Federal Aviation Administration

DOT/FAA/AM-08/7
Office of Aerospace Medicine
Washington, DC 20591

Use of Weather Information by General Aviation Pilots, Part II, Qualitative: Exploring Factors Involved in Weather-Related Decision Making

William R. Knecht
Civil Aerospace Medical Institute
Oklahoma City, OK 73125

March 2008

Final Report

OK-08-1997

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/AM-08/7		

4. Title and Subtitle	5. Report Date
Use of Weather Information by General Aviation Pilots, Part II, Qualitative: Exploring Factors Involved in Weather-Related Decision Making	March 2008
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Knecht WR	
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
FAA Civil Aerospace Medical Institute P.O. Box 25082 Oklahoma City, OK 73125	11. Contract or Grant No.
12. Sponsoring Agency name and Address	13. Type of Report and Period Covered
Office of Aerospace Medicine Federal Aviation Administration 800 Independence Ave., S.W. Washington, DC 20591	14. Sponsoring Agency Code

15. Supplemental Notes

Work was accomplished under approved task AM-A-02-HRR-521

16. Abstract

Interview data obtained from 221 general aviation (GA) pilots are qualitatively scored for factors which influence weather-related decision making. Factors finding relatively strong support are (a) the specific type of weather to be faced (storms, ice, visibility, and cloud ceiling are of greatest concern to GA pilots), (b) type of flight (IFR vs. VFR), (c) pilot physiological state (primarily disorientation), and (d) the inherent uncertainty of weather and the resultant cognitive difficulty of understanding this uncertainty. Factors finding more modest support are (a) social and/or economic pressures, and (b) impulsive behavior. Additionally, relatively strong support is found in previously unpublished data for the influence of mission goals. Research directions, remediations, and the value of qualitative analysis are discussed.

17. Key Words	18. Distribution Statement
General Aviation, Weather, Risk Factors	Document is available to the public through the Defense Technical Information Center, Ft. Belvior, VA 22060; and the National Technical Information Service, Springfield, VA 22161

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

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

ACKNOWLEDGMENTS

The author gratefully acknowledges the efforts of Tom Chidester and Mike Wayda for editing, Dennis Beringer and Jerry Ball for data collection, of the various site points-of-contact who made that data collection possible, and of all the pilots, without whose participation this study would not have come to fruition.

CONTENTS

Use of Weather Information by General Aviation Pilots, Part II, Qualitative: Exploring Factors Involved in Weather-Related Decision Making

INTRODUCTION

BACKGROUND AND PURPOSE

While the causes of aviation accidents are varied and many, adverse weather remains a major, elusive cause of general aviation (GA) fatalities. Weather was cited as causal in only 4% of GA accidents but it accounted for 12 to 17% of fatalities, since about 70% of weather-induced accidents prove fatal (AOPA, 2005).

The U.S. Federal Aviation Administration has a stated current goal of reducing GA fatalities (FAA, 2006). To this end, weather accidents are targeted for reduction.

This calls for psychological research. Yet, the more we learn, the more we appreciate how delicately the complexity of weather interacts with the intricacy of the human mind and the pilot's unique task-world. The problem is not simple.

This report is the second in a two-part series, Part I being *Use of weather information by general aviation pilots, Part I, quantitative: Reported use and value of providers and products* (Knecht, 2008). In Part I, we examined quantifiable aspects of how an interviewed sample of 221 GA pilots actually used the weather information available to them.

Here in Part II, the remaining interview data are examined for themes—factors seeming to influence pilot weather-related decision making. The mission is to look beyond quantitative analysis to explore both known and novel weather-related ideas worthy of further investigation or actual intervention.

METHOD

Design

The original data collection involved onsite interviews with GA pilots. The interview instrument itself is shown in Appendix A. In addition to its quantitative research items, this instrument contained qualitative items designed to elicit free responses. Free-responses are often useful in getting respondents to think beyond the rigid limits imposed by checkbox items.

Participants

During July and August, 2005, FAA staff conducted on-site interviews with 230 GA pilots at locations across 5 states (CA, OK, ND, IL, FL). Four venues were university-based flight schools; the fifth was a helicopter training course. Of these 230 pilots, 221 ultimately provided usable data. Median pilot age was 23 years; median flight experience was 245 hours. Women comprised 14% of the sample. All were volunteers paid for their services as subject matter experts.

Procedure

Like the Part I study, all responses were referenced to a common benchmark—a "standard flight," defined as a 4-hour flight through "weather serious enough to challenge *your* skill level and the aircraft's capabilities." This benchmark was crucial to the study. Without it, pilots would have substituted their own private definitions of "bad weather," making it impossible to relate their attitudes and behavior to any common real-world standard.

Pilots were asked open-ended questions and Likert-scale items designed to capture their thought processes while dealing with adverse weather. The open-ended responses were then scored according to a coding scheme (rubric) laid out in Appendix B.

Rubrics are central to qualitative analysis. A rubric is a scoring methodology, a systematic way of defining a set of key factors well enough to let a rater recognize and tally specific instances within some given text, speech, or behavior (Miles & Huberman, 1994). Multiple instances of a single factor then constitute a "theme." A theme can be unique to an individual, but we are usually interested in themes involving more than one person. Naturally, the more respondents who mention a theme, the more universal we consider it.

Rubrics typically take time to develop. They evolve gradually, within the context of specific data, using a process of deduction and induction applied iteratively. Deduction is top-down, logical reasoning starting with general principles and then looking for specific instances in specific data. Induction is the reverse, the bottom-up formation of general conclusions after looking at specific data.

Consequently, three influences shaped the evolution of our rubric (a) *deductive*, (b) *inductive*, and (c) *sponsor-driven*. Cognitive and behavioral psychological theory guided the search for top-down, deductive evidence of certain themes in the data. Conversely, reviewing specific pilot responses induced other themes from the bottom-up. Finally, project sponsors had specific questions about mission-characteristic effects. The rubric was amended to assess those questions.

Methodological issues

Issues of reliability and validity take on a markedly different role in qualitative analysis than they do in quantitative analysis. First, the concept of "themes" lends itself less to discreteness and definability and more to broadness and generality. Consequently, we typically recalibrate our priorities regarding experimental error when we go out "fishing for factors" this way.

Second, in quantitative analysis the focus is almost always on controlling Type I error (the misidentification of factors as "significant" which are truly not). Whereas, in qualitative analysis the focus is frequently on controlling Type II error (the *failure* to identify as significant those factors which truly are). This difference in focus exists because quantitative analysis is about hypothesis-testing, whereas qualitative analysis is more often about hypothesis-generation.

