Dimensions of Pilot Experience and Their Contributing Variables

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Pilot experience is generally recognized as an insulating factor against erroneous weather-related decision making in General Aviation (GA). A pilot's level of experience is traditionally taken to correspond to the total flight hours accrued. However, there is some evidence from aviation accident databases and research that total flight hours on its own, may be an inadequate measure of pilot experience. Indeed, pilot experience may be viewed as a multidimensional attribute, with each dimension made up of several elements or variables. How individual elements align with different dimensions, or the extent to which each dimension or the elements thereof contribute to good judgement and aeronautical decision making during adverse weather encounters is unclear. This paper reports initial results from research work carried out to evaluate the extent to which total flight hours and other flight hour related experience variables are associated with the outcome of pilots' in-flight encounters with adverse weather.

Weather is a critical consideration for flight and is often cited as a causal or contributory factor in aircraft accidents (AOPA, 2009; Knecht and Lenz, 2010). Weather related GA accidents consistently involve the highest rate of fatalities of all GA accident causes (AOPA, 2009; Knecht, 2008). In 2011 for instance, 40 out of 54 weather related accidents in the non-commercial fixed-wing GA flights were fatal and 28 out of 43 were fatal in 2010 (AOPA 2011; 2012)

Most accidents caused by adverse weather generally give reasonable warning to the pilot (AOPA, 2011). Therefore, some have suggested most accidents and incidents in weather are preventable (Weener, 2014). However, adverse weather presents pilots with a dynamic, safety critical situation in which time is often limited and information uncertain. Decision making under

such contexts has been described as “Naturalistic Decision Making” (Klein, Orasanu, Calderwood & Zsambok, 1993). Decision making within naturalistic contexts has been the subject of much research and our current understanding is that experience plays an important role in them (Klein, 2008). There is some consensus across different fields of endeavor that operators with high levels of experience make more accurate decisions under conditions with severe time pressure and information uncertainty compared to inexperienced operators (Adams and Ericsson, 1992).

In aviation, studies indicate pilot experience is an insulating factor against erroneous decision-making during encounters with adverse weather (Wiegmann, Goh and O'Hare, 2002). Some researchers have suggested expertise results from the experiences accumulated from time spent practicing within a domain (Ericsson, 2004). In aviation, this is tacitly understood to correspond to the total flight hours accrued. Pilot experience is typically evaluated on the basis of the total number of flight hours accumulated (Wiegmann, Goh and O’Hare, 2002; Wiggins and O’Hare, 2003; Johnson and Wiegmann, 2011). Indeed, several studies have found that pilots with higher total flying hours (more experienced) make better judgements and decisions about hazardous weather situations than pilots with lower total flying hours (Johnson and Wiegmann, 2011; Goh and Wiegmann, 2002).

Erroneous decisions made by pilots during encounters with adverse weather is often cited as a cause of GA accidents (O'Hare and Smitheram, 1995; Goh and Wiegmann, 2002; Wiggins and O’Hare, 1995; 2003). Such findings highlight two of the challenges associated with the use of total flight hours as a measure of pilot experience. First, a review of NTSB reports for related accidents reveals many involve pilots with a high number of total flying hours (Landsberg, 2004; NASA, 2007). Accidents which involve such experienced pilots suggest total flight hours may be an inadequate measure of experience. Indeed, Kochan, Jensen and Chubb (1997) have noted that more than total flying hours is required to make an expert pilot and suggested other dimensions such as the relevance, meaningfulness, recency, number and variety of the experience are also important. However, so far, no studies have been carried out to investigate the impact, if any, these dimensions may have in pilot decision making.

