Federal Aviation Administration

Safer Skies:
A Focused Safety Agenda

General Aviation

Weather Joint Safety Analysis Team

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Executive Summary

In order to lower the fatal accident rate in aviation, it is critical to address the causes of accidents involving General aviation (GA) aircraft, which comprise more than 90% of the aircraft in the United States. Weather is a major cause of fatal GA accidents and has the highest rate of fatalities, over 80%. The societal cost of the approximately 200 annual fatalities in GA weather accidents is over $500 million[1]. Virtually all fatal GA weather accidents result from attempts to conduct operations: under visual flight rules while in instrument conditions (the largest number of fatalities); in thunderstorm areas; in structural icing conditions; and in areas of turbulence.

The General Aviation (GA) Weather Joint Safety Analysis Team (JSAT) which prepared this Report, was composed of 20 FAA and GA Industry members. Team members were selected based on their organizational affiliation, their operational experience, and their technical expertise in specific areas such as: flight operations, air traffic control, human factors, aviation psychology, aircraft power plants, weather products, and avionics and ground systems, engineering, manufacturing, and maintenance.

The Team reviewed all 151 fatal GA weather accidents in 1995. Twenty-two accidents were selected for root cause analysis by the JSAT because they were representative of the total and had sufficient report data to perform a thorough root cause analysis. The Team identified 370 case-specific interventions (actions that address particular root causes), which were later condensed. Interventions that would not have a significant impact on fatal accident reduction were eliminated, and a final list of 20 interventions was produced. The interventions were grouped by root cause and then ranked according to their effectiveness and feasibility.

Although the primary responsibility for implementing most interventions rests with the FAA, the report also identifies several joint FAA/Industry tasks. Implementation of these interventions cuts across many FAA lines of business and multiple industry groups.

From the list of ranked interventions, the <u>Team created five prioritized recommendations for significantly reducing fatal GA weather accidents while maintaining or improving the capacity, utility, efficiency, and affordability of GA operations</u>. The following recommendations are listed in order of priority, with Recommendation 1 being the highest priority. The specific elements of the following interventions are set forth in Section VI below, and are integral parts of

[1] Impact of New Technologies in Pilot Decision Making, 1998, at 22, FAA and SAMA; five year average, 1990 – 1994, 209 weather-related fatalities per year, based on NASDAC data. Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs, Office of Aviation Policy and Plans, 1989 ($1.74M in 1987$, adjusted by CPI).

these recommendations. All recommendations are part of an integrated process, which includes better decision making, technology, and training. The recommendations are intended to result in a weather information system that makes it easier for pilots to understand potential weather hazards and make sound decisions to avoid them.

<u>Recommendation 1</u>: Provide better information to pilots on the location and severity of weather hazard areas, and better methods of using weather information to make safe decisions on how and when to make a flight.

The greatest proportion of fatal, GA weather accidents can be eliminated by implementing the functional group of interventions contained within this recommendation as a group.

- **Produce, and make operational, graphical weather information products that show how and when flights can be made safely.**

- **Improve the PIREP collection / dissemination system with a common database for controllers, pilots, FSS specialists and dispatchers**.

- **Improve certification to accelerate the equipage of GA aircraft with low-cost avionics for data-link display of weather graphics**.

- **Expedite implementation of the Flight Information Service (FIS) program to provide a national weather data-link system**.

- **Improve ATC weather information knowledge and dissemination, and develop procedures for handling aircraft that are not weather-tolerant (i.e., not equipped to avoid or cope with weather and are of relatively low performance to climb above or fly around it)**.

- **Develop a "model" Flight Operations Manual for assessing weather risks and avoiding or coping with weather hazards.**

- **Improve the FSS system, including DUATS, FSS equipment and weather briefings.**

Recommendation 1 supports strategic decision making in avoiding weather hazard areas by providing pilots with accurate and precise graphical weather products and improved methods of disseminating weather information. This recommendation also improves pre-flight briefings and en route advisories for pilots who use a phone, radio, personal computer, or a data link and moving-map display system. Improving PIREPs and weather information for controllers supports tactical decision-making. The "model" Flight Operations Manual further

enhances pilot decision making by providing recommendations and guidance for the use of weather information.

The data indicate that providing pilots with better information on the location and severity of weather hazard areas would have a greater impact on preventing accidents than would increased pilot training using existing weather data. Accordingly, interventions to improve flight training were grouped into the second priority recommendation.

Recommendation 2: **Improve weather training materials and programs to disseminate them.**

- **Improve training materials, with updated practical guidance on weather hazard risk assessment, avoidance, and recovery.**

- **Improve flight instructor and pilot continuing education programs on weather hazards and decision making.**

Recommendation 2 provides for better training of pilots to avoid and cope with weather hazards through improved training materials and enhanced continuing education programs to disseminate such materials.

Recommendation 3: **Develop mountain and low altitude airspace communications, navigation and surveillance (CNS) infrastructure, procedures, and information of hazardous weather.**

- **Develop enhanced operational procedures for mountain operations.**

- **Exploit new CNS systems in mountainous areas to improve pilots' ability to fly safely below freezing levels or cloud bases.**

- **Expedite implementation of precision GPS approaches and runway environment improvements into smaller airports and heliports.**

- **Require that obstructions be lighted during low-visibility conditions.**

- **Encourage pilots to make hazardous weather reports by providing immunity from enforcement.**

Recommendation 3 enhances the low-altitude NAS infrastructure typically used by small airplanes and rotorcraft. It improves awareness of hazardous weather in low-altitude airspace by encouraging pilots to make reports of instrument conditions and icing without fear of enforcement.

<u>Recommendation 4</u>: Improve technology for rotorcraft and small airplane weather operations.

- **Facilitate rotorcraft-IFR operations by developing low-cost, IFR avionics and reducing rotorcraft certification costs.**

- **Create improved terrain and obstruction data for use in electronic databases.**

- **Increase R&D for on-board systems, such as forward-looking icing and turbulence detectors, which help pilots identify and cope with weather hazards.**

Recommendation 4 provides safety improvements that are technology-based, some of which will have a larger impact on accidents after the 10 year period because there will be a longer lead time to implementation.

<u>Recommendation 5</u>: Remove regulatory impediments to weather safety, improve certification process, and implement services to encourage voluntary installation of aircraft systems to make small aircraft more weather-tolerant.

- **Define use of "VFR not recommended" and "known and forecast" icing in ways that are operationally useful to pilots**

- **Streamline approval processes to encourage installation of equipment that enables pilots to retain control in IMC and icing**

- **Implement systems to provide graphical display of traffic information for use when ATC frequency must be abandoned to gather weather information.**

Conclusion

- Producing more stringent rules related to weather will not increase safety.
- Total pilot training hours should be retained at the same level, but may be refocused to maximize the safety benefit.
- The proposed recommendations should be implemented immediately, without further accident studies.

This report must be considered in the context of at least 11 aviation weather-safety studies that preceded it. Although these other studies used different methods of analysis, their recommendations are similar to the recommendations contained in this report. The Team has taken the next step by prioritizing many

of the previous recommendations. The Team believes that the similarity between the recommendations in this report and those in previous reports further supports the Team's conclusion that implementing the above recommendations will be effective in substantially reducing fatal GA weather accidents.

I. Introduction

Problem Statement. In order to lower the fatal accident rate in aviation, it is critical to address the causes of accidents involving General aviation (GA) aircraft, which comprise more than 90% of the aircraft in the United States. Weather is a major cause of fatal GA accidents and has the highest rate of fatalities, over 80%. The societal cost of the approximately 200 annual fatalities in GA weather accidents is over $500 million[2].

II. Background

Safer Skies: A Focused Safety Agenda

This report was prepared by the GA Weather Joint Safety Analysis Team (JSAT) in support of the Federal Aviation Administration's Safer Skies Focused Safety Agenda. The goal of the Safer Skies initiative is to significantly reduce fatal accident rates in aviation. The achievement of this goal is based on the JSAT process, which is a data-driven approach to developing and prioritizing recommendations for action to reduce accident rates.

Weather JSAT

The GA Industry and the FAA formed a committee that identified the leading causes of fatal GA accidents. Six major categories, including weather, were identified as leading causes based on accident rate statistics. Weather accidents were identified as one of the leading causes of GA fatalities and an obvious area for improvement. Between one-quarter and one-third of fatal GA accidents are weather related.[3] This report is the result of an intense, six-month effort to analyze the root causes of fatal GA weather accidents and to recommend interventions to reduce the fatal weather accident rate.

The GA Coalition (GAC) and FAA Joint Steering Committee (JSC) chartered the Weather JSAT to analyze the root causes of fatal, GA weather accidents and recommend interventions that could be accomplished in a cooperative fashion by the FAA and GA Community. The Weather JSAT Charter is in Appendix A. The JSC appointed one industry representative and one FAA representative as co-chairs of the JSAT. The JSC and JSAT co-chairs then selected 20 team members that together represented a cross-section of FAA and GA Community. Two consulting members and one FAA Liaison member were also included.

Team members were selected based on their organizational affiliation, their operational experience, and their technical expertise in specific areas such as: flight operations, air traffic control, human factors, aviation psychology, aircraft

[2] Id.
[3] Safety Review, General Aviation Weather Accidents, AOPA ASF, 1996.

power plants, weather products, and avionics and ground systems, engineering, manufacturing, and maintenance. Almost all team members were pilots with varying levels of operational experience. A list of team members and their organizational affiliation can be found in Appendix B.

General Aviation Operations

Weather affects every flight, but not all weather conditions are equally hazardous to all flights. Air-carrier aircraft are generally able to avoid or tolerate most weather hazards because of on-board equipment and performance capabilities to climb above or circumvent them. Many GA aircraft are operated at low altitudes in localized weather situations, and in areas without weather reporting or other infrastructure designed to mitigate the effects of weather (e.g., precision instrument approaches and lighting systems). Most GA pilots do not have the support of a dispatcher or a co-pilot, and their aircraft are often not weather-tolerant because they lack performance (e.g., altitude and range) and equipment (e.g., storm detection and ice protection).

The current FAA system for producing and disseminating weather information does not adequately inform GA pilots of when and how a flight can be made safely.[4] Pre-flight information does not sufficiently direct the pilot's attention to the most relevant data on weather hazards, and it is sometimes not interpreted properly by the Flight Service Station Specialist or the pilot.

As the flight progresses, pre-flight information diminishes in value because of the time delay between the observation or forecast and the pilot's actual encounter with the weather.[5] Useful in-flight weather information is further reduced by the dissemination system, which forces pilots to leave the ATC frequency to gather critical weather information. In current operations, this results in GA pilots attempting to avoid weather hazards by relying on out-the-window information, limited information from ATC, some automated weather broadcasts, and en route briefings from FSS, when able.

III. Goal and Objective

Goal: Significantly reduce the rate of fatal GA weather accidents over the next 10 years.

Objective: Produce a set of intervention strategies that achieves the goal, while maintaining or improving the capacity, utility, efficiency, and affordability of GA operations.

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[4] The Weather JSAT did not review the quality of information from private weather services.
[5] Impact of New Technologies on Pilot Decision Making and reduction of Fatal Weather-Related Accidents, December 1998. P. 10

IV. Scope

The Team selected for review the 1995 reports of fatal, GA weather accidents, as categorized by the National Transportation Safety Board (NTSB). This was the most recent year for which all accident reports were available. The FAA's Safety Office determined that one full year of accident reports would be a representative sample of all fatal, GA weather accidents. General Aviation was defined as flight operations conducted under Parts 91, 125, 133, 135, and 137. In 1995, there were no Part 125 or 133 fatal weather accidents, and only one under Part 137. The Weather JSAT reviewed all 151 reports, analyzed a sample of 35 accident reports of airplanes and rotorcraft operating under Parts 91 and 135, and made recommendations based on a detailed analysis of 22 accidents.

Routine IMC– low ceilings or fog, obscurations to visibility, rain, and snow -- were a cause or factor in an overwhelming majority of fatal weather accidents, not only for Part 91 operators, but also for Part 135 operators and even Part 121 operators.[6] Thunderstorms, icing and turbulence cause a comparatively smaller number of fatal GA weather accidents and account for the remaining fatalities. Inadequate weather information received by the pilot, insufficient decision-making skills to use this information once received, and aircraft that are not weather-tolerant all contribute to fatal, GA weather accidents.

V. Method

The GA Weather JSAT Charter contained the following tasks:

- Review a representative sample of publicly available accident studies.
- Analyze an appropriate number of individual accidents to validate the completed studies.
- Develop a list of "causal factors" or problem statements.
- Recommend intervention strategies based on their analysis.

