Collegiate Aviation Review

UNIVERSITY AVIATION ASSOCIATION

Fall 2014 Volume 32: Number 2

The Peer Reviewed Journal of the University Aviation Association

UNIVERSITY AVIATION ASSOCIATION

COLLEGIATE AVIATION REVIEW

Mary E. Johnson, Ph.D., Editor
David C. Ison, Ph.D., Associate Editor

Fall 2014 **Volume 32: Number 2**

The Collegiate Aviation Review (CAR)
Fall 2014, Volume 32, Number 2
Mary E. Johnson, Editor

All correspondence and inquiries should be directed to:

University Aviation Association
2415 Moore's Mill Road, Ste. 265-216
Auburn, AL 36830
Telephone: (334) 528-0300
Email: CARjournal@uaa.aero

ISSN Number: 1523-5955

Editorial Board
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Collegiate Aviation Review

ACKNOWLEDGEMENTS

No juried publication can excel, unless experts in the field serve as anonymous reviewers. Indeed, the ultimate guarantors of quality and appropriateness of scholarly materials for a professional journal are the knowledge, integrity, and thoroughness of those who serve in this capacity. The thoughtful, careful, and timely work of the Editorial Board and each of the following professionals added substantively to the quality of the journal, and made the editor's task much easier. Thanks are extended to each reviewer for performing this critically important work. In addition to the members of the Editorial Board, the other reviewers for this issue include:

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STATEMENT OF OBJECTIVES

The *Collegiate Aviation Review* is published semi-annually by the University Aviation Association. Papers published in this volume were selected from submissions that were subjected to a blind peer review process, for presentation at the 2014 Fall Education Conference of the Association in Daytona Beach, Florida.

The University Aviation Association is the only professional organization representing all levels of the non-engineering/technology element in collegiate aviation education. Working through its officers, trustees, committees and professional staff, the University Aviation Association plays a vital role in collegiate aviation and in the aviation industry.

The University Aviation Association accomplishes its goals through a number of objectives:

To encourage and promote the attainment of the highest standards in aviation education at the college level.

To provide a means of developing a cadre of aviation experts who make themselves available for such activities as consultation, aviation program evaluation, speaking assignments, and other professional contributions that stimulate and develop aviation education.

To furnish a national vehicle for the dissemination of knowledge relative to aviation among institutions of higher education and governmental and industrial organizations in the aviation/aerospace field.

To foster the interchange of information among institutions that offer non-engineering oriented aviation programs including business technology, transportation, and education.

To actively support aviation/aerospace-oriented teacher education with particular emphasis on the presentation of educational workshops and the development of educational materials in the aviation and aerospace fields.

University Aviation Association

2415 Moore's Mill Road, Ste. 265-216
Auburn, AL 36830
Telephone: (334) 844-2434
Email: CARjournal@uaa.aero

Call for Papers

The *Collegiate Aviation Review* (*CAR*) is the refereed journal of the University Aviation Association (UAA). Both qualitative and quantitative research manuscripts relevant to aviation are acceptable. The *CAR* review process incorporates a blind peer review by a panel of individuals who are active in the focus area of each manuscript. Additional recommendations are also provided by the editors of the *CAR*. A list of all reviewers is published in each edition of the *CAR* and is available from the *CAR* editor.

Authors should e-mail their manuscript, in Microsoft Word format, to the editor at CARjournal@uaa.aero no later than January 15 (Spring 2015 issue) or July 1 (Fall 2015 issue).

Previous editions of the *CAR* should also be consulted for formatting guidance. Using Times New Roman 12 point font with 1.25" margins, the paper should be single spaced with a space before and after each heading. Manuscripts must conform to the guidelines contained in the *Publication Manual of the American Psychological Association, 6th edition*. Specifically, this means that submissions should follow the formatting found in the manual, e.g. proper use of the headings, seriation, and in-text citations. The references section must be complete and in proper APA format. Submissions that include tables and figures should use the guidelines outlined in the APA manual. In order to better align the *CAR* with the general research community, submissions using quantitative analysis should take into account the recommendations of the APA Task Force on Statistical Inference. Papers that do not meet these expectations will be returned to the author for reformatting.

All submissions must be accompanied by a statement that the manuscript has not been previously published and is not under consideration for publication elsewhere. Further, all submissions will be evaluated with plagiarism detection software. Instances of self-plagiarism will be considered the same as traditional plagiarism. Submissions that include plagiarized passages will not be considered for publication.

If the manuscript is accepted for publication, the author(s) will be required to submit a final version of the manuscript via e-mail, in "camera-ready" Microsoft Word format, by the prescribed deadline. All authors will be required to sign a "Transfer of Copyright and Agreement to Present" statement in which (1) the copyright to any submitted paper which is subsequently published in the *CAR* will be assigned to the UAA and in which (2) the authors agree to present any accepted paper at a UAA conference to be selected by the UAA, if requested. Students are encouraged to submit manuscripts to the *CAR*. A travel stipend for conference attendance up to $500 may be available for successful student submissions. Please contact the editor or UAA for additional information.

Questions regarding the submission or publication process may be directed to the editor by email to: CARjournal@uaa.aero.

Editor's Commentary

This edition of the *CAR* contains seven articles selected from 14 articles submitted for the fall 2014 edition. As this is the first edition of the *CAR* that I am serving as editor, I want to convey my sincere appreciation for the efforts of the editorial board and the reviewers. Special recognition goes to David Ison, the previous editor and now associate editor of the *CAR,* for his efforts in smoothing the transition between editors, and to David McAlister who has been the vital link between the *CAR* and the UAA Fall conference planning.

In this issue, the papers encompass a broad range of the aviation system from pilots to mechanics, flight schools, airports, and commercial carriers. The perceptions of flight school administrators on new pilot certification requirements are presented. Several papers in this issue focus on the impacts of technological advancements incorporated into commercial and general aviation. In addition to cockpit technology, this edition contains a paper on perceptions of new technologies from the viewpoint of airline mechanics. Perceptions of air carrier employees on fuel conservation are explored. It is important that the research published in the *Collegiate Aviation Reveiw* encompass the vital issues facing the global airspace system.

This fall I am updating the contact information for reviewers and seeking additional reviewers to better serve the journal in a broad range of topics. The *CAR* accepts book reviews (non-peer reviewed), methodological papers, statistical analysis reviews, exploratory studies, and qualitative and quantitative research papers. If you have a question about publishing in the *CAR*, please do not hesitate to contact me.

Thank you to all who support the *CAR*.

Cordially – Mary E. Johnson, PhD, Editor

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Examining the Relationship between Familiarity and Reliability of Automation in the Cockpit

Rian Mehta, Stephen Rice, and Scott Winter
Florida Institute of Technology

Abstract

This study sought to determine the correlation between familiarity and perceptions of reliability, as associated to specific aviation-related automated devices. Participants' experience levels ranged from non-pilots to novice pilots to certified flight instructors. It was hypothesized that familiarity has a direct correlation with ratings of reliability for various aviation-related automated devices and that the correlation across devices for each participant would be positive. The researchers expected to find a difference in the familiarity-reliability relationship as a function of experience. Findings showed that there was a significant positive correlation between familiarity and reliability for every single automated device. A positive correlation across automated devices for 87% of the participants was also found. Interestingly, the study did not find any relationship between experience and the familiarity-reliability relationship.

Introduction

Automation has become a part of our everyday lives. The general public has grown accustomed to a great number of automated applications, from cruise control to automatic transmissions. Within aviation, pilots are becoming more accustomed to glass panel displays, autopilots, and Global Positioning System (GPS) navigation as a part of everyday flying. People tend to have blind faith that certain components will reliably perform the tasks expected of them. However, they may be less trusting of other aids and devices. The current study sought to determine the correlation between personal experiences and history (i.e. familiarity) with an automated device and ratings of the same device's perceived reliability. The research team predicted that the participants' rating of reliability would have a direct relationship with their trust in that particular aid, device, or system, showing the relationship between familiarity and reliability. The study included 181 participants with different levels of aviation experience, ranging from non-pilots to Certified Flight Instructors. The non-pilots were deemed to have aviation experience by virtue of their ground training and college level education in the non-flight aspects of the aviation industry. The participants were asked to rate their familiarity and perceived reliability for a number of different aviation related automated devices and aids.

Humans' trust in automation has been widely researched, and what the implications of the same could mean throughout the industry. Additionally, familiarity has also been seen as a predictor of trust between humans and within interpersonal interactions (Jian, Bisantz, & Drury, 2000). This study is unique in that it works to enhance the industry's understanding of trust and familiarity by attempting to find a correlation as it relates to multiple automated aids. This study aims to understand the extent to which familiarity with an automated device increases or decreases a person's perception of the system's reliability. There may be, of course, certain exceptions showing negative correlations between familiarity and perceived reliability. These exceptions may result from a participant's negative experiences with a specific automated aid or device. Trust is defined in social psychology as the predictability of another person (Deutsch, 1958; Eckel & Wilson, 2004; Ergeneli, Saglam, & Metin, 2007); research has also shown that this concept can likewise be applied toward automation (Parasuraman & Riley, 1997; Reeves & Nass, 1996; Rice, 2009). Once trust in an item or person is affected or lost, it is an extremely powerful psychological occurrence; it can be very difficult to overcome, even over an extended period of time. In certain cases, once trust is lost, it may never be regained (Slovic, 1993). In these cases, increased familiarity and exposure to a device operating accurately may take years of effort to regain lost trust.

The following sections outline the industry's research on trust in automation, familiarity between human operators and how familiarity can be used as a predictor of perceived reliability in automation. This will clearly outline the necessity for the current study and allow for a discussion of the much larger implications that this study could have on the aviation industry as a whole.

Automation

Automation is defined by Wickens and Hollands (2000) as a mechanical or electrical task or accomplishment of work that otherwise would need to be accomplished by a human operator. Parasuraman, Sheridan, and Wickens (2000) identify four stages of automation: synthesis, diagnosis, response selection, and response execution functions. Automated aids can assist a human in times of high workload, or perform a task that a person is not suited to perform accurately and precisely, and can often replace the human from these tasks (Rice & Geels, 2010). The next step in understanding automation fully is to determine the extent to which human beings rely on automation to perform accurately and consistently. Research demonstrates that the acceptance and perceived reliability that a person places in an automated system can be affected by that individuals' trust in the system (Sheridan, 1998).

Unfortunately, automation is not always accurate, and like any system, has the propensity to fail. It is for this reason that people may be wary of completely trusting automation, and a cautious attitude toward automation is perfectly healthy. Automation can fail to catch potentially hazardous situations (misses), or issue alerts for events that did not actually occur (false alarms). Both failures have been shown to negatively affect an operator's trust in the system (Geels-Blair, Rice, & Schwark, 2013; Parasuraman & Riley, 1997; Rice, 2009; Rice & Geels, 2010). Repeated failures of an automated system could lead us to explore the possibility that continued exposure to such events could create a psychological tendency to have less perceived reliability in that particular automated system. Conversely, repeated exposure to a system that performs accurately and efficiently on a constant basis, it may, either falsely or accurately, increase the operator's sense of reliability in the system.

Familiarity with Humans

Previous studies have greatly researched several different facets of trust in automation (Gefen, 2000; Gulati, 1995; Larzelere & Huston, 1980; Lee & Moray, 1994; Luhmann, 1979; Luhmann, 2000; Minsky, 2003; Muir & Moray, 1996; Sheridan, 1988), and several works have documented the different relationships between humans, and how trust affects the same. Familiarity has been defined as a complex understanding frequently based on prior interactions, experiences, and learning of others (Luhmann, 1979). Luhmann (2000) clearly warns against confusing the concepts of familiarity and trust. He explains that familiarity is an unavoidable occurrence, but trust has to be earned within this set of familiarity. Changes within the natural set of occurrences are bound to take place, and these changes may not necessarily affect our familiarity with a system or human being, but they will affect our trust (Luhmann, 2000). Gefen (2000) researched the relationship between familiarity and trust in the context of e-commerce, which found that even though trust and familiarity are different, familiarity does affect trust. Minsky (2003) differentiates between two types of trust, namely familiarity based trust, and reliability based trust, which infers that familiarity based trust is based on personal familiarity. Interpersonal relationship studies, within the business realm, have been researched, and it has been noted that people are more likely to build alliances and trust business partners with whom they have prior ties. Familiarity leads to laxer practices as firms build confidence in their partners, which is the direct display of their trust in the other set of human counterparts (Gulati, 1995). Larzelere and Huston (1980) measure trust in terms of benevolence and honesty between partners. From their studies, they were able to determine that several factors affected the measure of trust, some of which included predictability, reliability, and dependability. Studies prior to the current research (Lee & Moray, 1994; Muir & Moray, 1996) took the opportunity to apply these measures of trust to determine if they were similar for an operator's trust in automated systems. They developed an additive trust model that included six components: predictability, dependability, faith, competence, responsibility, and reliability. It has also been noted that possible factors in trust include reliability, robustness, familiarity, understandability, explication of intention, usefulness, and dependence (Sheridan, 1988). Trust is therefore crucial in the overall role of familiarity and the connection between trust, familiarity and reliability is the key to this researchers' observations. Trust could therefore be categorized as the emotional and psychological construct that aids in the development of familiarity, thus affecting the individual's perceptions of reliability.

Familiarity with Equipment

Numerous studies have researched the connection between trust and automation, as well as the relationship between human operators and their use of automation within the scope of their required tasks (Dzindolet, Peterson, Pomranky, Pierce, & Beck, 2003; Jian, Bisantz, & Drury, 2000). Jian, Bisantz, and Drury (2000) saw the need to be able to effectively measure a human operator's trust in automation and their effective use through an empirically determined scale. Trust is an extremely powerful psychological occurrence. Interestingly, once people are informed as to why automation might fail or make errors, their trust and reliance in the automation is renewed, even though the increase is unwarranted (Dzindolet et al., 2003).

Novice versus Experts

The differences between novices and experts from several fields have been researched greatly to measure their variations, including those relating to aspects of aviation (Li, Baker, Lamb, Grabowski, & Rebok, 2002; Kasarskis, Stehwien, Hickox, Aretz, & Wickens, 2001; Rowe & Wright, 2001; Thomson, Önkal, Avcioğlu, & Goodwin, 2004). It has been found that since aircraft mechanical reliability has improved over the decades, the causes of accidents have shifted heavily onto the pilots, and this is where pilot experience becomes a factor. In today's aviation environment, with so many mechanical enhancements and automated features available to a pilot, approximately 70-80% of accidents, regardless of experience, occur due to human error (Li, Baker, Lamb, Grabowski, & Rebok, 2002). It was found that expert pilots were more adept to identifying low risk situations, while novice pilots are more likely to overestimate the potential for a hazardous situation (Thomson, Önkal, Avcioğlu, & Goodwin, 2004). Thomson, Önkal, Avcioğlu, and Goodwin (2004) also go on to state that experts are customarily thought to have characteristics and knowledge that allow them to better perform relevant task than novices. Interestingly, Rowe and Wright (2001) aim to show that there is very little evidence to support the generally accepted concepts that experts judge risks differently, and are more veridical than novices. As experience (measured in terms of flight hours) relates to flying skills, expert pilots were found to have more active scan patterns than novice pilots. This finding translates into better, more consistent and more efficient flying skills as they relate to airspeed maintenance and landing performance (Kasarskis, Stehwien, Hickox, Aretz, & Wickens, 2001). Within the vast array of research conducted on the differences between novices and experts in several fields and situations, no prior studies discuss the differences of the two groups as they relate to familiarity and reliability in automation.

An important part of this current study lies in the fact that a varied sample of participants from different levels of aviation experience was used to collect this data. The range of knowledge and experience varied from non-pilots, to novice pilots beginning their aviation education, all the way up to seasoned flight instructors with several thousands of hours of flight experience. The inclusion of non-pilots was to serve as benchmark for lack of flight experience and give the perspective of a person unfamiliar with instruments and automation in the cockpit. This is important to the study, as the researchers were able to gauge the variations from several different levels of experience to see if they all behave in a similar manner universally. This may have major implications in the findings, as it could suggest how level of experience influences one's view toward automation reliability.

Current Study

Previously studies have paved the path in the research of trust relating to automation, and the manner in which familiarity between human beings affects trust. The current study goes into depth to examine the familiarity of human operators and non-operators with automation, which is something that has yet to be conducted within this field of research, and may have significant promise for future research. The survey asks participants to rate their familiarity with a range of automated aids and devices, as well as their feelings of reliability in those same devices. If familiarity with automation is found to have a significant correlation with peoples' concept of reliability in the automation, it can be hypothesized that trust in automation has a direct relation to one's familiarity with the same. This would mean that the more familiar the participant is with an automated system, the higher the rated reliability will be from the participant. Our hypotheses were as follows:

1) It was predicted that the between-participants correlation between familiarity and reliability would be positive. It was expected this would exist across all participant levels and that this would apply to all automated devices.
2) It was predicted that the within-participants correlation between familiarity and reliability would be positive. It was expected this would exist across all participant levels as well.
3) It was predicted that there would be a noted difference in the correlational analysis of the familiarity-reliability relationship as a function of experience as measured by flight hours.

Method

Participants. 181 persons (19 females) participated in the study. The mean age was 21.17 (*SD* = 4.46). The data was collected from college students and university professionals associated with an aviation college at the subject university. There are eleven different subsets of data that were collected from participants in different aviation related college courses (see Table 1). All participants were members of the subject university's College of Aeronautics as either students or flight instructors.

Materials and Recruitment. The study was completed using paper surveys that were administered to participants; seven randomized versions of the instrument were created to reduce order effects. To recruit participants, members of the research team solicited volunteers from various level courses within the College of Aeronautics from introductory students with minimal or no flight experience to university flight instructors. A listing of sections surveyed can be found in Table 2. The items listed are described as automation, and the argument of the definition of automation is extensive. The items are a wide range of instruments, aids, and devices, and have been specifically chosen to be the best representation of items used in the cockpit that would serve the purpose of the study. Participants were informed that completion of the survey was optional and separate from any course requirements, and no compensation was provided to participants for survey completion.

Table 1

Data as a Function of Coursework

	Between	Within	N
Introduction to Aviation Human Factors	.41	.37	30
Aeronautics 1 (Section 1)	.43	.41	24
Aeronautics 1 (Section 2)	.20	.31	17
Aeronautics 1 (Section 3)	.27	.45	18
Aeronautics 2 (Section 1)	.35	.42	16
Aeronautics 3 (Section 1)	.41	.49	11
Aeronautics 3 (Section 2)	.47	.58	11
Aeronautics 4 (Section 1)	.32	.56	8
Advanced Aircraft Systems (Section 1)	.38	.24	9
Advanced Aircraft Systems (Section 2)	.13	.50	7
Certified Flight Instructors	.23	.33	23

Procedure. After obtaining institutional review board (IRB) approval, participants were instructed that the survey instrument was designed to gather information on their familiarity and perceived reliability of 33 aircraft components (see Table 2). These items were selected as a mixture of commonly used instruments on board general aviation aircraft as well as complex automated systems found on larger commercial airliners. The researchers instructed participants to review each instrument and then rate their familiarly, from -3 (extremely unfamiliar) to 3 (extremely familiar), and reliability, from -3 (extremely unreliable) to 3 (extremely reliable) using the Likert scale. The order of the two ratings was counter-balanced, and participants were instructed not to go back once they had provided answers. Following this, basic demographic information was sought from participants, along with number of flight hours (as an indicator of experience), following which they were dismissed from the room.

