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Causes of General Aviation Weather-Related, Non-Fatal Incidents: Analysis Using NASA Aviation Safety Reporting System Data

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16. Abstract

Adverse weather remains a major cause of general aviation accidents. However, weather alone is never the sole culprit. Searching for other salient causal factors, we turned to *incident analysis*. Incidents are less serious than accidents, but far more common, and have witnesses to better determine causes.

The current research examined 100 GA weather-related incident reports made to the Aviation Safety Reporting System (ASRS) during 2005-06. With pilot permission, ASRS gathered additional data on nearly 300 variables related to possible root causes. The following factors seemed to constitute a problem for 5%, or more, of pilots:

1. *Darkness* (4 dusk +17 night = 21% of pilots).
2. *Moisture* affecting visibility (clouds, fog, rain, snow > 50%) and/or *air movement* affecting aircraft handling (thunderstorm, icing, turbulence > 25%).
3. *Multiple weather factors* experienced simultaneously (85%).
4. Failure to get a *preflight weather briefing*, or “briefing” with only a low-grade (non-aviation-oriented) source (5%).
5. Deterioration of *weather forecast accuracy* over time (66% correct forecasts at departure, decreasing to 37% correct at destination).
6. *Weather* that materialized *worse than predicted* (35%. This implicitly includes lack of en-route forecast updates).
7. *Lack of weather-related training and experience* (> 50%, non-instrument-rated and new instrument-rated pilots).
8. *Inadequate equipment* (less-experienced pilots tend to have less-capable airframes and avionics).
9. Ambulance missions (7%, particularly helicopter ambulance).
10. “Non-weather-related factors”: decision-making (26%), time pressure (21%), “get-home-itis” (9%), aircraft equipment problem (8%), fatigue (7%), distraction by passenger or crew (5%).

In broad terms, this analysis reveals two major at-risk target groups with distinct training needs:

- Non-instrument-rated pilots
- Newly minted instrument-rated pilots

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CONTENTS

LIST OF ABBREVIATIONS

ACARS	Aircraft Communications Addressing and Reporting System
ADM	Aeronautical decision making
ATC	Air traffic control
ATP	Air Transport Pilot
CFI	Certified Flight Instructor
CFII	Certified Flight Instructor-Instrument
CFIT	Controlled flight into terrain
FAA	U.S. Federal Aviation Administration
FBO	Fixed-base operator
FSS	Flight Service Station (a.k.a. AFSS, Automated Flight Service Station)
GA	General aviation
GPS	Global Positioning System
HCA	Hierarchical cluster analysis
IFR	Instrument flight rules
ILS	Instrument landing system
IMC	Instrument meteorological conditions
IR	Instrument-rated
NAS	National Airspace System (U.S.)
NEXRAD	Next-Generation Radar
non-IR	Not instrument-rated
NTSB	National Transportation Safety Board (U.S.)
NWS	National Weather Service (U.S.)
PTT	Push-to-talk (microphone key)
TAA	Technically Advanced Aircraft
VFR	Visual flight rules
VMC	Visual meteorological conditions
VOR	VHF omnidirectional range

Causes of General Aviation Weather-Related, Non-Fatal Incidents: Analysis Using NASA Aviation Safety Reporting System Data

INTRODUCTION

A pilot, his wife, and daughter fortunately survived the accident below.

In August of 2005, the pilot had received his private pilot certificate on a Tuesday, and this accident occurred the following Saturday. It was his first cross-country flight, travelling with his family, from Fort Mill, NC, to Myrtle Beach, SC, to enjoy the beach.

While en route, he had seen an area of weather along the route and diverted to Lumberton, NC. In Lumberton, he was checking the automated weather terminal at the fixed base operator (FBO) when an instrument-rated (IR) pilot and a flight instructor offered assistance. They suggested that he take his family to lunch while the thunderstorms passed, and the trip could likely be completed as planned after lunch. Instead, he elected to depart immediately and return home, attempting to do so before the weather reached the Lumberton airport.

As he taxied out for departure, the approaching weather was now visible; however the winds were calm. As he began his takeoff, the storm winds began to impact the runway area. The plane became airborne, and the pilot was in the process of retracting the landing gear when the gusts and downdrafts struck, driving the aircraft into the ground and literally breaking it into pieces. Remarkably, no one was injured. As bystanders arrived on the accident scene to offer assistance, they heard the pilot say, "Why didn't somebody tell me it could be this bad?"

Motivation for the Current Study

The above story starkly reminds us how easily bad weather can kill general aviation (GA) pilots. Why? In truth, the typical "weather accident" involves not just adverse weather but additional factors as well (Wiegmann & Shappell, 2003). So, what are these factors that conflate with and potentiate weather to bring on accidents?

This study will involve a *data-mining* approach, rather than the hypothesis-testing approach commonly used in experimental studies. Its purpose will be to look for *relations* between potential causal factors in existing data, with the intent of identifying factors that relate to each other. For instance, do low-hour pilots also tend to fly less weather-capable aircraft? If so, we could hypothesize that aircraft weather capability and pilot flight experience *interact* to increase weather-flight risk. Such a hypothesis could subsequently be tested in a flight simulator study, and the results be made known to FAA policymakers and rulemakers, as well as to pilots and equipment manufacturers.

Background—Quantifying the Degree of Risk Posed by Adverse Weather

Natural forces can be capricious, powerful, hard to understand, and physically hard to control or avoid. Consequently, weather-related accidents are disproportionately disastrous compared to most other types of accidents. According to a U.S. National Transportation Safety Board (NTSB) report, "about two-thirds of all... GA...accidents that occur in instrument meteorological conditions (IMC) are fatal" (NTSB, 2005). Based on a study of Australian GA accidents and incidents,[1] Batt & O'Hare (2005) stated that 76% of GA visual flight rules flight-into-instrument meteorological conditions (VFR-into-IMC) accidents involved a fatality.

According to NTSB data, VFR-into-IMC was the top single cause of GA fatalities during the years 1983-2002 (Bazargan, 2005). In an effort to quantify this risk, Bazargan defined a metric[2] called "risk ratio" R as

$$R_{\text{VFR-into-IMC}} = \frac{N_{\text{Fatal VFR-into-IMC accidents}} / N_{\text{Fatal accidents}}}{N_{\text{Non-fatal VFR-into-IMC accidents}} / N_{\text{Non-fatal accidents}}} = 16.8 \qquad (1)$$

[1] Mishaps fall into three formal categories. "Fatalities" involve just that. "Accidents" involve substantial, non-fatal damage to persons and/or property. Finally, "incidents" involve no fatalities and no substantial damage but represent situations where a lapse or potential lapse of safety occurred, or came close to occurring, in the judgment of some expert, either a pilot, air traffic controller, or professional safety official.

[2] The symbol "N" stands for "number of."

By way of context, other top GA accident causal factors have far lower risk ratios

(e.g., $R_{airspeed} = 1.7$, $R_{aircraft\ control} = 2.8$).

Categorizing and Modeling the Causes of Risk

To better understand what causes weather-related accidents, we seek to organize and categorize risk factors. Our approach is to examine perceptual errors, skill errors, decision errors, and procedural violations.

Perceptual Errors

Perceptual errors are particularly associated with adverse weather. The brain cannot accurately process what the senses do not accurately perceive. For example, judging cloud clearance is notoriously difficult (Coyne, Latorella, & Baldwin, 2005, Wiggins & O'Hare, 2003), as is judging slant range through fog or mist. Likewise, a violent updraft can appear without prior cues or warning almost instantaneously near thunderheads and literally rip the wings off a small aircraft. How do we avoid what we cannot even see? The answer lies in learning to assess the *likelihood of risk* and in practicing *strategic avoidance*[3] when that likelihood reaches a certain threshold.

Skill Errors

Skill errors are easy to understand but harder to correct because we tend not to be aware of a given skill deficiency until after some close call points it out to us. This is a particular problem with skills normally not required, which consequently are rarely practiced. A good example would be a pilot from a normally warm, dry climate suddenly encountering wing icing. How do we maintain proficiency at something we rarely get to practice?

Skill errors can be difficult to identify as accident causes after the fact because, in the case of fatalities, there is no pilot left alive to interview. Conversely, in non-fatal cases, people may not perceive (and rarely openly admit to) their own shortcomings, especially when doing so might result in swift, substantial punishment by authorities. This can make objective study of skill errors difficult.

Decision Errors

Pilot decision errors are another, often-quoted, psychological factor involved in GA accidents. This falls under the rubric of "aeronautical decision making" (ADM). Appendix A contains an extensive list of ADM error factors (FAA Joint Safety Analysis Team, 2002). These have been listed as causal in as many as 50% of GA accidents, depending on the reviewer. (Wiegmann & Shappell, 1997; Jensen, 1995).

Decision errors may be influenced by unconscious conditions, including subtle affective (emotional) motivations. For example, Batt & O'Hare (2005) concluded that the *midpoint* of an adverse-weather flight—no matter how long the flight—may represent a psychological "tipping point," after which there is an increased tendency for an adverse-weather flight to end up VFR-into-IMC (as opposed to weather avoidance or diversionary landing). This finding supports a variety of hypothesized psychological motivations for VFR-into-IMC, ranging from the folksy "get-home-itis" to the more esoteric idea of "sunk cost"[4] (Kahneman & Tversky, 1979; Goh, Wiegmann, & O'Hare, 2002).

Procedural Violations

Seasoned accident investigators will quickly add "pilot not following proper procedures" as a cause of many accidents. However, ADM and procedural violations must be related since, if we assume that most pilots *know* most procedures, then a decision *not* to follow a proper procedure can usually be defined as poor decision making.

However, there are inherent problems with simply declaring "poor decision making" as a *cause* of accidents. First, blaming "poor decision making" alone is a tautology.[5] Since we usually *define* a "poor decision" as "one that winds up having bad consequences," it then logically follows that 100% of all accidents must be caused by *someone* exhibiting "poor decision making" somewhere.

This leads to a classic situation in logic called the *nominal fallacy.*[6] Setting up "poor decision making" as a one-size-fits-all causal factor may sound satisfying, but it does not really explain anything. Take for example "controlled flight into terrain" (CFIT). No normal person purposely crashes a perfectly good airplane. Yet, there is often a tendency to think that, when such an accident is blamed on "poor decision making," we have actually explained what caused that accident.

Nothing could be further from the truth. When it comes to weather, two pilots can make very similar decisions, yet one pilot ends up arriving safely while the

[3] For instance, maintaining proper distance from an entire region of thunderheads, rather than just the few closest to us.

[4] *Sunk cost* is the notion that the more time or treasure we have "sunk into" (i.e., "invested in") some plan, the more many of us stubbornly stick to that plan, even when confronted with apparent loss and failure of the plan. Perversely, the human mind is often more attracted to *uncertain gains* than it is repelled by *uncertain losses*.

[5] A tautology is an argument that is true merely by how its terms were defined in the first place. The statement "All men are mortals, therefore all men die" is a tautology because the word "mortal" is already predefined as "subject to death." Rephrased, the original statement then becomes "All men are subject to death, therefore all men die," which sounds far less erudite than the original statement. Colloquially, a tautology might be thought of as a trivial statement dressed up to look like a profound one.

[6] The nominal fallacy is the mistake of thinking that, by assigning a name to something, we have actually explained it. For instance, claiming that "gravity" causes objects to fall actually explains nothing about what *causes* gravity—only how gravity *behaves*. *How* something behaves is different from what *causes* it to behave.

other ends up crashing. So did the pilot who crashed exhibit "poor decision making" while the other did not? Obviously, there is much more to the "quality" of a decision than whether or not it results in success on a single, given occasion.

Modeling Accident Causality and Risk

H.W. Heinrich (1959) proposed a "pyramid model" of accident causation and risk (Figure 2), in suggesting that for every major fatal accident there are multiple non-fatal accidents, for every non-fatal accident there are multiple incidents, and for every incident there are multiple unreported unsafe acts.

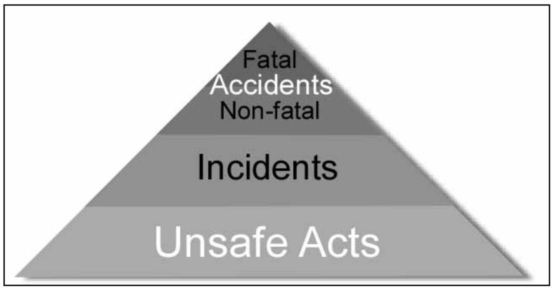

Figure 2. A modified "Heinrich Pyramid."

The Heinrich model assumes that some percentage of unsafe behaviors become incidents, a smaller percentage become accidents, and an even smaller percentage become fatalities. Informationally, this implies that over a reasonably long period of time, a known set of unsafe acts contains information about the smaller set of incidents, which itself contains information about the even-smaller set of accidents, and so on.

This implies that we can learn something about one category in the pyramid by studying the category beneath it. For instance, studying incidents should tell us something about accidents (Nazeri, Donohue, & Sherry, 2008). In formal terms, incidents are considered precursors to accidents.

The Devil Is in the Details

All of this means we have to probe deeply into specific details of a given accident to try to see subtle and often-hidden relations between those details to understand that accident. This takes detective work. It requires data and methodology.

In this report, we are going to pursue the logic of the Heinrich model and look for features that may discriminate one hazard category or group from another. Thus, if we can find such discriminating features, we can start understanding these hazardous situations, to whom they tend to happen, and how to keep them from happening in the future.

METHOD

How These Data Were Collected

To look for categories of hazardous situations and their root causes, we normally need large amounts of data, otherwise we run the risk of incurring sampling error.[7] This report analyzes data collected from 100 detailed aviation incident reports.[8] Incident analysis is a highly useful technique for gathering data and generating hypotheses about "how pilots nearly get into trouble." Like the Heinrich Pyramid, incident analysis relies on the modest assumption that studying a fairly large group of people *nearly* getting into trouble can tell us much about how a small group of people may *actually* get into trouble in the future. This approach is particularly useful in situations where accidents tend to (a) be inherently rare, (b) have missing or incomplete telemetry, and (c) involve fatalities, making it impossible to interview key witnesses.

Put rather starkly, we can interview a survivor.

The data for this report were collected specifically for the FAA by the Aviation Safety Reporting System (ASRS). By its own self-description (ASRS, 2006),

> The ASRS was established in 1975 under a Memorandum of Agreement between the Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration (NASA). FAA provides most of the program funding; NASA administers the program and sets its policies in consultation with the FAA and the aviation community. NASA has chosen to operate the program through a contractor selected via competitive bidding.
>
> The ASRS collects, analyzes, and responds to voluntarily submitted aviation safety incident reports in order to lessen the likelihood of aviation accidents. ASRS data are used to:
>
> • Identify deficiencies and discrepancies in the National Aviation System (NAS) so that these can be remedied by appropriate authorities.
>
> • Support policy formulation and planning for, and improvements to, the NAS.
>
> • Strengthen the foundation of aviation human factors safety research. This is particularly important since it is generally conceded that over two-thirds of all aviation accidents and incidents have their roots in human performance errors.

These voluntary incident reports form one of the major sources of aviation safety research data in the U.S. By reputation, ASRS is both non-punitive and strongly committed to maintaining the anonymity of its reporters.

[7] Sampling error is error created by measuring a sample rather than the entire population. The smaller the sample size, the greater the risk of that sample failing to resemble the broader population.

[8] N=100 is arguably a medium-sized sample. Therefore, readers may want to consider this study exploratory.

This includes granting of provisional legal immunity to pilots who file an incident report, as long as the incident involved no criminal activity or accident (ASRS, 2010).[9] Over the years, pilots, controllers, and aircraft maintenance personnel, both private and commercial, have learned that the ASRS is a non-threatening way to report aviation safety issues to personnel in the FAA whose job it is to study such issues. This makes ASRS data particularly valuable in trying to do proactive safety research.

The ASRS maintains a small-but-expert analytical staff, including data analysts with pilot, air traffic control, and/or aircraft maintenance experience, plus retrieval specialists who can mine their extensive database for specific information. We turned to this staff to engage participants who had previously submitted incident reports naming weather as a factor.

Participants

During 2005 and early 2006, ASRS staff kept a running list of weather-related GA incidents reported on their standard intake forms. They telephoned each pilot who had experienced a weather-related incident, explaining this research study, and requesting the pilot's participation as an aviation professional. Those agreeing to participate received a weather incident follow-up instrument developed specifically by one experimenter (Lenz) for this study (see Appendix B). The interview asked detailed questions about pilot demographics and factors that might have contributed to the incident. Each packet was sent via overnight delivery with a prepaid return envelope to convey a sense of gravity and professional respect. Participants were not financially compensated. One hundred twenty-one interviews were sent out before the requisite 100 responses were finally obtained, equivalent to a response rate of 83%.

Analytical Procedure

The intent behind this analysis was to identify what kinds of things go wrong with flights when weather enters the picture, to whom those things seem to be happening, how those factors relate to one another, and what, if anything, might be done to reduce future risk.

The analytical procedure started by coding "Yes" responses to interview questions as "1" and "No" responses as "0." This allowed statistical analysis, primarily with nonparametric procedures (Hollander & Wolfe, 1999).