Selected accidents were analyzed using a "Root Cause Analysis" (RCA) process developed by Apollo Associated Services. The RCA method was used to identify the specific causes of the fatal, GA weather accidents analyzed by the Team, and develop interventions that may have prevented these accidents.

Selection of Accident Reports

To select the best cases for RCA, the Weather JSAT separated into nine smaller groups with at least one experienced pilot in each group. Each group completed

[6] Air Crew Weather Data Requirements Analysis, January 2, 1996

an initial analysis of 18 cases. This method allowed all 151 fatal GA weather accident reports to be reviewed before specific reports were selected for analysis and consideration by the entire Weather JSAT. Using the criteria below, a sample of 12 fatal, GA weather accidents were selected for RCA by the entire Team. These accident reports were selected because they:

- Fit the definition of a "weather accident" adopted by the GA Weather JSAT:

- Inadequate pilot performance, in that the pilot failed to change the operative flight plan (the route and altitude the pilot plans to fly from the aircraft's present position to its destination) in order to maintain safe separation from a Weather Hazard Area because of insufficient information on the location and severity of Weather Hazard Areas; or, insufficient knowledge, skill and judgment to properly interpret available information

- Inadequate aircraft performance or equipment to avoid or tolerate the weather hazard without catastrophic results.

- Contained sufficient data for analysis and formulation of reasonable conclusions about the root causes of the accident; and

- Represented the major categories of fatal, GA weather accidents (i.e., IMC, thunderstorms, icing, and turbulence), and contained systemic operational failures that caused the accident.

Utilizing these criteria, ten additional cases were analyzed by smaller groups of the Weather JSAT to address specific areas that the entire Team did not have enough time to address during joint meetings. Hence, the interventions recommended in this report are based on a sample of 22 fatal accidents. Each of these accidents was assigned to one of five categories: VFR-into-Instrument Meteorological Conditions (IMC), Thunderstorms, Icing, Turbulence, and Rotorcraft. Accident reports representing conditions unique to mountain, coastal and flatland areas were included within each category. The Team found reasonable agreement between the distribution of the types and frequency of accidents in the sample used for analysis and the distribution of accident types determined in a multi-year study recently completed by AOPA ASF.[7] (See Appendix M for statistics on GA fatal accident types)

As an additional check, a small group of Team members reviewed Aviation Safety Reporting System (ASRS) occurrences and summary reports of non-fatal general aviation weather encounters. This group's findings further supported the JSAT's selection of accidents as typical. The ASRS data offered valuable

[7] AOPA Air Safety Foundation, 1996 Safety Review of General Aviation Weather Accidents.

insight into the causes of weather encounters in circumstances similar to some of the fatal accidents that were analyzed using RCA.

Analysis of Accident Reports

A systematic approach was used to compile data from the full NTSB accident reports. A Summary Sheet was completed to capture the significant aspects of the accident (e.g., pilot characteristics, aircraft type and equipment, mission length, terrain, weather information known to the pilot, the actual weather situation). An Event Sequence Form was completed to document the chronological order of events (see Appendix G for a sample of each form). Charts and other resources were then used to reconstruct flight segments and weather information, including freezing levels and cloud bases and tops.

The Team used the RCA process to create cause-and-effect charts that identified root causes for particular accidents. (See Appendix H, sample root cause chart) This process goes beyond merely describing accidents in terms of "get-home-itus" or "pilot error", and determines the probable causes of each accident.

The analyses of the 22 accidents resulted in 370 interventions. These interventions were grouped according to root cause and successively reduced in number by combining interventions that were similar across weather-hazard types, grouping those that addressed particular systemic causes, and deleting those that were assigned a low-priority based on ratings of effectiveness and feasibility.

VI. Accident Root Causes and Interventions

The interventions were organized into seven root cause categories. (Note: the root cause categories are not necessarily listed in priority order):

- **Pilot**: Inadequate initial and continuing pilot education and formal operational procedures for making weather decisions, and in controlling the aircraft in weather.

- **Aircraft**: Inadequate weather avoidance and tolerance equipment and performance of most GA aircraft.

- **Information**: Inaccurate, imprecise and untimely information on the location and severity of weather hazard areas.

- **Air Traffic Control**: Inadequate weather information and procedures from controllers to assist small aircraft in avoiding or coping with weather.

- **Mountain Operations**: Lack of special procedures for mountain operations.

- **Regulations and Enforcement Practices**: That discourage reporting of PIREPs and requests for ATC handling to avoid or exit weather hazards.

- **Rotorcraft and Low Altitude Operations**: Inadequate procedures for safe IFR operations in low altitudes and small airports and heliports.

1. Pilot: Inadequate initial and continuing pilot education and formal operational procedures for making weather decisions

Root Cause 1. Some pilots lack sufficient skill and knowledge to obtain all pertinent weather information and make decisions on avoiding or exiting hazardous weather. In addition, some pilots lack sufficient understanding of the limitations of their aircraft relative to weather hazards, and of the adverse effects of such hazards on aircraft performance and control.

Intervention Strategy: GA pilot knowledge, skill, and judgment in weather decision making should be improved by updating initial training, improving the effectiveness of continued education, and providing a model flight operations manual primarily for use by non-salaried pilots. These materials would teach pilots how and when to safely make the flight.

1-1. Joint (FAA and GA Community Responsibility): **Improve training materials, with updated practical guidance on weather hazard risk assessment, avoidance, and recovery**.

a) Provide a practical application of meteorology on avoiding or exiting from hazardous weather areas:
   - Obtain and properly using all pertinent and emerging new sources of weather information to continuously assess weather risks and reevaluate the decision to continue on a planned route,
   - Have a practical understanding of weather dynamics, including the variability of weather hazards,
   - Plan alternate courses of action with in-flight decision points
   - Understand the limitations of various ATC weather resources concerning hazardous weather (e.g., the ability of ATC radar system to display thunderstorms),
   - Resist passenger and other social pressures to proceed into weather hazard areas, and
   - Request priority ATC handling to avoid or exit weather hazard areas.

b) Minimize the probability of an accident if weather hazards are encountered:
   - Understand the effects on aircraft performance and control during encounters with weather hazards (e.g., "turn radius" in mountainous operations, etc.),
   - Avoid and recovering from upset or loss of control if weather hazards are encountered,
   - Control an aircraft with ice accretion (e.g., proper airspeeds, appropriate use of flaps with tail-plane ice, proper use of auto pilot, control of asymmetric thrust, and the development and use of an abnormal procedure checklist), and
   - Avoid obstructions in low visibility.

c) Maximize training effectiveness:
   - Emphasize computer-based and simulator training, videos, and other interactive, multi-media techniques, and
   - Include simulations of common types of weather accidents with out-the-window depictions of IMC, icing, thunderstorms, and displays of NEXRAD, lightning detectors, and datalink weather hazard displays.

1-2. Joint: **Improve flight instructor and pilot continuing education programs on weather hazards and decision making**

a) Increase the distribution of FAA and GA Community weather-training materials:
   - Ask distinguished speakers and popular personalities to promote such materials,
   - Increase financial support for weather safety programs and video distribution, and
   - Include weather-training aids on an expanded and user-friendly FAA Web page, with links to Web sites containing industry weather training materials.

b) Continuously improve weather guidance material:
   - Update and revise Aeronautical Information Manual (AIM) sections and Advisory Circulars (AC)(e.g., the Flight Training Handbook, Aviation Weather Handbook, and Aviation Weather Services Handbook) to include applied weather decision-making sections, and
   - Develop a schedule to review and update FAA weather guidance material to ensure its timely release to pilots.

c) Provide the latest weather training material to flight instructors:
   - Provide Certified Flight Instructors (CFI) annually with Flight Review safety topics that are based on accident/incident history and ASRS reports and promote effective basic instrument flying skill for exiting from IMC,

- Develop new weather guidance materials for instructors and inform them during the Flight Instructor Refresher Course.
- Flight instructor groups emphasize and provide these materials to their membership.

1-3. Joint: **Develop a "model" Flight Operations Manual (FOM) for assessing weather risks and avoiding or coping with weather hazards.** The model manual would be similar to a Flight Operations Manuals used by corporate flight departments. It would contain decision models and other materials that help the pilot determine the "weather-risk index" of a flight, and identify the best practices for making weather decisions. The FOM should include:

a) A risk assessment method that considers typical GA pilot training, experience, currency or lack thereof, specific GA aircraft capability, terrain, weather, night operations, flight altitude, and the quality of pertinent weather information. The materials would incorporate principles from:
   - The FAA Aeronautical Decision Making (ADM) risk assessment model[8],
   - The "personal minimums" concept , and
   - The safety assessment method used in aircraft systems certification analyses.

b) The best practices for avoiding and dealing with weather hazards that may be encountered. These practices would provide procedures for making pre-flight and in-flight decisions regarding weather hazards, such as developing alternate and diversion plans appropriate to the type of aircraft and pilot for avoiding or immediately exiting from a weather hazard when conditions deteriorate.

c) The FOM should include a section for each of the following types of operations.
   - VFR pilots flying simple, fixed-gear, single-engine airplanes without ice protection or storm avoidance equipment,
   - IFR pilots flying complex, high-performance, single engine airplanes without ice protection, but with some storm protection,
   - IFR pilots flying single- or twin-engine airplanes with ice protection equipment and airborne weather radar, and
   - Various typical rotorcraft operations.

2. Aircraft: Inadequate weather avoidance and tolerance equipment, and insufficient performance of most GA aircraft

[8] FAA AC Number 60-22, December 13, 1991

Root Cause 2. Most GA aircraft lack equipment to adequately avoid, exit or tolerate inadvertent encounters with weather hazard areas (See Appendix D for definition of "weather hazard area").

Intervention Strategy: Encourage accelerated voluntary equipage of new low-cost avionics and aircraft equipment that enables pilots to avoid or tolerate inadvertent encounters with weather hazards (See Appendix D for definition of "weather hazard").

2-1. Joint: **Improve certification to accelerate the equipage of GA aircraft with low-cost avionics for data-link display of weather graphics** (e.g., data link and graphic displays of weather that overlay navigation or terrain data):

a) Implement the Flight Information Services (FIS) system, which would provide weather information, including free "basic" weather products, to create an incentive for operators to equip with these avionics by providing benefits for equipped aircraft, and to seek training on the best use of FIS,
b) Implement the recommendations from RTCA Task Force 4 to reduce avionics prices though reduced certification costs and delays, and
c) Provide other incentives for pilots to acquire and use these avionics.

2-2. FAA: **Develop streamlined approval process to encourage installation of equipment that enables pilots to retain control in IMC and icing.**

a) Implement a streamlined process for certifying and approving the installation of wing-leveler auto pilots,
b) Approve the proposed rule revision to allow the substitution by a non-tumbling, standby attitude indicator for a turn and bank indicator, and
c) Applying Advisory Circular AC 23.1309-1C. to reduce the cost of proved ice-protection systems for single-engine airplanes.

2-3. FAA/NASA: **Increase R&D for on-board systems, such as forward-looking icing and turbulence detectors, which help pilots identify and cope with weather hazards.**

a) Develop affordable on-board, forward-looking detection systems for IMC, thunderstorms, icing, and turbulence,
b) Develop affordable ice-protection systems and airframe ice-accretion sensors that are coupled to performance and control degradation warning systems [e.g., NASA Advanced General Aviation Transport Experiments (AGATE) Ice Protection Program),
c) Approve better, ice-accretion, qualification tool (computer codes) to minimize expensive icing flight tests,
d) Develop affordable horizontal situation indicators, gyroscopes, air-data computers, attitude-heading reference systems, and intuitive primary flight displays, and

e) Develop affordable synthetic vision to “see through” clouds.

3. <u>Information:</u> Inaccurate, imprecise and untimely information on the location and severity of weather hazard areas.

Root Cause 3. Observations and forecasts of weather hazard information are not timely, accurate, or precise enough. In addition, the FAA lacks an adequate system for disseminating weather hazard information.

Intervention Strategy: Improve and disseminate weather observations, forecasts, and weather graphics to provide timely, accurate, and precise information regarding the location of weather hazard areas for both pre-flight and in-flight planning. The information must change from telling the pilot why the flight cannot be made to accurately informing the pilot how and when it can be made safely, so the pilot can make an appropriate decision.

