2007

# Aviation Weather Encounter Study: Some Preliminary Findings

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# AVIATION WEATHER ENCOUNTER STUDY: SOME PRELIMINARY FINDINGS

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The purpose of this study was to identify the circumstances associated with encounters with adverse weather by general aviation pilots. Self-report data were analyzed for 224 pilots who completed an internet-based questionnaire, and who reported their principal residence as North America. Three groups were identified on the basis of their weather encounters: No-Weather, Near-Weather, and In-Weather. The data provide a description of the demographic characteristics of the pilots, along with details of the events and conditions that existed prior to and immediately following their in-flight weather encounters. Analyses were also conducted comparing the demographic and other characteristics of the three pilot groups. The descriptive data were found to be informative and of potential application in intervention development. Comparisons of the three groups, however, revealed very few statistically significant differences.

## Introduction

Despite a wide variety of training and regulatory initiatives, weather-related decision-making continues to account for a significant proportion of fatal aircraft accidents in the United States and elsewhere (Batt & O'Hare, 2005; National Transportation Safety Board, 2003). This suggests that either the underlying basis of poor weather-related decision-making has yet to be understood or that there are a number of bases that have yet to be examined in concert.

It is generally agreed that there are two explanations for poor weather-related decision-making. The first, and most evident explanation in the literature, relates to the notion that pilots ignore the features associated with a deterioration in the weather conditions until the situation becomes impossible to redress. This has been termed a 'plan-continuation error', but is colloquially referred to as 'press-on-it-is' (Wiegmann, Goh, & O''Hare, 2002).

A plan-continuation error has been variously explained as a product of: an underlying predisposition towards risky activities (Cohen, 1993; Hunter, 2006); an over-estimation of one's personal capacity to respond to threats to the safety of the aircraft (Wiggins, Connan, & Morris, 1996); sunk cost, in which time already invested predisposes an interpretation of the features of the environment more positively than might normally be the case (Wiegmann et al., 2002); and prospect theory, in which the perception of a potential loss is associated with a willingness to engage in activities that might be regarded as 'risk-seeking' (O'Hare & Smitheran, 1995).

The second explanation for poor weather-related decision-making relates to the suggestion that pilots either misinterpret, fail to perceive, or fail to integrate information, rather than ignore the features associated with deteriorating weather conditions (Hunter, Martinussen, & Wiggins, 2003; Wiggins & O'Hare, 2003). This explanation is based on the assumption that weather-related decision-making occurs under uncertainty, and that the features associated with the timely detection of deteriorating weather are subtle. As a result of this subtlety, the features can be difficult to identify and integrate, particularly when a pilot may be focusing his/her attention towards the operation of the aircraft.

Empirical evidence is available to support both explanations, suggesting that the underlying basis of poor weather-related decision-making is more complex than might be explained by either operational experience or the principle that pilots ignore features in the environment. The primary aim of the present study was to begin to develop an understanding of the complexities associated with poor weather-related decision-making by identifying the range of preconditions and local factors that are associated with an unintended visual flight into instrument meteorological conditions.

While there have been a number of epidemiological studies of cases of inappropriate weather-related decision-making, the aim has generally been to identify a single factor that might explain the behavior of pilots. These factors have included the experience of the pilot, the nature and purpose of the flight, whether the aircraft was being flown by an owner-pilot, or the occupation of the pilot (Knecht, Harris, & Shappell, 2005). Few studies have examined the relationship between the preconditions and the local factors that may have occurred at the time of the incident.

In examining preconditions and local factors associated with weather-related decision-making errors, the ideal approach would likely involve the utilization of aircraft accident and incident reports that have been subjected to various tests as part of a comprehensive investigative process. However, many cases of unintended visual flight into instrument meteorological conditions remain unreported. Those cases that have been investigated, generally do not include detail sufficient to identify the range of preconditions and local factors that may have prevailed at the time (Australian Transport Safety Bureau, 2004).

In the absence of suitable accident or incident reports, the alternative is to seek information directly from pilots who have been involved in various weather-related decision-making events. This raises a number of methodological issues, the most significant of which is the reliance on the memory of the pilot. For example, it may be the case that the specific details associated with an event are unable to be recalled or are reconstructed as a means of explaining a particular occurrence (Robinson, Johnson, & Robertson, 2000). These effects can be overcome, to some extent, by restricting, for events recalled, the timeframe within which the event occurred. It might also be argued that unintended visual flight into instrument meteorological conditions is sufficiently memorable insofar as there is a threat to the safety and security of the aircraft and its passengers.