What we have to understand is the relation between Type I and Type II errors. "Truth" can be thought of as a "signal," and signal detection theory says that whenever we choose to capture more signal (increase the hit rate, minimize Type II errors), this *inevitably* comes at the expense of increased false alarms, namely increased Type I error (Green & Swets, 1966). A finer-mesh net catches more fish—but also more flotsam.

The point is that quantitative and qualitative analysis are really two methodologies designed to do different things. Where quantitative analysis tests hypotheses, qualitative analysis can generate new hypotheses. Researchers must simply make clear when they are engaged in each type of analysis and properly limit the interpretation of subsequent results.

RESULTS

Since the rubric was iteratively shaped by three influences (deductive, inductive, sponsor-driven), the results are presented under similar headings.

Deductive (top-down, theory-driven) themes

Theme 1: *Type of weather.* Psychologically, weather is a set of specific stimuli. So, certainly, different types of weather must affect pilot decisions differently. Change the weather, change the decision.

Following a deductive approach requires first listing the main weather factors pilots *could* discuss. Next, using their free-response answers (Appendix A), the factors they actually *did* discuss could be scored and tabulated.

An endnote [page 9] clarifies the complete methodology and exactly how to read Table 1.[1] Briefly, each cell represents the percentage of pilots who discussed that factor at least once in their interview. If a given pilot mentioned a given factor more than once, it still counted only once. Note that neither rows nor columns need

Table 1. Percentages of the 221 pilots who referred at least once to each weather factor in their interview. Data to the left refer to preflight. Data to the right refer to in-flight. Row "IR" data came from instrument rated pilots, row "Non-IR" from non-IR pilots. Row "Total" combines both IR and non-IR responses. "Storms" mainly means thunderstorms, but also tornadoes + hurricanes. "Wind" includes turbulence + wind shear. Significant results are bold+highlighted ($p_z < .05$ (uncorrected for number of comparisons), 1-tailed for all but "(Non-IR-IR)" scores, which reflect $p_z < .02$, 2-tailed, corrected for number of comparisons). See Endnote for details.

	Storm, (incl.T-storm, tornado, hurricane)	Rain	Snow	Ice	Hail	Cloud ceiling	Visibility	Wind/Turbulence		Storm, (incl.T-storm, tornado, hurricane)	Rain	Snow	Ice	Hail	Cloud ceiling	Visibility	Wind/Turbulence
	Preflight									**In-flight**							
Total	**83**	5	7	**48**	5	**46**	**57**	**52**		**81**	5	4	**42**	5	**41**	**49**	38
Non-IR	**78**	10	6	25	3	**51**	**64**	**63**		**66**	9	3	22	4	**48**	**66**	37
IR	**86**	3	7	**57**	6	**44**	**54**	**47**		**87**	3	4	**50**	5	38	**42**	38
(Non-IR)-IR				**-32**						**-21**			**-28**			**24**	

total to 100%. Factors with percentages significantly higher than average ($p < .05$) are shown boldfaced and highlighted in gray. Statistical issues are elaborated in a second endnote.[2]

The row labeled "Total" represents instrument-rated and non-instrument-rated pilots combined. Higher-than-average *combined-group preflight* factors mentioned by pilots were

- storms 83%
- ice 48%
- cloud ceiling 46%
- visibility 57%
- wind 52%

In the same row, farther to the right, above-average *combined-group in-flight* factors mentioned were

- storms 81%
- ice 42%
- cloud ceiling 41%
- visibility 49%

This gave us a rough idea of what factors seemed to mentally dominate the average pilot over the entire length of a flight, namely storms, ice, ceiling, and visibility.

A brief note about snow: Since the interviews were conducted in the summer, it is perfectly natural to wonder if the relatively low numbers for snow were merely due to the current air temperature. If we had interviewed during the winter, would snow have received higher priority? The honest answer is that we simply do not know. There is a modest validity crosscheck in the fact that pilots did emphasize icing. However, icing can occur nearly year-round, especially carburetor icing (and the pilots rarely distinguished between icing types in their responses). So the question remains debatable, and the only valid (but, unfortunately, cost-prohibitive) way to settle it would be to reconduct the study during the winter.

Theme 2: *IR versus non-IR flying.* Because instrument-rated (IR) pilots are trained to fly in a different physical environment from non-IR pilots, it made sense to split Table 1 in half on this basis. The two additional rows labeled "Non-IR" and "IR" also use boldface and gray to highlight significantly above-average cells ($p < .05$).

The patterns that emerged for the two groups looked fairly consistent and jibed with practical experience. Storms, ice, ceiling, and visibility are logically both common *and* potentially dangerous to all pilots at all phases of flight.

So how did IR pilots' flying differ from non-IR? The "(Non-IR) – IR" row shows *percentage differences* between the two groups.[3] Significant differences (greater than 20 points, $p < .02$) emerged for

- Preflight ice -32%
- In-flight ice -28%
- In-flight storms -21%
- In-flight visibility +24%

Negative numbers (less than zero) meant the factor was bigger to IR pilots. Numbers greater than zero meant the factor was bigger to non-IR pilots.

Again, this jibed with experience. Non-IR pilots must avoid in-flight restrictions to visibility, while this is much less an issue with IR pilots.

Stepping back to get the big picture, it was easy to see that instrument flight rules (IFR) flight has a lot more built-in ambiguities than visual flight rules (VFR) flight. First, IR pilots should (and did) talk more about preflight and in-flight ice because ice would not automatically *preclude* flying, whereas it usually would for non-IR pilots. Second, in-flight storms should (and did) elicit more responses from IR pilots because they would certainly be more likely to fly near (and, sometimes, into) weather capable of storm intensity.

Third, wind and turbulence loomed larger for everyone during preflight than in-flight. That might seem counter-intuitive. But it may simply have been a technicality. The term "in-flight" does not technically include the landing phase, whereas preflight planning always includes all phases of flight, including landing, when wind and turbulence are most likely to be hazardous.

To summarize, in some ways the environmental context, training, and equipment used in instrument meteorological conditions (IMC) is quite different from visual meteorological conditions (VMC). The basic hazards are the same but vary mainly in intensity and frequency of encounter.

Theme 3: *Social and economic pressure.* Pilots often cite social and economic pressures as reasons for taking chances they would not otherwise take. For example, Rhoda and Pawlak (1999) found that commercial airline pilots were more likely to penetrate storms in terminal airspace when following another aircraft. In one sense, proximal pilots form a "society" where one member influences the risk-taking of others.

Here, at least 48 pilots reported external social or business-related pressures to fly in marginal weather. So, in an informal sense, pressure certainly was a theme.