Design. A correlational design was employed for this study including between and within subjects analyses.

Results

Out of the 181 total participants, 169 provided viable data. The most common reason for dropping a participant's (11) data were due to a failure to input responses. One additional participant was dropped due to a failure to provide demographic data. All analyses used a two-tailed analysis per the non-directional hypotheses.

The mean familiarity score was 1.01 (SD = 1.05) on a scale from -3 (extremely unfamiliar) to 3 (extremely familiar). The mean reliability score was 1.40 (SD = 0.45) on a scale from -3 (extremely unreliable) to 3 (extremely reliable).

Table 2

Between-Participant Correlations for Each Automated Device

Type of Device	Correlation
Air Data Computer	0.54
Airspeed Indicator	0.41
Altimeter	0.34
Anti-Ice Controls	0.36
Attitude Indicator	0.39
Attitude, Heading, and Reference System	0.44
Autopilot	0.42
Brakes	0.36
Cabin Pressurization System	0.19
Communication Radio	0.20
Crew Alerting System	0.43
Engine Indication	0.45
Flight Management System	0.24
GPS	0.30
Heading Indicator	0.25
Heads Up Display	0.34
Inclinometer	0.48
Inertial Guidance System	0.15
Lights	0.31
Magnetic Compass	0.22
Mode Control Panel	0.36
Multi-Function Display	0.49
Navigational System	0.43
Oxygen Controls	0.32
Primary Flight Display	0.46
Rudder Pedals	0.44
Servo Actuator	0.32
Throttle Levers	0.50
Traffic Collision Avoidance System	0.36
Turn and Bank Indicator	0.40
Vertical Speed Indicator	0.42
Yaw Rate Sensor	0.34
Yoke	0.54

The overall between-participant correlations for all participants ranged from .15 (p = .05) to .54 ($p < .001$), with a mean score of .37, $p < .001$. These values can be found in Table 1. The overall between-participant correlations for Non-US participants ranged from -.78 ($p < .001$) to .89 ($p < .001$), with a mean score of .34, $p = .01$. The overall between-participant correlations for US participants ranged from -.64 ($p < .001$) to .91 ($p < .001$), with a mean score of .42, $p = .01$. The overall between-participant correlations for female participants ranged from -.56 ($p = .01$) to .77 ($p < .001$), with a mean score of .34, $p = .15$. The overall between-participant correlations for male participants ranged from -.78 ($p < .001$) to .91 ($p < .001$), with a mean score of .39, $p < .001$.

The overall within-participant correlations ranged from -.78 ($p < .001$) to .91 ($p < .001$), with a mean score of .40, $p = .02$. 147 out of 169 participants had positive correlations (Binomial probability $P(x{=}147)$, $p < .001$).

There was no significant correlation between flight time and the within-participants consistency coefficient, $r = -.05$, indicating that there was no relationship between level of expertise and the familiarity-reliability relationship. There was no significant correlation between age and the within-participants consistency coefficient, $r = -.08$, indicating that there was no relationship between age and the familiarity-reliability relationship.

Table 2 presents the data by course/section. As can be seen in the table, every course/section followed the same pattern as the overall data. The between-participant correlations for the courses/sections ranged from .13 to .47, with a mean score of .37. The within-participant correlations for the courses/sections ranged from .24 to .58, with a mean score of .40.

Discussion

The purpose of the study was to further analyze the relationship between familiarity and reliability (a construct related to trust). Prior research has indicated that there may be a positive correlation between the two variables; however, it has not been pursued in the field of aviation to the degree that would allow for strong generalizations. In the current study, aviation students (from non-flight up to certified flight instructors) in the College of Aeronautics at the subject university were given a list of 33 common automated devices in the cockpit and asked to rate how familiar they were with the devices, and how reliable they felt the devices to be. In general, the research team predicted a positive correlation between familiarity and reliability across all devices and participants. The findings are discussed here.

The first hypothesis was that the between-participants correlation between familiarity and reliability would be positive. It was expected that this would exist across all participant levels, and that this would apply to all automated devices. The findings supported this hypothesis; in fact, the between-participants analyses showed that there was a significant positive correlation between familiarity and reliability for every single automated device.

While it is possible that this relationship might not exist for some other automated devices, the current data provide strong evidence towards a possible future generalizable positive relationship between the two variables. Furthermore, this relationship exists across all levels of coursework and experience in the Aeronautics program.

The second hypothesis predicted that the within-participants correlation across automated devices for each participant would be positive. This was the case for 87% of the participants. These results indicate that the positive within-participants correlation between familiarity and reliability exists for the vast majority of participants in the study. These results are surprising, given that human attitudes and behavior tend to have a large amount of variance. To have 87% of participants agree about a particular relationship between variables allows us to not only generalize the effects across automated devices, but also across the general population of Aeronautics students at the subject university. The sample population is a mix of pilots and non-pilots with a specific purpose of understanding the relationship and the differences in the relationship as a function of experience or lack thereof with aviation systems.

The third hypothesis was that the relationship between flight hours (experience), and the within-participants consistency coefficient would show that more experienced pilots would have a stronger familiarity-reliability relationship. The data did not support this hypothesis. Instead, the results indicate that there was no significant relationship between level of experience and the familiarity-reliability relationship. Thus, the correlation between familiarity and reliability appears to be constant across all levels of experience up to certified flight instructor. It is also important to note that none of the other demographics collected correlated with this familiarity-reliability relationship.

Practical Implications

The findings of this study offer some practical implications. First, it is clear that designers of automated systems must take into account the operator's familiarity with the device before assuming high-perceived reliability in the system. It is already known that more opaque automated systems (Wickens & Holland, 2000) result in lowered trust in the system. Designers need to create automated systems that are transparent and easy to become familiar with. Training should focus on helping the operator to become familiar with the device, including understanding the algorithms behind the automation.

Most automated devices fail eventually, and sometimes frequently. Operators need to have an understanding of why the devices fail, so that when a device does operate inaccurately, there is not a total loss of trust due to ignorance of the reason behind the failure. Learning why a device fails is a way of becoming more familiar with it; therefore, even though an individual is becoming more familiar with a faulty device, they might still perceive it as being more reliable. This has been shown through prior research (Dzindolet et al., 2003), and an example in the aviation industry in the Traffic Collision Avoidance System (TCAS). All pilots know that the TCAS frequently produces false alarms; however, most pilots still value the system and the regulations still requires compliance because it saves lives.

Another interesting finding was the lack of relationship between experience (as measured by flight hours) and the familiarity/reliability relationship. The relationship appears to be robust across the sample, at least within this study. None of the other demographic variables collected in this study were shown to have a relationship with familiarity/reliability either. This may indicate that there is some other variable or factors that influence how operators determine familiarity and perceived reliability within a system. Further research should seek to examine for other predictors that could influence the relationship between familiarity and reliability. The likely line of research would include studies that seek to determine the quantity of familiarity needed to produce the quality of reliability to meet industry best practices.

Limitations and Recommendations for Future Research

The current study has certain limitations common to studies of this nature. First, the correlations found in the study do not prove causation. It is possible that other confounding variables may be interacting with the two variables measured and causing a misunderstanding of the data. Further research should focus on experimentally testing these findings while controlling for possible confounds in order to provide causal inferences.

A second limitation is demographics of the participants; they were all from the same aviation program at the subject university, therefore it is possible that many had similar forms of training and experiences. They were fairly young; mean age was about 21 years old. All the participants come from a Part 141 school. Future studies should include participants from other schools (including Part 61), different age groups, and potentially includes commercial pilots, and not just students with commercial flight ratings. Most of the participants were male; a function of the demographics of the aviation program. The researchers were unable to find gender differences because of this, and thus further research should include more females in order to make gender comparisons.

A third limitation that prevented us from making meaningful comparisons between the different courses was the unequal number of participants in the courses. Introduction to Aviation Human Factors had 30 participants, while Aeronautics 4 had only eight. The researchers hope that future research will allow for sampling a higher number of advanced students compared to what the research team was able to deliver here.

Conclusions

The purpose of this study was to determine the relationship between familiarity and reliability using an aviation related sample from a small to medium sized university in the southern part of the United States. The findings of the study indicate significant, positive correlations between familiarity and reliability for both the between and within participants conditions. Interestingly, the study did not find any relationship between experience (as measured by flight time) and the familiarity/reliability relationship, which seems to indicate that this relationship is robust across all levels of experience. Additionally, none of the other demographic variables collected correlated with the familiarity/reliability relationship. This highlights the need for continued research on this topic to enhance the understanding of the relationship between familiarity and reliability within an aviation related field.

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The Prevalence and Limitations of Electronic Charts in University Flight Training

Tyler A. Babb
Middle Tennessee State University

Abstract

The use of electronic charts in pilot training has greatly increased in the last several years. UAA member universities continue to instruct using paper navigation charts, as these are still used for training and have not significantly changed in decades. However, the aviation industry has embraced electronic charts in the cockpit. Many airlines, charter companies and fractional operators have already transitioned to electronic charts. This study had two main research questions: (1) how commonly are electronic charts being used by pilots in university flight training, and (2) what are the benefits and limitations of electronic charts are as identified by students using electronic charts? A total of 84 professional pilot students were surveyed at a UAA member university. The majority of students surveyed indicated that they used electronic charts. Specific data was gathered on types of devices and software used, limitations of the devices and software, and pilot attitudes toward this new technology. Student attitudes toward the use of electronic charts were found to be generally positive.

Introduction

Airlines, charter companies, fractional operations and flight schools are all seeing a trend toward the use of electronic flight bags. Electronic Flight Bags (EFBs) perform many functions for current professional pilots including the essential function of providing electronic chart data. As of June 24, 2013, American Airlines had implemented electronic flight bags and completely replaced paper charts on all of its aircraft, and the airline plans to implement electronic chart use for their regional carrier, American Eagle, as well (American Airlines, 2013). Airlines such as Jet Blue Airways and U.S. Airways are also transitioning to electronic charts in the cockpit (Moorman, 2013). Current pilots in training thus have an increasing chance of using electronic charts in their future professional flying careers.

As operators have implemented electronic charts, flight schools have responded by using tablet computers such as iPads not only to view charts but to enhance training. Flight schools are collaborating with avionics distributors to fully integrate tablets into flight training. Ray Swanson is the vice-president of distribution and avionics for Tecnam North America. Mr. Swanson believes that affordable tablet computers will become a cornerstone of flight training, and the flight training industry can use tablet computers for flight planning, enhancing instruction/reference materials, and tracking student progress (Croft, 2010).

As other flight schools are building programs to support electronic charts, university pilot training programs should create programs as well. University Aviation Association member universities are "remaining on the forefront of technology innovations" (Arch & Sherman, p.18, 2006). If the pilots enrolled in these programs are using electronic charts, the universities should be aware of this and develop programs as other flight schools have. The purpose of this study was to find out how many professional pilot students are using electronic charts at a particular UAA university and to identify the limitations of the electronic charts as identified by the participants.

Literature Review

Understanding the benefits of electronic chart usage provides a background as to why they have become so popular. Financial benefits are always desired by operators and flight schools. The companies that provide electronic charts are confident in the affordability of their product. ForeFlight mobile is a common electronic chart provider and provides electronic charts to the U.S. Coast Guard, Flight Options, and Frontier Airlines (Berrett, 2014). The CEO of Foreflight Tyson Weihs stated that, "One customer alone saved more than $16,000 annually in printing and overnight shipping costs" (Berrett, 2014, 96). For operators, implementing electronic charts is simply good business.

If a technology can be implemented efficiently in the cockpit then pilots themselves feel safer. In a recent study on pilots adapting to Technically Advanced Aircraft (TAA), regional airline pilots and instructors were asked about pilots' ability to interpret TAA technology in the cockpit. The concern was that pilots who had not seen or flown TAA aircraft would have trouble adjusting to the technology in the cockpit when hired by the airline. The majority of pilots and instructors surveyed (85%) "…agreed that using advanced technology made a safer pilot" (Renzo & Bliss, p.48, 2010). Electronic chart technology has been developed and integrated much like TAA. Electronic chart technology could enhance flight safety.

As with any technology, reliability is a major concern. The devices used to perform advanced functions in the cockpit must be trusted by the pilots that use them. In order to fully trust a technology, the pilot must believe that the technology or system is reliable. If the systems provide reliability, the operator (pilots) will be more likely to trust the system (Bhana, 2010). Not all technology is flawless, and the trends of reliability for devices and software must be observed by pilots in order to truly trust any new technology.

Classroom technology has progressed with the industry technology. In a study of UAA member universities, the issue of classroom technology matching industry technology was closely observed (Arch & Sherman, 2006). This research involved an online survey of thirty-four UAA member universities and focused on Technically Advanced Aircraft

(TAA), and the use of classroom technology and software. In their research, they found that "the majority of UAA respondents felt that technology is very important in the classroom, aircraft, and department/student support systems" (Arch & Sherman, p.18, 2006).

The implementation of available technology is growing at an increasing pace. This trend will continue to present significant challenges for the aviation community (FAA, 2006). It is the responsibility of universities and the FAA to train and regulate these technologies as they become the industry standard. As for educators, we must remain capable of teaching these new technologies properly as they arise. Joe Clark of Embry-Riddle Aeronautical University stated, "How we initially teach our students to fly and use automation will stay with them for a lifetime" (Clark, p. 20, 2014). It is critical that these students receive complete initial instruction on these technologies to become safe and efficient professional pilots in the future.

There are many factors that influence the prevalence of electronic charts, including the costs associated, the level of training (certificate), and the student's willingness to trust the technology. As electronic charts are more commonly used for training, new complications may develop due to the nature of the devices used to view the charts. This research focused on the prevalence and limitations of the devices and the technology as used for training at a UAA member university.

Methodology

A paper survey was completed by current pilots in training at a UAA member four-year aviation university. The survey consisted of a total of 25 questions including yes/no, yes/not sure/no, and Likert scale answers. One of the purposes of the research was to determine if the total flight time or ratings acquired by the pilots had any effect on the usage of electronic charts. Thus, the pilots were asked for total flight time and ratings earned. There were no other demographical data collected to identify the participants. As required by the UAA member university's IRB requirements, the students were encouraged but not required to participate in the survey. The informed consent process included both a verbal consent to participate and paper documentation of consent as well. The university's IRB approval protocol number was 14-327.

Limitations

The research included pilots from all stages of training from student pilots to instrument instructors. The pilots' knowledge of VFR and IFR charts and limitations became apparent during the survey process. For example, some student pilots were currently using only VFR charts on software that provided both VFR and IFR charts. These pilots were not sure about the coverage areas and limitations of electronic IFR charts. These pilots in training may need to access only VFR information so that they access charts applicable to their current training.

This research was limited due to the fact that the survey population was relatively small. Also, the participants were all enrolled at one university. Though not all university students are recent high school graduates, the majority of the participants were fairly young and thus more comfortable with the daily use of similar electronic devices.

Participants

This research involved surveys of 84 professional pilot students at the survey university. The pilots that completed the survey were enrolled in one of the following courses: (1) a private pilot ground course, (2) an instrument ground course, (3) a commercial/multi engine rating ground course, (4) a navigation course, or (5) a flight instructor ground course during the spring semester of 2014. The participants' pilot certificates ranked from Private Pilot to Flight Instructor-Instrument.

Materials and Procedure

The survey was completed on paper to encourage timely participation and simplify the survey process. During the spring 2014 semester, the printed surveys were distributed during the class time of the five previously mentioned aviation courses. All surveys were completed within a three week period. The survey included 25 questions including both qualitative and quantitative data to solicit specific information on the devices, software, and pilot thoughts on electronic charts.

It is apparent that future airline pilots have a high chance of seeing these systems in the cockpit one day. Participants were asked whether or not they expect to use electronic charts during their professional flying careers. Also, in order to determine how common electronic chart usage is among pilot students, a series of survey questions asked for details on their usage. Not all participants used electronic charts. The students that used electronic charts were asked additional questions to determine the extent of the usage, coverage areas, and type of uses (i.e. VFR, IFR). These participants were also asked questions referring to their particular devices and software.

Participants that currently used electronic charts were also asked about complications with the charts. The devices used and the software used can create issues with chart accessibility in flight. Survey questions asked if they carried backup charts, and if they had any way of charging their device during flight. The participants that did not use electronic charts were asked a series of questions regarding why they did not use electronic charts and what their comfort level would be transitioning to electronic charts in the future.

Results

Of the five classes surveyed, there were 84 participant responses. The highest rating obtained by each participant can be seen in Table 1 below. The participants included pilots at all levels of training. Two of the participants did not indicate their highest pilot rating.

Table 1

Survey Participation Numbers with the Highest Pilot Ratings Obtained by Participants

Rating	Number of Surveys
Student Pilot	21
Private Pilot	16
Instrument	16
Commercial	9
Multi Engine	10
CFI	4
CFII	6
MEI	0
Total	82

Total flight time data was also collected. This data was collected separately from rating information as not all pilots acquire particular ratings at a set number of total flight hours. The total flight time for each participant is shown in Table 2. Nearly half of the participants (46%) had between 100 and 250 hours of total flight time logged.

Table 2

Survey Participation Numbers as Indicated by Total Flight Time of Participants

Total Hours	Number of Surveys
0-25	5
25-50	18
50-100	11
100-250	39
250-500	9
More than 500	2
Total	84

The affordability of navigation charts affects all pilots during training. An early survey question asked “Do you think a professional pilot student could save money if that person bought both a device and a chart subscription instead of paper charts during their training?” This question was asked to all participants regardless as to whether the applicant used electronic charts. Of the 84 total participants, 79% responded “yes,” 11% responded “not sure," and 10% responded "no." This data is reflected in Figure 1. Only 10% of the participants believed that electronic charts were more affordable than paper charts.

