DOT/FAA/TC-14/44

Federal Aviation Administration
William J. Hughes Technical Center
Aviation Research Division
Atlantic City International Airport
New Jersey 08405

The Icemaster Database and an Analysis of Aircraft Aerodynamic Icing Accidents and Incidents

June 2015

Final Report

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/TC-14/44		

4. Title and Subtitle	5. Report Date
THE ICEMASTER DATABASE AND AN ANALYSIS OF AIRCRAFT AERODYNAMIC ICING ACCIDENTS AND INCIDENTS	June 2015
	6. Performing Organization Code ANG-E28
7. Author(s) Steven D. Green	8. Performing Organization Report No.
9. Performing Organization Name and Address Flight Operations Research 159 Beartown Road Underhill, VT 05489	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration 1517 Arthur Ave. Lakewood, OH 44107	13. Type of Report and Period Covered Final Report
	14. Sponsoring Agency Code AIR-100

15. Supplementary Notes

The Federal Aviation Administration Aviation Research Division COR was Timothy G. Smith.

16. Abstract

An investigation of in-flight and ground aircraft icing events from January 1982 to November 2011 was conducted. The first step in the investigation was to develop a comprehensive database (named Icemaster) of icing events during that period. The second step was to use this database to perform a statistical analysis of the entire database and a separate analysis of the initial conditions, occurrences, and pilot actions for each of the events.

Icemaster was constructed from the National Transportation Safety Board (NTSB) Aviation Accident Database, the Federal Aviation Administration's (FAA's) Accident/Incident Data System, and the National Aeronautics and Space Administration's Aviation Safety Reporting System (ASRS). This entailed a thorough, rigorous process of screening more than 200,000 event reports, which resulted in the final Icemaster database containing 308 in-flight icing events and 248 ground icing events.

Each event in the Icemaster database was analyzed with respect to initial conditions; ice protection type and operation during the event; and sequence of aerodynamic occurrences and pilot actions leading to the final outcome. The entire database was statistically analyzed with respect to historical trends for accidents and events; meteorological factors; aircraft power loadings; wing airfoil; and pilot experience.

The report yields more than 20 major findings and a number of conclusions and recommendations. Among the major findings are: (1) the majority of in-flight icing events with aircraft damage and personal injury were associated with a failure to operate the ice protection systems, (2) failure to ensure the complete removal of frozen contaminants from the critical surfaces occurred in 44% of the ground icing events, and (3) although the NTSB, FAA, and ASRS databases contain a wealth of information on aircraft events, inconsistencies, non-uniformity, and omissions in event documentation sometimes made both event and statistical analysis more difficult and less conclusive.

17. Key Words	18. Distribution Statement
Aircraft icing, Icemaster, Database, Icing accidents, Icing incidents	This document is available to the U.S. public through the National Technical Information Service (NTIS), Springfield, Virginia 22161. This document is also available from the Federal Aviation Administration William J. Hughes Technical Center at actlibrary.tc.faa.gov.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	135	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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LIST OF ACRONYMS

AIDS	Accident/Incident Data System
ASRS	Aviation Safety Reporting System
ASW	Artificial stall warning
ATC	Air traffic control
ATPL	Airline transport pilot license
BTS	Bureau of Transportation Statistics
CFR	Code of Federal Regulations
CVR	Cockpit voice recorder
DFDR	Digital flight data recorder
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FOD	Foreign object debris
GAATA	General Aviation and Air Taxi Activity
ICTS	Ice contaminated tailplane stall
IPS	Ice protection system(s)
L/D	Lift/drag
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NFDC	National Flight Data Center
NTSB	National Transportation Safety Board
SLD	Supercooled large droplet
STC	Supplemental type certificate
TAT	Total air temperature
TCDS	Type Certificate Data Sheets
TKS	Tecalemit/Kilfrost/Sheepbrige Stokes (Anti-icing/deicing system developed by three companies)

EXECUTIVE SUMMARY

An investigation of in-flight and ground aircraft icing events from January 1982 to November 2011 was conducted. The first step in the investigation was to develop a comprehensive database (named Icemaster) of icing events during that period. The second step was to perform a statistical analysis of the entire database and a separate analysis of the initial conditions, occurrences, and pilot actions for each of the events.

Icemaster was constructed from three prominent data sources: the National Transportation Safety Board (NTSB) Aviation Accident Database, the Federal Aviation Administration's (FAA's) Accident/Incident Data System, and the National Aeronautics and Space Administration's Aviation Safety Reporting System (ASRS). This entailed a thorough, rigorous process of screening more than 200,000 event reports. There were several levels in the process, beginning with identification of reports with words or phrases possibly associated with icing events and followed by several steps of exclusion of reports not pertaining to aircraft icing. The final Icemaster database contains 308 in-flight icing events and 248 ground icing events.

Each event in the Icemaster database was analyzed with respect to initial conditions; ice protection type and operation during the event; and sequence of aerodynamic occurrences and pilot actions leading to the final outcome. The entire database was statistically analyzed with respect to historical trends for accidents and events; meteorological factors; aircraft power loadings; wing airfoil; and pilot experience.

Major findings for in-flight icing include:

- The majority of events with aircraft damage and personal injury were associated with a failure to operate the ice protection system(s) (IPS)

- Although substantial airframe damage can be incurred without a stall, nearly all of the total hull losses and fatalities resulted from events that included a stall

- Supercooled large droplet conditions were associated with 35% of the aircraft destroyed, 39% of those substantially damaged, and 34% of the fatal accidents

The ground icing analysis showed that the failure to ensure the complete removal of frozen contaminants from the critical surfaces occurred in 44% of the events. Analysis of a number of events lent further support to the existing evidence that the ability of the cockpit crew to execute an effective cabin check for large aircraft may be limited.

The NTSB, FAA, and ASRS databases contain abundant information on aircraft events, and the icing events from those databases now populate the Icemaster database. However, inconsistencies, nonuniformity, and omissions in event documentation sometimes made both event and statistical analysis more difficult and less conclusive. Aircraft models were sometimes inconsistently designated, serial numbers were sometimes incomplete, and IPS usage was often inadequately documented.

1. INTRODUCTION

Following accidents at Roselawn, Indiana in October 1994 and Monroe, Michigan in January 1997, substantial effort was made to improve the understanding of aerodynamic icing events from the standpoints of design and certification and as flight operations. It was immediately apparent that there was not a robust understanding of the existing accident and incident data and that gaining such an understanding was seriously impeded by the absence of uniform, comprehensive data. This report describes the development and results of a multiyear effort to produce the requisite understanding of aerodynamic icing accidents and incidents, originally undertaken as a part of the Ice Protection Harmonization Working Group tasking in 1999 and then expanded under Federal Aviation Administration (FAA) contract from 2006–2012.

2. THE ICEMASTER DATABASE

The core of this investigation was the development of a relational database known as Icemaster. The principal function of this database is twofold: first, the standardization, unification, and organization of the existing data; second, a rigorous and consistent analysis of each event.

2.1 FILEMAKER SOFTWARE

The foundation for this project is Filemaker® 11, a relational database application. Its value was enhanced when an open database connectivity plug-in was developed that allowed data to be imported into Filemaker from a Microsoft® Access® database similar to that used by the National Transportation Safety Board (NTSB) for their Aviation Accident Database. This allowed complete access to all of the data in the NTSB's public files.

Filemaker also allowed for relational databases to be built that supported the working Icemaster database. This will be explained in subsequent sections.

2.2 DATA SOURCES

Three data sources were used: the NTSB Aviation Accident Database, the FAA Accident/Incident Data System (AIDS), and the National Aeronautics and Space Administration's (NASA's) Aviation Safety Reporting System (ASRS). The entire NTSB Aviation Accident Database and FAA AIDS databases were downloaded and incorporated into individual Filemaker databases. The entire ASRS database could not be downloaded; therefore, ASRS datasets were developed by conducting online searches.

The largest source of data was the NTSB Aviation Accident Database, which can be accessed online [1]. The NTSB data were limited to 1982 and later, yielding 69,807 events as of November 26, 2011. The reason 1982 was selected was because, prior to that year, NTSB data were formatted differently. This would have required a different construction of the Icemaster database with the possibility of some inconsistencies.

The FAA AIDS data can also be accessed online [2]. These data start January 1, 1975 and are comprised of 157,941 events as of November 26, 2011. However, to remain consistent with the

NTSB data, the FAA AIDS data used were also limited to 1982 and forward, which yields 141,655 reports.

Like the NTSB Aviation Accident Database and the FAA AIDS data, the ASRS data can be accessed online [3].

The ASRS database was initiated in 1976. The data available online are from 1988 forward. The downloaded data were based on search results from the online database. The search methods and results are described in section 3.3.

3. DEVELOPMENT OF RELATIONAL DATABASES

A separate Filemaker database was developed for each of the three source databases. These databases function to organize and decode the data obtained from the source databases; for example, all of the pertinent NTSB coded data from the Access database were translated into plain English.

Within each database, a search script was developed to identify relevant events that met the criteria for review. The script searched for information in relevant data fields, such as occurrences, sequence of events, and primary and secondary cause factors. The script also searched for a series of keywords in narrative fields and then color coded those keywords to make it easier to review the text.

3.1 THE NTSB DATA

The NTSB data, which contains all NTSB records currently in Microsoft Access format, were imported into the Filemaker relational database "NTSB Master Dataset." In "NTSB Master Dataset," several tables were searched for relevant events using a set of keywords and search terms that were selected after a review of the NTSB Access database data structure. Tables 1 and 2 describe the search script terms and keywords used to extract the data. Table 1 shows how to search to see if *ice* occurs in a data field with *wing* or *airframe* and if *icing conditions* occurs in a data field with *weather condition*. Table 2 shows the keywords searched in the summary of event (**narr_accf**), factual report of event (**narr_accp**), and cause of event (**narr_cause**) data fields.

Table 1. The NTSB Sequence-of-Event table search terms

Sequence-of-Events Table Data Field: Subject Code	Sequence-of-Events Table Data Field: Modifier Code
Wing	Ice
Airframe	
Weather condition	Icing conditions

Table 2. The NTSB Narrative table search terms

Narrative Table Data Field			Keyword
narr_accf (summary of event)	narr_accp (factual report on event)	narr_cause (cause of event)	ice
			icing
			frost
			freezing
			deice
			deicing
			stall
			buffet

In addition to the search terms shown in table 2, the **narr_accf**, **narr_accp**, and **narr_cause** fields were searched for the word *snow* when the phase of flight, as identified in the NTSB Occurrence Table **phase_of_flight** field, contained the word *takeoff*.

If *stall* or *buffet* appeared in any of the three fields in table 2, the record was initially retained. The purpose of including the *stall* and *buffet* terms was to color code those words for simpler review of the text. Events that yielded only the *stall* or *buffet* term, with no other reference to icing in any of the other fields in the Narrative, Occurrence, or Sequence of Events tables, were not retained.

The search within the "NTSB Master Dataset" Filemaker database resulted in 4194 events.

In addition to the events identified through the formal data-mining process, two events were added based on previous analysis showing an icing component not recognized by the NTSB. The first was an event of an aircraft with registration number N331PX, a Jetstream 31, at Joplin, Missouri on December 3, 1987. This event was most likely due to ice contaminated tailplane stall (ICTS). The second event involved an aircraft with registration number N1356P, an Embraer EMB-110, at Alpena, Michigan on March 13, 1986. This event indicated a change in lift/drag (L/D) ratio during a night approach in freezing precipitation.

Two additional Jetstream 31 ICTS events were added, both based on information included in the report for N167PC, a Jetstream event at Beckley, West Virginia. The two additional events were

for N838JS at Dayton, Ohio on December 23, 1990, and for an unidentified Jetstream 31 at Dayton, Ohio with the data and registration not specified.

After the addition of these events, the "NTSB Master Dataset" contained 4172 events.

3.2 THE FAA AIDS DATA

The FAA AIDS data were populated into the Filemaker relational database "AIDS Master Dataset." This database contains all data available from the Data Downloads page of the FAA website [2]. The "AIDS Master Dataset" database is comprised of two tables: one containing the narrative (Master Narrative Table) and a second containing all of the data except the narrative (Master Detail Table). The database fields are not titled, but instead identified by a letter-number code. Tables 3–5 detail the search terms and keywords used to extract the relevant events and the constraint terms used to filter out nonrelevant events. The "AIDS Master Dataset" search yielded 3992 events as of November 2011.

Table 3. The FAA Master Detail Table search terms

Master Detail Table Data Field	Search Term
C80	Icing on aircraft
C88	
C78	IMP/INADEQ SNICE/REMOVE FROMAC*
C86	

* = Improper/Inadequate Snow or Ice Removal From Aircraft

Table 4. The FAA Master Narrative Table search terms

Master Narrative Table Data Field	Search Term or Keyword
remark	ice
	icing
	frost
	freezing
	deice
	deicing
	stall
	buffet

Note 1: Events in which the **remark** field contained the term *snow* were also evaluated for several phases of flight pertaining to takeoff.
Note 2: Events that yielded only the *stall* or *buffet* term were not included.

Table 5. The FAA Master Detail Table snow terms

Master Detail Table Data Field	Search Term
C96	TAKEOFF GROUND ROLL
	TO INIT CLIMB (1ST PWR REDUCT)
	TO ABORTED (FIXED WING)
	TO ABORTED (COPTER/RUN TAKOFF)
	TO RUNNING (HELICOPTER/VTOL AC)
	TO VERTICAL (HELICOPTER ONLY)

3.3 THE ASRS DATA

The ASRS data were handled differently than the preceding two data sources because the entire ASRS database could not be downloaded and searched locally. This was due to a limitation on public access. Therefore, the ASRS database had to be searched online.

The primary search was performed using keyword occurrences in the **narratives** and **synopsis** fields. The keywords used were: *ice*, *icing*, *deice*, *deicing*, *freezing*, *frost*, *stall*, and *buffet*.

A second set of data were downloaded using a different search strategy. In this case, different fields were queried with logical terms that may pertain to icing and its effects. Table 6 shows the searches used.

Table 6. The ASRS search terms

ASRS Standardized Web-Based Data Constraints	Search Term
Environment_Weather	Icing
	Snow
Event Type_Inflight Event/Encounter	CFTT/CFIT
	Loss of Aircraft Control
	Altitude Excursion
	Unstabilized Approach
Aircraft_Flight Phase	Takeoff and Taxi (limited to narratives and synopses containing “snow”)
Primary Problem	Weather

CFTT = controlled flight toward terrain; CFIT = controlled flight into terrain

The results were populated into the Filemaker relational database “ASRS Master Dataset.” Because these different searches often yielded the same report, it was necessary to construct a duplicate filter within the “ASRS Master Dataset” database. The output of both search strategies was 18,798 ASRS reports.

This large set was narrowed in three ways:

1. Searching the **narrative**, **synopsis**, and **anomaly** fields for the following keywords: *ice*, *icing*, *deice*, *deicing*, *frost*, *freezing*, *stall*, *buffet*, and *snow*.

2. Identifying events in which the word *snow* appears in either the **narrative** or **synopsis** fields, and in which the flight phase is *taxi* or *takeoff*.

3. Searching the field **Weather Elements_Visibility** for these terms: *ice*, *icing*, *freezing*, and *frost*.

As was the case with the NTSB and FAA AIDS data, events yielding only the *stall* or *buffet* term were not included. The output of this refined search within "ASRS Master Dataset" was 5736 events.

4. CONSTRUCTION OF THE DATABASE

The Icemaster database was constructed with eight principal tables, as shown in table 7.

Table 7. Icemaster principal tables

Table Names	Number of Fields
Master	77
Aircraft	63
Meteorology	53
Disposition	106
Location	29
Discrimination	126
Analysis	113
Ishikawa	97

Each report in the Master table was given a database event ID number for reference to external databases. This number is the ev_id number for NTSB reports, the c5 field number for FAA AIDS data, and the ASRS record number for ASRS reports. These eight tables were then interrelated through a unique serial number generated for each report entered into the master table. This arrangement allowed duplicates to be identified by comparing the database event ID number with individual serial numbers.

These tables were populated with the output of searches that used the criteria for each source database described in section 3.

It is common for one event to generate a report in both the NTSB and FAA source databases. Typically, the FAA generates a separate report for an event investigated by the NTSB. Separate

reports for the same event also occur, to a lesser extent, between the ASRS database and the NTSB/FAA databases. The first step in the process of identifying multiple reports that describe the same event in the three source databases is a calculation completed in the Disposition table that matches NTSB and FAA reports. This calculation compares the aircraft registration between the NTSB and FAA data within the Icemaster database. When a match is found, the FAA report is subordinated to the NTSB report.

The ASRS reports contain no aircraft registration numbers and have limited date information. A database portal was developed to identify an ASRS report for the same event as another NTSB or FAA report. The portal searches for ASRS reports from the same state, year, and month as the NTSB or FAA report. The search is accomplished through a link to the "ASRS Master Dataset" described in section 3.3. The search results are displayed in the portal and a city name is associated with each report, enabling the investigator to more quickly find multiple reports for the same event. When an ASRS report is found that matches an NTSB or FAA report, it is subordinated to the NTSB or FAA report. If it is not already in the Icemaster database, it is imported automatically.

This technique proved so successful that similar portals were developed with links to the "NTSB Master Dataset" and "AIDS Master Dataset" databases. This was an effective way of circumventing the shortcomings in automatic data linking due to inaccurate data entry. It is common, for example, to find an NTSB report and an FAA report for the same event, differing in date by one day.

This process resulted in the following nonoverlapping sets of events:

- 1858 events with an NTSB and FAA report
- 20 events with an NTSB, FAA, and ASRS report
- 1 event with an NTSB, FAA, and 2 ASRS reports
- 38 events with an FAA report and an ASRS report
- 3 events with an FAA report and 2 ASRS reports
- 21 events with 2 ASRS reports

If an NTSB report existed, it was always considered the master report. If no NTSB report existed, the FAA report was considered the master report. If neither an NTSB report nor an FAA report existed, the first ASRS report was considered the master. The subordination system linked the reports together so that only one analysis was completed for each event.

The architecture of the Icemaster database takes into account this hierarchy among multiple reports for one event (see figure 1). The basic concept was to display all analysis data fields. The primary view shows data for the event, which includes meteorology data, aircraft certification data, and location data. While looking at this view, it is possible to select and display any of the **narrative**, **aircraft**, or **meteorology** data fields from the NTSB, FAA, and ASRS reports. This allows comparison and verification of data used in the master analysis.

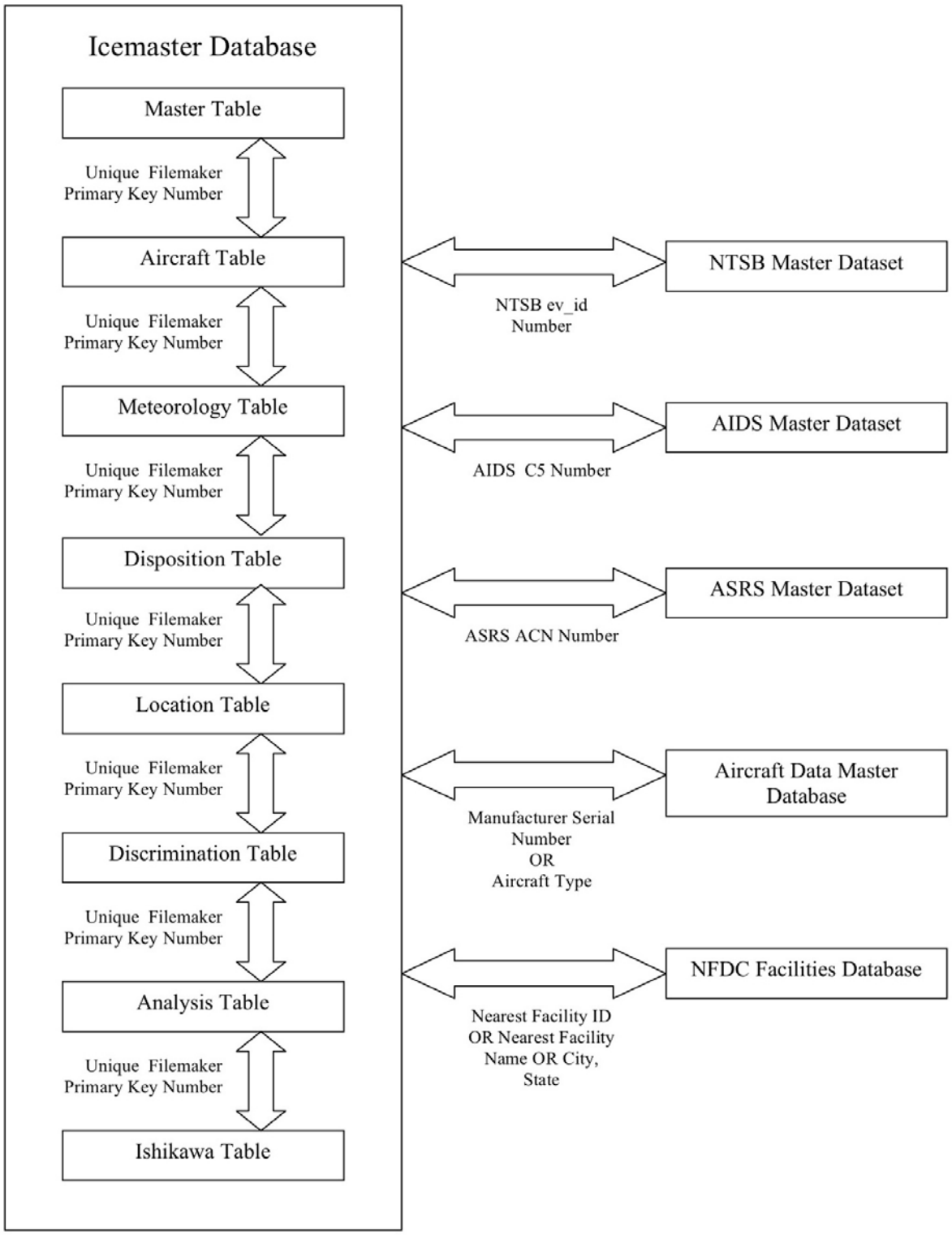

Figure 1. Icemaster database architecture

The output of the analysis is in the form of an individual Ishikawa diagram for each event (see figures 2 and 3). Most of this diagram is constructed directly from the Analysis table data fields,

but some parts of the diagram require additional manipulation of the data within the Ishikawa table. No analysis of the data is completed in the Ishikawa table; it serves only to facilitate the organization and presentation of the data.

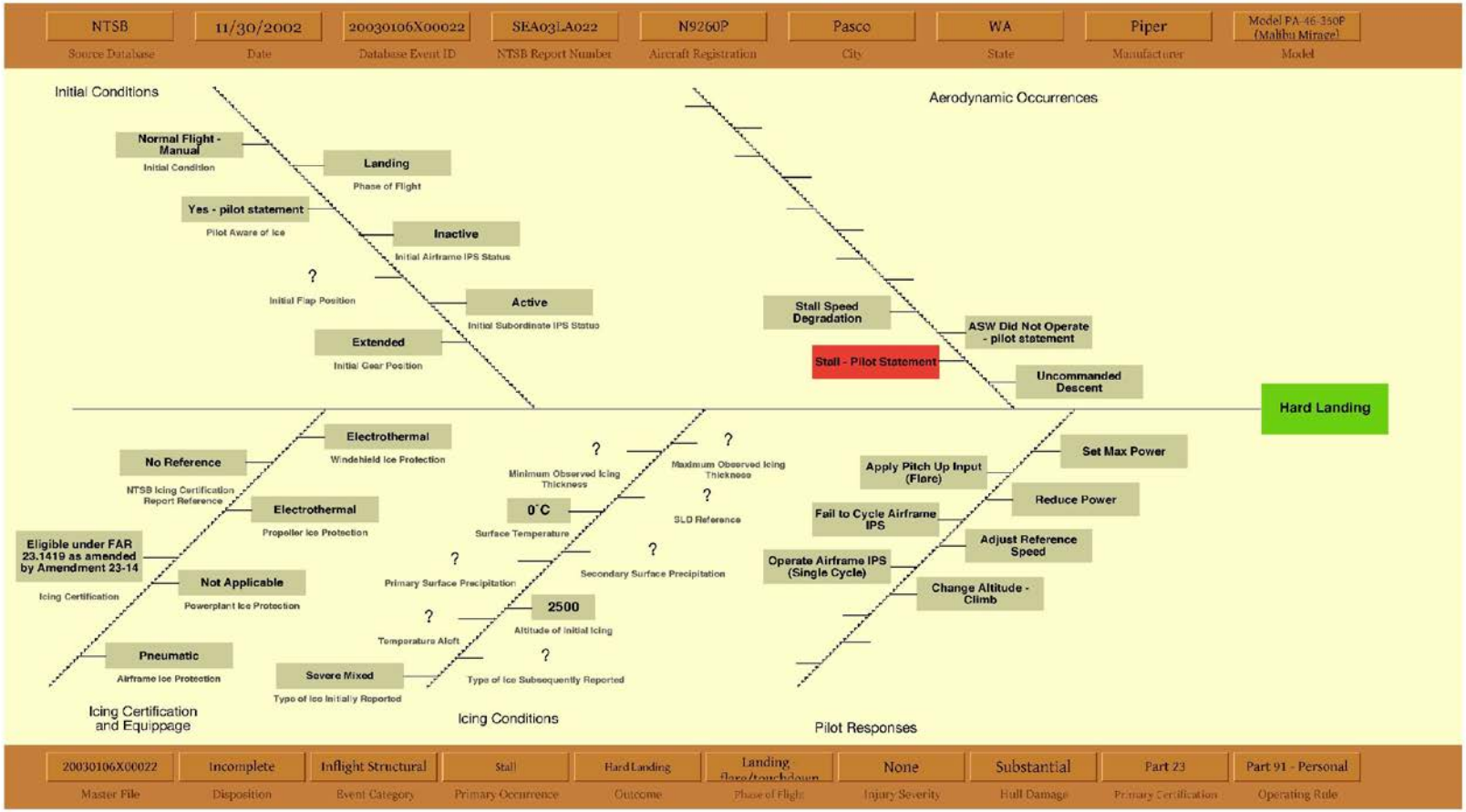

Figure 2. Example Ishikawa diagram—hard landing

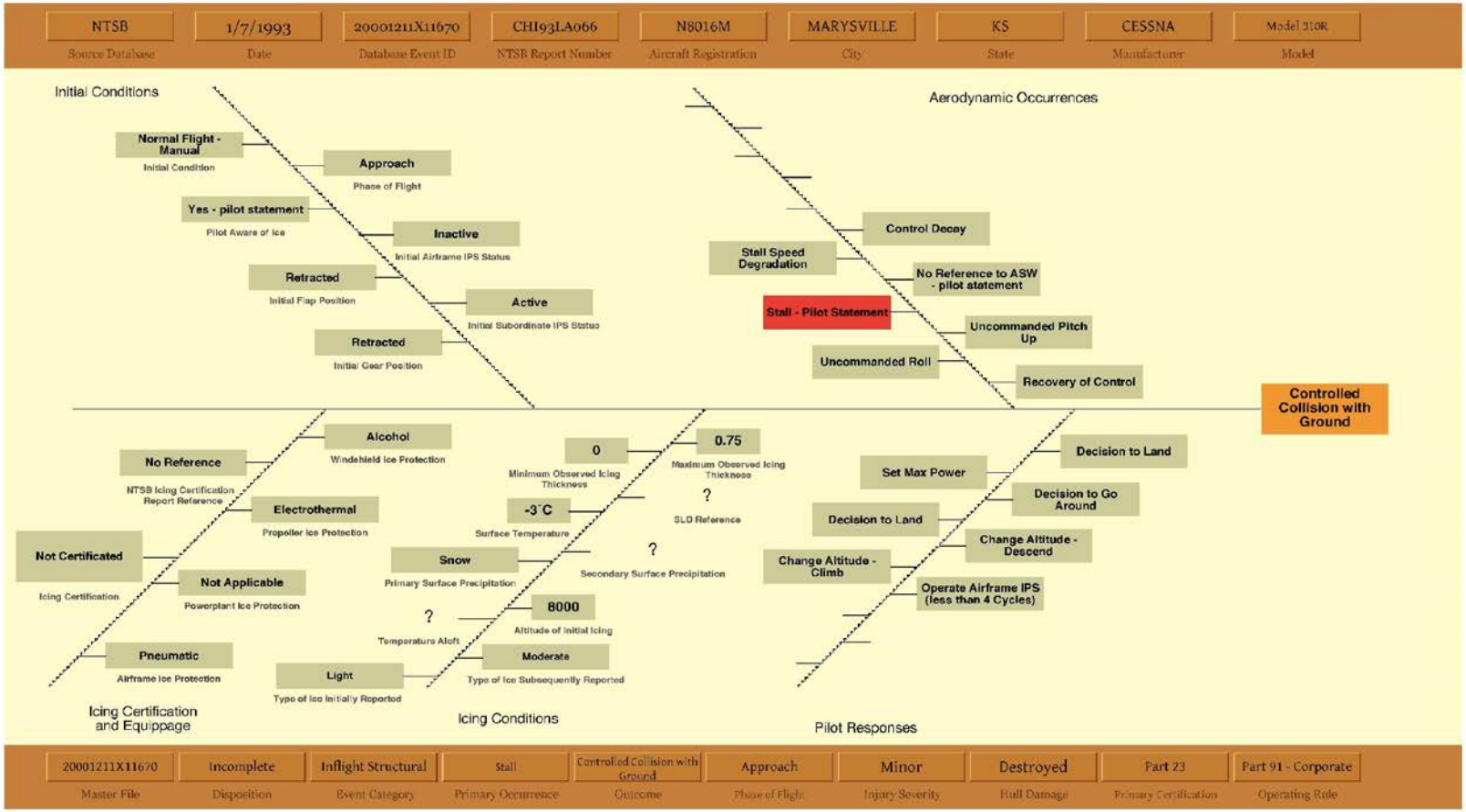

Figure 3. Example Ishikawa diagram—controlled collision with ground

The Aircraft table is related to all the other Icemaster tables and is also related to a separate, free-standing Filemaker database known as the "Aircraft Data Master Database." This separate database incorporates information from the Type Certificate Data Sheets (TCDS) of each aircraft in the database. The primary search relationship between the Aircraft table and the "Aircraft Data Master Database" is through the manufacturer's serial number. If that cannot be used, a generic search is done with allowance for a manual override. This allows the investigator to accept generic type certificate data if it is known to be valid or to manually overwrite it when appropriate.

Many of the data fields that accept analysis inputs are filled using a dropdown menu, ensuring standard data input.

To extract data for statistical and timeline-based analysis, an additional set of tables was constructed. These tables were designed to extract and aggregate data based on calendar criteria, and then export it in a form accepted by Microsoft Excel®. Likewise, a set of data extraction algorithms was constructed within the Icemaster database for data extraction not requiring a calendar count. Excel was used as the platform for statistical presentation and charting.

The Location table uses data from the National Flight Data Center (NFDC) stored in the "NFDC Facilities" database, another separate, free-standing Filemaker database, to extract latitude and longitude coordinates based on location information in the reports. The information may take the form of a simple city and state or may be in the form of an airport or facility identifier. In the NTSB reports that include a latitude and longitude for the accident site, the data are retained and the search results are discarded. The "NFDC Facilities" database was constructed using downloadable Excel data from the NFDC website [4].

5. INITIAL DATA EXCLUSION

Two levels of data exclusion were executed prior to beginning the detailed analysis, and one was executed during the analysis.

5.1 FIRST LEVEL OF DATA EXCLUSION

Five principal criteria for exclusion were considered prior to the actual analysis of each event:

1. The presence of carburetor icing, which could explain *ice* in the text.

2. The presence of fuel contamination.

3. Any loss of directional control on the ground that implied the aircraft was moving on an icy surface.

4. The absence of ice-protection equipment, with the exception of cases involving the takeoff flight phase.

a. The absence may have been inferred because the particular model was never eligible for the addition of ice-protection equipment.

b. The absence may have been inferred because only a post-manufacturing supplemental type certificate (STC) for ice-protection equipment existed (without a manufacturing option) and the terms *boot* or *TKS* did not appear in any text.

5. A flight phase (e.g., standing, parked, or taxi) that suggested the event was unqualified as an aircraft icing event.

a. The taxi phase of flight was not examined in either NTSB or FAA AIDS events because an event involving icing of aerodynamic surfaces (as opposed to movement surfaces) generally does not lead to an accident or reportable incident. In the ASRS data, the taxi phase was evaluated to recover data related to inadequate deicing.

Tables 8–12 show the specific constraint terms and keywords used to eliminate unqualified events.

Table 8. The NTSB Sequence-of-Events table constraint terms

Sequence-of-Events Table: Subject Code	Sequence-of-Events Table: Modifier Code
Fuel	Ice
	Contamination

Table 9. The NTSB Narrative table constraint terms

Narrative Table Data Field			Keyword
narr_accf,	narr_accp,	narr_cause	carburetor icing
			carburetor ice
			carb icing
			carb ice
			carburetor heat
			carb heat
			fuel contamination
narr_cause			failure to maintain directional control

Table 10. The NTSB Occurrence table constraint terms

Occurrence Table Data Field	Keyword
phase_of_flight	standing
	taxi

Table 11. The FAA Master Detail Table constraint terms

Master Detail Table Data Field	Search term
C6	<1982
C80	ICE/SLUSH RUNWAY
C88	ICE/SLUSH RUNWAY
C94	LOSS OF DIR CTL-GRND LOOP
	LOSS OF DIRECTIONAL CONTROL
C96	STARTING ENGINES
	IDLING ENGINES
	ENGINE RUN-UP
	IDLING ROTORS
	OPS ON GRND TO TKOF/RTRCRFT
	GROUND TAXI, OTHER AIRPLANE
	OTHER GROUND OPS
	ROLL-OUT (FIXED WING)
	ROLL-OUT (ROTORCRAFT)
C78	MISUSE CARBHT/DEIC PROC TB ENG
C86	MISUSE CARBHT/DEIC PROC TB ENG

Table 12. The FAA Master Narrative Table constraint terms

Master Narrative Table Data Field	Search term
remark	carburetor ice
	carburetor icing
	carb ice
	carb icing
	carburetor heat
	carb heat

Some additional tailoring of the data was done to account for such things as misspellings of the word "carburetor," different word orders in the narrative (e.g., carb bowl full of ice), and similar artifacts.

The data reduction described in this section resulted in 9176 remaining events.

5.2 SECOND LEVEL OF DATA EXCLUSION

Three additional steps were taken to eliminate events before beginning analysis. Part of this process was described in section 4.

First, the NTSB and FAA data were evaluated for commonality. Nearly all NTSB reports have a corresponding FAA report. Linking these appropriately adds information to the analysis and prevents the same event from being counted and analyzed twice. The reports were linked using an algorithm that searched for the aircraft registration and date between the two datasets. When both parameters corresponded, the two reports were linked automatically.

The second step was far more labor intensive and may be regarded as the first real analysis done with the reports. This involved a quick review of the **probable cause** (NTSB), **remark** (FAA), and **synopsis** (ASRS) of the remaining reports to determine their relevance. A part of the data extraction described in sections 3.1–3.3 involved color coding the text of keywords in the text fields, therefore making it easier to conduct a quick review.

Some shortcuts were applied to this search process. In the NTSB data, reports that contained keywords only in the factual report, but not the narrative or probable cause, were excluded. In the ASRS data, reports that contained only the word *snow* and did not explicitly reference a takeoff flight phase were excluded if the **anomaly** field did not contain references (e.g., "aircraft equipment problem – critical" or "inflight encounter with weather") that were known to be consistent with actual aerodynamic occurrences.

This second level of data reduction resulted in 1851 remaining reports available for analysis.

The third step was the subordination of related reports, previously described in section 4, which resulted in 1034 reports available for analysis.

5.3 THIRD LEVEL OF DATA EXCLUSION

The final level of data exclusion took place during the analysis. During the detailed analysis of the event, if it became apparent that certain data should not be included, then they were not. This may have been because of inadequate data, or simply because the analysis indicated that icing was not a significant factor.

6. THE USE OF NTSB PUBLIC DOCKETS

The NTSB maintains a docket for each accident or incident that it investigates. These dockets typically contain a set of relatively standard forms and may also include a large volume of additional information, depending on the event. In particular, dockets almost always contain a statement from the pilot-in-command, should he or she have survived, and witness statements and air traffic control (ATC) transcripts, if appropriate. The docket also contains photographic evidence, although the standard for this is remarkably poor. Some description of the wreckage and debris is typically included, based on the field investigator's notes. In some instances, those notes are also included.

The dockets are available in two forms, depending on their age. Events that took place earlier than approximately 1992 are stored on microfiche. Events that took place after 1992 are stored digitally. Recently, the NTSB has started putting their full dockets online.

This project used the data contained within 192 digital dockets and 176 microfiche dockets.

6.1 ORIGINAL DATA QUALITY

The consistency of data contained within the dockets is problematic. There is no assurance that any particular docket will contain the same types of documents that another docket may have. In some cases, only the NTSB Form 6120 is present, and in some of those cases, the form is not complete. Conversely, some dockets are remarkably thorough, containing original written statements and police reports.

The FAA AIDS reports are not supported by retained documentation. Therefore, additional materials—such as inspector's notes, etc.—are available only in rare cases. These materials are not obtainable through a standardized records management system. Unfortunately, the paucity of narrative documentation in many FAA reports renders them nearly unusable.

A number of errors existed between reports in factors such as date and location (e.g., the same event happening to the same aircraft registration number, but with reported dates one or two days apart). In addition, there are a few areas that make interpreting the events more challenging. The lesser of these is a propensity for the field investigator to cross off “cockpit switch documentation” under the disclaimer “switch positions not pertinent.” In the case of an icing-equipped aircraft involved in an icing accident, the switch positions for the deicing equipment are very pertinent, even considering the unreliability of post-accident documentation.

In some cases, documentation of the cockpit is impossible because of the state of the debris, particularly following a post-crash fire. However, in one case, the field documentation stated that the switches were all destroyed, though the accompanying photographs clearly showed some viable switches in positions that would have provided valuable information.

The most significant difficulty with NTSB documentation is the continuing failure to document ice protection system(s) (IPS) and certification status even when the accident clearly involves airframe icing. This problem is ubiquitous in Part 23 cases, particularly the certification status. At one point in the mid-1980s, the NTSB used a field documentation form that contained check boxes for icing equipage and icing certification. In many cases, these checkboxes were not used, even though they were present. More recent NTSB field documentation forms have no provision for the indication of ice protection equipment or certification.

There are 180 NTSB reports in the Inflight dataset. In 99 of these events, the NTSB documentation, including docket materials, makes no reference to icing certification. Seven cases exist for which the NTSB specifies that the airplane is icing certificated, but the TCDS indicates that icing certification was not an option for that airplane serial number.

In addition, a number of cases exist in which the NTSB documentation did not even formally mention icing equipage. In some cases, the icing equipage could be determined through the wreckage documentation. On occasion, icing equipage was determined by obtaining a marketing photograph available of that particular registration number on the Web, which was a last resort because there is no way to be sure that the ice protection equipment visible in the photograph was the configuration in use at the time of the event.

7. ANALYSIS METHODOLOGY

Analysis of each event included examination of the following areas:

- Initial conditions
- Aerodynamic occurrences
- Pilot actions
- Meteorology
- Aircraft equipment

7.1 INITIAL CONDITIONS

The initial conditions evaluated were:

- Autopilot operation
- Gear and flap position
- Pilot awareness of ice accretion
- Airfoil IPS status

- Subordinate IPS operation (e.g., pitot heat, prop heat, engine anti-ice, etc.)
- Windshield icing
- Over-gross-weight situations

Information on these conditions was generally obtained from the pilot or survivor statements. On occasion, it was extracted from docket documentation when it was available. The gross weight condition was considered unknown for ASRS reports—except those involving scheduled air carriers—unless specific information was available.

If the airframe IPS was a pneumatic system and was not being operated in an auto mode, the initial condition was considered inactive.

The presence of windshield icing was not sufficient for inclusion of an event in the Icemaster database if no aerodynamic occurrence was identified. However, if an aerodynamic occurrence was identified, the presence of windshield icing was included in the event description and analysis because it was important to be aware of the role it may play in an event. Windshield icing was exhibited in 41 of 308 inflight icing events.

Gear and flap positions were obtained from wreckage documentation when necessary. Pitch trim was not documented; previous efforts to do so have yielded little usable information because the field documentation is often ambiguous. For example, trim documented as “5 units down” does not explain whether this means the airplane nose was down or the trim tab itself was downwardly deflected.

7.2 AERODYNAMIC OCCURRENCES

The Analysis table contains twelve identical fields reserved for the manual entry of aerodynamic occurrences. These form the heart of the actual event analysis. The aerodynamic events are generally derived from crew, passenger, and witness statements. Digital flight data recorder (DFDR)/cockpit voice recorder (CVR) data were used when available. Though a number of different aerodynamic occurrences are documented, there are seven broad families of aerodynamic occurrences:

1. Uncommanded attitude changes and oscillations:

    a. Uncommanded pitch down
    b. Uncommanded pitch oscillation
    c. Uncommanded pitch up
    d. Uncommanded roll
    e. Uncommanded roll oscillation
    f. Uncommanded yaw
    g. Uncommanded yaw oscillation

2. Control degradations

   a. Control decay
   b. Unable to rotate
   c. Unable to flare
   d. Loss of lateral control
   e. Loss of directional control
   f. Loss of control (used when [d] or [e] cannot be positively verified)
   g. ICTS

3. Conditional performance degradations

   a. The L/D degradation

      i. Predicated on one or more reductions in performance capabilities listed under (4)

   b. Stall speed degradation

      i. Predicated on clear indications of a stall speed change due to ice accretion

   c. Performance degradation

      i. If L/D or stall speed degradation cannot be identified, the general term "performance degradation" is used

4. Reductions in or elimination of various performance capabilities

   a. Unable to accelerate
   b. Unable to climb
   c. Reduced climb performance
   d. Unable to liftoff
   e. Unable to maintain altitude
   f. Unable to maintain glide path
   g. Airspeed decay
   h. High sink rate
   i. Settled to surface
   j. Delayed liftoff

5. Buffets

   a. Aerodynamic buffet
   b. Control buffet

6. Stall warning

   a. Stick shaker operation
   b. Stick pusher operation
   c. Artificial stall warning (ASW) operation
   d. Statements affirming ASW operation
   e. Statements affirming failure of the ASW to operate
   f. Statements that, although detailed, make no reference to ASW operation

7. Stall

   a. Stall – passenger statement
   b. Stall – pilot statement
   c. Stall – inferred

      i. Predicated on subsequent loss of control, or on evidence characteristic of stall, such as wing rocking, uncommanded pitch down, etc.

   d. Stall – report narrative

Other specific events were recorded, such as deice fluid failure, engine malfunction, ice shedding, and pitch trim motion.

7.3 PILOT ACTIONS

The Analysis table contains ten fields for pilot actions. An additional field describes a reason for the action, insofar as it can be determined, for the pilot action. Pilot actions include control inputs, decisions to divert and land, preflight actions, flight path deviations, and the operation of the IPS. The data are derived almost entirely from pilot statements, with DFDR and CVR data used when available. Passenger and witness statements are also used, but to a much lesser extent.

7.4 OUTCOMES

The outcome of an event is determined from the report and/or the state of aircraft control at the time of ground contact. If the aircraft is out of control, the outcome is shown as an uncontrolled collision with the ground. If, however, the narrative clearly indicates some degree of control, then the outcome is shown as a controlled collision with the ground. Other outcomes are self-explanatory (i.e., normal landing, hard landing, land short, etc.). An abnormal landing term is used when a safe landing is made in an abnormal configuration (e.g., limited flaps or gear up).

7.5 ANALYTIC RELATIONSHIPS BETWEEN AERODYNAMIC OCCURRENCES AND PILOT ACTIONS

When interpreting the sequence of occurrences during an event, it is a significant risk to assume a relationship in time when none is documented. Without the presence of a CVR or DFDR, the sequence of occurrences may be established, but the time associated with or between occurrences

cannot reliably be determined. One use for the Ishikawa diagram is to avoid suggesting a particular timeline for the sequence of events.

