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AVIATION SAFETY

Preliminary Information on Aircraft Icing and Winter Operations

Statement of Gerald L. Dillingham, Ph.D.
Director, Physical Infrastructure Issues

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Highlights

Highlights of GAO-10-441T, a testimony before the Subcommittee on Aviation, Committee on Transportation and Infrastructure, House of Representatives

Why GAO Did This Study

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, as well as persistent efforts by the Federal Aviation Administration (FAA) and other stakeholders to mitigate icing risks, icing remains a serious concern. As part of an ongoing review, this statement provides preliminary information on (1) the extent to which large commercial airplanes have experienced accidents and incidents related to icing and contaminated runways, (2) the efforts of FAA and aviation stakeholders to improve safety in icing and winter weather operating conditions, and (3) the challenges that continue to affect aviation safety in icing and winter weather operating conditions. GAO analyzed data obtained from FAA, the National Transportation Safety Board (NTSB), the National Aeronautics and Space Administration (NASA), and others. GAO conducted data reliability testing and determined that the data used in this report were sufficiently reliable for our purposes. Further, GAO obtained information from senior FAA and NTSB officials, representatives of the Flight Safety Foundation, and representatives of some key aviation industry stakeholder organizations. GAO provided a draft of this statement to FAA, NTSB, and NASA and incorporated their comments where appropriate.

View GAO-10-441T or key components.
For more information, contact Gerald L. Dillingham at (202) 512-2834 or dillinghamg@gao.gov.

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Preliminary Information on Aircraft Icing and Winter Weather Operations

What GAO Found

According to NTSB's aviation accident database, from 1998 to 2009 one large commercial airplane was involved in a nonfatal accident after encountering icing conditions during flight and five large commercial airplanes were involved in nonfatal accidents due to snow or ice on runways. However, FAA and others recognize that *incidents* are potential precursors to accidents and the many reported icing incidents suggest that these airplanes face ongoing risks from icing. For example, FAA and NASA databases contain information on over 600 icing-related incidents involving large commercial airplanes.

FAA and other aviation stakeholders have undertaken many efforts to improve safety in icing conditions. For example, in 1997, FAA issued a multiyear plan for improving the safety of aircraft operating in icing conditions and has since made progress on the objectives specified in its plan by issuing regulations, airworthiness directives, and voluntary guidance, among other initiatives. Other government entities that have taken steps to increase aviation safety in icing conditions include NTSB, which has issued numerous recommendations as a result of its aviation accident investigations, and NASA, which has contributed to icing-related research. The private sector has deployed various technologies on aircraft, such as wing deicers, and operated ground deicing and runway clearing programs at airports.

GAO identified challenges related to winter weather aviation operations that, if addressed by ongoing or planned efforts, could improve safety. These challenges include (1) improving the timeliness of FAA's winter weather rulemaking efforts; (2) ensuring the availability of adequate resources for icing-related research and development; (3) ensuring that pilot training is thorough and realistic; (4) ensuring the collection and distribution of accurate weather information; and (5) developing a more integrated approach to effectively manage winter operations.

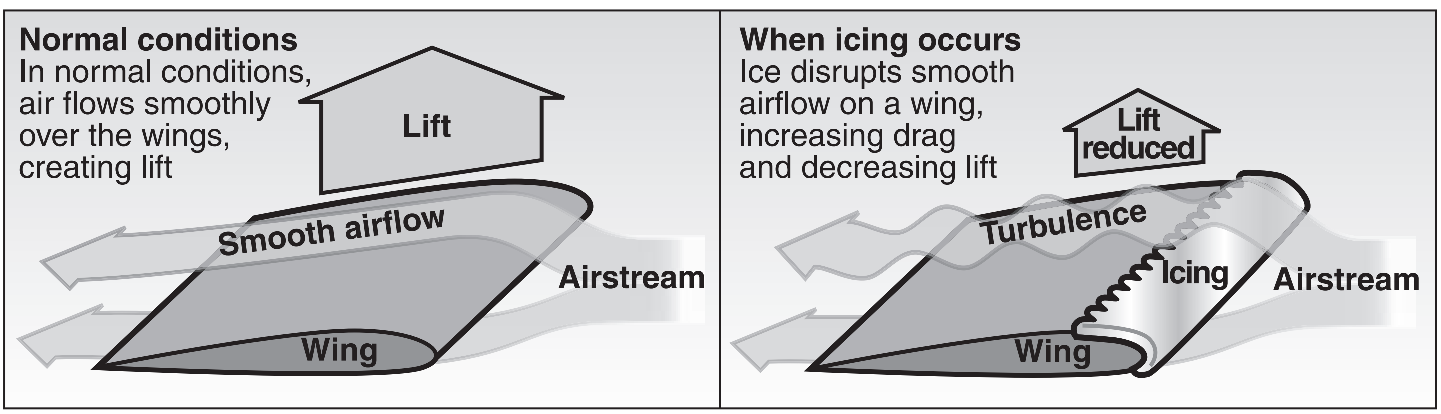
Example of Ground Deicing to Help Ensure Clean Aircraft

Source: Gerald R. Ford International Airport.

Mr. Chairman and Members of the Subcommittee:

Thank you for the opportunity to testify today on issues related to aircraft icing and conducting aviation operations on contaminated runways.[1] Icing can be a significant hazard for aviation operations of all types, including commercial flights, no matter the season of the year. As shown in figure 1, when there is ice on an aircraft's wings, it can disrupt the smooth flow of air over the wings and prevent the aircraft from safely taking off or decrease the pilot's ability to control the aircraft in flight. Depending on the location of the ice, the shape of the wing, and the phase of flight, even small, almost imperceptible amounts of ice can have a significant detrimental effect. Despite a variety of technologies designed to prevent ice from forming on planes or 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 concern. Furthermore, runways that have not been cleared of snow or ice can be hazardously slick for planes during takeoff and landing.