Social psychological theory elaborates this idea of "pressures" into better-defined and more measurable processes such as social facilitation, diffusion of responsibility, social assessment of risk, and obedience to authority. So did these pilots report any influence of these processes?

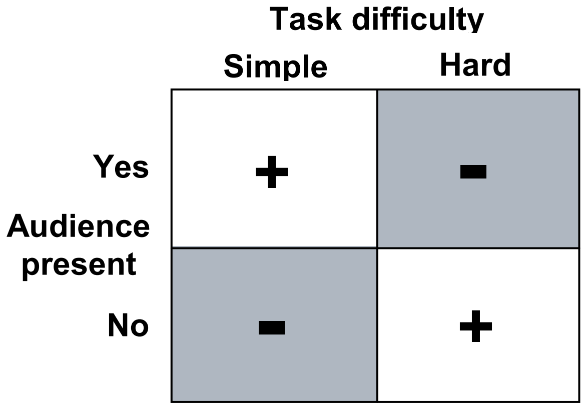


Figure 1. The 2x2 matrix of possibilities for task performance as defined by social facilitation theory. "**+**" means task performance is enhanced, "**-**" means it is degraded.

Honestly, there was little direct evidence here for diffusion of responsibility and social assessment of risk. While we cannot rule them out, we cannot find support, either. However, the reports of "pressure" were possibly consistent with social facilitation and/or obedience to authority.

Social facilitation describes the effect of an audience on task performance (Zajonc, 1965). Despite its name, social facilitation is not facile. For one thing, "facilitation" can be positive or negative. For another, outcomes depend on situational factors, for instance, task difficulty (Figure 1). For example, experienced runners tend to run faster in a group than when alone (the "Simple/Yes" cell). However, complex math problems are easier to solve when we are by ourselves (the "Hard/No" cell).

Does this theory apply to weather-related risk-taking? Recall that these pilots were predominately either students or flight instructors. If students said they felt pressure to expedite training, that pressure might be caused by social facilitation.

However, one fact argues against the social facilitation hypothesis and that is the theory itself. Weather flying is a difficult task. Therefore, as Figure 1 shows, the presence of the instructor in the cockpit should have inhibited student willingness to fly in bad weather, not facilitated it.

An alternate, simpler economic explanation might be more plausible, namely that flight training is expensive and students wanted to get through it as fast as possible. After all, many flight schools charge by the hour. Plus, time spent training is time away from earning money, so school carries a double incentive to finish fast.

Now what about instructors? Instructors reported occasional pressure from both their employers and students to fly in marginal weather. While this might be social facilitation, the more straightforward answer would again be economic. Students probably exert pressure because they are trying to finish fast. Employers probably exert pressure, partly in response to student pressure and partly because the faster a school moves students along, the more money it can make.

Finally, there was one more alternate social hypothesis to consider here, namely obedience to authority. In his classic experiment, Milgram (2004/1974) demonstrated that otherwise-normal people would administer supposedly lethal electrical shocks to strangers on command from an authority figure. If some people would do anything that extreme, might they possibly also dally a bit with bad weather, if pressured into it?

Now, an employer is definitely an authority figure. But, as any teacher will confirm, so is the modern student. This reflects the increasing tendency for schools to follow a business model where teachers have to treat students as customers (Armstrong, 2003). And, as we all know, the customer is always right.

The presence of passengers is another common social situation that could arguably influence risk-taking. However, the influence could conceivably go both ways. On the one hand, passengers can be a source of pressure to start or continue a flight into bad weather. On the other hand, since risk depends on what we stand to lose, the more lives that stand to be lost (and the closer they are to us) the greater the risk should be.

Table 2 was based on two interview questions, "Does having *non-family* (Q36, or) *family* (Q37) passengers affect your willingness to fly in bad weather?"

Here, most pilots basically said "no." While the reported concern for family passengers was significantly greater (X^2 = 32.4 (3), $p < .00001$), only 33% ((27+29+18)/221) reported more than "a little bit" of concern over having non-family passengers, as compared to 47% for family passengers.

Beyond the palpable conclusion that family trumps non-family, these results were hard to interpret. Could

Table 2. Influence of passengers (response frequencies)

"not at all" or "a little bit"	"somewhat"	"quite a bit"	"an extreme amount"
Q36 passengers are **not** family			
147	**27**	**29**	**18**
118	**27**	**37**	**39**
Q37 passengers **are** family (N = 221, both questions)			

the majority of passengers be quite so persuasive? Or could the majority of pilots believe in their own skill and luck so profoundly that having others on board added absolutely nothing to their perception of risk?

Both those conclusions are absurd. What is more believable is that multiple motivations are confounded here, some facilitative, some inhibitory. And the net effect that any given passenger must have on a pilot's willingness to take weather-related risks probably depends on the specific pilot plus the specific passenger plus the specific circumstances. A boss pressuring you to get to a meeting on time is different from taking your childhood friend out to practice touch-and-goes. Individuals matter, relationships matter, the flight mission matters, and so forth.

To wrap this up, both social and economic circumstances can obviously influence weather-related behavior. But there is a lot more to it than meets the eye. First, some factors may increase risk-taking, others decrease it. Second, situational details matter, and broad questions such as the ones asked here will not tease apart all the causal intricacies. Example: Question 17h was worded "Have social or business pressures ever influenced your GA go/no-go weather decision?" While not a terrible question, future interviews should try to devise more specific, theory-based questions better able to differentiate facilitation from inhibition and able to distinguish social inhibition from obedience, economic, and other motivations.

Theme 4: *Pilot physiological state.* Factors such as fatigue, hypoxia, and spatial disorientation affect weather-related decision making (Taneja, 2002). Interview time constraints prevented full exploration of all these factors, but we did sample disorientation. When asked, "How many times have you become so disoriented that you had to land or call ATC for assistance in determining your location?", 22 pilots responded (Q31, average 1.1 episodes per pilot). Additionally, when asked, "How many times have you become so disoriented after entering IMC that you had difficulty in maintaining aircraft control?", 35 pilots responded (Q33, average 1.5 episodes per pilot).

Given how relatively low-hour most of these pilots were, these numbers were surprisingly high. Fortunately, of pilots who admitted to disorientation, only 32% responded to *both* questions. Put another way, up to two-thirds of those who did experience serious disorientation may have undergone one-trial learning. Powerful experiences tend to have that effect.

Of course, the nagging facts remained that (a) about 20% of mostly low-hour pilots reported getting seriously disoriented at least once and (b) there are more physiological effects than just disorientation. It seems that serious physiological disruptions may be more common than we thought. Moreover, these people, even if they did learn effectively, learned the hard and dangerous way. And the handful who went through the experience more than once may constitute a target group in need of training or intervention.