Both quantitative and qualitative analysis were applied to the data.[10] The present report primarily concerns the quantitative data and seeks to identify salient issues involving significant numbers of pilots, either by comparing different groups of pilots within this sample to each other, or by comparing this sample to other samples or groups external to the study (e.g., to nationwide data collected by FAA or industry groups).

In selected instances where alternate data sources were available, the present findings were contrasted with findings based on those alternate sources. Such cross-checking can both strengthen pre-existing knowledge, as well as uncover the occasional contradiction, which can lead to further investigation and clarification.

Study Limitations

The current study has at least two limitations. The first is a limitation of the data sample itself. While this sample represents a nearly complete polling of all ASRS GA weather-related incidents reported during a good range of summer, fall, and winter months, it contains only reported incidents. It is virtually certain that many incidents go unreported. For one thing, not all pilots are aware of the ASRS. For another, people are almost universally averse to admitting mistakes, even when we know the proper venue for doing it. As a result, some incidents go unreported. The methodological issue is whether or not incidents that go unreported are basically the same as our sample, which are all reported incidents. If not, then our sample will be biased in unknown ways. Any systematic sampling bias limits how much we can generalize from this sample to the population of pilots and events at large.

Voluntary reporting systems are often suspected of bias. Rockwell, Roach, and Giffin used the ASRS database in their 1981 report, *A study of ASRS reports involving general aviation and weather encounters*. At that time, they perhaps overstated the issue, claiming "Clearly, there is no evidence that the data are representative" (p. 40). While such candor is laudable, there is little evidence to suggest that the data are *un*representative of GA pilots either. So, barring a compelling reason to mistrust these data, we can only state the concern and move on.

The second limitation of this study is a universal one, nonetheless rarely acknowledged, namely the issue of multiple comparisons. We intend to examine a large number of statistical results here and, by the very definitions of probability theory, a certain small number of those are likely to be "significant" merely by chance. This is usually about 5%, but does require acknowledgment.

[9] The intent here is not to exonerate wrong-doers, but to reward preporting of honest mistakes, which provides valuable data that can be analyzed, precisely as we are doing here.

[10] Quantitative analysis centers on numerical data amenable to statistical analysis, whereas qualitative analysis usually centers on non-numerical aspects of data such as behaviors or verbal responses.

RESULTS

Preliminary Conclusions

An endemic problem in data-mining studies is that results can seem scattered and disjointed because we are looking for many results of many sorts. One solution to this problem is to lay out brief conclusions first, followed by detailed analysis, finishing with a recap of the same conclusions. In technical terms, this cognitively *primes*[11] the reader and takes advantage of *primacy* and *recency* effects.[12]

Following that strategy, this report intends to show that the following specific factors constituted a problem for 5% or more of those pilots. To investigation professionals, this will clearly be a list of "usual suspects," for which we now have increased statistical evidence.

1) Low lighting (dusk or darkness)
2) Type of weather encountered (Table 1)
    a) deteriorating visibility (e.g., lowering ceiling, clouds, fog, rain, rising cloud tops, merging cloud layers)
    b) icing
    c) thunderstorms
    d) turbulence
3) Multiple weather factors experienced simultaneously (Figure 3)
4) Failure to get a *preflight weather briefing*, or "briefing" with only a low-grade (non-aviation-oriented) source (Figure 4, Table 2)
5) General deterioration of *weather forecast accuracy* over time (Table 3)
6) Weather that materialized *worse than predicted* (Tables 4, 10)
7) Lack of weather-related training and experience for both non-instrument-rated and new instrument-rated pilots (Tables 5, 8, 9, Figure 6)
8) Air ambulance missions (particularly helicopter ambulance)
9) Aircraft *lacking substantial weather information/handling/avoidance equipment* (Figures 5, 7)
10) Non-weather-related, *compounding factors* (Table 6, Figure 8, e.g., decision-making factors, time pressure, "get-home-itis," aircraft equipment problems, fatigue, distraction by passenger or crew)

A detailed summary of the analysis that lead to these assertions now follows. Readers wishing to postpone this detailed analysis may want to go directly to the Discussion section.

Table 1. Types of weather encountered.

Lowering ceiling	53	Rising cloud tops	17	Snow showers	8
Flew into clouds or fog	51	Icing	16	Ground fog	5
Deteriorating weather ahead	38	Turbulence	12	Strong cross winds	3
Reduced visibility	38	Merging cloud layers	11	Unknown, but IMC conditions	2
Broken or solid undercast	25	Other	10	Hail	0
Rain	19	Thunderstorms	9		

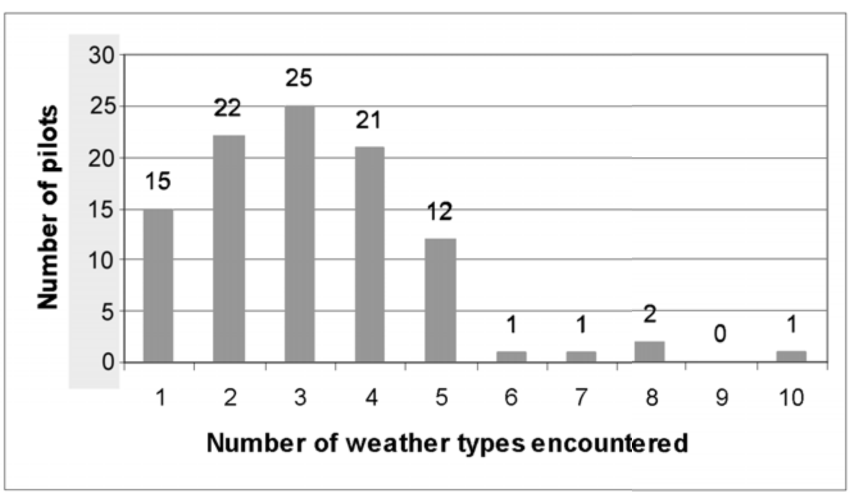

Figure 3. Number of different weather types encountered per incident.

[11] In cognitive priming, preliminary exposure to a particular stimulus enhances ("primes") the participant's subsequent sensitivity to later presentation of similar stimuli (James, 1890).

[12] When presented with lists of material, we tend to remember best what was first presented and last presented (Deese & Kaufman, 1957).

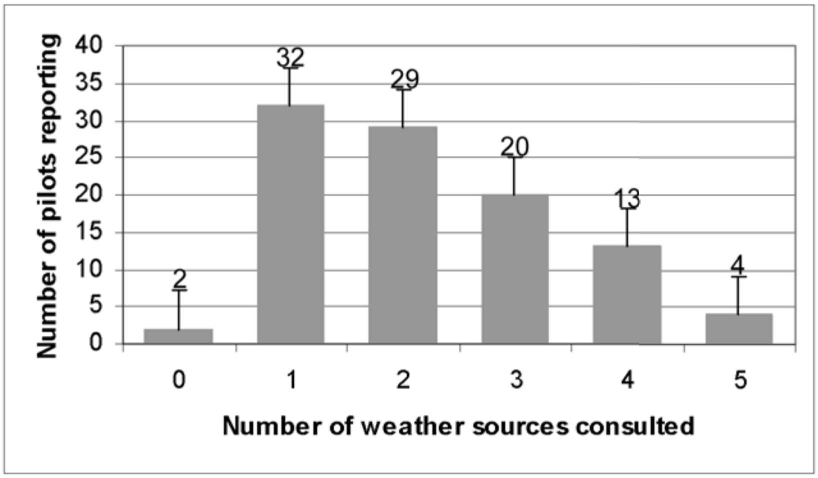

Figure 4. Number of weather sources consulted across the entire (N=100) group. Error bars reflect 1.0 standard error of the mean (group standard deviation/sqrt[N]). So, to estimate if one bar is significantly different from another, we compare the size of the difference between 2 data bars to the height of their error bars. A rule of thumb is that a data difference of twice the height of the larger error bar represents significance at $p < .05$.

Table 2. Frequency counts of current report's weather-use data compared to baseline usage.

Weather information source	Acronym	Current usage	Baseline usage*	Pilots who used only 1 source (n=32)**
(Automated) Flight Service Station	FSS	55	55	16
Direct User Access Terminal System	DUATS	33	37	2
Nat'l Oceanic & Atmospheric Admin/Nat'l Weather Service	NOAA/NWS	29	41	2
Commercial vendors		22	23	3
The Weather Channel	TWC	21	22	2
En-route Flight Advisory Service	Flight Watch	17	24	0
Pilot Reports	PIREPs	11	18	0
Pilots' Automatic Telephone Wx Answering Service	PATWAS	6	0	0
Transcribed Wx Broadcast (automated FSS telephone brief)	TWEB	4	0	2
Hazardous In-Flight Wx Advisory Service	HIWAS	2	11	0
Mean sources used per-capita		2.0	2.3	1.0
Correlation of this report with baseline = **.91** (p<.001, 2-tailed, Spearman's rho), with single-source pilots, rho = .56 (p=.094)				

* From Knecht (2005), adjusted for the different number of pilots in that study, to allow comparison with current study.
**Five single-source pilots reported using "Other" sources (not listed here).

Table 3. Forecast accuracy deterioration over time.

Actual "same-as-forecast" wx values v. expected values

	Actual	Expected
Departure	66	49.33
En-route	45	49.33
Destination	37	49.33
Column totals	*148*	*148*
χ^2	$p < .011$	

Table 4. Overall forecast accuracy.

Actual weather, as compared to predicted (expected values in parentheses)

	Better than	Same as	Worse than	Row totals
Departure	8 (13.5)	66 (66)	19 (13.5)	*93*
En-route	5 (20.0)	45 (45)	35 (20.0)	*85*
Destination	10 (24.0)	37 (37)	38 (24.0)	*85*
Column totals	*23*	*148*	*92*	N=263
χ^2	$p < .00001$			

Supporting Analysis—Whole-Group

ASRS Report

A detailed report of the data with summary analysis is available on-line from ASRS. This is entitled *General aviation weather encounters* (ASRS, 2007). Readers interested in getting the broadest possible view of these data are advised to consult that report. It is not the purpose of the present report to simply duplicate the ASRS findings but, rather, to expand on them.

Nature of the Weather Encountered

Lighting. The current data support the notion that low light is a hazard to GA flight, as reflected by the rate of incidents. By our tally, 79% percent of these incidents occurred during daylight, 4% at dusk, and 17% at night.[13] If we plausibly combine our dusk and night categories to create a "low-light" category, this 4+17 = 21% is significantly greater than the 13% normal, uneventful night flights reported by the FAA (2006, Table 4.1) *General aviation and air taxi activity survey* (p = .024, odds-ratio, 2-tailed).

Supporting Heinrich's notion (1959) that *incidents* inform us about *accidents*, night flight also dramatically increases the risk of accidents. According to an NTSB (2005, p 21) survey of 72 weather-related GA accidents, about 41% occurred at night and 59% during daylight (p = 1.53E-10, odds-ratio, 2-tailed).

Oddly, our low-light data are also significantly greater than the Rockwell et al. (1981) ASRS data, which reported just 12 of 177 (7%) GA incidents being at night (p < .001, odds-ratio, 2-tailed). Whether this reflects a reliable increase in the rate of night incidents from 1981 to 2007 is highly questionable, though. Two time samples alone cannot tell us enough about normal year-to-year variation.

Types of weather encountered. Next, Table 1 summarizes the types of weather these 100 pilots encountered.

Examining Table 1, what strikes us is the large number of pilots who encountered *multiple weather types* during their single incident, as Figure 3 shows.

Only 15 pilots reported encountering a single weather type during their incident. The mode and median were both 3, meaning *most pilots encountered multiple weather types in these incidents.*[14] *This seems logical; the more kinds of danger we face, the more likely we are to have a negative outcome.*

Information Quantity and Quality in Weather Information Briefings

Adequacy of preflight briefing. Probably the simplest explanation we could suggest for any incident would be if the pilot had just failed to get adequate preflight and/or in-flight weather briefings. Therefore, we examined these pilots' weather-source usage for any such evidence.

Only 1 of 100 pilots reported *not* requesting a preflight briefing. Another said he had tried but was unsuccessful. Superficially, this seems like most pilots requested a weather briefing. However, a crosscheck with other data categories eventually revealed 3 more pilots reporting no weather source, making a total of *5 pilots strongly suspected of not getting an adequate preflight briefing*.

Looking deeper, Figure 4 shows the number of weather sources reportedly used by pilots on the day of their incident.

Nearly one-third (32/100) of the pilots reported using only a single preflight information source. This could have been a problem, particularly for a cross-country flight—if that one source were informationally sparse or outdated. Keep in mind that a "source" such as the Flight Service Station potentially provides far more information than one such as AWOS. Not all sole-source briefings are of equal quality.

To examine this more deeply, Table 2 compares the current preflight and in-flight weather information source usage patterns to a previous study of 221 GA pilots who had *not* had a recent incident or accident (Knecht, 2008a). By comparing incident pilots to non-incident pilots, differences might be seen.

In Table 2, the column labeled "Current usage" lists total numbers of pilots in the current study who reported having used the weather information source listed in each row. Note that the numbers reported can exceed the number of pilots, since each pilot may use more than one source. The "Baseline usage" column shows corresponding usage from Knecht (2008a). These first two columns can therefore be compared. Likewise, the final column shows usage only for the 32 current-study pilots who reported using just one information source. As stated, these could represent a problem, *if* that one information source were relatively low-quality.

In Table 2, a strong correlation between "Current usage" and "Baseline usage" would suggest that, *as a group*, the current pilots used numbers and kinds of weather information sources significantly similar to ones typically used by other pilots. Indeed, this is the case (Spearman's *rho* (ρ) = .91, p_ρ = .0002, 2-tailed). Consequently, at the group level, there is nothing to suggest abnormality in the current pilots' choices of weather information sources.

Single-source briefees. Now, let us examine the "1-source" column, which represents the potentially more prob-

[13] Our tallies correlate very highly with the NASA ASRS report. Any small discrepancies are merely due to slightly different methods of categorizing certain kinds of data.

[14] The mode is the most-common response. The median is the number at which 50% of respondents fall above, 50% below. The mean is the numerical average. When responses are smoothly and evenly distributed around the average, the mean is preferred. Otherwise, the mode and median are better at conveying what the "average response" looks like.

lematic sub-group of 32 pilots who used only a single briefing source. First, 16 pilots did use an FSS briefing and 2+2+3=7 more used DUATS, NWS, or commercial vendors—all high-quality sources. For those 23 there was no apparent problem.

Nonetheless, as a sub-group, these single-source pilots had a usage pattern suspiciously dissimilar to our baseline ($\rho = .56, p_\rho = .094$, 2-tailed, NS). Of the 32-23=9 remaining pilots, two reported obtaining no briefing, plus one said he briefed, but failed to mention the source, plus two more "briefed" from The Weather Channel, which is a citizen-oriented source, not an aviation source. This left a total of *five pilots who arguably received an inadequate preflight briefing*.

Forecast accuracy. Next, we checked *forecast accuracy* because weather that materializes worse than forecast can certainly create problems.

Table 3 addresses both the issue of *average forecast quality* and the issue of how weather *information quality deteriorates over time*. First, the low average predictive accuracy expected by chance (49.33%) implies that the actual number of correct forecasts for the entire group was low to start with.[15]

Second, the statistical comparison between actual and expected (chance) values ($p_{X^2} < .011$) shows that *average forecast accuracy did, indeed, deteriorate over time.[16] The "Expected" column shows values we would conservatively expect—if* the column average of 148/3 = 49.33 were a correct estimate of overall prediction accuracy, *and* one which never deteriorated over time. Comparing the actual values to those expected, we can see how the values 66, 45, 37 represent information deteriorating significantly over time.

Table 4 addresses forecast accuracy in a slightly different way.[17] If we assume that, by pure chance, an equal number of forecasts should turn out better-than-predicted versus worse-than-predicted, then we see that *significantly more of these forecasts turned out worse than expected* ($p_{X^2} < .00001$).[18]

Pilot Weather Training, Experience, and Expertise

Pilots' training and experience are important factors to explore, particularly instrument rating, general flight experience, and specific weather experience. In Table 5, the rows labeled "Median" show that *most of these pilots had little experience flying in adverse weather*, certainly in comparison to full-time professional pilots.[19]

Unfortunately, Table 5 reflects considerable missing data. Pilots seemed to have relatively little trouble remembering their total instrument hours. Yet, simulator hours and instrument approaches were a different story. It is unclear whether some pilots omitted answers for lack of a clear memory (or records), or whether the intent was to purposely withhold potentially self-incriminating information.

Therefore, Table 5 shows the data in two ways, both as means and medians based on actual data[20] (columns labeled "Actual") and also where zeros were substituted for missing values (columns labeled "Zeros"). Because of the inherent uncertainty of these data and because a small number of very high-time pilots inflated some means, medians should be considered the more informative and reliable measures of central tendency.

With that caveat, Table 5 bears out the previous assertion that most of these pilots had little experience with weather flying. Median instrument hours for even the instrument-rated pilots lay between just 42-48, with only two median instrument approaches within the past 90 days.