3-1. FAA/National Weather Service (NWS)**: Produce and make operational graphical weather information products that show how and when a flight can be made safely**

a) Provide real-time, automated graphical forecasts of all weather hazards, instrument meteorological conditions (IMC), icing, thunderstorms, and turbulence, in 1-6 hour time increments to show the location, time of onset, probability of occurrence, and severity of the weather hazard areas, including training for proper useof this information,
b) Include sufficient accuracy and precision so pilots perceive forecast information as valid (i.e., as a “real” weather hazard area to be avoided because the products increase the probability of detection decrease the false alarm rate),
c) Accelerate the transition of new weather products from experimental to operational status by approving and funding the NWS Aviation Weather Center’s path to operations (Test, Experimental, Guidance, Operational) program, which is based on utility and emphasizes user feedback to the product designers,
d) Accelerate FAA funding for the flight verification program to confirm the validity of new experimental weather products,
e) Fully fund the Aviation Weather Research program's R&D request, which is required for the development of these new weather products, especially the ceiling and visibility area forecast programs,
f) Provide FAA radio spectrum and funding for an automatic airborne weather data-collection program expanded to include GA aircraft. This would improve weather forecast modeling by including airborne equipment to collect more and better airborne electronic weather data from GA aircraft and regional airline aircraft operating at low altitudes, and

g) Issue generic operational approvals by FAA Flight Standards for use of new weather products.

3-2. FAA: **Improve the PIREP collection and dissemination system with a common database for controllers, pilots, FSS specialists and dispatchers**

a) Encourage more controller involvement in the PIREPs system, by creating simple methods for controllers to enter, retrieve, and disseminate PIREPs,
b) Develop a common PIREP database for use by controllers and FSS specialists,
c) Provide FSS specialists with Aircraft Situation Display (ASD) that indicates the location of the pilot receiving the in-flight briefing,
d) Enable service providers (ATC, including FSS specialists, and FIS service providers), to access PIREP information from airline dispatch centers,
e) Implement pilot and FSS procedural changes that increase the number and quality of PIREPs, and
f) Provide a dedicated frequency for PIREPs in each terminal area.

3-3 FAA: **Expedite implementation of the Flight Information Service (FIS) program to provide a national, weather data-link system.** The FIS system will enable pilots to receive weather information in flight without the need to leave the ATC frequency.

a) Provide FAA spectrum for data broadcasts by two competing service providers, and
b) Require deployment of the FIS system to be completed by June of 2000.

3-4. FAA: **Improve the FSS system, including DUATS, FSS equipment and weather briefings.**

a) Improve FSS specialist initial and recurrent training, and supervisor quality control methods, to ensure that specialists do the following:

- Advise pilots on the time that a weather hazard area will move into a planned flight route,
- Describe the location of weather hazard areas relative to the proposed route of flight and ground reference points that pilots can easily identify (e.g., VORs),
- Suggest alternative flight routes, altitudes, and times that are appropriate for pilot and aircraft capability, and weather and terrain characteristics,
- Provide only the information that is specific to a flight and interpretation of weather hazards, and
- Emphasize the importance of FSS Specialist training, enhanced by computer-based tutorials and reinforced by Air Traffic Bulletins.

b) Improve FSS equipment:

- Provide a link between the FSS weather display and the home computer displays of pilots to create an interactive briefing system that enables both the pilot and the FSS specialist to view the same weather graphics,
- Accelerate the implementation of advanced weather graphics for FSS specialists, and
- Enable FSS specialists to access information from airline dispatch centers and meteorology departments (e.g., new convective weather products now used for Collaborative Decision Making purposes).

c) Determine the adequacy of FSS services and eliminating current FSS system design flaws that prevent pilots from understanding the location and severity of weather hazard areas.

d) Improve DUATS:
- Include more graphics,
- Eliminate non-relevant information, and
- Developing and including a weather-risk assessment model.

4. Air Traffic Control: Inadequate weather information provided by controllers and insufficient procedures available to assist small aircraft in avoiding or coping with weather hazards.

Root Cause 4. ATC procedures and equipment do not provide for adequate collection or dissemination of information on weather hazard areas, or for the special handling needs of GA aircraft that are not weather-tolerant those that are not equipped to avoid or cope with weather and are of relatively low performance.

Note: Although controllers are not required to separate aircraft from weather, they have some weather-related responsibilities, such as informing pilots of pertinent weather information, such as radar echo intensity. The root cause analysis revealed that these responsibilities were not always fulfilled. For example, pilot reports weren't solicited when certain adverse weather conditions existed or were forecasted, radar navigation guidance and / or approval to deviate around weather was not approved when requested by the pilot, and information on reported or observed weather conditions was not issued. (See Order 7110.65 section 2-6). On the other hand, pilots are required to maintain contact with ATC while operating IFR or to obtain permission to enter certain types of airspace when VFR. Although this type of communication with ATC serves to reduce collision risk, at times the risk associated with collision is less than the risk associated with encountering a weather hazard.

Intervention Strategy: Enhance ATC equipment and services to provide adequate collection and dissemination of information on weather hazard areas. Develop improved procedures for the special handling of aircraft that are not

weather-tolerant. Implement systems that provide pilots with proximate traffic information displays and enable them to get more weather information.

4-1. FAA: **Improve ATC weather information knowledge and dissemination, and develop new procedures for handling aircraft that are not weather-tolerant**

a) Educate controllers on the need to provide special handling to small aircraft, by emphasizing in controller recurrent training:
   - The impact of weather hazards on small aircraft, including safe distances of aircraft from thunderstorms,
   - Weather hazard communication issues, such as informing pilots of expected time in icing conditions, and
   - That "user preferred trajectories" for small aircraft are often requested for safety, in addition to economic reasons.

b) Enable controllers to provide better information on weather hazard areas to pilots:
   - Provide controllers with better tools to enable them to see weather hazards,
   - Develop tools within the next 10 years that allow a wider range of controller responsibilities, including communication of weather hazards to pilots,
   - Provide additional controller training on understanding and disseminating the location of convective weather as shown on existing displays,
   - Enhance ATC weather displays such that weather hazards are easier for controllers to identify, understand, and disseminate, and
   - Improve the transfer of weather information among Center Weather Service Unit meteorologists, controllers, FSS Specialists and pilots.

c) Enable controllers to provide special handling of aircraft that are not weather-tolerant:
   - Implement the draft "Aviation Weather Policy, Aircraft Hazardous Weather Avoidance" and recognizing controller responsibilities to assist pilots in avoiding weather hazards,
   - Authorize special handling by controllers when a safety-related action is necessary, but is not yet an emergency (e.g., have pilots tell controllers they "REQUIRE lower due to ice"),
   - Minimize aircraft exposure to possible icing conditions by developing new terminal area climb and descent procedures for non-ice certificated aircraft,
   - Create standard methods of quickly accepting "pop-up" IFR flight plans, by increasing the versatility of the ATC system, while not encouraging a lack of pre-flight planning,

- Create a procedure for re-entering the IFR system after encountering IMC on a visual transition to land at one airport following an IFR approach to another, and
- Allow pilots to leave the ATC frequency for sufficient time to gather weather information.

4-2 FAA: **Implement systems to provide graphical traffic information for use while away from ATC frequency to gather weather information**, or provide traffic awareness information without use of ATC resources to facilitate acquisition of weather information from FSS or dispatcher:

a) Expand the range of the Traffic Information Service (TIS) system to 100 nm in areas where there are coverage gaps,
b) Implement TIS-Broadcast as part of the FIS system if feasible, and
c) Determine the appropriate link to support ADS-B.

5. Mountain Operations: Lack of special procedures for mountain operations

Root Cause 5. NAS infrastructure (communications, navigation, surveillance, and weather observing systems) and procedures are inadequate for traversing mountainous areas at low altitudes.

Intervention Strategy: Improve NAS infrastructure and procedures to reduce weather risks specific to mountain regions.

5-1. Joint: **Enhance operational procedures for mountain operations**:

a) Improve the usability of charts in mountainous areas, including recommended pass routes coupled with ground markers,
b) Improve chart readability to highlight potential hazards, especially at night,
c) Create a pictorial display of recommended VFR and IFR procedures for traversing and "escaping" mountain passes safely,
d) List recommended weather information sources and safety criteria (e.g., wind, visibility, and ceiling), and
e) Place AWOS units or remote TV cameras in critical mountain passes.

5-2 FAA: **Exploit new communication, navigation, and surveillance systems in mountainous areas to improve ability of pilot to fly safely below the freezing level or cloud bases**:

a) Expand the area of effective, air-ground communications through the use of new private-sector communications systems (e.g., air cellular, LEO satellite) that can be linked to ATC, and
b) Provide lower minimum en route altitudes using routes defined by GPS or other new navigation systems consistent with their limitations.

6. Regulations and Enforcement Practices: That discourage reporting of PIREPs and timely requests for ATC handling to avoid or exit weather hazards.

Root Cause 6. Pilots are discouraged from reporting hazardous weather and making timely requests for special handling because of fear of enforcement. Some FAA weather information is not effective in helping pilots avoid weather because of the overuse of "VFR Not Recommended", and "occasional moderate icing" advisories.

Intervention Strategy: Redirect FAA regulatory policies to encourage pilots to report hazardous weather and seek appropriate handling without fear of reprisal, and maximize the usefulness of forecasts to pilots by not presenting the worse possible scenario.

6-1. FAA: **Encourage pilots to make hazardous weather reports (verbal or electronic) by providing immunity from enforcement**. Shift the emphasis from enforcement to safety.

6-2. FAA: **Define use of "VFR not recommended", and "known and forecast" icing, in ways that are operationally useful to pilots**. Definition of the term "severe" in icing forecasts should be the same for both flight operations and aircraft certification standards.

7. Rotorcraft and Low Altitude Operations: Inadequate procedures for safe IFR operations in low altitudes and small airport/heliport environments.

Root Cause 7. Rotorcraft operations have adverse weather difficulties beyond those affecting airplanes.

Intervention Strategy: Improve current rotorcraft procedures and related low-altitude infrastructure for hazardous weather operations.

7-1. FAA/NASA: **Facilitate rotorcraft IFR operations by developing low-cost avionics and reducing rotorcraft certification costs**:

a) Develop low-cost rotorcraft IFR instrumentation (e.g., gyros),
b) Perform R&D to produce technology that looks ahead to see wires and towers, and
c) Reduce the cost of IFR rotorcraft certification.

7-2. FAA: **Create improved terrain and obstruction data for electronic data bases**:

a) Enhance electronic databases with high-resolution terrain and obstacle data for GPS moving map displays to inform pilots of these hazards,
b) Include power lines and towers over 100 feet in existing databases for use in rotorcraft moving-map displays in heavily used rotorcraft areas,
c) Require pre-construction notification to the FAA of all towers 100 feet or more for inclusion in obstacle databases, and
d) Provide more detailed obstruction charting for rotorcraft operations in heavily used rotorcraft areas.

7-3. FAA: **Require that obstructions be lighted during low visibility conditions**:

a) Light tall towers when visibility is below 3 miles during the day, and
b) Install “power markers" (induction lights) on power lines in heavy rotorcraft use areas.

7-4. FAA: **Expedite implementation of precision GPS approaches into smaller airports and heliports**:

a) Accelerate publication of precision IFR GPS "standalone" approaches to eliminate situations where VFR transitions must be made between an airport with an approach and the actual destination in low visibility conditions,
b) Establish low-level departure procedures that allow departures in the direction of the route to avoid creating a fuel-critical situation later in the flight, and
c) Issue a rule establishing alternate airport minimums for rotorcraft.

VII. Priority Ranking: Effectiveness and Feasibility

A. Method of Evaluation and Ranking

Interventions were evaluated by requiring each Team member to assign an effectiveness, feasibility, and overall priority score for each intervention. Effectiveness and feasibility are defined in Appendix D. Team members used the following 1 to 4 scale to rate the **effectiveness** of interventions:

None (little or no potential for preventing the accident)	1
Low (some potential for preventing the accident)	2
Moderate (moderate potential for preventing the accident)	3
High (high potential for preventing the accident)	4

Similarly, Team members used the following 1 to 4 scale to rate the **feasibility** of interventions:

Impossible to achieve wide implementation	1
Very difficult to achieve wide implementation	2
Moderately difficult to achieve wide implementation	3
Easy to achieve wide implementation	4

Finally, Team members assigned an overall priority rank (viz., high, medium, low) to each intervention based on their understanding of its significance for reducing the rate of fatal GA weather accidents. Average effectiveness and feasibility scores were computed and then summed to create a total score for each intervention. Interventions were then ranked in descending order based on their total score.