Theme 5: *Impulsivity*. Nearly every adult acts impulsively at least once in their adult life. Pilots are specifically trained to minimize impulsive behavior. Do they?

Fortunately for this analysis, more than a few pilots felt comfortable enough to admit to various kinds of impulsive or accidental rule-breaking behaviors such as taking off with no weather planning at all (Q17g, 40 affirmative responses) or flying into IMC without proper rating or aircraft (Q32, 35 affirmatives).

This is evidence we should conservatively call "unintentional impulsivity" because none of the questions overtly asked about intentions (realistically, how many pilots would have admitted, in writing, to an FAA official, that they had intentionally broken any rule?)

So, these answers did show that pilots do act on impulse once in a blue moon. While the vast majority of this behavior obviously did not result in serious consequences in the sense of having hurt someone, the potential seriousness was impossible to gauge because the sample was biased. It contained no one who had ever been killed as a result of impulsive behavior. If such pilots could talk, they might judge impulsivity far more harshly than either we or these pilots did.

Inductive (bottom-up, emergent) themes

Induction is the opposite of deduction. In examining the data, patterns and themes emerge, induced by the evidence.

Theme 6: *The uncertainty of weather.* A strong theme gradually materialized after multiple reviews of the data. It started with the broad idea of *uncertainty*. Pilots made at least 30 general and 21 specific remarks concerning the uncertainty of weather. So how could this effect of uncertainty be best understood?

There are at least four main influences that drive the uncertainty of weather prediction

- Weather is chaotic
- Most of us have difficulty understanding probabilities
- Weather forecasts are biased towards false alarms
- Weather risk increases with flight length

First, weather truly is hard to predict. Compared to simple, orderly probabilistic systems like cards or dice, the earth's surface, oceans, and atmosphere form a complex, chaotic system in the strictest mathematical sense (Gleick, 1987). The mathematical models that forecasters use to make predictions are, by definition, simplifications which contain error. Over time, this error gets amplified and, inevitably, the forecast becomes less and less accurate. Anything over 24 hours is literally a "long time" in forecasting.

Second, estimating and understanding probabilities is something most of us are not terribly good at, particularly with rare events. Kahneman, Slovic, and Tversky (1982) and many others have shown that people often *under*estimate the occurrence of likely events that happen to be commonplace while *over*estimating the occurrence of much less likely events that merely happen to be more dramatic. The chance of being killed by lightning is a good example. Many of us would think this is fairly common, yet lightning claims just about 200 Americans each year (National Weather Service, 2006a). This is a small figure compared to the 44,000 typically taken by car accidents (Bureau of Transportation Statistics, 2006). It is as if we have a built-in tendency to confuse high drama with high likelihood.

A third factor driving the uncertainty of weather prediction is the fact that weather forecasts are biased towards false alarms. From a static observer-centered point of view—the point of view of any given observer standing still on the ground—weather forecasts tend to overpredict the chance of bad weather. This is a rather obscure mathematical artifact which requires some explanation.

Bad weather is something we want to detect. It is a "signal" buried in "probability noise." This lets us draw the four outcomes defined by signal detection theory (Figure 2).

A "false alarm" happens when bad weather is predicted, but the actual weather turns out good (or at least better than predicted). A "miss" is when good weather is predicted, but the actual weather turns out bad (or at least worse than predicted).

Predicted weather	Actual weather: Bad	Actual weather: Good
Bad	HIT	FALSE ALARM
Good	MISS	CORRECT REJECTION

Figure 2. The 2x2 matrix of possibilities for weather prediction, as defined by signal detection theory.

Misses and false alarms are our two types of mistakes. Too many of either and we start mistrusting the weather forecast.

Weather forecasters do not want us to mistrust the forecast. But they also know that people dislike being surprised by unexpected bad weather far more than they do being surprised by unexpected good weather. So, forecasts are typically conservative and effectively overpredict bad weather. In fact, when the forecast says "20% chance of rain," all it really means is that, within a rather large, pre-specified geographical area during a pre-specified time period, there is a 20% chance of at least .01 inches of rain falling somewhere (National Weather Service, 2006b).

This way of defining bad weather automatically leads to likelihood overestimation. The easiest way to understand is to think of weather as a shotgun. If you shoot at a cereal box 100 yards away, you may have a 20% chance of hitting it. But the chance of hitting a flea on top of that box is much smaller. Smaller size—less chance of getting hit. Now, just imagine you are the "flea" and the "cereal box" is the size of Connecticut. The idea is that weather probabilities apply to large geographic regions, not to one, tiny person. Your chance of personally being hit by something is typically much less than the forecast suggests.

Unfortunately, this bias has a great effect on aviation. Given this built-in tendency for false alarms, pilots start *expecting* the actual weather to be less severe than predicted. And then, like the boy who cried "Wolf," along comes a time when the actual weather turns out far worse than predicted. Given enough time, this is statistically almost certain to happen.

The fourth influence driving the uncertainty of weather prediction is yet another statistical quirk, one biased in the opposite direction to the one just discussed. Longer flights usually involve more bad weather than short flights. The reason is based in statistical mechanics (Knecht, 2000) but is easy to understand: The farther you fly, the more airspace you plow through. The more airspace you plow through, the more chance you have of running into bad weather somewhere. It is like walking through a minefield. The farther you travel, the more likely you are to step on something bad.

So, to summarize, uncertainty is rampant in weather forecasting. First, weather is chaotic, hence, truly hard to predict. Second, we innately tend to overestimate the likelihoods of some events while underestimating others. Third, weather forecasts are biased to overpredict bad weather for stationary observers. Finally, an opposite bias also occurs: that longer flights run greater weather risk.

With so many deep and contradictory forces at work, is it any wonder why weather confuses us?

Fortunately, many of the pilots we interviewed openly acknowledged this issue of uncertainty. At least 86 explicit references were made to specifics such as "expecting the unexpected" and of having preconsidered options such as diverting to alternate airports or driving instead of flying. This showed an appreciation of the underlying problem and a healthy evolution of strategies to combat it.

Sponsor-driven questions

This work was partially tasked to address an additional, sponsor-driven question, namely:

Theme 7: *To what extent do mission goals influence weather analysis and decision making?* Unfortunately, there was little evidence in this study to illuminate that theme beyond discussion of Theme 3. Since the current interview questions specified neither a range of weather nor of missions, it was no surprise that mission goals did not come up spontaneously as a theme.

