviation Administration:

In collaboration with the National Weather Service, develop a graphical forecast depicting potential areas of supercooled large droplet icing conditions in Alaska and make this information available to pilots. (A-22-21)

To the National Weather Service:

Work with the Federal Aviation Administration to develop a graphical forecast depicting potential areas of supercooled large droplet icing conditions in Alaska and make this information available to pilots. (A-22-22)

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For more detailed background information on this report, visit the NTSB investigations website and search for NTSB accident ID ANC21LA073. Recent publications are available in their entirety on the NTSB website. Other information about available publications also may be obtained from the website or by contacting–

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