In addition, the percentage of "high" overall priority rankings for each intervention was calculated by summing the number of high-priority rankings and dividing this sum by the total number of rankings voted for a given intervention. The overall priority ranking was not used to determine the priority level of interventions. The extremely high correlation (0.89) between the intervention

total scores (i.e., E+F) and priority rankings indicated that the rankings provided redundant information and were not needed to determine the priority level of interventions.

As a comparison, a method of separating the effectiveness and feasibility rankings into three categories each (high, medium, and low) was also used to determine the priority level of interventions. The results of this method were similar to those found by using the total score for each intervention. Therefore, the following tables were created using the total score for each intervention.

B. First-Priority Interventions

First-Priority Intervention Selection Criteria: **A 6.0 or greater total score (E+F).**

The Team believes that the six first priority interventions, plus the first of the second priority interventions, form an interdependent functional group. These interventions combine to greatly enhance the capability of GA pilots to avoid weather hazards by providing much better information on the location of weather hazard areas and better operational guidance for using this information.

The six first-priority interventions are listed in descending order of total score. See pages 11-26 for details of these interventions.

First-Priority Interventions	E	F	E+F
3-1 **Produce and make operational graphical weather information products that show how and when a flight can be made safely.**	3.9	2.8	**6.7**
3-2 **Improve the PIREP collection and dissemination system to include a common database for controllers, pilots, FSS specialists and dispatchers.**	3.4	3.3	**6.7**
2-1 **Improve certification to accelerate the equipage of GA aircraft with low-cost avionics for data-link display of graphical weather information.**	3.7	2.8	**6.5**
3-3 **Expedite implementation of the Flight Information Service (FIS) program to provide a national, weather data-link system.**	3.2	3.0	**6.2**
4-1 **Improve ATC weather information knowledge and dissemination, and develop new procedures for handling of aircraft that are not weather-tolerant.**	3.2	3.0	**6.2**
1-3 **Develop a "model" Flight Operations Manual for assessing weather risks and avoiding or coping with weather hazards.**	2.8	3.2	**6.0**

Together, these six interventions, plus the first intervention in the second priority group, were combined to form Recommendation 1: **Provide better information to pilots on the location and severity of weather hazard areas, and better methods of using weather information to make safe decisions on how and when to make a flight.**

Better strategic decision support for avoiding weather hazard areas is provided by accurate and precise graphical weather products and improved methods of disseminating them to pilots. The dissemination methods cover pre-flight briefings and en route advisories, and apply to pilots who use a phone or radio, as well as those with personal computers and data-link cockpit displays. Better tactical decision support is provided through improved PIREPs information and better weather information from controllers.

The first-priority interventions recognize that few aircraft are currently equipped with new technologies for data-link display of weather information. However, the number of aircraft equipped with such displays is expected to increase over the 10-year period of the Safer Skies Agenda. The first-priority grouping addresses the issue of mixed equipage during this period by improving both the analog-voice and digital-data components of weather information dissemination systems. Finally, the first-priority grouping calls for a "model" Flight Operations Manual that will aid pilots in making better, safer "go/no go" and deviation decisions.

Implementation of the first-priority interventions would provide pilots with better information on the location and severity of weather hazard areas. Consequently, the Team determined that interventions in this grouping will decrease the rate of fatal GA weather accidents more than interventions that focus on training pilots to make better decisions using the current quality of weather information. Hence, interventions to improve training were included in a second-priority functional group.

The data indicates that providing pilots with better information on the location and severity of weather hazard areas would have a greater impact on preventing accidents than would increased pilot training using existing weather data. Accordingly, interventions to improve flight training were grouped into the second priority recommendation.

C. Second-Priority Interventions

Second-Priority Intervention Selection Criteria: A **5.0 – 5.9 total score (E+F).**

Eight interventions met the criteria and were included in the second-priority group.

Second-Priority Interventions	E	F	E+F
3-4 **Improve the FSS system, including DUATS, FSS equipment and weather briefings.**	2.6	3.3	**5.9**
1-1 **Improve training materials, with updated practical guidance on weather hazard risk assessment, avoidance, and recovery.**	2.6	3.3	**5.9**
5-1 **Develop enhanced operational procedures for mountain operations.**	3.1	2.5	**5.6**
1-2 **Improve flight instructor and pilot continuing education programs on weather hazards and decision making.**	2.3	3.2	**5.5**
5-2 **Exploit new CNS systems in mountainous areas to improve ability of pilot to fly safely below freezing levels or cloud bases.**	3.2	2.3	**5.5**
7-4 **Expedite implementation of precision GPS approaches at smaller airports and heliports.**	2.5	3.0	**5.5**
7-3 **Require that obstructions be lighted during low-visibility conditions.**	3.2	2.2	**5.4**
6-1 **Encourage pilots to make hazardous weather reports by providing immunity from enforcement.**	2.8	2.6	**5.4**

One of these second-priority interventions was grouped with the first priority interventions in Recommendation 1.

Two of these second-priority interventions provide for improved initial training and continuing education programs, and were grouped into Recommendation 2: **Improve weather training materials and programs to disseminate them.**

The other five second-priority interventions call for improved procedures in mountain, low-altitude, small airport operations, and better lighting and marking of obstacles for safer low-altitude operations. Immunity from enforcement is provided to improve weather data input to weather forecast models. These interventions were grouped into Recommendation 3: **Develop mountain and low altitude airspace communications, navigation and surveillance (CNS) infrastructure, procedures, and information of hazardous weather.**

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D. Third-Priority Interventions

Third-Priority Intervention Selection Criteria: All other remaining interventions not meeting the above criteria.

Third-Priority Interventions	E	F	E+F
7-1 **Facilitate rotorcraft IFR operations by developing low-cost avionics and reducing rotorcraft certification costs.**	3.2	2.4	**5.6**
6-2 **Define use of "VFR not recommended" and "known and forecast icing" in ways that are operationally useful to pilots.**	2.5	2.8	**4.9**
2-2 **Streamline approval processes to encourage installation of equipment that enables pilots to retain control in IMC and icing.**	2.7	2.2	**4.9**
7-2 **Create improved terrain and obstruction data for use in electronic databases**.	2.5	2.4	**4.9**
2-3 **Increase R&D for on-board systems, such as forward-looking icing and turbulence detectors, which help pilots identify and cope with weather hazards.**	3.1	2.0	**4.8**
4-2 **Implement systems to provide graphical display of traffic information for use when ATC frequency must be abandoned to gather weather information.**	2.2	2.0	**4.2**

Although, they are important for reducing the rate of fatal, GA weather accidents, the third-priority interventions are expected to have a lessor impact during the 10-year Safer Skies Agenda because they are still evolving and may not be feasible for several more years.

The interventions that would improve technology to enhance rotorcraft operations, improve terrain and obstruction data bases, and provide new on-board systems to help pilots cope with weather were grouped into Recommendations 4: **Improve technology for rotorcraft and small airplane weather operations**.

The remaining interventions were grouped into Recommendation 5: **Remove regulatory impediments to weather safety, improve certification process, and implement services to encourage voluntary installation of aircraft systems to make small aircraft more weather-tolerant.**

VIII. Conclusions

A. The FAA weather information and dissemination system must undergo fundamental changes to better support the flight planning needs of GA pilots.

Forecasts of weather hazards, relative to aircraft and pilot limitations, should provide information to enable the pilot to determine route and timing options for a safe and timely arrival at the intended destination. Pilots need intuitive information on the location, onset time, and severity of weather hazard areas to support pre-flight and in-flight decision- making. The overuse of statements such as "VFR not recommended" and the forecast of icing and thunderstorm conditions over very large areas for extended time periods, when inaccurate, degrade the safety benefits and the credibility of the weather briefing.

B. Intuitive graphical depictions of weather hazard areas made available directly to pilots are the most effective form of decision support for most weather hazards.

Excessive information, especially when irrelevant to a flight, impairs the pilot's understanding of how and when to make the flight safely. For example, the irrelevant information contained in a DUATS briefing can obscure the relevant information, create uncertainty for the pilot, and interfere with pilot decision making.

C. Many of the JSAT Recommendations have been included in previous studies.

Many of the recommendations made in this report were made previously in at least 11 other studies by credible groups who analyzed weather-related accidents. These groups include the National Research Council, the Aviation Weather Users Group, the AOPA ASF, and FAA or its contractors. There are no quick or inexpensive solutions to the weather-accident problem and progress towards effective solutions based on these recommendations has been slow, if at all. Of the 20 interventions recommended by the Weather JSAT:

- Nine were made previously in eight or more studies, and.
- Another three were made previously by four or more studies.

See Appendix I for a cross-reference of our interventions recommended in this report to the recommendations made in the previous 11 studies.

The proposed recommendations should be implemented immediately, without further accident studies. The limited resources of both and FAA and the GA Community should be focused on implementing these recommendations. .

D. Interventions must be implemented as high priority in order to achieve the goals of the Safer Skies Safety Agenda.

A high priority program must be established for the FAA to realize a measurable reduction in the fatal weather accident rate. Such a program is one that, contains milestones, near-term schedule dates, and provides adequate resources to achieve the milestones by the scheduled dates. The Joint Safety Implementation Team (JSIT), or any other implementation groups, must have a significant representation of users and other persons with direct operational knowledge. To retain the momentum of the JSAT, the implementation process should be expedited to result in implementation plans for these recommendations that are approved by the Administrator within 6 months of completion of this Report.

E. ASRS information should be used in developing and assessing the effectiveness of the interventions.

ASRS information can provide real-time feedback on system effectiveness and an indication of emerging risk areas before accidents occur. The use of “call backs” to ASRS reporters (by NASA to protect the reporter’s confidentiality) may be a powerful tool to get information about a specific occurrence and system operation.

F. Significant reduction in fatal accidents requires an implementation process with accountability elements

The Team believes that the following are crucial to the success of the program.

- Joint, FAA Lead: **Establish a process to follow up on the interventions recommended by the JSAT**, including tracking the office assigned each task, the milestones and schedule, and the actual progress made against that schedule**.**

- FAA: **Incorporate into the implementation of the interventions a mechanism for measuring their effectiveness** in accident reduction.

- GA Community: **Review the FAA’s intervention follow-up data** listed above.

G. Producing more stringent rules related to weather will not increase safety.

The regulations applicable to weather accidents are summarized in Appendix L. It shows that regulations for weather accidents are already in place. The FAA's focus should shift from regulatory enforcement to implementation of new safety technologies and procedures. Very few GA pilots intentionally violate the rules concerning weather.

H. Currently required pilot training hours are adequate.

Total pilot training hours should be retained at the same level, but may be refocused to maximize the safety benefit. Training to use new weather information and technologies is appropriate, but must be counterbalanced by reductions in other training. The Team believes the FAA should redirect the training time rather than increase it.

I. The RCA process revealed that descriptors (e.g., "get-home-itus", "press-on-itus", and "get-there-itus", "pilot error") are not sufficient to determine the underlying causes of the weather accidents.

Use of these terms indicates a failure to understand the real causes of these accidents, and does not lead to effective solutions.
See Appendix E for additional discussion of the circumstances surrounding decisions made to continue flights when weather hazards may, or may not, be encountered.

J. JSAT lessons learned.

See Appendix J for Lessons Learned on the JSAT and RCA processes.

K. Accident report data deficiencies.

Deficiencies in GA accident reports are described in Appendix K.

Appendix A

Joint Safety Analysis Team (JSAT) Charter for General Aviation Weather

Purpose: Complete an in-depth review and analysis of pertinent data focusing on general aviation weather accidents and make implementable recommendations to reduce these accidents.

Background: Industry (GAAPC), NASA, and FAA have agreed to team up to identify and implement a data driven, cost/benefit focused, safety enhancement program designed to reduce fatal general aviation accidents. The FAA, NASA, and GAAPC have further agreed that cooperatively targeting a small number of critical and highly leveraged safety intervention strategies will maximize the safety benefit to the aviation community. To achieve this goal, the three organizations have chartered six working groups referred to as JSATs.

Structure: The Weather Team will be co-chaired by an Industry and FAA representative who will recruit qualified representatives from industry, NASA, and the FAA to serve as team members. The co-chairs will facilitate team meetings as necessary and will serve as the points-of-contact to the JSC. The team co-chairs will also maintain contact with the other JSAT co-chairs to take advantage of all the teams' collective experience.

Tasks:

- The team will review a representative population (sic) of publicly available accident studies related to weather factors.
- The team will analyze an appropriate number of individual weather related accidents to validate the completed studies.
- The team will develop a list of "causal factors" or problem statements.
- The team will recommend intervention strategies to reduce weather related fatal airplane accidents based on this analysis.

