

Analysis of Weather Information Types and Delivery Formats Most Desired by Ga Pilots in Nigeria During Critical Phases of Flight – Takeoff and Landing

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Executive Summary

The lack of integrated weather information in the General Aviation (GA) cockpit has been one of the major problems in the aviation community. Until recently, the most common means of receiving weather information in the GA cockpit has been from radio communication. To obtain updated enroute weather information, GA pilots are forced to rely on ground-based services such Flight Service Stations (FSS) and Air Traffic Control (ATC). In an effort to rectify the lack of integrated weather information in the GA cockpit, the Federal Aviation Administration (FAA) plans to develop and introduce a system that was provide near-real time weather information. The purpose of this study was to examine and determine the weather information sources and products most desired by pilots. The study was also designed to determine GA pilots most preferred format of delivering weather information into the cockpit This study is primarily designed, quantitatively, to analyze the general aviation pilots' weather information needs. A questionnaire were the primary tool for obtaining the raw data. Once the data has been collected, quantitative analysis techniques were applied to further investigate different categories of GA aviators and their weather needs during various phases of flight. The qualitative research in this study commenced with an extensive review of previous studies related to weather information in the GA cockpit. Hopefully this approach provided current information on how best to provide accurate, timely and dependable weather information in the GA cockpit. It is expected that the study was generate a comprehensive dataset on the preference of weather information needs among Nigerian general aviation pilots. The findings will hopefully inform on policies and interventions aligned with ICAO safety standards. It also showed the difference in format of weather delivery preferred by general aviation pilots when transitioning from pre-flight to in-flight operations.

Keywords: *weather report, aviation safety, aeronautical decision making (adm), and flight operations*

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I. Introduction

Aviation is one of the safest modes of transportation in the world; however, aviation has not been able to escape the negative effects of weather. General aviation is particularly affected by weather because of the unavailability of integrated weather information in the general aviation cockpit. Despite the broad availability of weather information today, weather still remains the single largest cause of aviation incidents and accidents, especially in General Aviation (GA) (Johnson, N., Wiegmann, D., & Wickens, C. 2006). It has been difficult for GA pilots to receive and process weather information in a timely manner, assimilate that information into a clear mental picture, and apply effective in-flight weather decision making. As a result, the FAA and the NASA have initiated programs to examine and study the possible system that was provide weather information to pilots in the best possible way. The Federal Aviation Administration (FAA) has stated “with many weather providers and weather products, it can be very difficult for pilots to screen out non-essential data, focus on key facts, and then correctly evaluate the risk resulting from a given set of circumstances” (P. 1).

Until recently, the most common method of getting weather information in the cockpit has been from direct observation of the environment, aircraft instrumentation, radio communication, and the on-board outside air temperature gauge (Kara, A. L., & James, P. C. 2002). General aviation pilots are forced to depend on contacting weather information services such as Flight Service Stations (FSS), to obtain reliable, en-route weather information. In an effort to improve integrated weather information in the general aviation cockpit, the FAA and NASA plan to introduce a system that was provide near-real-time weather information. The information were presented in a comprehensive form which was, hopefully, integrate data and information from all currently

available sources. The system currently under development is referred to as the Next Generation Air Transporting System (NextGen).

Several studies have been conducted to determine the proper information to be provided in the cockpit. This study intended to examine the needs of general aviation pilots with regards to this information. There are many important reasons why this study was contribute to the aviation field. From a human factors perspective, providing the proper weather information was help decrease workload and increase situational awareness. During in-flight weather encounter pilots are forced to make radio enquiries from in-flight weather providers such as a Flight Service Stations (Schvsneveltdt, Lamonica, & Beringer, 2012). To acquire the needed information, the pilot must rely on clear and effective radio communications. They have to listen, interpret and then ferret out the information critical to their flight. At the same time they must remain responsive to ATC communications, maintain control of the aircraft, monitor flight instruments and ensure a degree of situational awareness adequate for safety of flight. The introduction of a more effective, integrated weather information system was help reduce the complexity encountered in a weather-related situation. The goal of this study is to provide input from general aviation aviators that can be used to develop an accurate, timely weather information system that was reduce the clutter and complexity of information in the cockpit.

With this goal in mind, a number of studies were examined that were directly related to the availability, type and format of weather information needed by the general aviation pilot. Herein general aviation is defined in Title 14 of the Code of Federal Regulations (CFR), Part 91). Prior researches (Latorella & Chamberlain, 2002) focused on weather information usability, utility, valuation, and preferences from GA pilots.