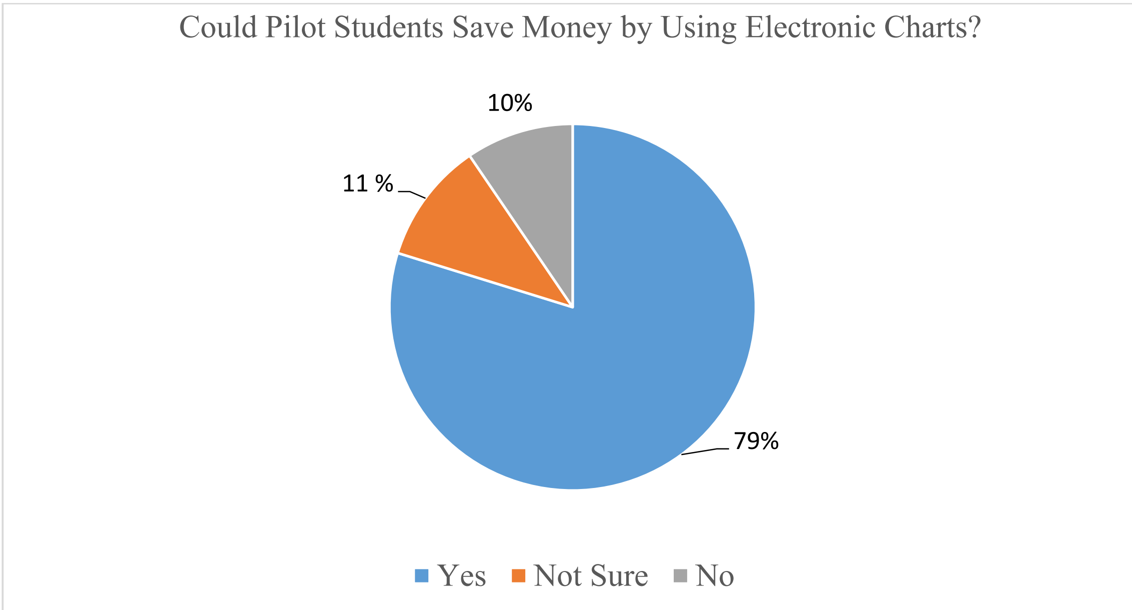

Figure 1. Professional Pilot Student Perceptions of the Affordability of Electronic Charts and Paper Charts

Another early survey questions was asked to establish how familiar the student was with small touch screen devices which are commonly used to view electronic charts. When asked "Have you ever used a tablet computer (or similar touch screen device)?" 95% of the respondents replied "yes," and only 5% of the participants replied "no." The overwhelming majority of the pilots interviewed had used a tablet computer or similar touch screen device at some point prior to the survey.

To determine student perspective on the future use of electronic charts in the industry, all participants were asked "Do you expect to use electronic charts in your professional flying career?" As shown on Figure 2, 93% of participants responded "yes," five percent of participants responded "not sure," and two percent of participants responded "no."

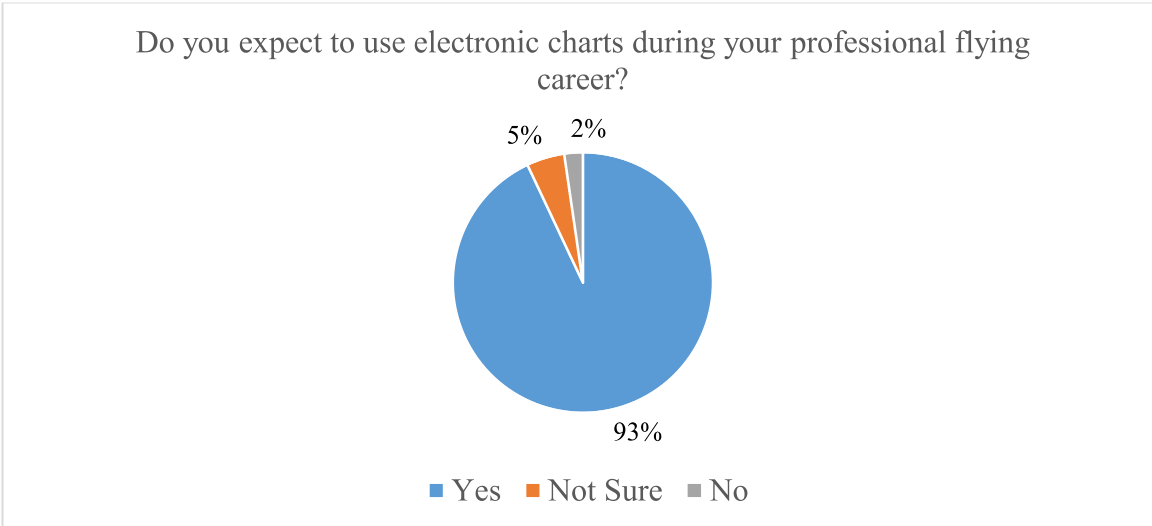

Figure 2. Student Perceptions on the Prevalence of Electronic Charts in Future Professional Pilot Positions

The prevalence of electronic chart usage was one of the main purposes of this research. To determine the current prevalence of professional pilot student electronic chart usage, the question "Do you use electronic charts?" was asked. Of the total 84 participants, 81% replied "yes" as displayed in Figure 3.

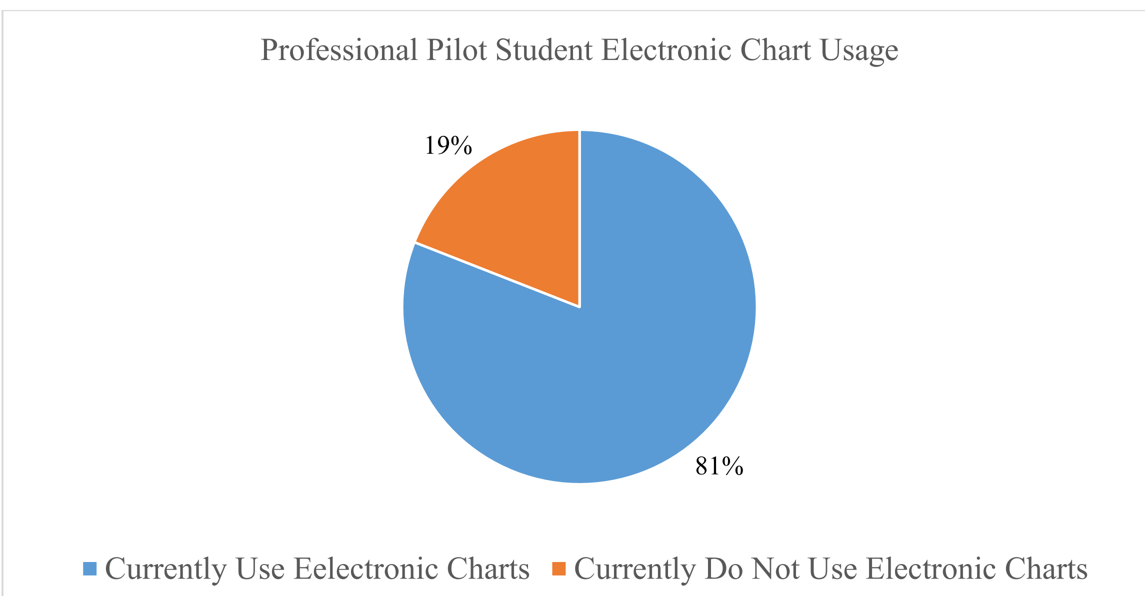

Figure 3. The Current Prevalence of Electronic Charts with the Participant Group

Because each participant had indicated their current hours, the data collected from each survey was used to determine if total flight hours were a factor in the use of electronic charts. As the total times progressed from zero to 100 hours, the data indicates that the usage grows significantly. The percentage of participants which used electronic charts based upon total flight time is depicted in Table 3.

Table 3

Participant Electronic Chart Usage According to Total Flight Time

Total Hours	Number of Participants	Percentage of Participants that used electronic charts
0-25	5	20%
25-50	18	66%
50-100	11	82%
100-250	39	92%
250-500	9	89%
More than 500	2	100%

After establishing which participants used electronic charts, the survey collected more specific data about the sources of the charts. Participants were asked "What type of application or software provides the charts to you?" As displayed in Figure 4, 94% of the pilots who use electronic charts used ForeFlight Mobile. Other providers included Garmin Pilot, Jeppesen, and fltplan.com, each with one response.

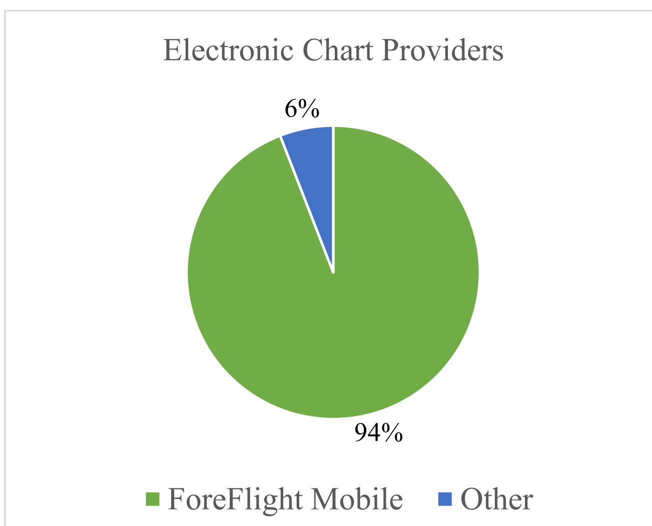

Figure 4. Sources of Electronic Charts for Professional Pilot Students Actively Using Electronic Charts

All of the chart information must be FAA approved and current. The FAA has long been providing paper charts to pilots, and in the future the FAA may provide electronic charts directly to the pilot. The subsequent survey question asked "If the FAA were to provide electronic charts, would you use those instead of your current provider?" Of the total eighty-four participants, 51% responded "yes," 39% responded "not sure," and 10% of the participants responded "no."

Electronic charts are currently provided for VFR and IFR purposes. To determine the prevalence of both types of usage, the participants were asked "Do you use electronic charts for VFR charts?" The corresponding coverage areas were also collected. Of the 68 applicable participants, 91% used electronic VFR charts. Of those responses, 58% had access to VFR charts for the entire contiguous U.S., and 29% of the respondents had access to VFR charts in the local region.

The following survey question asked "Do you use electronic charts for IFR Charts?" The corresponding coverage areas were also collected. Of the applicable 68 participants, 79% indicated that they use electronic IFR charts. Of those 54 responses, 57% indicated that the IFR charts available to them covered the entire U.S., and 30% indicated that their IFR chart subscription covers the local region only. The majority of participants that used electronic IFR charts had coverage of the entire contiguous U.S.

The type of device used to access electronic charts is another important factor. The participants were asked "What type of device do you use for electronic charts?" Figure 5 indicates that the Apple iPad was the most common device and was used by 62 of the 68 electronic chart users (91%). This data included multiple versions and sizes of the iPad. Other responses included the Nexus 7, the Samsung Galaxy Tablet, the Kindle Fire, and the iPhone, each with one response.

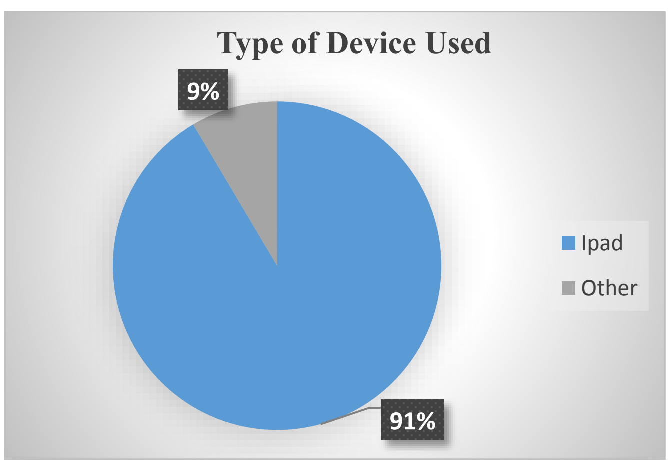

Figure 5. Types of Devices Used in the Cockpit for Electronic Charts

The size of the device is another factor to consider, as a small screen may fit better in the cockpit, but may require more work from the pilot to scroll across sectionals and/or IFR low enroute charts. The participants were asked "If it were acceptable to the FAA, would you be comfortable using your mobile phone to access essential navigation information?" Of the eighty-four participants, 60% of the responses indicated "yes," 13% replied "not sure," and 27% replied "no."

As far as the size of the device, the underlying issue is that of visibility and chart usage. Pilots are constantly trained on limitations. The limitations of electronic charts not only include the coverage areas but also the usability and dependability of the devices in flight. The participants that used electronic charts were asked "Have you ever had complications with accessing electronic charts in flight?" If the participant responded "yes", then that person was asked to provide details about the occurrence. Not all participants that answered "yes" provided details of the event.

Of the 68 applicable participants, 33% reported some type of complication while the charts in flight. The types of complications included overheating, lack of current or applicable charts, loss of 3G or 4G connectivity, battery failure, screen glare, and application crashes. An "other" option with an open response was provided, but zero participants indicated "other". This data is summarized in Table 4.

Table 4

Reported Complications of Electronic Chart Usage for Pilot Participants

Type of Failure	Number of Reported Complications
Overheating	6
Current/applicable chart not downloaded	3
Loss of 3G/4G service	2
Battery failure	2
Screen Glare	1
Application crash	1

As a pilot gains more experience, the total time using electronic charts could increase the chances that the pilot will have encountered a complication with the charts. With the total times and complication rates collected, the data indicates the chances of the participants experiencing these complications based upon total time. As shown in Figure 6, the more flight time a pilot has does in fact increase the chances of that pilot having complications with electronic charts. It is important to note that the amount of total flight time using electronic charts was not collected.

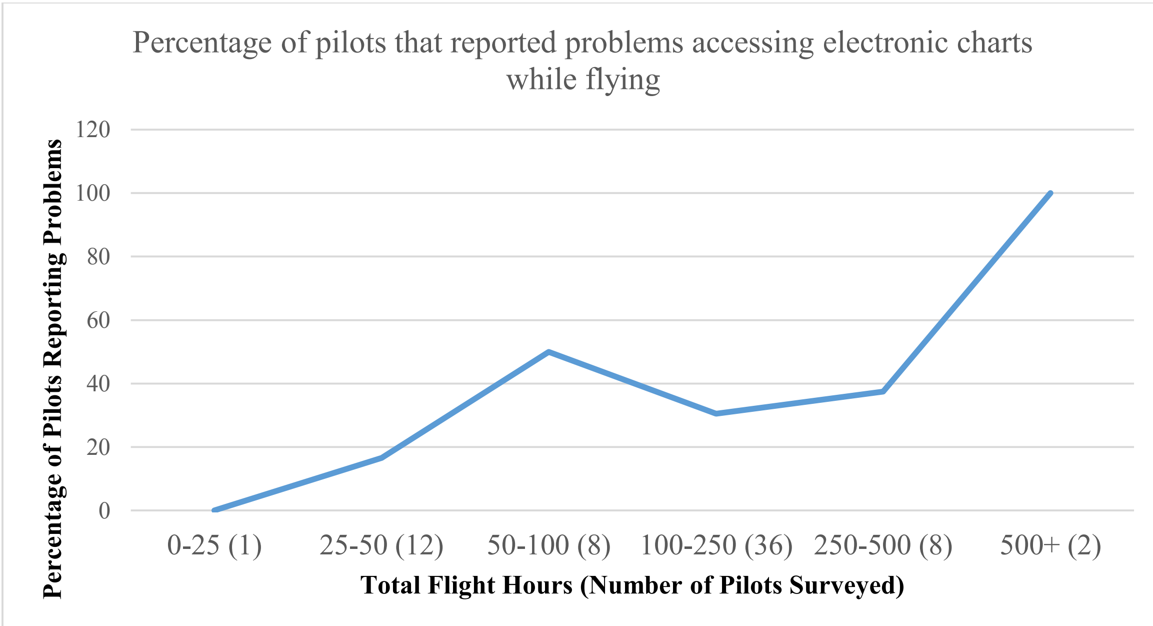

Figure 6. Percentage of Reports of Complications with Electronic Charts for Participants Based Upon Total Flight Time

Overheating of the devices was reported as the most common complication. The second most common complication was the lack of either a current chart or the applicable chart for a particular flight. Battery life and the loss of 3G/4G service in flight were equally reported for the third most common complication for accessing electronic charts while in flight.

Battery life for the device itself is critical when considering the usability of the device. As previously shown in Table 4, battery failure was a common complication of electronic charts. The participants that used electronic charts were asked "Do you have any way to charge your device during flight?" Of the applicable participants, 62% indicated "yes," 37% responded "no," and 1% responded "not sure," as indicated in Figure 7.

Due to the possibility of electronic chart complications and battery limitations, pilots should consider carrying backup charts. Redundancy is a common theme in aviation, from two magnetos to two engines and now to two charts. It is important to note that the following data was gathered from both pilots that fly with only electronic VFR charts as well as pilots that fly with electronic VFR and IFR charts.

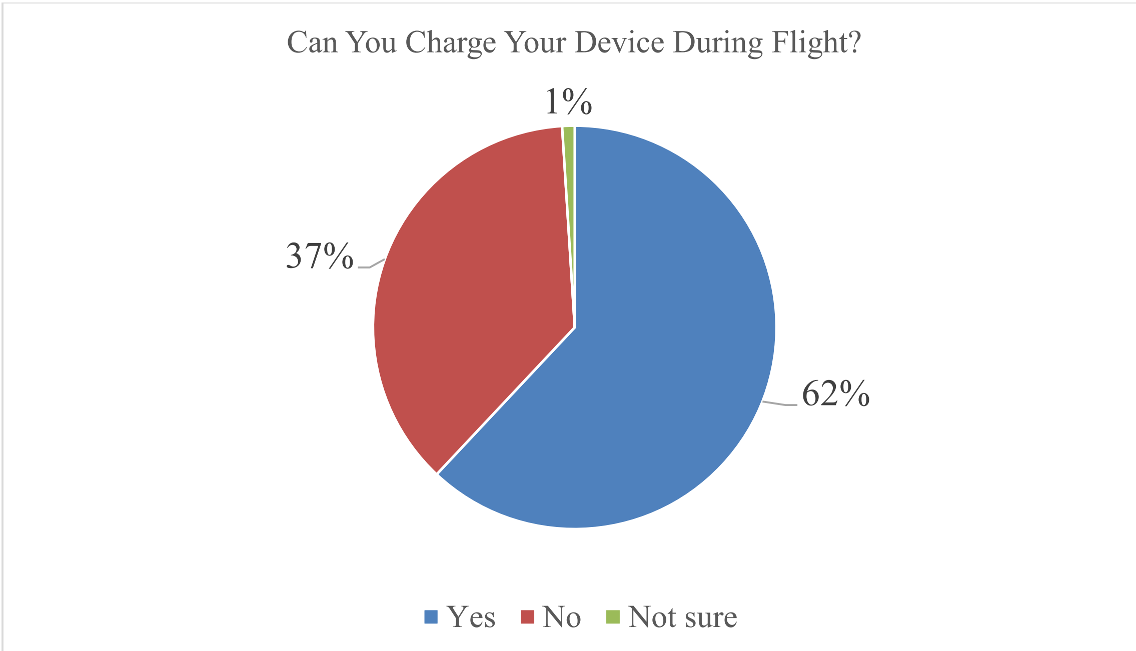

Figure 7. Device Charging Capability in Flight by Pilots Using Electronic Charts

Pilots that used electronic charts were asked if they fly with backup charts of some type. Information from the applicable participants indicated that 36% always carried backup charts, 47% sometimes carried backup charts, and 17% never carried backup charts. This data is presented in Figure 8.