Secondly, some researchers have reported finding experience had no positive effect on decision making during adverse weather encounters. For instance, Goh and Wiegmann (2001) as well as

the NTSB (2005) have found experience in terms of total flight hours had no positive effect on decision making during encounters with adverse weather. Instead, researchers have found other measures of experience to be more appropriate in determining superior decision-making performance in certain adverse weather situations. For instance, Wiggins and O'Hare (1995) found that a proximal measure of experience, such as cross-country flight hours was a better predictor of differences between the weather-related decision-making performance of experienced and inexperienced pilots than a global measure of experience such as total flight hours. Similarly, Wiegmann, Goh and O'Hare (2002) found that recent flight experience (hours flown in the last 90 days) was a better indicator of the accuracy of pilots' weather-related decision making than total flight hours.

The foregoing suggests a one-dimensional definition of experience, based on total flight hours may lack the resolution or discriminatory power required to fully elucidate the nature of experience that supports accurate decision-making during adverse weather encounters in GA. If that is the case, our ability to better understand and take advantage of any positive effects of experience to influence the outcome of such encounters is limited.

Experience as a Multidimensional Attribute

There is some research as well as anecdotal evidence to suggest experience is a multidimensional attribute, with each dimension made up of several elements or variables. Apart from the number of total flight hours a pilot may have accumulated, several other elements such as the number of hours flown in the aircraft make/model, total hours flown in the last 90 days, cross-country hours flown, instrument rating, certificate type and airplane rating have also been mentioned as important variables that determine the accuracy of decision making during encounters with adverse weather (Kochan, Jensen and Chubb, 1997; Wiggins and O'Hare, 1995; NTSB, 2005; Wiegmann, Goh & O'Hare, 2002).

However, not much work has been done to empirically investigate and ascertain the efficacy of the variables in helping pilots avoid accidents during encounters with adverse weather, or the relationship between the dimensions and variables, Therefore, we do not know whether any of the elements of experience alone or in combinations, reflect or are predictive of the likelihood of an accident. This paper presents the first results from a series of studies carried out to investigate

the extent to which of some of the experience dimensions and variables identified in previous research, contribute to decision making during adverse weather encounters.

Approach to the Study and Data Collection

This study is predicated on the understanding that adverse weather encounters occur randomly, so nothing prevents a pilot from encountering one during a flight. Weather related incidents and accidents may be viewed as two distinct states with the potential for a unidirectional transition. An incident is an encounter with adverse weather that was resolved and did not transition to an accident state, while an accident refers to one that was not resolved and transitioned to an undesirable state, an accident. Viewed in this way, it then becomes possible to consider and investigate the key variables that that prevent a transition from incidents to accidents, since that is the preferred outcome. The general belief is that what prevents these randomly occurring incident involving adverse weather encounters from transitioning into accidents is the pilot's experience. So, if experience truly makes a difference to the outcome of adverse weather encounters, we should see significant differences between the operational experience profile of pilots who had accidents during adverse weather encounters and those who did not. Any operational experience variable that does not differ significantly between both sets of pilots may be viewed as having no effect on the outcome of adverse weather encounters.

To explore this conceptualization and thus, address the questions posed in this study, the experience profiles of a sample of pilots who had accidents from encounters with adverse weather was compared to that for a comparable sample of pilots whose encounters with adverse weather did not result in accidents. Queries were run on both the NTSB and ASRS databases to identify reports of General Aviation (Part 91) fixed wing accidents and incidents respectively, between January 1, 2005 and December 31, 2015, in which experience or decision making during adverse weather encounters was determined to be a cause or factor. Each report identified by the query was subsequently reviewed to ensure it met the criteria specified in advance for the study. Accidents and incidents during the take-off and landing phases of flights were excluded, since they could be indicative of short comings in airmanship, rather than decision making mediated by experience. Similarly, accidents and incidents during adverse weather encounters involving student pilots and those in which equipment failure was deemed a cause or factor were also excluded. Reports with incomplete date were also excluded from the study out of concern

that the nature of the missing data may not be random. A total of 595 reports, comprising 218 accident and 377 non-accident flights between January 1, 2005 to December 31, 2015 satisfied criteria for inclusion in the study. Pilot experience data was then extracted from the reports and collated for analysis.