Fortunately, the basic question was addressed by prior work. In unpublished data gathered by Knecht, Harris, and Shappell (2005), 105 GA pilots were asked about their willingness to fly in assigned visibilities ranging from 1-5 sm and ceilings of 1000-2000'. One debrief question was, "If your flight mission had been critical (for example, delivering a human heart for surgery), how much would that change your willingness to take off/continue?"

Given that hypothetical situation, virtually *everyone* indicated a strong willingness to fly in the visibility/ceiling combination to which they had been assigned. This was particularly striking, given that many had actually chosen not to fly, even when offered $200 to do exactly that. Now, while respondents admittedly may have been merely trying to cast themselves in a good light, the chances are good that these answers really did reflect a genuine, altruistic human concern for fellow citizens.

If so, then this addresses the influence of flight mission. Given an extremely critical mission, nearly all pilots will fly into some fairly bad weather. Conversely, given severe weather coupled with an unimportant mission, nearly no one will.

That defines two ends of a continuum. But remember that this is a multidimensional decision landscape with many possible weather characteristics and mission characteristics. As is usual in such cases, details are critical, and every scenario ends up having to be examined separately.

DISCUSSION AND CONCLUSIONS

This research was the second in a two-part series. Part I looked at quantitative data from 221 GA pilot interviews, categorizing the types of weather information pilots could use versus the ones they say they do use (Knecht, 2008).

Here in Part II, the emphasis was qualitative. Using the same data set, we looked for further evidence of weather-related factors that influence pilot decision making and which were either logically deducible facts or which could be arrived at inductively by scoring and tallying pilots' free-response items. The underlying goal was hypothesis-generation for possible future exploration.

The following factors were fairly strongly supported:

1. "Short list" of weather types uppermost in pilots' minds
   a. storms
   b. ice
   c. deteriorating visibility
   d. lowering cloud ceilings
2. Specific pilot factors influencing the "short list"
   a. instrument rating
   b. experience with weather
3. Spatial disorientation
4. Uncertainty
   a. forecast accuracy decreases as lookahead time increases
   b. forecast probabilities are greatly misunderstood by most people
   c. forecasts routinely overpredict bad weather for stationary observers
   d. weather risk increases as flight length increases

The following factors found modest support:

5. Social and economic pressures can increase risk-taking
6. Strictly impulsive behavior is rare but does exist

Finally, there was narrowly focused (but fairly strong) support found in previously unpublished data for the influence of:

7. mission goals

Factors 1 and 2 receive extensive *intellectual* training in GA flight training. But one important thing new pilots typically lack is the "fear factor" which can only be learned from the *physical and emotional* experience of storms, ice, and inadequate visibility.

Factor 3 concepts are also covered in flight training. But, again, unless pilots have spent time in special full-motion disorientation training simulators, physiological effects will probably end up being learned the "old-fashioned" way.

Most of Factor 4 receives little emphasis. We will return to it in a moment.

Factor 5 is one everybody acknowledges but nobody does much about because it is about psychology, not strictly about pilot training. To resist social and economic pressures takes knowledge, wisdom, and character as pilot-in-command. Flight schools cannot teach wisdom. That is a lifelong process. But they can offer guidance, encourage pilots to develop personal minima, and share personal accounts of weather encounters, both their own and those of pilots they know. Personalization can help make the abstract more concrete.

Factor 6 is the reason there are few "old, bold pilots." Impulsivity catches up with them. Impulsivity is aviation's crabgrass—we can control it but can never completely get rid of it. Our culture values daring behavior. Flying is synonymous with daring. So how do we honor our culture and still teach the disciple that discretion is usually the better part of valor? Maybe the answer is to teach that there is no honor in *unnecessary* risk.

Little direct support was found for Factor 7 in these data (although it was in other, unpublished data). Given the right mission, pilots will take on considerable risk. But the relation is complex and the details of the mission and the weather both matter.

Most of these factors are well-known and our rediscovery of them far from ground-breaking. But they are real, and our focus on them has to remain relentless.

Factor 4 is perhaps the most intriguing and novel part of this report. We all know weather is uncertain, but we rarely sit down and think exactly *why* it is uncertain and why it is that the human mind has such difficulty with this particular style of uncertainty.

The uncertainty of weather starts with the physical world. Weather is complex and chaotic in the true mathematical sense—impossible to fully model, impossible to fully predict. That leaves probability as the best we can do to express how weather behaves.

Probabilities segue into psychology. By nature, the human mind hates uncertainty. The greater the uncertainty, the more uncomfortable we are with it. This discomfort is deep-rooted, genetic, and probably related to survival of the species. We seem to have biases. We overestimate some odds and underestimate others. Why? Because, in the still of the night, there may be tigers. And, those of our ancestors biased to worry a little too much about tigers may have ended up living longer than those who worried too little. So, these mental biases may be the remnants of tendencies that, under more primitive circumstances, conveyed survival advantage. But, here in the modern world, a side effect is that we overestimate the average severity of weather forecasts.

Intuition tells us that bad weather is less likely to happen than the forecast says—*if* you stand in one spot. Now, statistical mechanics shows that intuition was right.

Finally, as if all this were not enough, we now know that the opposite is true, too, provided we are *not* standing in one spot. The farther we fly, the more adverse weather we're likely to encounter.

We now have a clearer understanding of why weather forecasting is inherently problematic and will never be trivial. This is no cause for alarm or discouragement, but pilots do need to come to the same kind of clear understanding. Exactly how to do that will occupy us for some time to come.

Suggestions for further study and/or intervention

Uncertainty is the pilot's greatest enemy. What we know and know of, we can either cope with or avoid. Five healthy, positive weather-related responses are:

1. Use and understand the modern weather products.
2. Expect the unexpected.
3. Always have multiple, workable options thought out ahead of time.
4. Do not wait to learn about weather the hard way.
5. There is no honor in unnecessary risk.

We can teach weather skills. The utility of low-cost, PC-based weather training comes to mind, as well as low-cost cockpit weather information devices (and we need to stress that the Flight Service Station is the lowest-cost "device" of all).

Ultimately, we need even more reliable, more effective weather forecasts. In the meantime, pilots need to seek out the excellent preflight preparation products already in place (e.g., www.aviationweather.gov). Pilots need to understand clearly what those mean and how to use them. Right now, these weather providers are new, and we are all still learning how to make the most of them. Familiarity and understanding will spontaneously increase with use, so that aspect is self-correcting. In the meantime, human factors study of the graphic user interfaces might be of service to the National Weather Service and should be considered.