Figure 1: Effect of Ice Build-up on Aircraft Wings



Sources: GAO and FAA.

[1]In this statement we use the term *icing* to refer to icing of airplane surfaces. We use the term *contaminated runway* to refer to ice, snow, slush, frost, or standing water on the runway. The presence of standing water, snow, slush, or ice on the runway at low temperatures may be defined as icing conditions for the airplane, which may require certain ground icing procedures (e.g., checks or deicing of wings). Runways that are contaminated with snow, slush, or ice are generally associated with operations in winter conditions.

Based on an ongoing review for this Subcommittee, as well as for the Senate Aviation Subcommittee and Senator Charles Schumer, my testimony today discusses preliminary information on (1) the extent to which large commercial airplanes have experienced accidents and incidents related to icing and contaminated runways, (2) the efforts of FAA and other aviation stakeholders to improve safety in icing and winter weather operating conditions, and (3) the challenges that continue to affect aviation safety in icing and winter weather operating conditions. My statement is based on our analyses of data related to icing obtained from FAA, the National Transportation Safety Board (NTSB), the National Aeronautics and Space Administration (NASA), and others. It also includes updates from FAA of information published in our related reports. It reflects our discussions with senior FAA, NTSB, NASA, and National Oceanic and Atmospheric Administration (NOAA) officials and representatives from the Flight Safety Foundation and several aviation industry organizations.[2] As part of our ongoing review, we performed this work from August 2009 to February 2010 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our review objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives. Further, we conducted data reliability testing and determined that the data used in this report were sufficiently reliable for our purposes. We provided a draft of this testimony to FAA, NTSB, and NASA officials to obtain their comments. In response, FAA, NTSB, and NASA provided additional information that we incorporated where appropriate.

[2]The Flight Safety Foundation is an independent, nonprofit, international organization engaged in research, auditing, education, advocacy, and publishing to improve aviation safety.

Although Large Commercial Airplanes Have Experienced Few Icing-Related Accidents since 1998, the Many Reported Icing Incidents Suggest that Icing Is an Ongoing Risk to Aviation Safety

According to NTSB's aviation accident database, from 1998 to 2009 one large commercial airplane was involved in a nonfatal accident after encountering icing conditions during flight and five large commercial airplanes were involved in nonfatal accidents related to snow or ice on runways.[3] Although there have been few accidents, FAA and others recognize that incidents are potential precursors to accidents.[4] Data on hundreds of incidents that occurred during this period reveal that icing and contaminated runways pose substantial risk to aviation safety. FAA's database of incidents includes 200 icing-related incidents involving large commercial airplanes that occurred from 1998 through 2007.[5] These data covered a broad set of events, such as the collision of two airplanes at an ice-covered gate, and an airplane that hit the right main gear against the runway and scraped the left wing down the runway for about 63 feet while attempting to land with ice accumulation on the aircraft. During this same time period, NASA's Aviation Safety Reporting System (ASRS) received over 600 icing and winter weather-related incident involving large commercial airplanes.[6] These incidents reveal a variety of safety issues such as runways contaminated by snow or ice, ground deicing problems, and in-flight icing encounters. This suggests that risks from icing and other winter weather operating conditions may be greater than indicated by NTSB's accident database and by FAA's incident database. FAA officials point out that there is no defined reporting threshold for ASRS reports and because they are developed from personal narrative, they can be subjective. However, these officials agree that the ASRS events must be thoroughly reviewed and evaluated for content to determine the relevancy

[3]By large commercial airplanes, we mean those airplanes operating under part 121 of title 14 of the Code of Federal Regulations (CFR). Among other things, part 121 applies to air carrier operations involving turbojet airplanes or any airplane with a seating capacity of more than 9 passengers or a maximum payload capacity of more than 7,500 pounds.

[4]An incident is defined by NTSB as an occurrence other than an accident associated with the operation of an aircraft that affects or could affect the safety of operations.

[5]FAA's database contains data generated by FAA investigations of aviation incidents. These data are generated by officials charged with investigating incidents.

[6]This voluntary system is administered by NASA. It contains voluntary reports, which are later de-identified, from pilots, controllers, maintenance technicians, and other operating personnel about human behavior that resulted in unsafe occurrences or hazardous situations. NASA seeks to avoid double counting of incidents by ensuring that multiple reports for a single incident are grouped together under that incident. Because ASRS reporting is voluntary, it is unlikely to cover the universe of safety events. It is also possible that ASRS incident data may overlap with FAA incident data, because a single incident may be entered into FAA's incident database by an FAA inspector and reported to ASRS by a pilot or bystander. However, the extent to which overlap occurs is unknown.

to icing and the extent and severity of the safety issue. The contents of the ASRS data system also demonstrate the importance of aggregating data from all available sources to understand a safety concern.[7] See table 1 for the number of icing and winter weather-related incident reports from ASRS for large commercial airplanes.

Table 1: Icing and Winter Weather-Related Incident Reports for Large Commercial Airplanes by Category of Incident, 1998 to 2007

Category	Number of Reports
Anti-ice or deicing incident/procedure	179
Controllability issue—ground	72
In-flight encounter—aircraft equipment problems	72
In-flight encounter—airframe and/or flight control icing	69
Other winter weather incident	42
Surface marking and signage obstruction	41
Runway, ramp, or taxiway excursion	36
Runway, ramp, or taxiway incursion	34
Controllability issue—air	32
Maintenance incident	19
Ramp safety—personnel risk or injury	17
In-flight encounter—sensor type incident	15
Total	**628**

Source: GAO analysis of NASA ASRS data.

Note: An excursion occurs when an aircraft unintentionally exits a runway, ramp, or taxiway. An incursion occurs when an aircraft enters a runway, ramp, or taxiway without authorization.

