National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: October 12, 2005

In reply refer to: A-05-024 through A-05-029

Honorable Marion C. Blakey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

The National Transportation Safety Board has found that, over the last 20 years, about two-thirds of all general aviation (GA) accidents that occur in instrument meteorological conditions (IMC) are fatal—a rate much higher than the overall fatality rate for GA accidents. Accordingly, the Safety Board undertook the safety study, *Risk Factors Associated with Weather-Related General Aviation Accidents*, to better understand the risk factors associated with accidents that occur in weather conditions characterized by IMC or poor visibility ("weather-related accidents").

Previous Safety Board Studies of Weather-Related GA Accidents

The Safety Board published reports on weather- or visibility-related GA accidents in 1968,[1] 1974,[2] 1976,[3] and 1989.[4] The 1968 study considered in detail all GA accidents that occurred in 1966 and included an analysis of the weather- and pilot-related causes and factors cited in the Board's accident findings. The remaining studies each examined a large number of accidents sampled over several years based on common causal or contributing factors, including fatal weather-involved GA accidents (1974), nonfatal weather-involved GA accidents (1976), and accidents in which VFR-into-IMC was cited as a probable cause or contributing factor (1989).

Recommendations from the 1968, 1974, and 1976 studies were directed to the FAA, the Environmental Science Services Administration,[5] and the National Oceanic and Atmospheric

[1] National Transportation Safety Board, *An Analysis of U.S. General Aviation Accidents Involving Weather as a Cause/Related Factor 1966*, Notation 155 (Washington, DC: 1968).

[2] National Transportation Safety Board, *Special Study of Fatal, Weather-Involved General Aviation Accidents,* NTSB-AAS-74-2 (Washington, DC: 1974).

[3] National Transportation Safety Board, *Nonfatal, Weather-Involved General Aviation Accidents*, NTSB AAS-76-3 (Washington, DC: 1976).

[4] National Transportation Safety Board, *General Aviation Accidents Involving VFR Flight Into IMC,* NTSB/SR-89-01 (Washington, DC: 1989).

[5] The Environmental Science Services Administration was the predecessor agency to the National Oceanic and Atmospheric Administration.

Administration (NOAA). (The 1989 report did not generate any new recommendations.) Recommendations from the 1968 and 1974 studies focused on increasing pilots' knowledge and awareness of weather through training and through expansion of weather forecasting and reporting products tailored to pilots. Conversely, recommendations associated with the 1976 study emphasized hazards associated with winds during the landing phase of flight and did not pertain to conditions of reduced visibility.

Previous Safety Board Recommendations Pertaining to Weather

In addition to the recommendations associated with the safety studies described above, the Safety Board has issued 82 recommendations relating to GA flight in IMC or visibility-related weather conditions since 1968.[6] These recommendations have addressed a variety of topics, which may be grouped into three broad areas: the collection and dissemination of weather information, pilot training and operations, and air traffic control (ATC). Most of these recommendations were addressed to FAA, NOAA, or the National Weather Service (NWS),[7] which is part of NOAA.

Other Research on Flight in IMC

Weather-related accidents in general, and VFR-into-IMC accidents in particular, have generated considerable interest from other governmental agencies and the aviation research community. Studies have focused on pilots' evaluations and assessments of deteriorating visibility[8] or on their flight-related decisions in the presence of weather.[9] Additionally, some researchers have suggested that a lack of good weather information during flight contributes to the incidence of weather-related accidents.[10]

A substantial amount of existing research has used questionnaires or flight simulators in laboratory settings. Laboratory studies allow for scientific control but fail to replicate the complex demands placed on pilots conducting real-world flight operations. For example, flight simulator studies have provided a better understanding of the types of evaluation and decision-making errors that can lead to weather-related accidents. Far fewer studies have linked specific pilot, aircraft, or flight-related factors to the occurrence of actual weather-related accidents. Because of its role as the primary investigator of U.S. civil aviation accidents, the Safety Board is uniquely suited to gather information related to weather-related accidents and to identify the factors that distinguish them from successful flights.