Oddly, these findings partially contradict the earlier Rockwell et al. (1981, p. 49) analysis of ASRS data, which concluded, "In general, the analysis of weather-related incidents involving GA did not indicate glaring deficiencies in skill or training of the GA pilot." We would not call the current pilots "glaringly deficient," of course—simply "relatively inexperienced." For the moment, we have no firm idea why our results differed with Rockwell's. Their conclusion seemed to be based mainly on their median non-instrument-rated pilot having about 500 overall flight hours and 75% of their instrument-rated pilots having more than 1500 overall flight hours. Instrument flight-related hours were not presented. Perhaps, in 1981, knowledge about the ASRS and its purpose was less widespread, resulting in a bias for mainly seasoned pilots to report incidents.

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[15] It is important to state that absolutely no aspersions are being cast on these specific weather reports or any provider who supplied them. Remember that our data sample is biased. We purposely selected a sample of weather *incidents*, not typical flights. Therefore, these reports imply nothing negative about normal U.S. forecast accuracy.

[16] We must keep in mind that, on average, *all* weather forecast accuracy decreases with time because weather is technically chaotic, therefore exquisitely dependent on initial conditions, modeling assumptions, and even rounding error during execution of computer modeling (Gleick, 1987).

[17] Tables 3 and 4 reflect a small (but not problematic) number of missing values (some pilots did not answer all the questions).

[18] To illustrate Table 4's expected values for, say, departure weather, (8+19)/2 = 13.5. This is an unconventional way of calculating the expected frequencies compared to the regular chi-square (X^2) method. However, conventional X^2 still produces the same conclusion, $p_{X^2} = .002$ (X^2 is always 2-tailed).

[19] If medians of 0 seem odd, recall that the median is the "balance point" of a distribution, the point at which half the cases fall below and half above. In the case of continuously varying quantities such as time, a median can take a continuous (non-integer) value. But in the case of discrete quantities such as instrument approaches, the median often takes an integer value. In that case, given a distribution comprised mainly of 0s, the median will be 0.

[20] In which case, means were based only upon the numbers of pilots acually reporting data.

Table 5. Pilot flight hours.

"Actual" is observed # of pilots answering. "Zeros" are values of 0 substituted for missing data.		Instrument h		Simulated under-the-hood h		Simulator h		Instrument approaches—12 mo		Instrument approaches—90 d	
		Actual	Zeros	Actual	Zeros	Actual	Zeros	Actual	Zeros	Actual	Zeros
Non-instrument-rated (n_{max}=27)	n_{basis}*	*23*	*27*	*24*	*27*	*13*	*27*	*6*	*27*	*4*	*27*
	Mean	9.4	8.0	16.3	14.5	13.1	6.3	2.2	0.5	3.7	0.4
	Median	**0**	**0**	**10**	**10**	**6**	**0**	**1.5**	**0**	**0**	**0**
	Minimum	0	0	0	0	0	0	0	0	1	0
	Maximum	120	120	55	55	70	70	5	5	5	5
Instrument-rated (n_{max} =73)	n_{basis}	*71*	*73*	*72*	*73*	*61*	*73*	*57*	*73*	*47*	*73*
	Mean	647.4	629.7	102.2	100.8	85.8	71.7	18.0	14.1	7.1	4.4
	Median	**48**	**42**	**71**	**70**	**25**	**25**	**8**	**7**	**2**	**2**
	Minimum	0	0	0	0	0	0	0	0	1	0
	Maximum	10000	10000	700	700	1000	1000	150	150	45	45
Combined (N_{max} =100)	n_{basis}	*94*	*100*	*96*	*100*	*74*	*100*	*63*	*100*	*51*	*100*
	Mean	491.3	461.9	80.7	77.5	73.0	54.1	16.5	10.4	6.5	3.3
	Median	**27**	**23**	**55**	**53**	**25**	**11**	**7**	**3**	**3**	**0**
	Minimum	0	0	0	0	0	0	0	0	0	0
	Maximum	10000	10000	700	700	1000	1000	150	150	45	45

*n_{max} is the *maximum* possible number of IR or non-IR pilots. However, not all pilots answered every question. Therefore, n_{basis} is the *actual* number of pilots who did—the *basis* of each metric—which may reflect missing data and be less than n_{max}.

In Table 5, note that 73 of the current 100 ASRS pilots were instrument rated ("n=73"). This is higher than the U.S. GA national average of 51% (GAMA, 2005). In absolute numbers, IR pilots are represented here nearly 3 times as often as non-IR pilots (73/26 = 2.81). This might tempt us to conclude that IR pilots are more at-risk than non-IR pilots ($p_{X}2 < .001$). However, a simpler alternative is, again, that instrument rated pilots may be merely more likely to be familiar with the ASRS, hence more likely to fill out a report.

One aspect of pilot experience that these data, unfortunately, do not address is the possibility that some of these pilots may have successfully taken considerable risks with weather in the past. Behaviorally, to arrive at one's destination constitutes a direct reward (*positive reinforcement*), while avoidance of damage to oneself or one's aircraft constitutes an indirect *negative reinforcement.*[21] *Such a combination of reinforcers represents a theoretical encouragement to take risks—if* a pilot had been successful at it recently. Unfortunately, it is difficult to get any person to admit, in writing, to past risky behavior, let alone a pilot who may fear the loss of his/her certification.

Equipment Factors

Who flies what? Certainly, the kinds of equipment available to a pilot influences that pilot's ability to deal with adverse weather. Here, 92 of 100 pilots shared the disadvantage of flying relatively *lightweight, highly weather-susceptible aircraft*. Seventy-nine were flying light, single-engine aircraft, six were in light twins, six in helicopters, and one flew a glider (of the remaining eight, three were corporate jets, five were turboprops).

Helicopters are overrepresented in these data. The General Aviation Manufacturers Association (GAMA, 2005) reports that 1.6% of U.S. pilots are helicopter-rated, versus 6% of this sample ($p < .001$, odds-ratio). The explanation may be simple, however: Helicopters are the vehicle of choice in air-ambulance work, which is largely in a class by itself regarding pilot and mission motivation. Mission difficulty can be high in remote or unimproved areas, and response time is almost always a factor. Ambulance pilots are highly motivated to fly, even under adverse conditions. Consequently, they can be expected to incur more than their share of bad-weather encounters. They may also be more motivated to report incidents, due to their status as commercial carriers.[22]

We next examined the relation between level of pilot training and quality of equipment. Intuition suggests that the more experienced pilots probably fly the more capable aircraft. Conversely, we expect the less experienced pilots to fly the less capable aircraft, which may be a problem.

Figure 5 graphically depicts the significant relations between human and equipment categories found in these data. Because an airplane is a "package of components," these human-equipment interrelations form a web of Spearman ρ (*rho*,[23] nonparametric) correlations.[24] Only correlations significant at $p < .001$ (2-tailed) are shown,

[21] Negative reinforcement is not punishment, as commonly thought. It is "relief from ongoing punishment." So, technically, cessation of the risk-taking pilot's *anxiety* would be the negative reinforcer in this paradigm (Macintosh, 1974).

[22] Recall that limited legal immunity is granted to pilots who file an incident report with ASRS, as long as no criminal activity or accident occurs.

[23] Do not confuse the Greek symbol ρ (rho) with the letter *p*, which is used for "probability" (e.g., *p*-value).

[24] These correlations were derived by simply summing, for each pilot, the "Equipped" scores within each major block in Section D of the interview. One point was granted for each box checked, then the number of points summed to give that pilot's score for that block. Pilot ratings were coded as 2 points for ATP, 1 point for non-ATP IR, 0 points for non-IR. Airframes were rated by the categories shown in Appendix C. Because this resulted in different maxima and minima for different factors, raw numbers were normalized to "min=0, max=10" scores before computing the correlations.

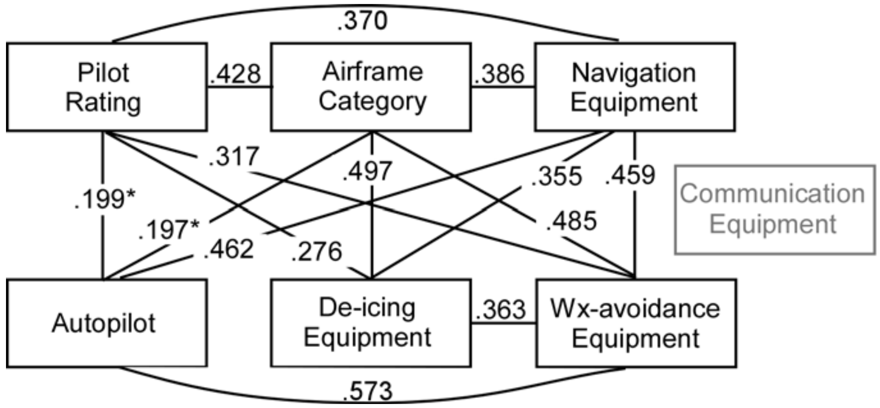

Figure 5. Correlations between major equipment types (data derived from Appendix B, section D).

Table 6. Non-weather factors contributing to the incident.

Factor	N
Decision making	**26**
Other	**23**
Time pressure	**21**
"Get-home-itis"	9
Aircraft equipment problem	8
Fatigue	7
Distraction by passenger or flight crew	5
Illness	3
Company or FBO policy	0

except for those marked with an asterisk * (p <.01, 2-tailed).[25]

In Figure 5, "Pilot rating" means either Air Transport Pilot (ATP), non-ATP-instrument-rated (non-ATP IR), or non-instrument rated (non-IR). Note that the higher the pilot rating, the better the equipment generally is. Communication Equipment shows no significant correlations with other factors because all aircraft started out with functioning communication gear, and the questionnaire did not make particularly fine distinctions between different types.

Effect sizes. Here, statistical significance is half of the issue. Significance embodies reliability, meaning repeatability. The other half is effect size (ρ^2), which estimates how much of the underlying variation in scores is explained by the relation itself (e.g., $.573^2 = .328 \approx 33\%$ of the total score variation explained). The ρ^2 (not shown) here all imply that, while all these relations are reliable, they are modest in strength.

In short, Figure 5 shows a modest-but-reliable tendency for the higher the pilot's rating, the more likely he or she is to fly a more expensive, better-equipped aircraft. Finally, note that the presence of ATPs here demonstrates that even the best-trained pilots, flying superior equipment, can still wind up having occasional trouble with weather.

Non-Weather-Related Factors

Sixty-three percent of pilots reported additional "factors other than weather that contributed to the incident." These came in all shapes and sizes. Table 6 briefly summarizes.

These are all recurring themes familiar to accident investigators. The concern about "Decision making," as stated earlier, is that this is a very broad category and one that does not suggest specific remedies.

Time pressure is certainly a perennial issue. The ASRS (2007) report offers more detail than we shall cover here. However, we can add that a prior study of pilots who had not been involved in any sort of incident (Knecht, 2008b) revealed that at least 48 of 221 (22%) experienced external social or business-related pressures to fly in marginal weather at some point in their careers.

The rest of the factors in Table 6, although less prevalent here, are also well-known. Many of these "Other"-category responses are captured in the textual responses to Section F of the interview (Appendix B).

Recovery Strategies

As a group, these pilots seemed to prefer some recovery strategies over others. Table 7 shows the most popular. These are rank-ordered by frequency of occurrence (note that some pilots used more than one recovery strategy, so that the sum of the "Totals" row will exceed 100).

[25] Note that the sheer amount of communication equipment pilots have typically has little or no relation to anything else examined here, which explains why there are no links to that factor.

Table 7. Recovery strategies.	Descended to stay below wx	Other	Landed at destination	ATC offered assistance	Deviated around wx	180-degree turn	Instrument approach	Requested IFR clearance from ATC	Climbed above wx	Broke out on top	Landed enroute (other than alternate)	Landed at alternate
Totals	**34**	**25**	**23**	**21**	**20**	**19**	**16**	**14**	**13**	**12**	**12**	**11**
Rank of totals	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*10*	*11*

Overall, there are significant differences between categories here ($p_{\chi^2} = .004$). Yet, it is difficult to say exactly which categories differ significantly from which other categories because there are so many possible comparisons. The "Other" category is a potpourri, not a unitary entity, so landing at destination was actually the second-highest ranked category, and so forth.

We will return to the topic *recovery strategies* later, after we have a better grasp of how best to organize the data.

Summary of Whole-Group Analysis

Preliminary Statistical Summary

At this point, let us pause briefly to summarize the whole-group results for these N=100 pilots reporting these ASRS weather-related incidents. Reported "themes" could be characterized as:

1) Darkness
2) Moisture affecting visibility (clouds, fog, rain, snow) and/or *air movement* affecting aircraft handling (thunderstorm, icing, turbulence)
3) Multiple weather factors experienced simultaneously
4) Inadequate preflight weather briefing
5) Deterioration of *weather forecast accuracy* over time
6) Weather that materialized *worse than predicted* (this implicitly includes lack of en-route forecast updates)
7) Lack of weather-related training and experience (non-instrument-rated and new instrument-rated pilots)
8) Air ambulance missions (particularly helicopter ambulance)
9) Aircraft *lacking substantial weather information/handling/avoidance equipment*
10) Non-weather-related, *compounding factors* (e.g., time pressure, "get-home-itis," fatigue)

Parsing the Group Data on the Basis of This Preliminary Analysis

The above look at the whole-group data was certainly useful. Next, it was logical to wonder if there were some way to sub-divide the data into some simple, logical categories, after which additional themes and issues might become easier to see.

This approach follows a certain logic. For instance, Burian (2001) reported that ATPs and certified flight instructors (CFIs) differ significantly from non-instrument-rated (private) pilots in weather knowledge. That kind of distinction is useful as a heuristic in accident investigation because it can help guide an investigator in looking for specific details during a given accident. Knowing whether the pilot were, say, an ATP might prompt us to ask certain questions we might otherwise avoid, since ATPs are likely to be highly trained and experienced.

Parsing the data by pilot rating. The idea of sub-dividing our data by pilot rating was first supported by a hierarchical cluster analysis (HCA).[26] Normally, HCA is used with continuously varying (as opposed to discrete, e.g., integer) data. However, Finch (2005) suggested that HCA can be acceptably per-formed on binary data (the yes/no kind we have here). HCA calculates a "mathematical distance" between patterns of data, thereby sorting individual cases into dissimilar groups composed of similar cases.

Detailed discussion of the HCA will be omitted here for reasons of brevity. However, HCA strongly suggested dividing the data into the following three main groups, based on training and experience.[27]

1. air transport pilot—ATP
2. non-ATP instrument-rated pilotsnon—ATP IR
3. non-instrument-rated pilotsnon—IR

That stated, we can detail major characteristics of each group, as supported by the data, beginning with the non-IR group.

Non-Instrument-Rated Pilots

Weather Training and Experience

When it comes to non-IR pilots and weather, two obvious candidate problems are *lack of training and experience*. As previously stated, Rockwell et al. (1981) implied that these were not a factor in their data. However, Table 5 has already challenged that conclusion. Figure 6 gives a

[26] Cluster analysis is an approach to modeling. It starts with a set of measurements ("variables") taken on individuals ("cases"—here, individual pilots). It then explores the relations between variables by combining individual cases into groups ("clusters"). The end goal is to group cases so that those within the same cluster are more similar to each other than they are to cases from different clusters. This similarity is operationalized by calculating "mathematical distances" between cases and clusters. Once complete, it becomes our job to interpret what each cluster means in logical and practical terms.

[27] Individuals requiring details of the HCA may directly contact the first author of this report.

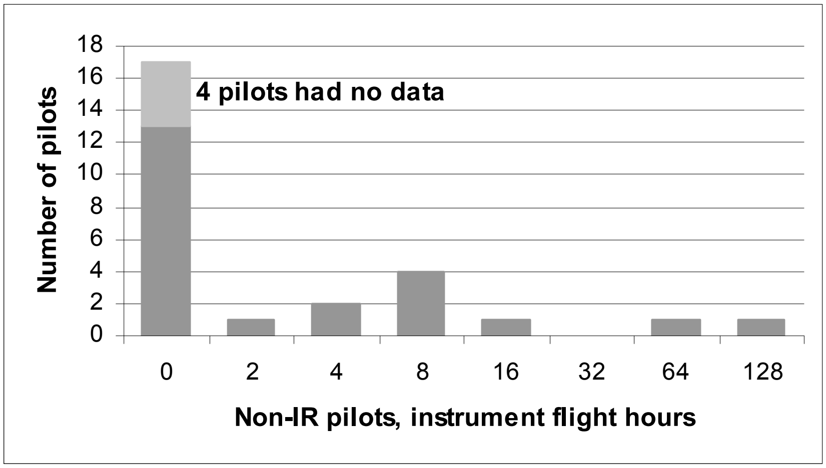

Figure 6. Numbers of non-instrument-rated pilots (vertical axis, linear scale), grouped by instrument flight hours (horizontal axis, logarithmic base-2 scale).

more detailed look at non-IR pilots' actual instrument flight hours.[28]

Unsurprisingly, the median non-IR pilot had zero instrument hours and zero instrument approaches. Of the 27 non-IR pilots, 12 said they were currently working to obtain an instrument rating. However, at the time of their incident, 13 said they had no actual instrument hours. Four failed to answer the question, so there were perhaps as many as 17 with no actual instrument hours. Only 7 pilots had even 8 h or more. Granted, "no instrument hours" does not necessarily mean "no weather experience." But, we can only analyze the data at hand.