While this testimony focuses on large commercial airplanes, I would like to note that from 1998 to 2007, small commercial airplanes and noncommercial airplanes experienced more icing-related accidents and

[7] We plan to report in the spring of 2010 on FAA's use of data to be proactive in its oversight of key safety areas.

fatalities than did large commercial airplanes, as shown in table 2.[8] This is largely because, compared to large commercial airplanes, small commercial airplanes and noncommercial airplanes (1) operate at lower altitudes that have more frequent icing conditions, (2) have a higher icing collection efficiency due to their smaller scale, (3) are more greatly impacted by ice as a result of their smaller scale, (4) tend to have deicing equipment rather than fully evaporative anti-icing equipment, (5) may not have ice protection systems that are certified, nor are they required to be, because the airplane is not approved for flight in known icing conditions, and (6) may not have ice protections systems installed.

Table 2: Icing and Winter Weather-Related Accidents and Fatalities for 1998 to 2009, Incidents for 1998 to 2007

	Large commercial airplanes	Small commercial airplanes	Noncommercial airplanes
Icing-related accidents, including in-flight and runway	6	49	510
Fatalities in icing-related accidents	0	27	202
Icing-related incidents in FAA's database	200	119	567
Icing-related incidents in NASA's ASRS database	628	102	422

Source: NTSB for accidents and fatalities; FAA and NASA for incidents.

Notes: For all three types of airplanes, accident data for 2008 and 2009 are incomplete because NTSB has not completed all of its accident investigations that occurred during those years. For small commercial and noncommercial airplanes, the number of accidents and incidents also includes carburetor icing.

[8]By small commercial airplanes, we mean those airplanes operating under part 135 of title 14 CFR. Among other things, part 135 covers commuter operations on airplanes, other than turbojet powered airplanes, with 9 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 14 CFR part 91. 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.

FAA and Other Aviation Stakeholders Have Undertaken a Variety of Efforts Aimed at Improving Safety in Icing/Winter Weather Conditions

FAA Adopted a Plan to Increase Safety in Icing Conditions and Has Taken Other Actions to Improve Safety in Winter Weather

Following the 1994 fatal crash of American Eagle Flight 4184 in Roselawn, Indiana, FAA issued a multiyear plan in 1997for improving the safety of aircraft operating in icing conditions and created a steering committee to monitor the progress of the planned activities.[9] Over the last decade, FAA made progress on the implementation of the objectives specified in its multiyear plan by issuing or amending regulations, airworthiness directives (ADs), and voluntary guidance to provide icing-related safety oversight.[10] For example, FAA issued three final rules on icing:

- in August 2007, a rule introduced new airworthiness standards to establish comprehensive requirements for the performance and handling characteristics of transport category airplanes in icing conditions;[11]
- in August 2009, a rule required a means to ensure timely activation of the ice protection system on transport category airplanes; and

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[9]FAA's 1997 Inflight Aircraft Icing Plan describes various activities planned to improve safety for aircraft operating in icing conditions. Recent FAA documentation indicates that the agency aims to provide better icing forecast technology and to develop ice-resistant pavement surfaces, improved deice/anti-ice technology, and more efficient ground icing detection.

[10]An airworthiness directive is a legally enforceable rule that may apply to aircraft, aircraft engines, propellers, and appliances. FAA issues an airworthiness directive when it determines that (1) an unsafe condition exists in the product and (2) the condition is likely to exist or develop in other products of the same type or design.

[11]In general, a transport category airplane is an airplane with maximum takeoff weight (MTOW) greater than 12,500 pounds or with 10 or more passengers, 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 passengers. Transport category airplanes operate under 14 CFR part 25.

- in December 2009, a rule required pilots to ensure that the wings of their aircraft are free of polished frost.[12]

FAA has also proposed an icing-related rule in November 2009, on which the public comment period closed February 22, 2010; this rule would require the timely activation of ice protection equipment on commercial aircraft during icing conditions and weather conditions conducive to ice formation on the aircraft.[13] In addition, FAA is developing a proposed rule to amend its standards for transport category airplanes to address supercooled large drop icing, which is outside the range of icing conditions covered by the current standards.[14] Since 1997, FAA has issued over 100 ADs to address icing safety issues involving more than 50 specific types of aircraft, including ADs that required the installation of new software on certain aircraft and another that required operators and manufactures to install placards displaying procedures for use of an anti-icing switch on certain aircraft. Additionally, FAA has issued bulletins and alerts to operators emphasizing icing safety issues. As part of our ongoing review, we will conduct a more comprehensive evaluation of FAA's progress on the implementation of the objectives specified in its multiyear in-flight icing plan. Among other things, we will also analyze the results of FAA's surveillance activities related to monitoring air carriers' compliance with existing regulations and ADs.

FAA also provided funding for a variety of icing-related purposes. For example, FAA has supported NASA research related to severe icing conditions and the National Center for Atmospheric Research (NCAR) research related to weather and aircraft icing. Furthermore, FAA has provided almost $200 million to airports through the Airport Improvement Program (AIP) to construct deicing facilities and to acquire aircraft deicing equipment from 1999 to 2009. See appendix I for a detailed listing of AIP icing-related funding by state, city, and year.

[12]14 CFR Part 135, §135.227 and 14 CFR Part 91, §91.527. Frost-polishing is accomplished by scraping or buffing frost accumulations so as to obtain a smooth surface. The polished frost requirement does not apply to large commercial aircraft (part 121) because part 121 did not permit operations with polished frost prior to the implementation of this new rule.

[13]This proposed rule only applies to airplanes with an MTOW of 60,000 pounds being operated under 14 CFR part 121.

[14]Supercooled large drops have a diameter greater than 50 microns and include freezing drizzle and freezing rain. These droplets can form into ice beyond the normally protected areas of aircraft.

