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How General Aviation Pilots Use Weather Information Providers and Products

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Data obtained from 221 general aviation (GA) pilots were examined to determine usage patterns for weather information. Weather products, providers, and en-route information sources were ranked according to relative use and rated by perceived information value, frequency of use, and time invested per usage. The measures were highly correlated. Conclusion #1: A small fraction of pilots show sparse use patterns, and these may be at risk for flying with inadequate preparation. Conclusion #2: There seems to be a strong tendency for many pilots to prefer relatively simple forms of information (e.g. METARS). This may present a problem, given the often-complex nature of weather.

Introduction

Glossary

AC	Severe Weather Outlook Narrative
ADDS	Aviation Digital Data Service
AFSS	Automated Flight Service Station (a.k.a. FSS)
AIRMET	Area Meteorological Forecast
AOPA	Airline Owners and Pilots Association
ATIS	Automated Terminal Information System
AWOS	Automated Weather Observation System
DUATS	Direct User Access Terminal Service
EFAS	En-route Flight Advisory System (a.k.a. FSS Flight Watch)
FAA	U.S. Federal Aviation Administration
FA	Aviation area 18-h forecast
FD	Winds and temperatures aloft
FSS	Flight Service Station (a.k.a. AFSS)
GA	General aviation
GPS	Global Positioning System
HIWAS	Hazardous Inflight Weather Advisory System
LLWAS	Low-level Windshear Alerting System
METAR	Meteorological Aerodrome Report
NEXRAD	Next-generation Radar (Doppler radar)
NOAA	U.S. National Oceanic and Atmospheric Administration
NWS	U.S. National Weather Service
PIREPS	Pilot reports
SD	Hourly weather reports
SIGMET	Significant Meteorological Forecast
TAF	Terminal Aerodrome Forecast
TIBS	Telephone Information Briefing Service
TWC	The Weather Channel
TWEB	Transcribed Weather Broadcast
VFR	Visual flight-rules flight
WW	Weather Watch bulletin

Background and terminology

Weather remains a major cause of general aviation fatalities. Figure 1 illustrates that, while weather was cited as causal in only 4% of GA accidents from 1998-2003, it accounted for 12-17% of fatalities, since about 70% of weather-induced accidents proved fatal (AOPA, 2005).

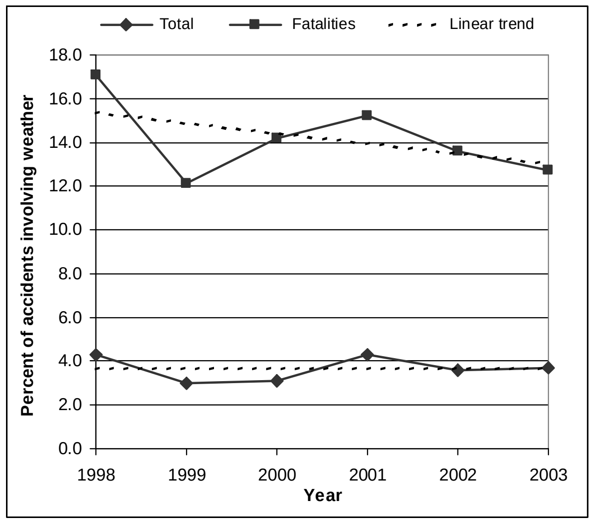

Figure 1. (Lower line) percent of GA accidents involving adverse weather. (Upper line) percent of fatalities resulting from those accidents (from AOPA's 2003 Nall Report). Dashed lines added to show linear trend (upper line slope = -.47, p = .33, NS).

The U.S. Federal Aviation Administration has a stated current goal of reducing GA fatalities (FAA, 2006). To this end, weather-related accidents are targeted for reduction. But, the complexity of weather and the corresponding need for pilots to understand the weather situation that may impact any given flight requires effective analysis, summarization, and communication of weather information.

Weather information comes mainly in the form of products and providers. A weather *product* is a relatively small package of related information constituting a stand-alone report (e.g., METAR or TAF). Weather *providers* are organizations dedicated to bundling weather products into convenient, user-friendly form. The FSS is a good example of a weather provider. Providers try to give pilots a strategic sense of the weather to complement the tactical sense given by the separate weather products themselves. There are many weather providers, most of them commercial, for-profit. High-end providers offer features rivaling those available to airline dispatchers.