The sequence of aerodynamic occurrences in each event is based on a narrative sequence as expressed in the statements given by crew, passengers, and witnesses. In many cases, very little information is available, particularly if there were no survivors. However, the absence of information does not suggest the absence of any number of typical or atypical aerodynamic occurrences. For example, in cases that result in a loss of control and uncontrolled collision with the ground, events such as wing rocking or control degradation may have taken place, but cannot be documented.

Each accident or incident is reconstructed in the way a piece of pottery might be reconstructed at an archaeological site. In most cases, it is doubtful that all of the pieces have been collected from the evidence. Some missing pieces are estimated based on a likely assembly of the existing pieces.

This reconstruction has been done to some extent in this analysis. For instance, a stall is assumed to have occurred prior to a loss of control, simply because there is no other way that ice accretion can lead to a loss of control. Performance degradation (degradation of L/D ratio, a change in the stall angle of attack, or both) is presumed to have taken place before the stall in these cases. However, depending on the extent of available information, the type of performance degradation may be indeterminate.

Many pilot actions can be related to aerodynamic occurrences. However, though a direct cause-and-effect relationship may be discernible from an aerodynamic occurrence to a pilot action, the reverse is not possible because it is almost never discernible from the narrative data. Undoubtedly, some aerodynamic occurrences are direct results of pilot actions; however, this cannot be reliably established from the available data.

7.6 CRITICAL OCCURRENCES

The critical occurrence was defined as the most severe aerodynamic occurrence to have taken place during the event. In this analysis, a stall is considered the most severe aerodynamic occurrence possible; a stall warning is less severe, and degradation of L/D ratio in the absence of any stall warning is even less severe. For example, if a stall occurred, then the stall would be the critical occurrence. If degradation of L/D ratio took place, and no other more severe aerodynamic occurrence was documented, then the degradation of L/D ratio would be identified as the critical occurrence. If a stall was preceded by degradation of L/D ratio, the stall would be identified as the critical occurrence.

7.7 PHASE OF FLIGHT

The phase of flight associated with the event is that in which the first aerodynamic occurrence took place. This is likely not the phase of flight in which icing conditions were first encountered or ice first accreted; therefore, an event may have a report of rime ice at cruise altitude but the phase of flight for the event is specified as “landing.”

7.8 ICING CERTIFICATION

Most of the aircraft in this database that were certificated for flight in icing were certificated under Federal Aviation Regulation (FAR) 23.1419, Amendment 23-14, FAR 25.1419, or earlier certification bases. No aircraft were identified that were certificated under FAR 23.1419, Amendment 23-43. A subset of aircraft, such as the Beech King Air 200 and the BAE Systems Jetstream 31, were certificated as Part 23 airplanes, but using a FAR 25 icing certification basis.

Data concerning icing certification can be problematic. For Part 25 aircraft, the assumption was made that the aircraft was certificated for icing. For Part 23 aircraft, this assumption cannot be made. If the serial number was available, either through the report or through a search of the registration, the "Aircraft Data Master" database, containing TCDS information, could be accessed to determine whether the serial number fell within the range of aircraft that were eligible for icing certification if properly equipped.

Proper equipage is a weak link in the data. Although the aircraft involved in in-flight events were known to be equipped for flight in icing, it was not possible to determine whether the equipment installed met the requirements of the certification basis. The NTSB and the FAA do not adequately record this data in their respective databases.

If the serial number could not be determined, certification was assumed if all examples of that particular model were certificated. Otherwise, without a positive indication from the report data, icing certification was listed as unknown.

For cases in which the TCDS does not state the icing certification basis, but a note appears in the TCDS stating that the aircraft is approved for flight in icing, the icing certification basis is shown as approved.

7.9 OPERATION OF IPS

Information was extracted regarding if and when the airframe IPS was operated. It was found that, in the case of pneumatic systems, it was often possible to determine that the system had been cycled less than four times; in some cases, only one time. Because specific cycle counts above three were not seen in the narratives, the classification of "multi-cycle" was used to indicate that the pneumatic system had likely been cycled manually for more than three cycles.

Pneumatic systems that were equipped with and used the auto-cycle option are classified as such. Pneumatic systems that were cycled, but for which no information is available regarding how many cycles, are classified as "unknown cycle" events.

Thermal systems and Tecalemit/Kilfrost/Sheepbrige Stokes (TKS) systems are indicated separately.

7.10 STALLS

Three parameters were evaluated with respect to stalls, the first and foremost being the presence of a stall. A stall was indicated if it was referenced in the report or in the pilot statement. In some of these cases, there was some doubt as to whether a stall had actually taken place; however, there was no objective method for reclassifying those cases.

If there was no reference to a stall, but evidence was present that indicated one, then the stall was inferred based on descriptors of the aircraft motion. For example, pilot or witness reports of a roll oscillation ("wings rocked back and forth"), an uncontrolled roll off on one wing, or a sudden pitch down were taken as indications of a stall.

The second parameter was ASW, including stick shaker activity if the aircraft was so equipped. If no information was available regarding ASW, it was classified separately from cases in which the stall warning was not given. One aspect specifically noted was the absence of a reference to ASW by a surviving pilot. Because pilots are familiar with the indications of stall warning, it was considered significant if they made no mention of a warning in their statement. This consideration was not applied to statements of surviving passengers. If the pilot's statement/interview contained no reference to ASW, it is shown in the following figures as "not reported."

The third parameter evaluated was the presence of aerodynamic warning of stall, either through airframe or control buffet. This was also distinguished from those cases for which a pilot statement could not be obtained and those for which a surviving pilot had submitted a statement.

7.11 STALL PRECURSORS

During the analysis of the events, it was noted that certain types of aerodynamic occurrences were often reported to precede more severe occurrences, such as a stall. Generally, these were airspeed decay, reduction in climb performance, inability to climb, inability to maintain altitude, inability to maintain a glide path, or high sink rate. It has been hypothesized that all of these events are associated with a change in the L/D ratio for the configuration being used at the time. This may be useful in understanding the nature of severe events. A precursor marker, L/D degradation, was placed in the sequence of aerodynamic occurrences prior to the actual stall.

In very few cases, an increased stall speed has been specifically reported. This has been identified in the aerodynamic occurrence sequence as stall speed degradation.

Finally, in cases that involve a stall for which no specific preceding degradations can be identified, the term "performance degradation" has been placed in the aerodynamic occurrence sequence. In those cases for which a stall has been inferred based on the evidence, the performance degradation is also inferred and so noted.

7.12 SUPERCOOLED LARGE DROPLET AND GLACIATED CONDITIONS ANALYSIS

The existence of supercooled large droplet (SLD) conditions was assessed based on a range of inputs. The primary input was the presence of SLD in the official meteorological report associated with the event. As the vertical (altitude) or horizontal distance between the official reporting site and the event site becomes larger, it is reasonable that confidence in the presence of SLD at the point-in-space where the accident was initiated will be diminished. For example, an accident that originated at 10,000 feet of altitude may not have encountered SLD, even though SLD was reported at the ground a mile away. However, there is no way to know precisely what the aircraft encountered. Moreover, because the actual point in space where the event was initiated is almost always impossible to associate confidently with a distance from the meteorological reporting site, there is no way to weight proximity to the site. Therefore, the presence of SLD is simply reported as either documented or not documented.

Initially, an effort was made to catalog the source of the weather observation (e.g., Automated Surface Observing System or trained observer). However, this information was so inconsistently reported as to be inconclusive, so the effort was discontinued. The question of whether freezing precipitation is under-reported because of system limitations remains unanswered.

The reporting of SLD informally during the investigation is loosely related to the official meteorological report and its associated problems. This may have been done through police or witness reports, or through a detailed meteorological report completed during the investigation. In all of these cases, the presence of SLD has been noted, but uncertainty remains regarding the relationship of SLD to the event.

Throughout the assessment of SLD, it is important to recognize that events could involve SLD without any documented indication. Likewise, it is possible that for events associated with SLD conditions, SLD was not actually encountered by the aircraft.

A more reliable indicator of SLD is reported side-window icing or ice observed aft of the protected surfaces. Typically, these indicators were reported by the flight crew, although ice aft of a protected surface may also have been observed by an investigator. All of the sources for this data have been identified in the Icemaster database.

Glaciation at the altitude of the event is not reported. However, a meteorological or informal report of snow at the surface was interpreted to indicate the possibility of glaciation at the point in space where the event was initiated, unweighted for vertical or horizontal proximity to the meteorological reporting site. This is consistent with the manner in which surface observations of SLD were treated.

7.13 TYPES OF EVENT DATA

The three types of event data for this project have inherently different reporting criteria or thresholds. The first type, reported accidents, must meet defined criteria. Because of the severity of these events, it is unlikely that any go unreported. The second type, reported incidents, must likewise meet defined criteria; however, because the severity of the events is considerably lower,

it is possible for a number of these events to have occurred without being reported. The third type, NASA ASRS reports, has no defined reporting criteria. Furthermore, the collection of data for this source is dependent on pilot awareness of the program and is strongly motivated by an immunity incentive that precludes the FAA from taking certificate action in most cases.

The ASRS data were vetted during the project development so that inclusion of an ASRS report in the data requires either an aerodynamic occurrence or a procedural failure. However, there is no way to know how many similar events have occurred and have not been reported. The number of events is probably considerable.

Because of these factors, possibilities for statistical evaluation are limited. The identification of precursor characteristics is valuable. In many, if not most, Part 23 accidents, there are almost no data available regarding pilot actions or decisions because of the absence of survivors or flight data recorders. Even with Part 25 accidents, when fatal to the crew (such as the Roselawn and Monroe accidents), analysis must rely on CVRs, which generally yield little information about the pilots' perceptions and nonverbal responses.

The value of including the ASRS data lies with the study of pilot perceptions and actions. It might be said that the ASRS reports do not mirror the accidents because the pilot submitting the ASRS report generally experienced a successful outcome. However, there are a number of patterns apparent that can also be seen in those accidents for which a pilot statement is available. Taken together, this suggests a good likelihood that those accidents lacking survivor information probably looked similar, at least initially.

Because Part 121 air carrier crews are more aware than other crews of the ASRS system, and likely more concerned with the possibility of certificate action, the ASRS data tends to originate predominately with the professional crews in Part 121 operations. However, there is no way to estimate how many serious events not resulting in damage or injury go unreported.

7.14 SEVERITY PRESENTATION

Severity has been represented through reported hull damage, using lighter shades to indicate lighter damage. The use of hull damage is a more uniform indicator of severity than injury to passengers and crew, as this is a function not only of the severity of the accident, but also of how many people were on board the aircraft. One fatality could result from the same accident that would have resulted in ten fatalities, depending on the number of people on board. In both cases, the hull damage would be reported as "destroyed."

Where applicable, the severity data have been presented in stacked bar charts.

Because the ASRS reports do not indicate a level of damage (typically there is none), an empty dashed line is used to distinguish this data from the NTSB damage classification of "None."

7.15 SIZE SCALE PRESENTATION

To incorporate early ASRS data for which the type of aircraft was not identified but a scale reference was provided, the older ASRS size scale matrix was used for all events in the database. This matrix is defined as follows:

SMA	-	small aircraft (less than 5000 lb)
SMT	-	small transport (5,000–14,500 lb)
LTT	-	light transport (14,501–30,000 lb)
MDT	-	medium transport (30,001–60,000 lb)
MLG	-	medium large transport (60,001–150,000 lb)
LRG	-	large transport (150,001–300,000 lb)
HVT	-	heavy transport (more than 300,000 lb)
WDB	-	wide-body (more than 300,000 lb)

If a specific type was known, the actual maximum certificated gross weight was used to determine to which of the size scale matrix bins it belonged. In cases for which a serial number was known, this was fairly precise; if the serial number was not known, but the type was, the maximum known gross weight for that type was used.

8. OVERVIEW OF THE ICEMASTER DATASETS

The Icemaster database provides two distinct datasets.

The Inflight Icing Dataset comprises 308 events, of which 166 are classified as accidents and 142 as either reported incidents or ASRS reports. All of these events involve aircraft that were, at a minimum, equipped with airfoil IPS.

The Ground Icing Dataset comprises 248 events, of which 128 are identified as accidents and 120 as either reported incidents or ASRS reports. These events involve all aircraft, regardless of ice protection capability.

The study period for both data sets spans the years 1982–2010.

8.1 HISTORICAL TREND OVERVIEW

Figures 4 and 5 show the historical trends of both inflight and ground icing data, spanning the seasons 1982-1983–2009-2010. To provide perspective, these data have been supplemented with historical trend plots of three additional parameters.

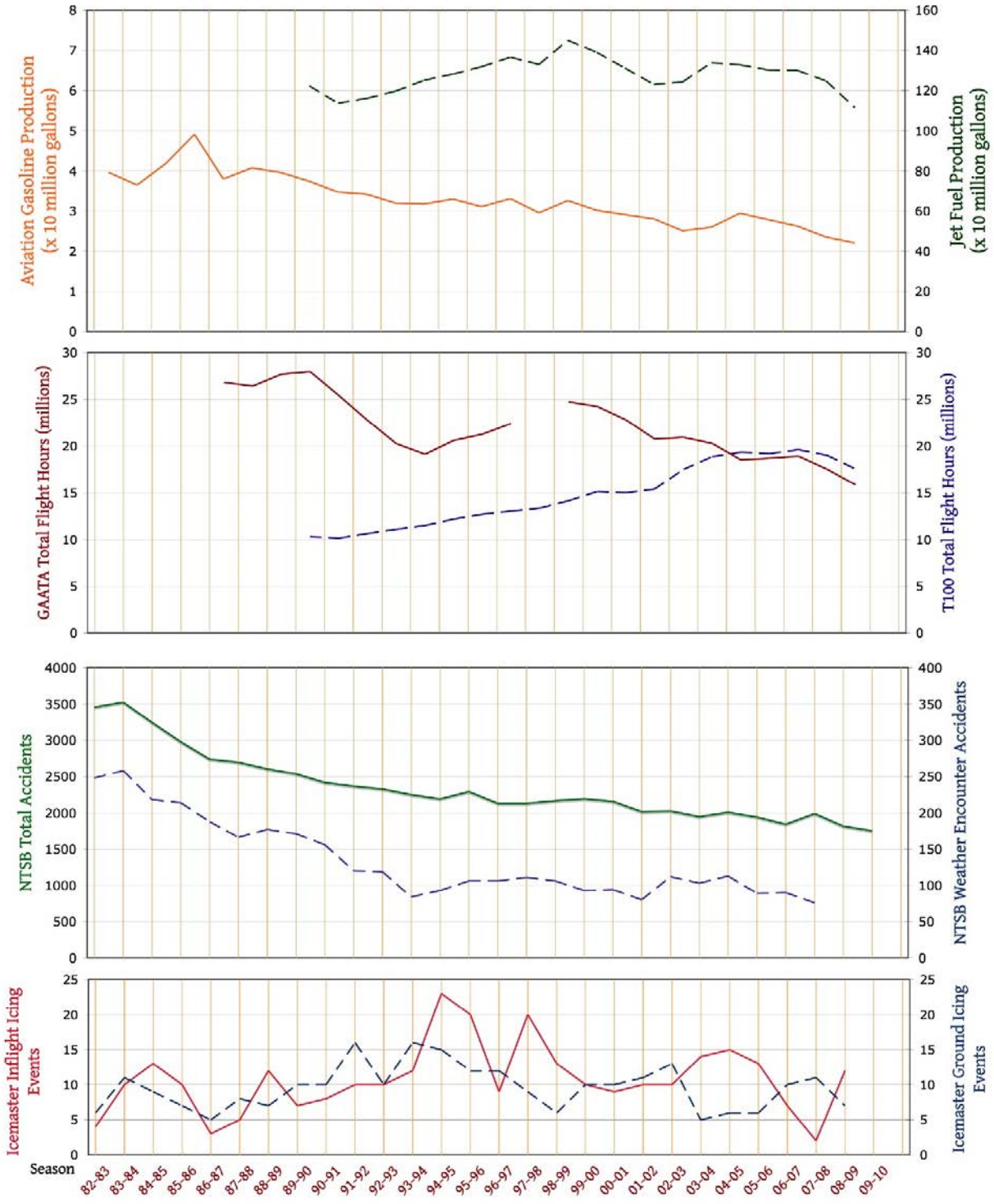

Figure 4. Historical trend comparative analysis—accidents and events

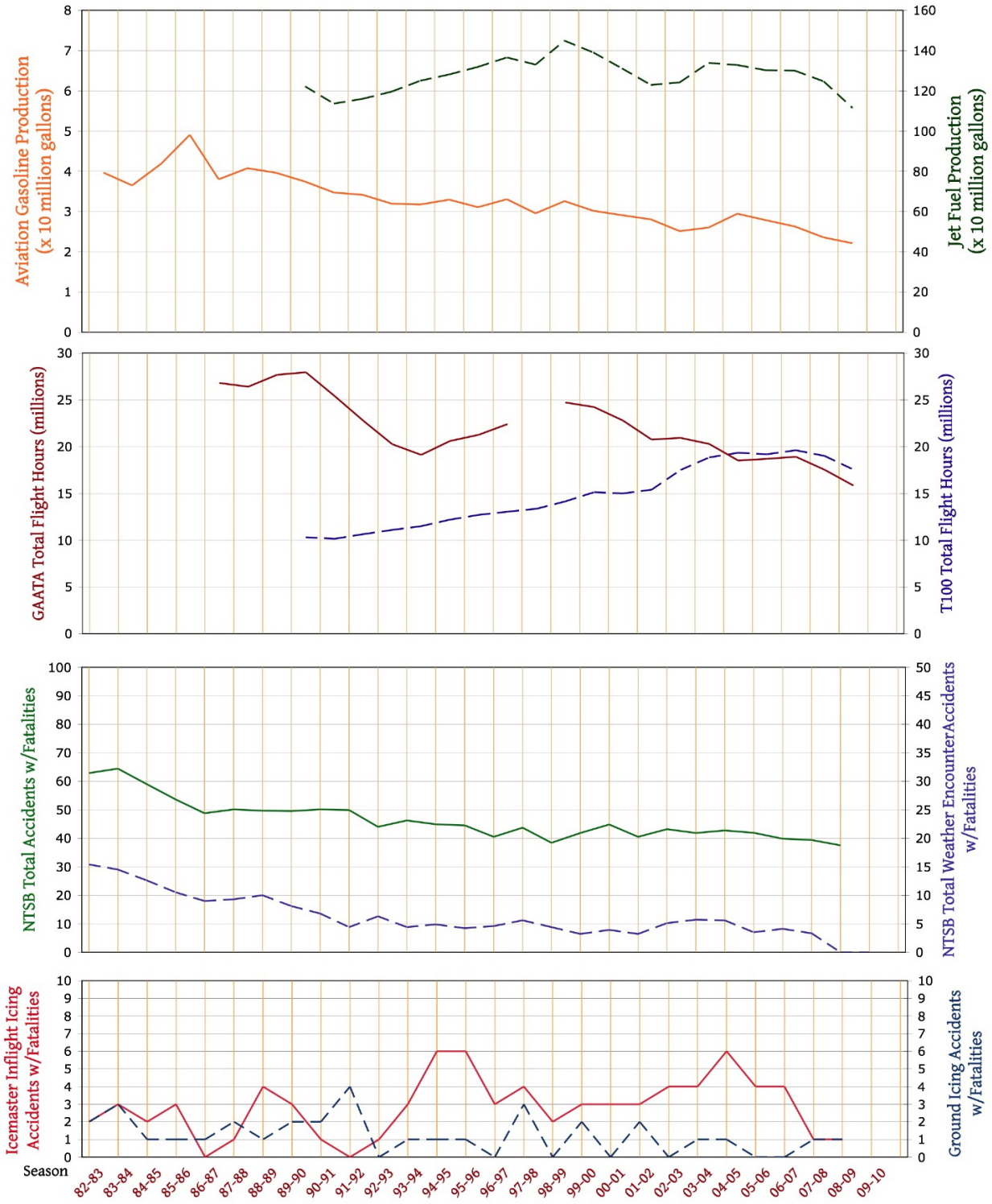

Figure 5. Historical trend comparative analysis—fatal accidents

The first set of parameters is the total number of NTSB accidents compared with the subset of weather-related NTSB accidents. The weather-related parameter is drawn from a search of NTSB records for occurrences of *inflight encounter with weather*. Both parameters indicate a steady decline in accidents during the period of investigation. The first question to consider is why? Is it due to improvements in safety, reduction in operating hours, or other factors?

The next set of parameters follows this question by examining the total fleet operating hours during the period of investigation. Two data sources are presented: General Aviation and Air Taxi Activity (GAATA) data and T-100 data[1] from the Bureau of Transportation Statistics Form 41.

The GAATA data for total operating hours also show a steady decline over the study period. However, the reliability of the methodology used in collecting GAATA data has been questioned on a number of occasions, particularly by the NTSB in its 2005 special report [5]. The NTSB questioned the FAA's assumptions regarding the relationship between aircraft registration currency and flight activity.

During this research, the GAATA data have proven less than robust, as has been observed by other users of the data. Data for 1998 was judged to be so questionable that it was omitted from the plot.

No independent measure of the T-100 data reliability was identified. A steady increase in activity is indicated, which is somewhat contrary to the decline shown in the GAATA data and the NTSB accident data. However, at least for the NTSB data, general aviation comprises the bulk of the accident data, therefore driving the overall accident numbers down as total flight hours decline.

A final set of parameters is shown to provide another external reference—one that requires less interpretive finesse. These are the total volumes of aviation gasoline and jet fuel grade kerosene produced during the years of the study period. The data for aviation gasoline was obtained from the Department of Energy, whereas the jet fuel data were obtained from the Bureau of Transportation Statistics (BTS).[2]

The plot of aviation gasoline production seems to track with the decline in both total NTSB accidents and the overall flight hours shown in the GAATA data, with occasional increases shown in the GAATA data possibly reflecting some of the questionable assumptions noted by the NTSB. The jet fuel plot also seems to corroborate the T-100 data trend, indicating a steady increase in civil jet operations during the 1990s, a sharp drop following the September 11th attack, a weaker increase during the mid-2000s, and another drop recently. However, only one of these parameters seems to show any similar geometry to the icing event plots: the plot of total weather-related accidents.

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[1] From the BTS website: "The Air Carrier Statistics database, also known as the T-100 data bank, contains domestic and international airline market and segment data. Certificated U.S. air carriers report monthly air carrier traffic information using Form T-100."

[2] The BTS indicated that some questions remained about the comparative value of some years in its data on aviation gasoline. The Department of Energy data on jet fuel, however, does not differentiate between civil and military use, whereas the BTS does.

It must be noted that the annual number of icing events is relatively small, and, therefore, more strongly influenced by the addition of one event. That said, the left halves of the weather-related accident plot, and both icing plots, diverge significantly. Though the overall weather-related accident trend is in sharp decline, the icing events are increasing. This includes the very significant spikes in icing events during the 1994-1995 and 1997-1998 seasons. During this period, the weather-encounter accident plot changes slope, and the icing spikes may be a part of the reason for the shallow hump in the middle of the weather-related plot. Nonetheless, the weather-encounter accident plot has remained fairly steady since that period.

9. INFLIGHT ICING INVESTIGATION

All of the events analyzed within the Inflight Icing Dataset involve aircraft that were, at a minimum, equipped with airfoil IPS. Figures 6–9 show the source database mix, critical occurrences (as defined in section 7.6), outcomes, and flight phases. These figures provide a general overview of the data; however, some interpretive caution is recommended. For example, the critical occurrence is the most critical of several occurrences. In the more severe cases, several occurrences may be subordinated to the charted critical occurrence that, in a less severe event, would have been charted as the critical occurrence. With respect to flight phase, this represents the phase of flight in which the critical occurrence took place; it does not reflect the onset of the ice accretion or of precursor occurrences.

A wide range of data has been captured in this dataset. However, normalizing this data is problematic. For example, though scale appears to play a significant role in the likelihood of an icing event, parameters that are closely related to scale (e.g., IPS design, type of powerplant, the influence of propeller efficiency, pilot experience, and actual flight time in icing conditions) are difficult, if not impossible, to evaluate independently.

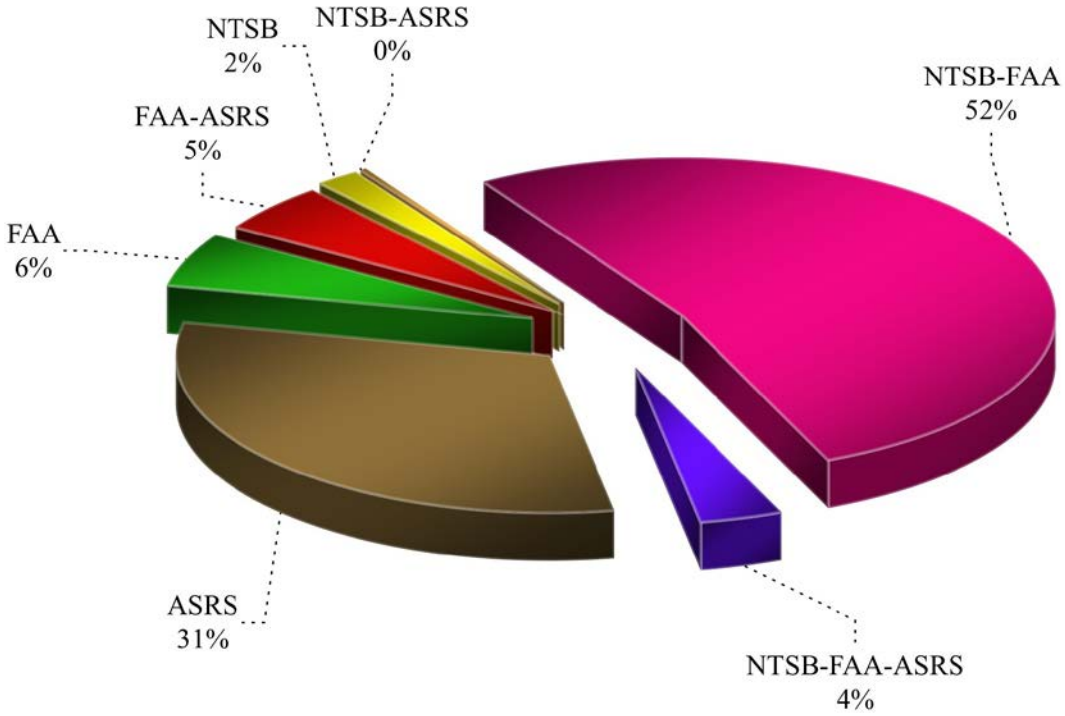


Figure 6. Inflight Icing Dataset: data sources

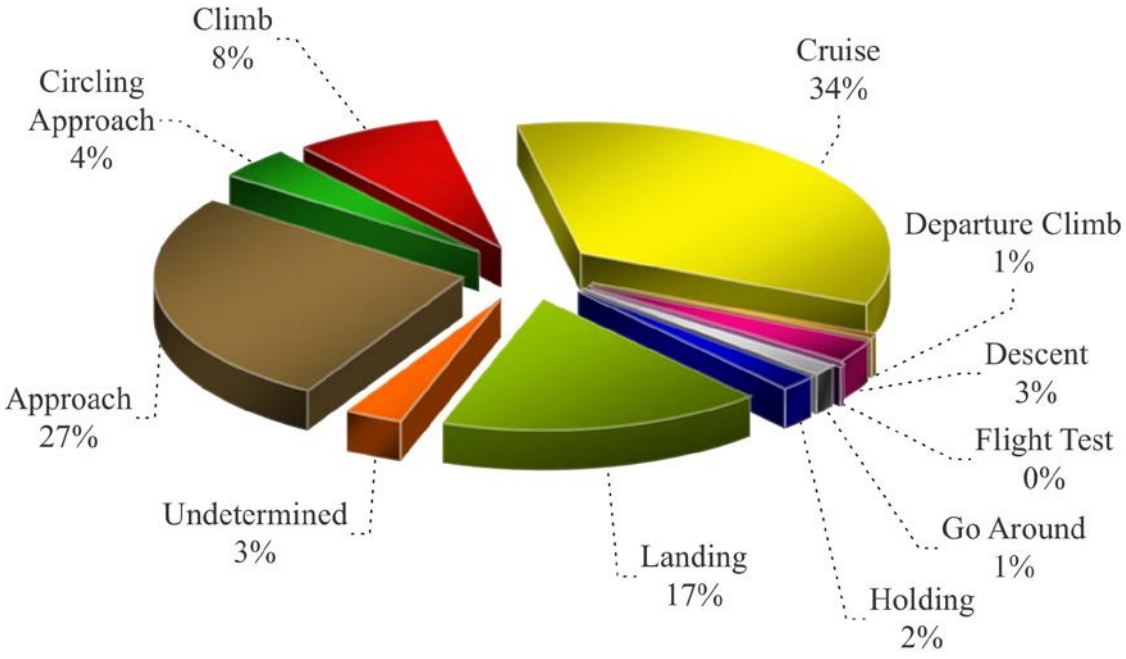


Figure 7. Inflight Icing Dataset: phase of flight of event

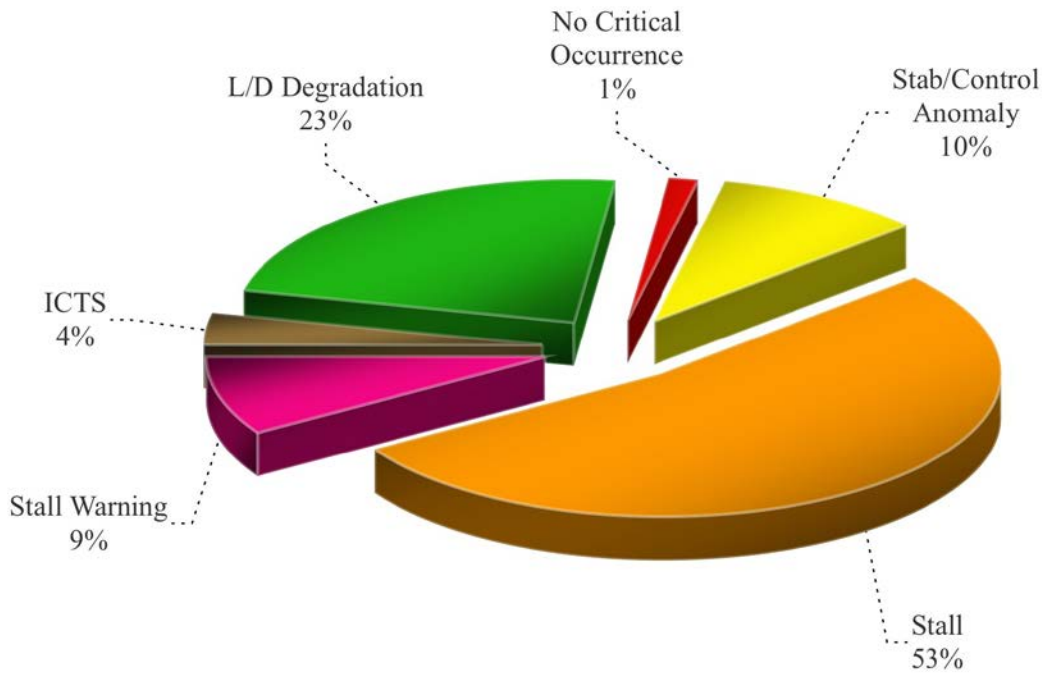


Figure 8. Inflight Icing Dataset: critical occurrence of event

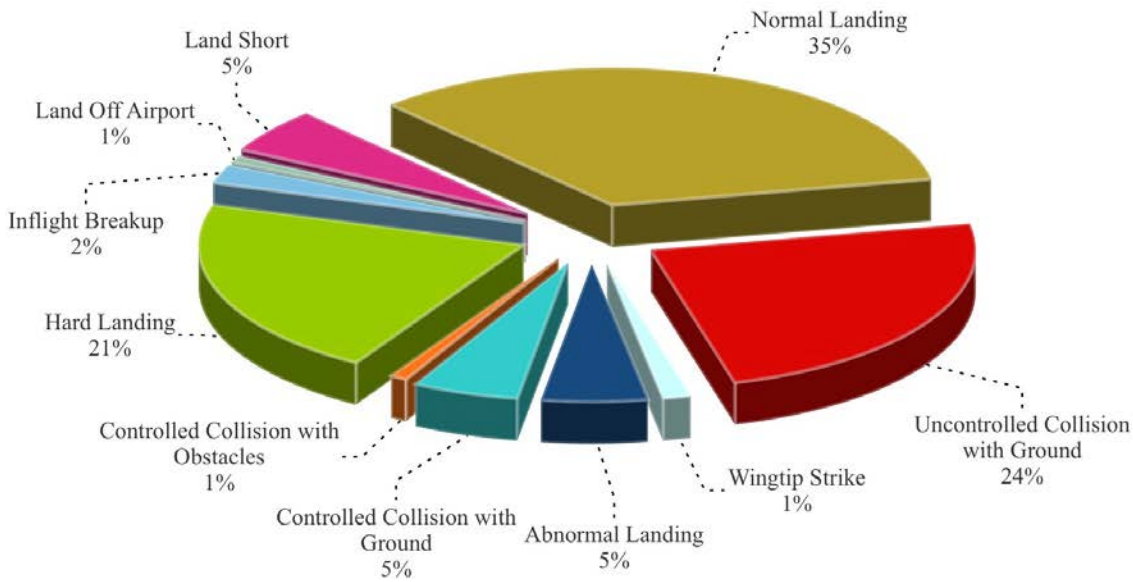


Figure 9. Inflight Icing Dataset: outcome of event

9.1 INVESTIGATION OF METEOROLOGY

In figure 4, two notable spikes in the number of inflight icing events can be seen for the 1994-1995 and 1997-1998 winter seasons. The spikes seem to be independent of a variety of conditions (in the sense that if the plotted data is restricted to data meeting a particular condition, the spikes are still present) such as the operating rule, as shown in figure 10. The proximity of

these spikes to the October 1994 accident at Roselawn, Indiana and the January 1997 accident at Monroe, Michigan raises the possibility that some larger climatological factors may influence the particular severity of an icing season, and that perhaps a particularly severe season may be more challenging to the certifications and operating procedures in use.

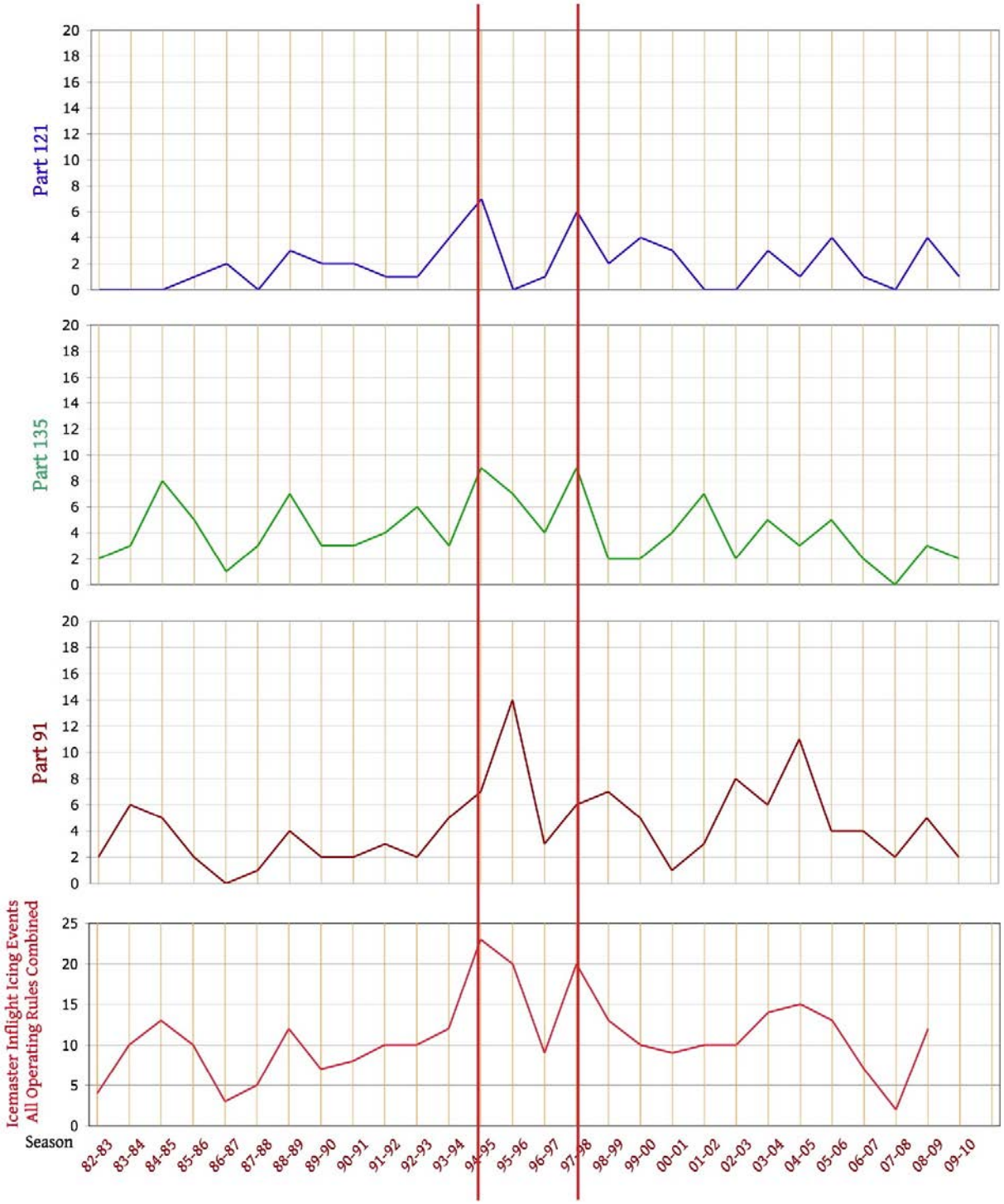


Figure 10. Historical trends for inflight icing events with respect to operating rule

In this study and in similar previous works, the presence of SLD has been identified in approximately 30% of the icing events. However, the uncertainty in the assessment of SLD described in section 7.12 must be considered for this study; the presence of SLD at the surface does not mean it was a factor in the ice accretion at altitude and the absence of SLD at the surface does not mean it was absent at altitude.

Figure 11 shows the breakdown of SLD and snow in the Inflight Icing Dataset. In figure 12, which shows the distribution of events with respect to aircraft weight, severity, and precipitation type, SLD appears in approximately 30% of the events for each aircraft weight category. This proportion was also observed by the author when evaluating the events segregated according to operating rule whether the event was an accident or an incident, type of critical occurrence, or outcome. This demonstrates that the identification of SLD for the event seems not to be sensitive to any of these conditions. Figure 13, which is a 28-year timeline of the Inflight Icing Dataset broken out by SLD and non-SLD events, is consistent with this idea in that the SLD and non-SLD events generally trend together and show a trend consistent with that in figure 10, including the aforementioned seasonal spikes.

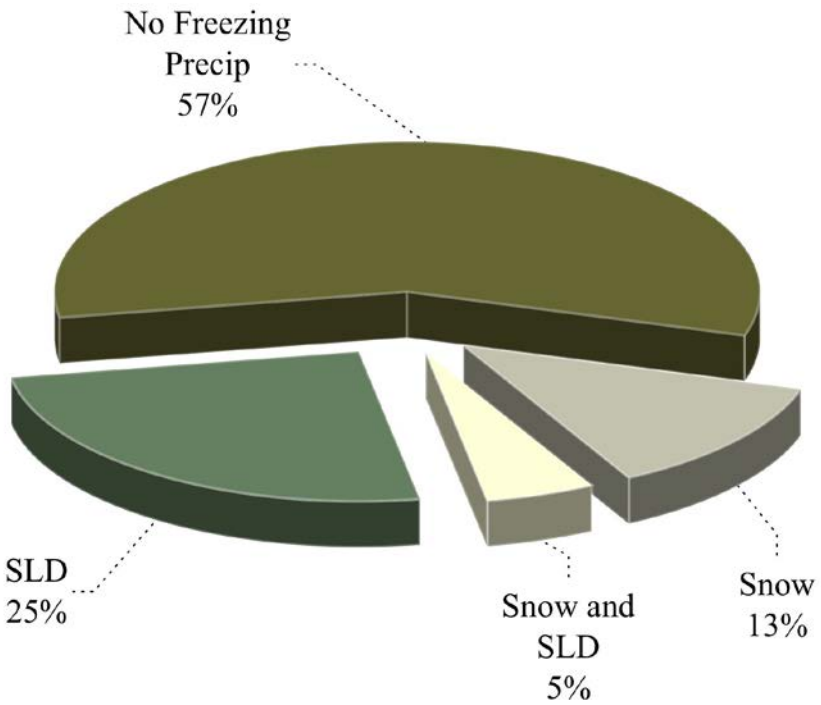


Figure 11. Inflight Icing Dataset: observed and inferred SLD or snow for events

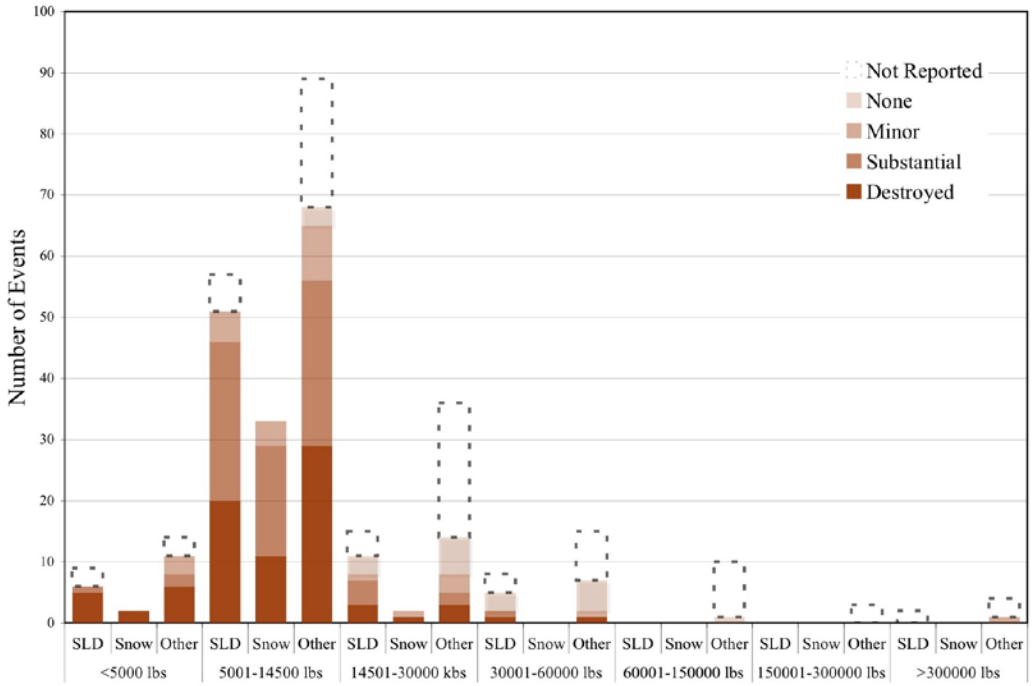


Figure 12. Inflight Icing Dataset: event severity with respect to observed and inferred precipitation

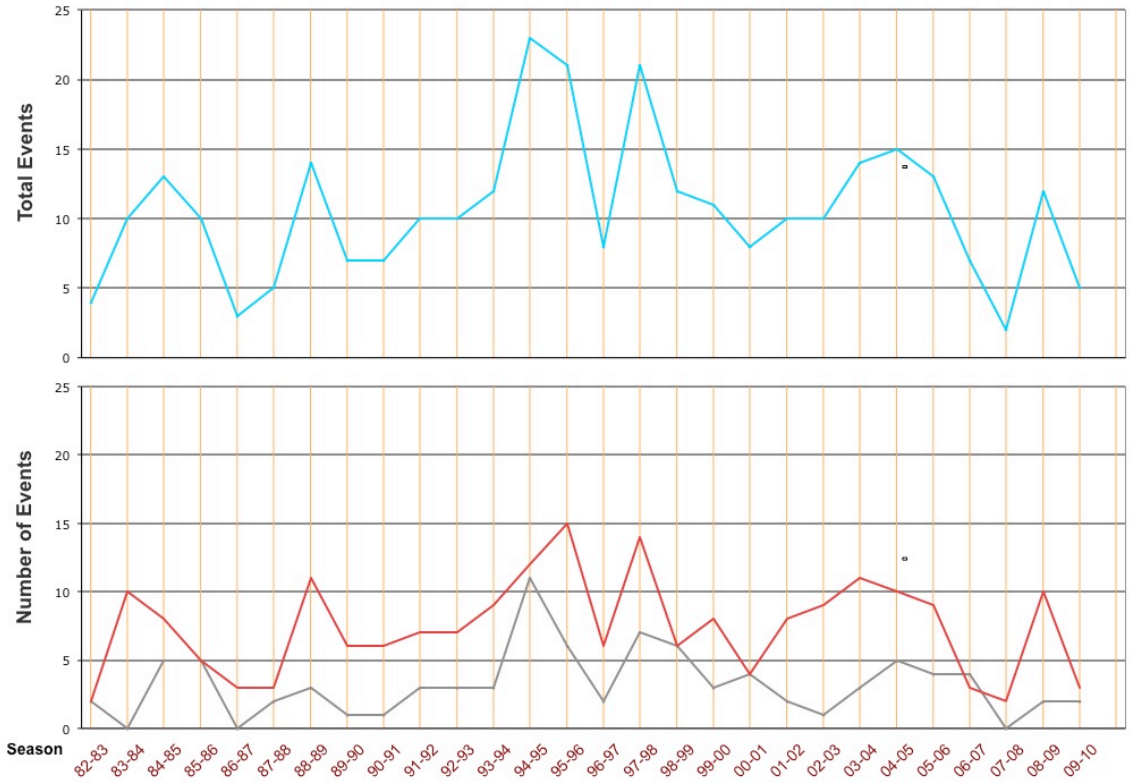


Figure 13. Historical trend of SLD and non-SLD inflight events

Figure 14 shows the sources of SLD data within the dataset associated with SLD. An inference of either freezing rain or freezing drizzle was made when a surface meteorological report indicated rain or drizzle, without a reference to freezing, but also reported the surface temperature to be less than 0°C. The term “met analysis” refers to those NTSB reports in which a more extensive meteorological analysis was completed, and which contained evidence of an SLD environment.