Product: The team will provide the Joint Steering Committee (JSC) final report by April 1, 1999, containing our recommended safety intervention strategies. The final report will include discussion on the process and assumptions used in the analysis. The team will also provide periodic status reports on work in progress as may be requested from the JSC.

Resources: The JSC members who approve this JSAT charter agree to provide the people, money, and organizational support to carry out this charter.

Appendix B

Statement of Team Consensus

The undersigned Members of the General Aviation Weather Joint Safety Analysis Team (GA Weather JSAT), as individuals and as representatives of their organizations, have reached consensus on interventions recommended in this Report.

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* Denotes a team member who participated on a consulting basis only.

Appendix C

Acronyms

AC	Advisory Circular
ADM	Aeronautical Decision Making
ADS-B	Automatic Dependent Surveillance-Broadcast
AGATE	Advanced General Aviation Transport Experiments
AIM	Aeronautical Information Manual
AOPA	Aircraft Owners and Pilots Association
ASD	Aircraft Situation Display
ASF	AOPA Air Safety Foundation
ASRS	Aviation Safety Reporting System
AT	Air Traffic
ATC	Air Traffic Control
AWOS	Automated Weather Observation System
CFI	Certified Flight Instructor
CNS	Communications, Navigation, Surveillance
DUATS	Direct User Access Terminal Service
FAA	Federal Aviation Administration
FIS	Flight Information Service
FOM	Flight Operations Manual
FSS	Flight Service Station
GA	General Aviation

GAAPC	General Aviation Action Plan Coalition
GAC	General Aviation Coalition
GPS	Global Positioning System
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
JSC	Joint Steering Committee
JSAT	Joint Safety Analysis Team
JSIT	Joint Safety Implementation Team
LEO	Low Earth Orbiting (satellites)
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NEXRAD	Next-Generation Radar
NTSB	National Transportation Safety Board
NWS	National Weather Service
PIREP	Pilot Weather Report
R&D	Research and Development
RCA	Root Cause Analysis
TIS	Traffic Information Service
TV	Television
VFR	Visual Flight Rules
VOR	Very-high Omnidirectional Range Beacon

Appendix D

Definitions

Aviation Safety Reporting System (ASRS)	A formal hazard reporting system funded by FAA and administered by NASA offering anonymity and limited immunity for reporters who are usually pilots, mechanics, air traffic controllers or flight attendants.
Data	Codified observations, symbols that represent objects, events, and properties.
Data link	Digital telecommunications capability which supports communication between airborne and ground based-computers and their operators. This system may be used to transmit weather information, using text and/or graphics, from the ground to the aircraft.
Effectiveness	Prioritization of the intervention strategies based on the breath and depth of their relative potential for preventing accidents. Effective recommendations are those that address important root causes of fatal weather accidents. Effectiveness ratings were from least effective (1) to most effective (4).
Feasibility	The current potential for implementation of the intervention strategy(s) on system-wide basis within years. Feasible recommendations are those that have a reasonable chance of being implemented while maintaining or increasing the capacity and affordability of GA. Ratings were from least feasible (1) to most feasible (4).

GA Community	For the purpose of this report, to delineate responsibilities for tasks: All of the sector stakeholders in general aviation, including industry and non-industry participation, but excluding the FAA (eg. aircraft owners and operators, pilots, manufacturers, maintenance professionals, and service providers, etc.).
Implementation	The means for accomplishing the incorporation of a given intervention
Intervention	Suggested solutions, things to do to prevent or lessen the identified problem.
Intervention Strategy	A proposed activity or system-wide change intended to prevent, correct or mitigate an identified safety problem associated with a cause of a fatal accident.
Priority Program	A defined program with: Measurable objectives; Intermediate milestones and schedule dates; Sufficient resources to meet the objectives and schedules; Program Manager Authority to accomplish the tasks.
Root Cause	A specific systemic reason or factor that contributed to a fatal accident.
Weather Accident	As defined by the JSAT: An accident caused by: • The pilot's failure to change the operative flight plan (the route and altitude the pilot plans to fly from the aircraft's present position to its destination) in order to maintain safe separation from a Weather Hazard Area because of: insufficient information on the location and severity of Weather Hazard Areas; or insufficient knowledge, skill and judgment to properly interpret available information • Inadequate aircraft performance or equipment to avoid or tolerate the weather hazard without catastrophic results.

Weather Hazard	As defined by the JSAT: A weather phenomena that could have a catastrophic effect on the flight of a specific pilot, aircraft, and mission. This effect could be caused by a structural failure, insufficient aircraft performance to maintain terrain or obstacle clearance, inability of the pilot to navigate clear of terrain or obstacles, or the inability of the pilot to control the aircraft. Weather Hazards are determined in reference to the capabilities of the pilot and the aircraft. They include: 1. IMC 2. Thunderstorms 3. Icing 4. Turbulence
Weather Hazard Area	As defined by the JSAT: A portion of airspace specified horizontally, vertically, and temporally, that must be avoided to maintain safe separation from weather hazards within it. It is an area within which a pilot cannot reliably avoid weather hazards through normal deviations because of the relatively close spacing, severity level, or growth rate of the weather hazard contained in it.

Appendix E

Weather Accident Cause Observations

Observations of Co-Chairs

Probabilities of Events the Cause Accidents

Effective interventions are those that reduce the probabilities of events that, when they occur in combination, lead to fatal weather accidents. For example, in VFR into IMC accidents, the probability of an accident is the product of the following sub-element probabilities:

- The probability of an unintended encounter with IMC along the planned route that cannot be avoided through deviations based on visual acquisition by the pilot, including with assistance from FSS or ATC, and

- The probability that the pilot will be unable to control the aircraft in IMC for the duration of the encounter; or

- The probability the pilot will be unable to navigate clear of terrain or obstructions in IMC.

In thunderstorm accidents, the probability of an accident is the product of:

- The probability of encounter with thunderstorms along the planned route that cannot be avoided through deviations based on visual acquisition by the pilot, including with assistance from FSS or ATC.

- The probability gusts will exceed the structural strength of the aircraft; or

- The probability the pilot will lose control in an upset caused by the thunderstorms, and

- The probability that the pilot will not be able to regain control before striking the ground.

Effective interventions for these accidents are those that reduce any of these probabilities. Combinations of interventions can reduce all of these probabilities, and therefore have a major impact on the incidence of accident. This is why the Team has grouped interventions into recommendations.

There are relatively few situations, when typical small aircraft are used for transportation, where a VFR pilot has a 0% probability of encountering hazardous weather on the planned route. Likewise, there are relatively few

situations where the pilot has a 100% probability of encountering hazardous weather along a route. GA pilots need assistance in making accurate weather risk assessments or various route and departure time options in order to determine how and when a flight can be made safely.

The Critical Element of "Time" in Analyzing Weather Accidents and Interventions

The element of time is crucial to causing and preventing weather accidents. The purpose of most general aviation flights can be stated as traveling from a departure point A to a destination point B within a desired time of arrival window (the desired time or arrival plus whatever amount of delay is still considered to still be "on schedule"). This can be called Plan A. A weather accident occurs when the pilot does not change from Plan A to Plan B (or subsequent Plans) in order to maintain safe separation from a Weather Hazard Area. All weather decisions made during the flight -- the route, altitude, speed, intermediate stops, etc. – are the means to the end of getting to the planned destination within the desired time-of-arrival window.

Any flight (from any departure point to any destination point) can be made safety (with no chance of an encounter with a hazardous weather area) by waiting until there is no possibility of a weather hazard along the route. For certain flights, arriving two days later than intended is not "significant" (retired person on a long trip to see the country). For most flights, however, there is a rather narrow band of arrival times that constitute a successful flight, and delays beyond this period are "significant". Any hazard can be avoided by deciding not to depart, by departing earlier or later, or by changing the flight plan route in flight if the decision is made early enough to always maintain separation between the aircraft and the weather hazard area.

The pilot's ability to reassess the situation, essentially "resetting" the flight for the next segment and making a new decision on whether to continue and a new assessment of aircraft location, in a timely manner requires that the pilot receive updated weather information continuously along the flight.

Institutional Barriers to Analysis

Although currently undefined, the terms "get-home-itus", "get-there-itus", and "press-on-itus" appear to mean one of the following errors of judgment and may suggest that the pilot deserved their fate for making these errors.

1) The pilot made the flight after estimating an unreasonably high risk of encountering a weather hazard he would not be able to avoid, and without an exceptional circumstance to justify this risk (e.g., a likely loss of life if the flight is not made), or

2) The pilot made the flight after inaccurately under-estimating the risk based on the available weather information, because of excessive self-confidence or gross ignorance.

It is unlikely that the FAA or GA Community can address the first type of error, but fortunately the cases indicate that these cases are rare. Recommendations 1 and 2 address the second type of error.

All pilots, including GA pilots, want to make “successful” flights -- they want to arrive at their intended destination with all aboard unharmed and unfrightened. For this reason, they strive to avoid weather hazards. However, flights that are cancelled, return to the destination, divert to another destination, or are substantially late because attempts to avoid a possible weather hazard that does not in fact exist also are unsuccessful. These failures have often have substantial adverse consequences, such as:

- The loss of a major business opportunity because of missing a meeting.
- The loss of income because of missing a day of work.
- The loss of a family vacation because of missing a scheduled event.
- The cost of several last minute airline tickets home.
- The loss of the family’s support for the continued use of small aircraft.
- Missing a hotel or rental car reservation.
- Disappointing family or friends who had planned on the trip.

These are reasonable motivations for intelligent and rational people to complete their flights as planned. Unless counterbalanced by an accurate estimate of the significant risk of encountering a weather hazard on the planned route, they are good reasons for making or continuing a flight. Persons who do so, and in the vast majority of flights complete their flights safely because their estimate of risk turns out to be correct, should not be condemned because they make a mistake in judgment caused by inadequate weather information or methods for making flight plan decisions.

Beyond these typical motivations, there are sometimes extraordinary pressures to make a flight in the face of potential weather hazards. Emergency medical flights are an area where extreme pressure (to save the life of injured persons) was identified and was then addressed through clear operational procedures to enable the pilot to make decision to avoid weather hazards. Operators should avoid creating situations where extreme pressures to complete a flight are created, such as not paying commercial pilots for turning back to the departure airport because of deteriorating weather.

Appendix F

Listing of Accidents Analyzed

Location	Case Number	Aircraft Model	Part	Weather
Blyn, WA	SEA95FA037	C-172N	91	IMC
Coldfoot, AK	ANC95FA129	C-170	91	IMC
Fifield, WI	CHI95FA259	Cherokee	91	IMC
Buskin, AK	ANC95FA090	Cherokee 6	135	IMC
Mintonville, KY	MIA95FA070	C-172N	91	IMC
Mammoth, CA	LAX95FA210	C-P201N	91	IMC
Fishkill, NY	NYC96FA004	C-206A	91	IMC
Fond du Lac, WI	CHI96FA029	Warrior	91	IMC
Irvine, CA	LAX95FA339	Bell 206L	135	IMC
Los Angeles, CA	LAX95FA079	Bell 296	135	IMC
E. Cameron, GM	FTW95FA116	Bell 206	135	IMC
League City, TX	FTW96FA028	BO 105	135	IMC
Jackson, PA	NYC95FA050	Agusta 109	91	IMC
Chamblee, GA	ATL95FA046	Bonanza	91	IMC
Oceanside, CA	LAX95FA129	Cherokee	91	IMC
Cedar Key, Fl	MIA 95FA175	Mooney	91	Thunderstorm
Vero Beach, FL	MIA95FA087	Skymaster	91	Thunderstorm
Milford, UT	SEA95FA095	C-T210C	91	Icing
Memphis, TN	MIA96FA048	Saratoga	91	Icing
Chippawa, WI	NYC95FA056	Malibu	91	Icing
Thompson, UT	SEA95LA185	C-177 RG	91	Turbulence
Howard, CO	FTW95LA113	Saratoga	135	Turbulence