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[6] Recommendations were selected for this group if they affected GA flight in weather conditions, even if they were issued in the context of an accident that did not involve GA operations.

[7] NWS responsibilities include providing weather forecasts in support of aviation and the mission of the FAA.

[8] D.A. Wiegmann, J. Goh, and D. O'Hare, *Pilots' Decisions to Continue Visual Flight Rules (VFR) Flight into Adverse Weather: Effects of Distance Traveled and Flight Experience,* FAA Technical Report, ARL-01-11/FAA-01-3 (2001).

[9] B. Burian, J. Orasanu, and J. Hitt, "Weather-Related Decision Errors: Differences Across Flight Types," *Proceedings of the 14th Triennial Congress of the International Ergonomics Association/44th Annual Meeting of the Human Factors and Ergonomics Society* (San Diego, CA: 2000), 1, 22-25.

[10] K. Latorella, S. Lane, and D. Garland, *General Aviation Pilots' Perceived Usage and Valuation of Aviation Weather Sources*, NASA Technical Memorandum 211443 (2002).

Study Methodology

This study employed the case control methodology, which compared a group of accident flights to a matching group of nonaccident flights to identify patterns of variables that distinguished the two groups from each other. Safety Board air safety investigators (ASI) collected data from 72 GA accidents that occurred in IMC or marginal visual conditions between August 2003 and April 2004.[11] When accidents occurred, study managers also contacted pilots of flights that were operating in the vicinity at the time of those accidents for information about their flight activity. A total of 135 nonaccident flights were included in the study. All nonaccident pilots voluntarily consented to interviews and provided information about their flight, their aircraft, and details about their training, experience, and demographics. This control group information was compared with data that regional ASIs collected about the accident flights as part of their normal investigations. Additionally, the Federal Aviation Administration (FAA) provided information about pilots' practical and written test results and their previous accident/incident involvement.

Statistical analyses were used to determine the relationships between study variables and accident/nonaccident status and to identify variables that could be linked to an increased risk of weather-related GA accident involvement. The analysis revealed several pilot- and flight-related factors associated with increased risk of accident involvement, and the recommended approaches to mitigating those risk factors are discussed in the context of three issue areas:

- Ensuring a minimum level of proficiency for all pilots to recognize and safely respond to hazardous weather situations.

- Identifying and providing additional support for pilots whose performance history indicates an increased risk of weather-related accidents.

- Providing GA pilots with additional guidance regarding sources of preflight weather information.

The Safety Board emphasizes that the conclusions reached in this study are not based on a summary of accident cases, although the merits of such Board studies have proven valuable in the past. Rather, the results are based on a statistical comparison of accident and nonaccident flights that allows for the generalization of findings from this study to the wider population of GA pilots and flights that may be at risk for a weather-related accident.

Age-Related Differences

The analysis in this study identified significant differences between accident pilots and nonaccident control group pilots with respect to age, but the groups were not found to be significantly different in experience as measured in years as a pilot or total flight hours. The combination of these results indicated that pilots in the nonaccident group started flying earlier in

[11] Also included were accidents that appeared to have involved spatial disorientation, loss of control, or collision with terrain or object due to a lack of visual references or encounter with weather.

life, on average, than accident pilots. This finding was supported by the analysis that showed a significant difference between the accident and control groups with respect to age at certification, and analysis that identified pilot age at private certificate as a significant predictor of accident risk. Based on the results of its analyses of age-related data, the Safety Board concludes that pilots who start flying earlier in life are at lower risk of being involved in a weather-related GA accident than those who start flying when they are older, and age at first certificate is a better predictor of future accident involvement than age at time of flight.

The changes in cognitive and physical functioning that occur with aging are well documented.[12] Conditions typically associated with age-related performance decrements, such as visual impairment or decreased mobility, are generally considered to begin about age 60, and an age-related increase in driving risk has been identified after age 75.[13] However, this study identified a significantly lower risk for pilots who began flying at age 25 or younger. Therefore, the Safety Board concludes that the observed connection between age and accident risk in this study is not likely due to physical aging issues, but to other factors associated with the age at which a person starts flight training.