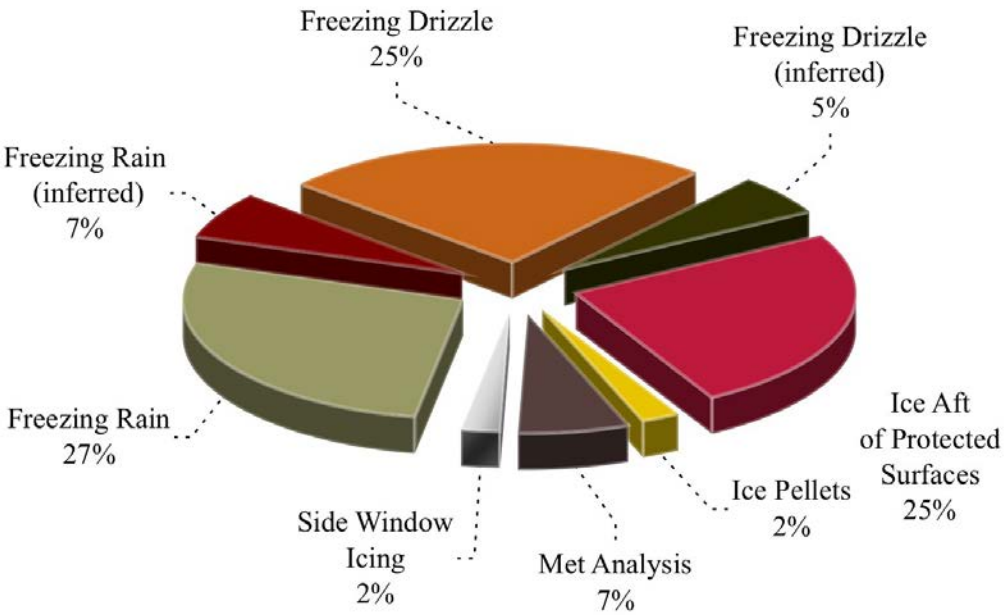


Figure 14. Inflight Icing Dataset: sources of SLD data

A second common precipitation parameter was snow. This is almost always derived from the Meteorological Aerodrome Report/witness reports, and is also nearly always reported with respect to the surface. Snow events are less well-represented than SLD, appearing in approximately 20% of the data. Furthermore, information regarding snow is somewhat less robust than that regarding SLD. Two factors need to be considered. First, as the data moves toward larger scale aircraft/less severe damage, the data source shifts towards the ASRS database. This data generally does not include any significant information on meteorology unless it can be extracted from the narrative, which occasionally is possible. Therefore, the presence of snow is much more likely to go unmentioned in the report. Second, the presence of SLD in the ASRS reports is generally more easily identified, because its existence can often be inferred from the pilot's description of the ice accretion. This is not the case with snow.

Finally, figure 15 shows a geographic distribution of the Icemaster Inflight Icing Dataset based on the presence of SLD conditions. The Great Lakes and Allegheny regions are prominent, as are the Colorado Front Range area and the Mississippi Valley. It is interesting to note the absence of events in the Carolina-Georgia area east of the Appalachian Mountains because freezing precipitation has been well documented in that region [6].

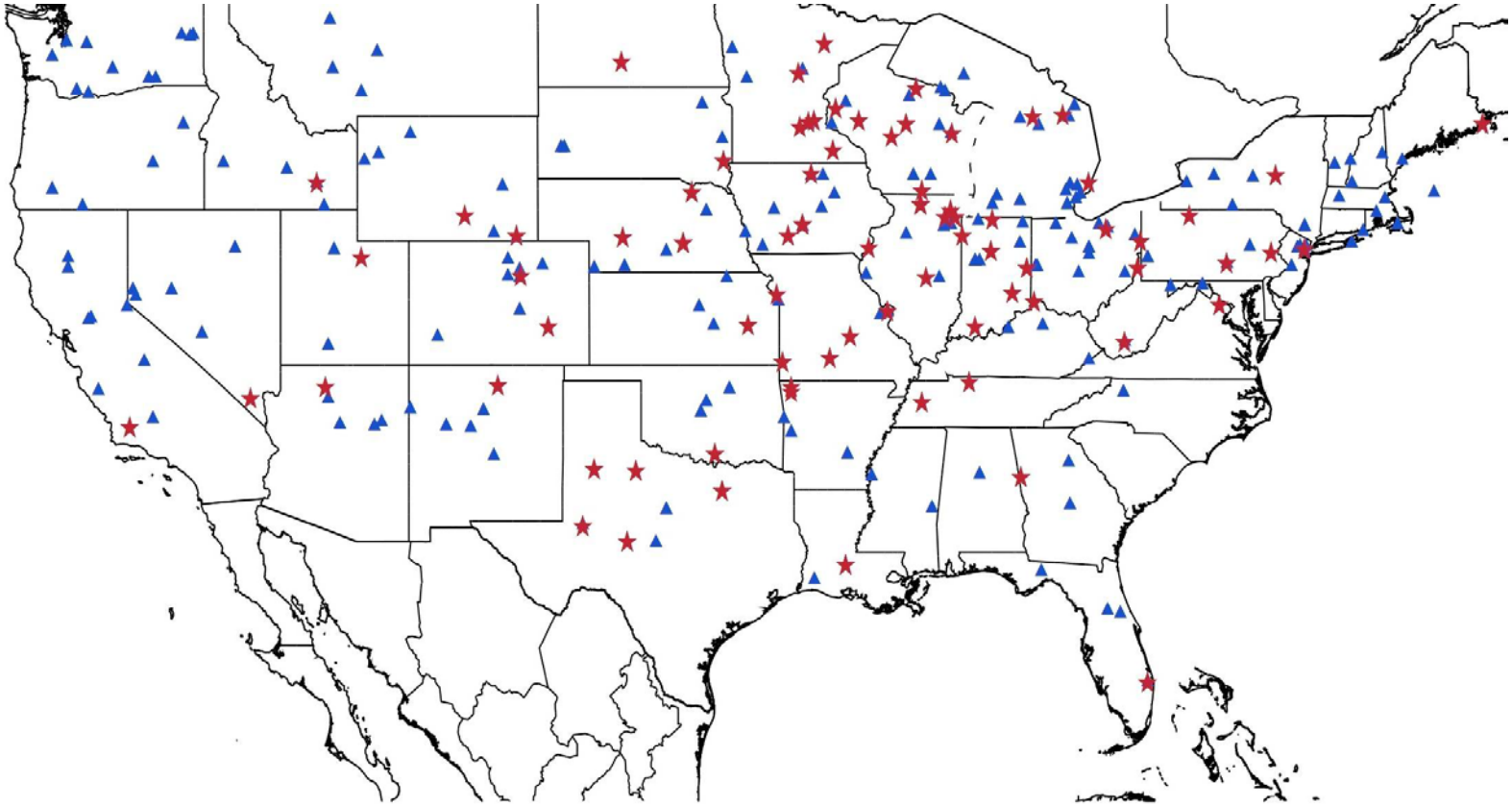


Figure 15. Geographic distribution of SLD and non-SLD inflight icing events

9.2 PILOT LICENSE AND EXPERIENCE

The role of pilot experience and the type of license held were investigated. Figure 16 shows the breakdown of types of licenses. It is reasonable to assume that a large number of pilots holding airline transport pilot licenses (ATPLs) are involved in icing events because this license is generally required for scheduled flying operations, which, in turn, are much more likely to be operating in all-weather conditions.

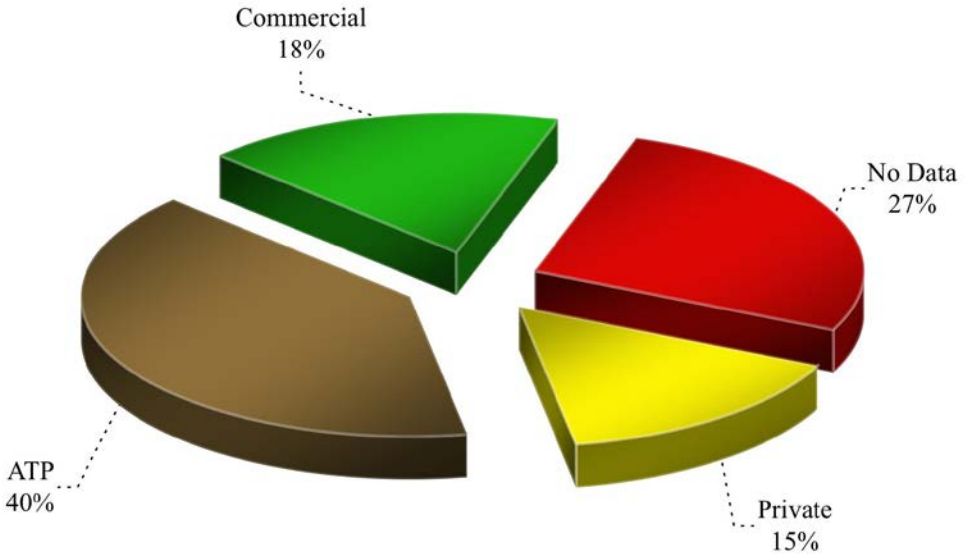


Figure 16. Inflight Icing Dataset: license of pilot-in-command for events

The median total flight time for the 225 events that provided experience data within the Inflight Icing Dataset is 3900 hours; the average total time is 5330 hours (see table 13). Within the 90 events in which the pilot held an ATPL, the median total time was 6680 hours and the average total time was 7590 hours.

Table 13. Normative pilot-in-command total flight time

	All NTSB Total Time	Icemaster Total Time	All NTSB Time in Type	Icemaster Time in Type
Median	8326	3900	538	370
Average	10243	5330	1456	925

The median time-in-type for the entire 225 events was 370 hours, although the average was 925 hours. The median time-in-type for the 90 ATP pilots was 547 hours and the average was 1264 hours.

These numbers can be compared to the total flight time and time-in-type data for all ATP pilots involved in accidents, as documented within the NTSB database. In 9725 accidents involving ATP licenses, the median total flight time was 8326 hours, with the average being 10,243 hours.

Looking at time-in-type within the same set of data, the median time in type for 8577 accidents is 538 hours, with the average being 1456 hours.

The smaller total time and time-in-type numbers associated with the icing data may reflect a type of scale effect. Aircraft that are more vulnerable to the effects of icing are typically operated by pilots earlier in their careers (therefore, a lower total time, and for shorter portions of their careers), resulting in a lower time-in-type. The overall NTSB data include aircraft types that are both less vulnerable to icing and more likely to be operated for extended portions of a pilot's career.

Figure 17 shows the relationship of license type and experience to event severity. There appears to be no correlation between license, total time, and hull damage severity. Experienced pilots are just as likely, if not more, to be involved in an icing event.

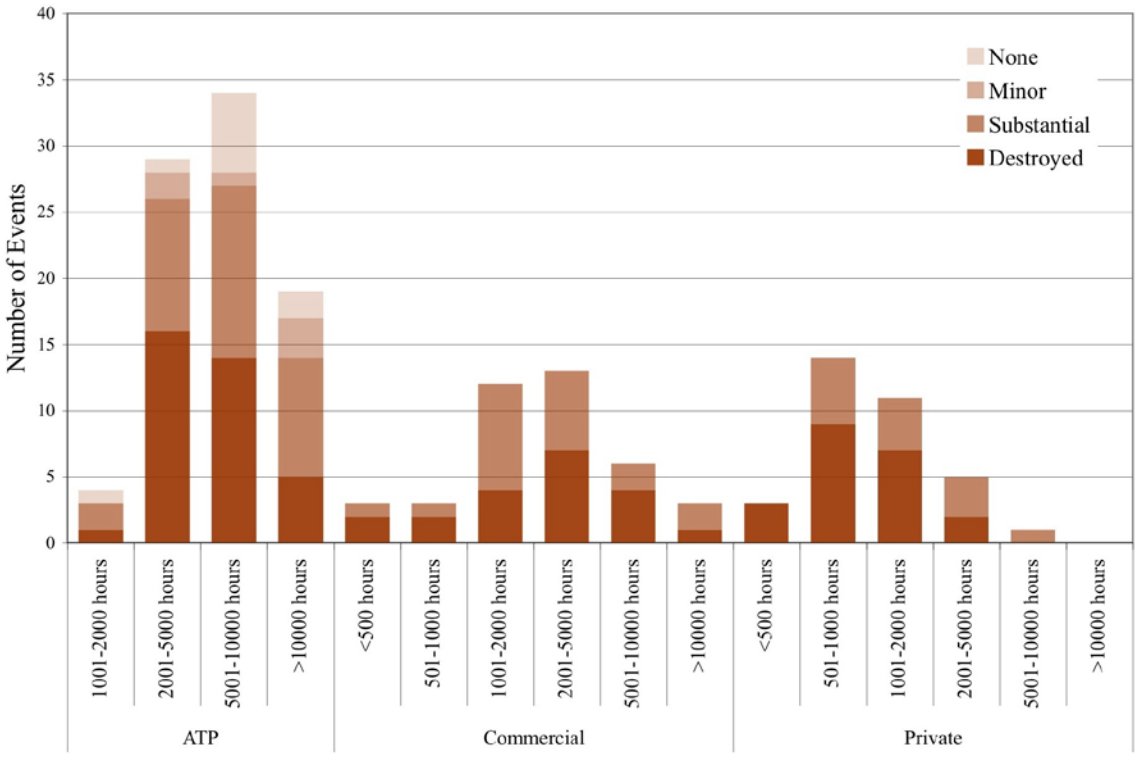


Figure 17. Event severity with respect to total flight hours of pilot-in-command

9.3 PILOT AWARENESS

Figure 18 refers to flight crew awareness that ice was accreting to the airframe prior to the icing event and the sources of that information. Information about the presence of an ice detector is almost impossible to definitively obtain. Of the 15 cases in which the pilot was known to be unaware of the icing, only eight resulted in accidents, the most prominent being the Airbus A300 upset near West Palm Beach in 1997 and the Embraer EMB-120 upset near Pine Bluff in 1993. Only one accident, a Cessna 208 at Steamboat Springs, Colorado, resulted in a fatality.

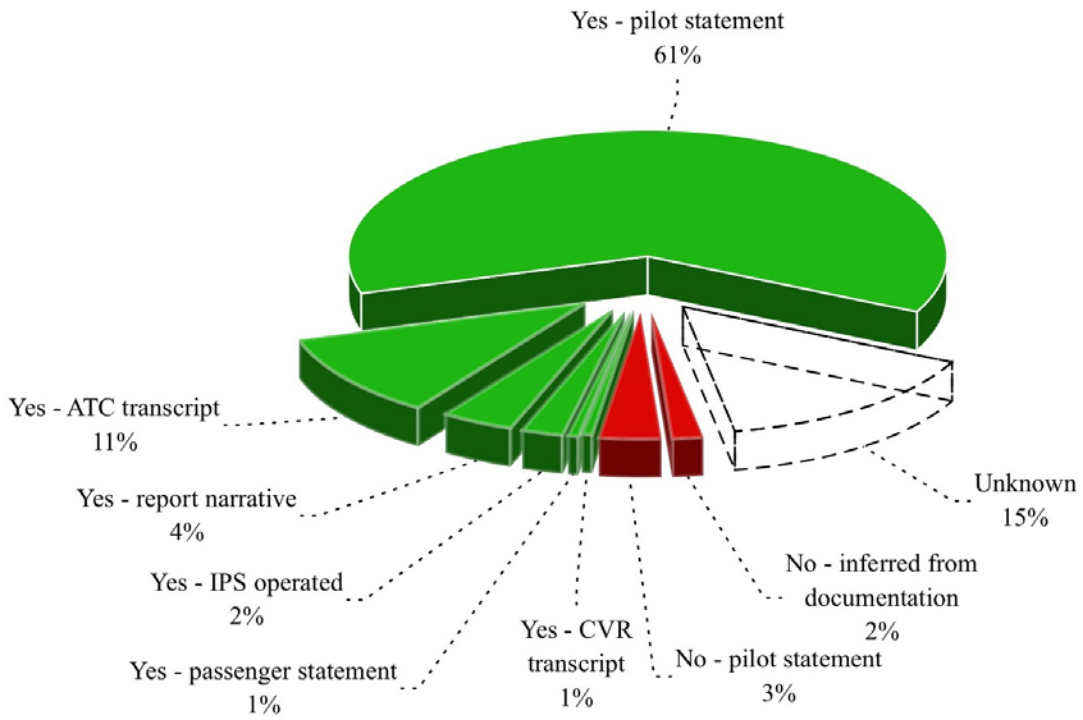


Figure 18. Inflight Icing Dataset: awareness of ice accretion of pilot-in-command for event

Of the 247 events in which the pilot was aware of the ice accretion, 52 resulted in a total of 92 fatalities. There were 45 events for which no information regarding pilot awareness is available, 39 of which resulted in a total of 128 fatalities.

Therefore, a lack of awareness of ice accretion does not seem to be a principal problem in the events.

9.4 INVESTIGATION OF SCALE, POWER LOADING, AND AIRFOIL SECTION

Figures 19 and 20 show the distribution of aircraft scale from the perspectives of icing certification and operating rule, respectively.

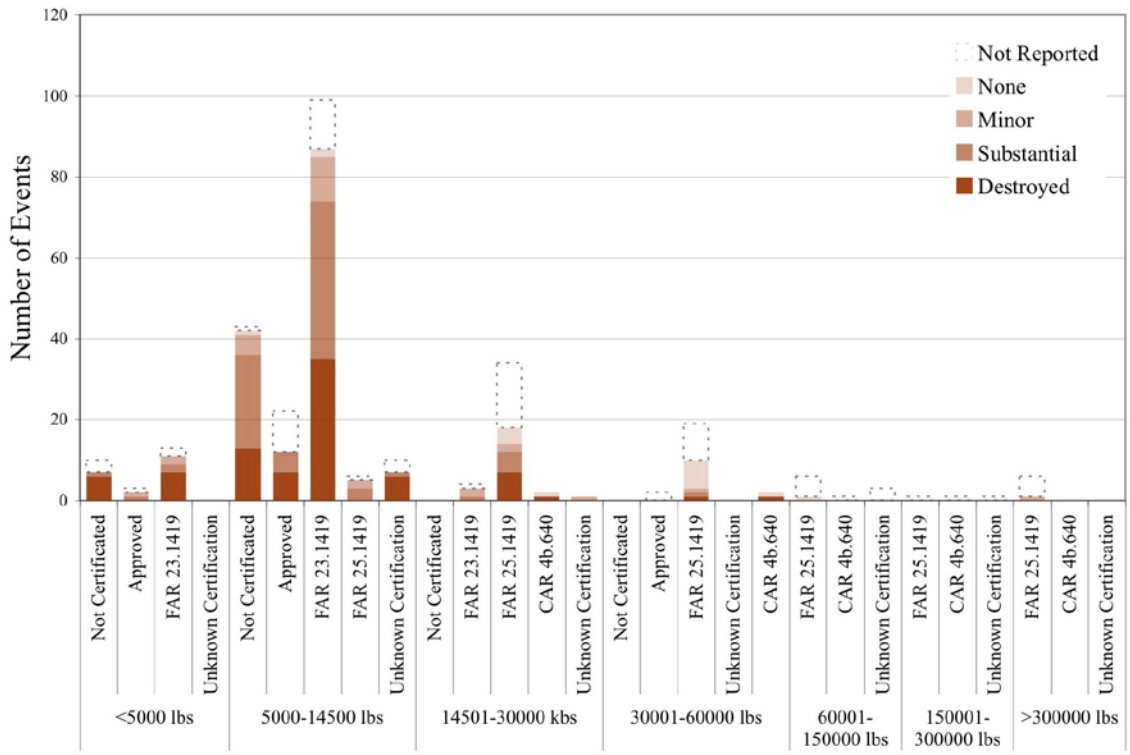


Figure 19. Event severity with respect to icing certification rule

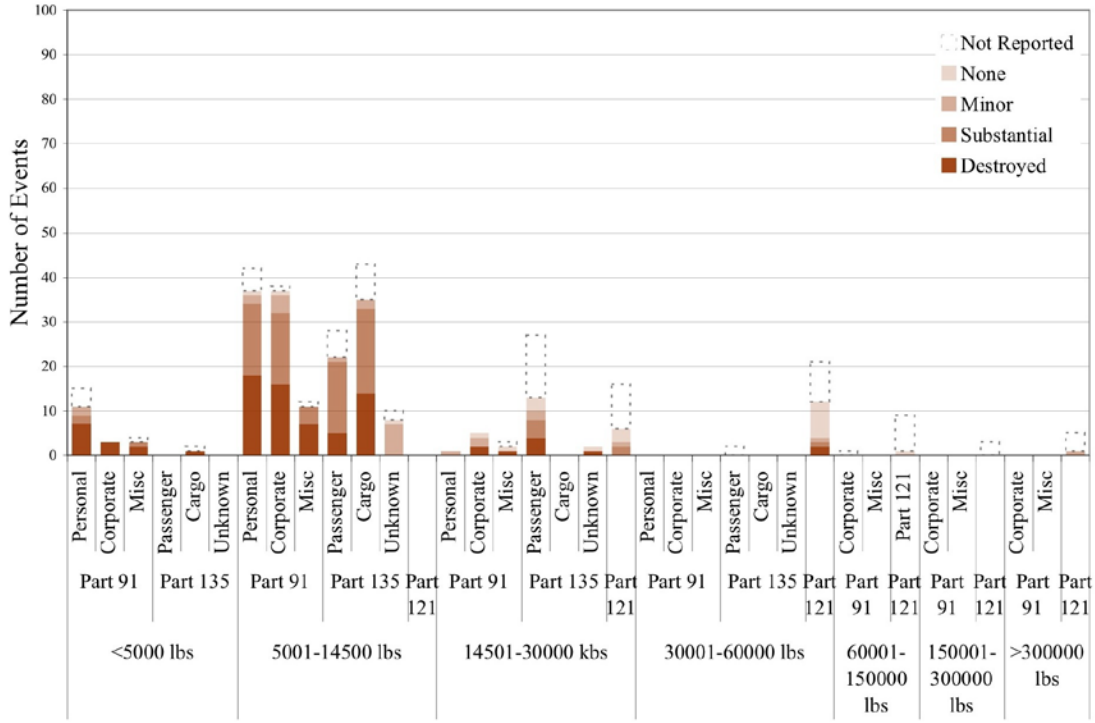


Figure 20. Event severity with respect to operating rule

The relative absence of aircraft weighing less than 5000 lb may be influenced by three factors. First, few of them are ice protected, so they would not appear in the Inflight Icing Dataset. Second, a sizable group of aircraft weighing less than 5000 lb is not equipped for instrument flight. Third, a slightly different set of these aircraft is not primarily used for cross-country flight, tending to missions that are more likely to be postponed or canceled during inclement weather.

Near the upper region of the less than 5000 lb weight class, these three distinctions begin to disappear. Equipage and mission capability become more aligned with cross-country instrument flight and, as such, IPS are more prevalent.

At the other end of the scale, some other distinctions exist that may influence the population of events within the larger scales. First, the difference in excess thrust available for jet aircraft as compared to propeller driven aircraft may play a role. Second, the operating environment of jet aircraft, particularly with respect to total air temperature (TAT) at lower altitudes, is less conducive to ice formation when exposed to typical icing conditions. Third, there may be some benefit to more advanced IPS, such as auto-cycling pneumatic or thermal anti-icing systems.

Nonetheless, these distinctions are unlikely to explain the differences in event population between the 5,000–14,500 lb class and the two heavier classes immediately adjacent to it. Up to the 60,000 lb scale, a significant number of the aircraft are propeller driven and pneumatically protected. The question of icing exposure must be considered.

Reliable data regarding actual exposure is not available. Some data addressing hours of operation, such as those contained in the GAATA and BTS outputs, are available; however, the nature of these data, whether it be a survey-based estimate, such as the GAATA, or limited to commercial operations, such as the BTS, suggest an incomplete picture of annual or seasonal operations. Further, the actual exposure is a function not only of flight time, but also of flight time in icing conditions, which cannot be extracted from any of the annual operating data.

Another way to look at the scale distribution is to search for other types of complete datasets that may characterize scale and exposure, albeit with less direct correlation to icing. Two such datasets are the FAA Aircraft Registry and the NTSB Aviation Accident Database itself.

The FAA Aircraft Registry is problematic in that it only reflects registered (or deregistered) aircraft, not operational aircraft. Further, the presence of an aircraft in the registry does not provide any information regarding hours of use. The FAA Aircraft Registry is useful only because it is so large that utilization is likely to be statistically normalized across various sub-fleets within the registry. As of this report, the FAA Aircraft Registry contains 504,842 entries regarding aircraft that are both current and deregistered.

The NTSB Aviation Accident Database, while being one of the sources of the Icemaster data, is also a standalone dataset with as close to a degree of universality as may be possible, given that it is unlikely that an accident record would not be entered in the NTSB database. Currently, at 61,941 events, it is also quite large, lending itself to the same type of normalization as the FAA Aircraft Registry.

In addition to the FAA Aircraft Registry fleet and the NTSB Aviation Accident Database fleet, two subsets of the NTSB data were extracted for comparative purposes. The first, the "NTSB Weather" dataset, was found by searching the **subject code** field of the NTSB Sequence of Events table for the terms *weather condition*, *flight into adverse weather*, and *flight into known adverse weather*, and then expanding the data by searching the **occurrence code** field of the NTSB Occurrences table for the term *inflight encounter with weather.*

A second subset, the "NTSB Loss of Control" dataset, was found by searching the **subject code** field of the NTSB Sequence of Events table for the term *aircraft control*, and then expanding the data by searching the **occurrence code** field of the NTSB Occurrences table for the term *loss of control – in flight.*

To use these datasets for comparison, two standardized fleets were defined. The Certificated Fleet is comprised of all aircraft that are either eligible for certification or other approval for flight in icing (through TCDS statements or other known aircraft flight manual statements). It does not include aircraft that are simply equipped for flight in icing. However, it may include aircraft that are eligible for icing certification but not actually equipped, or for those that are equipped but not in conformity with the TCDS icing certification requirements (there is no way to make this determination).

The Equipped Fleet is comprised of the Certificated Fleet and also of the multiengine aircraft for which the TCDS contains an icing equipment list or for which an icing equipment STC is known to exist. As is the case with the Certificated Fleet, there is no way to determine whether the aircraft is actually equipped. Single engine aircraft for which STCs exist are not included because of the premise that a very large percentage of this single engine fleet is not actually equipped for flight in icing, notwithstanding the availability of an STC.

The Certificated Fleet is more rigorously defined than the Equipped Fleet, which provides a larger comparative pool against which to test observations made for the former fleet.

Figure 21 shows the relationships between these four comparative datasets and the Inflight Icing Dataset. The two defined fleets, the Certificated Fleet and the Equipped Fleet, were extracted from all five datasets while maintaining the same relationships. All extracted data used for these comparisons were filtered to remove any events already residing in the Icemaster Inflight Icing Dataset to preclude the icing data from biasing the comparative data towards the icing data profile. Finally, because the FAA Aircraft Registry does not contain all deregistered aircraft from the study period, it is likely that some aircraft in the NTSB/Icemaster databases are not currently reflected in the registry.

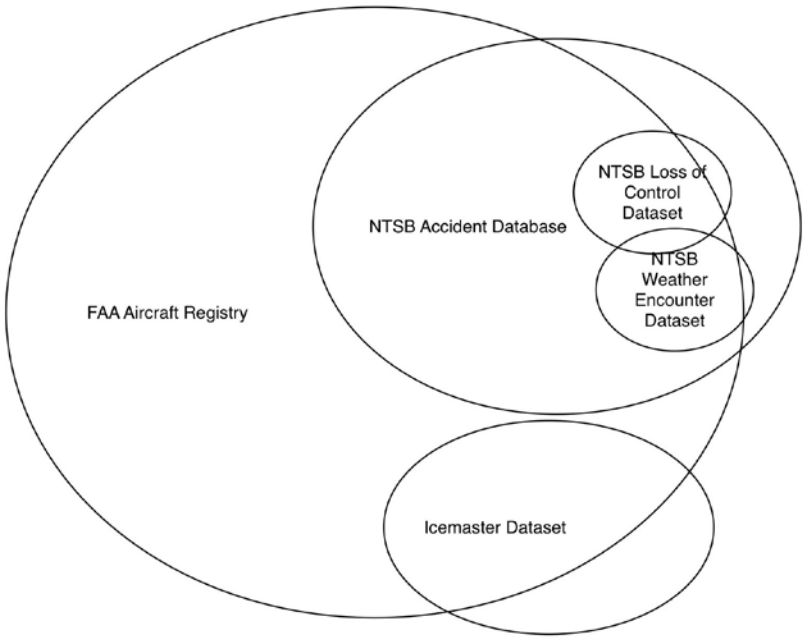


Figure 21. Venn diagram showing the relationship between comparative datasets

For the purposes of comparisons with turbojet-powered aircraft, the NTSB accident data and their derivatives were modified further to remove any events for which the word "turbulence" was used in either the **subject code** field of the NTSB Sequence of Events table or in the **occurrence code** field of the NTSB Occurrences table. The reason for this modification was to remove the significant bias in turbojet accident data toward encounters with turbulence, therefore making the turbojet and propeller-driven comparisons more compatible. Comparative data used without turbojet-powered aircraft were restored to include turbulence terms.

Figure 22 shows the relationship between jet-powered aircraft and propeller-driven aircraft within the FAA Aircraft Registry, NTSB Aviation Accident Database, NTSB Weather Accidents, and the Inflight Icing Dataset events. Though the overall presence of turbojet-powered aircraft in the NTSB accident data is proportional to their population in the FAA Aircraft Registry fleet, the smaller presence of these aircraft within the weather-encounter data are nearly the same as that in the Inflight Icing Dataset. This may suggest that factors other than excess thrust are involved, such as normal altitude profiles, pilot training/experience, or a tendency for jet aircraft to operate in a more standardized, better-equipped infrastructure than the propeller-driven fleet.

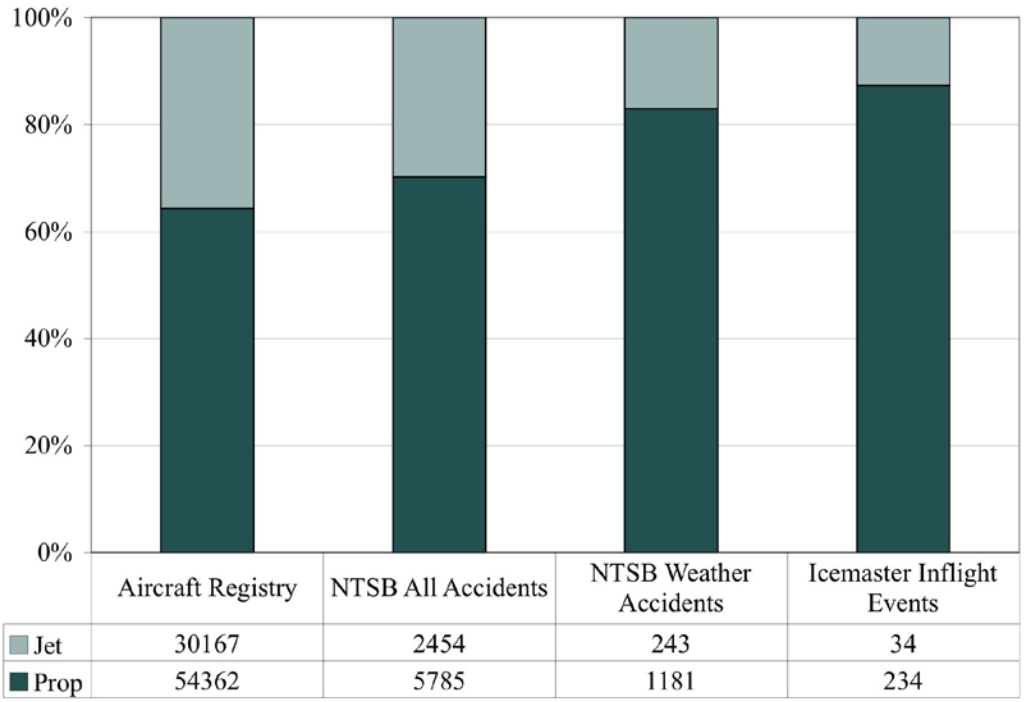


Figure 22. Normalized comparison of equipped jet vs. propeller fleets

Figures 23 and 24 show a comparison between reciprocating powered aircraft and turboprop aircraft for the Certificated Fleet and the Equipped Fleet, respectively. From these comparisons, most aircraft equipped for flight in icing conditions, but not explicitly certificated, are reciprocating powered airplanes. Nonetheless, as opposed to the comparison between jet-powered and propeller-driven aircraft, here there is no particular difference between reciprocating and turbine-powered aircraft within the propeller-driven fleet.

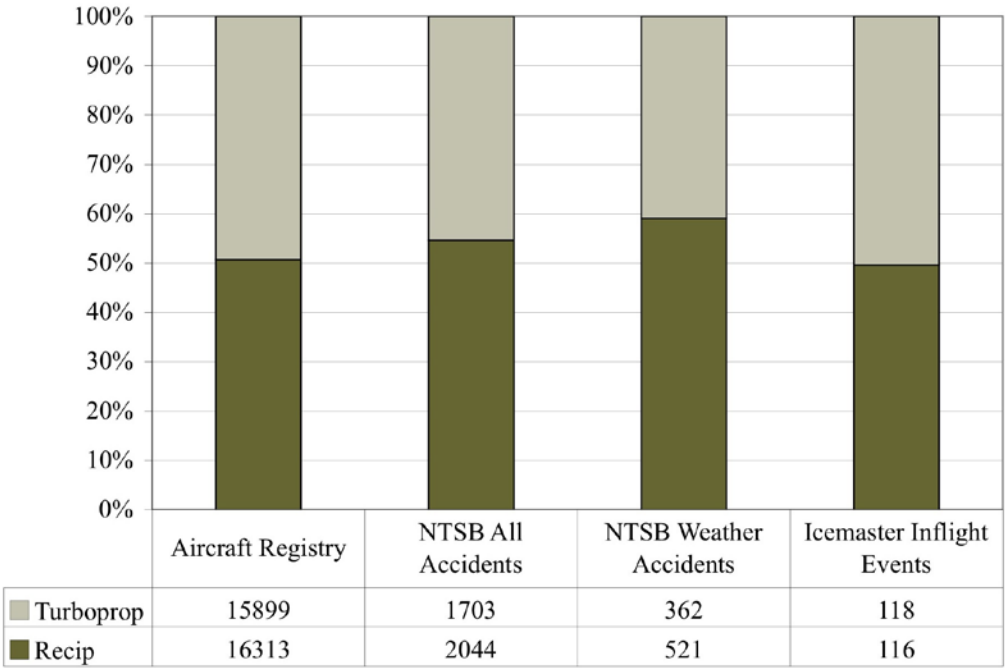


Figure 23. Normalized comparison of icing-certificated reciprocating vs. turboprop fleets

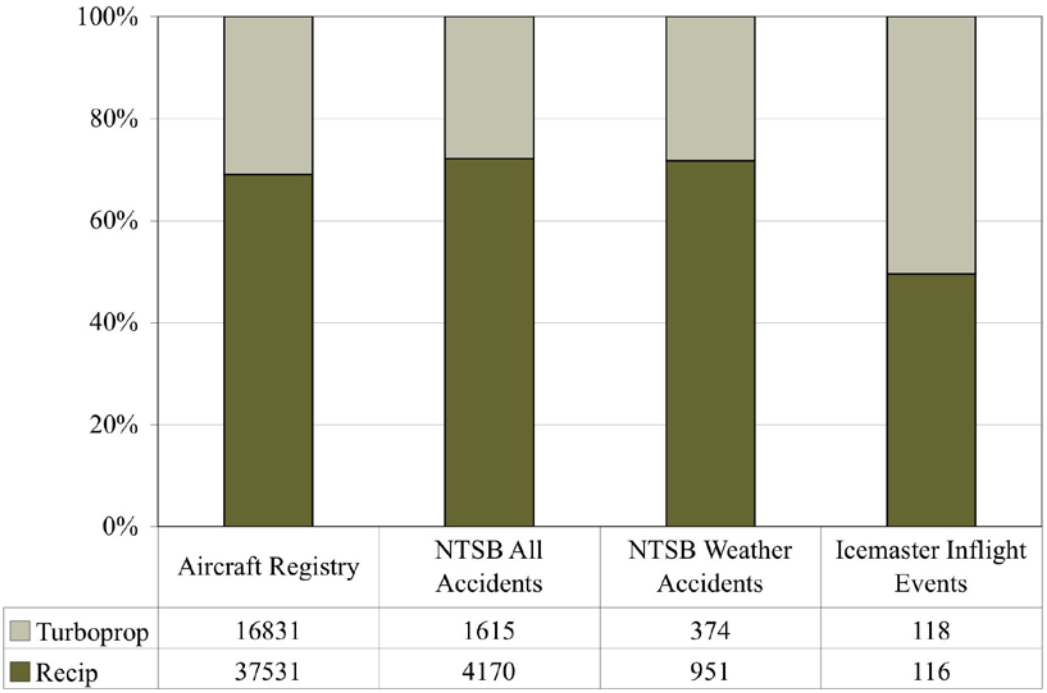


Figure 24. Normalized comparison of icing-equipped reciprocating vs. turboprop fleets

Figures 25 and 26 show the scale distributions between the four datasets, the former showing the Certificated Fleet, and the latter showing the Equipped Fleet. In these charts, a subset of the Inflight Icing Dataset, comprised of only accidents, is shown independently. An examination of

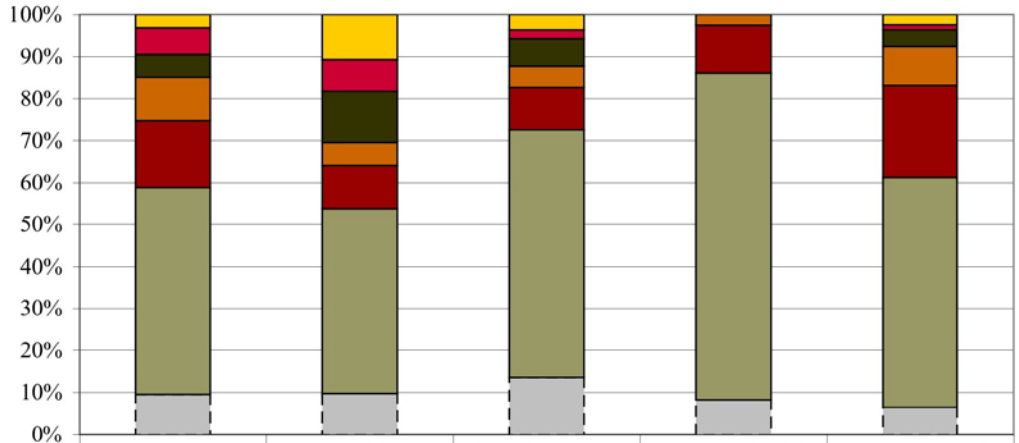
figure 25 suggests that the scale question is somewhat problematic. Four observations can be made:

1. Smaller scale aircraft may have more icing events because they have more accidents in general.

2. The presence of larger scale aircraft (those weighing more than 60,000 lb) is substantially diminished in the icing data as compared to both total registries and total accidents. There are no accidents involving aircraft with gross weights greater than 60,000 lb.

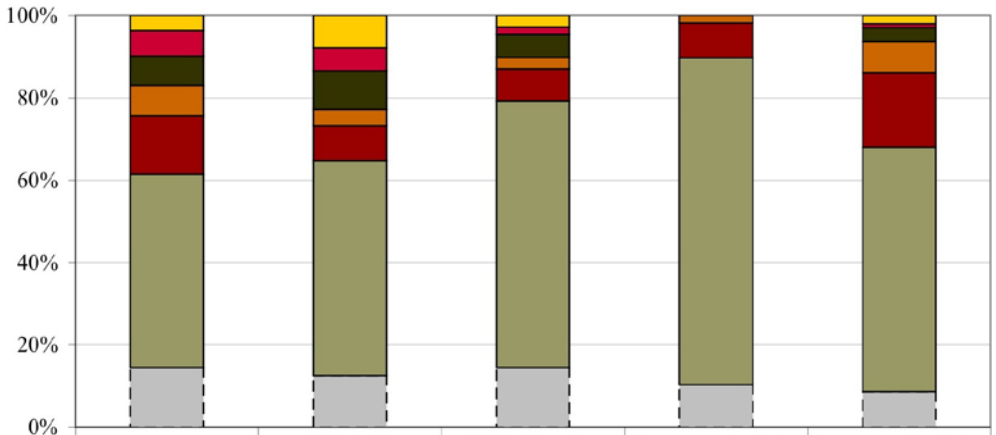
3. The distribution of scale in the weather accident column closely parallels that in the icing event column, with the exception of the 14,500–60,000 lb scales. These scales appear to be more susceptible to icing events than to the general case of accidents involving an inflight encounter with weather. This may simply be an artifact of the much smaller icing dataset, with which one event can significantly influence the data.

4. The presence of aircraft weighing less than 5000 lb is notably less in the icing data than in any of the other three normative data sets, including weather encounters. This may be a reflection of the adjustment to mission made by operators when faced with potential icing conditions.