After discovering how often backup charts were carried, the survey then asked if the backup charts were either paper or electronic. Data from the participants who used electronic charts indicated that 26% of these students carried paper backup charts. Electronic backup charts were more commonly used, as 68% percent of those pilots that carried backup charts were carrying electronic backup charts.

Not all of the participants used electronic charts. If the student did not use electronic charts the survey then instructed these participants to skip to the questions concerning why they did not and how they felt about the electronic charts. Only 19% of the survey participants indicated that they did not currently use electronic charts in the cockpit.

Pilots that used only paper charts were asked "Why don't you use electronic charts?" The options on the survey were (1) paper charts were thought to be less expensive, (2) the participant did not own a capable device, (3) the participant preferred paper charts, (4) the participant was concerned with losing or damaging a device, and (5) the participant's initial chart training was with paper charts. There was also an option for "other" but zero participants responded "other". Figure 9 summarizes the responses.

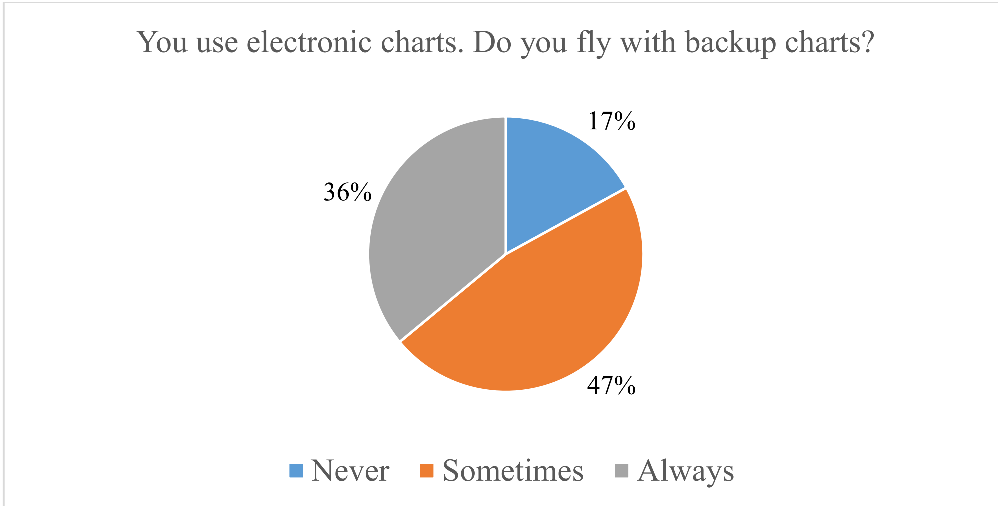

Figure 8. How Often Participants who Used Electronic Chart Carried Backup Charts

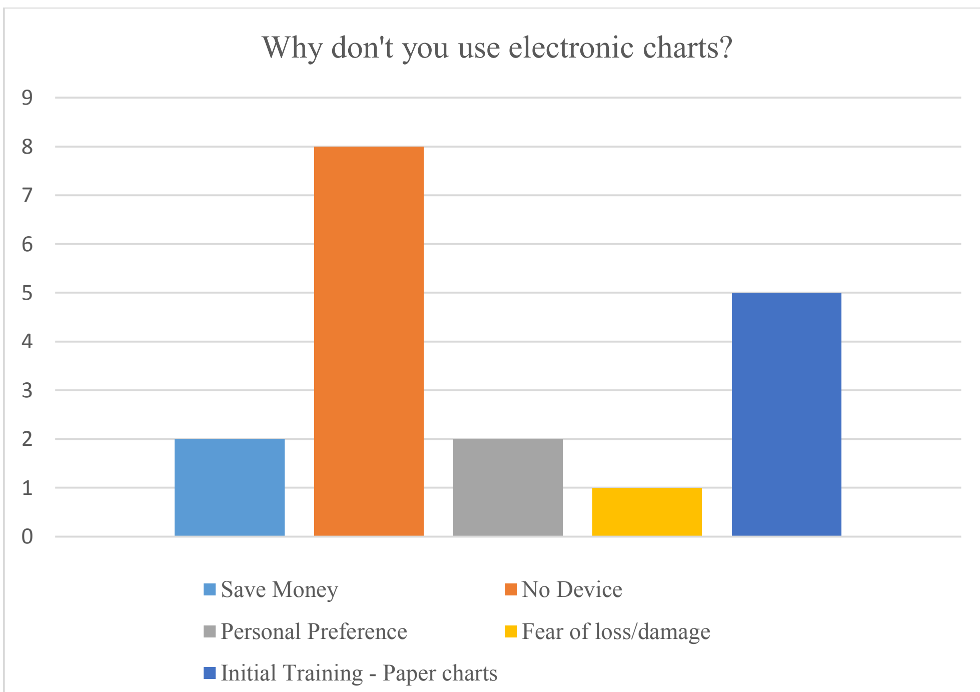

Figure 9. Reasons Why Some Surveyed Pilots Did Not Use Electronic Charts

The final question of the survey was an open ended question asking the participants' thoughts and concerns pertaining to the use of electronic charts in flight. All participants were asked to provide feedback, but not all participants answered the question. The most common concern was that of battery life and the pilot losing access to charts during flight.

This was reported by 15% of the participants. The second most common concern dealt with failure of either the application or the device (separate from battery failure). Failure of the device or application was also reported by 12% of the participants. The third most common concern dealt with the pilot desiring or needing some form of backup charts. Eight participants (10%) responded with this concern.

Participants also responded with their positive feedback on electronic charts. This data was gathered from all 84 participants, of which 21 of the total participants (25%) indicated that electronic charts were easier or more efficient than paper charts. Also, 15 participants (18%) indicated that electronic charts helped improve cockpit effectiveness and/or use less space in the cockpit. Six of the participants (7%) indicated that updating the charts was easier with electronic charts than it would be with paper charts.

Discussion

The participants for the survey were diverse in terms of pilot rating. Many of the participants (25%) were student pilots. Each rating from student pilot through multi-engine pilot had at least ten participants. This indicates that the majority of survey participants were pilots in training somewhere between student pilot and multi engine pilot.

Most of the participants (46%) had somewhere between 100 to 250 hours of total flight time logged. There were participants from each category from zero to 25 hours and participants with more than 500 hundred hours. This indicates that the survey collected data from pilots that are beginning training as well as pilots who are now providing training to others.

The majority of participants indicated that they believed that a pilot in training could save money by purchasing both a device and an electronic chart subscription as opposed to purchasing paper charts. To further investigate this issue, a simulation was developed to discover exactly how the cost of electronic charts compares to that of paper charts. If a pilot owns a capable device, the cost of the electronic charts is very competitive with the cost of paper charts.

Assuming that a student pilot (private student) progresses well and earns his or her private pilot rating within six months, that pilot would purchase paper charts including the items shown in Table 5 (Sportsman's Market, 2014). Regardless as to what type of charts a pilot uses, it is critical that the pilot maintain current air navigation charts for flying purposes. With the addition of electronic charts, it can now be determined what the costs are for these charts in the paper and electronic versions.

Table 5

Paper Chart Expenses for a Private Student Over a Six Month Period

Item	Cost
Sectional Charts (2)	$18.00
Plotter (1)	$6.00
AF/D (3)	$15.90
6 month total	$39.90

In a six month period, the average private student pilot will spend about $40 on charts, so a full year of current paper charts would cost nearly $80 plus any applicable shipping costs. For flight planning purposes with paper charts, the student would need to buy a VFR navigation plotter.

ForeFlight subscriptions cover all of the data these paper charts do, last for one year, and the standard version costs $75 (ForeFlight Mobile, 2014). Thus, the effective cost of the VFR electronic charts is nearly identical to the cost of VFR paper charts, assuming that the pilot has access to or owns an electronic device capable of using a current version of the electronic chart software.

Only 10% of the pilots that participated thought that electronic charts would be cheaper than paper charts even if a device was included in the cost. Pilot students are subject to buying numerous charts and other equipment, and the cost of charts can add an additional economic burden for pilots in training. In order to use electronic charts, a pilot must first have access or own a device on which to view the charts. These can get expensive, and as a new student pilot it can be intimidating to consider purchasing both a device and an electronic chart subscription. Current versions of the iPad start at $499 (Apple, 2014). The age of the device becomes an issue as well because software updates may require certain capabilities of your device and if the device ages, it may have software problems or be incapable of running the software. For example, the latest version of ForeFlight Mobile requires Apple iOs7, which cannot be operated by the original Apple Ipads (ForeFlight, 2014).

The vast majority of participants (95%) had used “a tablet computer or similar touch screen device” at least once before in their lifetimes. Touch screen devices have spread from personal cellular phone use to buying groceries on a daily basis. The ability to use these devices and understand the limitations of these devices should be included in current pilot training.

Most of the pilots indicated that they expected to use electronic charts during their professional flying career. Many of the pilot students at universities will go on to work for the regional and/or major airlines. However, not all pilots intend to work as airline pilots.

This could indicate why some students did not expect to use electronic charts in their professional flying career.

The majority of pilots surveyed used electronic charts. This was evident even at the "student pilot" level, indicating that some student pilots' first experience of planning true course, wind correction angles, ground speeds, and magnetic variation were all being supplied automatically by the software, as opposed to be interpreted accurately by the pilot using paper charts, a plotter and an E6B. This information brings up a critical point that aviation educators and flight instructors must now consider: should electronic charts be used for primary (original) flight planning education/training? More research is suggested in this area.

As a pilot's flight time increases, the survey indicates that the use of electronic charts is more common. This may be linked to the fact that a number of the private students are using paper charts and then transitioning to electronic charts during instrument training. Accessing and organizing instrument approach plates with a tablet computer was reported to be much easier than accessing the charts on paper.

Ninety-four percent of electronic chart users used the ForeFlight Mobile software. ForeFlight is a common provider and the standard subscription covers all of the data a pilot would otherwise have with a paper sectional chart and the paper airport/facility directory publication. The standard subscription to ForeFlight includes electronic FAA VFR sectionals, DOD/FAA terminal procedures, Airport/Facility Directory (A/FD) information, and IFR enroute charts. The software or application can work on a smart phone or a tablet computer and provides charts in the FAA/ NOAA format.

The effective date of navigation charts is always a concern to pilots. Current charts must be on board the aircraft to satisfy FAR 91.103: Preflight Action. The Federal Aviation Regulation requires that the pilot must be familiar with "For any flight, runway lengths at airports of intended use" (FAA, 2014). Historically pilots have had to purchase new paper charts as the charts are updated and check NOTAMs for changes to the information and/or procedures. Software such as ForeFlight mobile streamlines this process and updates the charts at the push of a button.

There may come a day when the FAA is distributing electronic navigation charts directly to the pilots without any outside commercial delivery. If the FAA were to offer electronic chart subscriptions directly to the pilots, then in theory the software subscription would become more affordable to the user. The survey participants were mixed in their opinions as to whether they would use FAA electronic charts as opposed to their current chart provider.

Participants were asked about using electronic charts for VFR and IFR purposes. The majority of the students which used VFR charts also used electronic charts for IFR purposes. Due to the common use of ForeFlight mobile for the participants surveyed, the majority of the participants had access to VFR and IFR charts for the entire contiguous U.S. area. The pilots using these charts must be familiar with the coverage areas and the currency of each coverage area on their devices as required by FAR 91.103.

As indicated on Figure 5, the majority of students (91%) using electronic charts were using some type of Apple iPad device to access chart information. The Apple iPad is a common device used by airline pilots as well. Jet Blue Airways has been operating with electronic charts since they began flying in 1998, but recently has transitioned to the use of the Apple iPad (Moorman, 2013). The research data included iPads of all types, including the iPad Mini which has a smaller screen than other iPads.

Most of these devices are not nearly as large as a VFR sectional chart, but are close to the size of a typical instrument terminal procedure or approach. The software allows for the pilot to zoom in and out of enroute charts and sectionals, but this task becomes more difficult with a smaller screen. The survey respondents were mixed in their opinions and comfort level of using a small device such as a smart phone to access critical chart information. Most smart phone screens are smaller than tablet screens and would thus be more difficult to use in the cockpit. The essential question is "Can the pilot view and interpret data by the device?" The FAA does not currently have a policy/regulation on the size of device, and for now it seems that this issue is up for individual FAA inspector scrutiny.

If a pilot is going to use a tablet computer or any electronic device to access critical navigation information, that person must be aware of the limitations of that device. Overheating of the devices was the most common complication reported. Pilots should be careful to store these devices in cool areas and to verify that when not in use, the device is in fact in "sleep mode" or shut down and consuming as little battery as possible.

Pilots should consider the battery life of the unit and how long it would last during a flight in addition to the currency and coverage area of the chart subscription. If the device is connected to a 3G/4G wireless connection and is constantly providing "geo-referenced" data (position information) during flight, the battery will drain faster. However, if the pilot is simply using the device to look at static information such as a saved approach plate, the battery would then last longer. The use of the device heavily influences the battery life. Additional research is suggested in this area.

Pilots using electronic charts must know how to conserve battery power. For example, if a pilot were to reference a chart half way through a three hour flight and then set the device down, the device may still be providing data while not being used. Once at the destination, the pilot could pick up the device only to find out that the battery has drained completely, creating a potentially serious scenario.

If a Private Pilot was flying on a VFR day and lost his/her electronic VFR charts while cruising in a sparsely populated area, that pilot could probably manage to get the aircraft on the ground safely. But if it were an IMC day and an IFR pilot flying in actual instrument conditions, planning to use the device for the approach at the destination, a device failure could cause a serious scenario. Hopefully the pilot would have checked during preflight to see if the destination airport had PAR or ASR capabilities to allow for a safe IFR approach and landing.

The pilots that used electronic devices were asked if they had any way of charging that device in flight. With this question, two things must be considered: (1) an aircraft with a suitable electrical outlet could charge the device for the entire flight as long as the aircraft electrical system is operating normally, and (2) external battery packs which could provide a charge in case of an emergency, and are adequately charged prior to each flight. There were 68 pilots surveyed that used electronic charts surveyed. The majority of the participants (63%) had some way of charging the device during flight. Less than half of the participants (37%) did not have any way to charge the device during flight. Not all aircraft are exactly alike, so in some cases the pilot could charge his or her device in one specific aircraft but not another. It is essential that the pilot knows if he or she can charge the device during flight. If not, the pilot should be sure that at the beginning of the flight the device has plenty of battery power for the time frame needed.

The total time of the pilots and an observation of those times with the complication rate revealed that higher total times correlated with higher failure rates. It is important to note that the pilots were not asked exactly how much of their total flight time was logged while using electronic charts. For example, a pilot in the 250 to 500 hour range could have recently switched to electronic charts and logged more than 240 hours using paper charts. Overheating of the device was the most common factor for electronic chart complications. This is understandable as most small piston powered aircraft used for training do not have air conditioning, and the cockpit is subject to plenty of heat and direct sunlight. When the device overheats, it simply shuts down.

The second highest reported electronic chart complication involved the pilot not having access to a current or applicable chart. Coverage areas must be understood by a pilot operating with electronic charts. If a pilot plans to fly to a particular airport or area, it is the pilot's responsibility to make sure the correct and current charts are on board.

The survey results indicated that 68% of pilots using electronic charts in the cockpit reported that they carry backup charts that were also electronic charts. If an iPhone has the same software installed as the device used then it could be suitable as a backup chart and this could indicated why so many pilots stated that they have electronic back up charts. As indicated in the results section, many of the participants were not comfortable using mobile phones to access essential navigation information. However, in the case that the primary device fails, the survey results indicate that these pilots would use a mobile phone if necessary as a backup source for electronic charts.

There are many reasons as to why a pilot may or may not use electronic charts. The results of this survey indicated that eight of the 16 applicable participants (50%) did not use electronic charts did not because they did not own a capable personal device. These students continue to require training and education on paper charts. Initial training using paper charts was indicated as a common reason why pilots did not use electronic charts. One participant indicated that his/her flight instructor did not allow the use of electronic charts prior to earning the private pilot rating. Individual flight instructors may choose to train their students as they see fit.

Conclusion and Recommendations for Further Research

This research indicates that the majority of pilots currently in training are using electronic charts. The charts are being used for many purposes at all levels of training. More specifically, the devices and software being used have only small variations. Specific limitations were identified as well. Educators and pilots should be aware of these limitations prior to using electronic charts in the classroom or in flight.

It is likely that many pilot students (at universities and otherwise) are not receiving adequate instruction on the software they are using. This research identified common devices and software used at this particular university. Training is required in a number of topic areas for certain pilot certificates, and electronic chart software must also be completely understood by the pilots in training. An organized approach to implementing integrating electronic charts into the curriculum is highly recommended. This should allow for individual UAA institutions to develop preferred software and devices as necessary.

Additional research is suggested in many areas including (1) connectivity to 3G/4G service while flying, (2) acquisition of current weather data during flight, (3) compass deviation caused by the devices, (4) affordability of IFR electronic charts versus IFR paper charts with numerous providers, and (5) battery life depending on the type of usage. Another research question should be addressed: will current students benefit from using electronic charts during university training when they have a high chance of seeing electronic charts in their professional flying careers?

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Specialized Aviation Flight Accreditation under Public Law 111-216: Aviation Program Administrators' Perceptions

Cody Christensen
South Dakota State University

Karen A. Card
University of South Dakota

Abstract

Under Public Law 111-216, program integrity and quality assurance of collegiate aviation programs were questioned (Airline Safety and Federal Aviation Administration Extension Act of 2010, 2012). The goal of this study was to update the field of specialized aviation accreditation in the new environment of the Airline Safety and Federal Aviation Administration Extension Act of 2010 and outcomes-based accreditation (Aviation Accreditation Board International, 2013). This is in response to the Sherman (2006) and Prather (2007) studies on why so few of the schools offering aviation-related curricula leading to an associate's or bachelor's degree seek specialized accreditation. The purpose of this study was to determine if aviation administrators perceive AABI outcomes as important and how effectively their programs prepared aviation graduates with competences in the accreditation outcomes. Additionally, this study addresses the level of academic studies that program administrators feel can substitute for flight time as outlined in the Notice of Proposed Rulemaking on Public Law 111-216. Administrators perceived AABI Core Outcomes—*aircraft characteristics* as well as *meteorology and environmental issues*—to be important and that their program was effectively teaching these competences. Administrators generally agreed that five hundred hours was an appropriate amount of time to credit a graduate of a four-year aviation program seeking a Reduced Airline Transport Pilot certificate, regardless of AABI accreditation status, which is the maximum time reduction for collegiate aviation students under the Reduced Airline Transport Pilot criteria published in 2013.