These *non-IR pilots arguably constitute a major target group*—over 20% of our total 100 incidents. By definition, non-IR pilots are supposed to see and avoid weather. With a limited "license to learn," other than from written and video training materials or when accompanied by an instructor or IR copilot, how can weather training and experience logically *not* be a relevant issue when these pilots find themselves caught in adverse weather?

One aspect of risk-taking has to do with whether a relatively inexperienced person will engage in a given behavior, knowing full well that there is risk involved. In our case, that meant a non-IR pilot taking off into forecast marginal visual meteorological conditions (MVMC) or worse.

Moreover, here, only nine pilots reported having visual meteorological conditions (VMC) forecast for all three phases of their flight. That means that *two-thirds of these non-IR pilots must have known that they were taking some risk.*

[28] A non-IR pilot can accrue flight hours as a student or when accompanied by an IR pilot.

Equipment

Non-IR pilots tended to fly the least weather-capable aircraft. Three categories of equipment that make an enormous difference in weather-handling ability are (a) weather-avoidance electronics (e.g., on-board weather radar, NEXRAD), (b) physical de-icing and anti-icing systems for lift, control, and thrust maintenance, and (c) attitude-stabilization equipment (autopilot, wing leveler). Of the 27 non-IR pilots,

- 89% had no major weather-avoidance electronics (weather radar, lightning detector/Stormscope, and so forth).
- 89% had no de-ice, anti-ice, or other related physical systems.
- 56% had no autopilot or wingleveler.

This pattern differs significantly from the other two pilot groups we will be discussing, mainly in weather-avoidance electronics. Eighty-nine percent of non-IR pilots lacked weather-avoidance electronics, versus 50% of ATPs, and 62% of non-ATP IRs ($p_{X}2$ = .012). There was a similar trend[29] in anti-icing systems (89% non-IR lacking them, vs. 61% ATP, vs. 71% non-ATP IR, $p_{X}2$ = .085).

Figure 7 shows how many pilots had 0, 1, 2, or all 3 equipment categories missing. Of course, the final subgroup is the least equipped to handle serious weather. Unfortunately, it is also the largest (n=14).

No non-IR pilot reported being completely without communication equipment. One pilot did report having no navigation equipment.

[29] A statistical "trend" is generally defined as one where $.05 < p \leq .10$.

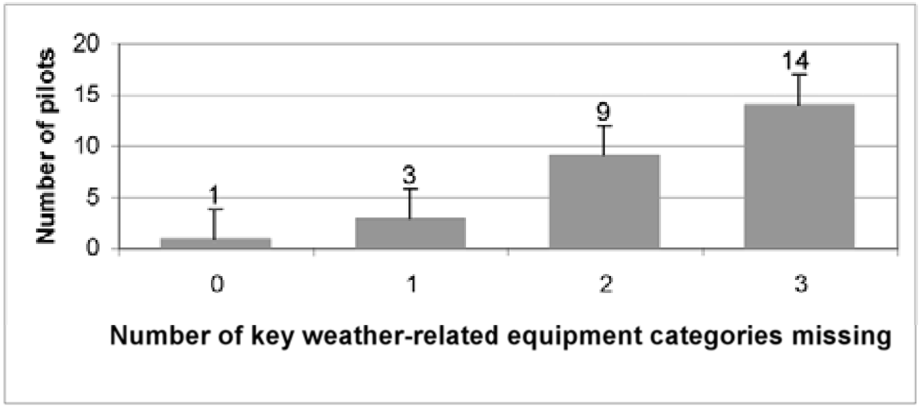

Figure 7. Numbers of non-IR pilots (vertical axis) lacking one or more categories (horizontal axis) of either weather-avoidance electronics, de-icing capability, and/or autopilot/winglever.

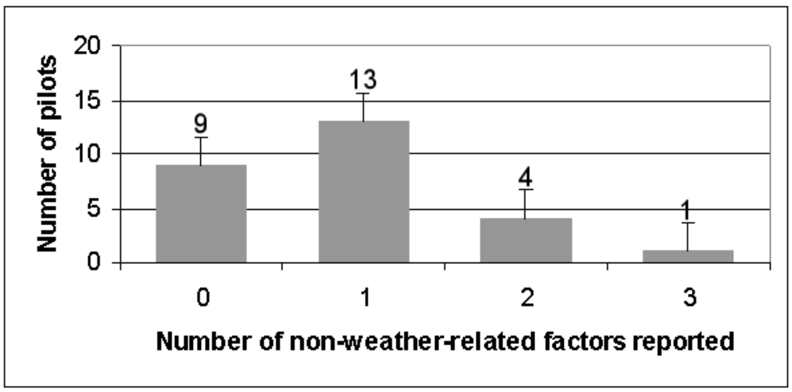

Figure 8. Numbers of non-IR pilots (vertical axis) reporting the number of non-weather-related factors (horizontal axis) that contributed to their incident.

Non-Weather Factors

Non-weather factors exacerbated weather factors. As we saw in Table 6 earlier, we needed a miscellaneous "Other" category to hold explanatory factors not fitting neatly under other categories. We expected there to be factors unrelated to weather that, nonetheless, helped to cause each incident.

Figure 8 shows frequency distributions for the 27 non-IR pilots concerning non-weather-related factors listed as influencing their incident.

Nine pilots said that such factors were not a consideration, while 18 (67%) said they were. Of the 18, 13 blamed a single factor, 4 blamed 2 factors, and a single individual blamed 3 factors.

Looking deeper, the two non-weather-related factors most commonly blamed by non-IR pilots were "decision making" (44%) and "time pressure" (22%). Additionally, of the sub-group of 5 pilots reporting 2 or more factors, 4 reported *both* decision-making and time pressure. This naturally leads us to speculate that time pressure and decision errors are related. There is certainly a large body of literature in psychology to support that idea (Orasanu & Martin, 1998).

Crosscheck With "Stories"

Section F of the ASRS interview allowed pilots to tell, in their own words, why the incident occurred. These "stories" should at least be consistent with the statistical data.

Straight to the point, little in these stories directly contradicted our main points. The major trouble with the stories themselves was the large number of them (Appendix D contains a synopsis). We needed a systematic way to organize them. One sensible way seemed to be by mission category, hence, that is how Appendix D is organized.

Summary—Non-Instrument-Rated Pilots

- Least training and experience
- Least-capable equipment
- Tended to fly despite bad weather forecast

Table 8. ATP versus non-ATP instrument-rated pilots—flight experience.

Category (median values)	ATP	non-ATP IR	p_U, 2-tailed	n_{ATP} (Missing)	$n_{non\text{-}ATP\ IR}$ (Missing)
Flight hours	11000	900	.0000001	17 (1)	54 (1)
Instrument hours	255	35	.004	18 (0)	53 (2)
Instr. approaches, past 12m	9	8	.992 (NS)	13 (5)	42 (13)
Instr. approaches, past 90d	3	3	.828 (NS)	14 (4)	32 (23)

Instrument-Rated Pilots

In contrast with the 27 non-instrument-rated pilots, the 73 instrument-rated pilots seemed almost confusingly diverse, especially when one looked at their stories (Appendix D). A way was needed to organize this diverse group into more meaningful sub-groups. As stated previously, analysis and logic suggested dividing the instrument-rated pilots into two sub-categories: the 18 who held the ATP certificate versus the 55 who did not.

Air Transport Pilots

As a group, *air transport pilots have the highest level of training and experience* of any major certificate available to civilian airmen and are the group most likely to be working as professional pilots. Of these 18 ATPs, 8 were flying as private individuals at the time of the incident. The other 10 were on the job, 4 flying under corporate auspices, 3 more as air taxi, and 3 as charter.

Table 8 provides more statistical support for why we should formally distinguish between ATP and non-ATP IR pilots.[30]

These ATPs reported 12 times higher median flight hours than the remaining instrument-rated pilots (11000 v. 900 h, p_U =.0000001). Instrument hours are also significantly different (p_U=.004). At first glance, the picture may seem different for 12-month (12m) and 90-day (90d) recency of experience in instrument approaches; no reliable differences are evident. But, unlike flight hours and instrument hours, the recency data are contaminated by large numbers of missing values. If all pilots had reported, the results may have been more consistent.[31]

As we saw in Figure 5, a*dvanced-certificate pilots tended to fly more capable aircraft*. We shall return to this point later.

One point of interest here is whether ATPs may be overrepresented or underrepresented in these data, compared to the national pilot population. The answer is that 18% of our pilots were ATPs versus about 23% of U.S. pilots (GAMA, 2005). This is not a significant difference (p_{χ^2} = .21, NS).

However, we need to keep two more things in mind. First, ATPs are arguably the group most likely to be familiar with the ASRS, thus to file incident reports. If correct, that would suggest that their true population *rate* of incidents may actually be less than other groups. Second, given that ATPs typically fly many *more miles* than other pilots, their effective *"incidents-per-mile-flown" rate* may actually be quite small compared to non-ATPs. While this logic is speculative, it would be worthwhile to pursue at a future date because it speaks to the effectiveness of training in reducing risks.

Now, what more in our data distinguishes ATPs from other instrument-rated pilots?

Table 9 shows significant differences between ATPs and non-ATP IR pilots found in these data. These are presented as sample means ($\bar{x}$), mean differences (deltas = $\Delta\bar{x} = \bar{x}_{atp} - \bar{x}_{non\text{-}ATP\ IR}$), and selected *p*-values (Fisher's exact test, 2-tailed). Table 9 shows every question on the interview where $|\Delta\bar{x}| \geq .25$. A few of these differences seem too complex to interpret, but the following points emerged as logical candidate differences between ATPs and non-ATP IR pilots:

1. More ATPs tried to deviate around adverse weather to avoid it ($p_{Fisher's\ 1\text{-}tailed}$ = .045).[32]
2. More ATPs used GPS and Weather Radar, and at least had Terrain Warning System.
3. More *non*-ATP IRs may have felt that the average en route and destination weather they had encountered in the past during most instrument flights was better than forecast.

Point 1 addresses a successful weather strategy used by top pilots. They are able to *deviate around weather*.

Point 2 addresses equipage. *The more weather-capable the aircraft, the better—as long as this does not encourage the pilot to take on additional risk.*

Point 3 addresses a possible attitude toward risk acceptance. While speculative because of marginal significances (.053, .084), it may be that *pilots who routinely encounter better-than-forecast weather recalibrate their expectancy of success upward, and wind up eventually getting caught for it,* as evidenced by this incident. Such a Bayesian

[30] Our group means were skewed by small numbers of high-hour pilots, so we compared groups with nonparametric Mann-Whitney U-tests. The terms n_{ATP} or $n_{non\text{-}ATP}$ refer to the number of pilots providing data in each respective category. (Missing) refers to the number who failed to provide data in that category (therefore, all n_{ATP} cells sum to 18 in the second-to-last column and all $n_{non\text{-}ATP}$ cells sum to 55 in the last column).

[31] If we redo Table 8's "past-12m" analysis substituting zeros for all missing values, we arrive at a trend of .076 in favor of ATPs.

[32] Use of the 1-tailed test is justified on the a priori assumption that ATPs would try more often to deviate around weather.

Table 9. ATP versus non-ATP instrument-rated pilots—other distinguishing features.

	N	Deviating from planned route during incident?	Encountered deteriorating wx ahead	Encounter consequences = "Other"	Recovered by deviating around wx	Had & used Dual VHF transceiver	Used GPS	Had Terrain Warning System	Used Weather Radar	Actual enroute wx on most instrument flights better than forecast	Actual destination wx on most instr flts better than forecast
	N	Section B		C		D				E	
$\bar{x}_{atp}$	18	0.67	0.61	0.50	0.44	0.89	0.94	0.39	0.33	0.06	0.17
$\bar{x}_{non\text{-}ATP\ IR}$	55	0.40	0.33	0.24	0.16	0.64	0.65	0.05	0.05	0.33	0.45
$\Delta\ \bar{x}$		0.27	0.28	0.26	0.28	0.25	0.29	0.33	0.28	-0.27	-0.29
p, 2-tailed		0.061[1]			0.024[1]		0.016[2]	0.001[2]	0.006[2]	0.053[3]	0.084[3]

Subscripts [1, 2] and [3] in the row above refer to list factors 1-3 in the text below.

"prior-history model"[33] may help explain "optimism bias," wherein pilots overestimate their own skill (O'Hare, 1990, Goh & Wiegmann, 2001, Wilson & Fallshore, 2001).

Most of this looks as if ATPs are the safer IR pilots. The one exception has to do with thunderstorm encounters. Four of 18 ATPs reported close encounters with thunderstorms, versus just 1 of 55 non-ATP IRs. This difference ($p_{Fisher's\ exact} < .012$, 2-tailed) is significant, statistically and implicationally. This may suggest that, when it comes to extremely deadly weather, some ATPs may be "selectively overconfident," although we need to interpret this cautiously.

Summary—ATPs

- Highest level of training and experience.
- Most-capable equipment.
- Most likely to deviate around weather and most successful at doing so.
- However, most likely to have a negative encounter with thunderstorms.

Non-ATP IR Pilots

This third major expertise group is the most difficult to characterize. Whereas the non-IR pilots typically have the least training, the least experience, and the least sophisticated equipment, and the ATPs tend to have the most of those, the 55 non-ATP IR pilots are "neither fish nor fowl." They have great diversity within their ranks and perhaps require the deepest scrutiny to understand and characterize.

One technique we can use with our data is to *threshold* them, meaning to filter the group averages to pull out the very smallest and very largest numbers.[34] This highlights extremes, which are theoretically categories of maximum information.

To complement thresholding, we will also consider each interview question separately, pulling out ones we know from either logic or prior analysis to be interesting, no matter what their value. While this is time-consuming, it is necessary in order to be thorough.

The first part of the callback interview (Appendix B, Section A) concerned flight planning and weather briefing. When we threshold the Section A group averages, what survives the filter is that all 55 non-ATP IR pilots reportedly tried to obtain a pre-flight weather briefing, and 32 (58%) briefed with FSS. Additionally, all pilots who used The Weather Channel also used at least one other source to brief. None of this indicates any particular problem with preflight briefing.

Looking deeper, the preflight forecasts showed 5%, 15%, and 13% of departure, en route, and destination forecast as IMC, respectively. This constitutes forecasted risk. However, these are IR pilots, so IMC is no prohibitor by itself.

Looking deeper still, we see that two pilots had IMC forecast for all three phases of flight (departure, en route, and destination). Additionally, five had thunderstorms predicted for one phase, and one had them predicted for two phases. Yet, again, thunderstorm *predictions,* alone, do not constitute automatic refusal for non-ATP IR pilots. Again, what they constitute is forecasted *risk*.

[33] Bayesian models form "If-Then" tree structures, each with associated probabilities-of-occurrence. They assume that prior success or failure probabilities influence current behavior.

[34] The lower bound for thresholding used here was "all questions with a group average of 10% or less." The upper bound was "all questions with 50% or greater." Be apprised that these are arbitrary values based mainly on logic, not expected *p*-values.

Table 10. Non-ATP IR pilots facing worse-than-predicted weather.

Phases of flight, actual wx worse than predicted	**0**	**1**	**2**	**3**
n (total=55)	19	25	9	2

Next, we can try to assess "cumulative forecast error." Table 10 shows that 36 non-ATP IR pilots (65%) wound up facing worse-than-predicted weather during one or more of the three phases of flight (departure, en route, or destination).

Worse-than-predicted weather is a problem. Note how nine pilots received a double-dose of misfortune and two a triple dose. This reiterates the theme of "bad-luck weather" we saw earlier in the whole-group analysis.

Of course, the obverse of bad luck is bad judgment. If 65% of non-ATP IR pilots could attribute their incident at least partly to bad luck, that means the remaining 35% logically could not. Assuming that the predicted weather was bad enough to warrant at least thinking about cancelling the flight—and this is not unreasonable, given that all these flights ended in weather-related incidents—*as many as one-third of non-ATP IR pilots appeared to know they were taking a risk, yet they took it anyway*.

Section B of the callback interview concerned information about the actual weather at the time of the incident, plus the use of ATC services. Here, we saw that 67% of ATPs tried to deviate around the weather, versus 40% of non-ATP IRs (we will return to this point later). Consequently, 53% of non-ATP IRs ended up flying straight into clouds or fog, and 51% encountered lowering ceilings (27% encountered both). Fortunately, only a single pilot ran into a thunderstorm, which, oddly enough, was a better record than the 4 ATPs who did run into one (p = .008, odds-ratio).

All this suggests that *non-ATP IR pilots may be overly bold about intermediate-severity weather*. But, they may actually do better than ATPs when it comes to taking severe weather seriously.

Sixty-two percent of non-ATP IRs said they attempted to obtain en route ATC assistance. This may not reflect a problem since the figure is about the same as ATPs (67%), and both are higher than non-IR pilots (52%). If it does reflect a problem, then all GA pilots are probably about equally involved.

Summary— Non-ATP IR Pilots

- May be susceptible to "prior history effect," where pilots who routinely encounter better-than-forecast weather recalibrate their expectancy of success upward and wind up eventually getting caught.
- Tend to be overconfident in the face of intermediate-severity weather.
- More likely to fly straight into adverse weather, rather than deviate around it.