	Aircraft Registry	NTSB All Accidents	NTSB Weather Accidents	Icemaster Inflight Accidents	Icemaster Inflight Events
>300000 lbs	1575	652	40	0	6
150001-300000 lbs	3311	456	25	0	3
60001-150000 lbs	2818	751	74	0	10
30001-60000 lbs	5246	331	56	3	23
14501-30000 lbs	8200	625	115	14	55
5000-14500 lbs	25400	2684	665	95	137
<5000 lbs	4858	588	151	10	16

Figure 25. Normalized comparison of scale within the icing-Certificated Fleet



	Aircraft Registry	NTSB All Accidents	NTSB Weather Accidents	Icemaster Inflight Accidents	Icemaster Inflight Events
>300000 lbs	3086	652	40	0	6
150001-300000 lbs	5235	456	25	0	3
60001-150000 lbs	5971	770	80	0	10
30001-60000 lbs	6231	332	40	3	23
14501-30000 lbs	12081	697	111	14	55
5000-14500 lbs	39664	4306	922	131	180
<5000 lbs	12261	1023	206	17	26

Figure 26. Normalized comparison of scale within the icing-Equipped Fleet

To more precisely examine the question of scale, data describing the maximum certificated gross weights was captured for the propeller-driven fleet. This was obtained from the TCDS when possible; otherwise, the data was taken from Jane's All the World's Aircraft [7] and the NTSB database when it was available and reasonable. Figures 27 and 28 show box and whisker plots of the gross weight data for the Certificated and Equipped Fleets, respectively, with severity represented by separate plots for events involving either fatal or serious injuries and those limited to minor or no injuries. Additionally, in these plots, aircraft with gross weights greater than 70,000 lb were omitted to keep the *Y*-axis down to a usable size.

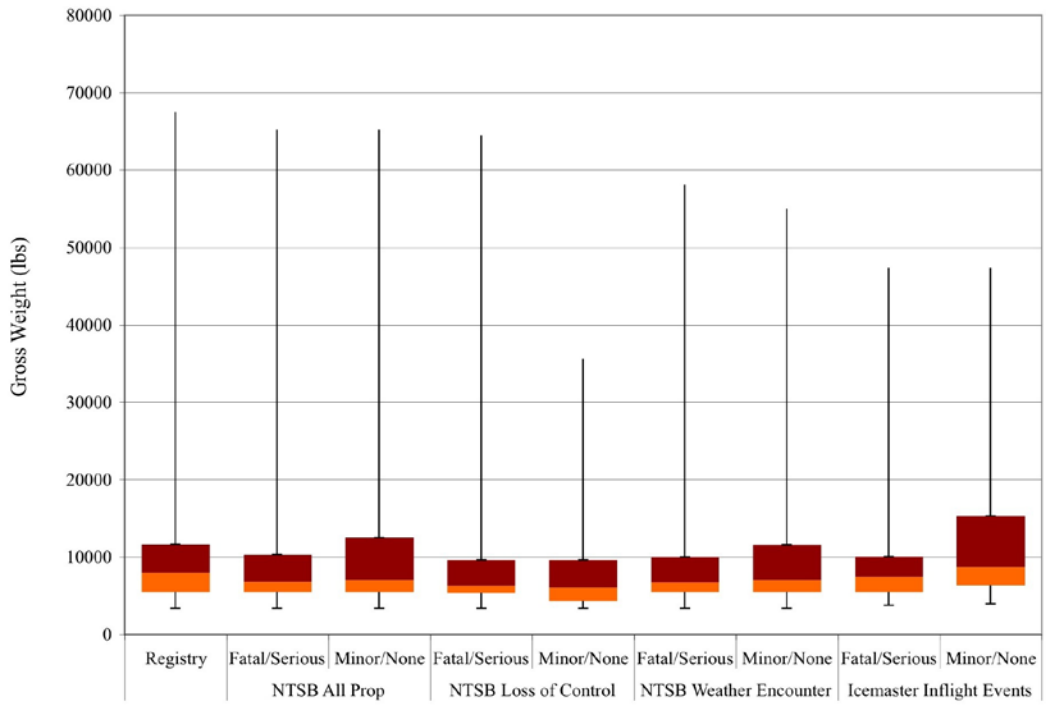


Figure 27. Maximum gross weight within the icing Certificated Fleet for events

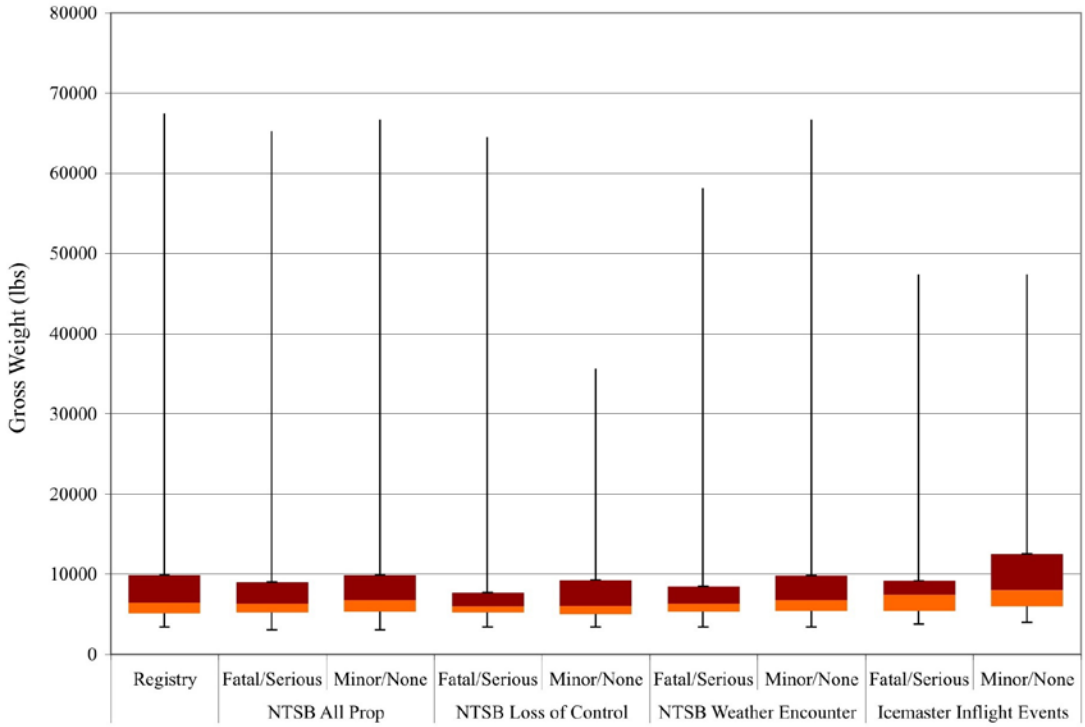


Figure 28. Maximum gross weight within the icing-Equipped Fleet for events

It is apparent that for scales beneath 60,000 lb, a scale factor is not definitive in the icing data; rather, the gross weight distributions and medians are almost identical to those in the FAA Aircraft Registry and NTSB Accident fleets. The two middle quartiles of data involving fatalities or serious injuries are very tightly compacted between gross weights of approximately 8,000–10,000 lb, whereas the middle two quartiles of data involving less serious injuries indicate a larger population of aircraft with gross weights as high as 15,000–16,000 lb. However, these distributions are not significantly different from those in the other comparative fleets. These comparative fleets are propeller-driven aircraft only. Within the turbojet fleets are some larger scale aircraft in the icing data (see figures 19 and 20).

A second parameter that was investigated is the design power loading. This parameter is of interest when considering the possibility that greater power, particularly in the case of turbojets, may play a role in minimizing event severity. Data for this investigation were obtained from the TCDS when possible; otherwise from Jane's All the World's Aircraft [7]. This data, for the same fleets, is plotted in figures 29 and 30.

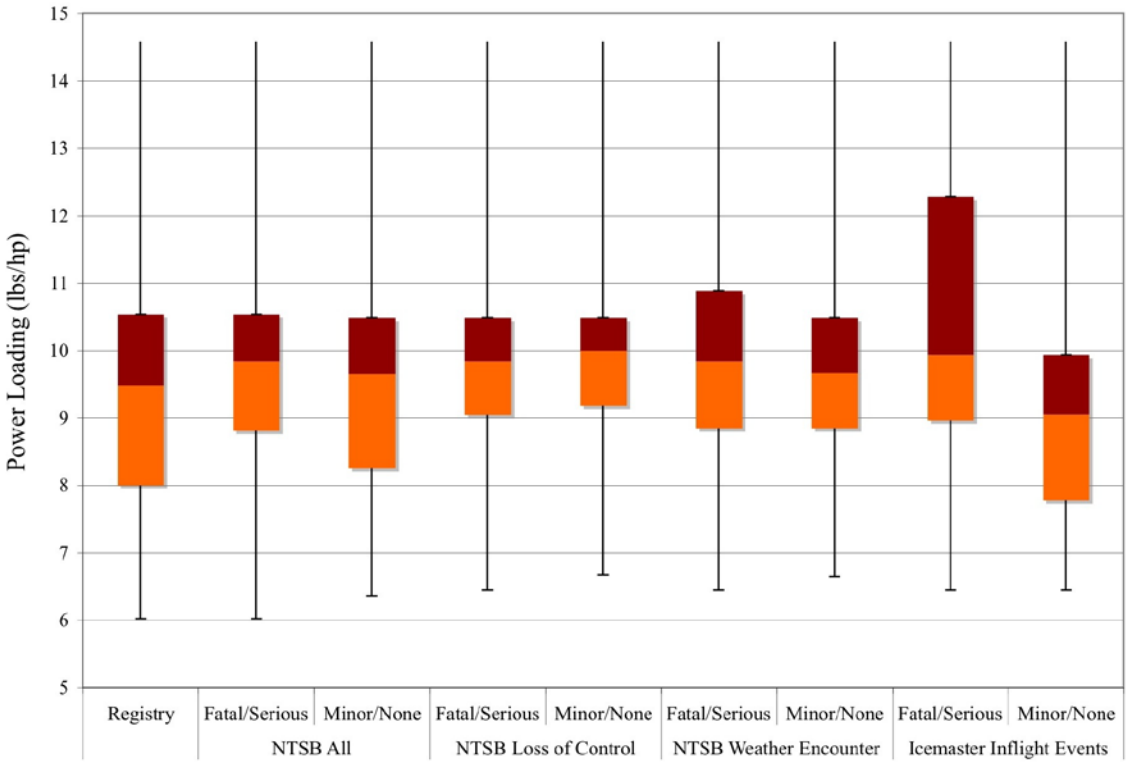


Figure 29. Design power loading within the icing-Certificated Fleet for events

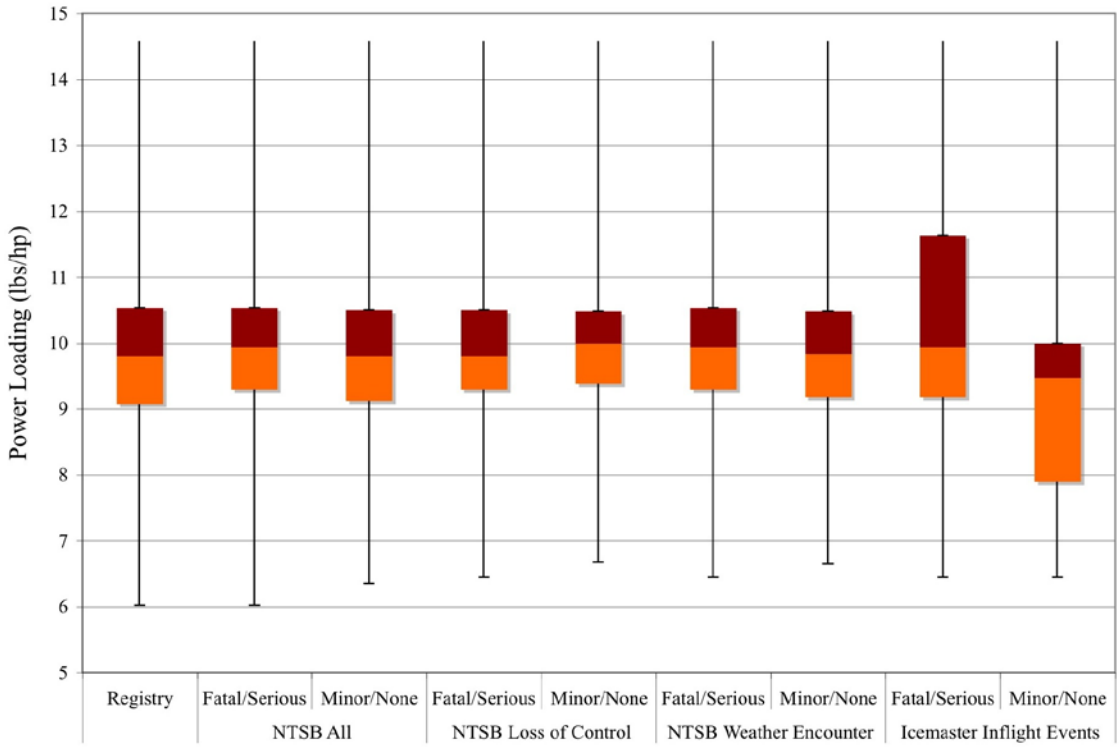
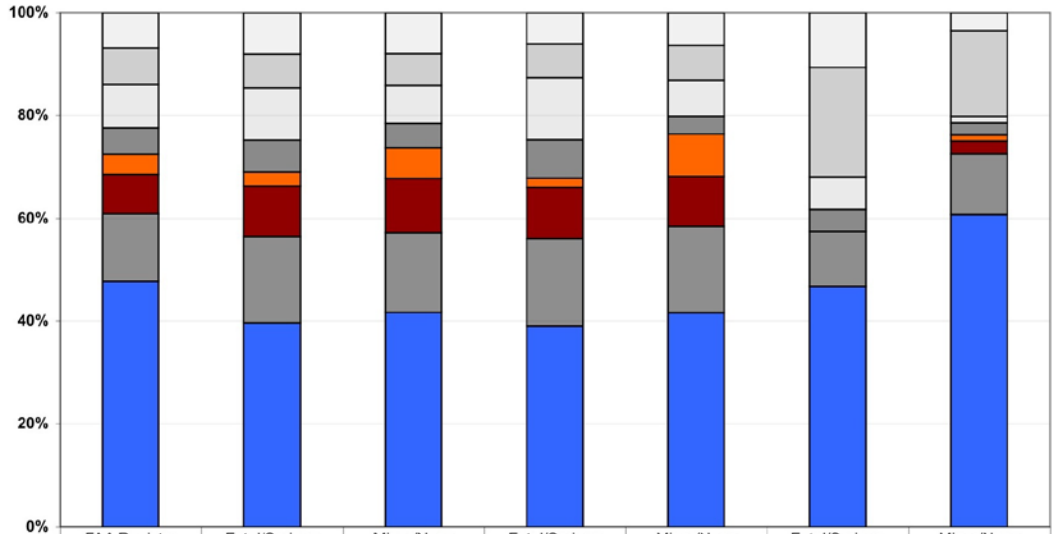


Figure 30. Design power loading within the icing-Equipped Fleet for events

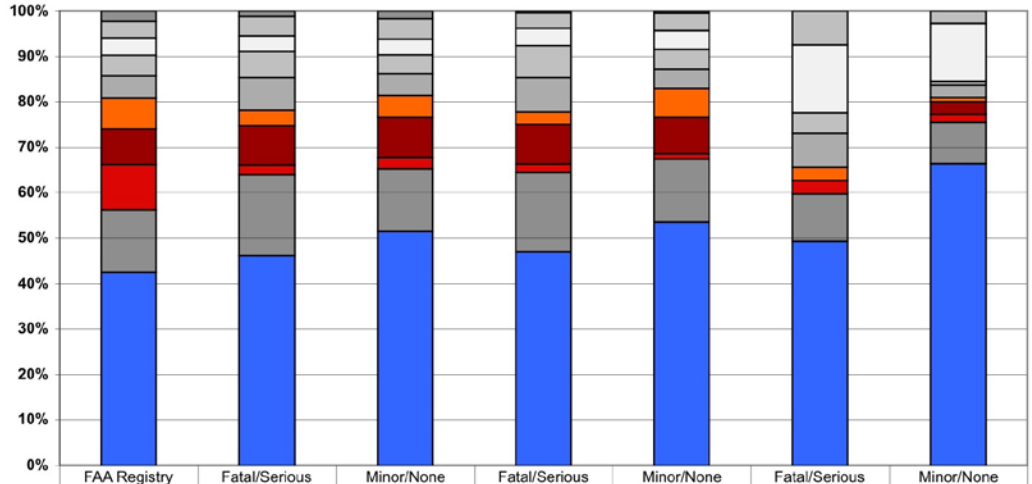
In both of these figures, the icing data shows significant shifts in the medians and distributions of the two middle quartiles between "more severe" and "less severe." This indicates that power loadings more robust than approximately 9 lb/hp may be useful in mitigating the severity of an icing event, whereas weaker power loadings may present increased vulnerabilities to ice. This is likely a reflection of the influence that increased drag has in a typical icing event.

While considering the question of increased drag, a third parameter was investigated: the distribution of airfoil sections. Airfoil data were extracted from David Lednicer's website, The Incomplete Guide to Airfoil Usage [8]. The output of this analysis is shown in figures 31 and 32 for the Certificated and Equipped Fleets, respectively.



	FAA Registry	Fatal/Serious	Minor/None	Fatal/Serious	Minor/None	Fatal/Serious	Minor/None
		NTSB All		NTSB Weather		Icing	
NACA 23015	1680	82	129	22	17	5	3
NACA 23017.424	1720	66	99	24	18	10	14
NACA 64A215	2052	104	120	44	19	3	1
NACA 23012	1228	62	77	27	9	2	2
NACA 65-415	977	29	96	7	22	0	1
NACA 63a415	1860	99	171	36	26	0	2
NACA 23016.5	3190	171	250	62	45	5	10
NACA 23018	11611	402	673	142	111	22	51

Figure 31. Airfoils within the icing-Certificated Fleet



	FAA Registry	Fatal/Serious	Minor/None	Fatal/Serious	Minor/None	Fatal/Serious	Minor/None
		NTSB		Weather		Icing	
NACA 2215	1042	22	51	2	2	0	0
NACA 23015	1680	82	129	22	17	5	3
NACA 23017.424	1720	66	99	24	18	10	14
NACA 64A215	2052	108	122	44	19	3	1
NACA 23012	2213	136	137	47	19	5	3
NACA 65-415	3133	65	139	17	28	2	1
NACA 63a415	3562	165	253	55	35	0	3
USA 35B	4488	39	72	12	5	2	2
NACA 23016.5	6268	337	397	109	61	7	10
NACA 23018	19304	876	1488	294	235	33	73

Figure 32. Airfoils within the icing-Equipped Fleet for events

The National Advisory Committee for Aeronautics (NACA) 23018 section is the most predominant airfoil in the propeller-driven fleet, being used on most Cessna twins, Beech King Airs, and Beech 18s, to name a few designs. There is nothing remarkable about the population of NACA 23018 airfoil sections in any of the comparative fleets because this section shows reasonable proportionality across the datasets. What is interesting about this analysis is the relative absence of three airfoils from the icing data: the NACA 63a415 (used on Piper PA-31 and PA-42 models), the NACA 65-415 (used on the Piper PA-34 model), and the USA 35B (used on the Piper PA-23 model).

Though there is a sizable population of PA-23 aircraft that are eligible for icing equipage, either through STC or original equipment, it is impossible to know how many are actually equipped and may be flown in icing conditions. Nonetheless, their presence in the overall NTSB accident data is limited with respect to the FAA Aircraft Registry population; this is also reflected in the NTSB Weather Encounter dataset. It is possible that this overall robust safety record is responsible for the small presence in the icing data.

The PA-31 and PA-34 aircraft fleets are split between those with an icing certification and those without. The larger, turboprop-powered PA-42 is certificated for icing across the fleet. These aircraft appear in the FAA Aircraft Registry and NTSB datasets with good proportionality; however, their presence in the Inflight Icing Dataset is substantially diminished. In the case of the PA-31/PA-42 fleet, no fatal icing accidents were noted.

The NACA 23018 airfoil section is the only airfoil with a sizable, multi-aircraft population that may allow investigation of the power loading question with the airfoil parameter isolated.

Power-loading data were extracted within the comparative fleets for aircraft using the NACA 23018 airfoil and those not using the 23018 section. Additionally, the NACA 23017.424 section, unique to the Cessna 208, was removed because the type represents a sizable portion of the Inflight Icing Dataset and has a relatively low-power loading in earlier versions. This may have heavily biased the power-loading data toward one particular type.

Figures 33–36 show the results of this inquiry.

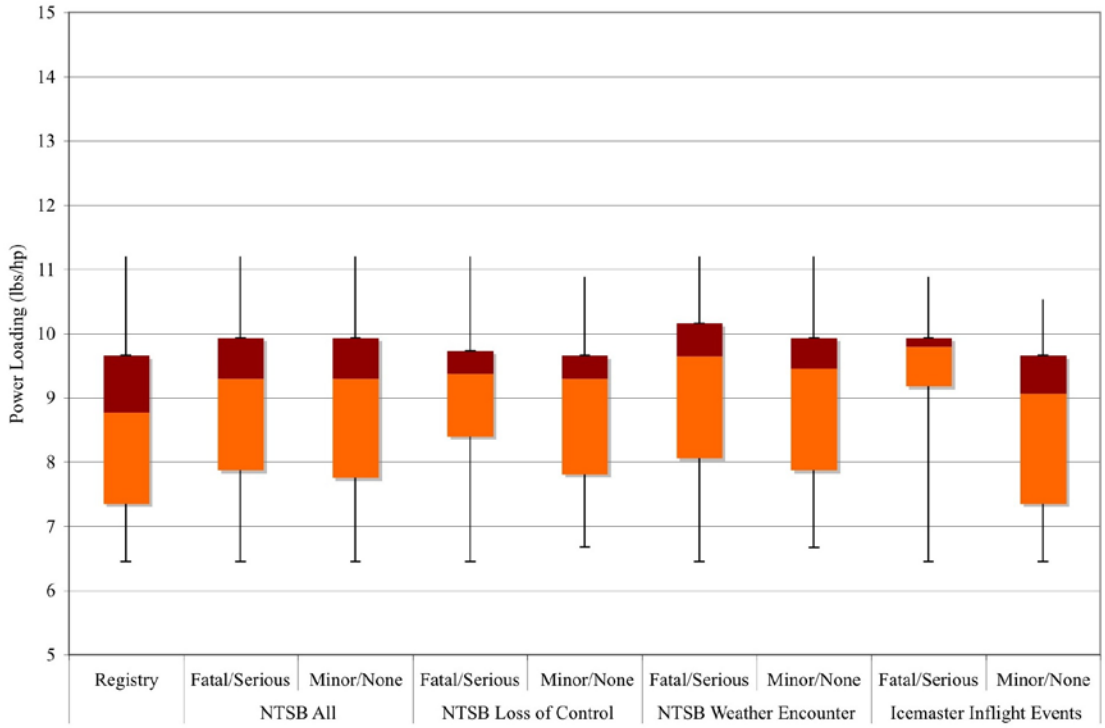


Figure 33. Design power loading within the icing-certificated NACA 23018 airfoil fleet

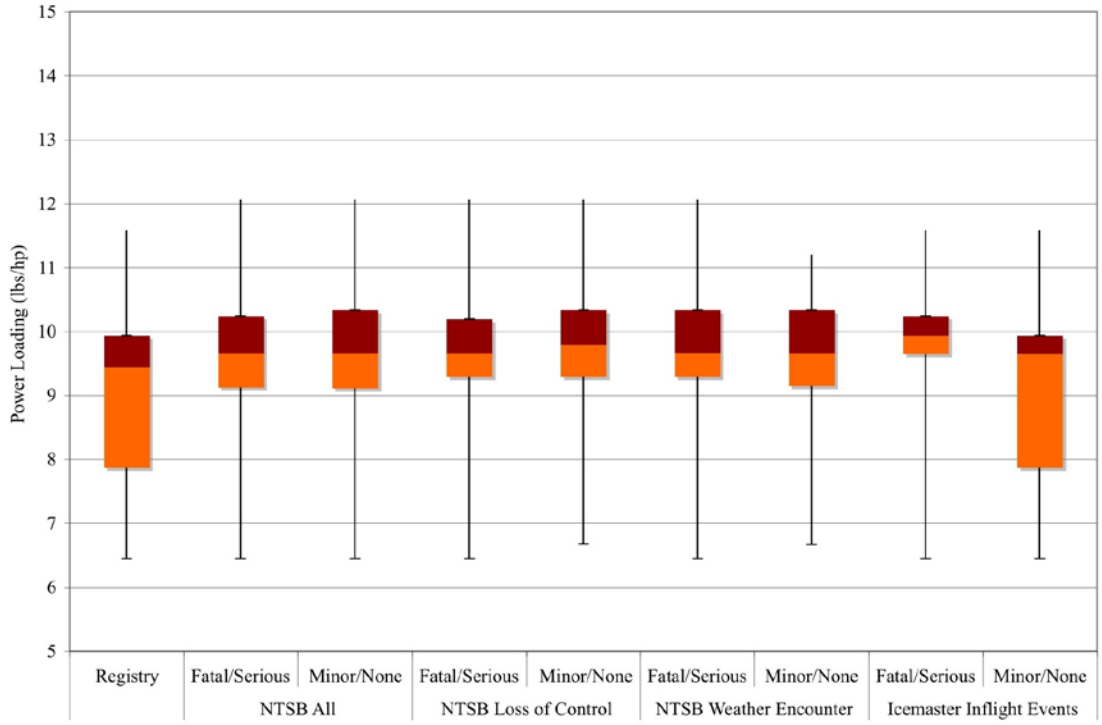


Figure 34. Design power loading within the icing-equipped NACA 23018 airfoil fleet for events

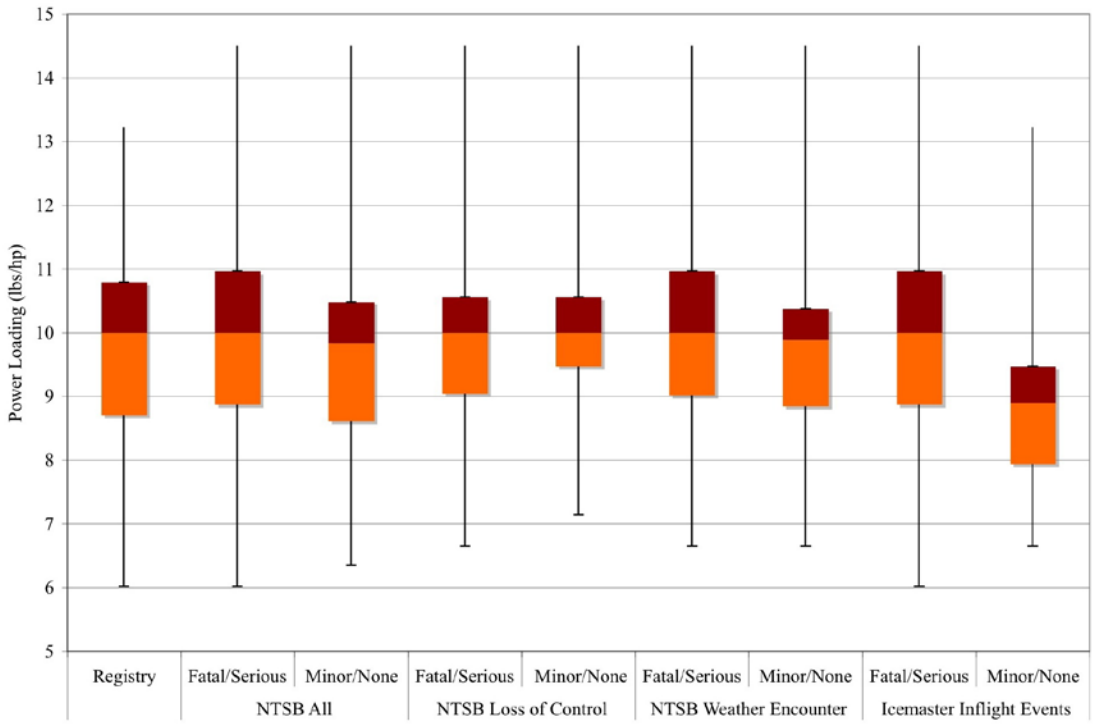


Figure 35. Design power loading within the icing-certificated non-NACA 23018 fleet for events

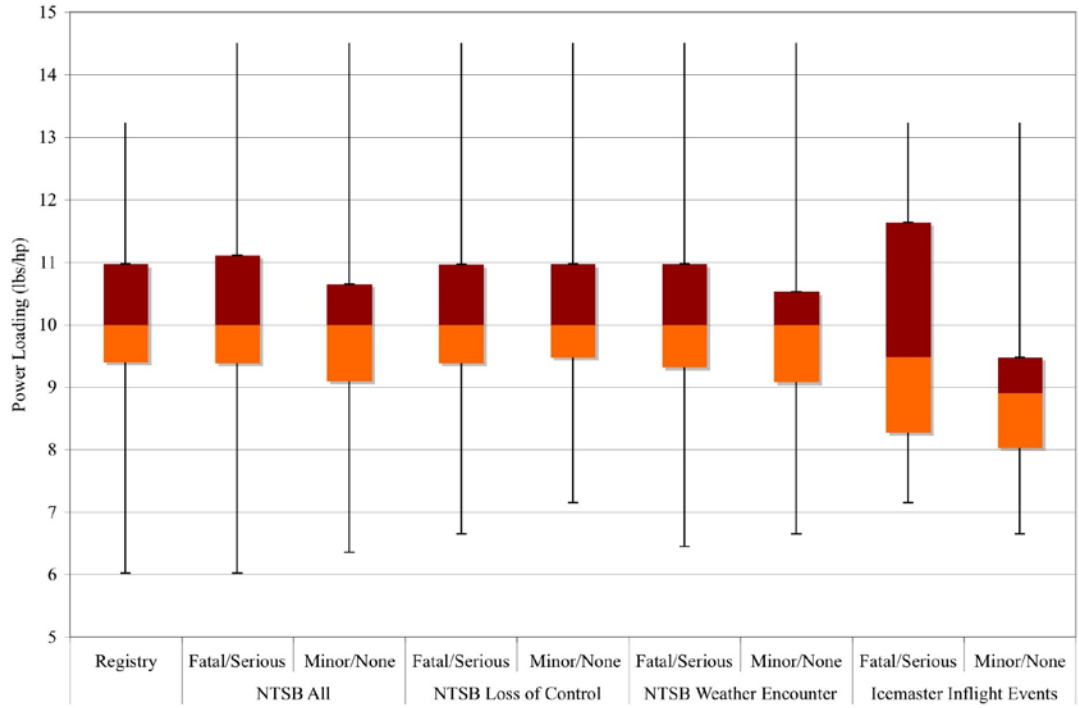


Figure 36. Design power loading within the icing-equipped non-NACA 23018 fleet for events

The shift in median power loadings observed in the icing data of figures 29 and 30 seems to be consistent both within the NACA 23018 fleet and external to that fleet. Within the 23018 fleet, approximately 75% of the events experiencing fatal or serious injuries involved aircraft with design power loadings of greater than 9.25 lb/hp. Conversely, approximately 75% of the events involving minor or no injuries occurred with aircraft having design power loadings of less than 9.25 lb/hp. A similar relationship appears to hold for aircraft that used airfoil sections other than the NACA 23018, although the medians for less serious and more serious events are much closer to each other and to the medians of the comparative fleets than the same medians are in the 23018 fleet.

These observations must be qualified with the sample sizes shown in table 14.

Table 14. Count of events with respect to airfoil family

Airfoil Section Fleet	Number of events involving fatal or serious injuries	Number of events involving minor or no injuries
NACA 23018 series	32	72
All other airfoils (except Cessna 208 airfoil)	38	57

9.5 INVESTIGATION OF IPS OPERATION

The basic distribution of data regarding operation of the IPS is shown in figure 37. The data were manipulated in an effort to see whether any observations could be made about IPS design and operation.

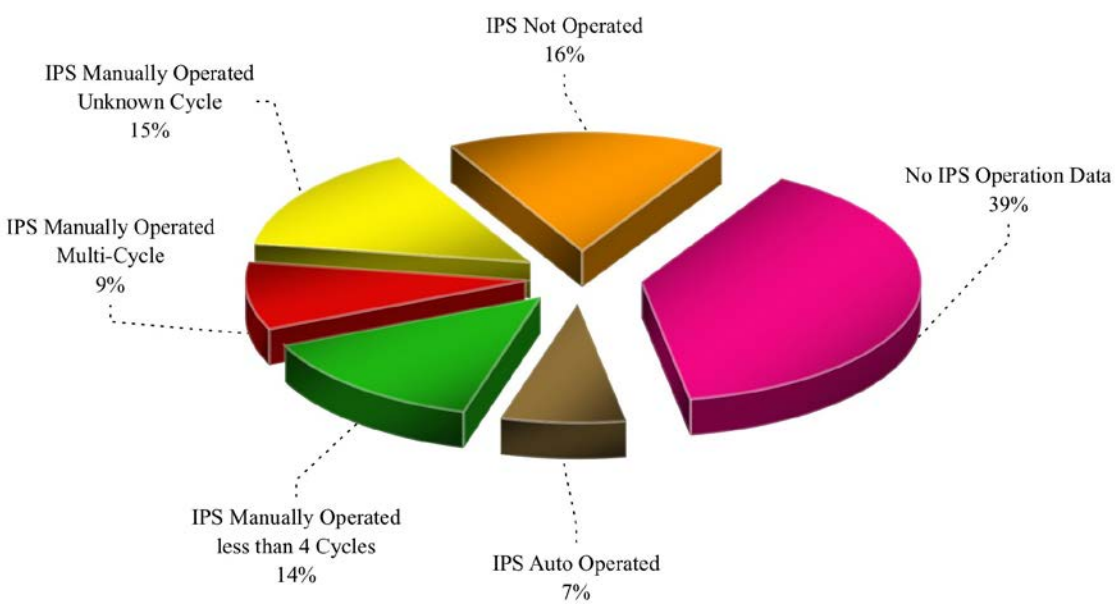


Figure 37. Inflight Icing Dataset: IPS operation for events

Figure 38 shows, by type of precipitation, the hull damage severity associated with several states of operation for the airframe IPS. It should be noted that the level of detail available regarding IPS operation is rather strongly correlated to the condition of the hull following the event. In those columns that provide greater detail, the number of actual hull losses is relatively low, whereas in the columns containing events for which no data are available, the hull losses are quite high.

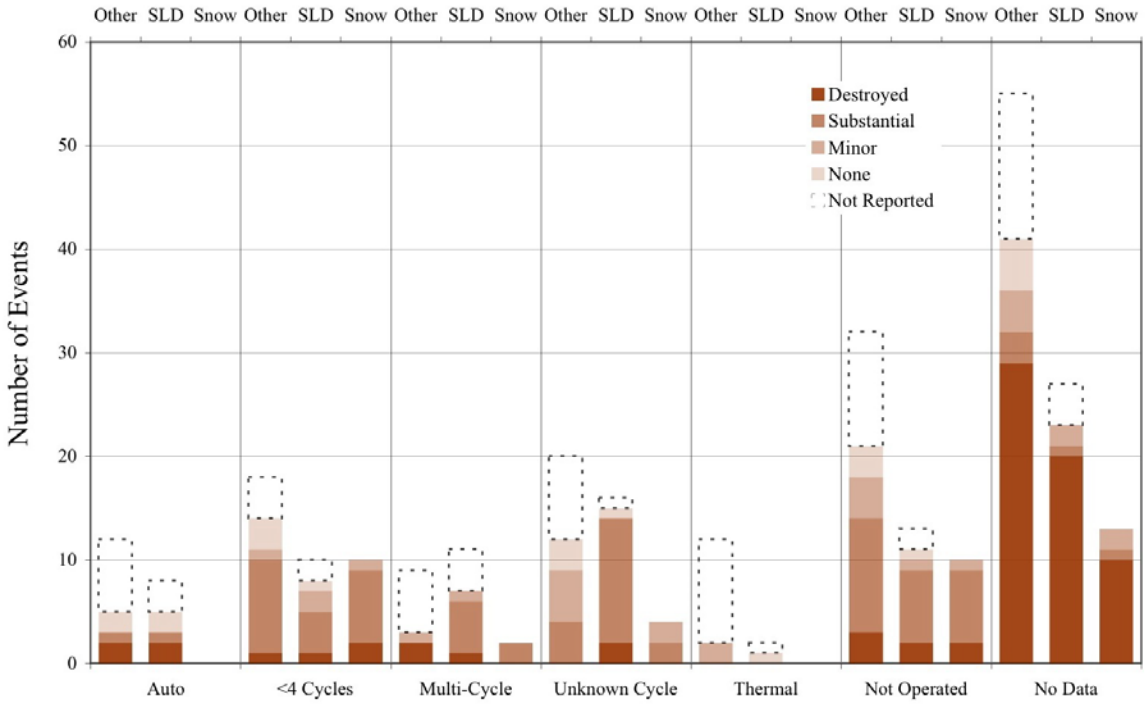
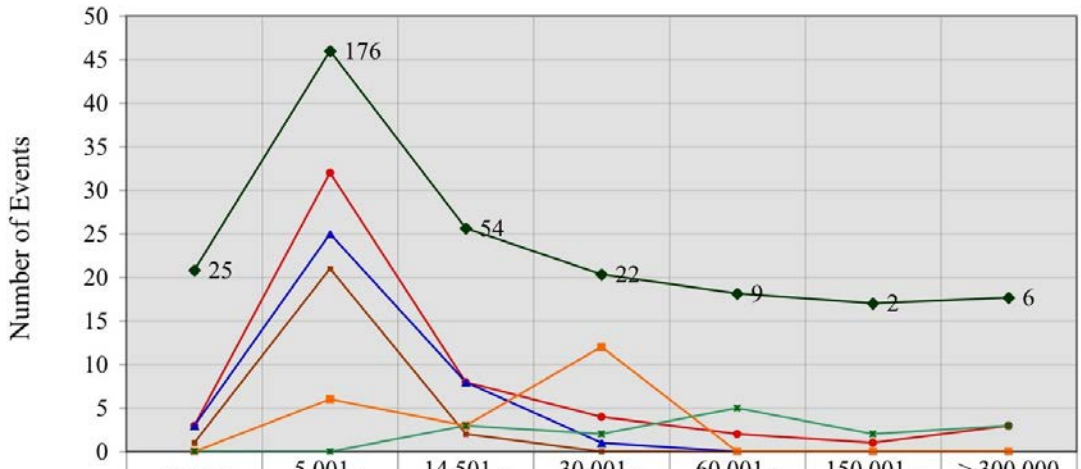


Figure 38. Event severity with respect to IPS operation and type of precipitation

Not surprisingly, a failure to operate the IPS can lead to a serious event. However, the prominence of the set of data in which the IPS was reported to have been cycled less than four times is noticeable.

Figure 39 shows the IPS operation with respect to scale. The top line shows the total population of events by scale. This line is built on a secondary *y*-axis scale and the values are shown. The remaining plots show the distribution of events with respect to scale based on IPS operation.



	< 5,000 lbs	5,001 - 14,500 lbs	14,501 - 30,000 lbs	30,001 - 60,000 lbs	60,001 - 150,000 lbs	150,001 - 300,00 lbs	> 300,000 lbs
Not Operated	3	32	8	4	2	1	3
<4 Cycles	3	25	8	1	0	0	0
Multi-Cycle	1	21	2	0	0	0	0
Auto	0	6	3	12	0	0	0
Thermal	0	0	3	2	5	2	3
All Events	25	176	54	22	9	2	6

Figure 39. The IPS operation with respect to scale for events

Within the 5,001–14,500 lb category (in which more than half of the data lie), it may be said that cycling the IPS less than four times appears to be better than not operating it at all, but is not as effective as cycling it more than four times. More effective still is an autocycled system. The autocycled plot rises within the larger scales, but this is because of the prevalence of this type of system in larger scale aircraft equipped with pneumatic ice protection.

The plot for thermal systems also follows the equipage distribution, appearing in consequence only in the larger scales. The data contain four hard-landing events involving aircraft equipped with and operating thermal airfoil IPS. The aircraft involved were a CL-600, Lear 31, Airbus A300, and Boeing 737. In all but the Airbus case, considerable residual ice was reported on unprotected surfaces. The Lear event reported ice strips approximately 1/2″ high, located 2″ or so aft of the leading edges of both wings and the stabilizer. The CL-600 had rough ice accreted to all unprotected surfaces and the 737 pilot reported several inches of horn-shaped ice adhering to the tail surfaces. In the Airbus case, ice accretion quantities were not reported.

It seems clear from this analysis that a regular, consistent cycling of the pneumatic system is optimal. However, a comparison of the data for non-SLD events versus SLD events in figure 38 seems to show that a consistent cycling approach to operating the IPS, though very effective in non-SLD environments, seems to be less effective at extinguishing events or reducing severity in the SLD cases. This seems reasonable given the tendency of SLD to accrete aft of the protected surfaces. However, the actual number of events in the data is quite small and it is probably best to say that the patterns do not show anything unexpected.

9.6 INVESTIGATION OF STALL WARNING AND EVENT PRECURSORS

Approximately half of the events in the dataset involved a stall, as shown in figure 40. Within that subset of stall events, the stall warning data are shown in figure 41.

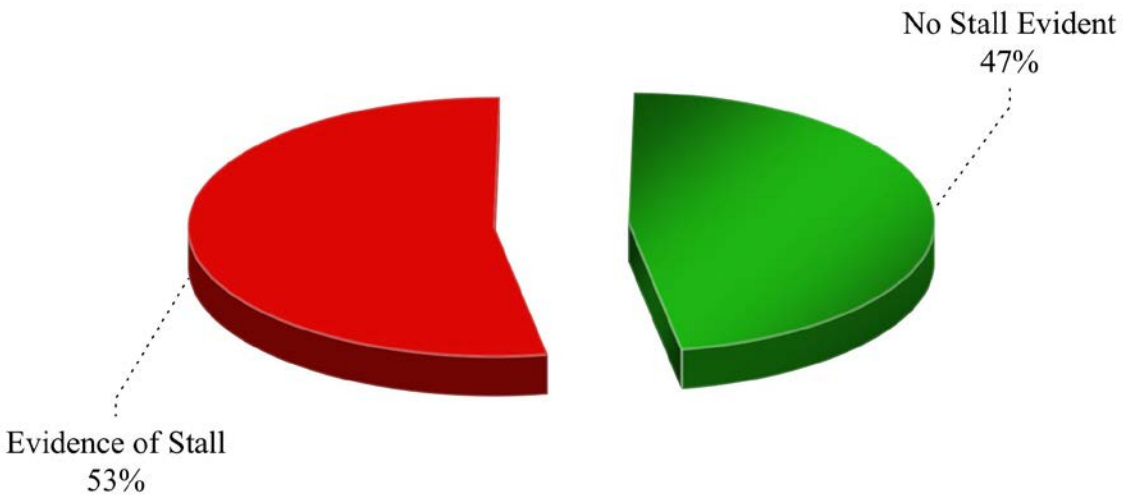


Figure 40. Inflight Icing Dataset: stalls during events

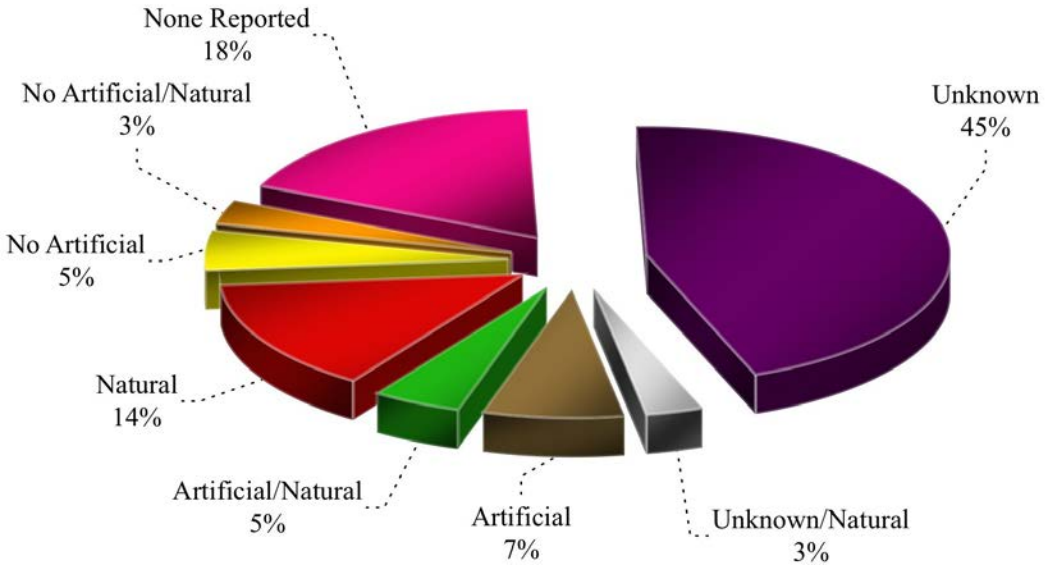


Figure 41. Inflight Icing Dataset: stall warnings for events with stall

Data regarding the presence of a precursor, such as degradation in the L/D ratio manifested through reductions in airspeed or climb rate, or even the inability to maintain altitude or glide path, were collected alongside data regarding artificial and natural stall warnings. The data are complicated primarily because of the absence of consistent detail. Figure 42 shows the entire dataset with respect to L/D degradations, stall speed degradations, and natural stall warnings and ASWs organized by the critical occurrence.