Introduction

The Airline Safety and Federal Aviation Administration Extension Act of 2010, a legislative mandate in response to the 2009 crash of Colgan Air Flight 3407, made a dramatic change in the job outlook of students in collegiate aviation. The Act essentially increased the flight time required to fly as a required crewmember in an airline environment from 250 hours to 1,500 hours. Also impacting collegiate aviation are the changes to specialized aviation accreditation that have taken place. In the last 10 years, the Aviation Accreditation Board International changed the accreditation criteria to outcomes-based accreditation. As a result of the FAA Extension Act of 2010 and outcomes-based accreditation, this study was conducted to identify what program administrators of collegiate aviation programs perceived as the impact of the Extension Act and accreditation on their programs. For this study, program administrators are defined as individuals who directly manage an aviation unit, including program chairs, department heads, program leaders, and supervisors.

Both the pilot training portion of the FAA Extension Act of 2010 and Aviation Accreditation Board International (2013) specialized accreditation essentially serve the same purpose—to produce highly competent aviation professionals. This study was limited to data collected in early 2013, after the enactment of the FAA Extension Act of 2010, which required all airline pilots to possess an Airline Transport Pilot certificate, but before the final ruling from the FAA in Advisory Circular 61.139 (2013). This study concluded before the FAA Administrator's provision, the Airline Transport Pilot Certification Training Program (2013), which allowed a reduction in total flight hours required for an ATP certificate.

One of the steps the FAA requires as part of the Reduced Airline Transport Certification process is to demonstrate completion of approved coursework in an approved higher education curriculum. Essentially, the FAA is determining that coursework completed by students pursuing the ATP can be used in lieu of some of the flight time requirement. On the other hand, AABI accreditation requires that graduates of accredited programs demonstrate proficiency in knowledge, skills, and attitudes before they can graduate.

The first purpose of this study was to determine aviation administrators' perception of outcomes in preparing professional pilots and the extent to which their programs effectively achieve the Aviation Accreditation Board International standards. Additionally, this study determined aviation program directors' perceptions regarding the level of academic studies that can substitute for flight time as outlined in the Notice of Proposed Rule Making (NPRM) on Public Law 111-216. Lastly, this study determined the extent to which the new Airline Safety and Federal Aviation Administration Extension Act of 2010 influenced administrators' decisions to seek specialized aviation accreditation.

Review of Relevant Literature and Research

While studies exist on specialized accreditation, only two authors—Sherman (2006) and Prather (2007) — specifically looked at the programs' willingness to participate in or barriers to aviation accreditation from a faculty standpoint. This study mirrored Prather's (2007) study with implication of AABI accreditation since the inception of Public Law 111-216 and before the final ruling from the FAA regarding the Reduced Airline Transport Pilot minimums guidance provided in Advisory Curricular 61.139 (2013). Another purpose of this study was to further the knowledge base on specialized aviation accreditation since Radigan's (2011) study on students' perceptions of aviation accreditation. This study looked at the individual outcomes of AABI and how aviation administrations perceived what standards are important and how effectively their program prepared aviation graduates with competences in the accreditation outcomes.

Sherman (2006) wanted to find answers to why faculty and administrators sought accreditation, time required for the accreditation process, and the use of human resources to complete the self-study. In his qualitative study, he surveyed faculty and administrators of aviation programs belonging to the University Aviation Association and by using the 2006 AOPA collegiate flight training issue.

From his research, Sherman concluded that current AABI accredited programs believe in AABI accreditation and have many reasons for their belief, including enhancing the quality of programs, prestige, and benefits of the external review process. His findings regarding why non-AABI accredited programs did not seek accreditation included lack of awareness among industry and students, the expense and time involved with the accreditation process, and the fact that many programs felt the standards only applied to larger programs.

Prather (2007) conducted research regarding why so few aviation programs sought accreditation through AABI and its precursor, the Council on Aviation Accreditation (CAA). Prather reported from the survey results that 65% of current non-AABI accredited aviation programs plan to seek accreditation in the future. He also found that the primary reason for not seeking accreditation included the time/expense/effort versus benefits of being accredited. Additionally, non-AABI accredited programs chose not to accredit because they had a similar accreditation already, lacked awareness of AABI, and, most interestingly, some programs felt they did not need to accredit their programs because their graduates were currently successful (Prather, 2006). He also pointed out that by maintaining accreditation, programs benefit from the rigors of an externally reviewed self-study process.

Radigan (2011) addressed specific questions regarding students' perceptions of quality in collegiate aviation based on accredited versus non-accredited programs. This research indicated that students of accredited programs perceive their education as being of higher quality than that of non-AABI accredited schools. She also observed, based on her findings, that "student perceptions of quality for curriculum and facilities and equipment are significantly higher in accredited programs" (p. 120).

As noted by the Council for Higher Education Accreditation (CHEA), in order to receive federal financial aid, all universities must be regionally accredited (Council for Higher Education Accreditation, 2002; Eaton & Council for Higher Education Accreditation, 2006). Aviation programs can either be regionally accredited through a CHEA organization or program accredited by an accreditation agency such as AABI, or both. Those flight programs that are AABI (2013) accredited adhere to an outcomes-based accreditation using the following outcomes:

AABI General Outcomes:

a. An ability to apply knowledge of mathematics, science, and applied sciences
b. An ability to analyze and interpret data
c. An ability to function on multi-disciplinary teams
d. An understanding of professional and ethical responsibility
e. An ability to communicate effectively, including both written and verbal communication skills
f. A recognition of the need for, and an ability to engage in, life-long learning
g. A knowledge of contemporary issues
h. An ability to use the techniques, skills, and modern technology necessary for professional practice
i. An understanding of the national and international aviation environment
j. An ability to apply pertinent knowledge in identifying and solving problems
k. An ability to apply knowledge of business sustainability to aviation issues

AABI Core Outcomes:

1. Attributes of an aviation professional, career planning, and certification
2. Aircraft design, performance, operating characteristics, and maintenance
3. Aviation safety and human factors
4. National and international aviation law and regulations
5. Airports, airspace, and air traffic control
6. Meteorology and environmental issues

Most aviation programs are currently part of a postsecondary educational institution that does meet the U.S. Department of Education's (2013) definition of an accredited institution which is the "recognition that an institution maintains standards requisite for its graduates to gain admission to other reputable institutions of higher learning or to achieve credentials for professional practice" (p. 1). Additionally that means under the proposed rule, a graduate of an accredited four-year post-secondary school who received a bachelor's degree in an aviation-related field and a commercial pilot certificate with an instrument rating from an affiliated Part 141 pilot school would be allowed to apply for the ATP practical test with 1,000 hours total time as a pilot, versus the current requirements of 1,500 total hours (Federal Aviation Administration, 2013).

The timing of this study creates relevance for the topic. Aviation accreditation has never been directly tied to training outcomes that explicitly help or hinder students. The NPRM on Public Law 111-216, in part, provides an incentive to students pursuing a career with the airlines by decreasing the amount of flight time required to qualify to fly in the United States airline environment if they graduated from an accredited institution. The Prather (2007), Sherman (2006), and Radigan (2011) studies took place before the requirements of

Public Law 111-216 were created. After this study was completed, Depperschmidt (2013) studied the impact of Public Law 111-216 on collegiate aviation and concluded the majority of flight programs have concerns with the new law and its impact on pilots pursuing airline careers in the United States.

Limitations

This study was delimited to collegiate aviation administrators' perceptions of specialized aviation accreditation across different factors and did not necessarily represent all of the aviation training sectors and cannot be generalized to those that did not participate in the study. The variables chosen to examine were limited to focus the scope of the study to factors of accreditation and Public Law 111-216. The perceptions and results are delimited to early 2013 while the NPRM on Public Law 111-216 was still in effect and before publication of Advisory Circular 61-139 (2013) which specifically addresses the reduced flight time requirement. Another limitation is that the aviation administrators' locations, missions, and sizes create unique environments. Therefore, the standards and perceptions being studied may not be applicable to the same magnitude at each institution, as many aviation flight programs are not accredited. It was important to also include their perceptions in this study because administrators who have not been through one or more accreditation cycles might not have the same insight into AABI Outcomes versus administrators who have been through the full accreditation process. This could limit the administrators' perception as to how qualified they are to measure their effectiveness at meeting each AABI Outcome.

Methodology

This study was designed to determine aviation program administrators' perceptions of specialized aviation accreditation regarding flight programs under Public Law 111-216. A quantitative methodology was used in this study to guide the following research questions:

1. What relationship exists between aviation administrators' perceptions of the importance of the AABI outcomes and how effective they perceive their programs are in preparing pilot candidates to achieve those standards?
2. To what extent do aviation flight program administrators perceive academic studies can substitute for flight time, as outlined in the NPRM on Public Law 111-216?
3. To what extent has the new the Airline Safety and Federal Aviation Administration Extension Act of 2010 influenced the program administrators' decision to seek specialized aviation accreditation?

Population

The population consisted of program administrators of baccalaureate degree-granting aviation programs in the United States and territories. The list was compiled from the Airplane Owners and Pilots Association annual college guide (2012) and cross-listed with the University Aviation Association (2012) database on collegiate aviation programs. In total, 82 aviation program administrators were selected as the population from universities and colleges offering training toward bachelor degrees. In January and February 2013 a survey and follow-up survey were electronically distributed to the population, with 34 program administrators completing the survey (response rate of 41.5%).

Research Instrument

Participants completed a 45-item survey that was developed by the researcher based on the work from Prather (2007), Sherman (2006), and the AABI accreditation general and core outcomes (AABI, 2013). The items included perceptions of the importance and effectiveness of the AABI accreditation outcomes (2013), perceptions on accreditation, and the Airline Safety and Federal Aviation Administration Extension Act of 2010, as well as demographic questions such as program size, accreditation status, and number of faculty. The items were answered by selection of Likert scale, multi-point scales, and one user response box. Descriptive statistics, such as means, percentages, standard deviations, Pearson correlations, and frequencies, were calculated for the variables.

To determine internal consistency, Cronbach's α, a coefficient of internal reliability, was applied to the Likert-scale questions (Cronk, 2010). According to Cronk (2010) reliability coefficients close to 1.00 are very good and coefficients close to 0.00 represent low internal reliability. Using SPSS version 22, an α of .947 resulted, indicating a high level of internal reliability.

Results

The respondents in this study consisted of 34 program administrators from four-year institutions that have an aviation flight program leading to a baccalaureate degree. The program administrators answered demographic questions about their aviation program, including the accreditation status and institutional size, measured both in number of students and of staff. The accreditation status breakdown of the study respondents' programs were 18 (52.9%) accredited or in candidate status by AABI, and 16 (47.1%) not accredited by AABI.

Institutional size was another piece of information collected. There were 15 (44.1%) responses from institutions with fewer than 100 students, 13 (38.2%) responses from institutions with 101-400 students, four (11.8%) responses from institutions with 401-1000 students, and two (5.9%) responses from institutions with 1,001 or more students.

In terms of full-time equivalent (FTE) aviation faculty at each institution, six (17.7%) indicated they had greater than 15 faculty, three (8.8%) indicated they had between 9-15 faculty, four (11.8%) indicated they had between 5-8 faculty, and 21 (61.8%) indicated they had four or fewer FTE faculty on staff at their institution, as shown in Table 1.

Table 1

Demographic of Participants (n = 34*)*

Characteristics	Frequency	Valid Percent
Accreditation Status		
Accredited/candidate status	**18**	**52.9**
Non-accredited status	16	47.1
Number of Aviation Students at Institution		
< 100	**15**	**44.1**
101 – 400	13	38.2
401 – 1000	4	11.8
> 1000	2	5.9
Number of Aviation Faculty at Institution		
1 – 4 FTE	**21**	**61.8**
5 – 8 FTE	4	11.8
9 – 15 FTE	3	8.8
> 15 FTE	6	17.7

Note. Largest groups are bolded.

Overall, aviation program administrators who participated in the survey cited each AABI General and Core Outcome as important to very important. *Making professional and ethical decisions* (*M* = 4.79, *SD* = 0.54) was the highest AABI General Outcome and *aviation safety and human factors* (*M* = 4.58, *SD* = 0.56) was the highest AABI Core Outcome. Aviation program administrators cited each of their programs as effective in meeting all AABI General and Core Outcomes. *Making professional and ethical decisions* was noted as the most effective general outcome (*M* = 4.09, *SD* = 1.13). Program administrators deemed the core outcome on the *attributes of an aviation professional, career planning, and certification* (*M* = 4.26, *SD* = 0.93) as the most effective outcome.

In order to test the relationship between variables, bivariate correlation was used. According to Cronk (2010) "correlations with an absolute value greater than 0.7 are considered strong. Correlations with an absolute value less than 0.3 are considered weak. Correlations with an absolute value between 0.3 and 0.7 are considered moderate" (p. 42).

There were no significant strong relationships between administrators' perceptions of the AABI General Outcomes they viewed as important and how effective they perceived their programs were in preparing aviation graduates to achieve those outcomes. However, there were eight significant moderate positive relationships between aviation program administrators' perceptions of the AABI General Outcomes viewed as important and how effective they perceived their programs were in preparing aviation graduates to achieve those outcomes. The full results for the Pearson correlation coefficient for AABI General Outcomes are illustrated in Table 2.

A significant strong positive relationship was found for how important and effective program administrators feel their programs are for AABI Core Outcomes on *aircraft characteristics*, r (31) = .721, p = .000 and *meteorology and environmental issues*, r (31) = .718, p = .000 as indicated in Table 3. All of the core outcomes results had moderate significant correlations and eight of the 11 AABI General Outcomes demonstrated a positive moderate correlation between perceived importance and effectiveness at meeting those two outcomes (Table 2).

Academic Substitution

The second research question probed to what extent aviation program administrators perceive that academic studies can substitute for flight time, as outlined in the NPRM on Public Law 111-216. Aviation program administrators were split on whether academic classroom time can be substituted for flight time for those students pursuing an Airline Transport Pilot certificate. As demonstrated in Table 3, of the respondents (M = 3.35, SD = 1.25), half agreed to strongly agreed (50.0%, n = 17) that classroom time can substitute for flight time. Eight (23.5%) participants were neutral on the subject.

Table 2

Pearson Correlation for Importance and Effectiveness of AABI General Outcomes

Characteristics of AABI General Outcomes	*MI*	*ME*	*r*	r^2	*p*
Apply knowledge of business sustainability to aviation issues (K)	3.71	3.33	0.565	0.319	.001
Use the techniques, skills, and modern technology necessary for professional practice (H)	4.44	4.06	0.524	0.275	.002
Engage in and recognize of the need for life-long learning (F)	4.09	3.52	0.499	0.249	.003
Assess the national and international aviation environment (I)	3.79	3.34	0.493	0.243	.004
Make professional and ethical decisions (D)	4.79	4.09	0.439	0.193	.011
Communicate effectively, using both written and oral communication skills (E)	4.65	3.85	0.413	0.171	.017
Assess contemporary issue (G)	3.88	3.56	0.391	0.153	.027
Analyze and interpret data (B)	4.41	3.73	0.346	0.120	.049
Apply knowledge of mathematics, science, and applied sciences (A)	4.38	3.94	0.317	0.100	.072
Work effectively on multi-disciplinary and diverse teams (C)	4.38	3.88	0.270	0.073	.129
Apply pertinent knowledge in identifying and solving problems (J)	4.59	3.97	0.217	0.047	.226
Characteristics of AABI Core Outcomes	*MI*	*ME*	*r*	r^2	*p*
Aircraft design, performance, operating characteristics, and maintenance (2)	3.55	3.53	0.721	0.520	.000
Meteorology and environmental issues (6)	4.00	3.85	0.718	0.516	.000
National and international aviation law, regulations, and labor issues (4)	3.67	3.59	0.698	0.487	.000
Airports, airspace, and air traffic control (5)	4.18	4.18	0.646	0.417	.000
Attributes of an aviation professional, career planning, and certification (1)	4.48	4.26	0.594	0.353	.000
Aviation safety and human factors (3)	4.58	4.24	0.457	0.209	.008

Note. MI = Importance ME = Effective *p* = Pearson Correlation

Table 3

Classroom Time Substituting for Flight Time and Extension Act Influence on Seeking Accreditation

Likert-Scale Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	M (SD)
Classroom time can substitute for flight time for students pursuing the Airline Transport Pilot Rating (n = 34)	3 (8.8%)	6 (17.6%)	8 (23.5%)	10 (29.4%)	7 (20.6%)	3.35 (*1.25*)
Influence of the Airline Safety and Federal Aviation Administration Extension Act of 2010 on Seeking AABI accreditation (n = 33)	10 (30.3%)	6 (18.2%)	11 (33.3%)	3 (9.1%)	3 (9.1%)	2.48 *(1.28)*
Influence of the Airline Safety and Federal Aviation Administration Extension Act of 2010 on Seeking any accreditation (n = 34)	10 (29.4%)	7 (20.6%)	10 (29.4%)	5 (14.7%)	2 (5.9%)	2.47 *(1.24)*

A follow-up question was asked to determine how many flight hours would be appropriate to substitute classroom time for flight time for students pursuing the ATP certificate. As displayed in Table 4, of the 32 responses (*M* = 2.41, *SD* = 0.91), 46.9% believe between 1-500 hours is the appropriate amount of time, followed by 31.3% who believe 501-750 hours is an appropriate amount to count as flight time under the new regulations.

Table 4

Specific Hours of Classroom Time Substituting for Flight Time for Students Pursuing an ATP

	Response Number	Valid Percent
Zero hours	4	12.5
1–500 hours	15	46.9
501–750 hours	10	31.3
751–1000 hours	2	6.3
>1000 hours	1	3.1
Mean	32	2.41
Standard Deviation		0.91

Decision to Seek Accreditation

The third research question asked if the Airline Safety and Federal Aviation Administration Extension Act of 2010 influenced administrators' decisions to seek accreditation. Two questions on the survey presented participants with opportunity to voice their opinions as to how strongly they felt the Airline Safety and Federal Aviation Administration Extension Act of 2010 influenced their decision to seek accreditation. Participants were most often neutral (*M* = 2.48*, SD* = 1.28), followed by disagreeing as to whether the Airline Safety and Federal Aviation Administration Extension Act of 2010 influenced their decision to seek AABI specialized accreditation as noted in Table 5. The second question revealed that many (*M* = 2.47*, SD* = 1.24) of the participants did not feel that the Airline Safety and Federal Aviation Administration Extension Act of 2010 had any influence on their decision to seek any accreditation as shown in Table 3.