Data Analysis

Data analysis started with exploration of the data using descriptive statistics, to summarize and gain some insight into the composition and nature of each experience variable and their distribution for the two groups of pilots in the study. Standard measures of central tendency including mean, median and mode as well as measures of dispersion such as standard deviation, minimum and maximum values were computed along with the frequency distribution for each variable. Individual experience variables were analyzed to determine whether they had any relationship with the outcome of adverse weather encounters. Specifically, Chi-square tests were used to determine the extent to which each element of experience or different levels of multi-level experience variables was associated with accidents. This was followed by a determination of the strength of any such associations in terms of odds ratios.

Three pilot experience variables were considered in this first part of the study; total flight hours, hours flown in the last 90 days and hours flown in airplane make and model. Since these are expressed as continuous variables, they were categorized for the Chi-square tests. Total flight hours was broken into three categories based on Federal Aviation Regulations eligibility requirements for pilot licensure. Accordingly, the first total flight hour category included pilots with 51-250 total flight hours, the next was made up of pilots with 251 – 1500 total flight hours, while the last category included pilots with more than 1500 total flight hours. Both hours flown in the last 90 days and hours flown in airplane make and model were broken into upper and lower median categories.

Results

Descriptive statistics

Descriptive statistics for the data collected indicates accident and non-accident pilots had mean total flight hours of 2223.54 and 6093.14 hours respectively. Similar values for the median total flight hours were 760.00 and 3900.00 flight hours respectively. The mean for hours flown in the last 90 days was 48.49 hours for pilots in the accident group and 75.21 hours for those in the

non-accident group, while the median hours flown in the last 90 days were 30.00 and 60.00 hours respectively. The mean hours flown in make and model for accident and non-accident pilots were 610.01 and 972.21 hours respectively, while the median values for accident and incident pilots were 174.00 and 453.00 hours respectively. Details of the descriptive statistics are contained in Table 1 below.

Variable		*Total Flight Hours*					*Hours in Last 90 days*					*Hours in Make and Model*				
	N	*Mean*	*SD*	*Med*	*Min*	*Max*	*Mean*	*SD*	*Med*	*Min*	*Max*	*Mean*	*SD*	*Med*	*Min*	*Max*
Total	595	4675.37	8879.98	2500	50	178000	65.42	64.7	50	0	680	300	1453.13	300	1	18300
Accident Pilots	218	2223.54	3528.57	760	50	22228	48.49	51.5	30	0	250	610.1	1580.37	174	2	9200
Incident Pilots	377	6093.14	10577.6	3900	57	178000	75.21	69.4	60	1	680	972.2	1358.76	453	2	9200