Group Pattern Differences

Now that we have learned to divide our pilots into three meaningful groups—(IR-ATP v. IR-non-ATP v. non-IR)—another useful statistical technique is to look for between-group differences on each separate interview question. With the data split in three, each interview question can now generate three separate means, one per pilot group, and we can examine high or low values, question by question. These can be organized into patterns representing themes, as Table 11 illustrates.

Using a chi-square (X^2) technique, we can compare expected counts (not shown) to actual counts (shown as proportions for easier interpretation) and then generate a probability estimate $p_{X}2$ for that pattern of occurrences. This lets us filter only those interview items revealing statistically significant high or low probabilities-of-occurrence (p<.05). These cells are highlighted in gray to "pop-out" visually.

The pattern differences that emerge in Table 11 are organized into themes. Starting with the top half of Table 11 and moving left-to-right, the first theme is labeled "Deception?" The question mark indicates that this is speculation. But, its three components suggest that some non-IR pilots may be "lying by omission" after mysteriously leaving several other key interview questions blank. Assuming that these omissions mean something, the notion that the least-experienced group might be prone to self-misrepresentation is certainly worth some consideration.

Next (unlabeled column), we note a problem discussed earlier, namely, ATPs flying into predicted thunderstorms. We will rejoin that theme later in the Discussion section.

Next, the"Flightplan" column suggests that non-IR pilots tended not to file flight plans. However, this was not illegal and may not mean much; the non-filing pilots were predominantly on pleasure flights.

Next, the "Weather" column suggests that ATPs encountered significantly more ground fog, while non-ATP IR pilots encountered more icing (simultaneously while lacking ice-capable aircraft). There is no obvious explanation in the data for either of these results; it may be serendipity.

Turning to *unpredicted* thunderstorms, we see a standout *low*-incidence group in the non-ATP IR pilots. By default, the numbers leave us with a relatively high incidence rate for ATPs (22%), which we previously mentioned, plus a moderate incidence (15%) for non-IR pilots. And, since all four non-IR thunderstorm encounters happened during pleasure flights, this raises a question about non-IR decision-making during pleasure flights.

Table 11. Significant group pattern differences between ATPs, non-ATP IR, and non-IR pilots (numbers represent proportions).

			Deception?				Flightplan		Weather			ATC		Consequences				Recovery	
	Air transport pilot?	Instrument rated?	Preflight weather forecast "Don't recall"	Enroute weather forecast "Don't recall"	Destination forecast "Don't recall"	Destination forecast thunderstorm	Did NOT file a flight plan	Filed an IFR flight plan	Encountered ground fog	Encountered icing	Encountered thunderstorms	Requested IFR clearance from ATC	Requested instrument approach from ATC	Aircraft equipment problem contributed to incident	Lost/unsure of position during incident	Experienced loss of control during incident	Incident resulted in "Other" consequences	Deviation around weather enabled recovery	Landing at alternate enabled recovery
μ_{ATP}	Y	Y	0.06	0.11	0.06	**0.28**	0.44	0.44	**0.17**	0.06	0.22	0.22	0.06	0.00	0.00	0.00	**0.50**	**0.44**	0.11
μ_{nATP}	N	Y	0.00	0.05	0.04	0.04	0.38	0.40	0.02	**0.25**	**0.02**	0.24	**0.25**	**0.15**	0.11	0.02	0.24	0.16	0.04
μ_{nIR}	N	N	**0.15**	**0.37**	**0.22**	0.04	**0.81**	**0.00**	0.04	0.04	0.15	**0.00**	0.04	0.00	**0.33**	**0.15**	0.07	0.11	**0.26**
pX^2			*0.02*	*0.00*	*0.03*	*0.00*	*0.03*	*0.00*	*0.05*	*0.03*	*0.02*	*0.04*	*0.03*	*0.04*	*0.01*	*0.03*	*0.02*	*0.03*	*0.02*
μ_{ATP}	Y	Y	0.00	**0.89**	**0.17**	**0.11**	**0.17**	0.00	**0.17**	**0.11**	**0.17**	**0.39**	**0.39**	**0.33**	**0.17**	**0.33**	**0.56**		
μ_{nATP}	N	Y	0.18	0.64	0.02	0.00	0.02	0.24	0.00	0.00	0.00	0.05	0.09	0.05	0.00	0.15	0.33		
μ_{nIR}	N	N	**0.33**	0.26	0.04	0.00	0.04	**0.48**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04		
pX^2			*0.04*	*0.02*	*0.05*	*0.01*	*0.05*	*0.01*	*0.00*	*0.01*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.04*	*0.00*		
			Single VHF transceiver-equipped	Dual VHF transceiver-equipped	HF transceiver-equipped	ACARS-equipped	Skyphone-equipped	Single VOR receiver-equipped	INS/IRS-equipped	INS/IRS used	Integrated area navigation-equipped	Terrain Warning System-equipped	Weather Radar-equipped	Weather Radar used	Wing/tail bleed-air anti-ice-equipped	Engine (air) inlet anti-ice-equipped	Approach-capable autopilot-equipped		
			Com					Nav					Avoidance		De-ice		A/P		

Regarding ATC issues ("ATC" column), the 0% requests for IFR clearance from non-IR pilots is trivial because non-IR pilots are not allowed to request IFR clearance. The higher non-ATP IR instrument approach request rate probably just reflects their not having filed IFR flight plans in the first place.

Regarding the "Consequences" column, it is something of a mystery why 15% of non-ATP IR pilots reported equipment problems versus 0% for the other two groups. Perhaps non-ATP IRs fly older aircraft or have more equipment than the non-IRs because they need it, yet lack a corporate employer to keep it all in tip-top shape.

Next, regarding the issue of disorientation, it comes as no surprise that 33% of the non-IR pilots became unsure of where they were during the incident, and 15% experienced loss of control. After all, this is our least-trained, least-experienced, poorest-equipped group.

Next, 50% of ATP incidents resulted in "Other" consequences. This category involves idiosyncratic behaviors and unique events, making statistical analysis unreliable.

The final column in Table 11 concerns "Recovery." This addresses problem-solving styles. We know that different pilots have different styles when it comes to weather. For instance, Ball (2008) found that pilots tended to be either "tactical thinkers" or "strategic thinkers," depending on whether they tried to pick their way through weather cells or tended to avoid lines of weather entirely.

Now let us take a brief, expanded look at preferred recovery strategies in before returning to finish discussing Table 11.

Table 12 implies that, when it comes to recovery strategies, "instrument-rated pilots seem to think alike." To understand this, note how the proportions in the dark-highlighted "ATP" row often appear similar to those in the "non-ATP IR" row immediately below it. These two rows correlate significantly ($\rho_{ATP\text{-}nonATPIR}$ =.632, p_ρ=.028, 2-tailed). However, the non-IR pilots' decision pattern (row) resembles neither of the other 2 rows ($r_{ATP\text{-}nonIR}$ = -.273, p_r=.390, NS and $r_{nonATPIR\text{-}nonIR}$ = -.068, p_r=.834, NS).[35] The correlation between ATP and non-ATP IR supports the assertion that instrument-rated pilots think alike. If reliable, these patterns would further support the idea that instrument-rated and non-instrument-rated pilots need to be treated differently because they recover from weather differently.

[35] In Table 12, proportions are calculated by dividing cell frequencies by the number of pilots in that category (e.g., 7 of 18 ATPs descended to stay below weather, so 7/18 = .39). Between-group tactical pattern similarity is based on Spearman rank-order correlation between each of the three pilot group's cell frequencies across 10 categories of recovery strategy (the category "Other" is excluded because it is not unitary).

Table 12. Recovery strategies, grouped by pilot rating.

		N	Descended to stay below wx	Other	Landed at destination	ATC offered assistance	Deviated around wx	180-degree turn	Instrument approach	Requested IFR clearance from ATC	Climbed above wx	Broke out on top	Landed enroute (other than alternate)	Landed at alternate
	Whole-group totals	100	**34**	**25**	**23**	**21**	**20**	**19**	**16**	**14**	**13**	**12**	**12**	**11**
By frequency	ATP	18	7	5	5	3	8	3	4	4	1	2	4	2
	non-ATP IR	55	20	14	14	12	9	9	10	10	7	4	3	2
	non-IR	27	7	6	4	6	3	7	2	0	5	6	5	7
By proportion	ATP		0.39	0.28	0.28	0.17	0.44	0.17	0.22	0.22	0.06	0.11	0.22	0.11
	non-ATP IR		0.36	0.25	0.25	0.22	0.16	0.16	0.18	0.18	0.13	0.07	0.05	0.04
	non-IR		0.26	0.22	0.15	0.22	0.11	0.26	0.07	0.00	0.19	0.22	0.19	0.26
	Whole-group rank		***1***	***2***	***3***	***4***	***5***	***6***	*7*	*8*	*9*	*10*	*10*	*11*
	ATP	18	2	3	3	5	**1**	5	4	4	7	6	4	6
	non-ATP IR	55	**1**	2	2	3	5	5	4	4	6	7	8	9
	non-IR	27	**1**	2	4	2	5	**1**	6	7	3	2	3	**1**

For the sake of completeness, the last four rows of Table 12 show the data as ranks, both for the whole N=100 group, and also broken out by pilot rating. This shows, for instance, that although the #1 *group* recovery strategy was to descend below the weather, ATPs preferred to deviate around it. Given the equipment, training, and experience of ATPs, these tactics make sense. Nonetheless, given the small number of pilots per cell, we need to keep sampling error in mind and refrain from assigning too much meaning to individual cell results. Statistically, *patterns* tend to be more reliable (e.g., overall correlations between one row and another).

Two broader notions fall out of this micro-analysis. First, pilots seem to have "mental priorities" of preferred solutions to a given weather problem. Second, because these were incidents, they obviously attempted recovery maneuvers that were not always successful. We will return to these ideas in later discussion.

Equipment

The above detailed analysis diverted us away from Table 11. Therefore, we now return to the bottom half of Table 11, noting that it all concerns equipment. So far, the message we have seen seems to be that ATPs tend to have the best equipment.

Following that theme, we can now see how our three pilot ratings differed in the kinds of aircraft they flew, as shown in Figure 9:

Figure 9 implies that ATPs operated the majority of high-performance jets and turboprops, while non-ATPs flew mainly single-engine, fixed-gear airframes. However, finding statistical support for that statement is not straightforward. There are too many equipment categories relative to the sample size of N=100, and many have values near 0, so there is no simple way to statistically analyze these patterns.[36]

Nonetheless, we *can* straightforwardly assert that the frequencies in Figure 9 are not distributed as we would expect by chance ($p_{\textit{Fisher's Exact Test}}$ = .0005). So, equipment differences may exist across certificate type; the question is where?

Table 13 shows 2-tailed Spearman r intercorrelations between the three groups' equipment patterns (minus seaplanes because no one had a seaplane).

To find where the deviation lies, we first note that the non-ATP IR pilots' equipment pattern is significantly *similar* to the non-IR pilots' (r = .821, p_r = .023, 2-tailed), while both those look *different* from ATPs (*p=NS*). So, we suspect that ATPs have different equipment from non-ATPs. The question is: "How?"

Next we calculate deltas—actual minus expected cell frequencies—for each Figure 9 equipment category.[37] Table 14 illustrates (positive values indicate that actual value > expected value; negative values indicate that actual value < expected value).

Table 14 informally implies that ATPs seemed to dominated in jets (Category 1, +2.5) and trail in single-engine, fixed-gear (Category 5, -4.7), while non-ATP IRs dominated in "retractable-gear, six-passenger, or known TAA (technically advanced aircraft)" (Category 4, +5.3), and non-IRs dominated in single-engine, fixed-gear (Category 5, +6.4). These equipment patterns are consistent with intuition, once again supporting the notion of treating ATPs, non-ATP instrument-rated, and non-instrument-rated pilots as separate entities. However, we must caution that Table 14 lacks the statistical rigor of our other analyses and should be treated as speculative.

[36] Chi-square (C^2) cannot not used here because 16 of 21 expected frequencies (seaplanes omitted) are < 5, grossly violating the assumptions of that analysis.

[37] Expected cell frequency comes from the standard C^2 method, namely *row total*col total/grand total.*

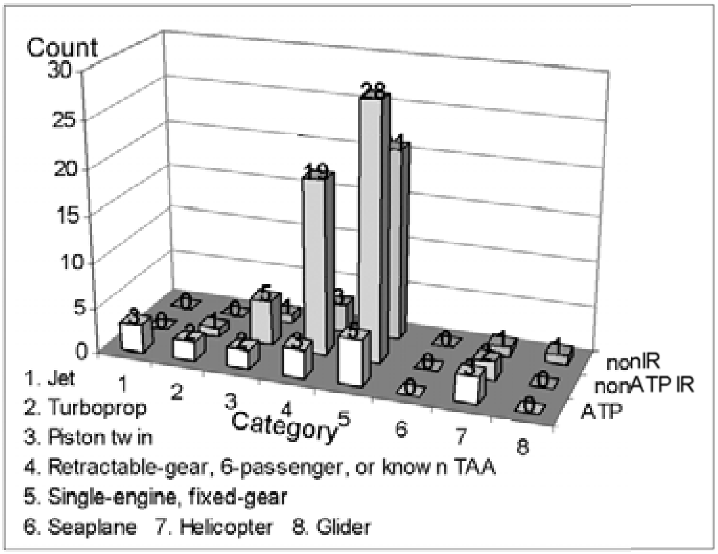

Figure 9. Equipment differences between ATPs, non-ATP IR, and non-IR pilots. Since there are exactly 100 pilots, the raw values for each category (vertical axis) are also the percentages relative to the entire group of 100.

Table 13. Equipment intercorrelations (p-values are in parenthesis).

	ATP	non-ATP IR
ATP	1.0	
non-ATP IR	0.604 (*.151*)	1.0
non-IR	0.480 (*.275*)	**0.821** (*.023*)

Table 14. Equipment category deltas (seaplanes omitted).

	Delta (Actual – Expected frequencies)						
Equipment category	**1**	**2**	**3**	**4**	**5**	**7**	**8**
ATP	2.5	1.5	0.6	-1.5	**- 4.7**	1.9	- 0.2
non-ATP IR	- 0.7	- 0.7	0.6	5.3	-1.7	-1.3	- 0.6
non-IR	- 0.8	-0.8	-1.2	**- 3.8**	6.4	- 0.6	0.7

DISCUSSION

Historically, adverse weather has been a major cause of general aviation accidents and fatalities. However, weather alone is never the sole culprit. There are always other factors involved. Some of these causal factors are more common than others. Some are easier and/or less expensive to fix. Some exert a greater impact on the accident and fatality rates

As investigators, we sometimes try to find these salient factors through *data mining*. In data mining, we search through recorded data for underlying statistical commonalities between seemingly disparate events, seeking to find risk factors that logically relate to one another.

Naturally, this works best with large amounts of high-quality data. Yet, GA accidents are relatively rare, often lacking a living witness to explain what happened. Consequently, we sometimes turn to *incident analysis*. Incidents are less serious than accidents, but many times more common, and there are witnesses to help better determine causes.

To data-mine weather-related GA incidents, we turned to the Aviation Safety Reporting System, a clearinghouse for public, anonymous reporting of U.S. aviation safety incidents. The current project followed up GA weather-related incident reports made to the ASRS during 2005-06. With the permission of pilots who had previously reported a weather-related incident, ASRS made 100 "callback" interviews to look deeper into this specific kind of incident. Each interview involved data collection on nearly 300 variables related to possible root causes. The resulting 30,000-odd data were mostly yes/no responses, the rest being free-response text.

In reporting these results, we need to keep in mind a few limitations as to how much we can generalize from this sample to GA pilots in general. First, while ASRS data are submitted voluntarily, it may contain unknown biases. Second, all samples contain sampling error, meaning they risk overrepresenting some factors while underrepresenting others, purely by chance. By the very definition of chance, we expect a small number (1-5%) of "statistically significant" relations to ultimately prove false.

With such caveats in mind, the ASRS staff prepared a preliminary report. This is available on-line, entitled *General aviation weather encounters* (ASRS, 2007).

To summarize the ASRS report, major problems seemed rare with

- Preflight weather briefing (99% reported briefing, 71% reported using 2 or more sources).
- Use of ATC in-flight services *when requested* (59% requested them).
- Awareness of geographic position (80% of pilots had GPS, presumably mostly hand-held units).

While substantial problems seemed evident with:

- Lack of weather-related experience for both non-instrument-rated and newly minted instrument-rated pilots.
- Weather conditions of deteriorating visibility and icing.
- Pilots failing to request in-flight ATC services (41%).
- Aircraft lacking substantial weather avoidance systems (66%).
- Non-weather-related, compounding factors, especially "decision making," "time pressure," "get-home-itis," and aircraft equipment problems.

Using that analysis as a springboard, the current report examines the data in greater detail. The following factors seemed to pose no discernable problem for most pilots:

1) All pilots at least had access to high-quality preflight weather information.
2) 95% were at least partially successful in getting a preflight weather briefing.
3) Group weather information-use patterns appeared normal as far as could be seen.