The FAA, NOAA, and a number of commercial providers make weather information available in formats designed to aid pilot decision-making. Yet, in many weather-related accidents, investigators found no evidence that the pilot sought out or obtained a weather briefing (Prinzo, Hendrix, & Hendrix, in press). This raises a normative question: To what extent do GA pilots actually make use of the weather services available to them?

Latorella, Lane, and Garland (2002) conducted a national survey which offers baseline insight into this question. In 1999, they surveyed 97 GA pilots to assess their preferences for weather information products and providers. At that time, the most "important" (defined as most highly rated) individual types of weather information were cloud ceilings, convective weather, lightning, icing, and visibility. The most important weather products were METARs and TAFs. Finally, the most important weather providers were the FSSs and DUATS.

Since that time, informational availability and richness have both grown, particularly regarding the Internet, so the distribution of preferences may have shifted somewhat. Also, Latorella et al., focused on perceived information availability, usefulness, and importance but did not assess the extent of actual usage. Therefore, a follow-on study seemed timely.

Purpose of this research

The purpose of this research was to explore how GA pilots use available weather information. What information actually is available? What do pilots seem to prefer? How much time do they spend in preflight planning for a bad-weather flight? Once aloft, what updates do they acquire, and how much time do they spend acquiring them?

To address these questions, we interviewed GA pilots concerning their use of weather information products and providers. The intent was to establish actual usage patterns in the field, in contrast to ideal usage patterns as recommended by the FAA.

Method

Design and participants

During July and August 2005, we conducted on-site interviews with 230 GA pilots at locations across 5 states (CA, OK, ND, IL, FL). Four of the venues were university-based flight schools, the fifth was a helicopter training course. Of these 230 interviews, 221 ultimately provided usable data (the remainder contained large numbers of unanswered questions). Medians were used to express averages when means were artificially elevated by extreme scores. Median pilot age was 23 years (range 18-78), median flight experience was 245 hours (range 15-18,000). Women made up 14% of the sample. All were volunteers paid for their services as subject matter experts.

Procedure

A full, written-interview protocol solicited both quantitative and qualitative responses, so both quantitative and qualitative analytical techniques were applied to understand weather usage.

In the qualitative aspect, pilots were asked open-ended questions, plus Likert-scale items designed to assess their thought processes when making decisions about weather. Responses were analyzed according to a coding scheme (rubric). These analyses are addressed in a separate paper titled "Use of weather information by general aviation pilots, Part II, qualitative: Exploring factors involved in weather-related decision making."

The current report focuses on the quantitative aspect. Pilots were asked to (a) rate weather products and providers on the basis of how much they typically used them, (b) assign each a value based on its information content, (c) estimate the percentage of times each was used on a "standard flight," and (d) estimate the number of minutes each was used on such a standard flight, when that item actually was used. A "standard flight" was defined as a 4-hour flight through "weather serious enough to challenge your skill level and the aircraft's capabilities."

Results

Weather providers

Table 1 shows how pilots rated the quality of various preflight weather information providers. Pilots supplied four ratings, plus one rating arithmetically derived from the last two ratings:

Table 1. Normalized ranks, values, frequency of use, and time spent using weather information providers.						
Provider	Format	Rank* 0-1	Value* 0-1	Used on % of flights	Min spent when used	Ave. min spent
FSS (standard briefing)	telephone	**1.0**	**1.0**	**61.5**	9.1	5.6
Public NWS or NOAA site	Internet	0.7	0.8	49.8	**13.9**	**6.9**
DUATS	Internet	0.7	0.7	34.0	8.9	3.0
Commercial vendor	Internet	0.4	0.5	28.7	5.0	1.4
The Weather Channel	Internet,TV	0.4	0.5	27.9	7.0	2.0
FSS (outlook)	telephone	0.2	0.3	14.4	2.4	0.3
DUATS	at airport	0.1	0.1	11.3	2.1	0.2
FSS (automated TIBS)	telephone	0.1	0.1	8.9	1.5	0.1
FSS (abbreviated)	telephone	0.1	0.2	9.2	1.8	0.2
Other sources		0.0	0.0	4.3	0.6	0.0
* 0 = "lowest," 1 = "highest."					Total min spent per flight	**19.8**