Table 1: Descriptive Statistics

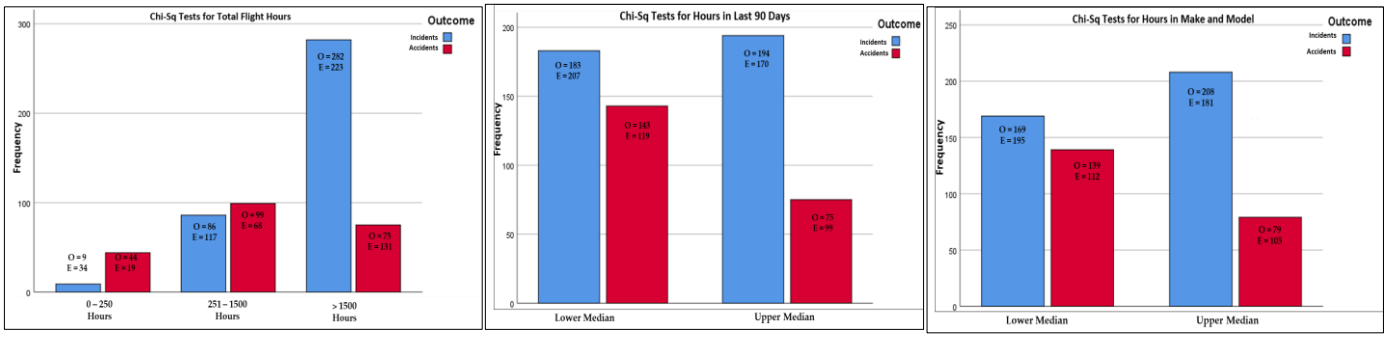

Figure 1: Chi-Square Test Results

Chi-Square Test Results

There were significant associations between total flight hours, ($\chi^2 = 109.37$, $p < 0.01$), hours in the last 90 days ($\chi^2 = 16.22$, $p<0.01$), hours in airplane make and model ($\chi^2 = 19.83$, $p < 0.01$) and the outcome of adverse weather accidents. For total flight hours, the largest differences existed between pilots within the lowest and highest categories. Pilots with 250 total flight hours or less accounted for 8.9% of the total number of accidents pilots but were associated with 20.20% of the accidents during adverse weather encounters. At the other end, pilots with more than 1500 total flight hours accounted for 60% of the total number of accidents pilots in the study and were associated with 34.4% of the accidents. Pilots that had between 251 and 1500 total flight hours made up 31.1% of accident pilots and were associated with 45.4% of the total accidents. Pilots with 250 total flight hours or less were much more associated with accidents (83%) than

incidents (17%). Those with between 251 to 1500 total flight hours were more evenly spread (53.50% and 46.50% for accidents and incidents respectively). The percentages for accidents and incidents were 21% and 79% respectively for pilots who had more than 1500 total flight hours. The chart on the left of Figure 1 displays the results of the Chi-square tests for total flight hours.

For hours flown in the last 90 days, 54.8% of all the pilots studied were in the lower median, while 45.2% were in the upper median. However, 65.6% of pilots in the lower median were associated with accidents, while only 34.4% of those in the upper category were. A larger percentage of pilots in the lower category were associated with accidents (43.9%), compared to those in the upper median (27.9%). The chart on the middle of Figure 1 displays the results of the Chi-square tests for hours flown in the last 90 days.

Hours in airplane make and model followed the same trend as hours in the last 90 days. A total of 51.8% of all the pilots studied were in the lower median, while 48.2% were in the upper median. However, 63.8% of pilots in the lower median were associated with accidents, while only 36.2% of those in the upper category were. A larger percentage of pilots within the lower median were associated with accidents (45.1%), compared to the percentage in the upper median (27.5%). The chart on the right of Figure 1 displays the results of the Chi-square tests for hours flown in airplane make and model.

Discussion

This study sought to determine pilot experience variables most associated with an accident during encounters with adverse weather in GA. Much of the previous research carried out in this area have involved the use of simulation and surveys to identify risk factors associated with accidents during adverse weather encounters or the decision-making processes that contribute to such accidents (Lanicci et al., 2012). In this study, experience data for pilots involved in actual, rather than simulated encounters with adverse weather is used to determine which elements of experience are significantly associated with accidents. One advantage of this approach is that the results have a higher level of ecological validity.

Experience is believed to enable more accurate situation assessment and decision making during dynamic, safety critical encounters in which time pressure exists. How different aspects of pilot

experience facilitate this during encounters with adverse weather, or which specific elements of experience more significantly impact the likelihood of accidents is not quite clear.

Associations Between Length/Duration of Experience and Accidents.

The elements of experience considered in this first part of the study were flight hour-based and delineated experience in terms of its length/duration. There were significant differences between accident and non-accident pilots on each of the length/duration experience variables evaluated. Lower levels of each experience element were significantly associated with accidents during adverse weather encounters compared to higher levels for each. This result agrees with those from several previous simulation-based studies on the subject, which also found similar associations between the elements considered here and accidents (Sawyer & Shappell, 2009; Wiegmann, et al., 2002). Chi-square tests on categorized levels of each length/duration experience variable showed statistically significant and increasing associations between increasing levels of each variable and accidents during adverse weather encounters. It is not clear whether any of the elements of experience alone or in combinations, reflect or are predictive of the likelihood of an accident. This is one of the questions to be investigated in the rest of the study.

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