In contrast, the following factors seemed to constitute a problem for 5%, or more, of pilots:

1) Darkness (4 dusk +17 night = 21%).
2) Moisture affecting visibility (clouds, fog, rain, snow > 50%) and/or *air movement* affecting aircraft handling (thunderstorm, icing, turbulence > 25%).
3) Multiple weather factors experienced simultaneously (85%).
4) Failure to get a preflight weather briefing, or "briefing" with only a low-grade (non-aviation-oriented) source (5%).
5) Deterioration of *weather forecast accuracy* over time (66% correct forecasts at departure, decreasing to 37% correct at destination).
6) Weather that materialized *worse than predicted* (35%. This implicitly includes lack of en-route forecast updates).
7) Lack of weather-related training and experience (> 50%, non-instrument-rated and new instrument-rated pilots).
8) Inadequate equipment (less-experienced pilots tend to have less-capable airframes and avionics).
9) Ambulance missions (7%, particularly helicopter ambulance).
10) "Non-weather related factors"
    a) Decision-making (26%).
    b) Time pressure (21%).
    c) "Get-home-itis" (9%).
    d) Aircraft equipment problem (8%).
    e) Fatigue (7%).
    f) Distraction by passenger or crew (5%).

Table 15. Weather-related group differences by pilot certification.

Group	Training	Experience (h flown)	Aircraft performance	Likelihood of A/C equipment problem	Advanced avionics	Ice-handling capability	Likelihood of a problem w. icing	Likelihood a problem w. thunderstorms	Likelihood of becoming lost or disoriented	Likelihood of A/C loss-of-control	Likelihood of recovery (LOR) by descent below wx	LOR by deviation around wx	LOR by 180-degree turn	LOR by landing at alternate	Type of weather most likely to be problematic
ATP	+	+	+	-	+	+	-	+	-	-	+	+	-	-	**Severe**
Non-ATP IR				+			+	-			+	-	-	-	**Intermediate**
Non-IR	-	-	-	-	-	-	-	+	+	+	+	-	+	+	**All**

The Importance of Training

One major result of the current study revolves around the usefulness of grouping pilots into 3 categories based on certification/training. Statistically and logically, three discrete groups emerged:

1) Air transport pilots (ATPs)
2) Non-ATP, instrument-rated pilots(non-ATP IR)
3) Non-instrument-rated pilots(non-IR, VFR, private)

These three groups displayed not only differences in flight hours, weather experience, and equipment, they also differed in the kinds of weather they attempted to fly in, as well as recovery strategies. Based on quantitative analysis of this ASRS data, we can summarize the main findings of this study in terms of these three groups.[38]

In Table 15, a "+" rating means "these pilots' group tended to score high on this factor." A blank cell means "average on this factor," and a "-" cell means "below average." "LOR" refers to "likelihood of recovery."

Table 15 implies that there are training and experience differences, equipment differences, and stylistic differences in the way pilots tend to handle weather. In fact, *each group seems to have problems with the exact worst category of weather with which it is legally and "culturally" expected to be able to cope*.

And, nowhere does acculturation come home to roost more than with non-instrument-rated pilots. These pilots are only trained in *avoiding* bad weather. So, when bad weather finally enters unannounced, it easily induces disorientation, strong emotions, and subsequent errors of judgment. For instance, non-IRs had the second-highest rate of thunderstorm encounters during their incidents. They also had the highest rate of becoming lost (33%), and the highest rate of aircraft loss-of-control (15%). Only 9 of 27 non-IR pilots reported having VMC forecast for all three phases of their flight—meaning that two-thirds apparently consciously knew that they were taking a risk by flying into marginal VMC or worse. Moreover, non-IRs' aircraft were typically the least capable at handling truly severe weather. Eighty-nine percent had no major weather-avoidance electronics, 89% had no physical anti-icing systems on the aircraft, and 56% had no autopilot or wingleveler. Fourteen (52%) were missing all three. Finally, nearly all their flight missions were either for pleasure or training, yet five pleasure flights were low-light (two dusk, three night), none had a flight plan, and all ended with severe visibility problems due to weather compounded by darkness.

Additionally, *ultra-low-hour, low-experience non-IR pilots constitute a major target group*, representing roughly 18-20% of these 100 incidents. Being at the bottom of the status hierarchy also constitutes a "multiple curse," having most, if not all, of the factors below stacked against them:

- Less training
- Less total flight experience
- Less weather experience
- Lower-performance aircraft
- Little ice-handling capability
- Lower-grade avionics

CONCLUSIONS AND RECOMMENDATIONS

In the short term, this analysis reveals two major at-risk target groups:

- Non-instrument-rated pilots
- Newly minted instrument-rated pilots

These are two distinct groups, with distinct training needs. Non-IR pilots need to be able to strategically recognize dangerous weather and have well-practiced tactics to avoid it. New IR pilots need the strategic ability to distinguish between handleable IMC and unhandleable IMC. Their training needs are bimodal. They need one set of well-practiced tactics for handleable IMC and a quite distinct set for unhandleable IMC.

[38] These reflect factors with arguable statistical differences. Note that all "miscellaneous" categories are absent because, by definition, these are catch-all categories, not discrete factors.

On the tactical level, while deviation around weather is an effective strategy for experienced pilots flying capable aircraft, it appears we need to emphasize 180° turns and landing-at-alternates as effective options for less-experienced pilots, particularly those flying more-basic aircraft.

Both groups need to be proactive about developing alternatives in the event of adverse weather. This means thinking about alternative actions *before* they are needed, not waiting until the last minute.

No matter what their training, experience, or equipment, all pilots need to develop and maintain a "risk conscience"—an inner sense of right and wrong when it comes to risk-taking. Whenever they meet with a weather situation that piques that conscience, they need to listen to it and activate those pre-planned alternatives.

Finally, both IR and non-IR pilots need a way to develop and maintain weather expertise in a safe setting. The most obvious and cost-effective ways to do this are through PC- and Web-based weather-skill testing and training programs, both in traditional knowledge-based format and flight simulator format. In particular, Bayesian adaptive testing[39] and adaptive training are new, exciting, cost-effective strategies that need to be seriously considered. Such technologies would use computer algorithms to quickly home in on a testee/trainee's level of ability and could deliver far more "bang for the buck" than current methods of weather-related testing and training.

Future Exploration

The results we have discussed raise a number of concerns. All are potential areas of research.

First, we are becoming increasingly aware that no single factor ever explains any incident or accident. Trouble is virtually always caused by some combination of events.[40] Consequently, effective categorization of accident causal factors helps organize and streamline the investigative process and guides the development of programs to fix problems. This process needs continuation, specifically investigation of what *combinations of factors* seem most hazardous.

Another concern has to do with how certain individuals may develop risky flying habits. This may involve sampling error. Sampling error happens when "too much luck"—good or bad—happens to us purely by chance. What may happen, psychologically, is that people who are consistently lucky may start developing ideas that they are immune to misfortune, while people who are consistently unlucky may start believing exactly the opposite. These beliefs may very well influence pilots' willingness to take risks with bad weather.

Additionally, the data examined here teach us the usefulness of considering the flight mission, because flight mission often comes with certain motivations and mindsets attached. The categories we looked at were:

1) Ambulance
2) Business
3) Passenger
4) Pleasure (Daytime v. Night + Dusk)
5) Training
6) Ferry
7) Freight
8) Miscellaneous

Causal/explanatory "stories" given by the pilots in each Training x Mission category are presented in Appendix D. The full analysis of these may be presented in a later report. For now, to summarize briefly, each category of flight mission looks like a world unto itself. The ATP flying the life-or-death ambulance mission is simply not the same as the non-IR pilot going out on a day off for a pleasure flight. The mission is different, the motivation is different, pilot training tends to be different, as does the airframe, avionics, and so on. This way of grouping data needs to be explored, but the methodology is largely qualitative, which explains why we defer it for the time being.

Finally, looking forward, the current study can be seen as preliminary to one planned by FAA's Aviation Weather Group (AJP-6810), which would evaluate weather-related accidents involving weather-datalinked aircraft. Datalink is designed to enhance safety by providing pilots with increasingly accurate, timely information on critical factors such as weather. Yet, logic suggests that a few problems may remain and/or new ones potentially created despite the new technology. What these are remains to be seen. However, certain methodologies employed in the current study may be portable and useful to such future studies.

[39] In computerized adaptive testing, after a correct answer, the test-taker is presented a more difficult question. Conversely, after an incorrect answer, a slightly less-difficult item is presented. In this way, the test "statistically homes in on the test-taker's reliable level of competence," and automatically stops the test once an arbitrary (e.g. 95%) statistical confidence level is achieved.

[40] It is a combinatorics problem. The number of ways p causes can form combinations of size k is $p!/k!(p-k)!$. As p grows, the number of combinations explodes. This is one of the things that makes accident investigation difficult.

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APPENDIX A

(Source: FAA Joint Safety Analysis Team. (2002). *General aviation decision-making, final report*. Retrieved Oct. 30, 2006 from www.faa.gov/about/initiatives/safer_skies/gajsc_documents/media/aeronautical.pdf)

Post-Classical ADM

Beginning in 1991 the FAA initiated a long-term research effort to develop a better understanding of pilot decision-making and to develop new interventions to improve decision-making. These studies have focused on how pilots acquire and use information to make decisions and, more recently, on how the personality attributes of pilots affect their decision-making.

Some of the research findings related to ADM are:

(a) When evaluating weather, pilots tend to let one good aspect of the weather compensate for bad aspects. For example, pilots let a high ceiling compensate for low visibility, when rating weather risk. Particularly for novice pilots, this is a potentially dangerous practice.

(b) Low-time pilots, in particular, seem not to take into account either dangers or resources outside a very narrow corridor along their planned route of flight. For example, they seem to exhibit “tunnel vision” and don’t consider the potential for weather to move across their route, nor do they consider using alternative airports located a short distance from their route of flight.

(c) Pilots allow their proximity to their destination to overrule caution when faced with deteriorating weather conditions. Pilots will press-on through conditions near their destination, while the same conditions when encountered early in the flight will result in a diversion.

(d) Some pilots, particularly those with low time, will make a decision when faced with a problem, and will then make no further efforts to diagnose the problem, seek help, consider alternatives, or evaluate the effectiveness of their decision.

(e) Many pilots are unable to judge when conditions have deteriorated to near or below VFR minima, and are unaware of the environmental cues that would alert them to this deterioration.

(f) Pilots differ in their perceptions of the degree of risk of flying activities, and those who perceive the lowest risk (usually of weather) tend to be more at risk for accident involvement. However, differences in risk tolerance are not related to accident risk.

(g) Pilots who believe themselves to be more in control tend to be at lower accident risk than those who believe that what happens to them is the result of outside factors (i.e., fate, luck, other people and organizations).

(h) Overconfidence in personal abilities and an inability to accurately assess visibility are associated with continued VFR flight into IMC in simulation studies.

(i) In tests of situational judgment, half of the time pilots will choose a course of action not recommended as best (i.e., safest) by a panel of instructors.

(j) Approximately 35% of private and commercial pilots have not attended a Safety Seminar in the last two years; 20% have attended 1 seminar. The predominant reason for not attending is “too busy.”

APPENDIX B

General Aviation Weather Encounters Supplemental Coding Structure

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NOTE 1.......This form provides for ALL fields and field values for the General Aviation Weather Encounters supplemental coding form database, including Full-Form Coding Form fields that will not be included in the reporter mail-out form.

NOTE 2.......This form is NOT formatted for distribution (in planning format only), and will not be formatted for distribution until the supplemental coding form questions are finalized).

NOTE 3.......When ASRS receives a weather-related report, it will contact the reporter and request their participation in the General Aviation Weather Encounters project. Those who agree to participate will be mailed the supplemental coding form (Part 1); this form will NOT contain the fields that provide data found in ASRS Full-Form Coding. When the completed form has been returned to ASRS, the supplemental data will be integrated with relevant ASRS Full-Form data in a General Aviation Weather Encounters database to create a complete, comprehensive record.

NOTE 4.......The original questionnaire asked event-specific information as well as some general information — we feel that this can be confusing to respondents. Thus, this supplemental coding form generally contains questions pertaining to the reported event. A general survey of GA Weather issues may best be conducted separately.

Part 1 — Supplemental Coding Form

Supplemental coding form to be mailed to project participants. Every effort has been made to convert narrative (anecdotal) responses to list selections, because narrative responses will most commonly need to be converted to lists in order to be meaningful.

- Section A — Flight Planning and Weather Briefings
- Section B — Incident Information
- Section C — Contributors and Consequences
- Section D — Aircraft Equipment
- Section E — Instrument-Rated Pilot Information
- Section F — Summary

Part 2 — ASRS Full-Form Coding Forms Fields

Data coded during standard ASRS Full-Form analysis.

- Section G — Administrative / General / Environment
- Section H — Aircraft Data
- Section I — Reporter Data

PART 1 — Supplemental Coding Form
(Mail-out to Study Participants)

Section A — Flight Planning and Weather Briefings

A.1 Did you attempt to obtain pre-flight weather information? *(Check one only)*
- ○ Yes (Go to Question A.2)
- ○ No (Skip to Question A.8)

A.2 What sources of weather information did you utilize? *(Check all that apply)*
- ☐ National Oceanic & Atmospheric Administration (NWS)
- ☐ (Automated) Flight Service Station (FSS)
- ☐ Direct User Access Terminal (DUATS)
- ☐ Commercial Vendors
- ☐ Hazardous Inflight Weather Advisory Service (via VORs)
- ☐ Transcribed Weather Broadcast (TWB)
- ☐ Pilots Automatic Telephone Weather Answering Service
- ☐ En route Flight Advisory Service
- ☐ The Weather Channel
- ☐ Other pilots
- ☐ Other (please specify): ____________________________

A.3 Were any of your attempts to obtain pre-flight weather information unsuccessful? *(Check one only)*
- ○ Yes
- ○ No

A.4 If you answered “Yes” to Question A.3 above, what were the reasons your attempts were unsuccessful? *(Check all that apply)*
- ☐ Did not know or were unable to find telephone or access numbers

TELEPHONE
- ☐ No telephone available
- ☐ No answer on telephone
- ☐ Telephone briefer did not have all requested information available
- ☐ Telephone briefer denied service

COMPUTER
- ☐ No online access available
- ☐ Could not connect online
- ☐ Could not maintain online connection
- ☐ Required information not available on computer
- ☐ Experienced difficulty with computer interface

OTHER
- ☐ Other (please specify): ____________________________

A.5 What was the preflight weather forecast for the following? *(Check one only in each category)*
- a) Departure airport............................... ○ VMC / ○ Marginal VMC / ○ IMC
- b) En route .... ○ VMC / ○ Marginal VMC / ○ IMC
- c) Destination airport .... ○ VMC / ○ Marginal VMC / ○ IMC

A.6 What were the forecast conditions for the following? *(Check all that apply)*
- a) Departure ....☐ Fog / ☐ Ice / ☐ Rain / ☐ Snow / ☐ Tstorm / ☐ Turbulence
- b) En route ....☐ Fog / ☐ Ice / ☐ Rain / ☐ Snow / ☐ Tstorm / ☐ Turbulence
- c) Destination.................☐ Fog / ☐ Ice / ☐ Rain / ☐ Snow / ☐ Tstorm / ☐ Turbulence

A.7 Was the actual weather better than, the same as, or worse than forecast? *(Check one only in each category)*
- a) Departure ....○ Better than… / ○ Same as… / ○ Worse than…
- b) En route ....○ Better than… / ○ Same as… / ○ Worse than…
- c) Destination.................○ Better than… / ○ Same as… / ○ Worse than…

A.8 If you answered “No” to Question A.1 above, why did you NOT attempt to obtain pre-flight weather information prior to departure? *(Check all that apply)*
- ☐ Did not believe pre-departure weather was necessary for the intended flight
- ☐ Was intimidated by process of obtaining weather
- ☐ Did not know or was unable to find telephone or access numbers
- ☐ No telephone available
- ☐ No online access available
- ☐ Other (please specify): ____________________________

Section B — Incident Information

B.1 Were you (the pilot) deviating from your planned route because of weather when the incident occurred? *(Check one only)*
- ○ Yes
- ○ No

B.2 What type of weather did you encounter? *(Check all that apply)*

☐ Broken or solid undercast
☐ Deteriorating weather ahead
☐ Flew into clouds or fog
☐ Ground fog
☐ Icing
☐ Lowering ceiling
☐ Merging cloud layers
☐ Snow showers
☐ Reduced visibility
☐ Rising cloud tops
☐ Strong cross winds
☐ Thunderstorms
☐ Turbulence
☐ Unknown? but IMC conditions
☐ Rain
☐ Hail
Other (please specify): ____________________________

B.3 Did you attempt to obtain en route assistance from ATC? *(Check one only)*

○ Yes (go to Question B.4)
○ No (go to Question B.5)

B.4 If you answered "Yes" to the Question B.3, what services did you request? *(Check all that apply)*

☐ Emergency climb/descent
☐ IFR clearance
☐ Vectors to an airport
☐ Vectors to VMC
☐ PIREPS
☐ Weather update
☐ Instrument approach procedure
☐ Other (please specify): ____________________________

B.5 If you answered "No" to Question B.3, what was the primary the reason you did not attempt to obtain assistance from ATC? *(Check one only)*

○ Did not feel ATC services were required
○ Did not know that ATC services were available
○ Did not know the frequencies to contact ATC
○ Did not know what services to ask ATC for
○ Knew that communications would not be possible at my altitude or location
○ Was afraid of a reprimand or certificate action
○ Other (please specify): ____________________________