The acquisition of event-related data in the aviation context can be problematic, given the relatively disparate nature of the population under investigation. This often necessitates the use of questionnaires, despite the fact that the level of detail acquired through questionnaires may be less than the detail acquired through an interview technique. However, Renshaw and Wiggins (in press) have demonstrated that the judicious use of the questionnaire technique can yield a relatively rich set of data associated with critical in-flight events.

The questionnaire employed in the present study was designed to acquire information pertaining to three different categories of pilot: Those who had never encountered deteriorating weather conditions in the five years preceding the completion of the survey; those who had experienced deteriorating weather conditions during the five years preceding the completion of the survey; and those pilots who had experienced unintended visual flight into instrument meteorological conditions. By comparing the preconditions and local factors associated with those events where pilots encountered deteriorating weather conditions but did not fly into instrument meteorological conditions to the preconditions and local factors associated with unintended visual flight into instrument conditions, it becomes possible to establish the extent to which combinations of preconditions and local factors are more or less likely to be associated with unintended flight into instrument conditions.

## Methods

### Participants

Participants were solicited from among visitors to a web site (http://www.avhf.com) oriented toward general aviation safety issues. Approximately 400 participants had completed some or all of the scales as of 1 December 2006. The present analyses, however, will be limited to the 224 pilots who reported their principal residence as North America. The mean age was 51.9 years (*SD* = 12.8), and total flying hours varied substantially with a mean of 2039 hours (*SD* = 3889).

### Procedure

A prominent notice was placed on the home page of the web site directing visitors to another page on which additional, detailed information regarding the study was contained. This second page provided potential participants with all the information necessary to make an informed consent decision to take part in the study. Upon indicating their consent to participate, they were then automatically re-directed to a web page on which they created a unique personal identifier ("call sign") and answered the following two screening questions:

> Q1. During the last 5 years, how many times have you been on a flight (as pilot-in-command) in which weather conditions prior to or during the flight were a significant factor, perhaps even a threat to the safety of the flight?
>
> Q2. During the last 5 years, how many times have you (as pilot-in-command) entered IMC <u>when you were not on an instrument flight plan and/or did not have an instrument rating</u>? That is, you flew into cloud or into an area where the visibility was clearly below the 3-mile [5-km] minimum without ATC clearance.

Pilots who responded to the first question with anything other than zero and responded with zero to the second question, were designated as Near-weather. They were then automatically re-directed to a web page containing questions regarding a recent event. Pilots who gave a non-zero response to the second question were designated as In-weather, and re-directed to a web page containing questions regarding their best-remembered event. The questions for Near-Weather and In-Weather were virtually identical. However, whereas the questions for Near-Weather asked about their flight in which weather was a significant factor, the questions for In-Weather asked about the flight in which they entered IMC without clearance.

Pilots who responded zero to both of the screening questions were designated as No-Weather, and were re-directed to the web page that collected demographic information. Upon completing the questions regarding their weather experiences, the pilots in Near-Weather and In-Weather were also directed to the same demographic information web page. Following completion of the demographic information page, all pilots completed a risk perception scale and, optionally, an aviation judgment scale. Neither of those later scales will be addressed in the current paper.

**Measures**

Pilots in both the Near-Weather and In-Weather responded to 53 questions dealing with their respective events. These questions were divided into categories and given in the following order:

> 1. General: When did the event occur, what happened (e.g., injuries), how long did it last.
>
> 2. Circumstances: Where did you get your weather brief, what did it say, what weather did you run into, had you seen this before.
>
> 3. Aircraft: Configuration, presence and use of autopilot and GPS.
>
> 4. Event details: Was the weather changing, why did you enter the weather (or fly near the weather), did you have trouble maintaining control, how did you feel during the event, describe the event in own words.

In addition to the 53 questions regarding the event, all pilots completed the background questions. These questions addressed total and recent aviation experience, aeronautical ratings, recent training events, personal minimums for local and cross-country flights, and hazardous events that had occurred during the previous 24 months.

**Results**

The sample was divided into three groups based on their previous experience with bad weather. The first group included those pilots who had never in the past five years experienced bad weather. This group (No-weather) included 54 pilots. The second group (Near-Weather) included those who had experienced, (one or more times) weather conditions during a flight that were a significant factor or possibly a threat to safety ($n$ = 86). The last group (In-Weather) included those who had, one or more times, entered IMC conditions when not on an instrument flight plan ($n$ = 84).