Runway safety is a key concern for aviation safety and especially critical during winter weather operations. For example, in December 2005, a passenger jet landed on a snowy runway at Chicago's Midway Airport, rolled through an airport perimeter fence onto an adjacent roadway, and struck an automobile, killing a child and injuring 4 other occupants of the automobile and 18 airline passengers.[15] According to the Flight Safety Foundation, from 1995 through 2008, 30 percent of global aviation accidents were runway-related and "ineffective braking/runway contamination" is the fourth largest causal factor in runway excursions that occur during landing. In fiscal year 2000, FAA's Office of Airport Safety and Standards initiated a program, which includes making funds available to airports through AIP, to accelerate improvements in runway safety areas at commercial service airports that did not meet FAA design standards.

Since 2000, FAA has provided about $200 million per year in AIP funding for the creation of runway safety areas. According to FAA officials, of the 619 runways that FAA determined needed improvement, 465 (74 percent) have been completed and 154 (26 percent) remain to be completed by 2015. The estimated cost to complete the remaining project is about $835 million.[16] In some cases where (1) land is not available, (2) it would be very expensive for the airport sponsors to buy land off the end of the runway, or (3) it is otherwise not possible to have the 1,000 foot safety area, FAA has approved the use of an Engineered Materials Arresting System (EMAS).[17] FAA supports EMAS installations through AIP funding, and currently, EMAS installations have been completed for 44 runways at 30 airports in the United States, with 4 more installations scheduled for

[15]NTSB concluded that the probable cause of the accident was the pilot's failure to use available reverse thrust in a timely manner to safely slow or stop the airplane after landing, which resulted in a runway overrun. NTSB's accident investigation report indicated that contributing to the severity of the accident was the absence of an Engineering Materials Arresting System, which was needed because of the limited runway safety area beyond the end of the runway.

[16]Public Law 109-115 adopted FAA's 2015 goal. FAA considers runway safety areas that meet 90 percent of the standards to be substantially compliant.

[17]EMAS uses materials of closely controlled strength and density placed at the end of the runway to stop or greatly slow an aircraft that overruns the runway. According to FAA, the best material found to date is a lightweight crushable concrete.

2010.[18] To date there have been five successful EMAS captures of overrunning aircraft.

Other Stakeholders Support and Augment FAA Efforts to Increase Safety in Winter Weather/Icing Conditions

Government and industry stakeholders, external to FAA, also contribute to the effort to increase aviation safety in winter weather/icing conditions. For example, NTSB investigates and reports on civil aviation accidents and issues safety recommendations to FAA and others, some of which it deems most critical and places on a list of "Most Wanted" recommendations.[19] Since 1996, NTSB has issued 82 recommendations to FAA aimed at reducing risks from in-flight structural icing, engine and aircraft component icing, runway condition and contamination, ground icing, and winter weather operations. NTSB's icing-related recommendations to FAA have called for FAA to, among other things, strengthen its requirements for certifying aircraft for flying in icing conditions, sponsor the development of weather forecasts that define locations with icing conditions, and enhance its training requirements for pilots.[20] NTSB has closed 39 of these recommendations (48 percent) as having been implemented by FAA, and has classified another 25 (30 percent) as FAA having made acceptable progress.[21] This combined 78 percent acceptance rate is similar to the rate for all of NTSB's aviation recommendations.

For more than 30 years, NASA has conducted and sponsored fundamental and applied research related to icing. The research addresses icing causes, effects, and mitigations. For instance, NASA has conducted extensive research to characterize and simulate supercooled large drop icing conditions to inform a pending FAA rule related to the topic. NASA

[18]Airports that are scheduled for 2010 installation of EMAS beds are Areta, California; Winston-Salem, North Carolina; Wilmington, Delaware; and Key West, Florida.

[19]This list, which NTSB has maintained since 1990 and revises annually, includes important safety recommendations identified for special attention and intensive follow-up.

[20]According to FAA, in response to NTSB's recommendation related to weather forecasts the agency sponsored the development of the Current Icing Product (CIP) and Forecast Icing Potential (FIP), which are computer-generated three-dimensional graphics containing information on the likelihood of an aircraft encountering icing conditions.

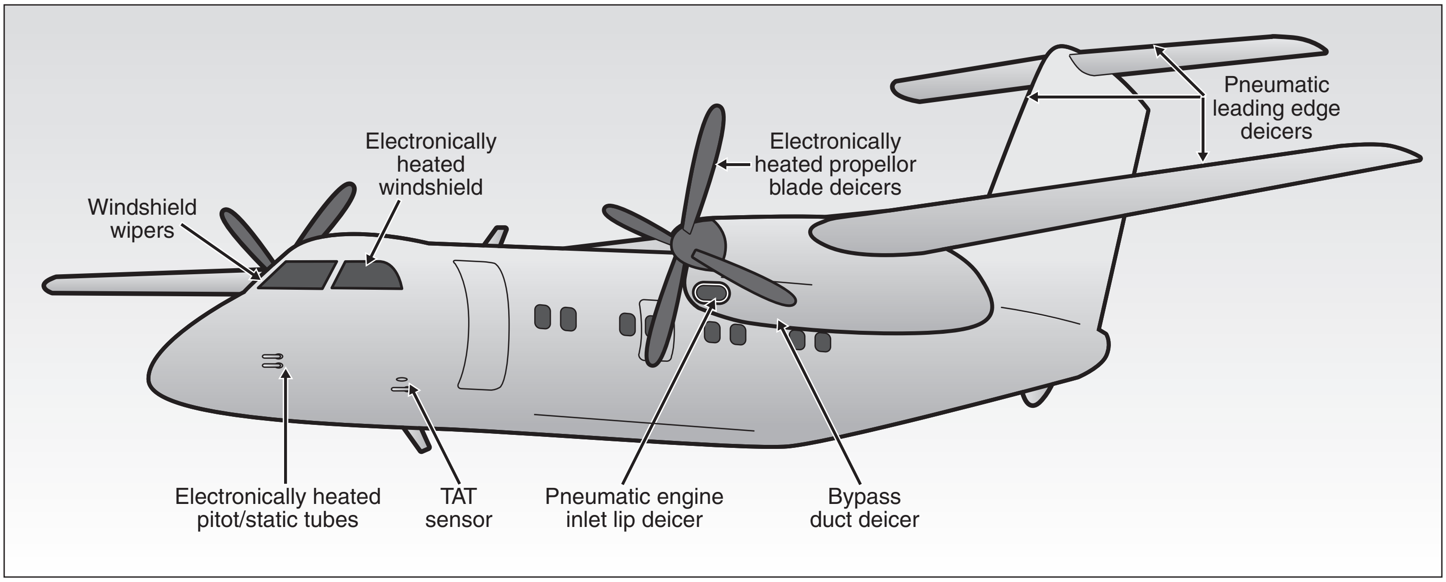
[21]In addition, NTSB has closed 8 of these recommendations as "unacceptable response" by FAA; has classified 6 of the open recommendations as "unacceptable response" by FAA; has closed 3 of these recommendations after concurring with FAA's rationales for disagreeing with the recommendations; and is awaiting FAA's response on 1 of these recommendations.