Discussion

Utilizing the population of just aviation program administrators, AABI General and Core Outcomes appear to be important objectives, and collegiate aviation programs should work to incorporate those outcomes into their curricula. The results of this study seem to indicate that regardless of specialized accreditation status, programs utilizing demonstrated outcomes contribute to producing highly competent aviation professionals, which is different than course content inputs that the FAA is certifying as part of the Institution of Higher Education's Application for Authority to Certify its Graduates for an Airline Transport Pilot Certificate with Reduced Aeronautical Experience 61.139 (2013). Program administrators perceive that graduates of four-year collegiate aviation programs meet most of the AABI Outcomes whether they were AABI accredited or not AABI accredited. This could signify that specialized aviation accreditation status may not be needed as an indicator of quality of a program or, more likely, that administers of non-accredited programs are unaware of the benefits provided through the full AABI accreditation cycle. Again, this study was looking at administers' perspectives on accreditation and did not take into account the rigorous process that ensures that programs meet AABI outcomes.

Making professional and ethical decisions and *aviation safety and human factors* were the highest cited AABI General and Core Outcomes, respectively. Since the enactment of the FAA Extension Act of 2010 and the Colgan accident in 2009, ethics in aviation and especially professionalism have taken center stage. This is indicated by program administrators citing *decision-making skills and aviation safety and human factors* as the most important AABI requirements.

Program administrators were also asked about how effective their specific program was at meeting each AABI General and Core Outcomes. Through this process each administrator answered that they perceived their programs were effective at meeting each AABI outcome. Previous studies have indicated that some program outcomes were not aligned with AABI outcomes and cited other factors for not seeking accreditation, such as financial resources, as a barrier to AABI accreditation (Prather, 2007; Sherman, 2006). It is important for program administrators and all stakeholders of both AABI accredited and non-accredited aviation programs to graduate high-quality aviation professionals.

While this study did not examine barriers to accreditation, it appears that the majority of the programs, both accredited and non-accredited, are perceived by their program administrators as effectively meeting AABI criteria and that they believe that AABI criteria are important for graduates of their programs. If program administrators of non-accredited program perceive that their program meets AABI General and Core Outcomes then these programs should go through the accreditation process for the benefit of their students and the profession. This indicates a paradigm shift in outcomes as not being a barrier to accreditation as they once were under the standards-based accreditation system of the past, as noted by Sherman (2006) and Prather (2007). This is different than the current guidelines set forth by the FAA in Advisory Circular 61.139 (2013) which states that "a graduate complete a specific number of credit hours in aviation coursework that has been recognized by the FAA as coursework designed to improve and enhance the knowledge and skills of a person seeking a career as a professional pilot," (p. 6). Because it appears that the FAA standards are being met, program leaders should reevaluate AABI accreditation as a way to provide external validation of their programs' quality to prospective students and governing boards should use AABI accreditation status as another means to verify that graduates are prepared as professional pilots.

Program administrators believe it is appropriate to substitute academic hours for minimum flight time requirements for students pursuing the Airline Transport Pilot certificate. From the study's results it is apparent that administrators of aviation programs feel that classroom time gathered in a collegiate aviation program can be substituted for flight time, which falls in line with the recommendation outlined in the NPRM on Public Law 111-216 (2010) and 14 CFR 61.160 aeronautical experience-airplane category restricted privileges (Federal Aviation Administration, 2013). The respondents disagreed that only graduates of AABI accredited programs should receive a decrease in flight time, and the FAA requirements are in keeping with that position in allowing all accredited schools, not just AABI accredited schools, to participate in the reduction of flight time.

When administrators were asked how much classroom time can substitute for flight time, the majority agreed or strongly agreed (61.8%) with the question asked that 500 hours is an appropriate reduction in flight time for graduates of four-year aviation programs. Interestingly, almost half of the administrators (46.9%, $n = 32$) surveyed cited that between 1-500 hours is the appropriate amount of time to substitute while almost one third (31.3%, $n = 32$) felt that between 501–750 hours was an appropriate amount of classroom time to substitute for flight time. After the data were collected, the FAA specified in 14 CFR 61.160 (2013) that 500 hours was the maximum amount of reduction for graduates of approved curriculum associated with Bachelor degree granting institutions, and issued a letter of authorization for the reduction in flight time. As this survey data was collected before the final ruling of 14 CFR 61.160, the researcher limited participants' choices, which did influence how respondents could answer the question. Additional information is needed to determine if the 500-hour reduction in flight time is perceived as the proper amount.

Lastly, this study determined the extent to which the Airline Safety and Federal Aviation Administration Extension Act of 2010 influenced administrators' decisions to seek specialized aviation accreditation. Program administrators were neutral as to whether the Airline Safety and Federal Aviation Administration Act of 2010 influenced a decision to seek AABI specialized accreditation. Most were in agreement that the Extension Act of 2010 did not influence their decision to seek any accreditation.

Based on the findings, programs that train graduates for careers in the field of aviation should follow the AABI General and Core outcomes as they are peer reviewed and have validated outcomes associated with high level programs. While each program operates differently and has inherently different outcomes, producing a high-quality, safety-orientated aviation professional should be a mainstay for all programs. The FAA approached the purpose of an approved curriculum as a way to improve and enhance the knowledge and skills of a professional pilot, but it did not take into account any outcomes of those courses.

While the FAA did not take into account AABI accreditation standards in preparing the Advisory Circular outlining the eight academic areas graduates must meet, all of the content requirements outlined in AC 61-139 (2013) are met by AABI Flight Education programs (Aviation Accreditation Board International, 2013). AABI outcomes-based accreditation could serve as a model for the new FAA guidelines as a way to verify that the outcomes of the courses are appropriate for preparing a professional pilot and not just the inputs of coursework.

Conclusion and Further Research

Additional research is needed on perceptions of how exactly this new rule will be assessed and providing the necessary outcomes expected from the FAA. Potential research could include outcomes-based accreditation in light of the new FAA R-ATP guidelines as a way to assess the validity of Public Law 111-216 and the FAA's Reduced Airline Transport Pilot criteria. Also, researching perceptions of accreditation under PL 111-216 from additional stakeholders such as current students, graduates, aviation professionals, and administrators would help to better understand how AABI could benefit or provide greater clarification to the outcomes proposed by PL 111-216.

This research determined that aviation program administrators recognized AABI Outcomes as important and identified their aviation programs as being effective at meeting most of the AABI Outcomes. Additionally, most administrators agreed that classroom time can substitute for flight time for those students pursing the ATP requirements, with 500 hours deemed as an appropriate amount to credit as adopted by the FAA. It is also important to note that the Airline Safety and FAA Extension Act of 2010 did not generally influence program leaders' decisions to gain regional or specialized (AABI) accreditation. Most universities with flight programs are in the process or have already submitted for a reduction in flight time under AC 61-139, which means that many of the standards already in place by collegiate aviation programs did not have to change. The next step for the FAA will be to determine whether the attributes and skills it perceived as important are in fact being effectively carried out under the Reduced Airline Transport Pilot training criteria.

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The Status of Safety Management Systems at FAR Part 139 Airports

Michael Robertson, Bryan Harrison, and Jose Ruiz
Southern Illinois University Carbondale

Abstract

The purpose of this study was to determine the current status of SMS development and implementation at FAR Part 139 airports across the United States. Research questions addressed the following: How many FAR Part 139 airports are engaged in SMS development and implementation? What progress is being made toward SMS development or implementation, as reported by FAR Part 139 airports? What reasons do FAR Part 139 airports identify for not developing or implementing SMS? The researchers utilized a ten question survey questionnaire to address these questions. Descriptive methods of analysis were used. Seventy-four percent of the respondents reported that they currently maintain an aviation safety program, but are not engaged in SMS development or implementation. It appears that many survey respondents are not willing to engage in the development and implementation of SMS until the FAA provides further guidance and resources, or mandates SMS adoption.

Introduction

In 2005, the International Civil Aviation Organization (ICAO) required member states to develop and implement Safety Management Systems (SMS) (ACRP, 2012, p. 5). The ICAO standard applies to international airports and includes certificated airports. ICAO defines SMS as "A systematic approach to managing safety, including the necessary organizational structures, accountabilities, policies and procedures" (ICAO, 2013, xii).

Between 2007 and 2009 the Federal Aviation Administration (FAA) funded 4 pilot projects that involved the development and implementation of SMS components at selected Federal Aviation Regulation (FAR) Part 139 airports of various sizes (ACRP, 2012, pp. 6-7). The majority of previous research has examined the perceptions of pilot project airport participants; this study seeks to determine the current status of SMS development and implementation at FAR Part 139 airports across the U.S. This was accomplished through a comprehensive review of current literature related to FAR Part 139 airport SMS, including a description of SMS, a review of the four SMS FAR Part 139 pilot projects, and current SMS guidance available to FAR Part 139 airports. The research study also reports the findings of a ten-question online survey questionnaire.

Research Questions

This study reports the development and implementation status of SMS at FAR Part 139 certificated airports. Research questions include the following:

1. How many FAR Part 139 airports are engaged in SMS development and implementation?
2. What progress is being made toward SMS development or implementation, as reported by FAR Part 139 airports?
3. What reasons do FAR Part 139 airports identify for not developing or implementing SMS?

Literature Review

Aviation Safety Management has significantly evolved in the last fifty years. Historically, safety management and safety improvement involved a "fly-crash-fix-fly" approach (Stolzer, Halford, & Goglia, 2008). Safety Management Systems (SMS) is a recent approach to aviation safety management that attempts to utilize a more proactive and predictive approach to reducing aviation accidents. SMS can be thought of as a tool to translate an organization's concerns about safety into effective actions to mitigate hazards. The FAA provides a framework for SMS in Advisory Circular (AC) 120-92A (2010), *Safety management systems for aviation service providers*. This Advisory Circular provides a uniform set of expectations for the aviation industry to follow during the adoption of SMS that is aligned with the format and structure set by the ICAO.

A brief overview of the four components of SMS and their elements needs to be discussed to understand the basic structure. The four components of SMS are policy and objectives, safety risk management, safety assurance, and safety promotion (ACRP, 2009). These components work together and contribute to the development of a positive safety culture within an organization.

The first component of SMS is policy and objectives. The management of an organization supports SMS by establishing policies and safety standards for the organization. The policy developed by management should establish the direction and guiding safety principles of the organization. The policy should improve communication to staff regarding the management's commitment to enhance safety (ACRP, 2009). Simply stated, a safety policy should describe the organization's overall approach to safety, while objectives should specify the desired outcomes the SMS is trying to achieve. Advisory Circular 120-92A defines an objective as "the desired state or performance target of a process. Usually it is the final state of a process and contains the results and outputs used to obtain the desired state or performance target" (p. 7). Objectives give the organization measurable targets that can be achieved within a specified period of time.

The second component of SMS is safety risk management (SRM). A key philosophy within SMS is to manage risk proactively. Safety risk management seeks to identify hazards and systematically assess the risk associated with those hazards. Risk is considered to have two components; likelihood of an occurrence and severity of the occurrence as it relates to a hazard (AC 120-92A, 2010). Controls are then put into place to lower the risk to an acceptable level. After risk is mitigated, it is important to monitor the mitigation of the risk through its entire life cycle (ACRP, 2009). The five steps in the safety management process include a description of the system, an identification of the hazards, a determination of the risk, a risk analysis and assessment, as well as, the treatment and monitoring of the risk.

The third component of SMS is safety assurance. The AC 120-92A (2010) defines safety assurance as "a formal management process within the SMS that systematically provides confidence that an organization's products/services meet or exceed safety requirements" (p. 8). The component includes self-auditing, external auditing and safety oversight. The goal of safety assurance is to ensure the policies, procedures and activities implemented by management to improve safety are effective (ACRP, 2009). Data collection and analysis facilitate continuous improvement, which is a core concept of SMS, and safety assurance provides the tools necessary to accomplish this core concept.

The fourth and final component of SMS is safety promotion. The purpose of safety promotion is intended to support the development of a strong safety culture. Tools should be in place to help facilitate the transferring of important information to individuals within the organization regarding hazards and their associated risks. Training, education, and other means of communication are key elements of safety promotion (ACRP, 2009).

All four of these components must exist and be executed for an effective SMS to exist within an organization. All four components rely on the existence and effectiveness of the other components. A strong safety culture is an integral part of SMS. An organization cannot have a successful SMS without the existence of a strong safety culture; invariably a strong safety culture helps in the development of SMS (Stolzer et al., 2008).

The FAA is now following ICAO's lead and is encouraging the aviation industry in the United States to adopt SMS. The FAA has sponsored four pilot studies involving the development and implementation of SMS at FAR Part 139 airports. Thirty-one FAR Part 139 airports throughout the U.S. participated in these pilot studies. "Beginning in April 2007 and concluding in early 2012, FAA provided opportunities for U.S. airports to gain knowledge and provide information and feedback to FAA by conducting SMS airport pilot studies" (ACRP, 2012, p. 2).

The first and second pilot studies were conducted in 2007, 20 airports received Airport Improvement Program (AIP) grants to fund the conduct of a program gap analysis and develop their SMS Manual (ACRP, 2012). The third study initiated on July 2008, was designed to gather information on scalability and how smaller airports could implement

SMS. The fourth study conducted in 2009, was an implementation study where 11 of the original 20 airports from the first and second study participated. This study investigated how airports implement the elements of Safety Assurance and Safety Risk Management at their respective airport environments (FAA, 2014).

In 2012, the Airport Cooperative Research Program (ACRP) sponsored a study titled ACRP Synthesis 37: Lessons Learned from Airport Safety Management Systems Pilot Studies, to provide FAR Part 139 airports with data and experiences from the four FAR Part 139 pilot studies previously mentioned. The Synthesis researchers surveyed the 31 airports to organize lessons learned, general findings, and trends. The researchers developed and conducted a 36-question survey that included such topics as including program logistics, planning, staffing, and SMS integration and implementation (ACRP, 2012).

Airport Cooperative Research Program Synthesis 37 identified many lessons learned. Airports participating in the study found that SMS development and implementation had many benefits, as well as challenges. Twenty-four of the 26 airports that participated in the study said they would continue to pursue the adoption of SMS. Some airports reported that SMS improved communication and increased safety awareness through data collection and trend analysis. In spite of these benefits, other airports indicated they were waiting for a final mandate from the FAA to officially assign staff and budgets to SMS development and implementation. "Airports are awaiting additional resources and forthcoming SMS guidance from FAA" (ACRP, 2012, p. 12).

Methodology

This exploratory study utilized a thorough literature review combined with a ten question survey questionnaire developed by the authors. Descriptive methods of analysis were used. Gliner, Morgan, and Leech (2009) define the descriptive approach to research as an approach "that answers descriptive questions using only descriptive, not inferential, statistics; summarizes data from the current sample of participants without making inferences about the larger population of interest; no comparisons or associations are made; does not have an independent variable" (p. 430). The study population consisted of 468 of the 542 FAR Part 139 airports in the U.S. Currently there is no comprehensive email list for all FAR Part 139 airports. The researchers were able to compile an email list of 468 of the 542 Part 139 airports. Four e-mail addresses were identified and returned as invalid. Of the 464 airports that were emailed a survey, 174 responded for a response rate of 37.5%.

All of the airports on the list were provided a cover letter and granted access to an online survey via survey monkey. The survey questionnaire was reviewed and approved by the Southern Illinois University (SIU) Human Subjects Committee. The airports were given an option to remove themselves from the email list and to receive no further communication from the researchers. The cover letter asked that the individual responsible for safety complete the survey. Survey participants were notified that their participation was voluntary. The survey was emailed to participants on two separate occasions spaced three weeks apart. The survey questionnaire can be found in Appendix A.

Findings

The findings section will address survey questionnaire responses. The first question sought to determine where the airport was located. The 169 survey respondents who answered this question represented 44 U.S. states. The states with 10 or more respondents were Texas 14 (8.28%), Florida 12 (7.1%), California 12 (7.1%), and Michigan 10 (5.92%).

The second question asked the participants to identify the classification of their airport. Thirteen respondents did not answer this question. Of the 161 that responded 97 (60.25%), were identified as Class 1 airports, 20 (12.42%) were Class 2 airports, 14 (8.70%) were Class 3 airports, and 30 (18.63%) were Class 4 airports. These results were close to the proportion of the classes of airports in the U.S., Class 1 (64%), Class 2 (15%), Class 3 (6%) and Class 4 (15%).

Question three asked respondents to rate their knowledge of SMS. The rankings included No Knowledge, Some Knowledge, Knowledgeable, Very Knowledgeable, and SMS Expert. One hundred sixty-six (166) of the 174 respondents answered this question. Ninety-four (56.63%) of respondents reported that they possessed "Some Knowledge." Fifty (30.12%) reported that they were "Knowledgeable." Fifteen (9.04%) reported that they were "Very Knowledgeable." Two (1.2%) reported that they were an "SMS Expert," while 5 (3.01%) reported that they had "No Knowledge" of SMS.

Question four asked respondents to rate their organization's willingness to pursue SMS. Nine (9) respondents elected not to answer this question. Figure 1 shows the response distribution of question 4.

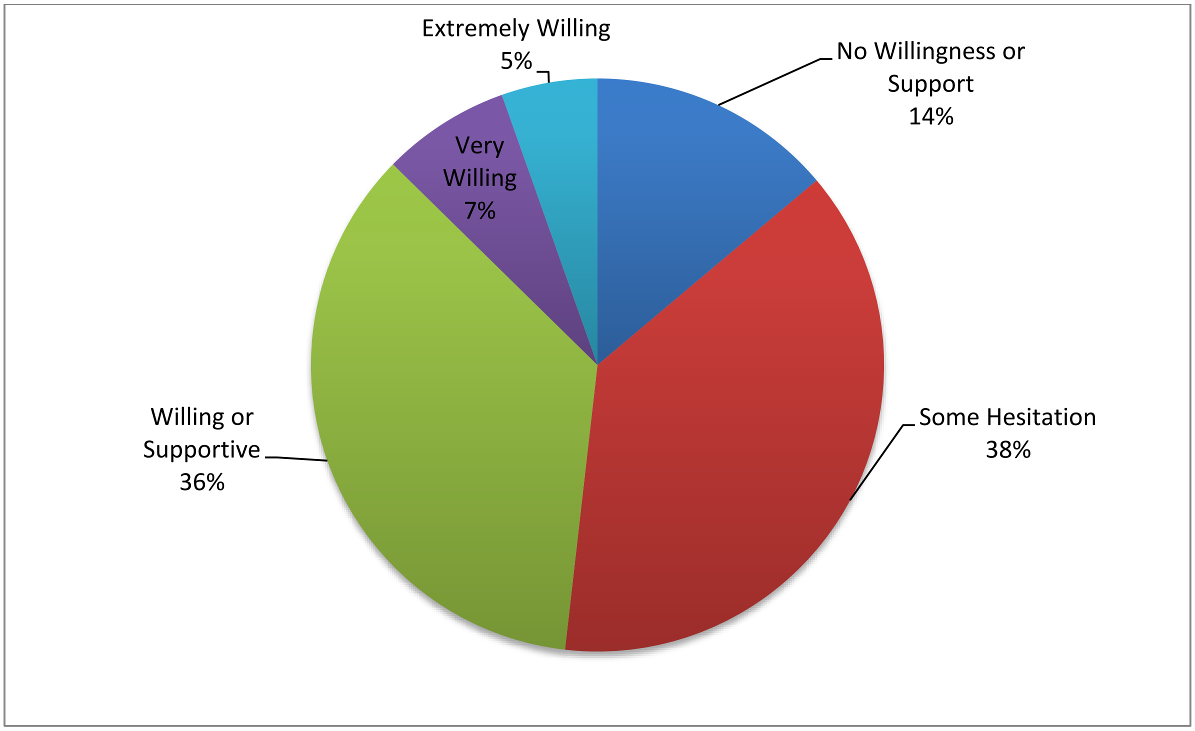

Figure 1. How would you rate your organization's willingness to pursue SMS?