1.2 Problem Statement

During pre-flight preparations, pilots have enough time to obtain appropriate weather information, interpret the data, and apply the information and analysis to make safe weather decisions. The weather information is provided by a number of weather providers. Weather information products are primarily presented in three different formats: Graphical, textual, and audio format (Keel *et. al* 2000). The first way of getting weather information during pre-flight operations is by accessing and interpreting graphical weather information. This information is available from several weather information providers via the internet. The most commonly used internet providers are the Direct User Access Terminal (DUAT) and the National Weather Services (NWS). In order to achieve a complete understanding of the synoptic situation, this graphical weather information is coupled with the textual information which is also available over the internet. Combined with these two sources the pilot also uses aural weather information by making direct inquiries by telephone to local Flight Service Stations. According to Lind, A. T., Dershowitz, A., & Bussolari, S. R. (1994), the combination of these three information formats gives pilots a convenient, user-friendly package that offers not only specific details, but they will provide a big picture overview of the current and forecasted weather at their departure location, along their route of flight, and at their destination. This comprehensive, preflight preparation greatly enhances safety of flight.

Unfortunately, in many cases, the forecasted weather obtained during pre-flight is not always reflected during the flight (Gupta, S. 2002). Consequently, pilots are prudent to make continuous inquiries concerning the en-route and destination weather during their flight. Unfortunately, the small GA aircraft are not equipped with sophisticated weather detection equipment unlike their larger commercial cousins. Pilots flying GA aircraft need to make frequent radio contact with in-flight weather services in order to obtain accurate, up to date, weather information.

In view of the limited time available to make good operational decisions, the current process of delivering weather information into the GA cockpit is inefficient (Morrow, D. G., & Prinzo, O. V. 1999). As a result, the GA cockpit is in need of a system that was provide low cost, near-real-time, integrated weather information.

1.3 Aim and Objectives

The aim of this research is to analyze the weather information types and delivery formats most desired by general aviation pilots in Nigeria during critical phases of flight – takeoff and landing

While the specific objectives are:

1. To examine changes in the **sources and types of weather information** used by pilots with varying **certificates and flight hours** during **inflight operations**.
2. To evaluate how the **perceived usefulness of weather information** varies across different **phases of flight**, namely preflight, departure, en-route, arrival, and descent.
3. To determine the **most feasible and effective formats** for presenting weather information in the cockpit environment.
4. To assess changes in pilots' **preferred weather information formats and delivery methods** during phases of flight.

1.4 Significance of Study

The significance of this study is to examine and understand general aviation pilots' needs with regard to in-flight weather information products and elements. In addition, by using the information on pilots' needs this study was attempt to determine the preferred means and format of providing weather information needed for safe flight operation (Stough, H. P., & Martzaklis, K. S. 2002). Taking into consideration the negative effects of weather on general aviation, this study was help determine the general aviation pilots' needs with respect to weather information in the cockpit. The means and format of presenting weather information products and elements needed for safe flight operation was also examined. A clear understanding of these needs and priorities hopefully lead to the introduction of more effective and reliable weather information in the cockpit.

Most importantly, the increased understanding of weather and situational awareness during flight was help provide a solution to the ultimate threads of weather on general aviation (James, P. C., & Kara, A. L. (2001). The number of weather-related incidents and accidents was eventually decrease by providing integrated and user-friendly weather information into the general aviation.

II. Literature Review

2.1 Weather Encounters Studies

The negative effect of weather on general aviation is well known and is being constantly studied. Issues related to weather encounters for operators of General Aviation aircraft are a top safety priority for the Federal Aviation Administration (FAA) and the aviation community. According to the FAA (2007), the general aviation pilot-related weather crashes in 2007 registered 51 (5.2 percent) total and 32 (14.8 percent) fatal pilot-related accidents. Most often, these resulted from pilots continuing VFR flight into instrument meteorological conditions (IMC). In the long term, weather accidents continue their gradual increase; therefore, the collection, synthesis, and delivery of timely, accurate, and integrated weather products is central to the safety of the National Airspace System. (Nall report, 2007. P. 5.).