- *Rank* reflected the group's relative rank-ordering of how much pilots felt they used any given weather provider.
- *Value* was a similar measure, reflecting how valuable the group felt that provider's information was.
- *Used on % of Flights* referred to percentage of flights on which pilots used each provider (answers left blank were coded as 0%).
- *Minutes Spent When Used* referred to the amount of time per flight a given provider was used, if and when it was used.
- *Average Minutes Spent* per flight was the result of multiplying *Used on % of Flights* times *Minutes Spent When Used.* As such, *Average Minutes Spent* was an estimate of how much time was spent on a given provider on the "average" flight, even though sometimes it may have been used and sometimes not.
- *Total Minutes Spent Per Flight* was simply the column sum of *Average Minutes Spent Per Flight*, totaled across all providers (19.8 min in this case).

Note that *Rank* could be distinct from *Value*. We might highly *value* a Rolls-Royce, yet *rank* it low by use, since we cannot afford to own one. Similarly, a high-end provider might have high value but be cost-prohibitive or require too much time investment for a private pilot flying for personal reasons.

Ranks and values were equilibrated (normalized) to a scale of 0 to 1.0 to allow for easier comparison of the data across *Rank* and *Value*. Here, "0" represented *least* valuable (or least-used) and "1" represented *most* valuable (or most-used).

Note that the FSS standard briefing was both ranked and valued highest (1.0) and said to be used on the highest percentage of flights (61.5%). This was closely followed by the public NWS/NOAA/ADDS Web sites, which actually experienced higher minutes-spent-when-used and overall average minutes used. Internet DUATS also received high scores across the measures. These findings were largely consistent with Latorella et al., although Internet use had grown much more prominent.

Commercial vendors received intermediate ranks across the board. These were paid services, which probably explained their more modest place among this group of younger pilots. Certainly, the quality of their information was quite high. In fact, much of it came directly from NOAA data feeds.

Finally, a surprising number of pilots reported using The Weather Channel, even though it was not an FAA-approved source. This was perhaps due to the sheer ease of turning on the television and watching. Also, the Internet-based TWC had a convenient feature allowing the user to type in a zip code and receive easy-to-understand forecasts based on current location. TWC seemed to give pilots something they wanted—a simple report, local and fast. The other sources were far more comprehensive, but that breadth came at the expense of extra time and effort needed to access and understand them.

Weather products

Table 2 shows pilot ratings for the quality of preflight weather information products. The format is similar to Table 1, sorted primarily by *Rank* and *Value* (again, normalized so that direct comparisons could be made across those two categories).

The most highly ranked, valued, and used weather products for this group were METAR and TAF. This was followed, rather distantly, by AIRMET/SIG–MET, FAs, and radar charts. Finally, ATIS, AWOS, radar summary charts, FD, and PIREPs showed ratings clustered roughly in third place.

The total estimated average number of minutes per flight spent reviewing preflight weather products was 16.6.

As expected, this was reasonably consistent with the 19.8 min estimated for providers.

En-route sources

Similarly to Tables 1-2, Table 3 shows pilot ratings for the quality of en-route information sources, again sorted by *Rank*. Two relatively simple sources—ATIS, and AWOS—were most highly ranked. Flight Watch, and ASOS were moderately ranked

Table 2. Normalized ranks, values, frequency of use and time using various w eather products.