Although there may be several reasons for this finding, one of the likely differences between pilots who begin flying at different ages is their motivation for learning to fly and what they plan to do with their flying privileges. These factors can affect initial choices about the type of flight training pilots pursue, but also have implications for the type of flying environment and oversight they will encounter over the long-term.

Many pilots who invest the time and money to learn to fly during their late teens or early twenties may do so with the intention of pursuing a career in aviation. In contrast, pilots who start flying in their 30s or later may be more likely to pursue flying for pleasure or personal transportation rather than as a potential career path. Support for this suggestion comes from this study's findings that nonaccident pilots had higher levels of certification, were more likely to be conducting paid flight operations, and were more likely to be flying an airplane belonging to someone else rather than their own airplane. The differences between pilots pursuing a career in aviation and those who fly for recreation or personal travel extend beyond flight hours and the equipment they operate, and those differences may explain the study findings.

Flight Training Differences

Many persons who start flight training with the intent of becoming paid professional pilots engage in full-time flight training that typically results in a regular schedule for practicing

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[12] For reviews of aging literature, see the following: (a) A.D. Fisk and W.A. Rogers (Eds.), *Handbook of Human Factors and the Older Adult* (San Diego, CA: Academic Press: 1997); (b) D.J. Hardy and R. Parasuraman, "Cognition and Flight Performance in Older Pilots," *Journal of Experimental Psychology: Applied* 3(4) (1997): 313-348; or (c) T.A. Salthouse, *Adult Cognition: An Experimental Psychology of Human Aging* (New York: Springer-Verlag, 1982).

[13] G.H. Li, E.R. Braver, and L.H. Chen, "Fragility Versus Excessive Crash Involvement as Determinants of High Death Rates per Vehicle-Mile of Travel Among Older Drivers," *Accident Analysis and Prevention,* 35(2) (2003): 227-235.

and testing knowledge and skills, regular oversight, and an immersion in the aviation environment. A typical professional pilot curriculum culminates with a commercial pilot certificate, multiengine rating, and either flight instructor or instrument flight instructor certificate. For these pilots, milestones like the private certificate or instrument rating are steps leading to the higher levels of experience and certification necessary for employment. Pilots who go on to find employment in aviation are subject to additional scrutiny and requirements from third parties such as their employers, the aircraft owners, their customers, and passengers.

Conversely, persons not training for a career in aviation may be more likely to train part-time with instructors at local airport fixed base operators (FBOs) or local flight schools, and to have longer intervals between training sessions. Persons who pursue flying for recreation or personal travel may view the private pilot certificate or instrument rating as a final—not a first—step in flight training. Pilots who do not pursue higher levels of certification are expected to maintain and improve their skills and knowledge on their own through regular flight activity. Unlike the direct and indirect oversight of most paid flight operations, pilots engaging in personal or business flight operations are required to fly with instructors again only to satisfy the flight review requirement of 14 *Code of Federal Regulations* (CFR) 61.56.[14] Consequently, the safety of personal flight operations may be more dependent on the skill, ability, and judgment of individual pilots.

Periodic training is an important part of maintaining and increasing knowledge and skills, and this seems to be particularly true for weather-related information and flight operations. For example, a survey study of the general weather knowledge of GA pilots[15] found no differences related to total hours of experience or experience during the previous 6 months after correcting for the highest level of pilot training/certification. These findings prompted the study author to conclude the following:

> It appears that pilots generally require formal training to obtain weather knowledge and cannot be expected to acquire it on their own as they simply gain more flight experience.

To obtain any pilot certificate, applicants are required to demonstrate aeronautical knowledge and skills related to identifying hazardous weather, obtaining and interpreting weather information, and performing associated decision-making tasks. After initial certification, the only specific weather-related requirement applies to instrument-rated pilots, who must maintain a minimum level of flight activity in order to exercise the privileges of that rating. The results from this study and previous research suggest that flight activity alone may not be sufficient to enable pilots to maintain or improve their ability to avoid hazardous weather conditions. The Safety Board concludes that periodic training and evaluation may be necessary to ensure that pilots maintain weather-related knowledge and skills.