In support of FAA and aviation industry efforts to improve awareness, knowledge, training, and procedures related to aviation weather in GA operations, FAA requested that the National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) undertake a study of GA weather encounter incidents. By gathering reports from the original incidents and accident reporters, the study made it possible for the NASA to obtain enhanced information about the factual details surrounding an incident/accident as well as subjective information that might otherwise remain unknown such as reporters' decision, practices and attitudes. The process used by the ASRS to conduct this project was to identify candidate reports from the overall report intake at ASRS and contact reporters by telephone to request their participation in the study. Those who agreed to participate were mailed a package that included a Supplemental Question Set (SQS) concerning their reported GA weather event.

The result of this study indicated a noticeable difference in the scenarios, experience, and recovery techniques between the instrument rated and non-instrument rated pilots. Also, it was found out that the weather was "worse than" forecasted for the departure airport 20 percent of the time, for the enroute segment 41 percent of the time, and for their destination airport 45 percent of the time. This is a clear indication that pilots lack the means of effectively getting updated weather information while in-flight. (NASA, 2007. P. 15).

Similarly, Lanicci and colleagues (2012) studied and analyzed cases involving general aviation pilots' weather encounters. They interviewed pilots who had experienced weather encounters, and examined their backgrounds, flight experience, and the details of the weather encounter. The study focused on two key areas:

1. Identifying the factors associated with weather-related accidents; and

2. Identifying the pilot decision-making processes that contributed to the accident. Additionally, they examined weather information data sources in order to compare the information the pilot encountered with the forecasted information available during the time of the encounter. In other words, the accuracy of the forecasted weather was examined. (P.1).

During pre-flight pilots use a variety of weather information providers to ensure against encountering unexpected adverse weather conditions. The results of the interviews indicated that, in the majority of cases, the pilots had not accessed all available and pertinent weather information. Regarding the weather information sources used, statistics gathered from the individual interviews indicated that pilots regularly consulted a FAA Direct User Access Terminal System 54.5% of the time, the National Weather Service 72.7% of the time and a Flight Service Station 77.3% of the time. (Lanicci and colleagues, 2012. P. 1-12).

The results from meteorological data analysis for each of these weather encounters were consistent with findings of larger general aviation weather accident studies in terms of the types of hazards encountered and flight phase during which the encounters occurred.

2.2 Weather Information Sources and Products

Additionally, some researchers have conducted studies to identify critical weather parameters, providers and products necessary for safe flight operations from the pilots' perspective. The study conducted by Schvaneveldt and colleagues (2012) is a very good example. With the development of the NextGen underway, Schvaneveldt and colleagues (2012) conducted a study to identify and verify weather factors important to the conduct of aviation activities and that would be important to consider in systems intended to operate within the NextGen environment. The study also provided analysis of weather factors and their priorities in various phases of flight. The report presents a listing of recognized aviation weather factors and hazards in their varying priorities and usage consistencies throughout the various phases of flight. This is followed by a listing of pilot-accessible products and providers of the related weather information and examples of graphical presentations. Included is a brief listing and discussion of avionics systems able to host these graphical data. The study provided recommendations for the presentation of weather information in the cockpit, the incorporation of decision aids, forecasts, reliability labeling, and display strategies. (P. 5-27).

2.3 Weather Information Access, Usage and Valuation

As previously mentioned, there are a number of providers and products available to pilots at all times which are used to make go-no-go decisions before flights and make viable safety decisions during flight. The patterns of weather information usage were examined in a study by Knecht (2008). The study was aimed at investigating how general aviation pilots use available weather information. This was accomplished by examining both pre-flight and in-flight operations. The pre-flight factors examined included all weather information that was available, which of this information did the pilots prefer, and how much time did the pilots normally spend on pre-flight planning during unfavorable weather. Factors examined for in-flight operational decisions were the updates acquired by pilots and the time spent acquiring the information. (P. 1-2).

According to the International Civil Aviation Organization (ICAO) (2012), during pre-flight planning pilots have all the time they need to acquire information from all the different kind of sources to make sure they make the best go-no-go decision. The point is, during pre-flight, pilots are not under any kind of pressure, so they can take whatever time they deem necessary to be certain of the decision they make. However, this is not necessarily the case once in-flight as time is very essential and extremely limited (Aircraft Owners and Pilots Association (AOPA) 2005). A lot is demanded of pilots while in-flight; they have to fly the airplane, pay attention to all navigational instruments, and conduct all required communications. Also, pilots will have to acquire updated weather information whenever the need arises. With all they have to do, the time constraint puts the pilots under great pressure to request weather information updates and make informed, safe decisions. The study conducted by Knecht provides insight into the time pilots spend acquiring weather data during these situations.