participated in research activities, partially funded by FAA, that developed additional knowledge and strategies which allowed forecasters to more precisely locate supercooled large drop icing conditions. Furthermore, NASA has an icing program, focused generally on research related to the effects of in-flight icing on airframes and engines for many types of flight vehicles. NASA has developed icing simulation capabilities that allow researchers, manufacturers, and certification authorities to better understand the growth and effects of ice on aircraft surfaces. NASA also produced a set of training materials for pilots operating in winter weather conditions. In recent years, NASA's funding decreased significantly, limiting the capability of its icing research program.

NOAA, the National Weather Service (NWS), and NCAR have efforts directed and funded by FAA related to predicting the location and severity of icing occurrences. NWS operates icing prediction systems and NCAR conducts research to determine more efficient methods to complete this task. For example, in 2006, NCAR introduced a new Web-based icing forecast tool that allows meteorologists and airline dispatchers to warn pilots about icing hazards up to 12 hours in advance. NCAR developed this tool using FAA funding and NWS facilitates the operation of the new icing forecasting tool. NWS also posts on the agency's Web site maps of current icing conditions, pilot reports, forecasts, and freezing level graphics.

The private sector has also contributed to efforts to prevent accidents and incidents related to icing and winter weather conditions. For example, as shown in figure 2, aircraft manufacturers have deployed various technologies such as wing deicers, anti-icing systems, and heated wings.

Figure 2: Aircraft Ice Protection Systems



Source: GAO, based on information from NTSB.

Notes: Pneumatic leading edge deicers are inflatable rubber “boots” on the leading edges of airfoil surfaces (including wings, horizontal stabilizers, and vertical stabilizers) that can be rapidly inflated and deflated with air pressure to break up ice accumulation. Similar technology is used for the pneumatic engine inlet lip and bypass duct deicer. The TAT (Total Air Temperature) sensor helps the pilot determine critical flight parameters such as true airspeed computation and static air temperature. Electronically heated propeller blade deicers, windshield, and pitot/static tubes operate in-flight to rid the aircraft of ice buildup and to prevent ice accumulation.

In addition, airports operate ground deicing and runway clearing programs that help ensure clean wings (see fig. 3) and runways. While critical to safe, efficient winter operations, these programs involve treating aircraft and airport pavement with millions of pounds of deicing and anti-icing compounds annually. According to the Environmental Protection Agency, these compounds contain chemicals that can harm the environment. Some airports can control deicing pollution by capturing the fluids used to deice aircraft using technologies such as AIP-funded deicing pads, where aircraft are sprayed with deicing fluids before takeoff and the fluids are captured and treated; drainage collection systems; or vacuum-equipped vehicles. Third-party contractors, rather than individual air carriers, are increasingly performing deicing operations at commercial airports. FAA does not currently have a process to directly oversee these third-party contractors but indicates that it has one under development.

Figure 3: Example of Ground Deicing to Help Ensure Clean Aircraft

Source: Gerald R. Ford International Airport.

Continued Attention to Regulation, Training, and Coordination Issues Could Further Mitigate the Risks of Winter Weather Operations

While FAA and others are undertaking efforts to mitigate the risks of aircraft icing and winter weather operations, through our interviews and discussions with government and industry stakeholders, we have identified challenges related to these risks that, if addressed by ongoing or planned efforts, could improve aviation safety. These challenges include (1) improving the timeliness of FAA's winter weather rulemaking efforts, (2) ensuring the availability of adequate resources for icing-related research and development (R&D), (3) ensuring that pilot training is thorough, relevant, and realistic, (4) ensuring the collection and distribution of timely and accurate weather information, and (5) developing a more integrated approach to effectively manage winter operations.

Improving the timeliness of FAA's winter weather rulemaking efforts. FAA's rulemaking, like that of other federal agencies, is a complicated, multistep process that can take many years. Nonetheless, NTSB, FAA, and we have previously expressed concerns about the efficiency and timeliness of FAA's rulemaking efforts. In 2001, we reported that a major reform effort begun by FAA in 1998 did not solve long-standing problems with its rulemaking process, as indicated both by the lack of improvement in the time required to complete the rulemaking process and by the agency's inability to consistently meet the time frames imposed by statute or its own guidance.[22] External pressures—such as highly-publicized accidents, recommendations by NTSB, and congressional mandates—as well as internal pressures, such as changes in management's emphasis continued to add to and shift the agency's priorities. For some rules, difficult policy issues continued to remain unresolved late in the process. The 2001 report contained 10 recommendations designed to improve the efficiency of FAA's rulemaking through, among other things, (1) more timely and effective participation in decision-making and prioritization; (2) more effective use of information management systems to monitor and improve the process; and (3) the implementation of human capital strategies to measure, evaluate, and provide performance incentives for participants in the process. FAA implemented 8 of the 10 recommendations.[23]