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[14] Although nonregulatory, many aviation insurance companies stipulate additional recurrent training in order to maintain policies and/or favorable rates.

[15] B. Burian, *General Aviation Pilot Weather Knowledge and Training*, final report of the FAA, grant #00-G-020 (2002).

The Safety Board therefore recommends that the FAA add a specific requirement for all pilots who do not receive weather-related recurrent training, that the biennial flight review include the following: recognition of critical weather situations from the ground and in flight, procurement and use of aeronautical weather reports and forecasts, determination of fuel requirements, and planning for alternatives if the intended flight cannot be completed or delays are encountered.

In addition, pilots who were required to demonstrate a minimum level of proficiency in flight by reference to aircraft instruments for certification should maintain that minimum proficiency. Therefore, the Safety Board also recommends that the FAA should, for pilots holding a private, commercial, or airline transport pilot certificate in the airplane category who do not receive recurrent instrument training, add a specific requirement that the biennial flight review include a demonstration of control and maneuvering of an airplane solely by reference to instruments, including straight and level flight, constant airspeed climbs and descents, turns to a heading, and recovery from unusual flight attitudes.

Test Performance and Accident Risk

In this study, pilots were grouped into high- and low-pass-rate groups depending on their cumulative past performance on FAA knowledge and practical tests. Knowledge tests are designed to assess an applicant's understanding of the information that is necessary to exercise the privileges of a particular certificate or rating. Practical tests, typically administered by FAA-designated pilot examiners, are designed to evaluate pilots' ability to apply their knowledge and skills in the actual flying environment. Overall, higher percentages of accident pilots were represented in the low-pass-rate group for both the knowledge and the practical test. Safety Board analyses indicated a significant difference between the accident and nonaccident groups, suggesting a relationship between test performance and subsequent accident involvement. Therefore, the Safety Board concludes that knowledge and practical test failures are both associated with a higher risk of a pilot being involved in a weather-related GA accident.

The Safety Board also notes that, unlike the practical test standards in which failure of one "area of operation" is grounds for failure of the entire test, no minimum number of questions must be answered correctly within a given "knowledge area" on the knowledge test. For example, an average of 12 out of 60 questions on the private pilot certification knowledge test are weather-related.[16] A pilot could answer all 12 questions incorrectly and still receive a score as high as 80 percent, which is well above the minimum passing score of 70 percent. The Safety Board concludes that a pilot can incorrectly answer all questions relating to weather on an airman knowledge test and still receive a passing score on the test.

The Safety Board believes that a basic understanding of aviation weather is an important prerequisite to obtaining any pilot certificate or rating. Therefore, the Safety Board recommends that the FAA establish a minimum number of weather-related questions that must be answered correctly in order to pass FAA airman knowledge tests. The establishment of such requirements

[16] According to the FAA Airman Testing Standards Branch, there are 10 versions of the private pilot airplane knowledge test, and the number of questions pertaining to weather range from 11 to 13.

will further ensure that pilots who pass a knowledge test will have demonstrated a basic understanding of aviation weather.

Pilot History of Accidents and Incidents

This study used FAA records to determine whether pilots with a history of accidents or incidents are at an increased risk of future weather-related accidents. Analysis of the accident and incident records for all study pilots showed significant differences between the accident and incident histories for the accident and nonaccident pilots. Not only were accident pilots significantly more likely to have had prior accidents and incidents, several accident pilots had been involved in more than one accident or incident before the study. Safety Board analysis indicated that pilots involved in prior accidents or incidents were about 3 times more likely to be involved in a weather-related accident than pilots with no record of accidents or incidents. This finding is particularly interesting because the increased risk was not limited to prior accidents and incidents involving weather. Therefore, the Safety Board concludes that a history of accident or incident involvement is associated with a higher risk of being involved in a future weather-related GA accident.