The Knecht study examined weather information used by 221 general aviation (GA) pilots. Knecht (2008) ranked weather products, providers, and en-route information sources according to relative use and rated them by perceived information value, frequency of use, and time invested per usage. On average, the pilots in this study estimated they spent 19.8 minutes with preflight weather providers, 16.6 minutes studying preflight weather products, and 7.3 minutes with en-route sources. According to the study, these time averages might be considered adequate. However, there was significant variability in the estimates which indicates that inadequate flight preparation might be expected by roughly 10% of pilots. Knecht (2008) concluded that a small fraction of pilots showed scarce patterns of use and these may be at risk for flying with inadequate preparation, and there seems to be a strong tendency for many pilots to prefer relatively simple forms of information (e.g., METAR). This may present a problem, given the often-complex nature of weather. (P. 2-5).

Existing aviation weather information can be difficult to obtain when it is most needed and may not be well formatted and presented for in-flight use. Because it is generally presented aurally, aviation weather information is often difficult to integrate with spatial flight information and retain for reference. Latoralla, Lane and Garland (2002), like Knecht, investigated weather information accessibility, usability and its influence on making effective weather decisions during adverse weather conditions. The study included such topics as a pilots' familiarity with specific weather information and the information providers and the importance of specific information during different phases of flight. These findings were then associated with the costs of the currently available in-flight weather information systems. (P. 1).

III. Methodology

This study is designed to explore how GA pilots use currently available weather information. What are the weather information sources most used and what weather parameters are most available and sought? How much time do pilots spend during preflight planning on the available weather information? Once aloft, what updates do they acquire? What format of information do pilots prefer? A user needs survey was used to gather the data and opinions of pilots on the weather information needs in the cockpit. Based on this information, characteristics and features of information format displays were described for analysis and coupled with a usability study. By conducting the usability study, the most preferred display format was determined. This result may be

helpful to systems designers to produce weather information displays that was provide more integrated weather information into the general aviation cockpits

3.1 Study Area

This study was focus on Nigeria’s general aviation hubs mostly flight schools in Zaria, Ilorin, Kaduna and Lagos. The sampling was targeted at the Nigerian General Aviation population and were conducted in a variety of venues. Visits to airshows, local flight schools, Nigerian Civil Aviation Authority NCAA and local flying safety presentations, fixed-base operations and wherever there is a target of opportunity where General Aviation Pilots may assemble. The survey was also be placed on line and advertised to local flying clubs and flying magazines.

3.2 Research Design

This study is primarily designed, quantitatively, to analyze the general aviation pilots’ weather information needs. A questionnaire was the primary tool for obtaining the raw data. Once the data has been collected, quantitative analysis techniques were applied to further investigate different categories of GA aviators and their weather needs during various phases of flight. The qualitative research in this study commenced with an extensive review of previous studies related to weather information in the GA cockpit. Hopefully this approach provided current information on how best to provide accurate, timely and dependable weather information in the GA cockpit.

3.3 Sample and Sampling Technique

3.31 Target Population

The target population is intentionally designed to include a wide range of experience: Flight hours, years of flying, certifications and aircraft type. The range of certification vary from a very basic student pilot to experienced pilots with a multi-engine commercial rating. For sample size, it is going to include a survey sample of active general aviation pilots from the flight schools.

3.4 Data collection Method

A questionnaire was the primary tool for obtaining the raw data. Once the data has been collected, quantitative analysis techniques were applied to further investigate different categories of GA aviators and their weather needs during various phases of flight. The qualitative research in this study commenced with an extensive review of previous studies related to weather information in the GA cockpit.

NCAA incident and audit reports (2018–2024) were analyzed to identify weather related events (e.g., unstabilized approaches, missed approaches, runway incidents and accidents). Link reported errors to patterns of weather phenomenon.

3.5 Data Analysis

Several analysis techniques such as T – test and Analysis of Variables (ANOVA) were used to analyze data collected from the survey. The analyzed data was hopefully in identifying some of the research questions including, but not limited to: How do the needs of general aviation pilots, in terms of the weather sources and required elements, change from pre-flight to in-flight to arrival at destination. How does the format of the information delivery change from pre-flight to in-flight to arrival at destination? Is there a consensus by pilots as to the preferred means of information delivery and format? How does the experience (hours) of the pilot play a role in his or her preference for weather information and format desired?