Appendix G

Examples of Case Report Summary and Event Sequence Data

Example of Case Report Summary

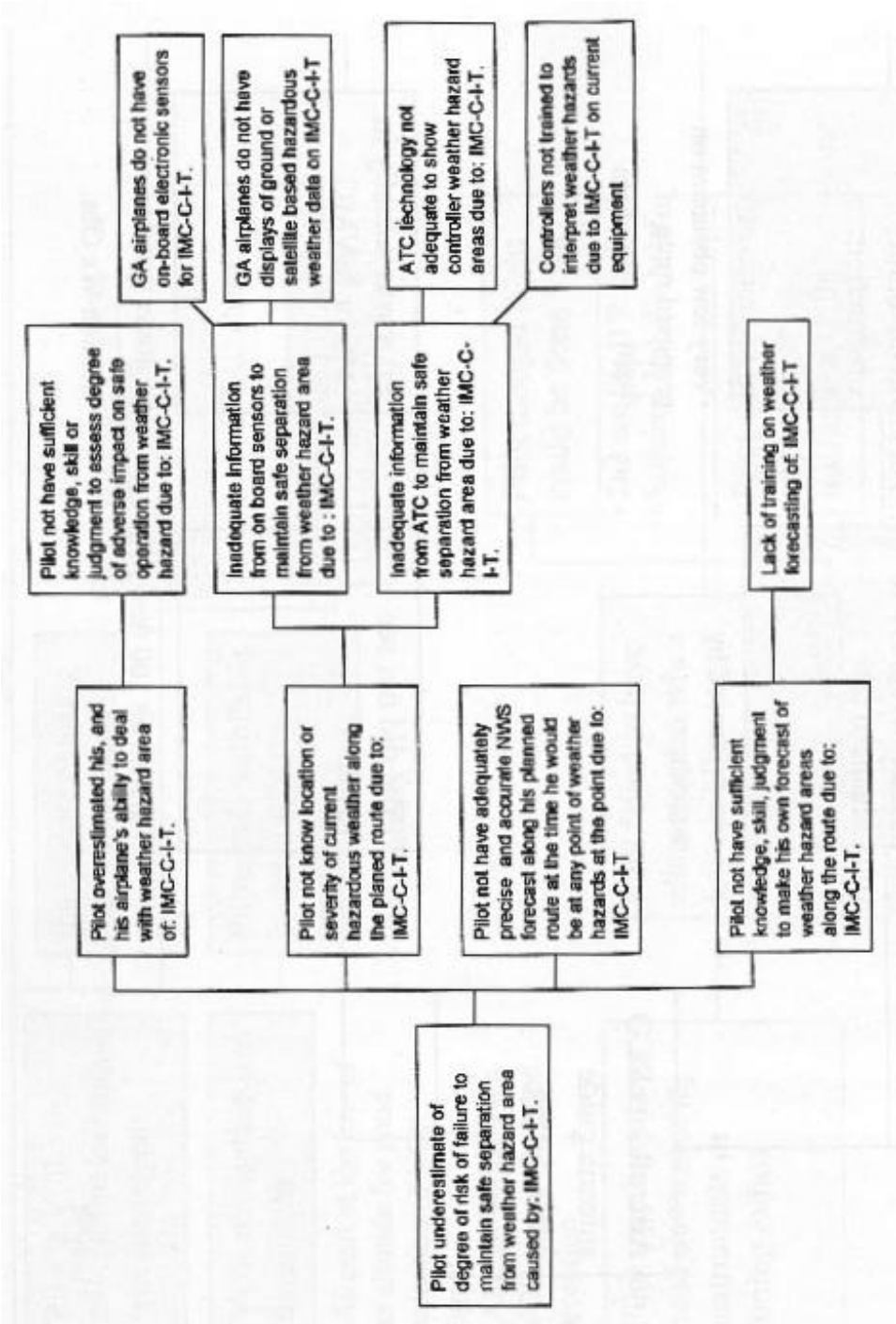
JSAT Accident Number		Aircraft Type	C-172
NTSB Accident No.	SEA95FA171	Location City, State	Quilcene, WA
Accident Date	8/5/95	Number on Board	2
N-Number	1464U	Injuries / Fatalities	0/2
Pilot Background Ratings: Total Time/Recent Time: Age & Years Flying: Other (Military,etc.)	**Pilot 1** Pvt, ASEL, IR 933, 295 in C-172, 117 actual IMC 53	**Pilot 2**	
Aircraft and Equipage C-172M Weather avoidance equipment: No Ice protection equipment: No Other (autopilot, etc.): Problem with Localizer earlier in day reported.			
Mission Type and purpose of flight: Personal, return trip to Olympia, where he left that morning. Month & Time of day & day/night conditions: August, afternoon, day. Planned distance and time duration: 100 nm, <1hr. From an island in the San Juans, past Seattle to the West, to Olympia (return flight from Olympia earlier that day). Altitudes MSL & AGL over flight: 3,500 MSL/AGL; then 1,500 MSL/AGL, then 3,400 MSL/0 AGL at time of impact in steeply rising terrain in narrow valley. VFR/IFR rules and Flight plan type (if any): VFR, trying to get IFR clearance. Terrain over route: water at SL, to mountains at 7,800 ft, impact at 3,400. Other factors (urgency, human factors from other activities):			
Weather Conditions and Information Actual weather situation: Witness in other aircraft of two plane formation: need to descend to 1,500 for cloud clearance. Weather information apparently known to pilot: Clouds nearly to the ground to the south in direction of flight.			
Accident Type and Location (Immediate pre-accident and accident site information). Weather accident, impacted mountainous terrain at 3,400 on side of 3,900 ft mountain. Apparently flying up road in valley.			
Fact Issues: Pilot aware if location of areas of hazardous weather relative to route of flight: Not preflight. Pilot aware of extent and severity of hazardous weather: Not preflight. Pilot had sufficient knowledge of how to properly interpret weather information: Yes. Pilot had equipment problems: Localizer, not relevant. Weather impaired aircraft performance or control: No. Weather upset aircraft: No. Pilot disorientation: Possibly. Pilot had experience in this weather/terrain situation: Yes. ATC assistance to pilot: No. Delay in getting IFR clearance contributing factor. Navigation type: Pilotage. Approach type: n/a Other: Alternator off, battery on, mag on left, key broken, throttle and mixture full. Both mags sparked and plugs appeared to be firing.			

Example of Event Sequence

Time	Event
1600 PDT	Flight of two aircraft departed Orcas Is, WA, bound for Olympia WA. No official weather brief, got PIREP from two pilots at airport. Poor weather not expected.
	Both climbed to 3,500 through San Juans, then forced to descend to 1,500 for cloud clearance. Encountered clouds, lead pilot said would go to SEA and get IFR, second pilot said he would drop down and break east, VMC. First pilot saw second turn to the east. First pilot did 360 waiting for clearance. Shortly after getting clearance (at 1,500), first pilot entered clouds in climb to 4,000. First pilot says cloud conditions to the south of Port Townsend were nearly to the ground.
1629:38	Pilot contacts Seattle Approach 3 nm north of Port Townsend, request IFR, 1,500.
1630:34	Pilot again contacts SEA, 2,000 ft.
1630:39	Told to remain clear Class B and stand by. 2,300 ft
1634:24	Controller contacts pilot, asks for a/c type and destination, 3,400 ft
1634:34	told to stand by for code, 3,300 ft
1634:49	Pilot makes garbled transmission, including “3,500”
1635:19	Controller asks for full call sign, no answer.
1635	Accident at Quilcene, impact with mountainous terrain

Appendix H

Sample Root Cause Analysis Chart



Appendix I

Cross Reference to Previous Studies

Intervention	1	2	3	4	5	6	7	8	9	10	11
1-1. Training Materials	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1-2. Continuing Education	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1-3. Flight Operations Manual	✓	✓		✓	✓	✓		✓	✓		✓
2-1. Data link and display Avionics Certification		✓	✓	✓	✓	✓	✓		✓	✓	✓
2-2.IMC and icing systems certification					✓						
2-3. R&D for new Technologies		✓	✓	✓	✓	✓	✓	✓	✓		
3-1. New Graphical Weather Products		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3-2. Improved PIREPs System	✓	✓		✓	✓	✓	✓		✓	✓	✓
3-3. Implement Weather Data Link System (FIS)			✓	✓	✓	✓	✓	✓	✓	✓	✓
3-4. Improve FSS System and DUATS		✓		✓	✓	✓		✓	✓	✓	✓
4-1. Improve ATC Weather Services		✓		✓		✓		✓	✓	✓	✓
4-2. Implement TIS											
5-1. Mountain operations				✓							
5-2. New CNS systems in mountains			✓	✓	✓	✓			✓		
6-1 Weather information enforcement immunity											
6-2 Definitions of VFR not recommended and icing					✓	✓				✓	✓
7-1 Facilitate Rootorcraft IFR operations											
7-2 Improved terrain data base											
7-3LlightedObstructtions											
7-4 GPS approaches						✓					

National Report Key

1- AOPA Air Safety Foundation, Safety Review General Aviation Weather Accidents (1996)
2- National Research Council's , Weather For Those Who Fly, March 1994
3- Impact of New Technologies on Pilot Decision Making and reduction of Fatal Weather-Related Accidents, December 1998
4- National Research Council's, Aviation Weather Services, A Call for Federal Leadership and Action
5- Air Crew Weather Data Requirements Analysis, January 2, 1996
6- Aviation Safety Plan, February 1996
7- Operations Concepts For Data-link Applications of Flight Information Services, March 14, 1996
8- National Aviation Weather Program, Strategic Plan, April 1997
9- US Department of Commerce, National Aviation Weather Program Plan (FCM-P27-1192), September 1992
10- National Aviation Weather User's Forum, 1993; FAA's External User Requirements Management Process and Plan 1995.
11- National Aviation Weather Program Council, Aviation Weather Initiatives, January 1999.

Appendix J

JSAT Lessons Learned

1. Most of the Team members needed more complete training to become proficient in performing the Root Cause Analysis (RCA). The best way to provide this proficiency is to have a person very familiar with the technique as applied to aircraft accident analyses participate with the JSAT and facilitate the discussion, at least at the initial team meetings.
2. It is essential that the full NTSB accident reports be used for any accident cause analysis. The computer report summaries are clearly inadequate for performing RCA.
3. The Team should have adequate administrative support to get the reports from the NTSB and copy and provide them to Team members. This must be accomplished at the first meeting to avoid wasting team member time and delaying the final report. The Team lost nearly two months because of a delay in acquiring and distributing the accident reports.
4. A “working” representative from major FAA offices must be included on JSATs, e.g., a current air traffic controller, pilots, etc.
5. Provide a presentation by the CFIT and Weather JSAT Teams to the co-chairs of the other JSATS on their process observations and recommendations before they begin their work.
6. It is important that the JSAT chairs aggressively pursue the goals of the JSAT to produce a report that will make a difference. The entire Team must be aware of the level of effort needed to accomplish a high-intensity short-term effort. Emphasize the importance of team building and consensus, and sharing the vision to meet the Safer Skies Agenda objectives. Stress the importance of meeting commitments and the team’s responsibility to get a report completed within the stated time schedule.
7. More time should be allowed to write the final report when large teams are involved (i.e., when there are over 15).
8. Team members must be experienced operationally
9. Team members must be able to commit at least 25% of their time to the JSAT effort.
10. The only way to complete a JSAT with a 25% effort in 6 months is to have strong support in the form of clerical assistance, on the job training, and an experienced facilitator. JSAT schedules must provide enough time to effectively complete the study given the level of administrative support and the percentage of time members can devote to the effort.
11. Provide a process to receive Joint Steering Committee feedback to the co-chairs on the Team’s progress. The Weather JSAT Team was fortunate to have several Joint Steering Committee members on our team to provide this feedback. This close link provided important coordination on the scope and direction the team was going.

12. All JSAT members must be allowed by their organization to give high priority to JSAT work.
13. Administrative support should be budgeted, even if it takes an outside contractor (similar to what is being done for the Commercial Aviation Safety Team).

Appendix K

Deficiencies in the Accident Data System

Information necessary to understand the root causes of accidents was often not collected by investigators. It is crucial to record in the accident report:

1) The weather information known to the pilot, including transcripts of all briefings, whether the pilot used DUATS or a private weather service, the weather channel, etc, discussions with other pilots, etc.
2) The weather information that was available to the pilot and may or may not have been known, i.e., all forecasts.
3) The actual weather situation the pilot would have encountered along the route of flight, based on all relevant observations for several hours leading up to the accident, PIREPs, witness statements, etc.

Additional information on the pilot would be very helpful, such as, currency and proficiency information, experience in the make and model aircraft and in the geographic area of the accident.

A second source of accident analysis problems is incomplete and inaccurate information provided by the NTSB to the National Aviation Safety Data Analysis Center. This affects the FAA's ability to make good management decisions based on the information in the NASDAC system. The problem is the transcription by the NTSB of the full NTSB accident report into the safety system computer database. The Team identified problems of data interpretation, summarization of narratives, and the simple transcription of data. Specifically, the Team found missing and internally inconsistent information, mistakes in summarizing the NTSB report caused by lack of operational understanding, narrative summaries that were not supported by the NTSB report.