Product	Format	Rank 0-1	Value 0-1	Used on % of flights	Min spent w hen used	Ave. min spent
METAR	text	**1.0**	**1.0**	**77.3**	**4.5**	**3.4**
TAF	text	**1.0**	**1.0**	**76.5**	**5.3**	**4.0**
AIRMET / SIGMET	text	0.5	0.7	47.6	3.7	1.8
FA	text	0.5	0.5	36.1	3.2	1.2
Charts, Radar (NEXRAD)	graphic	0.5	0.6	44.2	3.6	1.6
ATIS	radio	0.4	0.5	41.4	2.0	0.8
AWOS	radio	0.3	0.4	25.0	1.8	0.5
Charts, Radar summary	graphic	0.3	0.4	23.7	1.7	0.4
FD	text	0.3	0.4	30.0	2.2	0.7
PIREP	text	0.3	0.6	36.4	2.2	0.8
ASOS	radio	0.2	0.2	13.0	0.8	0.1
Charts, Prognostication	graphic	0.2	0.3	17.8	1.7	0.3
Charts, Weather depiction	graphic	0.2	0.3	15.1	1.8	0.3
Satellite (images of cloud cover)	graphic	0.2	0.3	20.9	1.8	0.4
Charts, Air- or Surface-analysis	graphic	0.1	0.2	12.8	1.0	0.1
Charts, Convective outlook	graphic	0.1	0.1	10.1	1.1	0.1
GPS	T or G	0.1	0.1	5.1	0.5	0.0
TWEB	radio	0.1	0.1	9.0	0.9	0.1
AC	text	0.1	0.1	4.7	0.4	0.0
FD	graphic	0.0	0.1	5.3	0.4	0.0
LLWAS	radio	0.0	0.0	0.9	0.1	0.0
SD	text	0.0	0.0	3.9	0.4	0.0
WW, AWW (w eather w atch bulletins)	text	0.0	0.0	0.1	0.1	0.0
Other sources		0.0	0.0	0.1	0.0	0.0
		Total min spent per flight				**16.6**

Table 3. Normalized ranks, values, frequency of use and time using various enroute w eather sources.

En-route source	Rank 0-1	Value 0-1	used on % of flights	Min spent w hen used	Ave. min spent
ATIS	**1.0**	**1.0**	**75.6**	**4.6**	**3.5**
AWOS	0.6	0.7	48.7	4.1	2.0
EFAS (Flight Watch)	0.4	0.6	29.1	4.1	1.2
ASOS	0.3	0.4	23.6	1.6	0.4
HIWAS	0.2	0.3	14.0	1.4	0.2
Avionics	0.1	0.0	8.3	1.2	0.1
TWEB	0.0	0.0	2.6	0.4	0.0
Other sources	0.0	0.0	4.0	0.3	0.0
		Total min spent per flight			**7.3**

Variation in weather information use

Table 4 summarizes the estimated average number of minutes these pilots reported spending on bad-weather briefing, using preflight providers, products, and en-route sources.

Table 4. Estimated average min spent on weather briefings by providers, products, and enroute sources.

	Providers	Products	En-route
Average time spent	19.8	16.6	7.3
Minimum	**3.10**	**3.97**	**0.99**
Maximum	138.5	154.6	92.0
Range	135.4	150.6	91.0
Bottom 10th percentile	9.0	8.8	2.5
Bottom 5th percentile	7.1	5.1	1.8

The group means looked acceptable (19.8 min use of preflight providers and 16.6 min for products, plus 7.3 min use of en-route sources). However, the data did point to a small percentage of pilots who focused too little on preparing for, and monitoring, potentially challenging weather. The minimums suggested that a few pilots did very little preflight preparation and nearly no weather monitoring once aloft. Ten percent of pilots reported spending less than 9 min on providers, less than 8.8 min on products, and less than 2.5 min on en-route updates. Five percent reported spending less than 7.1 min on providers, 5.1 on products, and 1.8 on en-route updates.

Discussion and Conclusions

The purpose of this research was to try to understand how GA pilots use the weather information available to them. This included documenting what weather sources were currently available, measuring pilot preferences for different providers and products, and assessing what preflight and en-route sources they reported using. Recall that a weather *product* (Table 1) is a small package of related information constituting a stand-alone report. Weather *providers* (Table 2) are organizations dedicated to bundling weather products into user-friendly formats.

For this study, 221 licensed GA pilots were sampled from 5 different instructional venues across the U.S. When asked how they typically prepared for a standard 4-h flight into weather bad enough to challenge their skills and the aircraft's capabilities, these pilots indicated a strong group preference for FSS standard briefings, NOAA/NWS Internet providers and, surprisingly, the Weather Channel.

An important finding here was that many pilots reported preferring relatively simple preflight weather products (METAR, TAF, AIRMET/SIGMET, FA) over more complex, yet informationally richer materials available (e.g., NEXRAD radar images). This has deep implications for the design of future weather products, particularly those on the Internet. Weather is complex by its very nature, and the challenge is to express that complexity in ways simple enough to be useful to the flying public.