IV. Results of the research

Pilot Qualifications

For the purpose of this study, pilot qualifications were considered to be flight certificates, ratings, and formal meteorological training (Williams, K. W. & Ball, J. D. 2003). The flight certificates and ratings of the 229 respondents are summarized in table 4-1.

CERTIFICATES	NONE	INSTRUMENT	MULTI-ENGINE	INSTRUMENT MULTI-ENGINE	CFI
Student (n = 38)	35	2	1	0	0
Private (n = 85)	45	36	1	3	0
Commercial (n = 98)	1	14	6	37	38
ATP (n = 8)	0	0	0	8	0

Table 4-1. Pilot Qualifications: certificates and ratings

As shown in table 4-1, 38 pilots (17%) held a Student Pilot Certificate, 85 (37%) held a Private Pilot Certificate, 98 (43%) held a Commercial Pilot Certificate, and 8 (4%) held an Airline Transport Pilot Certificate.

Eighty-one (35%) of the pilots responded that did not hold any rating. Fifty two pilots (23%) responded that they held an Instrument Rating. Eight pilots (4%) responded that they held Multi-engine Ratings, and 48 pilots (21%) held both Instrument and Multi-engine Ratings. Thirty-eight pilots (17%) responded that they held a Certified Flight Instructor (CFI) Certificates. Two pilots (<1%) held Helicopter Pilot Ratings.

The flight certificates and formal meteorological training of the 229 respondents are summarized in table 4-2.

CERTIFICATES	NONE	FLIGHT SCHOOL	COLLEGE CLASS	COLLEGE DEGREE	ARMY
Student (n = 38)	2	11	20	5	0
Private (n = 85)	15	34	25	9	1
Commercial (n = 98)	1	25	38	33	1
ATP (n = 8)	0	2	3	3	0

Table 4-2. Pilot Qualifications: certificates and meteorological training

Of the 229-pilots completing the survey, 18 (8%) had no Formal Meteorological Training. Two-hundred and eleven pilots (92%) indicated they had at least some formal meteorological training. Seventy-three of those (32%) received their meteorology training in flight school; 86 (38%) received formal meteorological training in college classes. Forty-nine (21%) had a college Degree in Meteorology. Two (<1%) received their Meteorological Training from the ARMY, and 1 pilot (<1%) indicated that he received his formal training from an online meteorology course.

Pilot Experience (Hours)

For the purpose of this thesis, pilot experience was measured using total flight hours. The 229 respondents in the study averaged 840 hours of total flight time. The median of the pilots' flight time was 250 hours. Figure 4-1 shows the number of participants divided into four groups: Up to 1000 hours, 1001 – 2000 hours, 2001 – 3000 hours, and more than 3000 hours.

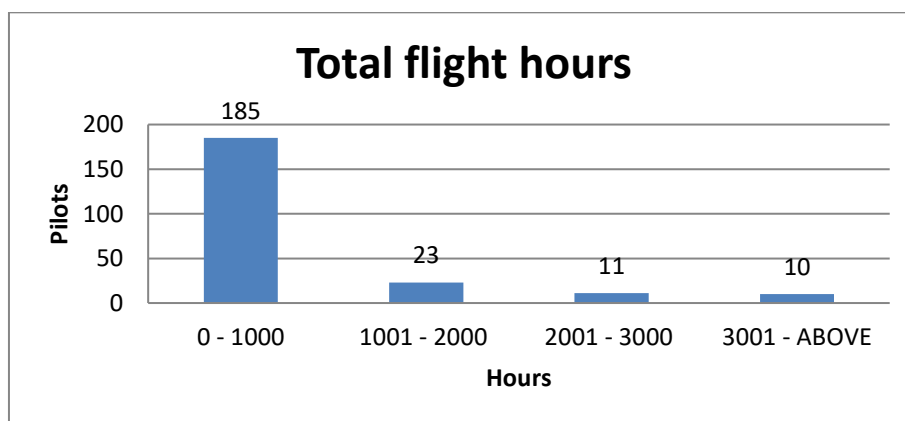


Figure 4-1. Respondents Flight Time (n=229)

It can be seen from the figure above that out of the 229 respondents, 185 (81%) reported that they had 1000 hours or lesser flight experience. Twenty-three (10%) indicated that they had between 1000 and 2000 hours, 11 (5%) reported between 2001 and 3000 hours and 10 (4%) had over 3000 hours of flight time. Two out of the 10 pilots with over 3000 hours reported having over 15,000 hours of flight time. These figures indicate that the results of this study were strongly skewed toward the younger pilots or least experienced pilots, those with lesser than 1000 hours of flight time.