The pilots who had experience with bad weather were asked about the main reason for entering bad weather, and if they entered the situation deliberately or inadvertently. More participants in the Near-Weather group (54%) than In-Weather group (33%) reported to have entered the situation deliberately ($Chi^2 = 7.1$, df = 1, $p$ >.01). The most frequent reason for doing so was "decided I could handle it" reported by 29% of the Near-Weather group, followed by didn't realize the severity" reported by 20% as the main reason. For the In-Weather group, the two most frequent reasons were "did not realize the severity" and "did not see the area of adverse weather", both reported by 18%.

The three groups were compared in terms of demographical variables and experience variables. There were no significant differences in age between the three groups. Flying experience in terms of total hours and recent hours (last 90 days) were compared between the groups (Table 1), and there were no significant differences between the groups. The pilots in the study had different types of certificates and they were grouped into two categories, private (student, recreational, sport, private) versus commercial (ATP and commercial). The percentage with a private pilot license was 64% for the No-Weather-group, 57% for the Near-Weather and 61% for the In-Weather-group. The difference between groups in terms of certificate held was non-significant ($Chi^2$ = .89, df = 2, $p$ >.05). The percentage with an instrument rating was 50% for the No-Weather group, 69% for the Near-Weather group, and 60% for the In-Weather group. The differences were not significant ($Chi^2$ = 5.1, df = 2, $p$ >.05).

The pilots were also asked about the personal minimum conditions for flying under Visual Flight Regulations. The results are presented in Table 1. The differences between groups were only significant for minimum visibility on a local flight, where the No-Weather group had higher standards than the In-Weather group.

The pilots were also asked about previous hazardous aviation events over the last 24 months (Table 1). There were no significant differences between the three groups.

Another purpose of the study was to examine possible differences between the two groups of pilots with experience with adverse weather both in terms of event characteristics, aspects of the flight as well as the weather conditions. We compared the groups in terms of the purpose of the flight (business vs pleasure), type of flight (cross country vs local), and whether or not they had passengers on board. The results are presented in Table 2.

The pilots reported where they had obtained weather information before the flight, and they were also asked to rate their understanding of the weather briefings. The group who had experienced IMC conditions (In Weather) reported to have a poorer understanding of the weather briefings compared to the Near-Weather group (Table 3). There were no differences between groups in terms of where they had collected information before the flight. The preflight weather forecast were generally better for the In-Weathers, whereas there were no differences in terms of how the weather turned out compared to the forecast (Table 2).

The pilots were also asked to rate how well they remembered the event, their anxiety level, and the perceived danger involved. The differences between groups were non-significant. The results are presented in Table 3.

**Discussion**

There are two general purposes served by this study. The first, and perhaps foremost, is simply descriptive. The data provide a reasonably reliable and quantitative picture of the conditions and events preceding a weather encounter. The second purpose is comparative. The data provide an opportunity to examine differences among the three groups, which may help us to understand why one group experiences a potentially very hazardous event, while the other does not.

Some of the descriptive results reveal interesting elements; for example, the high proportion of autopilots on-board and/or in-use. It is interesting to speculate how the presence and use of these devices may have affected the outcome of the weather encounters. Given the relatively high presence of these devices in aircraft that experienced adverse weather encounters, it might be profitable to design interventions that would encourage better use of these capabilities. This example illustrates the general utility of descriptive data. They provide a basis for informed decisions about the development of safety interventions and plans. Without those data, developers are forced to make assumptions about aircraft and pilot capabilities that may be false. These false assumptions may lead to interventions that are irrelevant or that fail to take advantage of pre-existing capabilities. Consider, for example, the difference between teaching pilots to maintain control of the aircraft while making a level, 180-degree turn to exit weather, as compared to teaching pilots to turn on the autopilot when nearing weather, and then to turn the heading control on the autopilot to a reciprocal heading in the event of entry into instrument conditions.

With respect to the second purpose of the study, comparisons among the three groups, at this point it seems clear that the most striking finding is that there really are few differences among the three groups. Based on the preliminary analyses conducted so far, pilots who fly near weather, pilots who fly into weather, and pilots who never go near weather are all quite similar in most respects. However, there are some intriguing differences (personal minimums for local visibility, understanding of weather briefs) that invite further investigation.