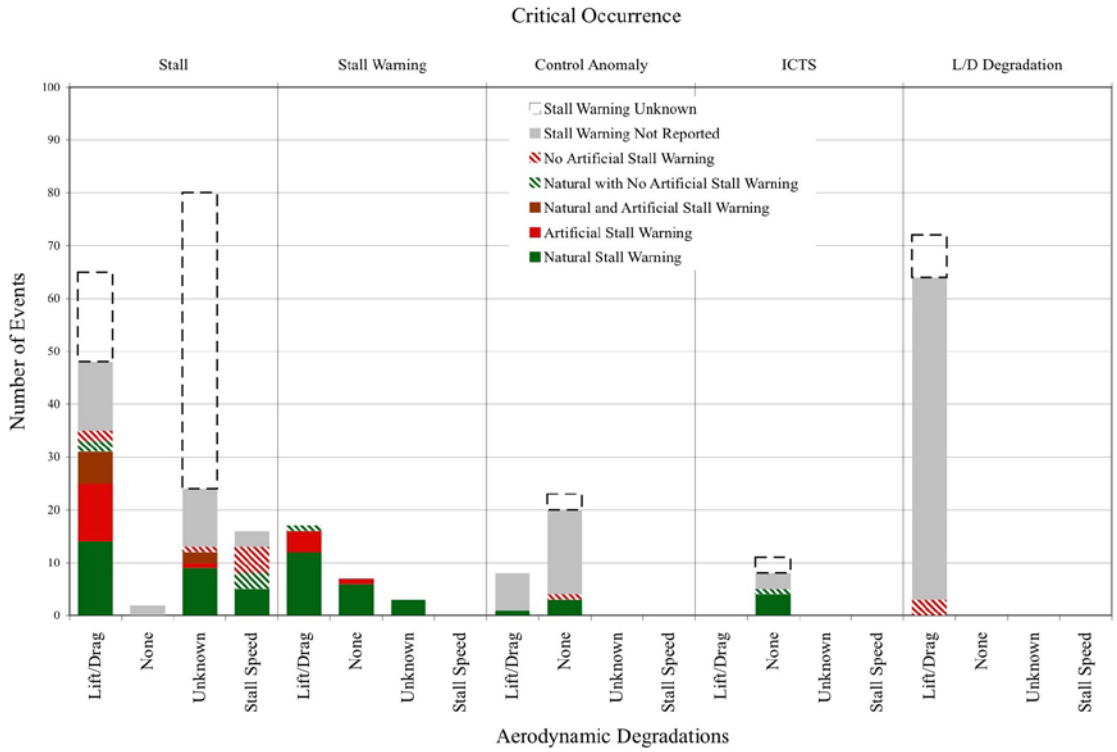


Figure 42. Stall warning relating to precursor and critical occurrence

There were 19 events for which the absence of an ASW was affirmatively reported in the data. In 13 of these cases, an actual stall was recorded as the critical occurrence. In one case, a natural stall warning was documented with no actual stall taking place. In five of these events, evidence was available indicating a stall took place at a higher indicated airspeed than the clean-wing stall speed for the aircraft.

There are 26 cases in which a stall was documented, but the pilots made no reference to ASW in their statements. The absence of a reference in the pilot statement cannot be construed as an affirmative indication that the ASW did not operate; however, had it operated, it seems likely that it would have been included in the pilot statement. To keep this distinction clear, these cases are shaded gray in figure 42. The events in which the operation of the ASW is simply unknown are not shaded and are bordered by a dashed line.

A natural stall warning was documented when an aerodynamic buffet was described by either pilot or passenger statements. In some cases, this was described as a control buffet. It is possible that a control buffet is not a natural stall warning, as in cases involving ICTS. However, making the distinction from pilot or passenger statements is difficult without informed observations. Therefore, any report of control buffet has been interpreted as possibly being a natural stall warning.

The data support the notion that some type of noticeable aerodynamic degradation is a common precursor to a stall event. In 65 cases in which the critical occurrence was an actual stall and 18 cases in which it was a stall warning, an L/D degradation was documented. This was also documented in seven of the control anomaly cases, but none of the ICTS events. There were 72 cases in which an L/D degradation was itself the most critical occurrence.

9.7 STALL RECOVERY OBSERVATIONS

Pilot statements, passenger statements, witness statements, CVR/DFDR data (when available), and any other evidence to build a sequence of aerodynamic occurrences and pilot actions were carefully examined. These two sets of data were related when the evidence could confirm a relationship (e.g., when a pilot input was in direct response to a particular aerodynamic occurrence). This is particularly useful with regard to stall and stall warning response.

Of the 308 events in the dataset, 163 involved a stall. In 22 cases involving a stall, the pilot applied a pitch-up control input in response to a stall manifested by either an uncommanded pitch down or an uncommanded roll. In 16 cases, there was clear evidence of a correct pitch-down recovery response, although nine of these events did not involve an actual stall, but only a stall warning. In 68 cases, there were no survivors or evidence from which to draw a conclusion regarding the stall recovery procedure. In the remaining 70 stall events, the data were insufficient to draw any conclusions regarding stall recovery procedures.

These data suggest that the initial response to stall indications may be incorrect in possibly half of the stall events.

9.8 ICE CHARACTERIZATION

Figures 43 and 44 show the terminology used to describe the ice and the estimated thicknesses.

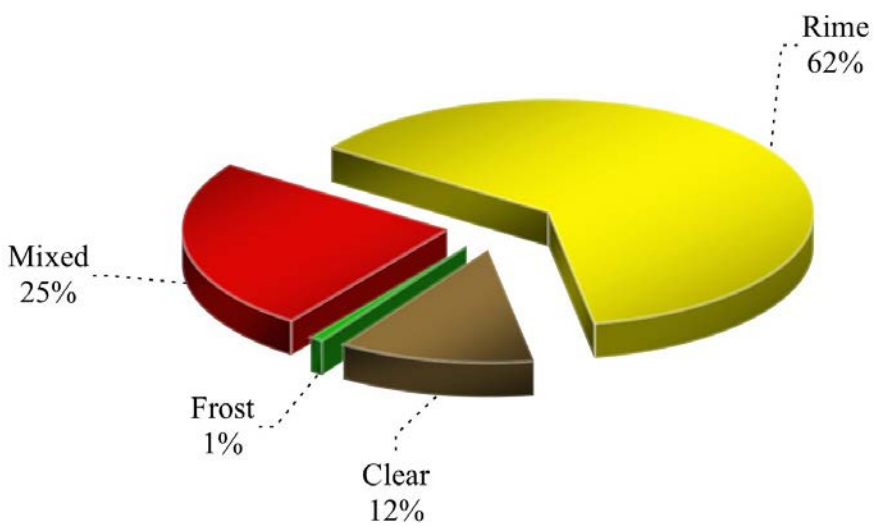


Figure 43. Type of ice reported for events

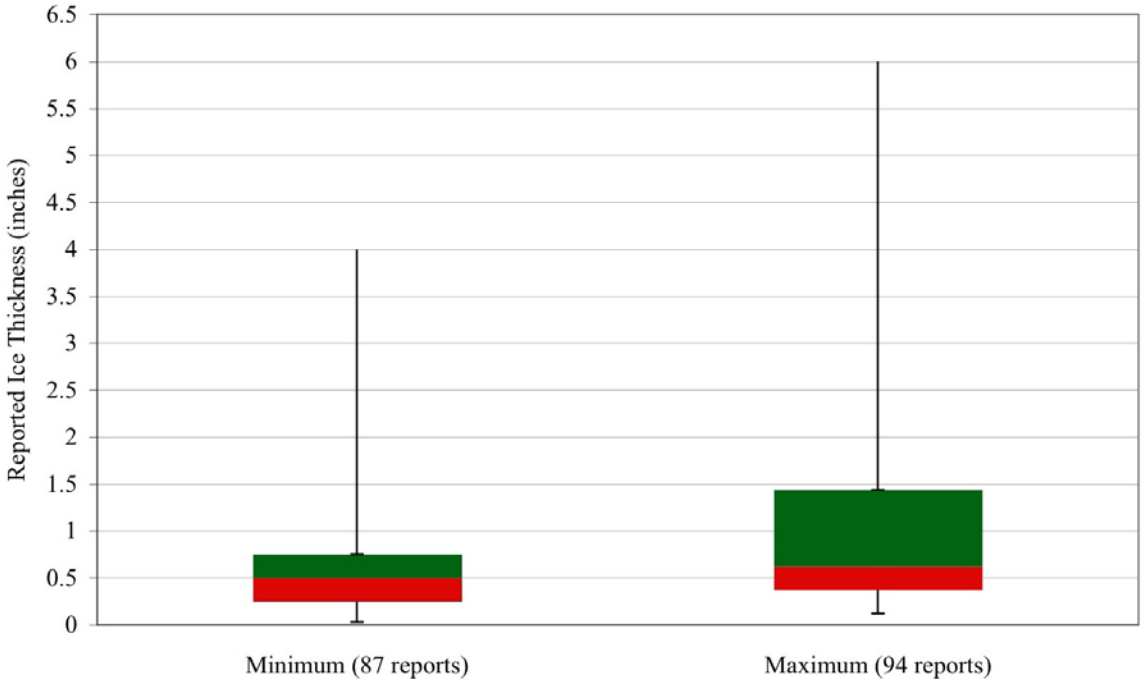


Figure 44. Minimum and maximum documented ice thickness for events

Figure 43 shows a breakdown of the type of ice identified in a number of the reports. Again, there is no particular pattern associated with what type of ice is being observed, suggesting that either the type of icing makes little difference or, perhaps even more likely, that the ability of the pilot or investigator to correctly identify it is limited.

Figure 44 shows two inter-quartile plots of the minimum and maximum ice thicknesses extracted from the reports. These are almost never objectively measured, but rather estimated, typically by the flight crew or investigator following the event. Data were collected regarding whether the ice was observed on protected or unprotected surfaces; in many cases, the surface is not reported. In a few cases, a period of time has passed, and some sublimation has probably had an effect. Typically, the ice thickness was reported as a minimum and a maximum, although occasionally only one thickness was reported. In that case, the data were interpreted within the context of the report; for example, statements such as “we had at least 1 inch of ice” were taken as a minimum with no maximum. The median of the minimum reported thicknesses is 0.5″; for the maximum reported thicknesses, the median is 0.625″.

Figure 45 is a compilation of the most conservative intensity descriptor used by either the flight crew (in written statements or as recorded in an ATC transcript) or the investigator, as submitted in the report. Although there appears to be almost no relationship between the descriptor and the outcome, an interesting observation can be made. The significant presence of the term “severe” in the incident column probably represents a reporting trigger. Encounters with light icing that do not result in an accident are probably not going to be reported.

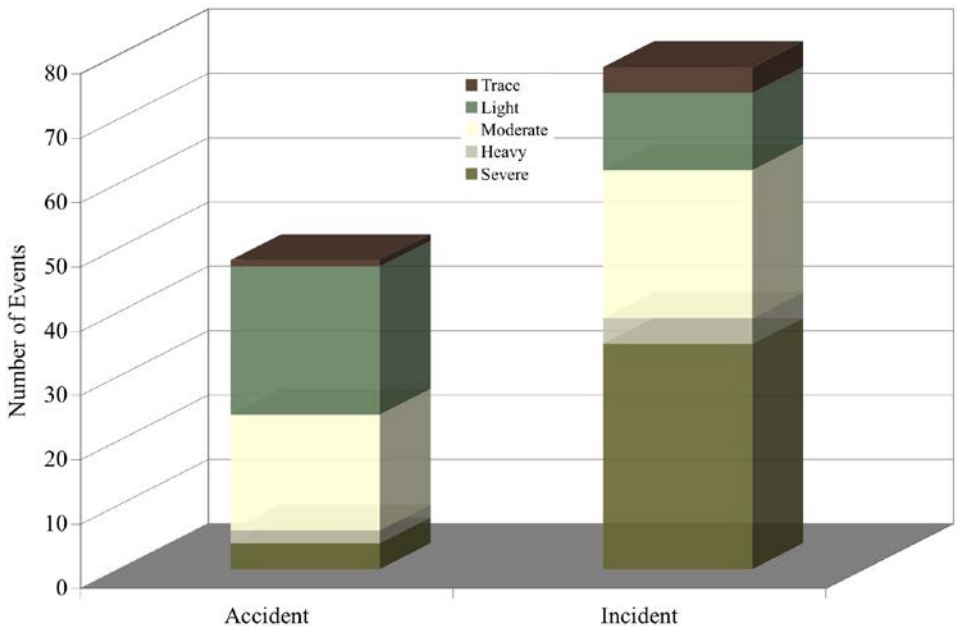


Figure 45. Intensity of ice reported for events

Conversely, the relative scarcity of the severe term in the accident column may simply be an artifact of the type of accident that yields survivors and, therefore, quality data. It may also reflect a misalignment of what the pilot thinks is a serious situation and what actually is. For example, once severe icing has been encountered, the pilot may respond with a more aggressive escape strategy, possibly avoiding an accident. But prior to that, while the icing is still considered light, the pilot may see no need for executing an escape strategy.

10. GROUND ICING INVESTIGATION

Unlike the inflight icing investigation, the ground icing investigation encompasses all aircraft, not just those equipped or certificated for flight in icing. There are 248 events in the database that are identified as ground icing events.

The ground icing data can be broken down into three basic categories:

1. Accidents and incidents that result in some degree of hull damage or injury.
2. Events that result in damage to turbine engines, but no hull damage.
3. Events in which the deicing procedures are compromised without damage or injury.

Most of the data within the latter two categories were discovered through ASRS reports, but the first category data were discovered through NTSB and FAA reports.

Of the 248 events, 128 are classified as accidents and 120 as incidents; 103 of the incidents are derived from ASRS reports. Resulting from these events were 450 fatalities (256 from Arrow Air at Gander) and 91 serious injuries. Of these aircraft, 44 were totally destroyed and 83 were substantially damaged.

Figures 46–48 provide an overview of the data sources, critical occurrences, and outcomes for the Ground Icing Dataset.

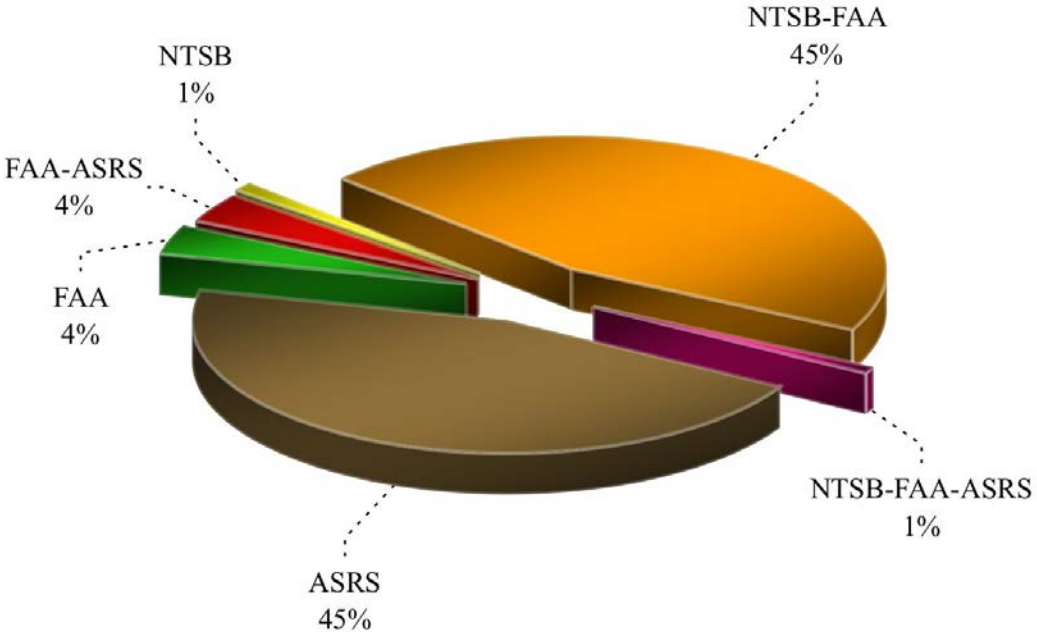


Figure 46. Ground Icing Dataset: data sources

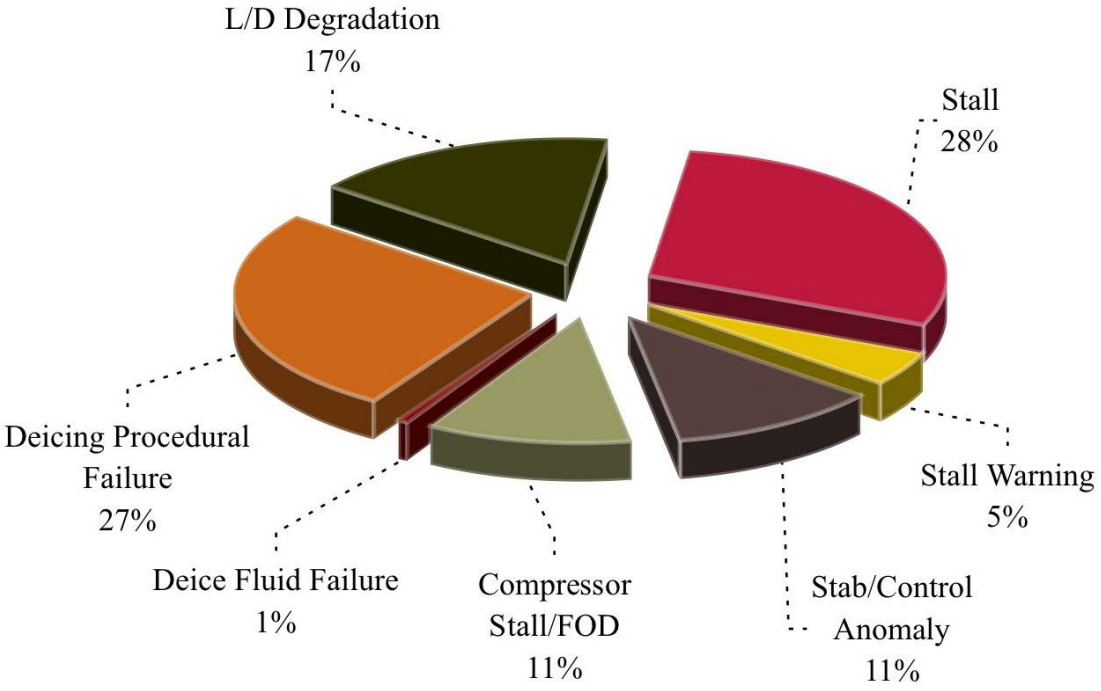


Figure 47. Ground Icing Dataset: critical occurrences of events

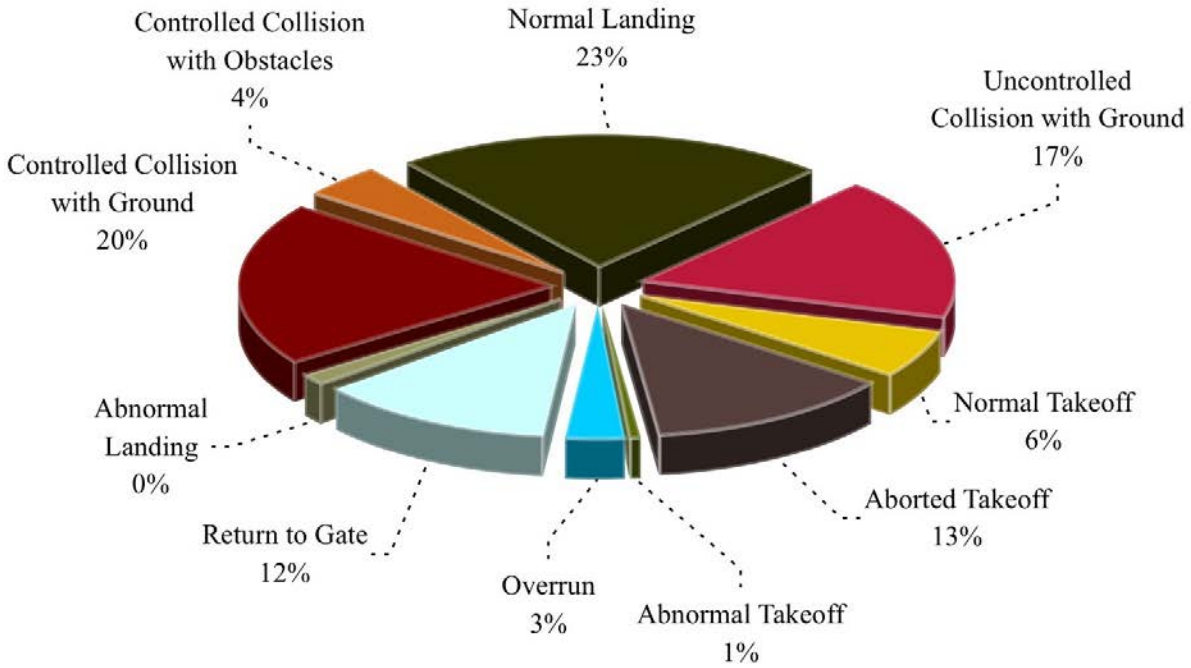


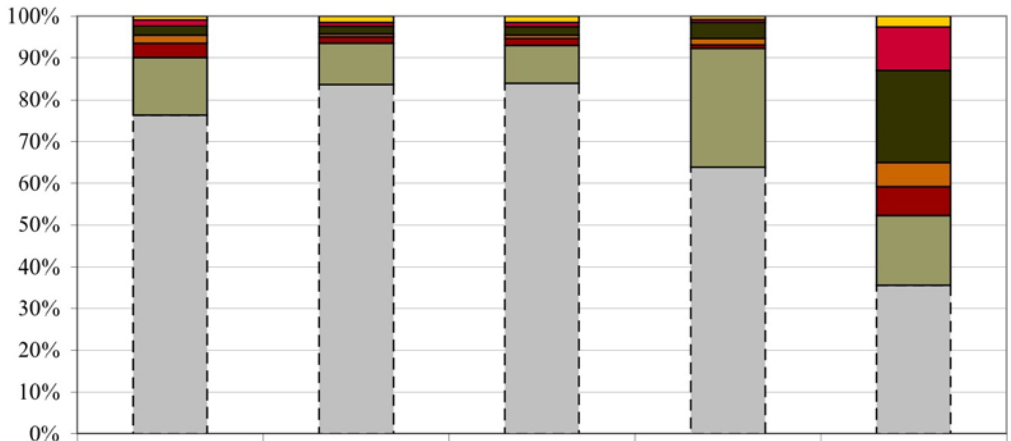
Figure 48. Ground Icing Dataset: outcomes of events

10.1 SCALE NORMALIZATION

Aircraft scale within the Ground Icing Dataset was normalized against the FAA Aircraft Registry and the NTSB Aviation Accident Database in the same way as the Inflight Icing Dataset (see figure 49). In this case, all powered, fixed-wing aircraft were considered, with the following exceptions:

- Homebuilts
- Warbirds
- Aircraft, other than crop dusters, operating on nonstandard airworthiness certificates

A smaller comparative subset of events was drawn from the NTSB Aviation Accident Database; in this case, those events that took place during the takeoff, takeoff roll, or takeoff-initial climb phases of flight.



	Aircraft Registry	NTSB All Accidents	NTSB Takeoff Accidents	Icemaster Ground Accidents	Icemaster Ground Events
>300000 lbs	3190	838	120	1	7
150001-300000 lbs	5241	616	94	1	27
60001-150000 lbs	7466	994	156	5	58
30001-60000 lbs	6794	449	66	2	15
14501-30000 lbs	12387	837	133	1	18
5000-14500 lbs	47894	5724	747	37	44
<5000 lbs	267202	48109	6816	83	93

Figure 49. Normalized comparison of scale within the powered, fixed-wing fleet for events

The significant presence of aircraft in the 60,001–150,000 lb and the 150,001–300,000 lb categories is mostly because of the prevalence of aft-mounted turbine engine configurations in these scales, and the resultant engine ice ingestion events following inadequate deicing. The definitions put forth in Code of Federal Regulations (CFR) 49 Part 830 preclude the classification of damage limited to a single engine as substantial; therefore, the damage to an engine because of foreign object debris (FOD) never results in classification as an accident. Within the 14,501–30,000 lb and 30,001–60,000 lb scales were 14 cases of failure to detect and remove ice on top of a T-tail, which is a common configuration within this scale.

10.2 OPERATING RULE

The FAR under which the aircraft was operated has a significant bearing on the data. Under Parts 121 and 135, the operator must have an approved ground deicing program established and defined in the company Operations Specifications. For nearly all Part 91 operations, this type of approved program is not required.

Figure 50 shows the type of operating rule in the Ground Icing Dataset. Figure 51 shows the event severity based on the operating rule, confirming that the majority of the data lie within the Part 91-Personal category of operating rule. This figure also shows the significant number of events within the 60,001–150,000 lb scale category that involve engine damage due to ice ingestion; this scale is the residence for most aircraft that use aft-mounted engines.

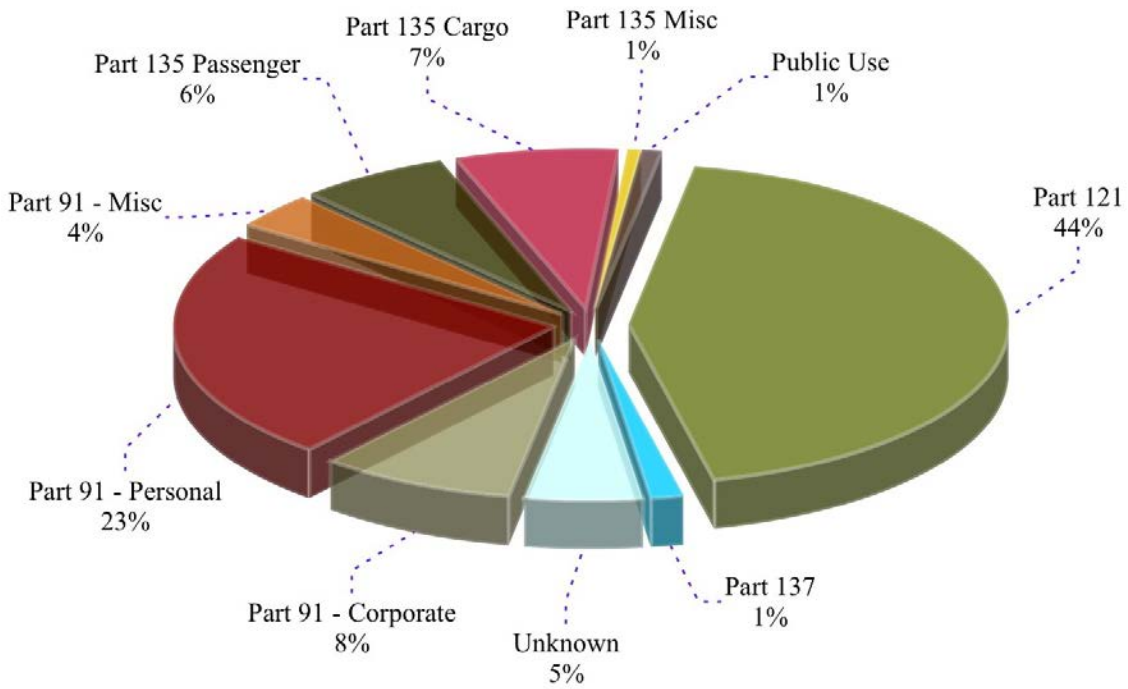


Figure 50. Ground Icing Dataset: operating rule for events

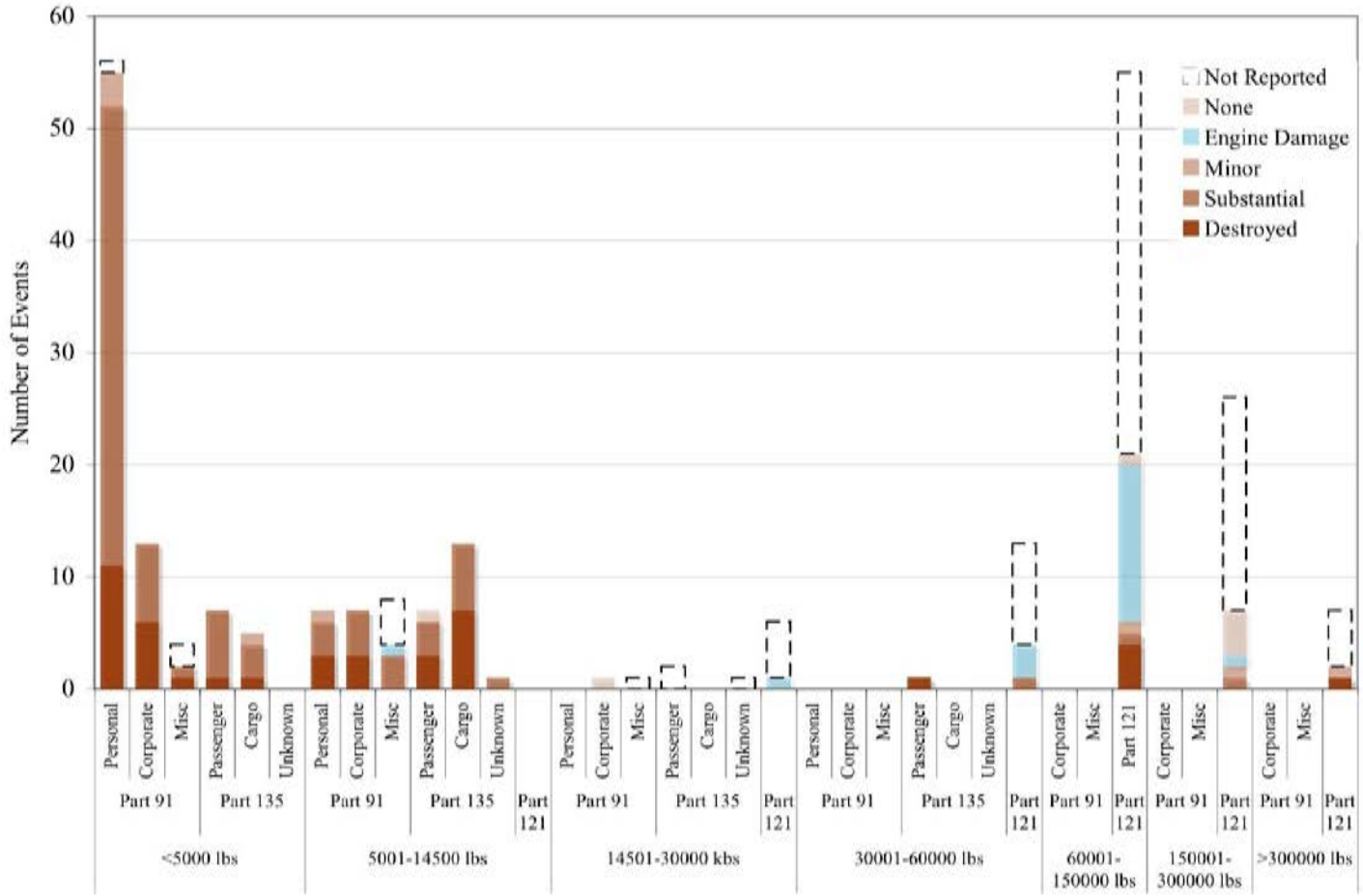


Figure 51. Event severity with respect to operating rule

With respect to the ground deicing program, this was not documented by the NTSB as a general rule. Larger, blue-cover reports contain this information, but less expansive investigations do not. Most of the Part 121 data were obtained through ASRS, which also does not document the ground deicing program approval. Generally speaking, a Part 121 operator will have an approved ground deicing program. The actual pedigree of that program would be very difficult to determine without access to the Operation Specifications, in particular A041 or A023.

More problematic is the program data relating to Part 135 operators, which also must have some type of operation specifications issued to define the program. These data are almost nonexistent.

10.3 METEOROLOGY

Figures 52 and 53 show the role of reported or observed ground icing conditions. The two principal types of ground icing that account for the majority of the data are snow and frost. It is interesting to note that freezing drizzle and freezing rain make up only 4% of the ground icing data. There may be a number of reasons for this. Freezing precipitation accounts for a small portion of the reported surface precipitation, and is unlikely to be commonly encountered. It is also more or less universally recognized as a hazard; however, in 22 cases, the flight crew believed that the snow would blow off of the wing during the takeoff roll.

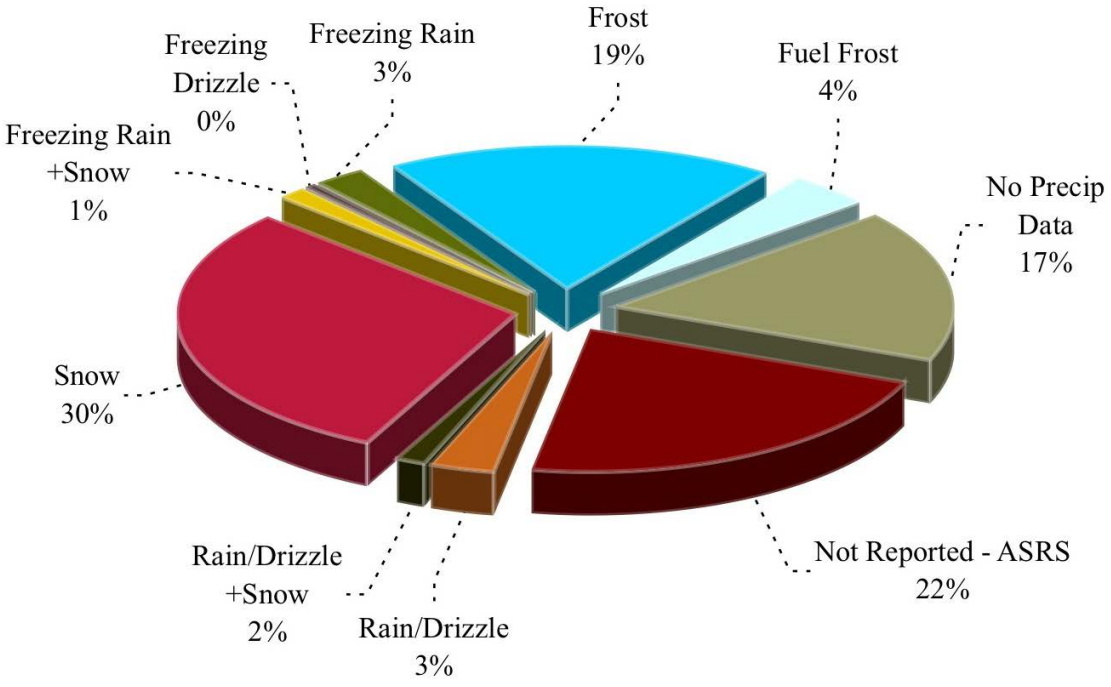


Figure 52. Ground Icing Dataset: observed or inferred surface precipitation for events

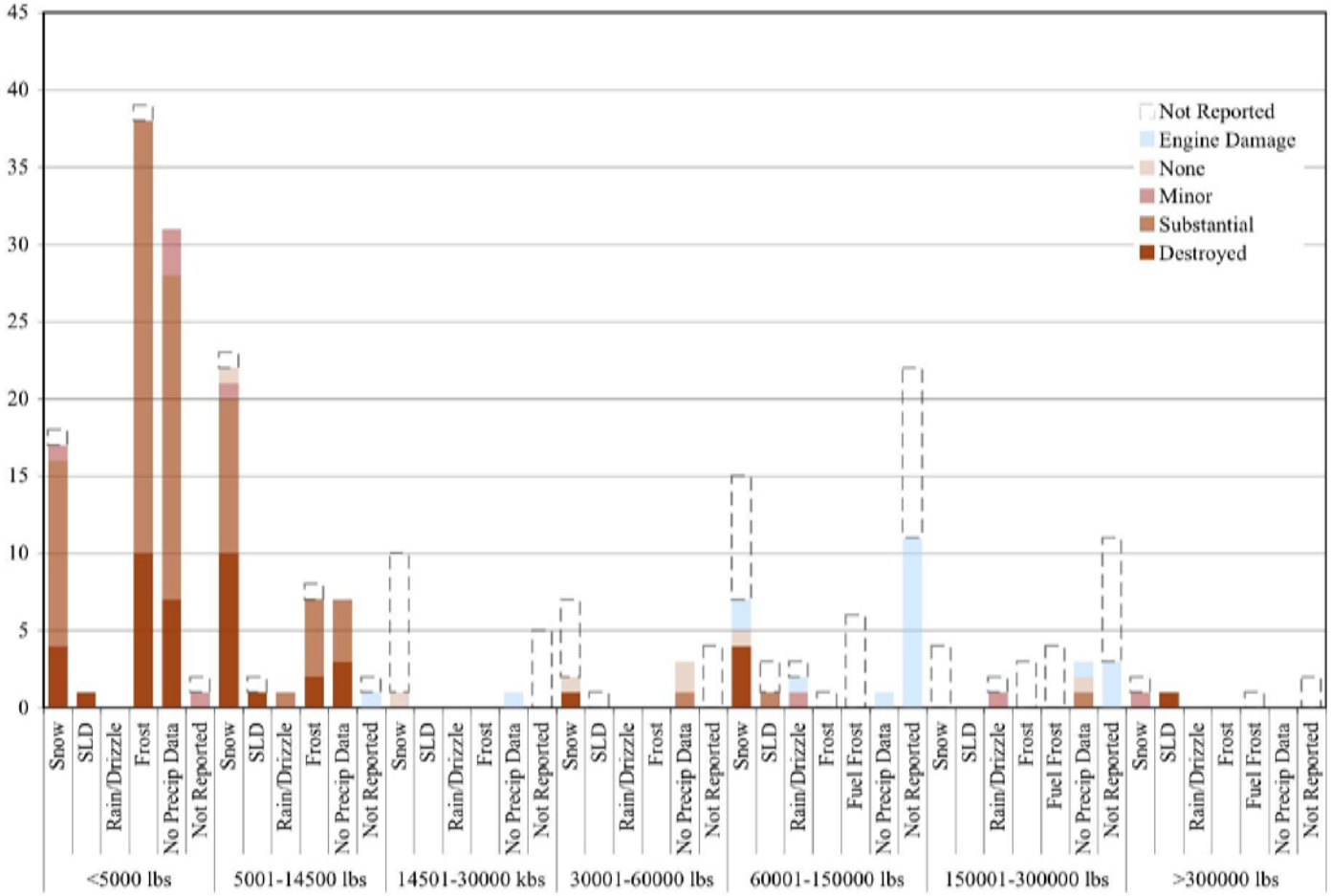


Figure 53. Event severity with respect to precipitation and scale

Though snow accounts for 33% of the data, frost is associated with 19% and is also the second most significant icing feature associated with hull damage and injury. Active frost was identified when the following conditions were present:

1. The temperature/dew point spread was 3°C or lower
2. The wind was at 10 knots or less

Alternatively, the frost was considered active if the following three conditions were indicated:

1. Temperature below freezing
2. Wind less than 10 knots
3. The narrative referred to frost

10.4 EVENT MORPHOLOGY

Ground icing accidents tend to fall into one of three broad categories:

1. A failure to deice
2. A failure to ensure complete ice removal
3. A failure to detect additional ice accretion following the deicing process

Figures 54 and 55 show the breakdown of these categories. The first category is associated with 48% of the data. Surprisingly, 16% involve situations in which the flight crew was aware of the ice but chose not to remove it prior to departure. A further 16% involve cases in which the flight crew was aware of ice remaining on the airframe following a deicing process. Figure 56 shows the event severity based on the types of deicing failures and the surface precipitation. This figure also reiterates the small role played by SLD in these types of events.