Tracking a Pilot's Testing and Accident/Incident History

The results of this study demonstrate that both poor test performance and prior accident/incident involvement are linked to future accident involvement among GA pilots. Prior accident and incident involvement may indicate a pattern of risk and operating performance, whereas knowledge and practical testing performance may reflect an airman's overall training, knowledge, skills, and proficiency. These findings suggest a possibility for reducing accidents by identifying pilots at increased risk for weather-related accident involvement.

Currently, no formal requirements exist for tracking and reviewing GA pilot performance histories. However, a 1996 law established such a system for air carrier pilots after a series of Safety Board recommendations,[17] and ultimately the action of United States Congress, led to the *Pilot Records Improvement Act* (PRIA).[18] The intent of the PRIA was to make operators aware of the performance history of potential employees so that they could make appropriate hiring decisions about applicants who have exhibited a pattern of performance problems or regulatory violations. Pilots with a history of testing failures or violations are not restricted from engaging in flight operations by the PRIA, but they may be subject to more scrutiny by potential air carrier employers than applicants with better performance histories.

Once pilots are hired, the PRIA precludes employers from using pilots' preemployment records. However, as a means to identify pilots who may be at risk of accident involvement, certain companies have established oversight programs that allow them to identify and track pilots who have demonstrated performance deficiencies or failures in the training environment. The Safety Board highlighted the importance of such programs during its investigation of the

[17] A-88-141 (Superseded), A-88-145 (Closed—Acceptable), A-89-004 (Closed—Acceptable), A-90-141 (Closed—Uunacceptable), A-90-144 (Closed—Acceptable), A-93-014 (Closed—Unacceptable).

[18] Section 502 of Public Law 104-26.

December 18, 2003, accident involving Federal Express Flight 647, [19] and recommended that the FAA require all Part 121 air carrier operators to establish similar programs. [20]

Although there are currently no formal efforts to identify and track pilots with patterns of performance that indicate they are at increased risk of weather-related GA accidents, the results of this study suggest that it would be possible to use existing records to develop such a program. Because of the associations between testing performance, past accident and incident involvement, and future accidents, the Safety Board recommends that the FAA develop a means to identify pilots whose overall performance history indicates that they are at future risk of accident involvement, and develop a program to reduce risk for those pilots.

Pilot Weather Briefing Sources and Methods

In addition to the statistical analyses conducted as part of this study, the numerous nonaccident pilot interviews provided an opportunity to identify other weather-related safety issues. One of those issues was the use of preflight weather information. A majority of accident and nonaccident pilots in this study had contacted the flight service station (FSS) before their flights, but most nonaccident pilots also reported checking other sources of weather information to supplement their FSS briefings. For example, many nonaccident pilots reported that they routinely use Internet and satellite services to obtain graphical depictions of current and forecast conditions. This information was consistent with previous surveys of GA pilots, which indicated that they rely on a variety of weather sources including sources that are not part of a standard FSS briefing.

Pilots may choose to supplement the standard FSS briefing with weather information from alternative sources for a number of reasons. With the proliferation of websites and electronic sources that provide weather information, pilots can now easily access detailed weather images that can be printed for use in the cockpit; they can also access interactive tools that provide a more detailed representation of in-flight weather conditions than would be available through oral or textual briefings. The Safety Board concludes that GA pilots routinely consult alternative sources of aviation weather to obtain information that is not currently available from a standard weather briefing.

Part 91 regulations do not specifically require the use of any particular sources of weather information for GA pilots, but do require that all pilots familiarize themselves with weather and weather forecast information before beginning a flight. The instructions given to pilots about how to obtain a good preflight weather briefing in FAA Advisory Circular AC00-45E, "Aviation Weather Service," are limited to FSS briefings and the direct user access terminal system (DUATS) and do not provide guidance on how to evaluate or select other sources of weather information, and the FAA Aeronautical Information Manual identifies FSS and DUATS as primary weather sources. Because FSS and DUATS are currently the only sources of weather

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[19] National Transportation Safety Board, *Hard Landing, Gear Collapse, Federal Express Flight 647, Boeing MD-10-10F, N364FA, Memphis, Tennessee, December 18, 2003* NTSB/AAR-05/01 (Washington, DC: NTSB, 2005).