B.6 If you were unable to obtain ATC services, or could not obtain them in a timely manner, what were the reason(s)? *(Check all that apply)*

☐ ATC would not provide clearance
☐ There was a delay in ATC providing clearance
☐ Request for an IFR or SVFR clearance was denied
☐ Too low for radar coverage
☐ Unable to contact ATC
☐ Other (please specify): ____________________________

Section C — Contributing Factors and Consequences

C.1 Were there factors other than weather that contributed to the incident? *(Check one only)*

○ Yes (Go to Question C.2)
○ No (Skip to Question C.4)

C.2 If you answered "Yes" to Question C.1, what non-weather related factors contributed to the incident? *(Check all that apply)*

☐ Company policy
☐ Distraction by pax or flight crew
☐ Aircraft equipment problem
☐ Fatigue
☐ FBO policy
☐ Get-home-itis
☐ Time pressure
☐ Illness
☐ Other (please specify): ____________________________

C.3 If you answered "Yes" to "Time Pressure" in Question C.2, what were the reasons for the time pressure? *(Check all that apply)*

☐ A "void if not off by…" ATC clearance
☐ Approaching darkness
☐ Deteriorating weather
☐ Schedule pressure
☐ Personal pressure to reach a destination on-time
☐ Family or other personal emotional pressures or distractions
☐ Other (please specify): ____________________________

C.4 What were the consequences of your weather encounter? *(Check all that apply)*

☐ Unable to maintain altitude
☐ Lost/unsure of position
☐ Landed below published IFR minimums
☐ VFR flight in IMC
☐ Made IFR approach without an IFR rating
☐ Landed VFR in IMC
☐ Landed without clearance
☐ Penetrated controlled airspace
☐ Loss of aircraft control
☐ Controlled flight toward terrain

☐ Precautionary landing or off-airport landing
☐ Runway excursion
☐ Other (please specify): ____________________________

C.5 What factors enabled you to recover from the weather encounter? *(Check all that apply)*

☐ Aircraft warning system
☐ Instrument approach
☐ ATC offered assistance
☐ Broadcast on 121.5
☐ Broke out on top
☐ Cancelled IFR
☐ Climb/attempted to climb
☐ Descended to stay below weather
☐ Radar vector
☐ Contacted ATC and requested IFR clearance
☐ Other (please specify): ____________________________
☐ Descended through hole in undercast
☐ Deviated around weather
☐ Ground proximity warning system
☐ Landed at destination
☐ Landed en route
☐ Vector to airport
☐ Vector to VMC
☐ 180 degree turn

Section D — Aircraft Equipment

NOTE 1....... Aircraft make and model is captured in ASRS Full-Form data.
NOTE 2....... We do not believe that aircraft year of manufacture provides useful information as many older aircraft have extensively modified avionics packages.

D.1 What type(s) of navigation and communication equipment were onboard the aircraft at the time of the incident, did you use it and, if equipped, was any of it unserviceable? *(Check all that apply)*

COMMUNICATION EQUIPMENT	EQUIPPED	USED	UNSERVICEABLE
☐ No communication equipment			
Single VHF transceiver	☐	☐	☐
Dual VHF transceiver	☐	☐	☐
Combination NavCom	☐	☐	☐
HF transceiver	☐	☐	☐
ACARS	☐	☐	☐
Skyphone	☐	☐	☐
Cell Phone	☐	☐	☐
Other (please specify): ____________	☐	☐	☐

NAVIGATION / FLIGHT MANAGEMENT	EQUIPPED	USED	UNSERVICEABLE
☐ No navigation equipment			
Single VOR receiver	☐	☐	☐
Dual VOR receiver	☐	☐	☐
ILS	☐	☐	☐
ADF	☐	☐	☐
DME	☐	☐	☐
GPS	☐	☐	☐
INS/IRS	☐	☐	☐
Integrated area navigation	☐	☐	☐
Moving map	☐	☐	☐
Terrain Warning System	☐	☐	☐
Other (please specify): ____________	☐	☐	☐

D.2 Was the aircraft equipped with any of the following weather-avoidance equipment, and if it was, what equipment was used during the incident? *(Check all that apply)*

EQUIPMENT	EQUIPPED	USED	UNSERVICEABLE
☐ No weather avoidance equipment			
Weather radar	☐	☐	☐
Lightning Detector/Stormscope	☐	☐	☐
Weather data link (NEXRAD, METARS, etc)	☐	☐	☐
Other (specify) ______________	☐	☐	☐

D.3 What type of de-ice or anti-ice or other equipment did the aircraft have at the time of the incident, did you use it, and if equipped was any of it UN-serviceable?
(Check all that apply)

EQUIPMENT	EQUIPPED	USED	UNSERVICEABLE
☐ No de-ice, anti-ice or other related equipment was installed			
Wing/tail De-icing boots	☐	☐	☐
Wing/tail Bleed-air anti-ice	☐	☐	☐
Wing/tail electrical anti-ice	☐	☐	☐
Wing/tail TKS (fluid-type anti-ice)	☐	☐	☐
Propeller de-ice or anti-ice	☐	☐	☐
Engine (air) inlet anti-ice	☐	☐	☐
Windshield de-ice or anti-ice	☐	☐	☐
Other (specify) _____________	☐	☐	☐

D.4 Did the aircraft have an autopilot and were you using it at the time of the incident? *(Indicate one type only, and note if used or unserviceable)*

EQUIPMENT	EQUIPPED	USED	UNSERVICEABLE
☐ No, the aircraft did not have an autopilot or wingleveler			
Wing leveler	☐	☐	☐
Basic autopilot autopilot	☐	☐	☐
Approach-capable autopilot	☐	☐	☐

Section E — Instrument-Rated Pilot Information

If you are instrument rated, please answer the questions in this Section; if you are NOT instrument rated, skip to Section F.

E.1 How many actual instrument hours have you flown?
____________________ (total hours)

E.2 How many simulated (under the hood) instrument hours have you flown?
____________________ (total hours)

E.3 How many simulator hours have you had?
____________________ (total hours)

E.4 How many instrument approaches have you conducted in actual instrument conditions in the past year?
____________________ (number)

E.5 How many instrument approaches have you conducted in actual instrument conditions in the past 90 days?
____________________ (number)

E.6 In the majority of your instrument flights, has the actual weather been better than, the same as, or worse than the reported weather at the following? *(Check one only in each category)*

E.10.a Departure airport .... ○ Better than… / ○ Same as… / ○ Worse than…
E.10.b. En route .... ○ Better than… / ○ Same as… / ○ Worse than…
E.10.c. Destination airport .... ○ Better than… / ○ Same as… / ○ Worse than…

Section F — Summary

F.1 Why do you think the incident occurred?

F.2 In retrospect, is there anything you would have done differently?

F.3 What would you recommend that others do to avoid a similar occurrence?

– END REPORTER SUPPLEMENTAL CODING FORM –

PART 2 — ASRS Full-Form Coding Fields
(Included in Final Data Set)

Note 3 ..... These fields are contained in all ASRS Full-Form records, and will not be required on the mail-out supplemental coding form.

Section G — Administrative / General / Environment

G.1 Accession Number:
[ASRS accession number, numeric value, 6 digits, unique]

G.2 Date of Incident:
[numeric value, MMYYYY]

G.3 Day:
[Sun, Mon, Tue, Wed, Thu, Fri, Sat]

G.4 Local Time of Day:
[0001 to 0600, 0601 to 1200, 1201 to 1800, 1801 to 2400]

G.5 Locale Reference:
[Airport (ID), NAVAID (ID & Type), Intersection (ID), Special Use Airspace (ID & Type), ATC Facility (ID & Type)]

G.6 State Reference:
[state]

G.7 Altitude:
[AGL — Single Value (feet), Lower Boundary (feet), Upper Boundary (feet); MSL — (Single Value (feet), Lower Boundary (feet), Upper Boundary (feet)]

G.8 Flight Conditions:
[VMC, IMC, Mixed, Marginal, Special VFR]

G.9 Weather Elements:
[Fog, Ice, Rain, Snow, Thunderstorm, Turbulence, Windshear, Other (element)]

G.10 Light:
[Dawn, Daylight, Dusk, Night]

G.11 Ceiling:
[Single Value (feet), Lower Boundary (feet), Upper Boundary (feet), CLR]

G.12 Visibility:
[Single Value (statute miles), Lower Boundary (statute miles), Upper Boundary (statute miles)]

Section H — Aircraft Data

H.13 RVR:
[Single Value (feet), Lower Boundary (feet), Upper Boundary (feet)]

H.14 Controlling Facilities:
[ARTCC (ID), TRACON (ID), Tower (ID), Military (ID)]

H.15 Coordinating Facilities:
[FSS (ID), CTAF (ID), UNICOM (ID), Commercial Radio (ID)]

H.16 Operator:
[Common Carrier (Air Carrier, Air Taxi, Charter); General Aviation (Corporate, Instructional, Private); Other (Government, Military Other). Additional data may be derived from the "Operating under FAR Part" field: Part 91, Part 119, Part 121, Part 125, Part 129, Part 135, Other (part number)]

H.17 Aircraft Make & Model:
[________________________]

H.18 Aircraft Configuration
[Number of Engines: ____________]
[Propulsion: None, Reciprocating, Turboprop/Turboshaft, Turbojet]
[Surface: Land, Sea, Amphibian]
[Gear: None, Fixed, Retractable]
[Wings: None, High, Mid, Low, Biplane, Rotary]

H.19 Operating Under FAR Part:
[Part 91, 119, 121, 125, 129, 135, Other _______]

H.20 Flight Plan:
[VFR, IFR, IFR combined VFR, DVFR, None]

H.21 Mission:
[Aerobatics, Agriculture, Ambulance, Banner Tow, Business, Ferry, Freight, Passenger, Photo

Shoot, Pleasure, Refueling, Repositioning, Skydiving, Tactical, Test Flight, Traffic Watch, Training, Other ___________]

H.21 Navigation In Use:

[Localizer, ILS, FMS/FMC, GPS/Area Nav, INS, NDB, Pilotage, VOR, Other _____]

H.22 Flight Phase:

[Ground: Parked, Pushback, Maintenance, Preflight, Taxi, Holding, Position and Hold, Takeoff Roll, Other ____]
[Climbout: Takeoff, Initial, Intermediate Altitude, Vacating Altitude, Other ____]
[Cruise: Level, Holding, En route Altitude Change, Other ____]
[Descent: Approach, Holding, Intermediate Altitude, Vacating Altitude, Other ____]
[Landing: Hold Short, Roll, Touch and Go, Go-Around, Missed Approach, Other ____]
[Other: Other ____]

H.23 Airspace Occupied:

[Class A (ID), Class B (ID), Class C (ID), Class D (ID), Class E (ID), Class G (ID), SUA (ID), Temp Use (ID)]

H.24 Component:

[Component Code _____, Design Deficiency, Failed, Improperly Operated, Malfunctioning, Not Installed, Incorrect Part]

Section I — Reporter Data

I.25 Involvement (truncated):

[…Pilot Flying, Pilot Not Flying, Receiving Instruction, Other ____]

I.26 Affiliation:

[Government: FAA, Foreign, Military, Other ___]
[Company: Air Carrier, Air Taxi, Charter, Corporate, Other ___]
[Other: Contracted Service Instructional Personal, Other ___]

I.27 Flight Crew:

[Single Pilot, Captain, First Officer, Relief Pilot, Second Officer, Navigator, Load Master]

I.28 Qualification:

[Student, Private, Instrument, Multi-engine, Commercial, ATP, CFI, Flight Engineer, Military]

I.29 Flight Time:

[Total (hours) ______]
[Last 90 Days (hours ______]
[Type (hours) ______]

APPENDIX C
Aircraft Classification Categories

7	A109	PA-28 Cherokee Arrow IV	4
	Aeronca Champion	PA-28 Cherokee/Archer II/Dakota/Pillan/Warrior	
	Aircoupe A2	PA-28 Cherokee/Archer II/Dakota/Pillan/Warrior	
2	Airliner 99	PA-28 Cherokee/Archer II/Dakota/Pillan/Warrior	
7	AS 350 Astar/Ecureuil	PA-28 Cherokee/Archer II/Dakota/Pillan/Warrior	
7	AS 350 Astar/Ecureuil	PA-28 Cherokee/Archer II/Dakota/Pillan/Warrior	
3	Baron 55/Cochise	PA-28 Cherokee/Archer II/Dakota/Pillan/Warrior	
2	Beechcraft Twin Turboprop Jet Undifferentiated or Other Model	PA-28 Cherokee/Archer II/Dakota/Pillan/Warrior	
	Bird Dog 305/321	PA-28 Cherokee/Archer II/Dakota/Pillan/Warrior	
7	BO105	PA-28 Cherokee/Archer II/Dakota/Pillan/Warrior	
4	Bonanza 33	PA-28 Cherokee/Archer II/Dakota/Pillan/Warrior	
4	Bonanza 33	PA-28 Cherokee/Archer II/Dakota/Pillan/Warrior	
4	Bonanza 35	PA-28 Cherokee/Archer II/Dakota/Pillan/Warrior	
4	Bonanza 36	PA-28 Cherokee/Archer II/Dakota/Pillan/Warrior	
	Caravan 1 208A	PA-28 Cherokee/Archer II/Dakota/Pillan/Warrior	
4	Cardinal 177/177RG	PA-31 Navajo Chieftan/Mojave/Navajo T1020	
4	Cardinal 177/177RG	PA-32 Cherokee Six/Lance/Saratoga	4
	Cessna 150	PA-32 Cherokee Six/Lance/Saratoga	4
	Cessna 150	PA-34-200 Seneca I	3
	Cessna 150	PA-34-200T Turbo Seneca II	3
	Cessna 150	Sail Plane	8
	Cessna 150	Skyhawk 172/Cutlass 172	
	Cessna 150	Skyhawk 172/Cutlass 172	
	Cessna 150	Skyhawk 172/Cutlass 172	
	Cessna 152	Skyhawk 172/Cutlass 172	
4	Cessna 210 Centurion / Turbo Centurion 210C, 210D	Skyhawk 172/Cutlass 172	
4	Cessna 210 Centurion / Turbo Centurion 210C, 210D	Skyhawk 172/Cutlass 172	
4	Cessna 210 Centurion / Turbo Centurion 210C, 210D	Skyhawk 172/Cutlass 172	
3	Cessna 310/T310C	Skyhawk 172/Cutlass 172	
3	Cessna 340/340A	Skyhawk 172/Cutlass 172	
3	Cessna 402/402C/B379 Businessliner/Utiliner	Skyhawk 172/Cutlass 172	
	Cessna Single Piston Undifferentiated or Other Model	Skyhawk 172/Cutlass 172	
4	Cessna Stationair/Turbo Stationair 7/8	Skyhawk 172/Cutlass 172	
1	Challenger Jet Undifferentiated or Other Model	Skyhawk 172/Cutlass 172	
	Cheetah, Tiger, Traveler	Skyhawk 172/Cutlass 172	
	Cheetah, Tiger, Traveler	Skyhawk 172/Cutlass 172	
	Christen Eagle II	Skyhawk 172/Cutlass 172	
1	Citation V	Skylane 182/RG Turbo Skylane/RG	4
3	Duchess 76	Skylane 182/RG Turbo Skylane/RG	4
	Experimental Aircraft	Skylane 182/RG Turbo Skylane/RG	4
	Experimental Aircraft	Skylane 182/RG Turbo Skylane/RG	4
1	Gulfstream V	Skylane 182/RG Turbo Skylane/RG	4
7	Jet Ranger Undifferentiated or Other Model	Skylane 182/RG Turbo Skylane/RG	4
7	Jet Ranger/Kiowa/206	Skylane 182/RG Turbo Skylane/RG	4
4	M-20 B/C Ranger	Skylane 182/RG Turbo Skylane/RG	4
4	M-20 K (231)	Skylark 175	
	Key	Skywagon 185	
1	Jet	Small Aircraft, High Wing, 1 Eng, Fixed Gear	
2	Turboprop	Small Aircraft, Low Wing, 1 Eng, Fixed Gear	
3	Twin-engine piston	SR20	4
4	Single-engine retractable gear OR 6-passenger-OR TAA	SR22	4
	(blank) Single-engine, fixed gear	Super King Air 200/Huron	2
6	Seaplane (none here)	Twin Otter DHC-6	3
7	Helicopter	Viking	
8	Glider		

APPENDIX D
Synopsis of Interview Section F, Free-Response Explanations of Why the Incident Occurred

Table D1 tabulates the 100 missions, grouped by three levels of pilot training (ATP, non-ATP-instrument rated (non-ATP IR), and non-IR pilots).

Table D1. Flight mission categories. "Night" includes dusk.

	N	Ambulance	Business	Ferry	Freight	Miscellaneous	Passenger	Pleasure Day	Pleasure Night	Training
ATPs	18	**3**	**5**				**4**	**4**	**1**	**1**
non-ATP IR	55	**2**	**8**	**2**	**3**	**4**	**6**	**19**	**6**	**5**
non-IR	27		**1**				**1**	**15**	**5**	**5**
column totals	100	5	14	2	3	4	11	38	12	11

Air Transport Pilots

There were 18 ATPs, falling into five primary mission categories.