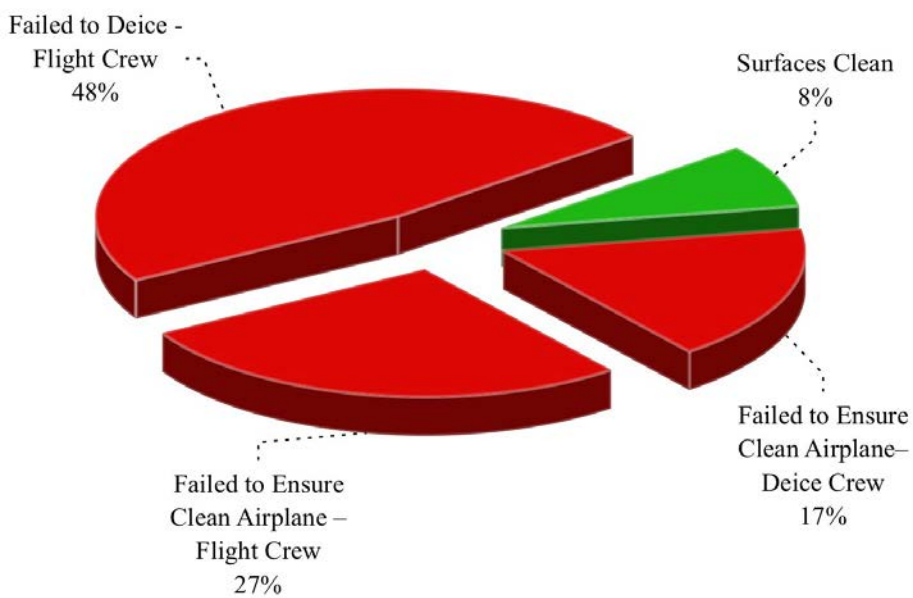


Figure 54. Aircraft surfaces status at ramp departure for events

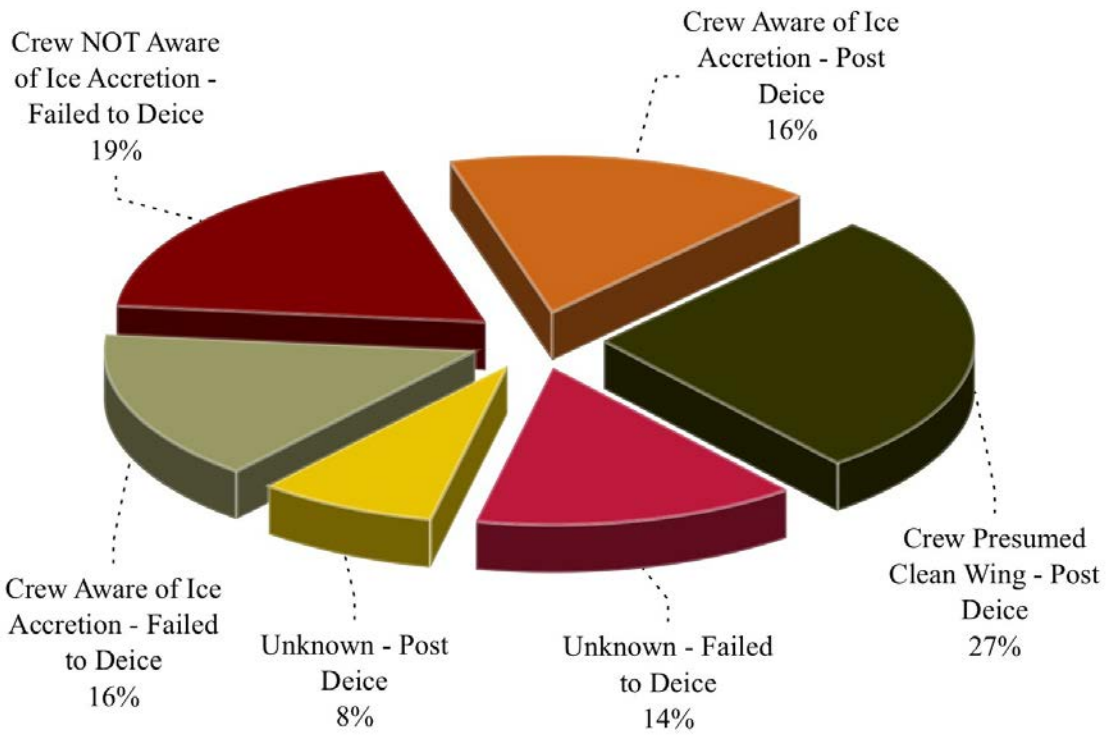


Figure 55. Flight crew awareness of ground ice accretion for events

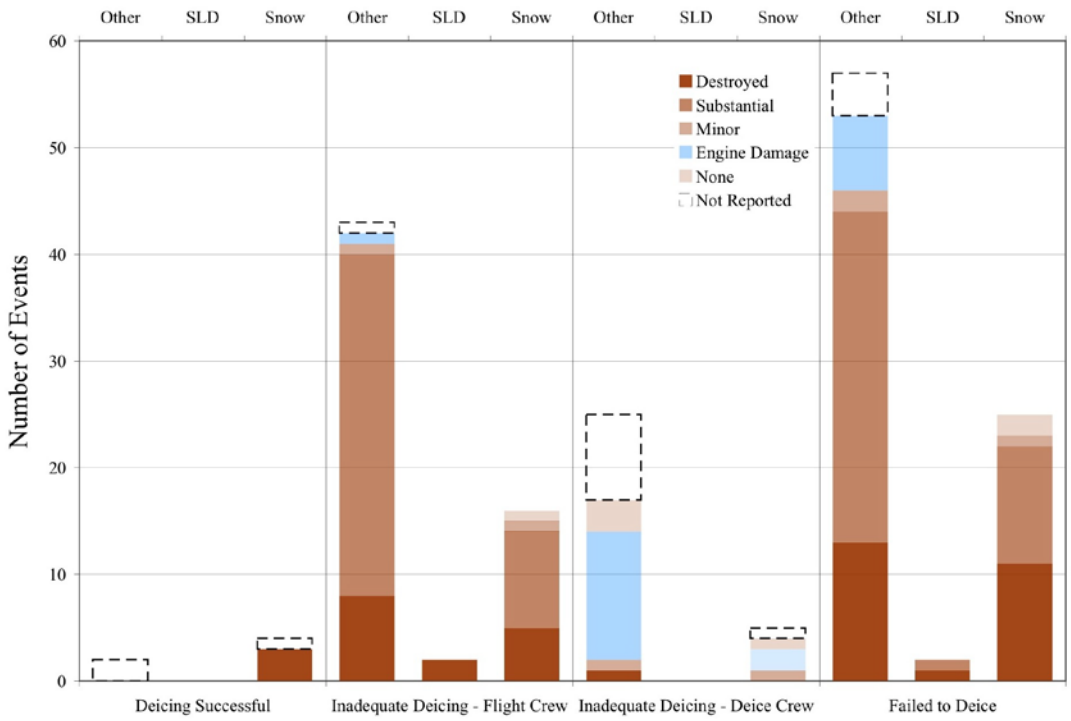


Figure 56. Event severity with respect to type of precipitation and deicing procedural failures

These categories can be further defined as follows:

- In a significant number of Part 91 operations for personal purposes, the pilot invested a considerable amount of time sweeping and scraping snow from the wings and tail of a small aircraft, yet failed to remove the underlying ice layer.

- The ground deicing crew failed to fully remove ice from the critical surfaces.

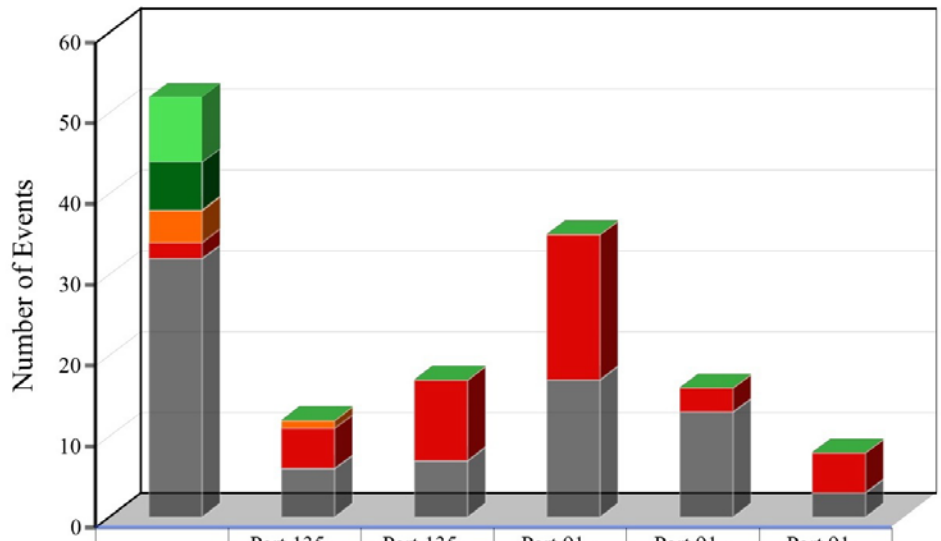
- Either the flight crew or the ground deicing crew, or both, failed to detect and remove ice on the upper surface of a T-tail configuration.

- In one manner or another, the pilot presumed that adequate precautions against ground icing had been taken, such as residence in a hangar or the use of wing covers. The significance of ice accumulation on uncovered surfaces and subsequent accretion once exposed to an ongoing ground icing condition was not recognized.

In 27 cases, the ice was detected following gate departure by a flight attendant, deadheading crew member, or passenger. A small number of reports documented the difficulty in inspecting the wing upper surface of large transport aircraft, particularly at night. In some cases, ice was described around the wing root to fuselage fillet; this area was not visible from the cabin windows.

10.5 ANTI-ICE PORTION OF A TWO-STEP DEICING PROGRAM

During active ground icing conditions, some method of providing anti-icing protection for the period between deicing and takeoff is required; this process is universally accomplished through a chemical application. However, for all but Part 121 operations, this part of the deicing process is generally not available. Figure 57 shows the data organized by operating rule with respect to deicing and anti-icing. In almost all of the Part 91 and Part 135 data, there was no reference to any kind of anti-ice step during active ground icing conditions.



	Part 121	Part 135 - Pax	Part 135 - Cargo	Part 91 - Personal	Part 91 - Corporate	Part 91 - Misc
Deice Completed/Anti-Ice Completed	8	0	0	0	0	0
Deice Completed/Incomplete Anti-Ice	6	0	0	0	0	0
Incomplete Deice/Anti-Ice Completed	4	1	0	0	0	0
Incomplete Deice/Incomplete Anti-Ice	2	5	10	18	3	5
Failed to Deice	32	6	7	17	13	3

Figure 57. Anti-ice step for events

However, with the exception of Part 121, all of the events associated with a failure to anti-ice during active ground icing conditions were also associated with a failure to ensure a complete deicing of the critical surfaces. Therefore, the relevance of the anti-icing step in these cases could not be determined.

10.6 REQUIRED PRE-TAKEOFF AND PRE-TAKEOFF CONTAMINATION CHECKS

If another approved means of ensuring that the critical surfaces are free of contamination is not applicable, a pre-takeoff contamination check is required by FAR 135.227 and 121.629 within 5 minutes of takeoff. If an approved ground deicing program is used, then the pre-takeoff contamination check is required only if the holdover time has expired or if there has been heavy snow (for which no holdover tables exist). Within the holdover time, under an approved program, a pre-takeoff check of representative surfaces is required.

Extracting the status of such checks from any of the reports was problematic. Figure 58 shows the results. In 34% of the cases, the check was not applicable because the aircraft remained at the gate; in 21% of the cases, the check was not required because of the absence of ground icing conditions. However, in 7% of the reports, the check was performed and apparently failed to detect existing ice.

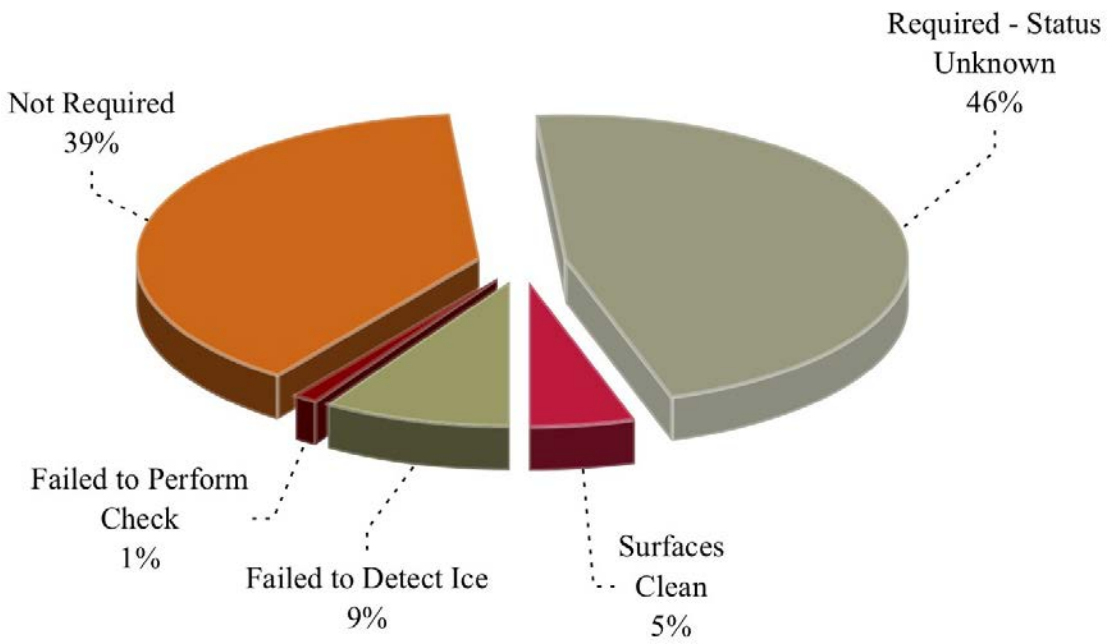


Figure 58. Pre-takeoff check for events

The 34% of reports in which a pre-takeoff check of some type was required, but yielded no data, are indicative of the problem in accurately measuring this parameter.

11. EVENT TEMPERATURE ANALYSIS

To perform this analysis, five different sets of temperature data were extracted. These were:

- Reported or observed surface temperatures associated with inflight icing events, with and without SLD
- Airborne temperatures associated with inflight icing events, with and without SLD
- Reported or observed surface temperatures associated with ground icing events

The first set of data comprised temperatures extracted from 414 events, with 75 of these being associated with SLD. This included the Inflight Icing Dataset events and events not eligible for inclusion in the Inflight Icing Dataset (generally due to the aircraft not being equipped for icing).

A significant limitation of this dataset is that the temperature itself was observed at the surface, but the actual icing in question may have taken place at altitude. It is possible for an event to report a surface temperature measured 20 miles or more horizontally and several thousand feet vertically from the event location. Some consideration was given to omitting the events that take place in the cruise flight phase, or even the cruise, climb, and descent phases. However, it is just as possible for a cruise event to report a surface temperature within a mile of the site and perhaps

only 2000 feet below; no particular algorithm could be devised that would not bias the data one way or another. Therefore, it is all included.

The second set of data is much more proximate to the ground icing events that generally took place very close to the temperature observation site. However, these events did not result from either reference 9 or SLD icing, but were most often associated with snow or frost. There are 114 data points in this set.

The third set of data consists of airborne temperatures reported by the flight crew, either in a post-event statement or through ATC transcripts. The data contains 46 reports, 19 of which are associated with SLD. A small number of airborne temperatures were extracted from radiosonde data correlated to the accident in a meteorological factual report.

This set of data is perhaps the most relevant to the task. However, it also has significant limitations. Almost none of these temperatures can be identified as either a static air temperature, TAT, or some other type of outside air temperature.

Figure 59 shows these three data sets, with the SLD events shown independently for a total of five plots. Table 15 shows the average, median, minimum, and maximum temperatures for the stated population. Though only 19 events yielded airborne temperature information when SLD was associated with the event, it is interesting to note that the temperature range is fairly tightly clustered around the median of -4°C.

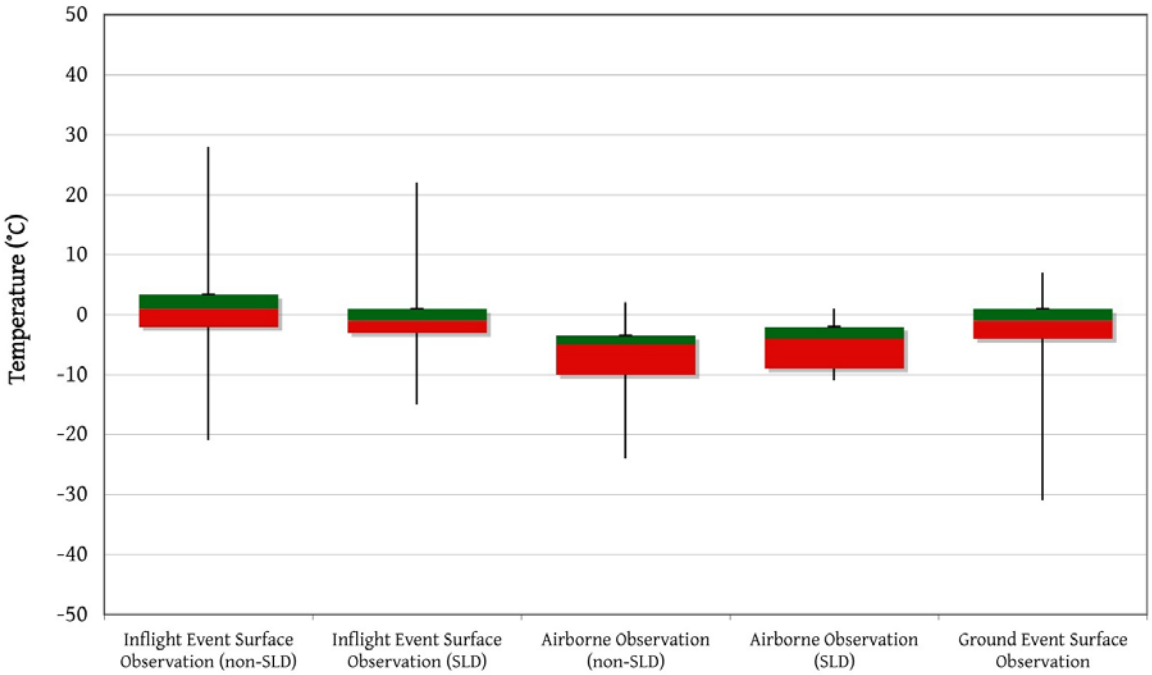


Figure 59. Event temperature distribution

Table 15. Temperature data for events

Data Set	Source	Average	Median	Minimum	Maximum	Population
Inflight	Ground observation, without SLD	1.26	1	-21	28	347
Inflight	Ground observation, with SLD	-0.38	-1	-15	22	66
Inflight	Airborne report or estimate, without SLD	-7.14	-5	-24	2	27
Inflight	Airborne report or estimate, with SLD	-4.93	-4	-11	1	19
Ground	Ground observation	-2.31	-1	-31	7	114

Figure 60 shows the altitude distribution for altitudes corresponding to an airborne temperature.

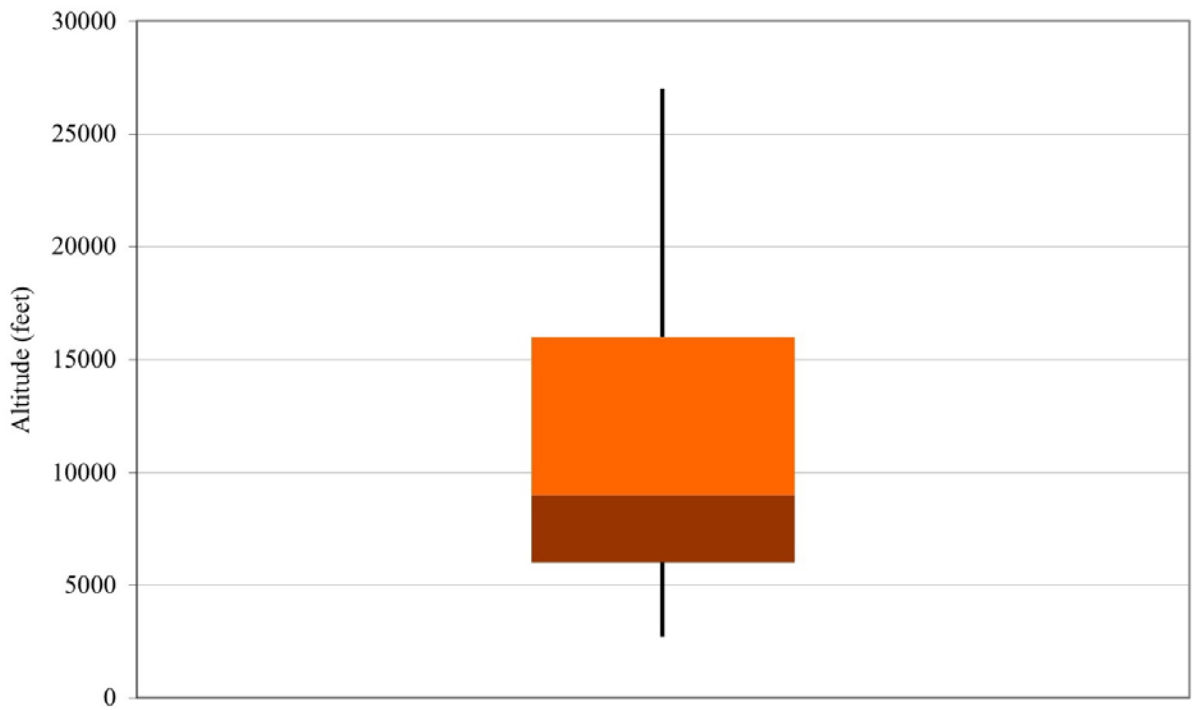


Figure 60. Altitude profile for recorded airborne temperatures at icing levels for events

12. SUMMARY

12.1 INFLIGHT ICING EVENTS

The IceMaster database consists of 308 events in the Inflight Icing Dataset. The major findings from the analysis of these events that took place from 1982–2010 are as follows:

- Thirty-two events (10.4%) involved aircraft with maximum gross weights greater than 60,000 lb. Of these events, 30 were reported through ASRS. None were classified as accidents.

- No aircraft damage or personal injury was associated with events for aircraft with thermal airframe IPS. However, four hard landings (1.3%) were associated with these systems.

- The majority of events with aircraft damage and personal injury were associated with a failure to operate the IPS. Events in which a pneumatic system was operated for less than four cycles constituted the second most numerous category.

- Though substantial airframe damage can be incurred without a stall, nearly all of the total hull losses and fatalities resulted from events that included a stall.

- The ASW did not operate in at least 19 of the 163 stall events (11.7%).

- In 65 of the stall events, 18 of the stall warning events, and seven of the control anomaly events, a precursor degradation was identified.

- In 22 of 38 stall or stall warning events that yielded adequate data, the pilot's initial response to a stall or stall warning was to apply nose-up pitch control inputs. In 16 cases, nose-down pitch input was applied.

- The SLD conditions were associated with 35% of the aircraft destroyed, 39% of those substantially damaged, and 34% of the fatal accidents.

- There does not appear to be a relationship between operating rule and the likelihood of an event. Part 135 aircraft were just as likely to be involved in an icing event as Part 91 aircraft. Considering that Part 135 has a regulatory weather-training requirement, and Part 91 does not, this point may speak to the effectiveness of that training.

- Aircraft that are certificated or approved (defined in section 7.8) for flight into known icing, or that are eligible for such certification if properly equipped, account for 81% of the events.

- Within the 308 event dataset, 10 events involved the MU-2; 10 involved the EMB-120; 17 involved either the ATR 42 or ATR 72; and 24 involved the Cessna 208. Therefore, 61 (19.8%) of the events involved these 5 aircraft.

- Aircraft with design power loadings of more than 9 lb/hp tend to have more-severe icing events (in terms of fatalities and serious injury) than those with power loadings of less than 9 lb/hp.

- The NACA 63-415 airfoil section, used on the Piper PA-31, and the NACA 65-415 section, used on the Piper PA-34, appear far less frequently in the inflight icing data, within a normalized fleet, than do aircraft equipped with the NACA 23012 or its variants.

12.2 GROUND ICING EVENTS

The Icemaster database comprises 248 events in the Ground Icing Dataset. The findings from the analysis of these events that took place from 1982-2010 are as follows:

- The failure to ensure the complete removal of frozen contaminants from the critical surfaces occurs in 44% of the events in the Ground Icing Dataset. It is particularly interesting within Part 91 operations because it reflects an effort to manually remove a portion of the contaminants, followed by a willingness to accept some remaining contamination.

- A substantial number of reports detailing a failure on the part of Part 121 certified ground deicing crews to ensure complete ice removal may indicate weaknesses in training/post-deice inspection capability.

- For large aircraft, the ability of the cockpit crew to execute an effective cabin check may be limited.

- The threat posed by incomplete deicing of turbine-powered aircraft with aft-mounted engines may not be accurately cataloged because of the definition of substantial damage contained within CFR 49 Part 830, Notification and Reporting of Aircraft Accidents or Incidents and Overdue Aircraft, and Preservation of Aircraft Wreckage, Mail, Cargo, and Records.

- It is likely that scale may play a role in ground icing events, although it may do so both indirectly and directly. For example, large-scale Part 121 aircraft have much better access to chemical deicing programs, and large-scale Part 91 aircraft, while also having such access, are much more likely to be parked in a hangar.

- Operations in active ground icing are largely conducted without any sort of anti-icing process in place for all but Part 121 and a few Part 135 operators.

12.3 EVENT DOCUMENTATION

NTSB documentation was used to assist in the development the database and in the analysis of the data. There were several issues with the use of this information, such as:

- There is frequent inconsistency/non-uniformity in the recording of standardized data, including but not limited to aircraft type and manufacturer's serial number. For example, a Model 310R manufactured by Cessna may be documented as C-310, C-310R, CE-310R, or just a 310. In parallel with this, the serial number may or may not include the appropriate manufacturers' prefix (e.g., 310R). Other serial numbers may not include appropriate dashes or key letters that differentiate it from other models. This lack of uniformity seriously compromises data extraction.

- +There is a pronounced inadequacy in the documentation of ice protection equipment as installed and the existence or validity of icing certification. It is essential to determine whether the particular serial number was both eligible for icing certification and equipped as required for such a certification. This type of documentation has historically been very sparse; in 99 of 180 NTSB reports, no reference was made to icing certification. In seven reports, the NTSB documentation indicated that the airplane was certificated for flight in icing when the TCDS for that corresponding serial number stated that icing certification was not an option. Consequently, great effort must be expended to approximate the equipage and certification status, without which erroneous or inaccurate conclusions can be drawn. Even with that effort, the conclusions drawn are less robust than they might be with better discipline in field documentation.

- The status of the IPS as found following the event is also inconsistently documented. Admittedly, the cockpit is actually destroyed in many cases to an extent making documentation impossible; however, in at least one case, the cockpit documentation in NTSB form 6120 indicated that all switches and indicators were destroyed, when an accompanying series of photographs clearly showed the Engine Inlet Heat and Pitot Heat switches in the "on" position, and the Airframe Ice Protection switch in the "off" position. It is more common for no information on system status to be recorded at all. Because it is known that, following the accident, controls and indicators may be found in positions that are not reflective of system status before the accident, a judgment as to the reliability of this type of data, based on the event severity, cannot be made if the data is never recorded.

13. CONCLUSIONS AND RECOMMENDATIONS

Through the development of the IceMaster database and the analysis of the inflight and ground icing data, the following conclusions and recommendation have been made:

- The role of supercooled large droplet (SLD) in icing events should be strongly emphasized in both training and procedural design. An SLD is reported in less than 1% of surface observations, yet is associated with up to 30% of all inflight icing events. There is a very strong relationship between SLD and an icing mishap.

- The effects of icing on the lift/drag (L/D) ratio, and the role of the L/D ratio in aircraft performance and power required for a given configuration, should be emphasized in training and procedural design. It is not enough to emphasize lift degradation; even with a

properly functioning IPS, there will be a degraded L/D ratio due to ice accretion on unprotected surfaces. The failure to adequately compensate (through changes in flight path management) for the effects of a degraded L/D ratio may initiate the sequence of events leading to a stall-induced accident.

- The significance of power loading, through the effect on required power caused by a degraded L/D ratio, may be appropriate for further investigation. It is possible that some type of standard for power loading may be useful in establishing icing certification, perhaps with respect to the presence of inter-cycle or residual ice.

- Though considerable wind tunnel and icing tunnel research has been completed on variants of the National Advisory Committee for Aeronautics (NACA) 23012 airfoil section, it may be appropriate to determine whether equivalent empirical or theoretical icing data exist for such airfoils as the NACA 63-415 and 65-415. Such data could be used for further comparative study between theoretical/empirical data and the icing event history of aircraft using these airfoil sections.

- Approved and accepted publications should be evaluated for language that may promote or advocate the infrequent operation of the IPS. This is particularly true with respect to pneumatic boots. It is clear from this data that 1/2″ or less of ice accretion can be sufficient to cause major and potentially life-threatening aerodynamic penalties on many aircraft. It is also clear that infrequent operation of the IPS, or the complete failure to operate them, is more likely to lead to an icing mishap than cases in which the systems are operated consistently and aggressively.

- The statement that there is a difference between the aerodynamic effects generated by rime ice as opposed to clear or glaze ice is common, but it may be of no real operational use. A more useful paradigm would be to describe ice in terms of SLD or non-SLD (e.g., whether it has accreted aft of protected areas or on a side window). This information, if clearly communicated through pilot reports, is likely to be far more useful in decision making than whether an ice accretion appears to be rime or clear ice.

- A specific effort should be made to improve field documentation of ice protection systems; verify aircraft icing equipage and certification; and accurately record the manufacturer's serial number and model. Without uniform, accurate information in these areas, the industry response to icing accidents and incidents is crippled before it even begins.

14. REFERENCES

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2. Federal Aviation Administration, “Aviation Data & Statistics: Data Downloads,” available at http://www.faa.gov/data_research/aviation_data_statistics/data_downloads/ (last accessed in April 2015).

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6. Bernstein, B.C., “Regional and Local Influences on Freezing Drizzle, Freezing Rain, and Ice Pellet Events,” *Weather and Forecasting*, Vol.15, 2000, pp. 485–508.

7. “Jane’s All the World’s Aircraft,” HIS Global Inc., London, England, Published annually.

8. “The Incomplete Guide to Airfoil Usage,” available at www.aerospace.illinois.edu/m-selig/ads/aircraft.html (accessed July 21, 2014).

9. Title 14 Code of Federal Regulations Part 25, “Airworthiness Standards: Transport Category Airplanes,” Appendix C, revised and reissued annually.

APPENDIX A—LIST OF EVENTS IN THE INFLIGHT ICING DATASET

Table A-1. List of events in the Inflight Icing Dataset

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001204X00016	NTSB	N4920M	Beech	95-C55	1/21/1999	Pellston, MI	20001204X00016	19990121000659A		ACC	Stall	Uncontrolled Collision With Ground
20001204X00024	NTSB	N20GT	Gulfstream	695A	1/12/1999	Wheeling, IL	20001204X00024	19990112013589A		ACC	L/D Degradation	Hard Landing
20001204X00031	NTSB	N181JW	Piper	PA-46-350P	1/24/1999	Rockford, IL	20001204X00031	19990124000709A		ACC	L/D Degradation	Land Short
20001204X00103	NTSB	N31UV	Cessna	310R	1/8/1999	Allentown, PA	20001204X00103	19990108000399A		ACC	L/D Degradation	Hard Landing
20001205X00458	NTSB	N497CA	Piper	PA-46-350P	4/4/1999	Waldron, AR	20001205X00458	1999040400293 A		ACC	Stall	Inflight Breakup
20001206X00614	NTSB	N5468G	Cessna	421C	1/26/1994	Mccook, NE	20001206X00614	19940126000879B		ACC	Stall	Uncontrolled Collision With Ground
20001206X02420	NTSB	N401AM	ATR	ATR72-212	10/31/1994	Roselawn, IN	20001206X02420	19941031036779B		ACC	Stall	Uncontrolled Collision With Ground
20001206X02698	NTSB	N5647D	Beech	E18S	12/8/1994	Kansas City, MO	20001206X02698	19941209041209A		ACC	Stall	Uncontrolled Collision With Ground
20001207X02840	NTSB	N421AW	Cessna	421C	1/20/1995	Angola, IN	20001207X02840	19950120000639A		ACC	L/D Degradation	Hard Landing
20001207X02938	NTSB	N62711	Piper	PA-23-250	2/15/1995	Minneapolis, MN	20001207X02938	19950214001799A		ACC	L/D Degradation	Hard Landing
20001207X02941	NTSB	N4092C	Cessna	T310R	2/14/1995	Grand Island, NE	20001207X02941	19950214002209B		ACC	L/D Degradation	Hard Landing
20001207X02954	NTSB	N69TM	Rockwell	690A	2/12/1995	Guthrie, OK	20001207X02954	19950212001519A		ACC	Stall	Uncontrolled Collision With Ground
20001207X03022	NTSB	N9YP	Piper	PA-46-310P	2/14/1995	Chippewa Falls,WI	20001207X03022	19950214046629A		ACC	Stall	Uncontrolled Collision With Ground
20001207X03107	NTSB	N9448B	Cessna	208B	3/2/1995	Ardmore, OK	20001207X03107	19950302004919B		ACC	L/D Degradation	Controlled Collision With Ground
20001207X03108	NTSB	N421BL	Cessna	421C	3/5/1995	El Prado, NM	20001207X03108	19950305003129A		ACC	Stall	Uncontrolled Collision With Ground

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001207X03137	NTSB	N266AT	ATR	ATR42-300	3/4/1995	Las Vegas, NV	20001207X03137	19950304035369C	298151	INC	Stab/Control Anomaly	Normal Landing
20001207X03246	NTSB	N4738A	Cessna	P-210N	4/12/1995	Belle Plaine, MN	20001207X03246	19950412007529A	195794	ACC	Stall	Uncontrolled Collision With Ground
20001207X04212	NTSB	N999AB	Beech	B-60	8/15/1995	Salina, KS	20001207X04212	19950815026719A		ACC	Stall	Normal Landing
20001207X04656	NTSB	N421TV	Cessna	421C	10/21/1995	Battle Creek, MI	20001207X04656	19951021033589A		ACC	Stall	Uncontrolled Collision With Ground
20001207X04825	NTSB	N1588G	Cessna	421	11/11/1995	Romeo, MI	20001207X04825	19951111041639A		ACC	Stall	Hard Landing
20001207X04838	NTSB	N5CX	Cessna	310R	11/28/1995	Michigan City, IN	20001207X04838	19951128045859A		ACC	Stall	Land Short
20001207X04955	NTSB	N1269G	Cessna	310R	12/20/1995	Bellville, OH	20001207X04955	19951220041549A		ACC	Stall	Uncontrolled Collision With Ground
20001207X04968	NTSB	N991PC	Cessna	560	12/30/1995	Eagle River, WI	20001207X04968	19951230042759A		ACC	Stall	Uncontrolled Collision With Ground
20001207X04979	NTSB	N222RB	Beech	58	12/22/1995	Minneapolis, MN	20001207X04979	19951222042439A		ACC	Stall	Land Short
20001207X04997	NTSB	N421EP	Cessna	421C	12/21/1995	Cleveland, OK	20001207X04997	19951221041679A		ACC	Stall	Uncontrolled Collision With Ground
20001208X05108	NTSB	N3679M	Piper	PA-34-200T	1/9/1996	Des Moines, IA	20001208X05108	19960110000249A		ACC	ICTS	Controlled Collision With Ground
20001208X05158	NTSB	N300SP	Beech	E90	1/31/1996	Flagstaff, AZ	20001208X05158	19960131003569A		ACC	Stall	Uncontrolled Collision With Ground
20001208X05205	NTSB	N693PA	Mitsubishi	MU-2B-36A	1/15/1996	Malad City, ID	20001208X05205	19960115000389A		ACC	Stall	Uncontrolled Collision With Ground
20001208X05308	NTSB	N159YN	Beech	1900D	2/7/1996	Bradford, PA	20001208X05308	19960207045349B		ACC	Stall Warning	Hard Landing
20001208X05909	NTSB	N9114Q	Piper	PA-46-310P	6/2/1996	Aitkin, MN	20001208X05909	19960602012249A		ACC	Stall	Inflight Breakup
20001208X07119	NTSB	N8005Q	Cessna	421B	11/19/1996	Olympia, WA	20001208X07119	19961119045409A		ACC	Stall Warning	Hard Landing

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001208X07138	NTSB	N998VB	Beech	C90	12/28/1996	Rhinelander, WI	20001208X07138	19961228042489A		ACC	Stall	Controlled Collision With Ground
20001208X07277	NTSB	N265CA	Embraer	EMB-120RT	1/9/1997	Monroe, MI	20001208X07277	19970109000259B		ACC	Stall	Uncontrolled Collision With Ground
20001208X07657	NTSB	N408GV	Cessna	208B	4/10/1997	Wainwright, AK	20001208X07657	19970410005709B		ACC	Stall	Uncontrolled Collision With Ground
20001208X07893	NTSB	N90070	Airbus Industrie	A300B4-605R	5/12/1997	West Palm Beach, FL	20001208X07893	19970512012989B	368582	ACC	Stall	Normal Landing
20001208X09139	NTSB	N79TH	Piper	PA-34-200T	11/2/1997	Lynn, IN	20001208X09139	19971102046079A		ACC	Stall	Inflight Breakup
20001208X09235	NTSB	N80GP	Beech	65-A90	11/13/1997	Wheeling, WV	20001208X09235	19971113032969B		ACC	Stall	Land Short
20001211X09409	NTSB	N738FX	Cessna	208B	1/20/1998	Grand Island, NE	20001211X09409	19980120009439B		ACC	L/D Degradation	Hard Landing
20001211X09433	NTSB	N26956	Cessna	340A	1/8/1998	Bethany, OK	20001211X09433	19980108006189B		ACC	Stall	Hard Landing
20001211X09530	NTSB	N108RS	Cessna	402B	2/27/1998	Mason City, IA	20001211X09530	19980227006219B		ACC	L/D Degradation	Hard Landing
20001211X09730	NTSB	N840FE	Cessna	208B	3/5/1998	Clarksville, TN	20001211X09730	19980305002709B		ACC	Stall	Uncontrolled Collision With Ground
20001211X09806	NTSB	N868FE	Cessna	208B	4/7/1998	Bismarck, ND	20001211X09806	19980407046779B		ACC	Stall	Uncontrolled Collision With Ground
20001211X11670	NTSB	N8016M	Cessna	310R-II	1/7/1993	Marysville, KS	20001211X11670	19930107001739A	231194	ACC	Stall	Controlled Collision With Ground
20001211X11684	NTSB	N342PX	Saab-Scania Ab (Saab)	SF340A	1/2/1993	Hibbing, MN	20001211X11684	19930102000019B	230237	ACC	Stall	Hard Landing
20001211X11962	NTSB	N99838	Aerospatiale	ATR42-300	3/4/1993	Newark, NJ	20001211X11962	19930304007729C	235939	INC	Stall	Normal Landing
20001211X12152	NTSB	N24706	Embraer	EMB-120RT	4/29/1993	Pine Bluff, AR	20001211X12152	19930429011019B		ACC	Stall	Abnormal Landing
20001211X13724	NTSB	N41010	Cessna	421B	11/6/1993	Greensburg, IN	20001211X13724	19931106042199A		ACC	Stall	Uncontrolled Collision With Ground
20001211X13730	NTSB	N2297C	Cessna	T303	11/25/1993	Rogers, AR	20001211X13730	19931125044419A		ACC	Stall	Uncontrolled Collision With Ground

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001211X14085	NTSB	N4644G	Cessna	414	2/13/1992	Logansport, IN	20001211X14085	19920213002919A		ACC	L/D Degradation	Hard Landing
20001211X16099	NTSB	N100EK	Beech	A60	11/21/1992	Snoqualmie Pass, WA	20001211X16099	19921121047529A		ACC	Stall	Inflight Breakup
20001212X16303	NTSB	N167PC	British Aerospace	3101	1/30/1991	Beckley, WV	20001212X16303	19910131001279B		ACC	ICTS	Hard Landing
20001212X20330	NTSB	N5918S	Beech	D-95A TRAVELAIR	1/6/2000	Dunbar, WI	20001212X20330	20000106000449B		ACC	Stall	Uncontrolled Collision With Ground
20001212X20551	NTSB	N875JC	Beech	58	2/14/2000	Cynthiana, KY	20001212X20551	20000214008349A		ACC	Stall	Uncontrolled Collision With Ground
20001212X21115	NTSB	N5113G	Cessna	414	5/31/2000	Monarch, MT	20001212X21115	20000531012979A		ACC	Stall	Uncontrolled Collision With Ground
20001212X22544	NTSB	N820FE	Cessna	208A	2/27/1990	Denver, CO	20001212X22544	19900227002919B		ACC	Stall	Uncontrolled Collision With Ground
20001212X22562	NTSB	N300CW	Mitsubishi	MU-2B-60	2/14/1990	Putnam, TX	20001212X22562	19900214002199A		ACC	Stall	Uncontrolled Collision With Ground
20001212X22877	NTSB	N112MP	Nihon	YS-11A-600	4/3/1990	West Lafayette, IN	20001212X22877	19900403012689C		INC	ICTS	Abnormal Landing
20001212X24701	NTSB	N1683T	Cessna	402B	11/8/1990	Pocatello, ID	20001212X24701	19901108049279B		ACC	L/D Degradation	Land Off Airport
20001213X25720	NTSB	N98683	Cessna	421C	5/28/1988	Shaver Lake, CA	20001213X25720	19880528023329A		ACC	Stall	Uncontrolled Collision With Ground
20001213X27373	NTSB	N84UM	Cessna	414	12/22/1988	Bloomville, OH	20001213X27373	19881222056989A		ACC	Stall	Inflight Breakup
20001213X27394	NTSB	N427MQ	Aerospatiale	ATR42-300	12/22/1988	Mosinee, WI	20001213X27394	19881222071639C	100792	INC	Stall	Normal Landing
20001213X27402	NTSB	N296MA	Mitsubishi	MU-2B-35	12/9/1988	Missing, PO	20001213X27402			ACC	Stall	Uncontrolled Collision With Ground
20001213X27525	NTSB	N500V	Mitsubishi	MU-2B	1/2/1989	Mansfield, OH	20001213X27525	19890102000069A		ACC	Stall	Uncontrolled Collision With Ground
20001213X27867	NTSB	N128MP	Nihon	YS-11A-600	3/15/1989	West Lafayette, IN	20001213X27867	19890315004619B		ACC	ICTS	Uncontrolled Collision With Ground

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001213X27963	NTSB	N5119C	Cessna	310	3/3/1989	Des Moines, IA	20001213X27963	19890303002959B		ACC	L/D Degradation	Hard Landing
20001213X27965	NTSB	N69806	Cessna	310Q	3/2/1989	Norfolk, NE	20001213X27965	19890302003439B		ACC	Stall	Hard Landing
20001213X29944	NTSB	N410UE	British Aerospace	BAE-3101	12/26/1989	Pasco, WA	20001213X29944	19891226053219B		ACC	ICTS	Uncontrolled Collision With Ground
20001213X30816	NTSB	N13808	Piper	PA-23-250	4/28/1987	Portland, ME	20001213X30816	19870429012519B		ACC	Stall	Uncontrolled Collision With Ground
20001213X32649	NTSB	N500TS	Aerostar	PA-60-600	12/3/1987	Mansfield, OH	20001213X32649	19871203069069B		ACC	Stall	Uncontrolled Collision With Ground
20001213X32832	NTSB	N3940C	Cessna	402B	2/18/1986	Rochester, MN	20001213X32832	19860218006109B		ACC	L/D Degradation	Land Short
20001213X32949	NTSB	N7774Q	Cessna	340	2/19/1986	Burns, OR	20001213X32949	19860219003429B		ACC	Stall	Hard Landing
20001213X33000	NTSB	N513DC	Mitsubishi	MU-2B-60	3/5/1986	Eola, IL	20001213X33000	19860305005329A		ACC	Stall	Uncontrolled Collision With Ground
20001213X33521	NTSB	N6728J	Beech	BE-99C	5/16/1986	Laramie, WY	20001213X33521	19860516082199B		ACC	Stall	Hard Landing
20001213X35337	NTSB	N423MQ	ATR	ATR42-300	12/18/1986	Detroit, MI	20001213X35337	19861218081799C		INC	Stall	Abnormal Landing
20001214X35486	NTSB	N4098S	Beech	BE-58	1/16/1985	Lafayette, IN	20001214X35486	19850116003539B		ACC	L/D Degradation	Hard Landing
20001214X35670	NTSB	N50NP	Beech	65-A80	2/4/1985	Soldotna, AK	20001214X35670	19850204005919B		ACC	Stall	Uncontrolled Collision With Ground
20001214X35805	NTSB	N540N	De Havilland	DHC-6-300	3/12/1985	Barter Island, AK	20001214X35805	19850312006599B		ACC	ICTS	Uncontrolled Collision With Ground
20001214X38299	NTSB	N81589	Rockwell	500-S	11/25/1985	Des Moines, IA	20001214X38299	19851125058059A		ACC	Stall	Uncontrolled Collision With Ground
20001214X38674	NTSB	N25	Cessna	CE500	1/20/1984	Yakima, WA	20001214X38674			INC	Stall	Hard Landing
20001214X38728	NTSB	N6895D	Aerostar	AEROSTAR 602P	2/3/1984	Bellaire, MI	20001214X38728	19840203002119A		ACC	Stall	Land Short
20001214X38988	NTSB	N260RA	Cessna	421C	3/21/1984	Joliet, IL	20001214X38988	19840321006879A		ACC	Stall Warning	Hard Landing