ENDNOTES

[1]To understand Table 1, first notice the highlighted "Total" on the left-hand side. Now follow the percentage of pilots who mentioned weather factors in that row.

Total	83	5	7	48	5	46	57	52

Each number represents the percentage of pilots who "voted" for that weather factor by mentioning it in their interview. Each cell percentage was calculated as

$$\frac{\text{\# of pilots who mentioned this factor at least once}}{\text{total \# pilots (N=221)}}$$

If a pilot mentioned a given factor more than once, it still only counted as one "vote." Therefore, the smallest percentage a given factor could get was 0% and the largest, 100%. Notice that rows do not add up to 100%. We do not expect them to, because each factor was separate and based on its own separate tally of votes.

The row at left labeled "Total" considered instrument-rated and non-instrument-rated pilots together as a total group. Higher-than-average percentages (highlighted, bold) that emerged *as preflight factors* were storms (83%), ice (48%), cloud ceiling (46%), visibility (57%), and wind (52%).

In the same row, farther to the right, similar numbers emerged for *in-flight* factors—ones supposedly influencing pilots' go/no-go weather decisions while in-flight.

11	81	5	4	42	5	41	49	38

Here, higher-than-average percentages emerging as *in-flight factors* were storms (81%), ice (42%), cloud ceiling (41%), and visibility (49%).

Instrument flying is different from VFR flight, so we sorted pilots by instrument rating. These percentages form the two rows labeled (at left) "Non-IR" and "IR." In these two rows, highlighting and boldface again mark the most frequently mentioned factors.

The limitations of Table 1 must be explained. Overall, what we were trying to do was get a sense of which weather factors were most important to pilots. Since each cell represented the percentage of pilots who mentioned a particular factor at least once during their interview, we assumed that the more pilots who mentioned that factor, the more important the factor was likely to be in their decision making. Thus, the higher numbers probably reflected the more important weather factors. The question then became how big did the numbers have to be to be considered reliable?

The first step was to compare each cell in a row with its corresponding row mean. This would determine which weather factors were above average. To establish reliability, in each of the "Total," "non-IR," and "IR" rows, a standard error of proportion (SEM_{row}) was calculated to estimate the stability of that row mean (Ferguson, 1971, ch. 12). Then, each individual cell score was evaluated against (row mean + 1.65 SEM_r, ≈ "$p < .05$," 1-tailed). Note that this is *not* the same as finding "the upper 5% of cell values." It represents finding which weather factors seem reliably *more important than average*. Thus we expect to see about half the factors identified, which is the case in Table 1. Statistical purists may criticize this method, but we need to keep in mind the largely qualitative, exploratory nature of this study.

The second thing we wanted to do was compare non-instrument-rated pilots with instrument-rated pilots to see which weather factors seemed more important to which group. This method was considerably more precise. It involved comparing cells by column, between "Non-IR" and "IR" for each weather factor. To do that, a separate SEM_{column} was calculated for each "(Non-IR) – IR" difference score (because SEM is a function of both proportions), and that was used to do *z*-tests (Ferguson, 1971, ch. 12). In this case, we elected to use a much more stringent criterion for reliability, $p < .02$, 2-tailed, to correct for multiple comparisons.

To summarize, the primary limitation here was that the method was extremely lax about the "row conclusions," while being moderately strict about "column conclusions." Therefore, the reader is strongly cautioned to keep this in mind, as appropriate to the circumstance.

[2]In Table 1 (and throughout this report), most numbers presented are not necessarily statistically significant. This involves a technical issue having to do with experimentwise error. When many statistical results are reported in one study, there is a good chance that at least some of those "significant" results will be false. However, if one uses standard procedure to statistically correct for this (e.g., the Bonferroni correction), then one lands squarely in territory where *nothing* is "significant." This is one reason why, in exploratory research such as this—and, particularly in qualitative research—results are typically presented "as is," with no deep statistical analysis, and no correction for experimentwise error.

[3]At first glance, it might seem appropriate to do analysis of variance (ANOVA) on these numbers. But many variables (e.g. ,storms, rain, hail) are correlated and, to an unknown degree, violating the assumptions of ANOVA and rendering it inappropriate.

REFERENCES

AOPA Air Safety Foundation. (2005). Nall Report--Accident trends and factors for 2003. Frederick, MD: Aircraft Owners and Pilots Association. Downloaded Dec. 22, 2005 from www.aopa.org/asf/publications/ 04nall.pdf.

Armstrong, M.J. (2003). Students as clients: A professional services model for business education. *Academy of Management Learning, 2*(4), 371-74.

Bureau of Transportation Statistics. (2006). *Distribution of transportation fatalities by mode*. Downloaded June 28, 2006 from www.bts.gov/publications/national_transportation_statistics/2002/html/table_02_04.html.

FAA. (2006). *Flight Plan 2006-2010.* Washington, DC: Federal Aviation Administration.

Ferguson, G.A. (1971). *Statistical analysis in psychology and education.* New York: McGraw-Hill.

Gleick, J. (1987). *Chaos: Making a new science*. New York: Viking.

Green, D.M. and Swets, J.A. (1966). *Signal detection theory and psychophysics*. New York: Wiley.

Kahneman, D., Slovic, P., and Tversky, A. (Eds.). (1982). *Judgment under uncertainty: Heuristics and biases.* New York: Cambridge.

Knecht, W.R. (2000). Modeling the Big Sky Theory. *Proceedings of the Human Factors and Ergonomics Society 45th Annual Meeting* (pp. 87-91). Santa Monica, CA: Human Factors and Ergonomics Society.

Knecht, W., Harris, H., and Shappell, S. (2005). *The influence of visibility, cloud ceiling, financial incentive, and personality factors on general aviation pilots' willingness to take off into marginal weather, Part I: The data and preliminary conclusions*. (Technical Report DOT/FAA/AM-05/7). Washington, DC: Federal Aviation Administration, Office of Aerospace Medicine.

Knecht, W. (2008). *Use of weather information by general aviation pilots, Part I, quantitative: Reported use and value of providers and products*. (Technical Report DOT/FAA/AM-08/6). Washington, DC: Federal Aviation Administration, Office of Aerospace Medicine.

Miles, M.B., and Huberman, A.M. (1994). *Qualitative data analysis*. Thousand Oaks, CA: Sage.

Milgram, S. (2004). *Obedience to authority: An experimental view*. New York: HarperCollins. (original work published 1974).

National Weather Service (2006a). *All about lightning*. Downloaded June 28, 2006 from noaa.kids.us/lightnin.htm.

National Weather Service (2006b). *Behind the forecasts*. Downloaded Apr. 13, 2006 from www.wrh.noaa.gov/sgx/research/Guide/Behind_the_Forecasts.pdf.