Question five asked respondents how familiar they were with documents that applied to SMS for airports. One hundred thirty-two (75.86%) of the 174 participants answered this question. The documents listed were Advisory Circular AC 120-92A; AC 150/5200-37; ACRP Report 1: Safety Management Systems for Airports, Volume 1: Overview; ACRP Report 1: Safety Management Systems for Airports, Volume 2: Guidebook; and ACRP Synthesis 37: Lessons Learned from Airport Safety Management Systems Pilot Studies. Table 1 shows the response distribution for this question.

Table 1

Are you familiar with any of the following documents that apply to Airport SMS?

Documents	Responses
AC 150/5200-37	113 (85.6%)
ACRP Report 1: Volume 1: Overview	77 (58.3%)
ACRP Report 1: Volume 2: Guidebook	60 (45.5%)
AC 120-92A	54 (40.9%)
ACRP Synthesis 37	44 (33.3%)

Question six asked what type of safety program was in place at their respective airport. Thirteen (13) of the 174 respondents elected to not answer this question. Figure 2 shows the response distribution to this question.

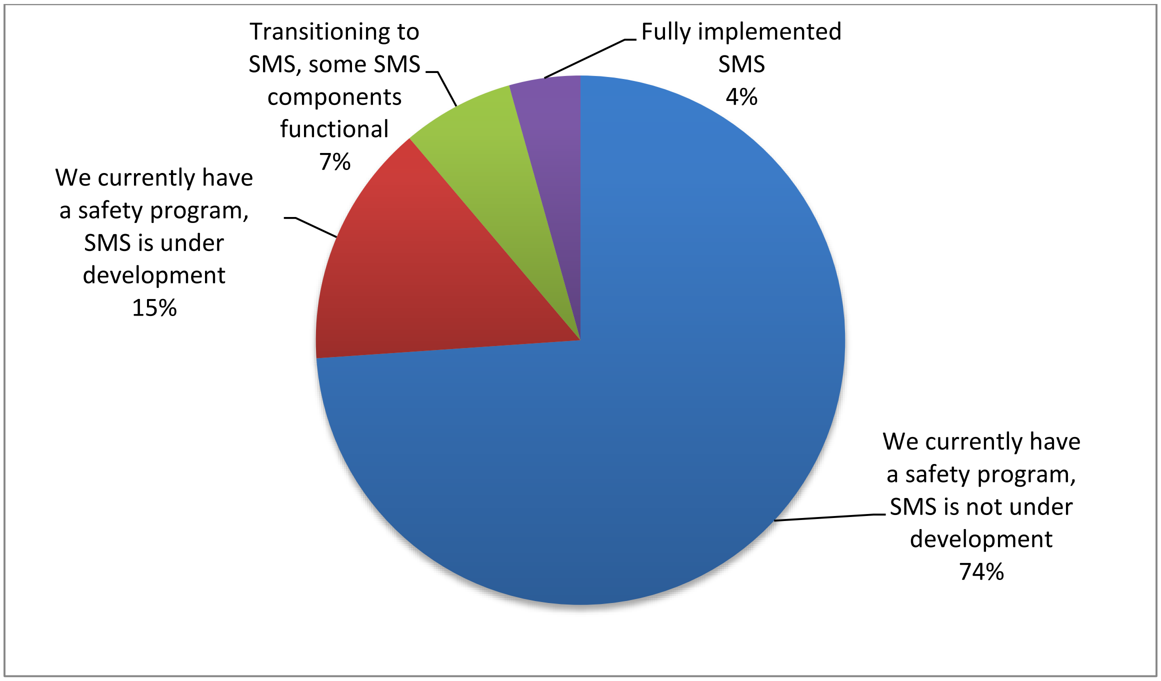

Figure 2. How would you describe your airport's current safety program?

Question seven asked respondents that if SMS was to be implemented in the future, at what point would they expect to have SMS fully in place. One-hundred forty-nine respondents (149) answered this question (86%). The choices ranged from within a year, 2-3 years, more than 3 years, and no idea. Ten (6.71%) said they would have SMS fully implemented within a year, 48 (32.21%) said 2-3 years, 29 (19.46%) said more than 3 years and 62 (41.61%) had no idea.

Question eight focused on those airports that said SMS was not under development. The question specifically attempted to identify what safety components the airport presently had in-place. One hundred thirty-seven (137) respondents (79%) answered this question. Table 2 shows the response distribution to question 8.

Table 2

Answer this question if SMS is not under development. Examining your current overall safety program, which of the following safety components are in place at your airport? (Check all that apply).

Components	Responses
Emergency Planning and Response	135 (98.6%)
Safety Training	120 (87.6%)
Safety Documentation	96 (70.0%)
Safety Promotion	82 (59.9%)
Safety Policy and Objectives	80 (58.4%)
Safety Committee	67 (48.9%)
Paper Reporting	64 (46.7%)
Regular Safety Audits	53 (38.7%)
Confidential Hazard Reporting and Tracking	34 (24.8%)
Web Based Reporting	18 (13.1%)

Question nine asked respondents that are in the process of developing or have implemented SMS specifically what SMS elements are in-place or have been completed? Thirty-two (32) of 174 respondents answered this question. Table 3 shows the response distribution for this question.

Table 3

Answer this question if SMS is under development. If you are developing or have implemented SMS at your airport which of the following components are in place or have been completed? (Check all that apply)

Elements	Responses
Safety Risk Management Processes	21 (65.7%)
Preliminary Gap Analysis	16 (50.0%)
SMS Training	16 (50.0%)
SMS Manual	14 (43.8%)
Regularly Conduct Safety Risk Assessments (SRA)	14 (43.8%)
SMS Promotion	13 (40.6%)
Safety Assurance Processes	11 (34.4%)
Detailed Gap Analysis	10 (31.3%)
Confidential Hazard Report Tracking and Documentation	10 (31.3%)
SMS Implementation Plan	10 (31.3%)

Finally, question ten of the survey asked, "If your organization is not considering the adoption of SMS, please indicate why." Seventy-six (76) of 174 respondents answered this question. The options given were "Lack of Funding", "Lack of Sufficient Manpower", "Liability Issues", "SMS is a waste of time", and "Increased Government Intervention." Table 4 shows the response distribution for this question.

Table 4

If your organization is not considering the adoption of SMS, please indicate why. (Check all that apply)

Reasons	Responses
Lack of Sufficient Manpower	61 (80.3%)
Lack of Funding	52 (68.4%)
Increased Government Intervention	30 (39.5%)
Liability Issues	12 (15.8%)
"SMS is a Waste of Time"	11 (14.5%)

Discussion

The following observations address the three research questions associated with the study, and provide the basis for the study's conclusions.

Research Question One

"How many FAR Part 139 airports are engaged in SMS development and implementation?" Based on the survey responses to question six, 74% percent or 119 of the 161 respondents reported that they currently maintain an aviation safety program, but are not engaged in SMS development or implementation. Thirty-five (35) respondents (22%) reported that their SMS was either under development, or they were in the process of transitioning to SMS and several SMS components/activities were functional. Seven (7) respondents (4%) reported that their SMS was fully implemented. This finding indicates that while respondents place a significant value on the inherent benefits of an aviation safety program, they did not believe that SMS development and implementation were critical to the maintenance of aviation safety.

Research Question Two

"What progress is being made toward SMS development and implementation as reported by FAR Part 139 airports?" Thirty-five respondents (22%) reported that SMS development, or some transition to SMS was underway within their organization on survey question six. An additional seven (7) respondents (4%) indicated that SMS had been fully implemented at their facility. On survey question eight, 137 of all survey respondents (79%) indicated that they already had at least one of the following SMS components and/or activities in-place: safety committee, confidential hazard reporting system, safety promotion, safety training, safety documentation, emergency planning, safety audits, safety policy, and objectives.

According to survey question three, 161 of all survey respondents (93%) reported possessing some level of knowledge regarding SMS. However on survey question seven, 29 respondents (17%) reported that SMS implementation would take more than three years to conduct. Sixty-two (62) respondents (36%) reported that they had "no idea" of when implementation would take place. While the majority of respondents (93%) report possessing some level of knowledge related to SMS, and on survey question nine, 79% of all survey respondents report currently being engaged in a large variety of required SMS functions and/or activities, they appear reluctant to fully adopt an SMS program. Why? The answers to our third research question respond to this issue.

Research Question Three

"What reasons do FAR Part 139 airports identify for not developing or implementing SMS?" On survey question ten, 76 respondents (44%) reported that their reasons for not developing and implementing SMS, which included: lack of funding, insufficient manpower, resistance to increased government intervention, liability issues, and the perception that "SMS is a waste of time." Additionally, ACRP Synthesis 37 (2012) reported several challenges experienced by SMS pilot project airports attempting SMS development including, lack of FAA support/resources, lack of management support and stakeholder "buy in" (p. 46). ACRP Report 1, Safety Management Systems for Airports (2009) lists several common challenges associated with SMS implementation including: management commitment, behavioral change, maintaining momentum, and cultural characteristics (pp. 59-60). It would appear that despite the documented benefits of SMS, survey respondents and SMS documents indicate that significant challenges exist with regard to developing and implementing SMS. For example, only half of the airports that responded that they were in process of SMS implementation said they had performed a preliminary gap analysis. This is an important step considered regulatory by ICAO.

Conclusions

Safety Management Systems are regarded as one of the aviation industry's most prevalent safety initiatives. Survey questionnaire data analysis indicates that FAR Part 139 certificated airports throughout the U.S. hold aviation safety in high regard. Many of the airports that participated in this study maintain safety components and perform safety activities in their existing safety programs that reflect many of the required components of SMS. As such, they do not feel aviation safety hinges on the development and implementation of SMS. It appears that many survey respondents are not willing to engage in the development and implementation of SMS until the FAA provides further guidance and resources or mandates SMS adoption. There are many reported challenges that are perceived to exist with the development and implementation of SMS. Having participated in the development of two airport SMS Manuals, and the implementation of one SMS, two of the researchers can attest to some of the challenges reported in this study. However, through this experience it was also discovered that several of these challenges could be overcome by developing creative solutions. The FAA has not mandated the development and implementation of SMS, but it does encourage the voluntary adoption of the safety initiative. The FAA believes that SMS provides airports with an added "layer of safety" (Safety Management System for Certificated Airports, 2010, p. 62,009). On the other hand, the results of this study indicate that airports are not wholly convinced that SMS is a significant improvement over their existing safety programs. As such, many survey respondents have adopted a "wait and see" approach to SMS development and implementation.

Recommendations

As this was an exploratory study, it was determined that descriptive methods of analysis were appropriate for reporting the data. The researchers believe that the survey data warrants additional analysis and the following research studies are recommended.

1. A research study that categorizes respondents by class of airport, and examines survey responses from different classes of airports using statistical analysis. How do the perceptions and attitudes of different classes of airports vary toward the development and implementation of SMS?

2. A research study that classifies respondents by geographic region, and compares survey responses from airports located in different regions of the U.S. How do the perceptions and attitudes of airports located in different regions of the U.S. vary toward the development and implementation of SMS?

3. A research study that examines the types of resources dedicated to SMS development and implementation by airports of varying size and complexity. A study of this nature would assist in addressing SMS scalability concerns based on specific airport characteristics.

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Appendix A

1. Please Classify for your Part 139 airport.
    - Class I
    - Class II
    - Class III
    - Class IV

2. In what state or U.S. territory does your airport reside?

3. How would you rate your knowledge of Safety Management Systems?
    1. No knowledge
    2. Some Knowledge
    3. Knowledgeable
    4. Very Knowledgeable
    5. SMS Expert

4. How would you rate your organization's willingness to pursue SMS?
    1. No willingness or support
    2. Some hesitation
    3. Willing or supportive
    4. Very willing
    5. Extremely willing

5. Are you familiar with any of the following documents that apply to Airport SMS? (Check all that apply)
    - AC 120-92A Introduction of Safety Management Systems for Air Operators
    - AC 150/5200-37 Introduction to Safety Management Systems for Airport Operators
    - ACRP Report 1: Safety Management Systems for Airports, Volume 1: Overview
    - ACRP Report 1: Safety Management Systems for Airports, Volume 2: Guidebook
    - ACRP Synthesis 37: Lessons Learned from Airport Safety Management Systems Pilot Studies

6. How would you describe your airport's current safety program?
    - We currently have a safety program, SMS is not under development
    - We currently have a safety program, SMS is under development
    - Transitioning to SMS, some SMS components functional
    - Fully implemented SMS

7. If your organization plans to implement an SMS, by when would you expect that your organization plans to have the SMS fully in place?
   - Within a year
   - Within 2-3 years
   - More than 3 years
   - No idea

Answer this question if SMS is not under development

8. Examining your current overall safety program, which of the following safety components are in place at your airport? (Check all that apply)
   - Safety Committee
   - Safety Policy and Objectives
   - Confidential Hazard Reporting and Tracking
     - Paper
     - Web Based
   - Safety Training
   - Safety Documentation
   - Emergency Planning and Response
   - Safety Promotion
   - Regular Safety Audits
   - Other___________________________

Answer this question if SMS is under development

9. If you are developing or have implemented SMS at your airport which of the following components are in place or have been completed? (Check all that apply)
   - Preliminary Gap Analysis
   - Detailed Gap Analysis
   - SMS Manual
   - SMS Training
   - SMS Promotion
   - Safety Risk Management Processes
   - Regularly Conduct Safety Risk Assessments (SRA)
   - Safety Assurance Processes
   - Confidential Hazard Report Tracking and Documentation
   - SMS Implementation Plan
   - Other__________________________

10. If your organization is not considering the adoption of SMS, please indicate why. (Check all that apply)
    - Lack of funding
    - Lack of sufficient manpower
    - Liability issues
    - “SMS is a waste of time”
    - Increased government intervention
    - Other_________________________

Understanding the Perceptions of Chinese Aviation Maintenance Technicians Related to the Implementation and Use of 3D Aircraft Maintenance Manuals

Yu Wang and Steven Leib
Purdue University

Abstract

Aircraft maintenance manuals (AMMs) contain important information for the continued airworthiness of aircraft and are crucial technical documents for assuring maintenance tasks are carried out properly. However, because of mass text descriptions and static pictures, traditional AMMs have limited ability to show complicated aircraft structures and maintenance procedures accurately and intuitively. In order to improve the accuracy and descriptive ability of maintenance manuals to reduce misleading information and unclear procedures, a new style of aircraft maintenance manual, a three-dimensional (3D) maintenance manual, has been developed. Features of this manual include the use of 3D animations and multiple views to simulate component removal and installation processes. This type of manual can present short animations matched to individual steps of procedures. The purpose of this research project was to investigate how well the concept of a 3D maintenance manual could be accepted by front-line mechanics in the aviation industry and identify their perceptions about the usefulness of the traditional versus 3D maintenance manuals. This was a qualitative study that used surveys to assess the perceived benefits and drawbacks of both the traditional AMM and the 3D AMM. Participants were 48 front-line mechanics at multiple airlines in China. The results showed that the 3D AMM has the potential to be used for maintenance tasks and improve aircraft maintenance efficiency. In addition, along with the results, the study considered some recommendations for the improvement of 3D AMMs and suggested further research into understanding how maintenance technicians could utilize these documents more effectively.

Introduction

Aviation maintenance has always been a part of aircraft operations. Historically, information regarding maintenance processes has been relayed to aviation maintenance technicians via paper manuals. These manuals contain large amounts of text, diagrams, schematics, and step-by-step procedures. A single aircraft often requires multiple maintenance manuals, especially in the case of commercial aircraft. Recently, maintenance operations have begun to include alternative methods of disseminating this information to technicians, such as online manuals, PDFs, etc. As technology continues to advance, it is not impossible to have aviation maintenance manuals incorporate three-dimensional animations, as part of maintenance tasks. While the use of 3D maintenance manuals is in its infancy, much research needs to be conducted to understand the future of 3D maintenance manual development. This study aimed to understand one aspect of this development.

Literature Review

Aircraft Maintenance Manual (AMM) Introduction

Aircraft maintenance includes the processes of overhaul, repair, inspection and modification of an aircraft or aircraft component, which is necessary to maintain its airworthiness. Similarly, reliable maintenance documentation with accurate description plays a very important role in ensuring the proper maintenance of complex aviation equipment such as aircraft engines (Geng, Tian, & Jia, 2011; Blue et al., 2002).

The International Air Transport Association (IATA) (2009) defines an aircraft maintenance manual as one that is "…produced and continuously updated by the aircraft manufacturer that contains procedures relating to the maintenance of aircraft, engines and components" (p. 15).

From a legal standpoint, the Federal Aviation Administration (FAA) imposes strict guidelines for the development and use of maintenance manuals. Federal Aviation Regulations (FARs) include several mandatory requirements for aviation organizations and operations that use manuals. According to the FARs (specifically 14 CFR §121.133[a]: Preparation) all air carriers are required to "…prepare and keep current a manual for the use and guidance of flight, ground operations, and management personnel in conducting its operations" (FAA, 1995, p.69). However, it is important to note that for the purpose of maintenance operations, Federal Aviation Regulations explicitly state that a paper manual is not the only allowable format: "…the certificate holder may prepare that part of the manual containing maintenance information and instructions, in whole or in part, in printed form or other form acceptable to the Administrator" (FAA, 1995, p.70).

As for the content of the maintenance manual, Federal Aviation Regulations also prescribe specific requirements as to what information should be included in all manuals: "Airworthiness inspections, including instructions covering procedures, standards, responsibilities, and authority of inspection personnel" (FAA, 2007, p.71) all must be incorporated.

Further investigation into the purpose and usage of aircraft maintenance manuals reveals a surprising amount of depth to how they are developed and utilized. Several research projects regarding maintenance documentation have shown the importance of aircraft maintenance documentation to ensuring safe operations.