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001214X39239	NTSB	N414EM	Cessna	414A	4/1/1984	Douglas, WY	20001214X39239	19840401007829A		ACC	Stall	Controlled Collision With Ground
20001214X40696	NTSB	N6231G	Cessna	421C	8/1/1984	Fort Lupton, CO	20001214X40696	19840801036589A		ACC	Stall	Inflight Breakup
20001214X41336	NTSB	N1569T	Cessna	414	10/23/1984	Cheyenne, WY	20001214X41336	19841023061659A		ACC	Stall	Controlled Collision With Ground
20001214X41339	NTSB	N1921T	Beech	99A	10/21/1984	Fort Morgan, CO	20001214X41339	19841021076049C		INC	Stall	Land Off Airport
20001214X41526	NTSB	N97RE	Rockwell	NA-265-25	11/5/1984	Chicago, IL	20001214X41526	19841105076409G		INC	ICTS	Normal Landing
20001214X41546	NTSB	N98995	Cessna	310R	11/30/1984	Eden Prairie, MN	20001214X41546	19841130064369A		ACC	L/D Degradation	Hard Landing
20001214X41654	NTSB	N41097	Cessna	421B	11/27/1984	Mason City, IA	20001214X41654	19841127066229B		ACC	Stall	Hard Landing
20001214X41688	NTSB	N37279	Cessna	310R	11/30/1984	Pocatello, ID	20001214X41688	19841130064259B		ACC	Stall	Land Short
20001214X41787	NTSB	N4864A	Cessna	T310R	12/4/1984	Lubbock, TX	20001214X41787	19841204067269A		ACC	L/D Degradation	Hard Landing
20001214X41794	NTSB	N69477	Cessna	340	12/14/1984	Odessa, TX	20001214X41794	19841214069309B		ACC	Stall	Hard Landing
20001214X42087	NTSB	N6087C	Cessna	T303	1/3/1983	Willard, WA	20001214X42087	19830103001999A		ACC	Stall	Uncontrolled Collision With Ground
20001214X42388	NTSB	N72B	Mitsubishi	MU-2B-60	3/24/1983	Jeffersonville, GA	20001214X42388	19830324075569B		ACC	Stall	Inflight Breakup
20001214X45251	NTSB	N90DF	Beech	BE-200	12/21/1983	Detroit, MI	20001214X45251	19831221062999A		ACC	Stab/Control Anomaly	Land Short
20001214X45292	NTSB	N9121S	Beech	58	12/27/1983	Marquez, NM	20001214X45292	19831227063379A		ACC	Stall	Uncontrolled Collision With Ground
20001214X45367	NTSB	N704M	Beech	TC-45J	12/5/1983	Kansas City, KS	20001214X45367	19831205059609A		ACC	Stall	Uncontrolled Collision With Ground
20001214X45391	NTSB	N6774R	Cessna	425	12/12/1983	Newburgh, NY	20001214X45391	19831212060329A		ACC	Stall	Uncontrolled Collision With Ground
20001226X45493	NTSB	N55QS	Cessna	310Q	12/14/2000	Chesterfield, NH	20001226X45493	20001214024719B		ACC	L/D Degradation	Controlled Collision With Ground

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001229X45499	NTSB	N4558S	Beech	58	12/18/2000	Huntingburg, IN	20001229X45499	20001218042969A		ACC	L/D Degradation	Land Short
20010208X00419	NTSB	N107BA	Beech	65-B80	2/7/2001	Sioux Falls, SD	20010208X00419	20010207009979B		ACC	Stall	Controlled Collision With Ground
20010214X00451	NTSB	N52BA	Beech	58	2/7/2001	Ainsworth, NE	20010214X00451	20010207004749B		ACC	Stall	Controlled Collision With Ground
20010522X00983	NTSB	N948FE	Cessna	208B	5/5/2001	Steamboat Spngs, CO	20010522X00983	20010505011749B		ACC	Stall	Uncontrolled Collision With Ground
20020124X00119	NTSB	N266CA	Embraer	EMB-120	3/19/2001	West Palm Beach, FL	20020124X00119	20010319039099B	508390	ACC	Stall	Abnormal Landing
20020205X00188	NTSB	N104CS	Aerostar	Aerostar 601P	1/25/2002	Chittenden, VT	20020205X00188	20020126001239A		ACC	Stall	Uncontrolled Collision With Ground
20020207X00197	NTSB	N1187G	Rockwell	500-S	1/18/2002	Baker City, OR	20020207X00197	20020118002129A		ACC	L/D Degradation	Hard Landing
20020227X00276	NTSB	N999N	Rockwell	500S	2/17/2002	Exeter, RI	20020227X00276	20020217002339A		ACC	Stall	Uncontrolled Collision With Ground
20020320X00371	NTSB	N208TF	Cessna	208B	3/6/2002	Barrow, AK	20020320X00371	20020306003309B		ACC	Stall	Controlled Collision With Ground
20020326X00397	NTSB	N228PA	Cessna	208B	3/15/2002	Alma, WI	20020326X00397	20020315005629B		ACC	Stall	Uncontrolled Collision With Ground
20020403X00453	NTSB	N948CC	Beech	E90	3/13/2002	Reno, NV	20020403X00453	20020313004909B		ACC	Stall	Uncontrolled Collision With Ground
20020917X01808	NTSB	N1847X	Beech	58	2/19/1982	St. Charles, IL	20020917X01808	19820219004849A		ACC	Stall	Hard Landing
20020917X02423	NTSB	N2672A	Cessna	340	1/6/1982	Rolla, MO	20020917X02423			ACC	Stall	Hard Landing
20020917X02446	NTSB	N363VA	Aerostar	PA-60-601P	2/23/1982	Carroll, IA	20020917X02446	19820224002629A		ACC	Stall	Hard Landing
20020917X02509	NTSB	N5358J	Cessna	421C	2/22/1982	Westerly, RI	20020917X02509	19820222025739A		ACC	L/D Degradation	Hard Landing
20020917X02575	NTSB	N36PB	Piper	PA-31-350	1/13/1982	Spokane, WA	20020917X02575	19820113000849A		ACC	Stall	Wingtip Strike
20020917X04485	NTSB	N1777E	Cessna	310R	12/18/1982	Gaylord, MI	20020917X04485	19821218064559A		ACC	Stall	Abnormal Landing

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20020917X04572	NTSB	N30RA	Cessna	310R	12/1/1982	Miles City, MT	20020917X04572	19821201066629A		ACC	Stall	Hard Landing
20021118X05475	NTSB	N514DB	Cessna	208B	11/8/2002	Parks, AZ	20021118X05475	20021108031689A		ACC	Stall	Uncontrolled Collision With Ground
20030106X00022	NTSB	N9260P	Piper	PA-46-350P	11/30/2002	Pasco, WA	20030106X00022	20021130035679A		ACC	Stall	Hard Landing
20030109X00040	NTSB	N5TV	Beech	BE-58	12/24/2002	Egypt, AR	20030109X00040	20021224036259A		ACC	Stall	Uncontrolled Collision With Ground
20030127X00114	NTSB	N944FE	Cessna	208B	1/24/2003	San Angelo, TX	20030127X00114	20030124001119B		ACC	Stall	Uncontrolled Collision With Ground
20030317X00345	NTSB	N9257X	Piper	PA-34-220T	3/5/2003	Rexburg, ID	20030317X00345	20030305002399A		ACC	Stall	Uncontrolled Collision With Ground
20030421X00535	NTSB	N183GA	Dassault Aviation	DA-20	4/8/2003	Swanton, OH	20030421X00535	20030408019819A		ACC	Stall	Uncontrolled Collision With Ground
20031103X01851	NTSB	N791FE	Cessna	208B	10/29/2003	Cody, WY	20031103X01851	20031029037849B		ACC	Stall	Uncontrolled Collision With Ground
20031217X02053	NTSB	N441W	Cessna	441	12/10/2003	Vestavia Hills, AL	20031217X02053	20031210034899A		ACC	Stall	Uncontrolled Collision With Ground
20040108X00031	NTSB	N911EA	Cessna	421C	1/3/2004	Window Rock, AZ	20040108X00031	20040103001549B	604121	ACC	Stall	Hard Landing
20040121X00083	NTSB	N595SW	Bombardier	CL-600-2B19	1/17/2004	Rapid City, SD	20040121X00083	20040117002589C		INC	Stab/Control Anomaly	Hard Landing
20040220X00211	NTSB	N300FB	Cessna	421	1/14/2004	Ravenna, OH	20040220X00211	20040114006359A		ACC	Stall	Hard Landing
20040402X00418	NTSB	N201UV	Mitsubishi	MU-2B-36	3/25/2004	Pittsfield, MA	20040402X00418	20040325003729B		ACC	Stall	Uncontrolled Collision With Ground
20041020X01663	NTSB	N1592T	Cessna	414	12/11/2003	Greeneville, TN	20041020X01663	20031211037469A		ACC	Stall	Uncontrolled Collision With Ground
20041209X01963	NTSB	N25SA	Cessna	208B	12/6/2004	Bellevue, ID	20041209X01963	20041206031339B		ACC	Stall	Uncontrolled Collision With Ground
20050106X00025	NTSB	N35403	Cessna	551	1/1/2005	Ainsworth, NE	20050106X00025	20050101002119A		ACC	L/D Degradation	Land Short

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20050118X00064	NTSB	N41WE	Beech	BE-90	1/11/2005	Rawlins, WY	20050118X00064	20050111000209B		ACC	Stall	Uncontrolled Collision With Ground
20050127X00111	NTSB	N310RA	Cessna	310J	1/3/2005	Davenport, WA	20050127X00111	20050103000699A		ACC	Stall	Hard Landing
20050216X00193	NTSB	N5DS	Cessna	414	1/19/2005	Akron, OH	20050216X00193	20050119004489A		ACC	Stall	Hard Landing
20050222X00211	NTSB	N286CD	Cirrus Design Corp	SR22 G2	2/6/2005	Norden, CA	20050222X00211	20050206002509A		ACC	Stall	Uncontrolled Collision With Ground
20050304X00267	NTSB	N500AT	Cessna	560	2/16/2005	Pueblo, CO	20050304X00267	20050216003009A		ACC	Stall	Uncontrolled Collision With Ground
20050314X00311	NTSB	N421HG	Cessna	421C	1/19/2005	Muncie, IN	20050314X00311	20050119001419A		ACC	L/D Degradation	Hard Landing
20050331X00387	NTSB	N770G	Pilatus	PC-12/45	3/26/2005	Bellefonte, PA	20050331X00387	20050326005469A		ACC	Stall	Uncontrolled Collision With Ground
20050505X00560	NTSB	N106PM	Cessna	T210N	5/3/2005	Kalispell, MT	20050505X00560	20050503008869A		ACC	Stall	Uncontrolled Collision With Ground
20050815X01241	NTSB	N805TH	Cessna	208B	11/4/2003	Bangor, ME	20050815X01241	20031104028349C		INC	Stab/Control Anomaly	Hard Landing
20051125X01889	NTSB	N5094C	Cessna	T310R	11/15/2005	Fergus Falls, MN	20051125X01889	20051115032259B		ACC	L/D Degradation	Hard Landing
20051125X01890	NTSB	N1153C	Aero Commander	500B	11/16/2005	Gaylord, MI	20051125X01890	20051116031999B		ACC	Stall	Uncontrolled Collision With Ground
20051207X01948	NTSB	N701QR	Cessna	425	11/29/2005	Belgrade, MT	20051207X01948	20051129028219A		ACC	Stall	Uncontrolled Collision With Ground
20060109X00033	NTSB	N390AE	Saab-Scania Ab (Saab)	SF340B	1/2/2006	Santa Maria, CA	20060109X00033		683042	INC	Stall	Normal Landing
20060109X00035	NTSB	N391QS	Cessna	560	1/5/2006	Woodruff, WI	20060109X00035	20060105000829B		ACC	Stall	Wingtip Strike
20060323X00332	NTSB	N331FC	Piper	PA-23-250	3/20/2006	Emporia, KS	20060323X00332	20060321007069B		ACC	Stall Warning	Controlled Collision With Obstacles
20060428X00490	NTSB	N289WB	Cessna	T310R	4/17/2006	Heber City, UT	20060428X00490	20060417004539A		ACC	Stall	Uncontrolled Collision With Ground

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20060512X00563	NTSB	N71MT	Corporate Jets Limited	BAE125-800A	5/4/2006	Lincoln, NE	20060512X00563	20060504013189G		INC	Stall	Abnormal Landing
20060816X01178	NTSB	N69KM	Cessna	421C	1/25/2006	Carson, WA	20060816X01178	20060125016149A		ACC	Stall	Uncontrolled Collision With Ground
20061031X01585	NTSB	N121LD	Cirrus	SR22	10/25/2006	Meadview, AZ	20061031X01585	20061025030429A		ACC	Stall	Uncontrolled Collision With Ground
20070105X00011	NTSB	N400CS	Cessna	414	12/26/2006	Johnstown, PA	20070105X00011	20061226028139B		ACC	Stall	Uncontrolled Collision With Ground
20070214X00181	NTSB	N45GM	Beech	H-18	2/9/2007	Great Bend, KS	20070214X00181	20070209001919B		ACC	Stall	Uncontrolled Collision With Ground
20070222X00212	NTSB	N111SC	Cessna	340A	2/16/2007	Council Bluffs, IA	20070222X00212	20070216001829A		ACC	Stall	Uncontrolled Collision With Ground
20070415X00413	NTSB	N511AT	Cessna	500	3/17/2007	Beverly, MA	20070415X00413	20070317003099B		ACC	Stall	Wingtip Strike
20080108X00030	NTSB	N37249	Cessna	310R	12/27/2007	Traverse City, MI	20080108X00030			ACC	Stall	Uncontrolled Collision With Ground
19831122072399G	FAA AIDS	N3858U	Beech	58	11/22/1983	Medford, OR	19831122072399G	19831122072399G		INC	Stall	Normal Landing
19851008056389G	FAA AIDS	N306D	Beech	65-B80	10/8/1985	Bryce Canyon, UT	19851008056389G	19851008056389G		INC	Stall	Abnormal Landing
19851124068429C	FAA AIDS	N7384F	Boeing	737	11/24/1985	Boise, ID	19851124068429C	19851124068429C		INC	Stab/Control Anomaly	Normal Landing
19860221010369G	FAA AIDS	N6771Y	Cessna	425	2/21/1986	Morgantown, WV	19860221010369G	19860221010369G		INC	Stall	Land Short
19871222080849C	FAA AIDS	N944FE	Cessna	208B	12/22/1987	Sacramento, CA	19871222080849C	19871222080849C		INC	Stall	Normal Landing
19890102008159C	FAA AIDS	N142AB	Cessna	650	1/2/1989	Columbus, OH	19890102008159C	19890102008159C		INC	Stab/Control Anomaly	Normal Landing
19890628050869C	FAA AIDS	N275UE	Emb	EMB120RT	6/28/1989	Klamath Falls, OR	19890628050869C	19890628050869C	115422	INC	Stall	Normal Landing
19910306019289G	FAA AIDS	N421FR	Cessna	421	3/6/1991	Green Bay, WI	19910306019289G	19910306019289G	172814	INC	L/D Degradation	Hard Landing
19910316019349G	FAA AIDS	N26033	Piper	PA46310P	3/16/1991	Ocala, FL	19910316019349G	19910316019349G		INC	Stall	Normal Landing
19911107055879C	FAA AIDS	N571DD	Beech	H18	11/7/1991	Springfield, MO	19911107055879C	19911107055879C		INC	L/D Degradation	Land Short

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
19911111051109G	FAA AIDS	N4738A	Cessna	P210N	11/11/1991	Minneapolis, MN	19911111051109G	19911111051109G	194839	INC	L/D Degradation	Hard Landing
19921106052169C	FAA AIDS	N898FE	Cessna	208B	11/6/1992	Johnstown, PA	19921106052169C	19921106052169C	225830	INC	L/D Degradation	Hard Landing
19940128011289C	FAA AIDS	N15818	Aerosp	ATR42-320	1/28/1994	Newark, NJ	19940128011289C	19940128011289C		INC	Stall	Normal Landing
19960103003009G	FAA AIDS	N181A	Cessna	310R	1/3/1996	Windsor Locks, CT	19960103003009G	19960103003009G	325548	INC	Stall	Hard Landing
19970108008539G	FAA AIDS	N6531N	Beech	B200	1/8/1997	Dallas, TX	19970108008539G	19970108008539G	357245	INC	L/D Degradation	Land Short
19970313009449C	FAA AIDS	N5034Q	Cessna	310N	3/13/1997	Brookings, SD	19970313009449C	19970313009449C		INC	Stall	Hard Landing
19980202012179C	FAA AIDS	N101GQ	Beech	200	2/2/1998	Cumberland, WI	19980202012179C	19980202012179C		INC	L/D Degradation	Land Short
19980206005629C	FAA AIDS	N9469B	Cessna	208	2/6/1998	Midland, TX	19980206005629C	19980206005629C	393201	INC	Stall	Hard Landing
19990120011349C	FAA AIDS	N424TE	Aerosp	ATR42-300	1/20/1999	St Louis, MO	19990120011349C	19990120011349C	425239	INC	Stall	Normal Landing
19991229036089G	FAA AIDS	N642BJ	Cessna	501	12/29/1999	Spokane, WA	19991229036089G	19991229036089G		INC	L/D Degradation	Hard Landing
20000620027549C	FAA AIDS	N340SF	Saab	SF340A	6/20/2000	Cleveland, OH	20000620027549C	20000620027549C	476789	INC	Stall Warning	Normal Landing
20031031028339G	FAA AIDS	N7912Q	Cessna	401B	10/31/2003	Denver, CO	20031031028339G	20031031028339G	598514	INC	L/D Degradation	Normal Landing
20041124032879G	FAA AIDS	N6171N	Beech	B300	11/24/2004	St Louis, MO	20041124032879G	20041124032879G	638841	INC	L/D Degradation	Hard Landing
20050124000779C	FAA AIDS	N563HK	Jetair	4101	1/24/2005	Pittsburgh, PA	20050124000779C	20050124000779C		INC	L/D Degradation	Normal Landing
104442	ASRS	Registration De-identified	Not Reported	Small Transport		South Lake Tahoe, CA	104442		104442	INC	Stall	Normal Landing
113621	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		Chicago, IL	113621		113621	INC	L/D Degradation	Normal Landing
171136	ASRS	Registration De-identified	Not Reported	Medium Large Transport, Low Wing, 2 Turbojet Eng		Syracuse, NY	171136		171136	INC	L/D Degradation	Normal Landing

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
186536	ASRS	Registration De-identified	Not Reported	Small Transport, Low Wing, 2 Turboprop Eng		Albuquerque, NM	186536		186536	INC	Stall Warning	Normal Landing
189745	ASRS	Registration De-identified	Not Reported	EMB-120		Fort Smith, AR	189745		189745	INC	Stall	Normal Landing
195988	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		Seattle, WA	195988		195988	INC	Stab/Control Anomaly	Normal Landing
196519	ASRS	Registration De-identified	Not Reported	Light Transport, High Wing, 2 Turboprop Eng		Jackson, WY	196519		196519	INC	L/D Degradation	Normal Landing
222004	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		Lebanon, NH	222004		222004	INC	Stall	Normal Landing
226123	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		Beckley, WV	226123		226123	INC	Stall	Normal Landing
228356	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		Robbinsville, NJ	228356		228356	INC	Stall Warning	Normal Landing
249506	ASRS	Registration De-identified	Not Reported	Small Transport		Yakutat, AK	249506		249506	INC	L/D Degradation	Normal Landing
250881	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		Kewanee, MS	250881		250881	INC	Stall Warning	Normal Landing
252178	ASRS	Registration De-identified	Not Reported	Medium Transport, High Wing, 2 Turboprop Eng		Lompoc, IN	252178		252178	INC	Stall Warning	Normal Landing
252307	ASRS	Registration De-identified	Not Reported	Medium Transport, High Wing, 2 Turboprop Eng		Lafayette, IN	252307		252307	INC	Stall Warning	Normal Landing

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
265218	ASRS	Registration De-identified	Not Reported	Any Unknown or Unlisted Aircraft Manufacturer		Athens, GA	265218		265218	INC	Stall	Normal Landing
265250	ASRS	Registration De-identified	Not Reported	Any Unknown or Unlisted Aircraft Manufacturer		Oakland, MD	265250		265250	INC	L/D Degradation	Normal Landing
301015	ASRS	Registration De-identified	Not Reported	690C		Corona, NM	301015		301015	INC	Stall Warning	Normal Landing
319433	ASRS	Registration De-identified	Not Reported	Any Unknown or Unlisted Aircraft Manufacturer		Red Bluff, CO	319433		319433	INC	L/D Degradation	Normal Landing
345751	ASRS	Registration De-identified	Not Reported	EMB-120		San Angelo, TX	345751		345751	INC	Stab/Control Anomaly	Normal Landing
390434	ASRS	Registration De-identified	Not Reported	1900		Versailles, OH	390434		390434	INC	L/D Degradation	Normal Landing
391293	ASRS	Registration De-identified	Not Reported	MD-80		Bradford, IL	391293		391293	INC	Stab/Control Anomaly	Normal Landing
392247	ASRS	Registration De-identified	Not Reported	402C		Redding, CA	392247		392247	INC	L/D Degradation	Normal Landing
392928	ASRS	Registration De-identified	Not Reported	DC-9-50		Madison, WI	392928		392928	INC	ICTS	Normal Landing
393189	ASRS	Registration De-identified	Not Reported	SF 340B		Louisville, KY	393189		393189	INC	Stall	Normal Landing
395823	ASRS	N284YV	Embraer	EMB-120ER		Sacramento, CA	395823		395823	INC	Stall	Normal Landing
397209	ASRS	Registration De-identified	Not Reported	421		Caldwell, NJ	397209		397209	INC	Stall	Normal Landing
405453	ASRS	Registration De-identified	Not Reported	SF 340A		Waterloo, IA	405453		405453	INC	L/D Degradation	Normal Landing

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
416160	ASRS	Registration De-identified	Not Reported	PA-46		Burlington, IL	416160		416160	INC	L/D Degradation	Normal Landing
453240	ASRS	Registration De-identified	Not Reported	3201		Washington, VA	453240		453240	INC	Stall Warning	Normal Landing
457893	ASRS	Registration De-identified	Not Reported	55		Port Huron, MI	457893		457893	INC	No Primary Occurrence 1	Normal Landing
464100	ASRS	Registration De-identified	Not Reported	SA226-TC		, ID	464100		464100	INC	L/D Degradation	Normal Landing
470303	ASRS	Registration De-identified	Not Reported	ATR42		Madison, WI	470303		470303	INC	L/D Degradation	Normal Landing
479942	ASRS	Registration De-identified	Not Reported	SF 340B		East Hampton, NY	479942		479942	INC	L/D Degradation	Normal Landing
541639	ASRS	Registration De-identified	Not Reported	208A		Fort Wayne, IN	541639		541639	INC	Stall	Normal Landing
565131	ASRS	Registration De-identified	Not Reported	200		Bakersfield, CA	565131		565131	INC	Stall	Normal Landing
572713	ASRS	Registration De-identified	Not Reported	208A		Elmira/Corning, NY	572713		572713	INC	L/D Degradation	Hard Landing
597221	ASRS	Registration De-identified	Not Reported	PA-34-200		Cleveland, OH	597221		597221	INC	L/D Degradation	Normal Landing
626725	ASRS	Registration De-identified	Not Reported	208A		Anaktuvuk Pass, AK	626725		626725	INC	L/D Degradation	Normal Landing
630442	ASRS	Registration De-identified	Not Reported	210		King City, NY	630442		630442	INC	Stall Warning	Normal Landing
814615	ASRS	Registration De-identified	Not Reported	340		, US	814615		814615	INC	Stall Warning	Normal Landing
815450	ASRS	Registration De-identified	Not Reported	737		Denver, CO	815450		815450	INC	Stall Warning	Hard Landing

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
101079	ASRS	Registration De-identified	Not Reported	MU-2B		Utica, NY	101079		101079	INC	L/D Degradation	Normal Landing
323820	ASRS	Registration De-identified	Not Reported	PA-31		Covington, OH	323820		323820	INC	Stab/Control Anomaly	Controlled Collision With Ground
325031	ASRS	Registration De-identified	Not Reported	Commercial Fixed Wing		Springdale, AR	325031		325031	INC	L/D Degradation	Normal Landing
327661	ASRS	Registration De-identified	Not Reported	SA227-AC		Helena, MT	327661		327661	INC	Stall Warning	Normal Landing
82159	ASRS	Registration De-identified	Not Reported	Small Transport, Low Wing, 2 Recip Eng		Chicago/Rockford, IL	82159		82159	INC	Stall Warning	Abnormal Landing
96530	ASRS	Registration De-identified	Not Reported	727		Chicago, IL	96530		96530	INC	Stall	Normal Landing
103210	ASRS	Registration De-identified	Not Reported	Small Transport		Rutland, VT	103210		103210	INC	Stall Warning	Normal Landing
164508	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		Newburgh, NY	164508		164508	INC	Stall Warning	Normal Landing
186235	ASRS	Registration De-identified	Not Reported	Small Transport, Low Wing, 2 Turboprop Eng		Pullman, MI	186235		186235	INC	L/D Degradation	Normal Landing
201550	ASRS	Registration De-identified	Not Reported	Small Aircraft, Low Wing, 2 Eng, Retractable Gear		Rapid City, SD	201550		201550	INC	L/D Degradation	Land Short
258855	ASRS	Registration De-identified	Not Reported	ATR42		Marquette, MI	258855		258855	INC	Stab/Control Anomaly	Normal Landing
279763	ASRS	Registration De-identified	Not Reported	421		Toledo, OH	279763		279763	INC	L/D Degradation	Normal Landing

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
286127	ASRS	Registration De-identified	Not Reported	EMB-120		Elko, NV	286127		286127	INC	Stall	Normal Landing
287615	ASRS	Registration De-identified	Not Reported	ATR 72		South Bend, IN	287615		287615	INC	Stall Warning	Normal Landing
287844	ASRS	Registration De-identified	Not Reported	SF 340A		Lake Charles, LA	287844		287844	INC	Stall Warning	Normal Landing
290058	ASRS	Registration De-identified	Not Reported	ATR42		Chicago, IL	290058		290058	INC	Stab/Control Anomaly	Normal Landing
295020	ASRS	Registration De-identified	Not Reported	Jetstream 31		Greenville, MS	295020		295020	INC	L/D Degradation	Normal Landing
297289	ASRS	Registration De-identified	Not Reported	PA-23		Rochester, NY	297289		297289	INC	L/D Degradation	Normal Landing
299812	ASRS	Registration De-identified	Not Reported	Commercial Fixed Wing		Keeler, MI	299812		299812	INC	Stall Warning	Normal Landing
302910	ASRS	Registration De-identified	Not Reported	EMB-120		Tallahassee, FL	302910		302910	INC	L/D Degradation	Normal Landing
326243	ASRS	Registration De-identified	Not Reported	Jetstream 31		Chicago/Rockford, IL	326243		326243	INC	Stab/Control Anomaly	Normal Landing
387762	ASRS	Registration De-identified	Not Reported	3201		St Louis, MO	387762		387762	INC	Stall Warning	Normal Landing
390641	ASRS	Registration De-identified	Not Reported	Any Unknown or Unlisted Aircraft Manufacturer		Marshalltown, IA	390641		390641	INC	Stall	Abnormal Landing
426036	ASRS	Registration De-identified	Not Reported	ATR72		Chicago, IL	426036		426036	INC	Stab/Control Anomaly	Normal Landing
456868	ASRS	Registration De-identified	Not Reported	EMB-110		St Louis, MO	456868		456868	INC	Stab/Control Anomaly	Normal Landing

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
466880	ASRS	Registration De-identified	Not Reported	Large Transport, Low Wing, 2 Turbojet Eng		Deland, CO	466880		466880	INC	Stab/Control Anomaly	Normal Landing
501516	ASRS	Registration De-identified	Not Reported	EMB-120		, US	501516		501516	INC	Stab/Control Anomaly	Normal Landing
564503	ASRS	Registration De-identified	Not Reported	402C		Santa Fe, NM	564503		564503	INC	No Primary Occurrence 1	Normal Landing
593040	ASRS	Registration De-identified	Not Reported	414		Telluride, CO	593040		593040	INC	Stall	Normal Landing
600763	ASRS	Registration De-identified	Not Reported	A321		Pittsburgh, PA	600763		600763	INC	Stab/Control Anomaly	Normal Landing
601847	ASRS	Registration De-identified	Not Reported	A300		Boston, MA	601847		601847	INC	Stab/Control Anomaly	Normal Landing
647858	ASRS	Registration De-identified	Not Reported	208A		Pocatello, ID	647858		647858	INC	Stab/Control Anomaly	Normal Landing
677752	ASRS	Registration De-identified	Not Reported	A300		, US	677752		677752	INC	Stab/Control Anomaly	Normal Landing
680162	ASRS	Registration De-identified	Not Reported	A300		, FO	680162		680162	INC	Stab/Control Anomaly	Hard Landing
682246	ASRS	Registration De-identified	Not Reported	208A		Columbus, OH	682246		682246	INC	Stall	Normal Landing
692028	ASRS	Registration De-identified	Not Reported	35		Buffalo, NY	692028		692028	INC	Stall	Normal Landing
727259	ASRS	Registration De-identified	Not Reported	A300		, US	727259		727259	INC	Stab/Control Anomaly	Normal Landing
813826	ASRS	Registration De-identified	Not Reported	CL-601		, US	813826		813826	INC	Stab/Control Anomaly	Abnormal Landing

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
820343	ASRS	Registration De-identified	Not Reported	Gulfstream III		Teterboro, NJ	820343		820343	INC	Stall Warning	Normal Landing
820593	ASRS	Registration De-identified	Not Reported	58		, US	820593		820593	INC	No Primary Occurrence 1	Normal Landing
140495	ASRS	Registration De-identified	Not Reported	Medium Large Transport, Low Wing, 2 Turbojet Eng		Colorado Springs, CO	140495		140495	INC	Stab/Control Anomaly	Normal Landing
228781	ASRS	Registration De-identified	Not Reported	Small Transport, Low Wing, 2 Recip Eng		Reno, NV	228781		228781	INC	Stab/Control Anomaly	Normal Landing
251615	ASRS	Registration De-identified	Not Reported	ATR42		Quincy, IL	251615		251615	INC	Stall	Normal Landing
282950	ASRS	Registration De-identified	Not Reported	100		Birmingham, AL	282950		282950	INC	Stall Warning	Normal Landing
519723	ASRS	Registration De-identified	Not Reported	MU-2B		Fairbanks, AK	519723		519723	INC	Stall	Normal Landing
19960131004129G	FAA AIDS	N416W	Israel	1124	1/31/1996	Morristown, NJ	19960131004129G	19960131004129G	327877	INC	Stall	Hard Landing
19981222045419C	FAA AIDS	N8187E	Doug	DC3C	12/22/1998	Cleveland, OH	19981222045419C	19981222045419C	423719	INC	Stall	Controlled Collision With Obstacles
20001211X09402	NTSB	N6669P	Cessna	P210N	1/7/1998	Decatur, IL	20001211X09402	19980107000149A		ACC	Stall	Uncontrolled Collision With Ground
389483	ASRS	Registration De-identified	Not Reported	MD-80		St Louis, MO	389483		389483	INC	Stab/Control Anomaly	Normal Landing
302130	ASRS	Registration De-identified	Not Reported	ATR42		Chicago, IL	302130		302130	INC	L/D Degradation	Normal Landing
774091	ASRS	Registration De-identified	Not Reported	31		, US	774091		774091	INC	L/D Degradation	Hard Landing

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
824501	ASRS	Registration De-identified	Not Reported	EMB ERJ 170/175 ER&LR		, US	824501		824501	INC	Stab/Control Anomaly	Normal Landing
19990105005759G	FAA AIDS	N7DM	Beech	58	1/5/1999	Spirit Lake, IA	19990105005759G	19990105005759G	424778	INC	L/D Degradation	Land Short
20011130X02327	NTSB	N228BH	Beech	C-99	11/29/2001	Flagstaff, AZ	20011130X02327	20011129032309B		ACC	L/D Degradation	Hard Landing
20031216X02050	NTSB	N399CZ	Beech	99	12/16/2003	Mosinee, WI	20031216X02050	20031216035399B		ACC	L/D Degradation	Hard Landing
20001214X41899	NTSB	N51SA	Cessna	402B TS	12/19/1984	Tonopah, NV	20001214X41899	19841219067919B		ACC	Stall	Controlled Collision With Ground
20001213X32822	NTSB	N723T	Beech	G18S	2/26/1986	Janesville, WI	20001213X32822	19860226006879B		ACC	L/D Degradation	Controlled Collision With Ground
20001212X20460	NTSB	N106RS	Piper	PA-23-250	2/15/2000	Amery, WI	20001212X20460	20000215018699B	463395	ACC	L/D Degradation	Abnormal Landing
20030110X00051	NTSB	N37221	Cessna	310R	1/4/2003	Ada, MN	20030110X00051	20030104000199A		ACC	Stab/Control Anomaly	Controlled Collision With Obstacles
19840109002319G	FAA AIDS	N9HM	Lear	35	1/9/1984	Salt Lake, UT	19840109002319G	19840109002319G		INC	Stall	Wingtip Strike
19920127005429G	FAA AIDS	N20BF	Cessna	441	1/27/1992	Green Bay, WI	19920127005429G	19920127005429G	200004	INC	Stall	Hard Landing
20001213X35337(A)	NTSB	N422MQ	ATR	ATR-42	12/18/1986	Detroit, MI	20001213X35337(A)	19861218081799C		INC	Stall	Normal Landing
20001212X16303(A)	NTSB	N838JS	British Aerospace	3101	12/23/1990	Dayton, OH	20001212X16303(A)			INC	ICTS	Abnormal Landing
20001212X16303(B)	NTSB	not reported	British Aerospace	3101		Dayton, OH	20001212X16303(B)			INC	ICTS	Normal Landing
20001212X16566	NTSB	N385MQ	Short Brothers	SD 3-60	3/2/1991	Chicago, IL	20001212X16566	19910302005719B	171762	ACC	L/D Degradation	Hard Landing
845030	ASRS	Registration De-identified	Not Reported	MU-2B		, US	845030		845030	INC	Stall	Normal Landing
881246	ASRS	Registration De-identified	Not Reported	208B		, US	881246		881246	INC	Stall	Abnormal Landing
802644	ASRS	Registration De-identified	Not Reported	SR22		Omaha, NE	802644		802644	INC	Stall Warning	Normal Landing

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
881955	ASRS	Registration De-identified	Not Reported	ATR72		, US	881955		881955	INC	Stab/Control Anomaly	Abnormal Landing
20001213X32758	NTSB	N331PX	British Aerospace	3101	12/14/1987	Joplin, MO	20001213X32758	19871214071219B		ACC	ICTS	Controlled Collision With Ground
20011126038439C	FAA AIDS	N398A	Cessna	208B	11/26/2001	North Platte, NE	20011126038439C	20011126038439C		INC	L/D Degradation	Abnormal Landing
20001213X33027	NTSB	N1356P	Embraer	EMB-110	3/13/1986	Alpena, MI	20001213X33027	19860313013319B		ACC	L/D Degradation	Controlled Collision With Ground
20090106X53332	NTSB	N70DD	Beech	58	1/3/2009	Brainerd, MN	20090106X53332	20090103002079B		ACC	L/D Degradation	Hard Landing
20090312X34256	NTSB	N402BP	Cessna	402B	3/10/2009	Aberdeen, SD	20090312X34256	20090310012539A		ACC	L/D Degradation	Hard Landing
20001208X05278	NTSB	N27989	Piper	PA-31-350	2/28/1996	Grand Canyon, AZ	20001208X05278	19960228003129B		ACC	L/D Degradation	Hard Landing
20090125000809C	FAA AIDS	N202UX	Beech	1900D	1/25/2009	Cheyenne, WY	20090125000809C	20090125000809C		INC	L/D Degradation	Hard Landing
20001212X23371	NTSB	N315RC	Piper	PA-46-310P	6/26/1990	Lakeville, MI	20001212X23371	19900626022609A		ACC	Stall	Uncontrolled Collision With Ground
423333	ASRS	Registration De-identified	Not Reported	747 Series Unknown		, FO	423333		423333	INC	Stall Warning	Normal Landing
20100106X55618	NTSB	N206AV	Beech	C-99	1/6/2010	Kearney, NE	20100106X55618	20100106025779A		ACC	Stall	Hard Landing
20070201X00128	NTSB	N425TN	Cessna	425	1/12/2007	Harbor Springs, MI	20070201X00128	20070112002279A		ACC	Stall	Uncontrolled Collision With Ground
20090116X02657	NTSB	N840NK	Gulfstream Aerospace Corp	Commander	1/15/2009	Wray, CO	20090116X02657	20090115000329A		ACC	Stall	Uncontrolled Collision With Ground
20090127X92950	NTSB	N902FX	Aerospatiale Alenia	ATR42-320	1/27/2009	Lubbock, TX	20090127X92950	20090127001639B		ACC	Stall	Controlled Collision With Ground
20100427X81628	NTSB	N1856S	Beech	58	4/27/2010	Bear Branch, KY	20100427X81628	20100427033009A		ACC	Stall	Uncontrolled Collision With Ground
20101227X00333	NTSB	N233DS	Cessna	340A	12/21/2010	Madison, WI	20101227X00333	20101221053669A		ACC	Stall	Hard Landing

Table A-1. List of events in the Inflight Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20110103X04612	NTSB	N385AS	Allen Raymond H	LANCAIR LEGACY	12/25/2010	Troy, MI	20110103X04612	20101225053939A		ACC	Stall	Hard Landing
20110223X51944	NTSB	N119RS	Cessna	310Q	2/21/2011	Romeoville, IL	20110223X51944	20110221003839A		ACC	L/D Degradation	Hard Landing
20110106000649A	FAA AIDS	N800GP	Gates	35A	1/6/2011	Springfield, IL	20110106000649A	20110106000649A		ACC	Not Reviewed	
934986	ASRS	Registration De-identified	Not Reported	B757-200		, US	934986		934986	INC	Stab/Control Anomaly	Abnormal Landing

ACC = accidents; INC = incidents; L/D = lift/drag; ICTS = ice-contaminated tailplane stall

APPENDIX B—LIST OF EVENTS IN THE GROUND ICING DATASET

Table B-1. List of events in the Ground Icing Dataset

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001206X00637	NTSB	N5384W	Cessna	P210N	1/10/1994	San Martin, CA	20001206X00637	19940110000249A		ACC	L/D Degradation	Controlled Collision With Ground
20001206X00896	NTSB	N2181Q	Cessna	177RG	3/1/1994	Longmont, CO	20001206X00896	19940301003159A		ACC	Stall	Controlled Collision With Ground
20001206X00973	NTSB	N36444	Aerostar	AEROSTAR 601P	3/18/1994	Limerick, PA	20001206X00973	19940318005849A		ACC	Stall	Uncontrolled Collision With Ground
20001206X02654	NTSB	N112KF	Piper	PA-18-150	11/24/1994	Glenburn, ME	20001206X02654	19941124048399A		ACC	Stab/Control Anomaly	Controlled Collision With Ground
20001207X02851	NTSB	N9461R	Cessna	208B	1/18/1995	Lubbock, TX	20001207X02851	19950118000559B	294265	ACC	L/D Degradation	Controlled Collision With Ground
20001207X04908	NTSB	N7734P	Piper	PA-24-180	11/9/1995	Hartford, VT	20001207X04908	19951109036349A		ACC	Stall	Uncontrolled Collision With Ground
20001208X06670	NTSB	N5343G	De Havilland	DHC-2	9/24/1996	Aniak, AK	20001208X06670	19960924029969B		ACC	L/D Degradation	Controlled Collision With Ground
20001208X07263	NTSB	N5AS	Cessna	401	1/22/1997	Crystal, MN	20001208X07263	19970122000769A		ACC	Stall	Controlled Collision With Ground
20001208X07495	NTSB	N753RA	McDonnell Douglas	DC-9	3/14/1997	Detroit, MI	20001208X07495	19970314047769B		ACC	Compressor Stall/FOD	Normal Landing
20001208X07534	NTSB	N4860T	Piper	PA-28-180	3/15/1997	Fort Collins, CO	20001208X07534	19970315003181A		ACC	Stall	Controlled Collision With Ground
20001208X09127	NTSB	N750GC	Cessna	208B	11/8/1997	Barrow, AK	20001208X09127	19971108032589B		ACC	Stall	Uncontrolled Collision With Ground
20001208X09286	NTSB	N5087Q	Cessna	402B	12/30/1997	Watertown, SD	20001208X09286	19971230039709B		ACC	Stall	Uncontrolled Collision With Ground
20001208X09373	NTSB	N9604H	Cessna	172	12/28/1997	Mansfield, MA	20001208X09373	19971228039489A		ACC	Stall	Controlled Collision With Ground

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001211X09599	NTSB	N79588	Cessna	172K	2/2/1998	Boxborough, MA	20001211X09599	19980202000879A		ACC	Stall	Uncontrolled Collision With Ground
20001211X11766	NTSB	N4182G	Cessna	402C	2/20/1993	Nome, AK	20001211X11766	19930220002949B		ACC	Stall	Controlled Collision With Ground
20001211X11770	NTSB	N5036U	Cessna	206	2/20/1993	Bradley Lake, AK	20001211X11770	19930220003009B		ACC	Stab/Control Anomaly	Controlled Collision With Ground
20001211X13941	NTSB	N3738A	Beech	V35B	1/26/1992	Manassas, VA	20001211X13941	19920126000999A		ACC	Stall	Uncontrolled Collision With Ground
20001211X13976	NTSB	N1974G	Cessna	421B	1/4/1992	Steamboat Spgs, CO	20001211X13976	19920104000139A		ACC	Stall	Uncontrolled Collision With Ground
20001211X14270	NTSB	N485US	Fokker	28-4000	3/22/1992	Flushing, NY	20001211X14270	19920322006959B		ACC	Stall	Controlled Collision With Ground
20001212X16434	NTSB	N565PC	McDonnell Douglas	DC-9-15	2/17/1991	Cleveland, OH	20001212X16434	19910217002609B		ACC	Stall	Uncontrolled Collision With Ground
20001212X16584	NTSB	N761MU	Cessna	T210M	3/1/1991	Taos, NM	20001212X16584	19910301003779B		ACC	Stall	Uncontrolled Collision With Ground
20001212X18011	NTSB	N2515A	Piper	PA-18-150	9/12/1991	Anaktuvuk Pass, AK	20001212X18011	19910912042829A		ACC	Stall	Uncontrolled Collision With Ground
20001212X18368	NTSB	N26697	Grumman	AA-5A	10/13/1991	Boxboro, MA	20001212X18368	19911013046029A		ACC	Stall	Controlled Collision With Ground
20001212X18565	NTSB	N6105Y	Beech	A36	12/10/1991	Rensselaer, IN	20001212X18565	19911210055339A		ACC	Stall	Uncontrolled Collision With Ground
20001212X20186	NTSB	N5187B	Cessna	208B	12/6/1999	Bethel, AK	20001212X20186	19991206046709B		ACC	Stall	Controlled Collision With Ground
20001212X20189	NTSB	N1864	Cessna	T207A	12/24/1999	Bethel, AK	20001212X20189	19991224041869B		ACC	L/D Degradation	Controlled Collision With Ground
20001212X20413	NTSB	N2469E	Cessna	172N	1/25/2000	Lincolnton, GA	20001212X20413	2000012500690 A		ACC	Stall	Controlled Collision With Ground

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001212X20426	NTSB	N9103N	Piper	PA-46-310P	1/11/2000	Bradford, PA	20001212X20426	20000111006549A		ACC	Stall	Uncontrolled Collision With Ground
20001212X20431	NTSB	N251BD	Mooney	M20K	1/23/2000	Pendleton, OR	20001212X20431	20000123006639A		ACC	Stall	Uncontrolled Collision With Ground
20001212X22479	NTSB	N854FE	Cessna	208B	1/29/1990	Schuyler Falls, NY	20001212X22479	19900129001249B		ACC	Stall	Uncontrolled Collision With Ground
20001212X22480	NTSB	N4688B	Cessna	208B	1/29/1990	Williston,, VT	20001212X22480	19900130002129B		ACC	Stall	Uncontrolled Collision With Ground
20001212X22586	NTSB	N8620N	Piper	PA-32-300	2/4/1990	Mammoth Lakes, CA	20001212X22586	19900204001569A		ACC	Stall	Controlled Collision With Ground
20001212X24172	NTSB	N2518A	Piper	PA-18-150	9/22/1990	Delta Junction, AK	20001212X24172	19900922043359A		ACC	L/D Degradation	Controlled Collision With Ground
20001212X24547	NTSB	N26853	Cessna	414A	10/17/1990	Jackson, WY	20001212X24547	19901017046249A		ACC	L/D Degradation	Aborted Takeoff
20001213X24890	NTSB	N2614U	Cessna	402	1/18/1988	Albuquerque, NM	20001213X24890	19880118000659B		ACC	Stall Warning	Aborted Takeoff
20001213X25091	NTSB	N2832J	Cessna	A188B	2/5/1988	Lodi, CA	20001213X25091	19880205001959A		ACC	L/D Degradation	Controlled Collision With Ground
20001213X27415	NTSB	N5570H	Piper	PA-11	12/23/1988	Winnett, MT	20001213X27415	19881223060079A		ACC	Stall	Uncontrolled Collision With Ground
20001213X29728	NTSB	N5511J	Piper	PA-32-260	11/25/1989	Eek, AK	20001213X29728	19891125046539B		ACC	L/D Degradation	Controlled Collision With Ground
20001213X29902	NTSB	N8569D	Piper	PA-18	12/22/1989	Pilot Point, AK	20001213X29902	19891222057249A		ACC	Stall	Uncontrolled Collision With Ground
20001213X32505	NTSB	N626TX	McDonnell Douglas	DC-9-14	11/15/1987	Denver, CO	20001213X32505			ACC	Stall	Uncontrolled Collision With Ground
20001213X32607	NTSB	N3644H	Mooney	M20C	11/14/1987	St. Marys, PA	20001213X32607			ACC	Stall	Uncontrolled Collision With Ground