Rhoda, D.A. and Pawlak, M.L. (1999). *An assessment of thunderstorm penetrations and deviations by commercial aircraft in the terminal area*. (Technical Report NASA/A-2). Lexington, MA: Lincoln Laboratory (MIT).

Taneja, N. (2002). Weather-related fatal general aviation accidents: Can spatial disorientation training be an effective intervention strategy? *Indian Journal of Aerospace Medicine, 46*(2), 59-64.

Zajonc, R.B. (1965). Social facilitation. *Science, 149*, 269-74.

SME#

APPENDIX A
Pilot Interview

1. Age____
2. Gender (male __, female __)
3. Primary occupation ____
4. Other current occupation(s)____________________
5. Past occupations(s) related to aviation______________________________________
6. Certificates and ratings (check each that applies)

	Sport		Airplane Single-Engine
	Recreational		Airplane Multiengine
	Private		Rotorcraft
	Commercial		Balloon
	ATP		Airship
	Instrument		Glider
	Flight Instructor		Powered-Lift

7. Type of flying you do (to the nearest 10 percent, for example, recreational 20%)
   recreational____ business____ corporate____ commercial____(these should add to 100%)

For questions below, "general aviation" (GA) means "any small aircraft not flying for hire."

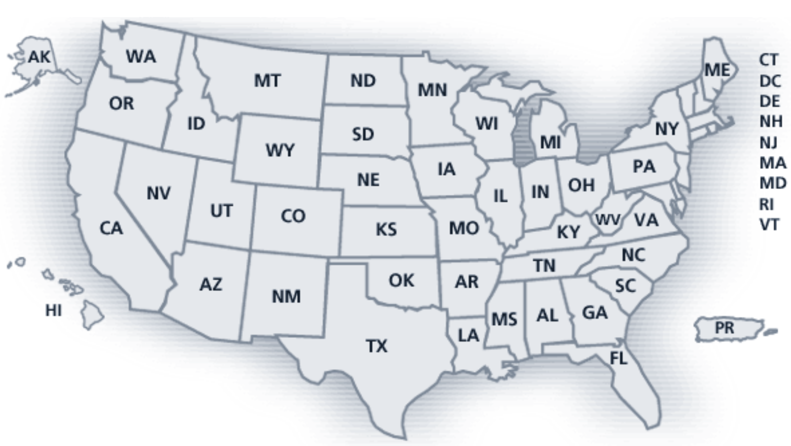
8. Your total GA flight hours (best guess) ___________ Total hours in last 90 days___________
9. Do you own your own GA aircraft, either by yourself or as a member of a partnership? (Y / N)
10. Type(s) of GA aircraft usually flown:____
11. Your normal personal minimum for GA VFR visibility ________ statute miles
12. Your normal personal minimum for GA VFR cloud ceiling ________ feet AGL

For questions below, if you're not a U.S. citizen, use "country" instead of "state"

13. Current home state (legal residence) _______________________
14. Approximate percentage of time you've flown GA in your home state _____% versus

    outside your home state _____% (est.: add up to 100%)

15. State(s) where you received GA pilot training____________________________
16. States where you've flown GA (put a check mark ✔ in each state name below)



If your flying has been largely outside of the USA, please list below the countries in which you regularly fly and the percentages of time spent in each (estimates):

Country	% time

This is a study about how GA pilots use weather information. Please bear in mind these things:

A. We already know the "textbook answers" for how pilots are *supposed* to use weather information. What we need to know is how real pilots are using real weather information in the real world.

B. Your responses are strictly anonymous and confidential.

C. In the next section we'll refer to "cross-country flights." That may mean different things to different people. So define "cross-country" as: 1) *Non-local* airport, far enough away that the weather could surprise you.

D. "Bad" weather can also mean different things. So define it as: Weather serious enough to challenge *your* skill level and the aircraft's capabilities.

SECTION TWO: CROSS-COUNTRY, BAD WEATHER GA FLIGHT

17. This question will ask details about how you get a PREFLIGHT weather briefing for CROSS-COUNTRY, GA FLIGHT when you ANTICIPATE BAD WEATHER. Use the definitions of "cross country" and "bad weather" from above in forming your responses.

    a. When do you start planning such a flight? (for example, the day before, the morning of, etc.)

    b. Where do you start researching the weather? (e.g., at home? At the airfield?)

    (Below, a weather "product" is a single report like a METAR, TAF, ASOS, or AWOS. A "provider" is an organization like the FSS that bundles individual products together to give a comprehensive wx outlook)

    c. List the main weather information provider(s) you consult. List the main products you use from each provider. What relative importance do you give to these products? (write "1" by the most important product, "2" by the second-most important product, etc.

    d. About how many minutes does usually it take to finalize your bad-weather GA plan?______

    e. List the major weather factors that would immediately trigger a no-go decision before takeoff.

    f. What weather factors would lead you to divert a flight in progress?

    g. Is there any time you anticipated bad weather but took off without planning for it? If so, describe it briefly. Remember—this is 100% anonymous, so do NOT name names of individuals involved.

h. Have social or business pressures ever influenced your GA go/no-go weather decision? (For example, have you ever made a risky flight on a dare, or has a boss ever pressured you into flying against your better judgment?). If so, describe it, taking care not to name names.

i. In plain words, describe what goes through your mind in planning for bad-weather, cross-country GA flight.

j. Briefly, how does your good-weather planning differ from your bad-weather planning?

k. If there were one thing you'd like to see improved about weather information, what would it be?

SECTION 3: CROSS-COUNTRY, BAD-WEATHER INFO. SOURCES (IN-DEPTH REPORT)

(As before, a "product" is a single report. A "provider" combines products to give a big picture)

18. Evaluate the top 5 *preflight* weather *providers* you use most to plan a *cross-country, bad-weather* flight.
    a. Rank: Using the 1-to-5 scale below, rank **ONLY** your **5** most-used providers (**leave others blank**).

1	2	3	4	5
most-used	above average	average	below average	least-used

    b. Value: Using the 1-to-5 scale below, rate the information value of each of those top 5 choices.

1	2	3	4	5
excellent	above average	average	below average	poor

    c. %: Estimate the percentage of cross-country, bad-wx flights you use each of these top 5 providers on. (NOTE: In 18c, 19c, and 20c, the percentages do NOT have to add up to 100%)
    d. Minutes: Estimate the average number of minutes spent on each of the 5 during bad-wx preflight.