NTSB's February 2010 update on the status of its Most Wanted recommendations related to icing characterized FAA's related rulemaking efforts as "unacceptably slow." In December 2009, at FAA's International Runway Safety Summit, NTSB's Chairman commented, "How do safety improvements end up taking 10 years to deliver? They get delayed one day at a time . . . and every one of those days may be the day when a preventable accident occurs as the result of something we were 'just about ready to fix.'" In particular, NTSB has expressed concern about the pace of FAA's rulemaking project to amend its standards for transport category airplanes to address supercooled large drop icing, which is outside the range of icing conditions covered by the current standards. FAA began this rulemaking effort in 1997 in response to a recommendation made by NTSB the prior year, and the agency currently expects to issue its proposed rule in July 2010 and the final rule in January 2012. However, until the notice of proposed rulemaking is published and the close of the comment period is known, it will be unclear as to when the final rule will be issued.[24] Much of

[22]GAO, *Aviation Rulemaking: Further Reform Is Needed to Address Long-standing Problems*, GAO-01-821 (Washington, D.C.: July 9, 2001).

[23]Additional information about the status of these recommendations is available at http://www.gao.gov/products/GAO-01-821.

[24]FAA is required by statute to issue a final regulation within 16 months of the last day of the comment period.

the time on this rulemaking effort has been devoted to research and analysis aimed at understanding the atmospheric conditions that lead to supercooled large drop icing.

In 2009, FAA completed an internal review of its rulemaking process that concluded that several of the concerns from 1998 that led to the agency's major reform effort remain issues, including:

- inadequate early involvement of key stakeholders;
- inadequate early resolution of issues;
- inefficient review process;
- inadequate selection and training of personnel involved in rulemaking; and
- inefficient quality guidance.

According to FAA's manager for aircraft and airport rules, the agency is taking steps to implement recommendations made by the internal review, such as revising the rulemaking project record form and enhancing training for staff involved in rulemaking. In addition, in October 2009, FAA tasked its Aviation Rulemaking Advisory Committee (ARAC) with reviewing its processes and making recommendations for improvement within a year. We believe these efforts have the potential to improve the efficiency of FAA's rulemaking process. Recently, moreover, FAA has demonstrated a commitment to making progress on some high-priority rules that have languished for a long time. For example, FAA officials have said that they intend to expedite FAA's rulemaking on pilot fatigue, which has been in process since 1992. The issue of insufficient rest emerged as a concern from NTSB's investigation of the February 12, 2009, crash of Continental Connection/Colgan Air Flight 3407 near Buffalo, New York.[25]

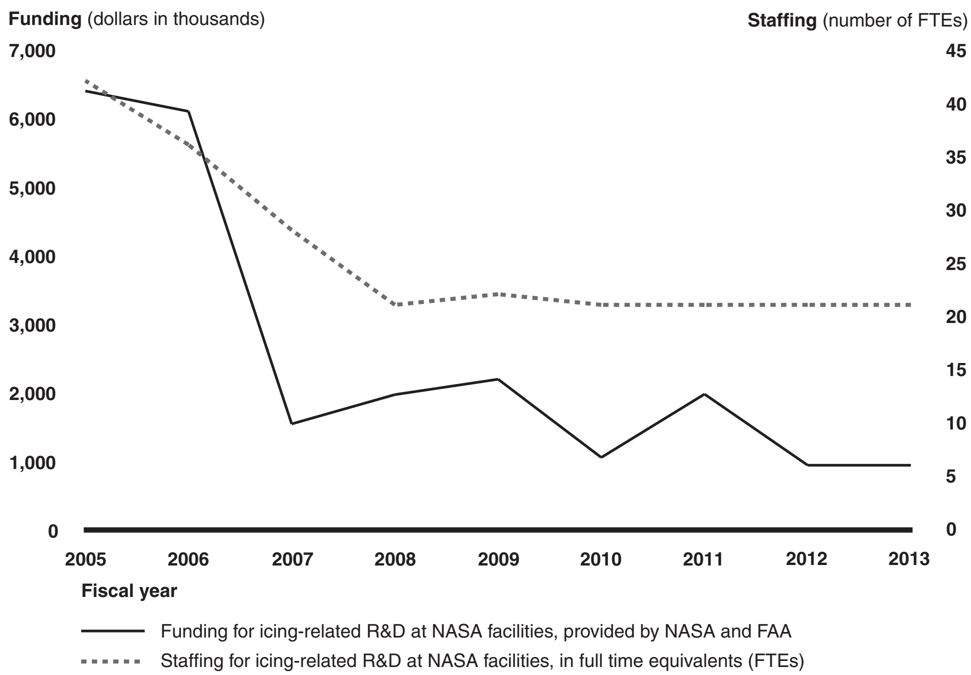
[25]In 1992, in response to NTSB recommendations, FAA established the flight crewmember flight/duty rest requirements working group of ARAC. However, by mid-1994 the working group had concluded its work, having failed to reach a consensus. Nevertheless, FAA issued a notice of proposed rulemaking in December 1995 to update the flight and duty regulations for airline pilots; however, in the intervening 14 years, the regulations have not been revised. In recent years, FAA has stated that it is developing a fatigue risk management system (FRMS) to provide an alternative to prescriptive limitations. Additionally, FAA has supported the adoption of FRMS programs among certain air carriers for their ultra-long-range operations.

Moreover, a capacity for progress in rulemaking will be critical because, as we have reported to this Subcommittee in our recent reviews of the transition to the Next Generation Air Transportation System (NextGen), many of the procedures that are proposed to safely enhance the efficiency and capacity of the national airspace system to address current delays and congestion in the system and to accommodate forecasted increases in air traffic will be dependent on the timely development of rules and standards.