Phases of Flight

The fourth question on the survey asked pilots to rate the usefulness of all weather information during each phase of flight. The idea was to have the pilots choose the phases of flight where the types of weather information were most useful. The usefulness was rated from 1 to 5 with 1 being essential and 5 not at all useful; as a result, the lower the value of the mean the more useful weather information is sought be at that phase of flight. The results are shown in figure 4-2.

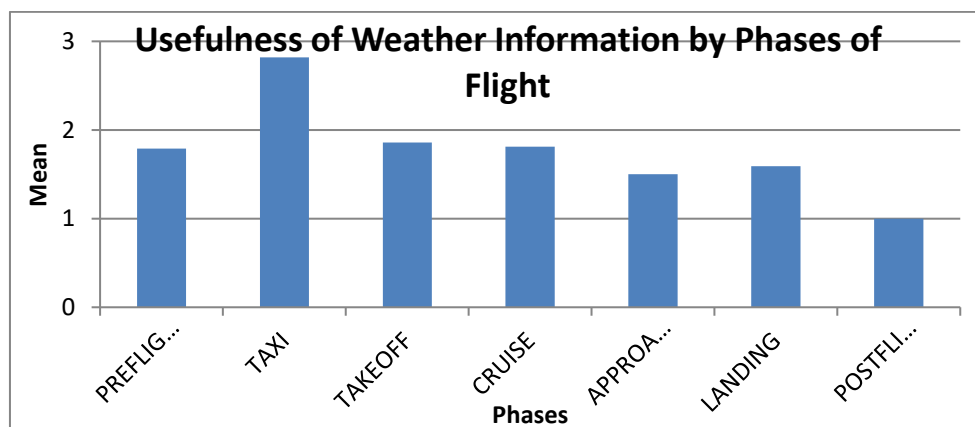


Figure 4-2. The Mean of Usefulness of Weather Information by Phases of Flight

Responses indicated that overall the participants felt that weather information was essential during the Approach phase of flight (n=228 $\mu=1.5$, STDEV=0.7), very useful during the Landing phase of flight (n=227, $\mu=1.6$, STDEV=0.9), useful during both Preflight (n=228, $\mu=1.8$, STDEV=1.2) and the Cruise (n=226, $\mu=1.8$, STDEV=0.9) phases of flight. Information was considered, lesser useful during Takeoff (n=227, $\mu=1.9$, STDEV=1.1), and least useful during Taxi (n=226, $\mu=2.8$, STDEV=1.2).

Weather Information Formats

As discussed in previous chapters, there are three main formats for presenting weather information: Audio, text, and graphics. In the fifth and last question of the survey participants were asked to rate how valuable these formats were with respect to flight planning preparations and in-flight decision-making. The value of the formats was rated on a scale of from 1 to 5 where 1 was extremely valuable, 2 was very valuable, 3 was valuable, 4 was lesser valuable, and 5 was the least valuable. Similar to the previous questions, the mean values of the responses are used to present the results which are shown in figure 4-3.

Broken down to preflight and in-flight, it can be seen that during pre-flight the graphics format (n=227, $\mu=1.91$, STDEV=1.1) was chosen most valuable. Text format (n=227, $\mu=2.04$, STDEV=1.0) was chosen as having a lesser value, and Audio (n=227, $\mu=2.26$, STDEV=1.3) was chosen as the least valued format. However, during in-flight operations the respondents chose the Audio Format (n=227, $\mu=1.6$, STDEV=1.1) as the format with the highest value, Graphics (n=227, $\mu=1.82$, STDEV=1.1) as a format with slightly lesser value, and Text (n=226, $\mu=2.45$, STDEV=1.2) as the format with the least value. The result showed a significant change in the pilots' preferred format preflight to in-flight.