Rank 1-5	Value 1-5	Provider	Format	Details	% of flights used on	Minutes spent
		Commercial vendor	Internet	Wx via internet, paid (Which site?__________________)		
		Public NWS or NOAA site	Internet	Wx via internet, free (Site(s)? _____________________)		
		DUATS	Internet	FAA Direct User Access Terminal		
		DUATS	at airport			
		FSS	telephone	Flight Service Station, automated briefing (TIBS)		
		FSS	telephone	FSS standard briefing		
		FSS	telephone	FSS, abbreviated briefing		
		FSS	telephone	FSS, outlook briefing		
		The Weather Channel	Internet,TV	Cable TV weather		
		Other sources		List____		

19. The same way you did in Q18, evaluate the top 8 preflight weather *products* you use most in planning a cross-country, bad-wx flight. “Text” format means sources you read yourself or that are read to you.
    a. Rank **ONLY** your **8 most-used** products. Write “1” next to the source you use most, etc.
    b. Rate the value each of these 8 using the 1-5 scale of Q18b, for its information value.
    c. Estimate the percentage of cross-country, bad-wx flights during which you used each of the 8.
    d. Estimate the average number of minutes spent on each of the 8 during bad-wx preflight.

Rank	Value	Product	Format	Details	% of flights	Minutes
1-8	1-5				used on	spent
		AC	text	Severe Wx Outlook Narrative (2-day convective outlook)		
		AIRMET / SIGMET	text	Icing, turbulence, IFR, convective advisories, watches		
		ASOS	radio	Automated Surface Observing System		
		ATIS	radio	Automated Terminal Information Service		
		AWOS	radio	Automated Weather Observing System		
		charts, Air- or Surface-analysis	graphic	Constant-pressure (isobar) charts		
		charts, Convective outlook	graphic	48-hr forecast charts for T-storm activity		
		charts, Prog.	graphic	12, 24-hr prognostication charts w. isobars, wx symbols		
		charts, Radar (NEXRAD)	graphic	Doppler radar maps		
		charts, Radar summary	graphic	Maps of precipitation regions		
		charts, Weather depiction	graphic	Maps with isobars, precip, IFR regions, ceilings		
		FA	text	Aviation area 18-hr forecast		
		FD	text	Winds and temps. aloft 12-hr forecast charts		
		FD	graphic	Winds and temps. aloft 12-hr forecast charts		
		GPS	T or G	Global positioning satellite		
		LLWAS	radio	Low-Level Wind Shear Alert System (at airports)		
		METAR	text	Meteorological Aviation Routine		
		PIREP	text	Pilot reports		
		Satellite	graphic	Satellite photos of cloud cover		
		SD	text	Radar weather reports (hourly)		
		TAF	text	Terminal Aerodrome Forecast		
		TWEB	text	Transcribed Weather Broadcast (over telephone)		
		WW, AWW	text	Weather Watch bulletins, severe		
		Other sources		List____		

20. The same way you did in Q18, evaluate the top 3 *en route* weather sources you use most during a cross-country, bad-weather flight (here, a “source” can *either* be a product *or* a provider).
    a. Rank: Rank **ONLY** your **3 most-used** sources. Write “1” next to the source you *use most*, etc.
    b. Value: Using the 1-5 scale of Q18b, how do you rate each of these 3 source’s information value?
    c. %: Estimate the percentage of cross-country, bad-weather flights you use these 3 sources on.
    d. Minutes: Estimate the average number of minutes you spend on each during bad-wx flight.

Rank	Value	Source	Details	% of flights	Minutes
1-3	1-5			used on	spent
		avionics	(e.g. on-board radar, Stormscope, etc) List________________________		
		ASOS	Automated Surface Observing System		
		ATIS	Automated Terminal Information Service		
		AWOS	Automated Weather Observing System		
		EFAS	Enroute Flight Advisory System (Flight Watch through FSS)		
		HIWAS	Hazardous Inflight Weather Advisory System (selected VORs)		
		TWEB	Transcribed Weather Broadcast (over VOR, NDB)		
		Other sources	List____		

21. Are there reasons why the preflight and enroute sources you USE most aren’t the ones you VALUE most? If so, why? (For example, some of the graphic Internet products download slowly on a modem. Or some products may be unavailable. Or you might consider some too incomplete or unreliable).

22. What percentage of FSS briefers do you think are National Weather Service-certified? (best guess) _____

23. What percentage do you think are pilots? _____

24. Would it matter to you if your briefer were not a pilot, as long as he/she were NWS-certified? (circle answer)

1	2	3	4	5
not at all	a little bit	somewhat	quite a bit	an extreme amount

25. If you use FSS weather briefings, how satisfied are you with them? (leave blank if you don't use FSS)

1	2	3	4	5
not at all satisfied	a little bit	somewhat	quite satisfied	extremely

26. What is the typical number of weather reporting stations (e.g. KOKC, KDWF) you check before an average 4-hour, bad-weather GA flight?____ The smallest number?_____ The largest number?_____

Regarding VFR LOCAL FLIGHT, what percentage of the time do you do the following (0-100%)?

27. I get a briefing on the weather before I take off ……………… ____

28. I request weather updates during flight ………………………… ____

Regarding VFR CROSS-COUNTRY FLIGHT, what percentage of the time do you do the following?

29. I get a briefing on the weather before I take off ……………….. ____

30. I request weather updates for route & destination during flight ____

Answer questions 31 through 34 using a scale of "0" through "6 or more": How many times have you …

31. become so disoriented that you had to land or call ATC for assistance in determining your location? ____

32. flown into areas of IMC without an instrument rating or an instrument-qualified aircraft? ………. ____

33. become so disoriented after entering IMC that you had difficulty in maintaining aircraft control? ____

34. turned back or diverted to another airport because of bad weather while on a VFR flight? ……….. ____

Use the scale below to answer Qs 35-38

1	2	3	4	5
not at all	a little bit	somewhat	quite a bit	an extreme amount

35. How much does the distance you have to fly through bad weather affect your willingness to fly? ____

36. Does having *non-family* passengers affect your willingness to fly in bad weather?……………….. ____

37. Does having *family* passengers affect your willingness to fly in bad weather? …………………… ____

38. Has social or corporate pressure ever affected your willingness to fly in bad weather? …………… ____

39. Have you ever had a life-threatening flight experience related to weather? (Y / N) ………………. ____
(On Q 39, if answer is 3, 4, or 5, please briefly describe your experiences).

THIS CONCLUDES THE SUBJECT MATTER EXPERT INTERVIEW. THANKS AGAIN.

APPENDIX B

(Top) Coding rubric for qualitative analysis, with frequencies of incidence.
(Bottom) Deductive versus inductive elements of the rubric.