Ensuring the availability of adequate resources for icing-related R&D. NASA is a key source of R&D related to icing. The agency performs fundamental research related to icing in house and sponsors such research at universities and other organizations. According to NASA officials, possible areas for increased support for R&D that could be helpful include pilot training, supercooled large drop simulation (both experimental and computational), engine icing, and the effects of icing on future aircraft wing designs. However, the amount of NASA resources (including combined amounts of NASA's budget and funding from FAA for aircraft icing R&D at NASA facilities) and staffing for icing research have declined significantly since fiscal year 2005, as shown in figure 4. According to NASA officials, there were several contributing factors to the decline in available resources including the fiscal constraints on the overall federal budget, a shift in the Administration's priorities for NASA, as well as a restructuring within the NASA's aeronautical programs to reflect the available resources and priorities. Because the outcomes of R&D are often required for the development of rules and standards, as well as for technological innovation, a decline in R&D resources can delay actions that would promote safe operation in icing conditions.

In June 2008, the FAA sponsored a symposium on fatigue management that provided an opportunity for subject matter experts to come together and discuss fatigue's effects on flight crews, maintenance personnel, and air traffic controllers. NTSB believes that fatigue management plans may hold promise as an approach to dealing with fatigue in the aviation environment. However, NTSB considers fatigue management plans to be a complement to, not a substitute for, regulations to prevent fatigue.

Figure 4: NASA Funding and Staffing for Icing-Related R&D, Fiscal Years 2005-2013



Sources: GAO presentation of NASA data.

Notes: Funding data represents three sources of funding for icing research at NASA. According to NASA, complete data are available for one source, while data for another source are only available for fiscal years 2005-2010, and data for the third source are only available for fiscal years 2005-2009. Amounts do not reflect icing-related funds received or could be received through other government programs or external partnership (i.e. Boeing) agreements. The funding costs do not include amounts for staffing.

According to FAA's chief scientist for icing, NASA's research to understand how icing affects various makes and models of aircraft in real time, which would ultimately help pilots determine how to respond to specific icing encounters, has been adversely affected by cuts to NASA's icing research budget. He further said that without NASA's research efforts, it would be uncertain who would conduct potentially important icing research.

Ensuring that pilot training is thorough, relevant, and realistic. Another icing-related challenge to aviation safety is pilot training. Aviation experts told us that pilots are likely to encounter icing conditions beyond their aircraft's capabilities at least once in their career. It is therefore important that pilots be trained to handle such conditions. Currently, icing must be covered in a commercial pilot's initial training and, while recurrent training may not always emphasize icing, it is covered on a rotational basis. Different weather conditions affect aircraft performance in a variety of ways, making it critical that pilots receive training relevant to the conditions they are likely to encounter. For example, it is important that regional airline operators provide region-specific training to their pilots as regional airline consolidations may cause pilots to fly a geographically wider variety of routes with more variation in weather conditions. Regarding pilot training, in January 2010, the FAA Administrator said, "The flying public needs to have confidence that no matter what size airplane they board, the pilots have the right qualifications, are trained for the mission, are fit for duty. . . . We know we need to reexamine pilot qualifications to make sure commercial pilots who carry passengers have the appropriate operational experience—they need to be trained for the mission they are flying." As part of our ongoing work, we will examine FAA pilot training requirements and the extent to which FAA ensures pilots are adhering to FAA training requirements in our final report.

Simulators are used to train pilots of large commercial airplanes for in-flight icing because it is not feasible to train in actual icing conditions, as they are difficult to predict and hazardous. However, reliance on simulators for training means that pilots may not be sufficiently prepared for a variety of real-world icing conditions. According to representatives of the Aerospace Industries Association, some characteristics of icing cannot currently be replicated and to improve simulators, researchers need to develop engineering tools to characterize ice shapes such as those resulting from supercooled large drops.

Ensuring the collection and distribution of timely and accurate weather information. Improving the quality of weather information could reduce the safety risks associated with winter weather operations. Pilots and operators use weather forecasts to decide whether it is safe to start a flight or, once aloft, whether it is preferable to continue on to the destination or divert to an alternate airport. Weather experts explained that weather forecasters are still far from being able to precisely predict icing conditions in the atmosphere and the impact of such conditions on individual aircraft. For this reason, FAA said icing forecasters generally provide overly cautious forecasts that cover a broad area. While this serves to warn pilots that icing could occur, representatives of the Air Line Pilots Association said that too many false alarms result in pilots ignoring subsequent forecasts of icing. These representatives also said that pilots do not know when they are entering severe conditions, as they are only given generalized statements about icing conditions.

Providing pilots with accurate weather information has been a long-standing concern: FAA's 1997 Inflight Aircraft Icing Plan recommended improving the quality and dissemination of icing weather information to dispatchers and flight crews. Since 1997, FAA, in conjunction with NOAA and NCAR, has developed improved icing forecasting products to improve icing weather information. Icing-related research is an important component of planning for the NextGen initiative. Currently, NextGen weather researchers are focused on creating technology and procedures that enable forecasters to provide pilots with more precise predictions of icing conditions, which they believe will address the problem of pilots ignoring traditionally unreliable icing forecasts. According to NWS and NCAR, real-time information about weather conditions could help forecasters create more precise forecasts and communicate the existence of dangerous weather conditions to pilots.

Developing a more integrated approach to effectively manage winter operations. FAA indicated that developing an integrated approach to effectively manage winter operations is among its top challenges related to aviation icing. It is important for FAA and the aviation industry to focus on how components of the aviation system interact and affect one another during winter operations. Airport surface conditions, aircraft ground deicing, aircraft in-flight icing and icing certification, the dissemination of airport condition information, air traffic handling of aircraft in icing conditions, and air traffic arrival and departure sequencing should be considered together as vital to safe operations in icing conditions and should not be viewed in isolation.

Mr. Chairman, we are continuing to collect and analyze information related to the issues that we have presented here today and expect to provide this Subcommittee and the co-requesters of this study a final report as soon as possible. This concludes my prepared statement. I would be happy to respond to any questions you or other Members of the Subcommittee may have at this time.