Category 1. (Ambulance, n=3)

This was fairly straightforward to explain. Two of the three pilots flew helicopters; the remaining pilot flew a turboprop (i.e., above-average aircraft). All unexpectedly hit VFR-into-IMC.

What makes this category stand out is that all three missions were highly motivated due to a seriously ill patient onboard. All were single-pilot missions. Additionally, only one pilot reported filing an IFR flight plan, two incidents occurred at night, and the remaining pilot reported having a distinct “lack of weather reporting stations” along his route. All this is to say that task demands were high, multiple factors were involved, time was critical, and the pilots were undoubtedly counting on a certain amount of luck that failed to materialize. By nature, medical flights are caught in a unique and constant three-way squeeze between medical pressures, weather pressures, and business cost constraints.

Category 2. (Business, N=5). All problems involved reduced visibility. All were daylight operations. One pilot’s reason for reporting simply centered around landing below minimums while trying to escape weather. The remaining four had more serious problems. Two could not maintain altitude due to ice, one encountered a thunderstorm and thought he’d been struck by lightning, and the last pilot was beaten by a hurricane accompanied by severe radio interference.

What typically unites business pilots is their mission, their motivation, their equipment, and their professionalism. Here, the mission is to make money. Motivation is high, yet not routinely honed to the life-or-death edge of the air ambulance pilot. Equipment tends to be good (though not always). Here, we had two jets, one turboprop, one twin piston, and a lone single-engine, fixed-gear plane (the ambitious-but-luckless pilot who encountered a hurricane).[1]

Category 3 (Passenger, n=4)

All four cases share the unspoken motivation to get passengers to a destination on time. All four were daylight operations, one helicopter, one jet, one 4-person single-engine, high-performance, and one twin piston. All but one pilot ran into weather worse than expected (and that remaining one expected thunderstorms). The first pilot particularly blamed pressure to reach the destination on time. The second saw the airport but ran into fog during the descent. The third blamed inaccurate en route weather reports for failing to emphasize the thunderstorms. The fourth blamed ATC for failing to understand the situation and giving “absurd requests” in the face of a thunderstorm encounter.

[1] Interestingly, that pilot reported 24,000 flight hours experience, with 9000 instrument hours (probably meaning “hours flying an IFR flight plan”). Still—hardly a novice.

Category 4 (Pleasure, n=5)

Four of these pleasure flights were daytime, with the remaining flight at dusk. All were single-engine aircraft with, at most, retractable gear. None had any weather avoidance equipment or de-icing equipment. Remarkably, all pilots had and used both GPS and moving map displays. All but one encountered weather worse than predicted, with the remaining pilot admittedly trying to outrun approaching darkness and visibly deteriorating weather. Two pilots filed an IFR flight plan, the remaining three filed no flight plan at all.

Pilot 1 admittedly failed to get a good preflight briefing (partly due to weather products being out of service at his departure FBO). Subsequently, he encountered severe turbulence and trouble maintaining altitude. Pilot 2 was (aforementioned) trying to outrun darkness and weather. Pilot 3 also admitted "get-home-itis," had not filed a flight plan, and landed at an alternate after breaking cloud-clearance regulations. Pilot 4 blundered near thunderstorms and went VFR-into-IMC. Pilot 5 said he "delayed departure too long," got too close to a thunderstorm, and penetrated controlled airspace.

Category 5 (Training, n=1)

This case was straightforward. The pilot had filed no flight plan, "didn't account for... nocturnal cooling affects [sic]" and then went VFR-into-IMC during a night operation.

Non-ATP Instrument Rated Pilots

The 55 non-ATP IR incidents fell into considerably more categories than any other group.

Category 1 (Ambulance, n=2)

This category was, in many ways, similar to ATPs—high time pressure, single-pilot helicopter operations that ran into weather after filing no flight plan. Both of these flights were in daylight, however.

One pilot reported having 160 actual instrument hours, the other failed to answer that question. Both failed to answer the questions about 12 m and 90 d instrument approaches. So, by default, we have to suspect that these pilots were relatively inexperienced with weather, especially given the usual platform they fly.

Considering the ATP ambulance pilots, along with the present ones, one suspects that the modus operandi of ambulance operations is "Fly first, apologize afterward." And who among us would challenge that policy once we found ourselves in need of such services? Medical operations have always been granted greater latitude in society, out of common sense and necessity. They do need to be considered in a category by themselves.

Category 2 (Business, N=8)

Only two pilots here filed an IFR flight plan, but all ran into reduced visibility conditions as the primary problem.

Beyond that, the secondary problems showed more scatter. The first reported time pressure due to fuel shortage (previous airport would not accept his credit card). Two more pressed on, believing conditions would improve. The fourth was insufficiently familiar with new GPS equipment. The fifth misjudged the service ceiling of his airplane. The sixth checked his departure ATIS, but not the weather at his destination airport. The seventh got caught in weather with a non-IFR certified plane. And the last simply admitted to "get-home-itis."

Category 3 (Passenger, n=6)

These were all single-pilot operations in moderately equipped aircraft ranging from single-engine, fixed-gear to twin piston. All but one flight was in daylight.

A uniting theme of these flights was that "other factors" came into play in every flight. Half were psychological pressures, the other half were equipment problems. Three pilots reported feeling pressured (one "felt pressured to get our guests back to Honolulu," another "let management talk me into attempting the flight I had already turned down," and the third was tired, felt ill, and wanted to get home). Three more pilots had equipment failures (one had an intermittent problem with the PTT [push-to-talk] switch that contributed to a loss of position awareness, a second "had problems with transponder and attitude indicator," and the third, night-flying, pilot lost cabin lights). All these factors contributed to unintended rule violations (primarily VFR-into-IMC), hence the ASRS reports.

Category 4 (Pleasure)

Category 4a (Pleasure, Night and Dusk, n=6).

There were 25 non-ATP IR pleasure flights. All were single-pilot operations. Since night flights present significantly greater challenges during weather encounters than equivalent daytime flights, the pleasure flights were, therefore, grouped by time of day, with one dusk flight grouped in with the night flights.

Understandably, all six night flights reported trouble with visibility, with fog, clouds, and undercast being the main problems. All ended in rule violations, five being VFR-into-IMC.

Oddly, despite everyone reporting at least one phase of flight as MVMC or worse, only three pilots filed an IFR flight plan. One of these subsequently had a brush with a thunderstorm. The other three pilots filed no flight plan at all. These three reported having just 50, 12, and 12 hours actual instrument experience, respectively (compare with 400, 360, and 20 for the pilots who filed IFR). Half the pilots openly admitted to "get-home-itis" as a motivator.

It is natural to wonder if these pilots may have had special equipment to give them an edge in nighttime flying. Five were both ILS- and GPS-equipped (but so were 19 of the 25 in the Pleasure category), with 3 of those having moving map displays. Of the three, two had lightning detection and autopilot. So these two were relatively well-equipped, and that may have been inspired confidence in their pilots.

Finally, one has to ponder the remaining pilot who had none of the above, was flying a Cessna 150 at night, into predicted rain and fog, with just 50 hours' instrument experience, and no flight plan on file. This was clearly a risky flight, given the circumstances.

Category 4b (Pleasure, Day, n=19)

This is the largest single category of any group, and is easiest summed up in Table D2.

Table D2. Possible causal factors, non-ATP IR pilots, daylight pleasure flights.

Pilot	Ran into unexpectedly bad weather	Less than 50 actual instrument h	Poor preflight/inflight weather briefing	"Get-home-itis"	Lack of experience	Complacency	Cockpit distractions	Knowingly taking risk	Equipment problems	Didn't contact ATC fearing cert. action	Physiological (fatigue, vertigo)	ATC uncooperative or too busy	Below radar or poor radio coverage	Unable to maintain altitude	Lost/unsure of position	Poor avionics	No flight plan filed
1	X	X	X		X					X							X
2	X	X	X														
3	X			X										X		X	
4	X	X							X					X			
5	X	X			X						X						
6	X		X	X						X	X						X
7	X	X		X	X						X			X			
8	X												X				
9						X						X					
10	X	X										X					X
11	X	X								X							X
12	X	X						X					X				X
13	X			X			X		X				X		X		X
14	X	X												X			
15	X														X	X	
16	X	X		X			X								X		
17	X	X												X			X
18	X			X		X											
19	X							X									X

These were all single-pilot flights except for #5. The most sophisticated airframe was a twin piston (#19). All others were single-engine piston, #1-7 being fixed-gear, #8-18 being retractable-gear, six-passenger, or known as technically advanced aircraft (TAA).

The most graphic truth that Table D2 illustrates is how multiple factors conspire to form an incident. The other thing it shows is how great the diversity is among causal factors, even within a logically defined group. This particular problem has plagued the field of accident investigation as long as it has existed.

Category 5 (Training, n=5)

These were fairly straightforward reports. All shared the common theme of an individual filing to avoid possible punishment. All involved single-engine, fixed-gear aircraft engaged in flight training.

Pilot 1 took off into IMC forecast for all three phases of flight, but the pilot was fatigued and became spatially disoriented after flying into clouds, leading to loss of aircraft control. Pilot 2 ran into a “fast-moving, low-level broken cloud layer” during touch-and-goes, resulting in VFR-into-IMC because he had not filed a flight plan. Pilot 3, with a total of 3.5 actual instrument hours, became unsure of his position and penetrated controlled airspace after being confused by complexity in the sectional map. The aircraft in question was relatively ill-equipped, having little in the way of advanced navigational aids. Pilot 4, an instructor, reported “student froze on controls,” causing VFR-into-IMC on a no-flight plan-filed flight. The fifth and final report appeared completely prophylactic. An instructor took off with a student on an IFR flight plan into forecast VMC, but ran into snow showers, successfully deviated, and filed—simply to head off any feared punishment by the FAA.

Category 6 (Ferry, n=2)

Two daylight ferrying flights were reported, both involving single-engine, fixed-gear aircraft, both straightforward. Pilot 1 reported becoming unsure of position, resulting in VFR-into-IMC. He blamed “Time pressure. My boss was rushing me and pushing me to go,” despite his facing deteriorating weather (primarily clouds and rain). These problems were compounded by an in-flight malfunction of both radio and ILS. Pilot 2 encountered rain, fog, and icing, and struggled to maintain altitude while fatigued and being “Unfamiliar with aircraft, area, and no real IMC experience” (9 hours actual instrument experience).

Category 7 (Freight, n=3)

These were high-hour professional pilots. Obviously, none of these incidents resulted in injury, and reports were filed to explain procedural deviations in case of a problem with corporate management. Pilot 1 encountered severe icing in a single-engine, fixed-gear plane that was otherwise well-equipped (weather radar, de-icing boots, prop and engine de-ice). This resulted in diverting to an alternate airport. Pilot 2 was flying a very well-equipped turboprop, encountered an out-of-service AWOS at destination, and continued to another airport rather than land without a weather report. Pilot 3 was flying a twin piston and also encountered icing severe enough to limit climb to 50 fpm. ATC was slow in granting clearance to climb beyond the icing layer. Finally, he inadvertently disconnected his autopilot on descent.

Category 8 (Miscellaneous, n=4)

Three of the four pilots left the mission category blank, hence they were grouped as miscellaneous by default. All were single-pilot, daylight flights. Pilot 1 was a 16 actual-instrument-hour pilot who went on his very first mission on a “Traffic Watch” flight. With no flight plan filed, he proceeded to fly VFR-into-IMC with near-CFIT because he “wanted to make a good impression on the traffic watch reporter that I was flying with.” Pilot 2, on an IFR flight plan, started picking up ice, experienced a delay in getting ATC descent clearance, and descended to warmer altitude. This was exercising judgment as pilot-in-command but was still technically a violation. Pilot 3 got squeezed between undercast and rising cloud tops and ended up inadvertently penetrating controlled airspace before being vectored to VMC by ATC. Pilot 4 ran into unexpected thunderstorms and went VFR-into-IMC, blaming the weather briefer at the FSS for failing to convey proper weather information, and blaming himself for failure to execute a 180 turn and leave the area while still possible.

Non-IR Pilots

The 27 non-instrument-rated pilots fell primarily into two main mission categories of pleasure and training.

Category 1a (Pleasure, Daytime, n=15)

Table D3 best summarizes the results.

If lack of experience seems to play a bigger factor here than it does with IR pilots on pleasure flights (Table D2), keep in mind that that is just a side-effect of our having grouped pilots by rating in the first place.

More strikingly, several categories seem relatively under-populated, for instance, cockpit distractions, overt acknowledgment of knowingly taking risk, fear of certificate action, ATC uncooperative/busy, and being out of radio or radar coverage. It is difficult to know what to make of such a *lack* of information, other than to intuitively sense a pattern, that pattern being summed up by the old saying, "We don't know what we don't know." In other words, the more seasoned IR pilots—particularly the ATPs—seem to know far better what to say on these reports than do these more casual, less experienced pilots. They seem more adept at telling the story of what happened to them and why.

Table D3. Possible causal factors, non-IR pilots, daylight pleasure flights.

Pilot	Ran into unexpectedly bad weather	Less than 50 actual instrument h	Less than 500 flight h	Poor preflight/inflight briefing	Poor planning / decision making	"Get-home-itis"	Lack of experience / unfamiliarity w. procedures	Perceptual misjudgment	Complacency / Inattention	Cockpit distractions	Knowingly taking risk	Equipment problems	Didn't contact ATC fearing cert. action	Physiological (fatigue, vertigo)	ATC uncooperative or too busy	Below radar or poor radio coverage	Unable to maintain altitude	Lost/unsure of position	Poor avionics	No flight plan filed
1	X	X			X															
2	X											X					X	X		X
3	X	X	X				X													X
4		X	X		X	X	X				X									X
5	X	X	X		X															
6	X	X	X		X		X													X
7	X	X	X		X	X														
8	X	X	X		X												X			X
9	X	X	X	X	X															
10	?	X							X			X						X		X
11	X	X																		X
12	X	X	X														X			X
13	?	X	?					X												?
14	X	X	X		X	X	X										X			X
15		X	X			X														X

Category 1b (Pleasure, Dusk and Night, n=5)

Flights 1-2 were dusk, 3-5 were night. Flights 1-3 were single-engine, fixed gear aircraft, 4-5 were single-engine, 4-passenger, fixed-gear. No pilot had filed a flight plan. Four of five pilots encountered weather worse than expected. Pilot 2 reported 55 hours actual instrument time, Pilot 6, reported 6 hours, the rest 0 hours.

Pilot 1 encountered ceiling and visibility degradation, had trouble contacting ATC because they were busy, had to wait for vectors, and wound up going VFR-into-IMC with a near-CFIT. Pilot 2 took off for a very brief hop of 75 miles without a preflight weather briefing, encountered a thunderstorm exacerbated by a dropout in radio reception, and ended up landing without clearance. Pilot 3 took off to practice night touch-and-goes, supposedly after briefing with the FSS (although all items pertaining to forecasts are "conveniently" unanswered). He encountered fog, contacted ATC, declared an emergency, and ATC vectored him to land at a military airport. Pilot 4 ran into unpredicted rain, undercast, and turbulence near destination, lost positional awareness, requested vectors, and ended up penetrating controlled airspace without clearance. Pilot 5 took off from an uncontrolled field to work on his night currency, ran into undercast, missed the airport cues, and went VFR-into-IMC.

What unites these pilots is that everyone reported loss of visibility and subsequent loss of position awareness. Low-light conditions of dusk or night obviously played a major factor in this. Moreover, even though Pilots 1 and 5 had GPS and ILS, either lack of experience, confusion, or both prevented them from successfully getting out of trouble by themselves. Fortunately, all were cool-headed enough to contact ATC, and this is undoubtedly what saved them from a tragic ending.

Category 2 (Training, n=5)

All five of these flights occurred during daylight. Four involved single pilots flying single-engine, fixed-gear aircraft; the remaining flight involved a two-place glider with an instructor and a student. All resulted in VFR-into-IMC. No one filed a flight plan. Three pilots had less than 500 flight h experience. Two were working on an instrument rating, but both had less than 7 hours' actual instrument time. Only one had an autopilot but it was unserviceable.

The individual stories within this group are sketchy. In a few cases there is a suspicious amount of critical missing information here. For instance, one pilot reported checking preflight weather but failed to specify what source he consulted. Four pilots simply reported the cause of their incident being weather closing in faster and more severely than predicted. The remaining (glider) pilot reported being caught in an updraft and swept up into IMC, claiming "ATC would not provide clearance," yet immediately contradicting himself, saying he "Did not feel ATC services were required."

Category 3 (Miscellaneous, n=2)

This contained two single-pilot VFR-into-IMC flights, one business flight (single-engine, fixed gear), one passenger flight (a tour helicopter). No flight plans were filed. Both pilots claimed to be working on their instrument rating, but the business pilot claimed only 5 h of actual instrument time (195 total flight h), the other left that item blank (1350 total flight h). The business pilot blamed the incident on an inaccurate weather report. The tour helicopter was playing "follow the leader" with another helicopter and flew into clouds hidden within haze.

The only destination weather source either pilot consulted was ATIS, with the business flight also consulting ASOS at departure. That immediately puts these two pilots into the "Inadequate weather briefing" category.