We suggest the following interventions to improve accident data:

1. Increase the qualifications for and training of the NTSB persons who input the NTSB reports into the database, to improve their ability to interpret the cases and summarize them.
2. Perform quality control checking of accident reports and databases.
3. Provide better instructions to investigators on the types of information to gather for the record in weather cases so that all relevant data is recorded.

Appendix L

Regulations Relating to Weather

Part 61: Certification: Pilots, Flight Instructors, and Ground Instructors
§ 61.65 Instrument rating requirements.
(b) *Aeronautical knowledge.* A person who applies for an instrument rating must have received and logged ground training from an authorized instructor or accomplished a home-study course on the following aeronautical knowledge areas that apply to the instrument rating sought:
(6) Procurement and use of aviation weather reports and forecasts and the elements of forecasting weather trends based on that information and personal observation of weather conditions;
(8) Recognition of critical weather situations and wind shear avoidance;
(9) Aeronautical decision making and judgement;

Subpart C – Student Pilots
§ 61.93 Solo cross-country flight requirements.
(e) Maneuvers and procedures for cross-country flight training in a single-engine airplane.
(3) Procurement and analysis of aeronautical weather reports and forecasts, including recognition of critical weather situations and estimating visibility while in flight;
(12) Control and maneuvering solely by reference to flight instruments, including straight and level flight, turns, descents, climbs, use of radio aids, and ATC directives.

Subpart E – Private Pilots
§ 61.105 Aeronautical knowledge.
(a) ***General.*** A person who is applying for a private pilot certification must receive and log ground training from an authorized instructor or complete a home-study course on the aeronautical knowledge areas of paragraph (b) of this section that apply to the aircraft category and class rating sought.
(b) ***Aeronautical knowledge areas:***
(6) Recognition of critical weather situations from the ground and in flight, wind shear avoidance, and the procurement and use of aeronautical weather reports and forecasts;
(13) Preflight action that includes –
(ii) How to plan for alternatives if the planned flight cannot be completed or delays are encountered.

§ 61.107 Flight proficiency.
(1) For an airplane category rating with a single-engine class rating:
(ix) Basic instrument maneuvers;
(x) Emergency operations;

Subpart F – Commercial Pilots
§ 61.125 Aeronautical knowledge.
(a) General. A person who applies for a commercial pilot certificate must receive and log ground training from an authorized instructor, or complete a home-study course, on the aeronautical knowledge areas of paragraph (b) of this section that apply to the aircraft category and class rating sought.
(b) Aeronautical knowledge areas.
(4) Meteorology to include recognition of critical weather situations, wind shear recognition and avoidance, and the use of aeronautical weather reports and forecasts;

(11) Aeronautical decision making and judgment;
(14) Night and high-altitude operations;

Subpart G – Airline Transport Pilots
§ 61.155 Aeronautical knowledge.
(c) Aeronautical knowledge areas.
(2) Meteorology, including knowledge of and effects of fronts, frontal characteristics, cloud formations, icing, and upper-air data;
(3) General system of weather and NOTAM collection, dissemination, interpretation, and use;
(4) Interpretation and use of weather charts, maps, forecasts, sequence reports, abbreviations, and symbols;
(5) National Weather Service functions as they pertain to operation in the National Airspace System;

PART 91, SUBPART B – FLIGHT RULES GENERAL
91.103 Preflight Action.
Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight. This information must include –
(a) For a flight under IFR or a flight not in the vicinity of an airport, weather reports and forecasts, fuel requirements, alternative available if the planned flight cannot be completed, and any known traffic delays of which the pilot in command has been advised by ATC;

91.183 IFR Radio Communications
The pilot in command of each aircraft operated under IFR in controlled airspace shall have a continuous watch maintained on the appropriate frequency and shall report by radio as soon as possible –
(b) Any unforecast weather conditions encountered;

Aeronautical Information Manual
Chapter 7. Safety of Flight
Section 1. Meteorology
7-1-1 National Weather Service Aviation Products
7-1-2 FAA Weather Services
7-1-3 Preflight Briefing
7-1-4 Enroute Flight Advisory Service
7-1-5 Inflight Weather Advisories
7-1-6 Categorical Outlooks
7-1-7 Telephone Information Briefing Service (TIBS)
7-1-8 Transcribed Weather Broadcast (TWEB)
7-1-9 Inflight Weather Broadcasts
7-1-10 Weather Observing Programs
7-1-11 Weather Radar Services
7-1-12 ATC Inflight Weather Avoidance Assistance
7-1-13 Runway Visual Range (RVR)
7-1-14 Reporting of Cloud Heights
7-1-15 Reporting Prevailing Visibility
7-1-16 Estimating Intensity of Rain and Ice Pellets

7-1-17 Estimating Intensity of Snow or Drizzle (Based on Visibility)
7-1-18 Pilot Weather Reports (PIREPS)
7-1-19 PIREPs Relating to Airframe Icing
7-1-20 PIREPs Relating to Turbulence
7-1-21 Wind Shear PIREPs
7-1-22 Clear Air Turbulence (CAT) PIREPs
7-1-23 Microbursts
7-1-24 PIREPs Relating to Volcanic Ash Activity
7-1-25 Thunderstorms
7-1-26 Thunderstorm Flying
7-1-27 Key to Aviation Routine Weather Report (METAR) and Aerodrome Forecasts (TAF)
7-1-28 International Civil Aviation Organization (ICAO) Weather Formats

Section 5 – Potential Flight Hazards
7-5-5 Mountain Flying

PRACTICAL TEST STANDARDS
Private Pilot

I Preflight Preparation

B Weather Information

Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to weather information b analyzing weather reports and forecasts from various sources with emphasis on:
   a. PIREP's
   b. SIGMET's AND AIRMET's
   c. Wind shear reports
2. Makes a competent "go/no-go" decision based on available weather information.

D National Airspace System

Objective: To determine that the applicant exhibits knowledge of the elements related to the National Airspace System by explaining:

1. Basic VFR Weather Minimums for all classes of Airspace.

VII Navigation

C Diversion

Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to diversion.
2. Selects an appropriate alternate airport and route.
3. Diverts promptly to the alternate airport.
4. Makes an accurate estimate of heading, groundspeed, arrival time, and fuel consumption to the alternate airport.

IX Instrument Procedures

A Straight-and-level Flight

B Constant Airspeed Climbs

C Constant Airspeed Descents
D Turns to Headings
E Recovery from Unusual Flight Attitudes
F Radio Communications, Navigation Systems/Facilities, and Radar Services

Instrument Rating

I Preflight Preparation

A. Weather Information

Note: Where current weather reports, forecsts, or other pertinent information is not available, this information will be simulated by the examiner in a manner which will adequately measure the applicant's competence.

Objective: To determine that the applicant:

1. Exhibits adequate knowledge of the elements related to aviation weather information by obtaining, reading, and analyzing the applicable items, such as -
   a. weather reports and forecasts.
   b. Pilot and radar reports
   c. Surface analysis charts
   d. Radar summary charts
   e. Significant eather prognostics
   f. Winds and temperatures aloft
   g. Freezing level charts.
   h. Stability charts
   i. Severe weather outlook charts
   j. Tables and conversion graphs
   k. SIGMET's and AIRMET's
   l. ATIS reports
2. Correctly analyzes the assembled weather information pertaining to the proposed route of flight and destination airport, and determines whether an alternate airport is required, and, if required, whether the selected alternate airport meets the regulatory requirement.

II Instrument Approach Procedures

A Nonprecision Instrument Approach

10. Applies the necessary adjustments to the published MDA and visibility criteria for the aircraft approach category when required, such as-
    d. National Weather Service (NWS) reporting factors and criteria.

B Precision Instrument Approach

9. Applies the necessary adjustments to the published MDA and visibility criteria for the aircraft approach category when required, such as-
   d. National Weather Service (NWS) reporting factors and criteria.

Commercial Pilot

I Preflight Preparation

B Weather Information

Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to weather information by analyzing weather reports, charts, and forecasts from various sources with emphasis on-
   a. convective SIGMET's
   b. SIGMET's
   c. AIRMET's
   d. Wind shear reports
   e. PIREP's
2. Makes a competent "go/no-go" decision based on available weather information.

D National Airspace System

Objective: To determine that the applicant exhibits knowledge of the elements related to the National Airspace System by explaining:

1. VFR Weather Minimums for all classes of airspace.

VII Navigation

C Diversion

Objective: To determine that the applicant

1. Exhibits knowledge of the elements related to diversion.
2. Diverts promptly to the alternate airport.
3. Makes an accurate estimate of heading, groundspeed, arrival time, and fuel consumption to the alternate airport

Airline Transport Pilot

V Instrument Approach Procedures

C. Precision Instrument Approaches

10. Applies the necessary adjustments to the published Decision Height and visibility criteria for the airplane Approach category as required, such as-
    d. National Weather Service (NWS) reporting factors and criteria.

D Nonprecision Instrument Approaches

9. Applies the necessary adjustments to the published Minimum Descent Altitude (MDA) and visibility criteria for the airplane approach category when required, such as-
   e. National Weather Service (NWS) reporting factors and criteria.

SUBPART D — VFR/IFR OPERATING LIMITATIONS AND WEATHER REQUIREMENTS

135.201 APPLICABILITY

This subpart prescribes the operating limitations for VFR/IFR flight operations and associated weather requirements for operations under this part.

135.203 VFR: MINIMUM ALTITUDES

Except when necessary for takeoff and landing, no person may operate under VFR—

(a) An airplane—

(1) During the day, below 500 feet above the surface or less than 500 feet horizontally from any obstacle; or

(2) At night, at an altitude less than 1,000 feet above the highest obstacle within a horizontal distance of 5 miles from the course intended to be flown or, in designated mountainous terrain, less than 2,000 feet above the highest obstacle within a horizontal distance of 5 miles from the course intended to be flown; or

(b) A helicopter over a congested area at an altitude less than 300 feet above the surface.

135.205 VFR: VISIBILITY REQUIREMENTS

(a) No person may operate an airplane under VFR in uncontrolled airspace when the ceiling is less than 1,000 feet unless flight visibility is at least 2 miles.

(b) No person may operate a helicopter under VFR in Class G airspace at an altitude of 1,200 feet or less above the surface or within the lateral boundaries of the surface areas of Class B, Class C, Class D, or Class E airspace designated for an airport unless the visibility is at least—

(1) During the day—1/2 mile; or

(2) At night—1 mile.

135.207 VFR: HELICOPTER SURFACE REFERENCE REQUIREMENTS

No person may operate a helicopter under VFR unless that person has visual surface reference or, at night, visual surface light reference, sufficient to safely control the helicopter.

135.209 VFR: FUEL SUPPLY

(a) No person may begin a flight operation in an airplane under VFR unless, considering wind and forecast weather conditions, it has enough fuel to fly to the first point of intended landing and, assuming normal cruising fuel consumption—

(1) During the day, to fly after that for at least 30 minutes; or

(2) At night, to fly after that for at least 45 minutes.

(b) No person may begin a flight operation in a helicopter under VFR unless, considering wind and forecast weather conditions, it has enough fuel to fly to the first point of intended landing and, assuming normal cruising fuel consumption, to fly after that for at least 20 minutes.

135.211 VFR: OVER-THE-TOP CARRYING PASSENGERS; OPERATING LIMITATIONS

Subject to any additional limitations in §135.181, no person may operate an aircraft under VFR over-the-top carrying passengers, unless—

(a) Weather reports or forecasts, or any combination of them, indicate that the weather at the intended point of termination of over-the-top flight—

(1) Allows descent to beneath the ceiling under VFR and is forecast to remain so until at least 1 hour after the estimated time of arrival at that point; or

(2) Allows an IFR approach and landing with flight clear of the clouds until reaching the prescribed initial approach altitude over the final approach facility, unless the approach is made with the use of radar under §91.175(i) of this chapter; or

(b) It is operated under conditions allowing—

(1) For multiengine aircraft, descent or continuation of the flight under VFR if its critical engine fails; or

(2) For single-engine aircraft, descent under VFR if its engine fails.

135.213 WEATHER REPORTS AND FORECASTS

(a) Whenever a person operating an aircraft under this part is required to use a weather report or forecast, that person shall use that of the U.S. National Weather Service, a source approved by the U.S. National Weather Service, or a source approved by the Administrator. However, for operations under VFR, the pilot in command may, if such a report is not available, use weather information based on that pilot's own observations or on those of other persons competent to supply appropriate observations.