[20] Recommendation A-05-014 was issued on May 31, 2005, and its status is "Open—Await Response."

information endorsed by the FAA for use by GA pilots, it is important to ensure that the information and services provided by those sources meet the needs of the GA pilot community.

In February 2005, the FAA announced that it had selected a contractor to operate the agency's FSS system, which comprises 58 stations throughout the United States. The Safety Board believes that the transition to new management for the FSS system is an opportune time for the FAA and its contractor to evaluate FSS methods for providing weather information. For example, the FAA should seek to understand why some pilots choose other sources over FSS briefings and to consider whether the FSS system would benefit from an updating and/or broadening of the services and products it provides. A better understanding of pilots' weather needs would allow the FAA and its contractor to improve the weather services and products they provide to pilots. The Safety Board therefore recommends that the FAA determine optimal information presentation methods and delivery systems for FSS weather information briefings, including the possibility of supplementing or replacing some portions of the current standard weather briefing with graphical data.

The results of study interviews suggest that many pilots use other sources to obtain weather data not included in a standard briefing and then contact FSS or DUATS to fulfill a perceived regulatory obligation. This creates the potential for pilot misinterpretation or confusion if weather information gathered from various sources appears to be more detailed than the FSS information. In some cases, the FAA and NWS contribute to this potential confusion by providing detailed graphical weather products with disclaimers indicating that the products are not suitable to meet the briefing requirement.[21]

Without specific guidance, some pilots may hesitate to consult electronic data sources or may use sources that are not adequate to meet the intent of 14 CFR Part 91.103. Therefore, the Safety Board recommends that the FAA revise guidance materials associated with pilot weather briefings to include guidance for pilots in the use of Internet, satellite, and other data sources for obtaining weather information suitable for meeting the intent of 14 CFR Part 91.103 and subsequently inform the aviation community about this change.

Recommendations

Therefore, the Safety Board recommends the following to the Federal Aviation Administration:

> Add a specific requirement for all pilots who do not receive weather-related recurrent training, that the biennial flight review include the following: recognition of critical weather situations from the ground and in flight, procurement and use of aeronautical weather reports and forecasts, determination of fuel requirements, and planning for alternatives if the intended flight cannot be completed or delays are encountered. (A-05-024)

[21] For example, the "standard briefing" section of NWS/FAA site www.aviationweather.gov contains all of the information cited in AC00-45E, "Aviation Weather Service," as constituting a standard briefing, as well as additional graphical weather products, yet it includes a disclaimer stating that it should be "used for advisory purposes only."

For pilots holding a private, commercial, or airline transport pilot certificate in the airplane category who do not receive recurrent instrument training, add a specific requirement that the biennial flight review include a demonstration of control and maneuvering of an airplane solely by reference to instruments, including straight and level flight, constant airspeed climbs and descents, turns to a heading, and recovery from unusual flight attitudes. (A-05-025)

Establish a minimum number of weather-related questions that must be answered correctly in order to pass Federal Aviation Administration airman knowledge tests. (A-05-026)

Develop a means to identify pilots whose overall performance history indicates that they are at future risk of accident involvement, and develop a program to reduce risk for those pilots. (A-05-027)

Determine optimal information presentation methods and delivery systems for flight service station weather information briefings, including the possibility of supplementing or replacing some portions of the current standard weather briefing with graphical data. (A-05-028)

Revise guidance materials associated with pilot weather briefings to include guidance for pilots in the use of Internet, satellite, and other data sources for obtaining weather information suitable for meeting the intent of 14 *Code of Federal Regulations* Part 91.103 and subsequently inform the aviation community about this change. (A-05-029)

In response to this letter, please refer to Safety Recommendations A-05-024 through A-05-029 in your reply. If you need additional information, you may call (202) 314-6170.

Acting Chairman ROSENKER and Members ENGLEMAN CONNERS and HERSMAN concurred in these recommendations.

Original Signed

By: Mark V. Rosenker
Acting Chairman