These data gave a sense of how younger pilots appear to use weather information. On average, these pilots estimated spending 19.8 min with preflight weather providers, 16.6 min with preflight weather products, and 7.3 min with en-route sources. Those averages, alone, might be considered adequate. However, there was considerable variability in the estimates, indicating that inadequate preparation might be anticipated by roughly 10% of pilots. Naturally, "time spent using" was not a perfect proxy for "amount learned," so we must not jump to the hasty conclusion that quantity of use equals quality of use. Nonetheless, even with that caveat, these data probably point to an identifiable group in need of attention.

To summarize, Conclusion #1 is that, despite the acceptable group averages on preflight and in-flight attention to weather, there seemed to be individuals spending as little as 3-4 min on pre-flight weather briefing and less than one minute on updates, once airborne. The lowest 10% of pilots reported spending less than 9 min on preflight adverse-weather briefing, and less than 2.5 min on en-route updates.

Conclusion #2 is that, while many pilots seem to value and use modern, sophisticated weather information providers, there seems to be a strong, counter-tendency to value and use that which is simplest, even if simplicity comes at the cost of greater risk. The most popular weather information products and en-route sources sampled here seemed to be among the simplest (e.g., METARs and TAFs). This has serious implications for user interface design, certification, and training.

It also may reflect a problem for some pilots, given the inherently complex nature of weather. While complex weather information may be available, it is not always what is sought out or understood. From a human factors perspective, there is a lesson for information system design in this: Weather information needs to be

- convenient
- comprehensive, and
- simple to understand

or there will be some pilots who either fail to acquire it or fail to understand it.

Hopefully, these points are not mutually exclusive. That which is convenient may not be comprehensive. That which is comprehensive can be difficult to understand. This calls for dialectic and resolution.

A second challenge lies in the complexity of the way weather factors interact with each other and the flight situation. Knowing facts about separate weather factors is necessary, but may not be sufficient to fully understand weather danger. For instance, darkness compounds problems with visibility (AOPA, 2005). Visibility and cloud ceiling interact in influencing GA pilots' takeoff decisions about marginal VFR weather (Knecht, Shappell, and Harris, 2005). Visibility, ceiling, precipitation, and terrain interact to influence pilot "go/no-go" comfort (Driskill, Weissmuller, Quebe, Hand, and Hunter, 1997).

In other words, the challenge is not just to identify a static set of "most significant weather factors." Specific circumstances can potentiate each other. Weather influences both "go/no-go" decisions and "continue/hold/divert" decisions, and the values of specific factors will interact in determining the most appropriate decision. So, the list of "most-important weather factors" undoubtedly shifts, given the unique circumstances of each flight. In the present study, our results apply to a "typical" 4-hour flight into anticipated-but-unspecified bad weather. Had we set up a different scenario, we might assume the dynamics of decision-making would shift somewhat with the specified circumstances.

These findings are directly comparable to, and extend, Latorella, et al.'s survey of GA pilot weather use in 1999. Both that study and the present research indicate that ceilings, convective weather, lightning, icing, and visibility remain prominent as primary information of concern to airmen. FSS also remains a versatile, popular weather information provider. DUATS is still highly valued and used, though it may have lost ground to NOAA/NWS Internet services. Finally, METARs and TAFs were popular weather products then, and are still at the top of the list now.

The Internet is clearly gaining ground. Yet, while Internet weather information has become more available, sophisticated, and widely used in the 6 years between this study and Latorella, et al, the raw information most GA pilots want to know appears to have largely stayed the same. Given recent investments in improving weather information quality and availability, it is surprising that longstanding sources such as METAR and TAF were rated so highly by users. This may parallel TWC's popularity in a tendency for users to want brevity and simplicity in summaries of weather information. This preference for simple weather products may belie the apparent "techno-savvy" of the next generation of pilots. In actuality, there may still be a relative lack of sophistication regarding the particular information they are retrieving, understanding, and using. Weather is complex, and all presentations of it are simplifications in some fashion. So how do we present the essentials without overwhelming the user? This is a major challenge for all of us concerned with keeping the blue side up.

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