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001213X32647	NTSB	N9438F	Cessna	208	12/19/1987	Bethel, AK	20001213X32647	19871219070739B		ACC	Stall Warning	Controlled Collision With Ground
20001213X32879	NTSB	N1507V	Cessna	172M	2/9/1986	Big Bear City, CA	20001213X32879	19860209019709A		ACC	L/D Degradation	Controlled Collision With Ground
20001213X34890	NTSB	N67H	Artic Aircraft Corp.	PRIVATEER S4	10/23/1986	Anchorage, AK	20001213X34890	19861023050049A		ACC	Stall	Uncontrolled Collision With Ground
20001214X35469	NTSB	N95HA	Beech	E18S	1/31/1985	Huntington, WV	20001214X35469	19850131002819B		ACC	Stall	Controlled Collision With Obstacles
20001214X35671	NTSB	N926AX	McDonnell Douglas	DC-9-15	2/5/1985	Philadelphia, PA	20001214X35671	19850205077839B		ACC	Stall	Controlled Collision With Ground
20001214X35771	NTSB	N18664	Cessna	177B	2/27/1985	Lee's Summit, MO	20001214X35771	19850227004599A		ACC	L/D Degradation	Aborted Takeoff
20001214X35776	NTSB	N91636	Cessna	182N	2/3/1985	Manville, NJ	20001214X35776	19850203003599A		ACC	Stall	Uncontrolled Collision With Ground
20001214X37934	NTSB	N3339R	Cessna	182L	10/27/1985	Anchorage, AK	20001214X37934	19851027054069A		ACC	Stall	Uncontrolled Collision With Ground
20001214X38325	NTSB	N9893M	Cessna	182P II	11/26/1985	Carson City, NV	20001214X38325	19851126074039A		ACC	Stall	Controlled Collision With Ground
20001214X38392	NTSB	N991OU	Grumman	AA-5A	12/1/1985	Fort Collins, CO	20001214X38392			ACC	Stall Warning	Controlled Collision With Obstacles
20001214X38504	NTSB	N36791	Piper	PA-32RT-300	1/11/1984	Basye, VA	20001214X38504	19840111001329A		ACC	Stall	Controlled Collision With Ground
20001214X38546	NTSB	N148PM	Fokker	F27-100	1/13/1984	Jamaica, NY	20001214X38546	19840113000789B		ACC	Compressor Stall/FOD	Controlled Collision With Ground
20001214X39143	NTSB	N218X	Beech	H-18	3/19/1984	Morrisonville, NY	20001214X39143	19840319009809B		ACC	Stall	Uncontrolled Collision With Ground

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001214X39377	NTSB	N33569	Piper	PA-34-200T	4/6/1984	Johnstown, PA	20001214X39377	19840406014179A		ACC	L/D Degradation	Controlled Collision With Obstacles
20001214X40924	NTSB	N84490	Cessna	188	9/22/1984	Chugiak, AK	20001214X40924	19840922050589B		ACC	L/D Degradation	Controlled Collision With Ground
20001214X41335	NTSB	N1597T	Cessna	414-8	10/20/1984	Cheyenne, WY	20001214X41335	19841020057279A		ACC	Stall	Controlled Collision With Obstacles
20001214X41493	NTSB	N1606U	Cessna	207	11/20/1984	Koliganek, AK	20001214X41493	19841120063449B		ACC	L/D Degradation	Controlled Collision With Ground
20001214X41809	NTSB	N601FP	Aerostar	PA-60-601P	12/16/1984	Mammoth Lakes, CA	20001214X41809	19841216076469A		ACC	L/D Degradation	Controlled Collision With Ground
20001214X41906	NTSB	N8974R	Champion	7HC	1/16/1983	Anchorage, AK	20001214X41906	19830116001029A		ACC	Stall	Controlled Collision With Ground
20001214X42838	NTSB	N40314	Maule	M-4-220C	4/26/1983	Malad City, ID	20001214X42838	19830426016099A		ACC	L/D Degradation	Overrun
20001214X45211	NTSB	N1296F	Cessna	C-185	12/23/1983	Naknek, AK	20001214X45211	19831223063429A		ACC	Stall	Controlled Collision With Ground
20001214X45239	NTSB	N761RN	Cessna	T210M	12/6/1983	White lk Twnshp, MI	20001214X45239	19831206075509B		ACC	Stall	Uncontrolled Collision With Ground
20010201X00382	NTSB	N747RC	Piper	PA 46-350P	1/19/2001	Chillicothe, OH	20010201X00382	20010119004449A		ACC	Stall	Controlled Collision With Ground
20010329X00669	NTSB	N375FE	McDonnell Douglas	DC-10	3/6/2001	Boston, MA	20010329X00669	20010303003559C	503724	INC	Compressor Stall/FOD	Normal Landing
20010507X00888	NTSB	N97168	Stinson	108	4/26/2001	WHITE POST, VA	20010507X00888	20010426016869A		ACC	L/D Degradation	Controlled Collision With Ground
20011010X02069	NTSB	N9530F	Cessna	208	10/10/2001	Dillingham, AK	20011010X02069	20011010037429B		ACC	Stall	Uncontrolled Collision With Ground
20011226X02439	NTSB	N3049Y	Cessna	182E	12/5/2001	Prescott, AZ	20011226X02439	20011205036309A		ACC	Stall	Uncontrolled Collision With Ground

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20011228X02461	NTSB	N3023K	Piper	PA-28RT-201	12/24/2001	Prescott, AZ	20011228X02461	20011224036849A		ACC	L/D Degradation	Gear Up Landing
20020103X00015	NTSB	N207TA	Cessna	208B	12/20/2001	Lewiston, ME	20020103X00015	20011221034009B		ACC	L/D Degradation	Overrun
20020228X00286	NTSB	N3829J	Cessna	150	2/5/2002	Talkeetna, AK	20020228X00286	20020205001259A		ACC	Stall Warning	Controlled Collision With Obstacles
20020917X01907	NTSB	N62AF	Boeing	737-222	1/13/1982	Washington, DC	20020917X01907	19820113069129B		ACC	Stall	Uncontrolled Collision With Ground
20020917X01941	NTSB	N2478Q	Cessna	182K	3/29/1982	St. Ignatius, MT	20020917X01941	19820329019269A		ACC	L/D Degradation	Overrun
20020917X02198	NTSB	N28867	Grum Amer	AA-5B	4/16/1982	Placerville, CA	20020917X02198	19820316004089A		ACC	L/D Degradation	Overrun
20020917X02245	NTSB	N731RG	Cessna	A188B	2/23/1982	Lodi, CA	20020917X02245	19820224005539A		ACC	L/D Degradation	Overrun
20020917X02457	NTSB	N82GB	Cessna	340A	4/7/1982	Lincoln, NE	20020917X02457	19820407008349A		ACC	Stall Warning	Controlled Collision With Obstacles
20020917X02564	NTSB	N8419J	Varga	2150A	3/10/1982	Marlboro, MA	20020917X02564	19820310012739A		ACC	L/D Degradation	Controlled Collision With Obstacles
20020917X04536	NTSB	N7611T	Cessna	172A	12/26/1982	Leadville, CO	20020917X04536	19821226066729A		ACC	Stall	Uncontrolled Collision With Ground
20020917X05060	NTSB	N2014D	Beech	C23	11/29/1982	Hazleton, PA	20020917X05060	19821129060469A		ACC	L/D Degradation	Controlled Collision With Obstacles
20021118X05478	NTSB	N80948	Cessna	172	11/9/2002	Anchorage, AK	20021118X05478	20021109033069A		ACC	Stall	Controlled Collision With Ground
20030127X00116	NTSB	N6312E	Cessna	172	1/18/2003	Chesapeake, VA	20030127X00116	20030118035299A		ACC	Stall Warning	Controlled Collision With Ground
20030204X00161	NTSB	N670CS	Cessna	172	1/31/2003	Lakeville, MN	20030204X00161	20030131001539A		ACC	Stall	Controlled Collision With Ground

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20030207X00180	NTSB	N48K	Beech	E18S	2/4/2003	Burlington, WA	20030207X00180	20030204001019A		ACC	Stall	Controlled Collision With Ground
20031209X02013	NTSB	N700QD	Socata	TBM 700	12/6/2003	Reading, PA	20031209X02013	20031206035559A		ACC	Stall Warning	Controlled Collision With Ground
20031212X02022	NTSB	N14XL	Iniziative Industriali Italian	Sky Arrow 650 TC	12/8/2003	Placerville, CA	20031212X02022	20031208034259A		ACC	Stall	Uncontrolled Collision With Ground
20031230X02094	NTSB	N9469B	Cessna	208B	12/20/2003	Covington, KY	20031230X02094	20031220036199B		ACC	Stall	Controlled Collision With Ground
20040930X01537	NTSB	N16894	McDonnell Douglas	MD-82	9/26/2004	Anchorage, AK	20040930X01537	20040926029749G		INC	Compressor Stall/FOD	Aborted Takeoff
20041203X01919	NTSB	N873G	Canadair	CL-600-2A12	11/28/2004	Montrose, CO	20041203X01919	20041128031429B		ACC	Stall	Uncontrolled Collision With Ground
20050127X00110	NTSB	N194JA	Cessna	414A	1/9/2005	Harbor Springs, MI	20050127X00110	20050109002479A		ACC	Stab/Control Anomaly	Overrun
20060313X00293	NTSB	N3511V	Beech	V35B	3/3/2006	Burns, OR	20060313X00293	20060303002539A		ACC	Stall	Controlled Collision With Ground
20071219X01978	NTSB	N925TT	Beech	200	12/10/2007	Salmon, ID	20071219X01978	20071210827979A		ACC	Stall	Uncontrolled Collision With Ground
19820202008609C	FAA AIDS	N705ZW	Dhav	DHC7102	2/2/1982	Ft Wayne, IN	19820202008609C	19820202008609C		INC	Stab/Control Anomaly	Normal Landing
19840330022119G	FAA AIDS	N2292M	Piper	PA28R200	3/30/1984	Los Alamos, NM	19840330022119G	19840330022119G		INC	L/D Degradation	Aborted Takeoff
19850227011369G	FAA AIDS	N136TC	Beech	A36TC	2/27/1985	Edmond, OK	19850227011369G	19850227011369G		INC	L/D Degradation	
19890208008439C	FAA AIDS	N214AA	Doug	DC982	2/8/1989	Los Angeles, CA	19890208008439C	19890208008439C	103750	INC	Compressor Stall/FOD	Normal Landing
19911006050549C	FAA AIDS	N429MQ	Aerosp	ATR42300	10/6/1991	Marquette, MI	19911006050549C	19911006050549C	191028	INC	Stall Warning	Normal Landing
19911204061129C	FAA AIDS	N922RW	Doug	DC931	12/4/1991	Detroit, MI	19911204061129C	19911204061129C	195982	INC	Compressor Stall/FOD	Normal Landing
19920201005919G	FAA AIDS	N48228	Cessna	152	2/1/1992	Milton, WV	19920201005919G	19920201005919G		INC	L/D Degradation	Land Off Airport
19940117002239C	FAA AIDS	N978DL	Doug	MD88	1/17/1994	Nashville, TN	19940117002239C	19940117002239C	261706	INC	Compressor Stall/FOD	Normal Landing

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
19940118004159C	FAA AIDS	N356QS	Boeing	72721	1/18/1994	Nashville, TN	19940118004159C	19940118004159C		INC	Stall Warning	Normal Landing
19940406013579C	FAA AIDS	N923CP	Cessna	421C	4/6/1994	Jackson, WY	19940406013579C	19940406013579C	267815	INC	Stab/Control Anomaly	Overrun
19960406021109G	FAA AIDS	N3372Q	Cessna	421B	4/6/1996	Columbus, OH	19960406021109G	19960406021109G		INC	Stab/Control Anomaly	Aborted Takeoff
19960924045789B	FAA AIDS	N53436	Dhav	DHC2*	9/24/1996	Aniak, AK	19960924045789B	19960924045789B		ACC	L/D Degradation	Controlled Collision With Ground
19961109040479C	FAA AIDS	N861MA	Dhav	DHC8102	11/9/1996	Detroit, MI	19961109040479C	19961109040479C		INC	Stab/Control Anomaly	Normal Landing
20001219027959C	FAA AIDS	N69740	Boeing	727224	12/19/2000	Windsor Locks, CT	20001219027959C	20001219027959C	495832	INC	Stall Warning	Normal Landing
20030102006879G	FAA AIDS	N961LL	Beech	B300	1/2/2003	Springfield, IL	20030102006879G	20030102006879G	570097	INC	Deicing Procedural Failure	Aborted Takeoff
20030223010089C	FAA AIDS	N522XJ	Bac	AVRO146RJ85A	2/23/2003	Romulus, MI	20030223010089C	20030223010089C	574957	INC	Stab/Control Anomaly	Aborted Takeoff
202214	ASRS	Registration De-identified	Not Reported	Small Aircraft, Low Wing, 1 Eng, Retractable Gear		Heber, UT	202214		202214	INC	Stall	Controlled Collision With Ground
81196	ASRS	Registration De-identified	Not Reported	Medium Large Transport, Low Wing, 2 Turbojet Eng		New York, NY	81196		81196	INC	Compressor Stall/FOD	Normal Landing
133082	ASRS	Registration De-identified	Not Reported	Medium Large Transport, Low Wing, 2 Turbojet Eng		Salt Lake City, UT	133082		133082	INC	Deice Fluid Failure	Normal Takeoff
196094	ASRS	Registration De-identified	Not Reported	Small Transport, Low Wing, 2 Turbojet Eng		Detroit, MI	196094		196094	INC	Stab/Control Anomaly	Normal Landing
294262	ASRS	Registration De-identified	Not Reported	B757-200		Chicago, IL	294262		294262	INC	Deicing Procedural Failure	Normal Landing
297953	ASRS	Registration De-identified	Not Reported	Commercial Fixed Wing		New York, NY	297953		297953	INC	Deicing Procedural Failure	Normal Landing
450566	ASRS	Registration De-identified	Not Reported	Beech 1900		Cheyenne, WY	450566		450566	INC	Stab/Control Anomaly	Normal Landing

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
507338	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		, WA	507338		507338	INC	Stab/Control Anomaly	Normal Landing
541910	ASRS	Registration De-identified	Not Reported	Do 328 TP (Turboprop)		, US	541910		541910	INC	Stab/Control Anomaly	Normal Landing
574524	ASRS	Registration De-identified	Not Reported	Regional Jet CL65, Undifferentiated or Other Model		Dallas-Fort Worth, TX	574524		574524	INC	Deicing Procedural Failure	Normal Landing
575167	ASRS	Registration De-identified	Not Reported	MD-80 Super 80		Dallas-Fort Worth, TX	575167		575167	INC	Compressor Stall/FOD	Aborted Takeoff
611487	ASRS	Registration De-identified	Not Reported	MD-80 Series (DC-9-80) Undifferentiated or Other Model		Chicago, IL	611487		611487	INC	Deicing Procedural Failure	Normal Landing
764827	ASRS	Registration De-identified	Not Reported	B737-300		, US	764827		764827	INC	Deicing Procedural Failure	Normal Landing
506959	ASRS	Registration De-identified	Not Reported	Jetstream 32		, US	506959		506959	INC	Stab/Control Anomaly	Normal Landing
770866	ASRS	Registration De-identified	Not Reported	Regional Jet 200 ER&LR		, US	770866		770866	INC	Stab/Control Anomaly	Aborted Takeoff
81817	ASRS	Registration De-identified	Not Reported	Medium Large Transport, Low Wing, 2 Turbojet Eng		Washington, VA	81817		81817	INC	Compressor Stall/FOD	Aborted Takeoff
104785	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		Cedar Rapids, IA	104785		104785	INC	Stab/Control Anomaly	Normal Landing
132281	ASRS	Registration De-identified	Not Reported	Large Transport, Low Wing, 3 Turbojet Eng		New York, NY	132281		132281	INC	Compressor Stall/FOD	Normal Landing
137565	ASRS	Registration De-identified	Not Reported	Small Aircraft, High Wing, 1 Eng, Fixed Gear		Pontiac, MI	137565		137565	INC	Stab/Control Anomaly	Normal Landing
168171	ASRS	Registration De-identified	Not Reported	Medium Transport, High Wing, 2 Turboprop Eng		Madison, WI	168171		168171	INC	Stab/Control Anomaly	Normal Landing

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
194669	ASRS	Registration De-identified	Not Reported	Small Transport, Low Wing, 2 Turboprop Eng		Cedar City, UT	194669		194669	INC	Deicing Procedural Failure	Normal Landing
199436	ASRS	Registration De-identified	Not Reported	Medium Large Transport, Low Wing, 2 Turbojet Eng		Cleveland, OH	199436		199436	INC	Deicing Procedural Failure	Normal Landing
203405	ASRS	Registration De-identified	Not Reported	Medium Large Transport, Low Wing, 2 Turbojet Eng		Providence, RI	203405		203405	INC	Stab/Control Anomaly	Aborted Takeoff
228838	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		Albuquerque, NM	228838		228838	INC	Deicing Procedural Failure	Normal Landing
233486	ASRS	Registration De-identified	Not Reported	Medium Large Transport, Low Wing, 2 Turbojet Eng		Salt Lake City, UT	233486		233486	INC	Deicing Procedural Failure	Normal Landing
236634	ASRS	Registration De-identified	Not Reported	Large Transport, Low Wing, 3 Turbojet Eng		Newark, NJ	236634		236634	INC	Compressor Stall/FOD	Normal Landing
256207	ASRS	Registration De-identified	Not Reported	Small Transport		Kotzebue, AK	256207		256207	INC	Compressor Stall/FOD	Abnormal Takeoff
262519	ASRS	Registration De-identified	Not Reported	Any Unknown or Unlisted Aircraft Manufacturer		St Louis, MO	262519		262519	INC	Deicing Procedural Failure	Normal Landing
263581	ASRS	Registration De-identified	Not Reported	Commercial Fixed Wing		Nashville, TN	263581		263581	INC	Deicing Procedural Failure	Normal Landing
264651	ASRS	Registration De-identified	Not Reported	Commercial Fixed Wing		Seattle, WA	264651		264651	INC	Compressor Stall/FOD	Normal Landing
290329	ASRS	Registration De-identified	Not Reported	F28 Undifferentiated or Other Model		Pittsburgh, PA	290329		290329	INC	Deicing Procedural Failure	Normal Landing
321980	ASRS	Registration De-identified	Not Reported	Commercial Fixed Wing		Pittsburgh, PA	321980		321980	INC	Deicing Procedural Failure	Normal Takeoff
322192	ASRS	Registration De-identified	Not Reported	Commercial Fixed Wing		New York, NY	322192		322192	INC	Deicing Procedural Failure	Return to Gate

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
324733	ASRS	Registration De-identified	Not Reported	MD-88		Covington, OH	324733		324733	INC	Compressor Stall/FOD	Normal Landing
324815	ASRS	Registration De-identified	Not Reported	MD-80 Super 80		, AB	324815		324815	INC	Compressor Stall/FOD	Aborted Takeoff
325901	ASRS	Registration De-identified	Not Reported	Medium Large Transport, Low Wing, 2 Turbojet Eng		Portland, OR	325901		325901	INC	Deicing Procedural Failure	Normal Landing
329930	ASRS	Registration De-identified	Not Reported	Commercial Fixed Wing		Harrisburg, PA	329930		329930	INC	Deicing Procedural Failure	Normal Landing
353800	ASRS	Registration De-identified	Not Reported	Commercial Fixed Wing		Denver, CO	353800		353800	INC	Deicing Procedural Failure	Normal Takeoff
354043	ASRS	Registration De-identified	Not Reported	B737-300		Jackson, WY	354043		354043	INC	Stab/Control Anomaly	Aborted Takeoff
354118	ASRS	Registration De-identified	Not Reported	B727		Seattle, WA	354118		354118	INC	Stall Warning	Normal Landing
393446	ASRS	Registration De-identified	Not Reported	ATR 72		Lubbock, TX	393446		393446	INC	Stab/Control Anomaly	Normal Landing
397964	ASRS	Registration De-identified	Not Reported	MD-80 Series (DC-9-80) Undifferentiated or Other Model		Reno, NV	397964		397964	INC	Compressor Stall/FOD	Aborted Takeoff
536824	ASRS	Registration De-identified	Not Reported	Cessna 150		Panama City, AK	536824		536824	INC	L/D Degradation	Aborted Takeoff
537082	ASRS	Registration De-identified	Not Reported	Jetstream 41		Sioux City, IA	537082		537082	INC	Deicing Procedural Failure	Normal Landing
644849	ASRS	Registration De-identified	Not Reported	MD-80 Series (DC-9-80) Undifferentiated or Other Model		, US	644849		644849	INC	Compressor Stall/FOD	Normal Landing
719345	ASRS	Registration De-identified	Not Reported	MD-83		Oklahoma City, OK	719345		719345	INC	Compressor Stall/FOD	Aborted Takeoff

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
719359	ASRS	Registration De-identified	Not Reported	MD-80 Series (DC-9-80) Undifferentiated or Other Model		, US	719359		719359	INC	Compressor Stall/FOD	Normal Landing
727604	ASRS	Registration De-identified	Not Reported	MD-80 Series (DC-9-80) Undifferentiated or Other Model		Dayton, OH	727604		727604	INC	Compressor Stall/FOD	Aborted Takeoff
764355	ASRS	Registration De-identified	Not Reported	MD-80 Series (DC-9-80) Undifferentiated or Other Model		, US	764355		764355	INC	Deicing Procedural Failure	Normal Landing
764908	ASRS	Registration De-identified	Not Reported	P180		, US	764908		764908	INC	Deicing Procedural Failure	Normal Takeoff
765422	ASRS	Registration De-identified	Not Reported	EMB ERJ 135 ER&LR		St Louis, MO	765422		765422	INC	Deicing Procedural Failure	Normal Takeoff
816752	ASRS	Registration De-identified	Not Reported	B737-700		Las Vegas, NV	816752		816752	INC	Deicing Procedural Failure	Normal Takeoff
825584	ASRS	Registration De-identified	Not Reported	MD-80 Series (DC-9-80) Undifferentiated or Other Model		, US	825584		825584	INC	Compressor Stall/FOD	Aborted Takeoff
20001205X00171	NTSB	N31975	Piper	PA-32RT-300	2/7/1999	Medina, OH	20001205X00171	19990207001149A		ACC	L/D Degradation	Controlled Collision With Obstacles
20001206X02618	NTSB	N2221R	Cessna	T210H	11/22/1994	Mount Hamilton, CA	20001206X02618	19941122038789A		ACC	Stall	Controlled Collision With Ground
20001207X02857	NTSB	N30898	Cessna	177B	1/1/1995	Torreon, NM	20001207X02857	19950101000079A		ACC	Stall	Uncontrolled Collision With Ground
20001207X04796	NTSB	N88BC	Cessna	207	11/3/1995	Toksook Bay, AK	20001207X04796	19951103035889B		ACC	Stab/Control Anomaly	Controlled Collision With Ground
20001208X05682	NTSB	N93HU	Aviat	A-1	5/2/1996	Togiak, AK	20001208X05682	19960502011929A		ACC	L/D Degradation	Controlled Collision With Ground

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001211X09485	NTSB	N50929	Air Tractor	AT-602	1/29/1998	Wrightsville, GA	20001211X09485	19980129000729A		ACC	Stall	Uncontrolled Collision With Ground
20001211X15575	NTSB	N3692Z	Piper	PA-18-150	9/13/1992	North Pole, AK	20001211X15575	19920914038319A		ACC	L/D Degradation	Controlled Collision With Obstacles
20001212X16251	NTSB	N4468L	Cessna	172G	1/5/1991	Wasilla, AK	20001212X16251	19910105000229A		ACC	Stall	Aborted Takeoff
20001212X20370	NTSB	N7VS	Cessna	414	1/26/2000	Oklahoma City, OK	20001212X20370	20000126000279A		ACC	L/D Degradation	Controlled Collision With Ground
20001212X21883	NTSB	N10572	Piper	PA-18	9/2/2000	McGrath, AK	20001212X21883	20000902042319A		ACC	Stall	Uncontrolled Collision With Ground
20001212X24169	NTSB	N7580Y	Piper	PA-18-150	9/22/1990	Coal Creek, AK	20001212X24169	19900922042159B		ACC	L/D Degradation	Aborted Takeoff
20001213X27678	NTSB	N5056Q	De Havilland	DHC-3	2/10/1989	Fairbanks, AK	20001213X27678	19890210034189B		ACC	L/D Degradation	Land Off Airport
20001213X27823	NTSB	N3281T	Beech	BE-18	3/9/1989	Covington, KY	20001213X27823	19890309003299B		ACC	Stall	Uncontrolled Collision With Ground
20051109X01815	NTSB	N6832A	Cessna	172	10/23/2005	Naknek, AK	20051109X01815	20051023030049A		ACC	Stall	Controlled Collision With Ground
19950410009559C	FAA AIDS	N310DC	Cessna	210L	4/10/1995	Albuquerque, NM	19950410009559C	19950410009559C	302095	INC	L/D Degradation	Gear Up Landing
20001211X13500	NTSB	N82231	Piper	PA-18	10/4/1993	Pilot Point, AK	20001211X13500	19931004037569A		ACC	Stall	Uncontrolled Collision With Ground
20001211X14357	NTSB	N9909Z	Cessna	U206G	4/2/1992	Kotzebue, AK	20001211X14357	19920402008319B		ACC	Stall	Uncontrolled Collision With Ground
20001212X20064	NTSB	N9933M	Cessna	207A	11/16/1999	Dillingham, AK	20001212X20064	19991116032169B		ACC	Stall	Controlled Collision With Ground
20001212X20086	NTSB	N1132A	Piper	PA-18-125	11/28/1999	Afton, WY	20001212X20086	19991128040319A		ACC	Stall	Uncontrolled Collision With Ground
20001212X20187	NTSB	N53910	Bellanca	8GCBC	12/11/1999	Wasilla, AK	20001212X20187	19991211046719A		ACC	L/D Degradation	Aborted Takeoff

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001213X28082	NTSB	N8272W	Piper	PA-28-180	4/14/1989	Milbank, SD	20001213X28082	19890414008089A		ACC	Stall	Controlled Collision With Ground
20001213X30048	NTSB	N3961G	Cessna	340A	1/22/1987	Bloomington, IN	20001213X30048	19870122000899A		ACC	Stab/Control Anomaly	Aborted Takeoff
20001213X30558	NTSB	N9073D	Piper	PA-18	4/5/1987	Valdez, AK	20001213X30558	19870405008509A		ACC	Stab/Control Anomaly	Controlled Collision With Ground
20001213X32231	NTSB	N1311D	Cessna	170	10/12/1987	King Salmon, AK	20001213X32231	19871012059239A		ACC	L/D Degradation	Aborted Takeoff
20001213X35339	NTSB	N4388X	Piper	PA-28-140	12/29/1986	Rawlins, WY	20001213X35339	19861229085979A		ACC	L/D Degradation	Controlled Collision With Ground
20001214X38738	NTSB	N30026	Piper	PA-32RT-300	2/24/1984	Lima, OH	20001214X38738	19840224004629A		ACC	L/D Degradation	Controlled Collision With Ground
20001214X38751	NTSB	N9832M	Maule	M-4S	2/5/1984	Three Forks, MT	20001214X38751	19840205002149A		ACC	Stall	Uncontrolled Collision With Ground
20001214X39432	NTSB	N8813J	Eagle Aircraft Co.	DW-1	4/30/1984	Spangle, WA	20001214X39432	19840430014939A		ACC	Stall	Controlled Collision With Ground
20001214X45246	NTSB	N7234D	Piper	PA-22-150	12/10/1983	Owosso, MI	20001214X45246	19831210060509A		ACC	L/D Degradation	Controlled Collision With Obstacles
20010110X00116	NTSB	N345CC	Beech	A36TC	1/19/1986	Louisville, KY	20010110X00116	19860119001509A		ACC	L/D Degradation	Aborted Takeoff
20010110X00166	NTSB	N27Y	Beech	E18S	1/2/1986	Terrell, TX	20010110X00166	19860102001709A		ACC	Stall	Controlled Collision With Ground
20021010X05307	NTSB	N144Q	De Havilland	DHC-2	9/20/2002	Bethel, AK	20021010X05307	20020920024539A		ACC	Stall	Uncontrolled Collision With Ground
20050414X00454	NTSB	N5006V	Air Tractor	AT-602	3/2/2005	Panama City, FL	20050414X00454	20050302002019A		ACC	Stall	Uncontrolled Collision With Ground
206452	ASRS	Registration De-identified	Not Reported	Widebody, Low Wing, 2 Turbojet Eng		Denver, CO	206452		206452	INC	Deicing Procedural Failure	Return to Gate

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
234432	ASRS	Registration De-identified	Not Reported	Medium Large Transport, Low Wing, 2 Turbojet Eng		Grand Forks, ND	234432		234432	INC	Deicing Procedural Failure	Return to Gate
236721	ASRS	Registration De-identified	Not Reported	Small Transport, Low Wing, 2 Recip Eng		Truckee, CA	236721		236721	INC	Deicing Procedural Failure	Return to Gate
290741	ASRS	Registration De-identified	Not Reported	B747 Undifferentiated or Other Model		Anchorage, AK	290741		290741	INC	Deicing Procedural Failure	Normal Landing
298028	ASRS	Registration De-identified	Not Reported	MD-83		Portland, OR	298028		298028	INC	Deicing Procedural Failure	Return to Gate
542133	ASRS	Registration De-identified	Not Reported	B757 Undifferentiated or Other Model		Eagle, CO	542133		542133	INC	Deicing Procedural Failure	Return to Gate
544088	ASRS	Registration De-identified	Not Reported	B737-700		Kansas City, MO	544088		544088	INC	Deicing Procedural Failure	Remained at Gate
640290	ASRS	Registration De-identified	Not Reported	B737 Undifferentiated or Other Model		Anchorage, AZ	640290		640290	INC	Deicing Procedural Failure	Return to Gate
687584	ASRS	Registration De-identified	Not Reported	B757-200		Seattle, WA	687584		687584	INC	Deicing Procedural Failure	Return to Gate
728868	ASRS	Registration De-identified	Not Reported	A319		, US	728868		728868	INC	Deicing Procedural Failure	Normal Takeoff
818222	ASRS	Registration De-identified	Not Reported	B737 Undifferentiated or Other Model		, US	818222		818222	INC	Deicing Procedural Failure	Return to Gate
20001214X42408	NTSB	N67943	Cessna	421C	3/18/1983	Gunnison, CO	20001214X42408	19830318008829A		ACC	L/D Degradation	Overrun
20001213X34951	NTSB	N33215	Cessna	177RG	10/6/1986	Glenwood Spring, CO	20001213X34951	19861006047899A		ACC	L/D Degradation	Controlled Collision With Ground
140961	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		, CO	140961		140961	INC	Deicing Procedural Failure	Aborted Takeoff
173662	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		Washington, VA	173662		173662	INC	Stab/Control Anomaly	Abnormal Takeoff

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
266901	ASRS	Registration De-identified	Not Reported	Commercial Fixed Wing		, AZ	266901		266901	INC	Stab/Control Anomaly	Aborted Takeoff
572071	ASRS	Registration De-identified	Not Reported	B737-800		, US	572071		572071	INC	Deicing Procedural Failure	Normal Landing
293310	ASRS	Registration De-identified	Not Reported	Any Unknown or Unlisted Aircraft Manufacturer		, PA	293310		293310	INC	Deicing Procedural Failure	Normal Takeoff
326004	ASRS	Registration De-identified	Not Reported	Light Transport		Seattle, WA	326004		326004	INC	Deicing Procedural Failure	Return to Gate
534106	ASRS	Registration De-identified	Not Reported	B737-300		, MO	534106		534106	INC	Deicing Procedural Failure	Return to Gate
565040	ASRS	Registration De-identified	Not Reported	B737-300		, TX	565040		565040	INC	Deicing Procedural Failure	Normal Takeoff
571783	ASRS	Registration De-identified	Not Reported	MD-90 Series (DC-9-90) Undifferentiated or Other Model		, UT	571783		571783	INC	Deicing Procedural Failure	Normal Takeoff
574077	ASRS	Registration De-identified	Not Reported	B737-700		Seattle, WA	574077		574077	INC	Deicing Procedural Failure	Return to Gate
353020	ASRS	Registration De-identified	Not Reported	Dash 8-100		Columbus, OH	353020		353020	INC	Stab/Control Anomaly	Normal Landing
395166	ASRS	Registration De-identified	Not Reported	ATR 72		Chicago, IL	395166		395166	INC	Stab/Control Anomaly	Normal Landing
261828	ASRS	Registration De-identified	Not Reported	Any Unknown or Unlisted Aircraft Manufacturer		Washington, DC	261828		261828	INC	Deicing Procedural Failure	Normal Landing
293716	ASRS	Registration De-identified	Not Reported	Any Unknown or Unlisted Aircraft Manufacturer		Pittsburgh, PA	293716		293716	INC	Deicing Procedural Failure	Normal Takeoff
20001207X02873	NTSB	N746FE	Cessna	208B	1/11/1995	Flagstaff, AZ	20001207X02873	19950111001739B		ACC	L/D Degradation	Uncontrolled Collision With Ground
19940304000909C	FAA AIDS	N601CA	Stbros	SD360	3/4/1994	State College, PA	19940304000909C	19940304000909C	265248	INC	Compressor Stall/FOD	Aborted Takeoff

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
20001214X38384	NTSB	N950JW	Douglas	DC-8-63	12/12/1985	Gander,	20001214X38384	19851212077879B		ACC	Stall	Uncontrolled Collision With Ground
680328	ASRS	Registration De-identified	Not Reported	MD-80		, US	680328		680328	INC	Compressor Stall/FOD	Abnormal Landing
780211	ASRS	Registration De-identified	Not Reported	Airbus Industrie Undifferentiated or Other Model		, US	780211		780211	INC	Deicing Procedural Failure	Return to Gate
496272	ASRS	Registration De-identified	Not Reported	MD-80		, KY	496272		496272	INC	Deicing Procedural Failure	Normal Takeoff
687575	ASRS	Registration De-identified	Not Reported	737		, CA	687575		687575	INC	Deicing Procedural Failure	Return to Gate
721758	ASRS	Registration De-identified	Not Reported	737		, CA	721758		721758	INC	Deicing Procedural Failure	Return to Gate
294591	ASRS	Registration De-identified	Not Reported	737		, MO	294591		294591	INC	Deicing Procedural Failure	Return to Gate
423777	ASRS	Registration De-identified	Not Reported	727		Bellaire, TN	423777		423777	INC	Compressor Stall/FOD	Aborted Takeoff
827469	ASRS	Registration De-identified	Not Reported	A320		, US	827469		827469	INC	Deice Fluid Failure	Deicing Fluid Failure
140484	ASRS	Registration De-identified	Not Reported	Large Transport, Low Wing, 3 Turbojet Eng		, ON	140484		140484	INC	Deicing Procedural Failure	Return to Gate
357891	ASRS	Registration De-identified	Not Reported	MD-80 Series (DC-9-80) Undifferentiated or Other Model		Dallas-Fort Worth, TX	357891		357891	INC	Deicing Procedural Failure	Normal Takeoff
392370	ASRS	Registration De-identified	Not Reported	B727-100		Chicago, IL	392370		392370	INC	Deicing Procedural Failure	Return to Gate
425120	ASRS	Registration De-identified	Not Reported	Sabreliner 65		Portland, ME	425120		425120	INC	Stab/Control Anomaly	Normal Landing

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
425267	ASRS	Registration De-identified	Not Reported	MD-80 Series (DC-9-80) Undifferentiated or Other Model		Baltimore, MD	425267		425267	INC	Compressor Stall/FOD	Aborted Takeoff
719247	ASRS	Registration De-identified	Not Reported	B737-300		Cleveland, OH	719247		719247	INC	Deicing Procedural Failure	Return to Gate
727664	ASRS	Registration De-identified	Not Reported	B757-200		, US	727664		727664	INC	Deicing Procedural Failure	Return to Gate
727379	ASRS	Registration De-identified	Not Reported	B767 Undifferentiated or Other Model		New York, NY	727379		727379	INC	Deicing Procedural Failure	Return to Gate
774175	ASRS	Registration De-identified	Not Reported	B767-300 and 300 ER		Washington, VA	774175		774175	INC	Deicing Procedural Failure	Return to Gate
821884	ASRS	Registration De-identified	Not Reported	B737-700		, US	821884		821884	INC	Deicing Procedural Failure	Normal Takeoff
863826	ASRS	Registration De-identified	Not Reported	B737-700		, US	863826		863826	INC	Deicing Procedural Failure	Return to Gate
866501	ASRS	Registration De-identified	Not Reported	EMB ERJ 145 ER&LR		, US	866501		866501	INC	Deicing Procedural Failure	Return to Gate
872309	ASRS	Registration De-identified	Not Reported	Dash 8-300		, US	872309		872309	INC	Stab/Control Anomaly	Aborted Takeoff
228204	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		Seattle, WA	228204		228204	INC	L/D Degradation	Normal Landing
774131	ASRS	Registration De-identified	Not Reported	MD-80 Series (DC-9-80) Undifferentiated or Other Model		Chicago, IL	774131		774131	INC	Not Reviewed	
173252	ASRS	Registration De-identified	Not Reported	Medium Large Transport, Low Wing, 2 Turbojet Eng		Philadelphia, PA	173252		173252	INC	Stall Warning	Normal Landing

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
257630	ASRS	Registration De-identified	Not Reported	Medium Large Transport, Low Wing, 2 Turbojet Eng		Dallas-Fort Worth, TX	257630		257630	INC	Compressor Stall/FOD	Normal Landing
20090506X83403	NTSB	N629SP	Cessna	TU206	5/6/2009	Bethel, AK	20090506X83403	20090506006219B		ACC	Stall	Uncontrolled Collision With Ground
168068	ASRS	Registration De-identified	Not Reported	Medium Large Transport, Low Wing, 2 Turbojet Eng		Salt Lake City, UT	168068		168068	INC	Deicing Procedural Failure	Normal Landing
20001214X35621	NTSB	N28BA	Douglas	DC-3	2/5/1985	Charlotte, NC	20001214X35621	19850205002269B		ACC	No Primary Occurrence 2	Abnormal Landing
20080116X00058	NTSB	N5187B	Cessna	208B	12/18/2007	Bethel, AK	20080116X00058	20071218828939B		ACC	Stall	Uncontrolled Collision With Ground
20090111X45527	NTSB	N604WP	Pilatus Aircraft Ltd	PC-12/45	1/11/2009	Hayden, CO	20090111X45527	20090111000499A		ACC	Stall	Uncontrolled Collision With Ground
19821128065569G	FAA AIDS	N3458H	Cessna	210	11/28/1982	Hayden, CO	19821128065569G	19821128065569G		INC	No Primary Occurrence 2	Aborted Takeoff
19921206054459G	FAA AIDS	N5981F	Cessna	210H	12/6/1992	Fitchburg, MA	19921206054459G	19921206054459G		INC	No Primary Occurrence 2	Aborted Takeoff
640668	ASRS	Registration De-identified	Not Reported	B757-200			640668		640668	INC	Deicing Procedural Failure	Return to Gate
685871	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		Nashua,	685871		685871	INC	Deicing Procedural Failure	Normal Takeoff
723765	ASRS	Registration De-identified	Not Reported	A300		Wichita, KS	723765		723765	INC	No Primary Occurrence 2	Normal Landing
764940	ASRS	Registration De-identified	Not Reported	Regional Jet 200 ER/LR (CRJ200)		, US	764940		764940	INC	Deicing Procedural Failure	Return to Gate
494779	ASRS	Registration De-identified	Not Reported	B727-200		, US	494779		494779	INC	Deicing Procedural Failure	Return to Gate

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
725169	ASRS	Registration De-identified	Not Reported	SF 340B		, US	725169		725169	INC	No Primary Occurrence 2	Normal Landing
193635	ASRS	Registration De-identified	Not Reported	Light Transport, Low Wing, 2 Turboprop Eng		Minneapolis, MN	193635		193635	INC	No Primary Occurrence 2	Normal Landing
260494	ASRS	Registration De-identified	Not Reported	Any Unknown or Unlisted Aircraft Manufacturer		Washington, VA	260494		260494	INC	Deicing Procedural Failure	Return to Gate
300212	ASRS	Registration De-identified	Not Reported	Learjet 35		, BC	300212		300212	INC	No Primary Occurrence 2	Normal Landing
325815	ASRS	Registration De-identified	Not Reported	Commercial Fixed Wing		Fayetteville, AR	325815		325815	INC	Stab/Control Anomaly	Abnormal Landing
354269	ASRS	Registration De-identified	Not Reported	B737-300		Albany, NY	354269		354269	INC	No Primary Occurrence 2	Normal Landing
424910	ASRS	Registration De-identified	Not Reported	757		Covington, OH	424910		424910	INC	No Primary Occurrence 2	Normal Landing
433789	ASRS	Registration De-identified	Not Reported	MD-80 Series (DC-9-80) Undifferentiated or Other Model		, AB	433789		433789	INC	No Primary Occurrence 2	Normal Landing
499040	ASRS	Registration De-identified	Not Reported	MD-80 Series (DC-9-80) Undifferentiated or Other Model		, US	499040		499040	INC	Compressor Stall/FOD	Abnormal Landing
103567	ASRS	Registration De-identified	Not Reported	Medium Large Transport, Low Wing, 2 Turbojet Eng		Dallas-Fort Worth, TX	103567		103567	INC	Deicing Procedural Failure	Return to Gate
919700	ASRS	Registration De-identified	Not Reported	B737-700		, US	919700		919700	INC	No Primary Occurrence 2	Normal Landing
923515	ASRS	Registration De-identified	Not Reported	MD-83		, US	923515		923515	INC	Compressor Stall/FOD	Aborted Takeoff

Table B-1. List of events in the Ground Icing Dataset (continued)

Event ID	Source	N-Number	Make	Model	Date	Location	Master Report	Related FAA Report	Related ASRS Report	Event Type	Primary Occurrence	Outcome
927485	ASRS	Registration De-identified	Not Reported	B737-300		, US	927485		927485	INC	Deicing Procedural Failure	Return to Gate
925302	ASRS	Registration De-identified	Not Reported	MD-80 Series (DC-9-80) Undifferentiated or Other Model		, US	925302		925302	INC	Deicing Procedural Failure	Return to Gate
929478	ASRS	Registration De-identified	Not Reported	Regional Jet CL65, Undifferentiated or Other Model		Atlanta, GA	929478		929478	INC	Deicing Procedural Failure	Return to Gate
934686	ASRS	Registration De-identified	Not Reported	Commercial Fixed Wing		Portland, OR	934686		934686	INC	Deicing Procedural Failure	Return to Gate
931880	ASRS	Registration De-identified	Not Reported	B757-200			931880		931880	INC	No Primary Occurrence 2	Normal Takeoff

ACC = accident; INC = incident; L/D = lift/drag; ICTS = ice-contaminated tailplane stall; FOD = foreign object debris