Perhaps the major lesson from the comparative analyses is that they demonstrate the difficulty, a priori, of identifying pilots who will have close-calls with weather, based solely on demographic variables. This may have implications for interventions or targeting of training. It may also have implications for the sort of variables we should be investigating. Clearly we must look beyond the surface characteristics and experiences if we are to develop a better understanding of causality in weather encounters, and by extension, weather-related accidents.

Some of the data (risk perception and pilot judgment) collected in this study, but not reported here due to space limitations, may improve understanding by looking beyond the surface demographic differences. Future analyses will include those data and will also examine those pilots in the In Weather group, to compare those pilots who flew deliberately into IMC with those pilots who entered IMC inadvertently. As additional data become available from pilots in Norway, Australia, and New Zealand similar analyses will be conducted using those pilots both within and between countries.

The present analyses have been preliminary, and based on only a portion of the total sample expected to be collected in this study. As more data become available, some of the trends noticed in the present analyses may become significant; such as the No-weather group being slightly less experienced and more cautious. Even so, it seems unlikely that substantial differences will be found among the three groups in the demographic and predecessor event data. Rather, much more research will be necessary to understand why very similar pilots dealt with very similar situations in quite dissimilar ways.

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***Table 1.*** Flying experience, personal minimums and hazardous aviation events for the three groups of pilots

| | No-Weather ($n$ = 53) | | Near-Weather ($n$ = 81) | | In-Weather ($n$ = 80) | | |
|---|---|---|---|---|---|---|---|
| Flying experience (hours) | *M* | *SD* | *M* | *SD* | *M* | *SD* | *F* |
| Total experience | 1619 | 4112 | 2354 | 3978 | 1999 | 3660 | 0.58 |
| Recent experience | 27 | 41 | 37 | 44 | 44 | 61 | 1.80 |
| Personal minimums[a] | | | | | | | |
| Ceiling: VFR local flight | 2.93 | 1.40 | 2.68 | 1.48 | 2.40 | 1.36 | 2.29 |
| Ceiling: Cross-country flight | 4.08 | 1.48 | 3.81 | 1.53 | 3.57 | 1.49 | 1.83 |
| Visibility: VFR local flight | 4.19 | 1.30 | 3.83 | 1.36 | 3.51 | 1.18 | 4.65* |
| Visibility: Cross-country flight | 4.92 | 1.53 | 4.57 | 1.43 | 4.54 | 1.34 | 1.42 |
| Hazardous aviation events (last 24 months)[b] | 1.02 | 1.55 | 1.26 | 1.31 | 1.51 | 1.97 | 1.51 |

*Note*. [a]Minimum ceiling was scored in ft from 1 = 1000ft to 6 = 5000ft and more. Visibility was scored from 1 = 1 mile to 7 = 11 miles or more. [b]The items in the scale were scored on a four-point scale (0 = none to 4 = four or more). *$p$ <.05.

***Table 2.*** Event characteristics for two groups (In-Weather and Near-Weather)

| | Near-Weather | In-Weather | Chi$^2$ |
|---|---|---|---|
| Purpose of flight- pleasure | 57% | 52% | .23 |
| Local flight | 10% | 23% | 5.37* |
| Passengers on board | 64% | 42% | 8.00** |
| Weather forecast en-route Visual meteorological condition | 48% | 71% | 8.51** |
| Actual weather (en-route) worse than forecast | 55% | 60% | .41 |

*Note*. *$p$ <.05. **$p$ < .01. **$p$ < .001.

***Table 3.*** Experienced anxiety and danger by the pilots during and after the episode

| | Near-Weather ($n$ = 82) | | In-Weather ($n$ = 82) | | |
|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *t* |
| Understanding of weather briefings[a] | 4.70 | .54 | 4.50 | .67 | 2.18* |
| Memory of the event[b] | 4.10 | .78 | 3.89 | 1.12 | 1.37 |
| Anxiety during the event[c] | 2.90 | .88 | 2.86 | .92 | .43 |
| Perceived level of danger[d] | 1.94 | .87 | 2.09 | 1.02 | -.99 |

*Note*. [a]Scale used was from 1 = very poor to 5 = very good. [b]Scale used was from 1 = very hazy to 5 = very clear. [c]Scale from 1= very relaxed to 5 = extremely tense and anxious. [d]Scale from 1= never in any real danger to 5 = extreme danger. *$p$ <.05 (two-tailed).