GAO Contact and Staff Acknowledgments

For further information about this testimony, please contact Gerald Dillingham at (202) 512-2834. Individuals making key contributions to this testimony included Laurel Ball, Shareea Butler, Colin Fallon, David Goldstein, Brandon Haller, David Hooper, Joshua Ormond, and Sally Moino.

Appendix I: FAA's Funding to the Airport Improvement Program for Icing-Related Projects, 1999—2009, by State and City

State/City	Year	Acquire aircraft deicing equipment	Construct deicing containment facility	Total amount
AK				
Fairbanks	2003		✓	**$2,069,333**
CO				
Denver	2000		✓	**299,974**
Denver	2001		✓	**6,200,000**
Denver	2004		✓	**7,700,000**
Denver	2005		✓	**9,909,845**
Denver	2005		✓	**3,211,130**
Denver	2006		✓	**2,634,739**
CT				
New Haven	2001		✓	**67,092**
IA				
Dubuque	2006	✓		**221,417**
IL				
Belleville	2005		✓	**202,572**
Belleville	2009	✓		**507,900**
IN				
Indianapolis	1999		✓	**5,654,999**
KS				
Wichita	1999	✓		**128,350**
Manhattan	2001	✓		**37,438**
Manhattan	2002	✓		**123,971**
KY				
Covington	1999		✓	**1,210,000**
Covington	2000		✓	**269,057**
Lexington	2000		✓	**198,000**
Lexington	2001		✓	**2,399,244**
Paducah	2007		✓	**91,037**
MD				
Baltimore	1999		✓	**3,403,519**
ME				
Bangor	2004		✓	**399,599**
Bangor	2005		✓	**1,384,222**

State/City	Year	Acquire aircraft deicing equipment	Construct deicing containment facility	Total amount
MI				
Detroit	2005		✓	**$2,950,000**
Detroit	2008		✓	**3,800,000**
Detroit	2009		✓	**1,889,237**
Kalamazoo	2004		✓	**203,468**
MN				
Bemidji	2005		✓	**12,065**
Bemidji	2005	✓		**161,478**
Brainerd	2008	✓		**204,250**
Hibbing	2005	✓		**280,690**
International Falls	2007	✓		**205,899**
Minneapolis	2001		✓	**7,660,984**
Minneapolis	2003		✓	**10,204,941**
St. Cloud	2000		✓	**58,500**
St. Cloud	2007	✓		**204,250**
MO				
Kansas City	2003		✓	**150,000**
Kansas City	2005		✓	**5,589,005**
Kansas City	2006		✓	**4,463,462**
MT				
Bozeman	1999		✓	**91,328**
Missoula	2008		✓	**4,363,460**
NC				
Charlotte	1999		✓	**145,051**
Kinston	2001	✓		**167,943**
NJ				
Morristown	2004		✓	**1,579,259**
NM				
Roswell	2008	✓		**116,051**
NY				
Buffalo	2006		✓	**816,891**
Buffalo	2008		✓	**500,000**
Islip	2009	✓		**288,591**
Islip	2007		✓	**46,550**
Ithaca	2009	✓		**113,735**

State/City	Year	Acquire aircraft deicing equipment	Construct deicing containment facility	Total amount
New York	2003		✓	**$6,856,488**
Newburgh	2000		✓	**1,400,000**
Rochester	2000		✓	**1,858,022**
Rochester	2001		✓	**973,860**
White Plains	2003		✓	**369,855**
White Plains	2003	✓		**262,678**
White Plains	2007	✓		**581,613**
White Plains	2008	✓		**296,283**
White Plains	2009	✓		**473,991**
OH				
Akron	2005		✓	**4,993,313**
Akron	2006		✓	**5,000,000**
Columbus	2002		✓	**5,173,023**
Toledo	2006		✓	**861,735**
Toledo	2007		✓	**77,524**
Toledo	2005		✓	**746,756**
Youngstown/ Warren	2008	✓		**246,687**
Youngstown/Warren	2007		✓	**22,609**
OK				
Tulsa	2004		✓	**381,239**
OR				
Portland	2000		✓	**6,173,126**
Portland	2001		✓	**9,645,738**
Portland	2002		✓	**488,743**
PA				
Bradford	2003	✓		**144,425**
Harrisburg	2000	✓		**86,920**
Latrobe	2006	✓		**118,883**
Philadelphia	2000	✓		**17,915,168**
Pittsburgh	2001		✓	**1,000,000**
Pittsburgh	2002		✓	**2,430,965**
Pittsburgh	2007		✓	**6,115,219**
Pittsburgh	2008		✓	**6,775,000**
State College	2002		✓	**89,092**

State/City	Year	Acquire aircraft deicing equipment	Construct deicing containment facility	Total amount
State College	2003		✓	**$221,883**
State College	2004		✓	**3,919,476**
TN				
Memphis	2007		✓	**1,440,412**
Memphis	2008		✓	**286,591**
Nashville	1999		✓	**1,356,970**
Nashville	1999	✓		**214,294**
Nashville	2000		✓	**832,306**
Nashville	2000	✓		**131,416**
Nashville	2007		✓	**44,491**
TX				
Beaumont/Port Arthur	2006	✓		**88,825**
Dallas-Fort Worth	1999		✓	**7,878,022**
Dallas-Fort Worth	2000		✓	**1,223,254**
Dallas-Fort Worth	2003		✓	**750,000**
Fort Worth	2003		✓	**13,075**
VA				
Roanoke	2002	✓		**387,827**
WA				
Bellingham	1999		✓	**75,000**
WI				
Eau Claire	2005	✓		**220,000**
Green Bay	2001		✓	**605,700**
WV				
Clarksburg	2001		✓	**66,825**
Clarksburg	2002		✓	**230,683**
Clarksburg	2004	✓		**220,139**
Huntington	1999		✓	**577,789**
WY				
Sheridan	1999		✓	**58,850**

Source: GAO analysis of FAA data.

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