(b) For the purposes of paragraph (a) of this section, weather observations made and furnished to pilots to conduct IFR operations at an airport must be taken at the airport where those IFR operations are conducted, unless the Administrator issues operations specifications allowing the use of weather observations taken

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135.225 IFR: TAKEOFF, APPROACH AND LANDING MINIMUMS

(a) No pilot may begin an instrument approach procedure to an airport unless—

(1) That airport has a weather reporting facility operated by the U.S. National Weather Service, a source approved by U.S. National Weather Service, or a source approved by the Administrator; and

(2) The latest weather report issued by that weather reporting facility indicates that weather conditions are at or above the authorized IFR landing minimums for that airport.

(b) No pilot may begin the final approach segment of an instrument approach procedure to an airport unless the latest weather reported by the facility described in paragraph (a)(1) of this section indicates that weather conditions are at or above the authorized IFR landing minimums for that procedure.

(c) If a pilot has begun the final approach segment of an instrument approach to an airport under paragraph (b) of this section and a later weather report indicating below minimum conditions is received after the aircraft is—

(1) On an ILS final approach and has passed the final approach fix; or

(2) On an ASR or PAR final approach and has been turned over to the final approach controller; or

(3) On a final approach using a VOR, NDB, or comparable approach procedure; and the aircraft—

(i) Has passed the appropriate facility or final approach fix; or

(ii) Where a final approach fix is not specified, has completed the procedure turn and is established inbound toward the airport on the final approach course within the distance prescribed in the procedure;

the approach may be continued and a landing made if the pilot finds, upon reaching the authorized MDA or DH, that actual weather conditions are at least equal to the minimums prescribed for the procedure.

(d) The MDA or DH and visibility landing minimums prescribed in Part 97 of this chapter or in the operator's operations specifications are increased by 100 feet and 1/2 mile respectively, but not to exceed the ceiling and visibility minimums for that airport when used as an alternate airport, for each pilot in command of a turbine-powered airplane who has not served at least 100 hours as pilot in command in that type of airplane.

(e) Each pilot making an IFR takeoff or approach and landing at a military or foreign airport shall comply with applicable instrument approach procedures and weather minimums prescribed by the authority having jurisdiction over that airport. In addition, no pilot may, at that airport—

(1) Take off under IFR when the visibility is less than 1 mile; or

(2) Make an instrument approach when the visibility is less than 1/2 mile.

(f) If takeoff minimums are specified in Part 97 of this chapter for the takeoff airport, no pilot may take off an aircraft under IFR when the weather conditions reported by the facility described in paragraph (a)(1) of this section are less than the takeoff minimums specified for the takeoff airport in Part 97 or in the certificate holder's operations specifications.

(g) Except as provided in paragraph (h) of this section, if takeoff minimums are not prescribed in Part 97 of this chapter for the takeoff airport, no pilot may take off an aircraft under IFR when the weather conditions reported by the facility described in paragraph (a)(1) of this section are less than that prescribed in Part 91 of this chapter or in the certificate holder's operations specifications.

(h) At airports where straight-in instrument approach procedures are authorized, a pilot may take off an aircraft under IFR when the weather conditions reported by the facility described in paragraph (a)(1) of this section are equal to or better than the lowest straight-in landing minimums, unless otherwise restricted, if—

(1) The wind direction and velocity at the time of takeoff are such that a straight-in instrument approach can be made to the runway served by the instrument approach;

(2) The associated ground facilities upon which the landing minimums are predicated and the related airborne equipment are in normal operation; and

(3) The certificate holder has been approved for such operations.

135.227 ICING CONDITIONS: OPERATING LIMITATIONS

(a) No pilot may take off an aircraft that has frost, ice, or snow adhering to any rotor blade, propeller, windshield, wing, stabilizing or control surface, to a powerplant installation, or to an airspeed, altimeter, rate of climb, or flight attitude instrument system, except under the following conditions:

(1) Takeoffs may be made with frost adhering to the wings, or stabilizing or control surfaces, if the frost has been polished to make it smooth.

(2) Takeoffs may be made with frost under the wing in the area of the fuel tanks if authorized by the Administrator.

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(b) No certificate holder may authorize an airplane to take off and no pilot may take off an airplane any time conditions are such that frost, ice, or snow may reasonably be expected to adhere to the airplane unless the pilot has completed all applicable training as required by §135.341 and unless one of the following requirements is met:

(1) A pretakeoff contamination check, that has been established by the certificate holder and approved by the Administrator for the specific airplane type, has been completed within 5 minutes prior to beginning takeoff. A pretakeoff contamination check is a check to make sure the wings and control surfaces are free of frost, ice, or snow.

(2) The certificate holder has an approved alternative procedure and under that procedure the airplane is determined to be free of frost, ice, or snow.

(3) The certificate holder has an approved deicing/anti-icing program that complies with §121.629(c) of this chapter and the takeoff complies with that program.

(c) Except for an airplane that has ice protection provisions that meet §34 of Appendix A, or those for transport category airplane type certification, no pilot may fly—

(1) Under IFR into known or forecast light or moderate icing conditions; or

(2) Under VFR into known light or moderate icing conditions; unless the aircraft has functioning deicing or anti-icing equipment protecting each rotor blade, propeller, windshield, wing, stabilizing or control surface, and each airspeed, altimeter, rate of climb or flight attitude instrument system.

(d) No pilot may fly a helicopter under IFR into known or forecast icing conditions or under VFR into known icing conditions unless it has been type certificated and appropriately equipped for operations in icing conditions.

(e) Except for an airplane that has ice protection provisions that meet §34 of Appendix A, or those for transport category airplane type certification, no pilot may fly an aircraft into known or forecast severe icing conditions.

(f) If current weather reports and briefing information relied upon by the pilot in command indicate that the forecast icing condition that would otherwise prohibit the flight will not be encountered during the flight because of changed weather conditions since the forecast, the restrictions in paragraphs (c), (d) and (e) of this section based on forecast conditions do not apply.

135.229 AIRPORT REQUIREMENTS

(a) No certificate holder may use any airport unless it is adequate for the proposed operation, considering such items as size, surface, obstructions, and lighting.

(b) No pilot of an aircraft carrying passengers at night may take off from, or land on, an airport unless—

(1) That pilot has determined the wind direction from an illuminated wind direction indicator or local ground communications or, in the case of takeoff, that pilot's personal observations; and

(2) The limits of the area to be used for landing or takeoff are clearly shown—

(i) For airplanes, by boundary or runway marker lights;

(ii) For helicopters, by boundary or runway marker lights or reflective material.

(c) For the purpose of paragraph (b) of this section, if the area to be used for takeoff or landing is marked by flare pots or lanterns, their use must be approved by the Administrator.

PAGE 135-45 AND 135-46 RESERVED FOR EXPANSION.

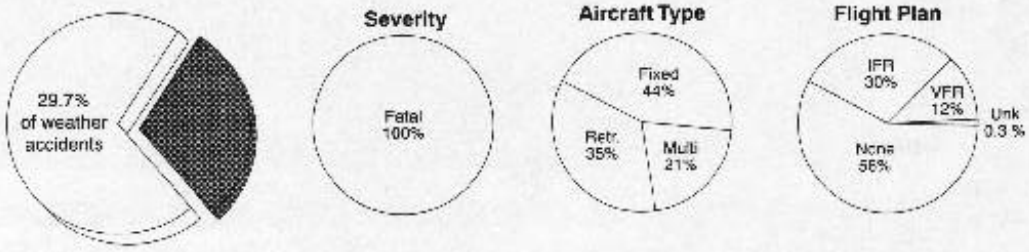
Appendix M

Statistics on GA Fatal Accident Types

Statistical Quick Look: Fatal Weather Accidents

1. Private pilots flying single-engine airplanes are most at risk.
2. 44 percent of the pilots—the largest segment—had over 1,000 total hours.
3. Most of the pilots received weather briefings and had current BFRs.
4. The cruise phase claimed the most accidents.
5. Attempting VFR flight under conditions of deteriorating weather and dark nights was named as the prime cause of fatal weather accidents. Other VFR-into-IMC situations were also prevalent.
6. 36 percent occurred at night.

Fatal Weather Accidents _____ 1,750 Total



Phase of Flight	
Preflight/Taxi	0.2%
Takeoff/Climb	19.5%
Cruise	41.2%
Descent	4.3%
Approach	18.0%
Landing	1.8%
Maneuver	12.2%
Other/Unknown	2.9%

# Acdts	Top Ten Factors
104	Attempted VFR flight in deteriorating weather/dark night
94	Initiated VFR flight into IMC, no instrument rating or experience
89	Continued VFR flight into IMC, no instrument rating or experience
76	Attempted VFR under overcast in mountainous/rising terrain
66	Descended below approach minimums during instrument approach
65	Improper IFR approach in IMC
65	Initiated VFR flight into known IMC conditions
60	Continued VFR flight into known IMC/deteriorating weather
55	Initiated IFR flight into reported adverse wx/turbulence/icing/T-storm
39	Exceeded design, airframe failure, VFR in IMC, limited instrument exp.

G. A. Weather Accidents

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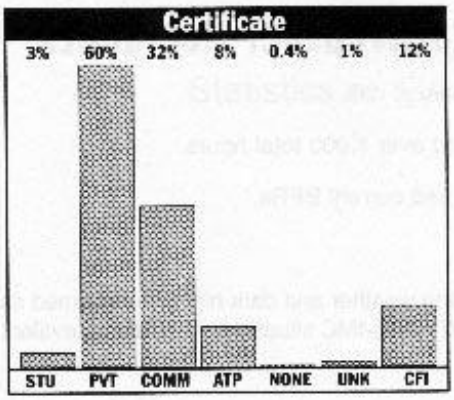
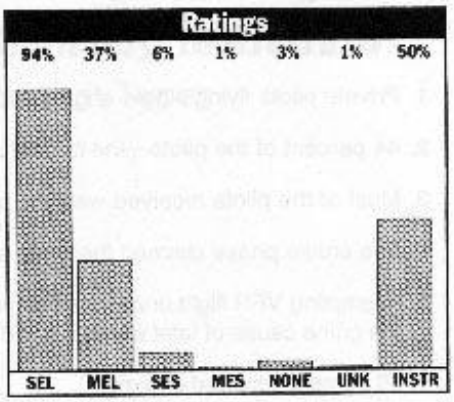
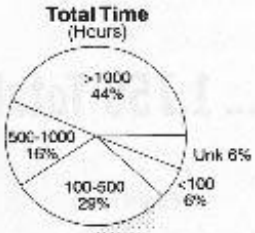
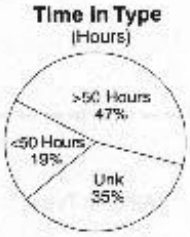
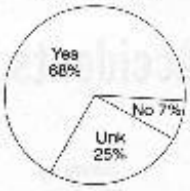




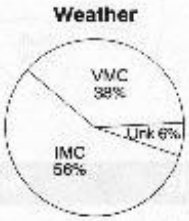


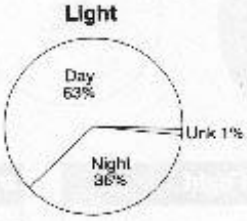


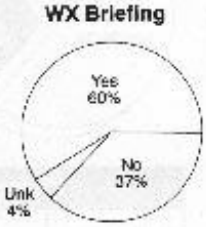


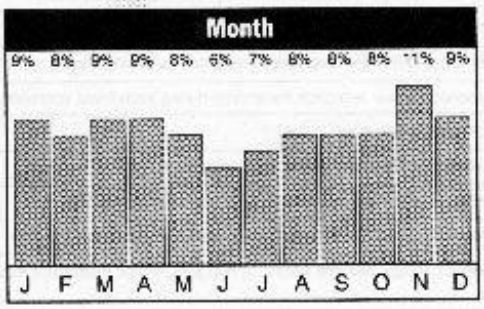
Flown in Last	Yes	No	Unk
24 Hours	40%	5%	54%
30 Days	41%	2%	57%
90 Days	57%	1%	42%

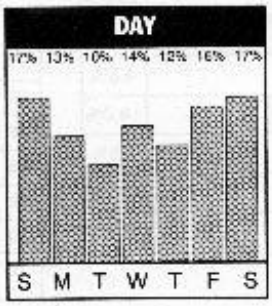
Statistical data presented on this page goes along with data on previous page.

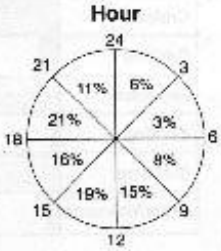












G. A. Weather Accidents

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