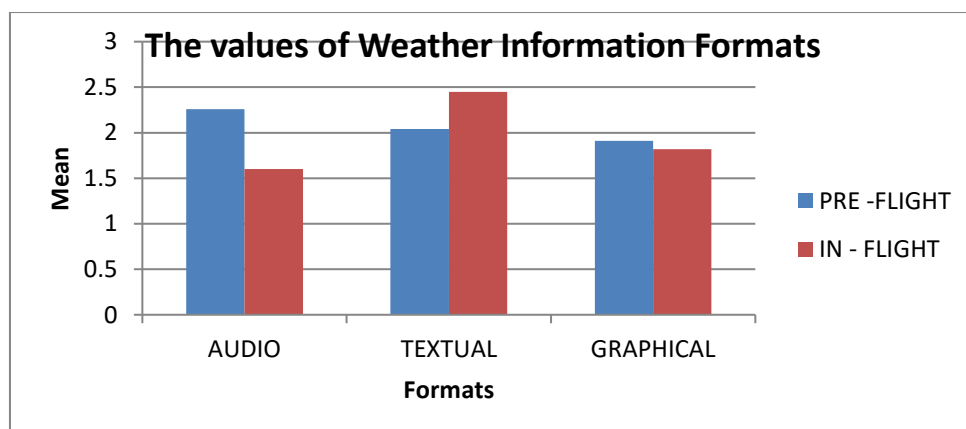


Figure 4-3. The Values of Weather Information Formats According to Preflight and In-flight

V. Discussion, Conclusion and Recommendations

Discussion of Phases of Flight

The usefulness of weather information was rated based on the phase of flight. The ratings used were; essential, very useful, useful, less useful, and not at all useful. The following phases of flight were used: preflight, taxi, takeoff, cruise, approach, and landing.

The first and highest rated where weather information was considered to be the most useful by pilots was the Approach phase. Landing was the second rated phase. Both Preflight and Cruise phases were rated as third. Takeoff was rated as fourth and Taxi was the fifth. The phase of flight where weather information was considered to be the least useful was Taxi. Because they are among the most critical phases of flight, it is not surprising that approach and landing were rated highest with 88% and 85% of the respondents rating the usefulness of weather information as either "essential" or "very useful". Eighty-one percent of the respondents agreed that weather information was at least "very useful" during the cruise phase. Although takeoff is also considered as a very critical phase, the usefulness of weather information was rather rated by fewer respondents (76%) as "essential" or "very useful". Only 36% stated that weather information was "very useful" or "essential" during the taxi phase of flight, and 29% indicated that weather information was "less useful" or "not at all useful" during taxi.

Conclusion

This study provided valuable insight into a wide range of General Aviation pilots' perceptions of which weather data was most important and what were the desired formats for each phase of flight. At present GA pilots appear to prefer weather information that is easily accessible and properly formatted. Pilot experience has a direct influence on the type of weather information desired. Respondents preferred a different format of weather delivery when transitioning from pre-flight to in-flight operations. This change may have been due to the lack of availability of the most desired format during in-flight operations. The results of this study may be useful in developing more effective formats and delivery systems of weather information in the GA cockpit.

Recommendations

Eighty one percent of the pilots in this study had less than 1000 hours. As a consequence, the results may have been skewed toward the more inexperienced pilot. Therefore, it may prove productive to repeat a similar study with a greater representation of more senior pilots.

Due to the frequency with which GA pilots wrote in additional selections of weather elements and products not offered in this survey, perhaps a similar study should be conducted where pilots are not offered choices of elements and products but are requested to list their top three most desired weather products and elements, in order of their importance, during the various phases of flight.

Although this study provided information on the preferences of the weather information desired it did not address the issue of "Why" the pilots thought these elements were most desirable. It is therefore recommended that such inquiries are made in future studies, because understanding "why" pilots make choices may prove very helpful in developing future in-flight weather delivery systems.

Prototype weather delivery systems should be created using the resulting "most desired" weather elements as indicated in this study. These prototype systems should be tested in the field to help determine their usefulness and desirability by GA pilots. The new formats should also be evaluated with respect to enhanced performance and effective decision making by GA pilots. This evaluation process should include human factor issues associated with the systems.

As the FAA is currently working towards developing new systems to provide weather information in GA cockpits, it is recommended that weather delivery systems be developed in all the three formats. The design should enable pilots to switch formats quickly based on their perceived need for different weather information. By providing all three formats pilots' should be able to more effectively access the full spectrum of the most desired weather information in their immediate surroundings which in turn was enable pilots to make a sound, effective, safe inflight decision.

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