In 2001, the FAA conducted a study focusing on aviation maintenance errors. The purpose of the study was to identify categories of human error related to installation during maintenance. Upon completion of the six-month study, researchers found that the failure to comply with technical maintenance documents was the primary contributing factor to maintenance errors. This study also referenced a company-wide intervention program, "Key Behaviors for Aircraft Maintenance & Hangar Inspection." The original objective of this program was to ensure that the engineering department and maintenance-related management provide mechanics with appropriate maintenance documentation (Johnson & Watson, 2001).

According to Avers, Johnson, Banks, and Wenzel (2012), the NASA Aviation Safety Reporting System indicated that 9,000 of 14,267 (approximately 64%) safety incidents coded in maintenance reports from 2001 to 2011, resulted from technical documentation or maintenance procedures or both.

Virtual Reality Introduction

Virtual Reality (VR) refers to a technology that is regarded as a natural extension to 3D computer graphics with advanced input and output devices. It has been regarded as a simulated 3D environment based on a computer, in which one can use a standard input tool (a key board or mouse) to operate objects. A 3D modeling software program can be used to create a model of the object that can be shown on the screen. The display technology can range from the basic display, a computer monitor, to the specialized head-mounted displays (HMD). To put it simply, virtual reality can be defined as a virtual environment where one can have a feeling of "being there" (Jataram, Connacher, & Lyons, 1997; Thalman & Thalman, 2003).

Virtual reality systems can work in a variety of forms and have applications in different industries (Brooks, 1999). Some applications, for example, include design review of an electric boat, astronaut training at NASA, merchant ship simulation, and flying a Boeing 747. Applications of VR also have a major influence on enhancing productivity and efficiency, improving team communication, and reducing costs.

Druck (2006) also pointed out the wide applications of VR systems in different industries. Virtual reality technology has become an exceedingly useful approach for engineers, researchers, scientists and manufacturers to improve product quality, design productivity and maintainability. There are applications of VR from entertainment to scientific visualization and from three-dimensional walkthroughs to real-time prototyping. VR technology also can be found in training, from flight simulators to surgery.

Virtual Reality in Maintenance Manuals

According to Geng, Tian, and Jia (2011), even though people have realized the importance of timely and proper maintenance, and the quality of maintenance in the aviation industry has been improved, traditional aircraft maintenance manuals (paper-based manuals) still have some drawbacks. For one, mass text descriptions and static pictures cannot demonstrate assembly and disassembly procedures clearly, intuitively, and accurately. There is still some misleading and ambiguous information that can lead to misunderstanding by front-line mechanics performing maintenance processes. This, as a consequence, might result in lower-quality maintenance, wasted time, and lost efficiency.

Avers, Johnson, Banks, and Wenzel (2012) proposed the concept of next-generation maintenance technical documentation. The current technical documentation does not have regulatory specification on media, format, turn-around times, etc. The next-generation technology (3D modeling, embedded video training, voice recognition, etc.) could allow engineers and mechanics to have access to the proper maintenance information conveniently. In the aviation industry, with the help of advanced technology, the goal of delivering the right form of maintenance information into the right hands at the right time and place is feasible.

Although there are many accomplishments of virtual reality in different arenas, VR technology has not been widely used in aviation maintenance. In recent times, an increasing number of experts, professors, and aviation maintenance-related organizations have realized the huge potential for VR implementation in aviation maintenance, especially in aviation maintenance manuals (Avers, Johnson, Banks, & Wenzel, 2012).

Based on the concept of virtual reality, Zhu, Tan and Wei (2010) pointed out the high application potential of 3D maintenance documents. They took the horizontal stabilizer of an aircraft as an example and utilized a 3D maintenance manual to show the procedures of virtual assembly. They concluded that 3D maintenance documents are able to clearly illustrate simulation processes with 3D animations, texts and 3D annotation. Illustrative texts can work together with 3D animations to provide an accurate description of maintenance processes. Intuitive animations make it easier for maintenance crews to understand assembly and disassembly processes compared to the text-only description. Thus, 3D maintenance manuals can, to a great degree, avoid ambiguity and provide a clearer illustration of maintenance processes in order to enhance the efficiency of assembly and disassembly.

Chaparro and Groff (2002) conducted a 3-phase research project to identify human factors in the improvement of aviation technical manuals and offered some recommendations for the improvement of aircraft maintenance documentation in their report. They found that the primary concern about maintenance manuals shared by most users turned out to be usability. Improving the usability of documents can enhance users' satisfaction level on maintenance manuals, decrease the maintenance cost, and ensure efficient maintenance tasks.

Chaparro and Groff (2002) also pointed out that there is a slow but steady trend to take the place of paper-based manuals with computer-based maintenance manuals. Computer-based manuals, including text, audio, and video-based media, can provide technicians and mechanics with a comprehensive, detailed and clear description of maintenance processes. Electronic documents can also be updated and distributed easily, take up less space, and allow mechanics to have access to information conveniently. Thus, the transition from paper-based manuals to electronic manuals could address many usability problems.

All in all, the information mentioned previously has indicated the implementation potential of 3D maintenance manuals in aviation maintenance operations. But how front-line workers are willing to utilize the new style of maintenance documents has yet to be fully understood. The purpose of this project was to obtain the front-line mechanics' perceptions and attitudes toward the implementation of 3D aircraft maintenance manuals and collect recommendations on the improvement of 3D maintenance documents.

Statement of the Problem

Regardless of the actual benefits provided by 3D maintenance manuals, their successful growth in the maintenance environment is rooted in the acceptance of those who would be using them. Research has yet to address the perceptions and attitude of aviation maintenance technicians themselves. How these individuals perceive the benefits of 3D maintenance manuals can provide much insight as to their course of implementation.

Research Questions

This study specifically intended to focus on the perceptions and attitudes of front-line aviation maintenance technicians who have had experience with paper-based manuals. Because these individuals would be the primary users of 3D aviation maintenance manuals, this study posed the following research questions regarding their perceptions about 3D manuals:

1. What are the perceptions of Chinese front-line aviation maintenance technicians toward the challenges and benefits associated with current paper-based manuals?
2. What are the perceptions of Chinese front-line aviation maintenance technicians toward the challenges and benefits associated with 3D-based manuals?
3. What are the attitudes of Chinese aviation maintenance technicians toward the future incorporation of 3D-based manuals into aviation maintenance operations?

Methodology

Research Type and Framework

This was a qualitative study that utilized a survey tool to understand the perceptions and attitudes of participants working at maintenance operations in China. Specifically, this project measured their responses regarding the benefits and challenges of both traditional paper manuals and 3D manuals, as well as the potential future incorporation of 3D manuals in an aviation maintenance operation in the Chinese culture. This project was supported by a university's Institutional Review Board (IRB).

Sample

There were 48 survey participants in this research study. Participants were front-line maintenance technicians certificated by the CAAC at multiple Chinese airlines. All participants were full-time front-line mechanics performing aircraft maintenance and repair tasks. Participants were contacted by emails and volunteered to participant in this study through an online survey.

Data Collection

An online survey was designed using Qualtrics (online survey software). This survey included a demonstration of the computer-based and animated 3D maintenance manual showing the removal process of the main oil/fuel heat exchanger. Solidworks and Cortona3D software were used by the researchers to design the demo of the 3D maintenance manual (see Figure 1). Eight qualitative questions based on a comparison between 3D and paper-based maintenance manuals were provided in the survey (see Appendix).

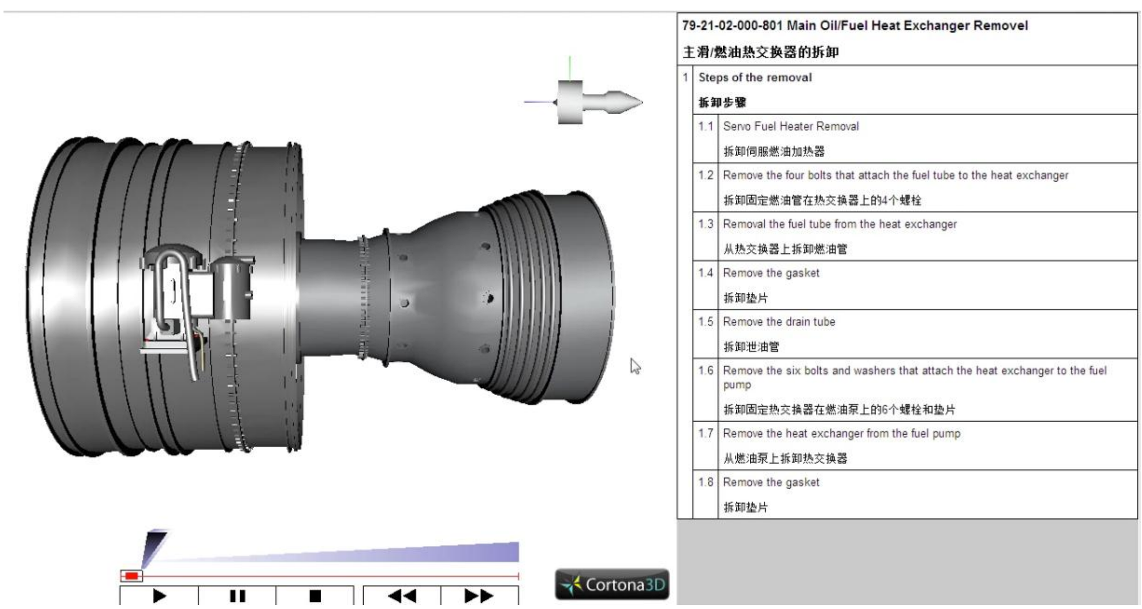

Figure 1. Static image from the demo of the 3D maintenance manual (developed from Solidworks and Cortona3D software)

Results

Forty-eight respondents from multiple Chinese airlines participated in the survey. Data analysis was carried out by coding their responses into common themes. The data was then grouped into three categories that respectively answered the three research questions, which will be discussed in the following section. They include: challenges of paper-based and 3D manuals, benefits of paper-based and 3D manuals, and respondents' acceptance of 3D manuals.

Challenges of Paper-based and 3D Manuals

With regard to the drawbacks of using paper-based manuals, the survey participants expressed concerns about fragility. One of main concerns was that paper manuals could become damaged easily. In addition, data collected indicated that because of lack of a retrieve function, searching desired content from a great deal of information from paper manuals might be a very time-consuming task. The low efficiency of locating useful information is a significant challenge for paper-based manuals. Furthermore, according to the feedback from front-line maintenance technicians, paper manuals are not environmentally friendly.

Regarding the challenges of 3D maintenance manuals, most of the respondents pointed out that the utilization of 3D maintenance manuals needs hardware support. In other words, in contrast to paper-based manuals, users need to use electronic equipment to display 3D maintenance manuals, which may not be convenient for use at a maintenance worksite. This is especially a concern in a poor maintenance work environment, such as wet or cold. In addition, 25% of respondents also appeared to have concerns about the cost of development of 3D maintenance manuals. These concerns were related to the complexity of aircraft systems, higher technical requirements, and that a greater amount of manpower involved might increase the cost of 3D manuals' development, design and revision. Another challenge pointed out by the respondents was regarding the accuracy of 3D maintenance manuals. Due to the complexity and diversity of aircraft structures, keeping the information displayed by 3D animations accurate could be very challenging.

Benefits of Paper-based and 3D Manuals

Regarding the merits of using paper manuals, the most frequent response received from participants was that paper manuals are "easy to use" [translated]. Responses indicated that paper manuals can easily be taken to jobsites and technicians can access them easily from the toolboxes during maintenance tasks. Additionally, 42% of respondents believed that paper manuals are good for eyesight and are very readable. Another benefit of using paper manuals reported by participants was that front-line maintenance technicians or mechanics are able to make notes and mark on paper manuals easily.

According to the comments from the respondents about the merits of 3D maintenance manuals, the biggest benefit of utilizing 3D manuals is that 3D animations are able to provide a clear, visual and direct overview of assembly and disassembly procedures. Technicians can experience real-time maintenance procedures just by seeing the 3D animations. In addition, responses indicated the visualization of maintenance procedures would lead to an easier and better understanding of the maintenance tasks for front-line technicians and mechanics, as compared to paper-based manuals. In terms of maintenance efficiency, all the respondents also gave positive comments about the potential improvement on the efficiency of maintenance tasks. In addition, most respondents commented that the ease and clarity of 3D maintenance manuals could help to reduce mistakes in interpreting the procedures and performing the tasks. Because of the additional features afforded by 3D animation software, 3D animations have the power to make specific and complicated maintenance steps more easily understood, so that the task can be completed more efficiently and effectively.

Respondents' Acceptance of 3D Manuals

The data collected indicated that participants were not only willing to adopt 3D maintenance manuals in their operation, but also were willing to encourage superiors to develop 3D maintenance manuals. Thirty-six out of forty-eight respondents had prior experience with various aspects of digital media for maintenance manuals, including online manuals and PDF documents, which suggested their openness to other forms of maintenance manuals. More importantly, all participants indicated explicitly that the incorporation of 3D maintenance manuals to aviation operations is a worthy pursuit. This finding can be seen from the participants' answers to the seventh survey question: "Overall, do you feel the incorporation of 3D maintenance manuals to aviation operations is worth pursuing?" All the 27 participants who completed this question provided a positive answer.

Discussion

As mentioned previously, all of the participants appreciated the value of incorporating 3D maintenance manuals in future operations. Participants acknowledged and appreciated the advantages that 3D manuals provide over paper-based manuals for the purposes of education/training, efficiency, and ease of use. The findings from this study suggest that 3D maintenance manuals could, to some degree, help mechanics learn the component removal processes more effectively, compared to 2D maintenance manuals. Plus, 75% of respondents already had some experience with alternative media for aviation maintenance information sharing. In other words, airlines, aircraft manufacturers and other aviation-related organizations have already started to establish and utilize different forms of maintenance manuals in the aviation maintenance operations. This also indicated maintenance technicians' openness to other forms of information presentation to accomplish maintenance tasks.

In addition, respondents identified several challenges and benefits associated with the use of 3D manuals. Based on their comments and suggestions regarding these benefits and challenges, it seemed participants' responses indicated uncertainty about the specific timeline of adoption of 3D manuals, but clearly expressed their expectation that 3D manuals would be incorporated into aviation maintenance operations. For example, one respondent stated," the 3D maintenance development is a long-term but rewarding project." [translated]. Across all participants, there was no indication that 3D maintenance manuals had no future in the aviation industry, or that the implementation of 3D maintenance manuals was a fruitless endeavor. Furthermore, there were no comments about specific challenges that indicated they could not be mitigated or resolved. However, several challenges of utilizing 3D maintenance manuals pointed out by the survey participants might need to be addressed in future studies, to better understand how 3D maintenance manuals could be used in future maintenance operations. Some possible recommendations for how to address the challenges of 3D manuals will be suggested in the next section.

More importantly, along with the data collection, the survey participants also provided some valuable recommendations and suggestions on the future implementation of 3D maintenance manuals into the aviation industry. For example, "multiple parties should be involved to develop 3D maintenance manuals" [translated]. This pointed out a very important success factor of the future implementation of 3D maintenance manuals in the aviation operations - a multi-party cooperation. According to the survey participants, developing a user friendly, powerful and accurate 3D maintenance manual is a long-term project, which cannot be achieved successfully without a strong collaboration from multiple parties. Based on the recommendations of respondents: aircraft manufacturers, airlines, aviation authorities, and other aviation maintenance-related organizations should be supportive on the design and development of this new style of maintenance manuals.

This study had several limitations that must be acknowledged. For one, the small sample size, to some degree, could restrict this project from drawing a more reliable conclusion. Additionally, survey participants of this research project were technicians from Chinese airlines. The results received from this research project may not be generalizable to other countries' maintenance technicians. For example, maintenance technicians working at airlines in the United States may have different thoughts about the implementation of 3D maintenance manuals in the aviation industry. Additionally, individuals from different age groups may have different views about new technology. Compared with older individuals, young people may have had more chances to utilize computer technology, and their direct experience with technology could impact the study. Therefore, it might be easier for young technicians to adjust to the advent of 3D maintenance manuals, than for experienced technicians who have been using traditional manuals for years and may or may not like to change the existing maintenance operations.

Conclusions and Recommendations

The main purpose of this research was to determine the perceptions of front-line maintenance technicians toward the implementation of 3D maintenance manuals into aviation operations. As discussed above, participants not only were willing to adopt the new style of manuals, but also encouraged the incorporation of 3D maintenance manuals into the aviation industry. In addition, according to the responses, 3D maintenance manuals appeared to have certain advantages over 2D maintenance manuals in the respects of ease of use, maintenance efficiency and, training. Although participants also recognized disadvantages to adopting 3D manuals, those disadvantages did not appear to outweigh the benefits, and there was overall strong support for 3D manuals.

There are several recommendations that can be discussed based on this research study. For one, there are a lot of opportunities to empirically measure and statistically compare aspects of improved efficiency and speed that accompany the use of 3D manuals as suggested by the results of this study. In the future, some research projects could focus on using quantitative methods to demonstrate a comparison between 3D maintenance manuals and 2D maintenance manuals regarding efficiency, accuracy and effectiveness. Some metrics, for example, could be the number of errors made by technicians in a certain amount of time, the overall time spent on certain tasks, and other comparative aspects between 3D manuals and 2D manuals.

Another recommendation for future research is to expand the sample size and include participants from different countries. In addition, future researchers could also take age as a consideration regarding the respondents' acceptance of 3D manuals. To include the influence of age in the data analysis about the acceptance of 3D maintenance manuals might be an interesting research aspect.

Additionally, some recommendations can also be made to address the challenges of using 3D manuals. For example, addressing the respondents' concern about the accuracy of 3D maintenance manuals might mean 3D maintenance manuals can be implemented as a complement to the paper-based or printed manuals. Text and animations can be used together at the beginning stages of 3D maintenance manual use. Then, when inaccurate information is found while using 3D maintenance manuals, programmers can update and correct it to improve the manuals' efficiency and accuracy. With regard to another challenge, 3D manuals are not easily taken to maintenance jobsites, because hardware support is required. However, the 3D maintenance manuals can be displayed by small and portable electronics, such as smart phones and tablets. These electronics can be more easily taken to the maintenance work sites. Lastly, regarding the challenges of the cost of 3D manual development, cooperation and information sharing among airlines, aircraft manufacturer and aviation authorities could reduce the cost to some extent of 3D maintenance manual development and updates as compared to relying on one entity.

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Appendix

Survey Questions for Study Participants

1. Please comment on the benefits of paper manuals in your operation.

请简述纸质版维修手册的优点。

2. Please comment on the issues (drawbacks) with using paper manuals in your operation.

请简述纸质版维修手册存在的问题（劣势）

3. Do you have experience with alternative media for aviation maintenance information sharing? If yes, please elaborate.

你是否接触过其他形式，非纸质版的维修文件。如果有，请详细说明

4. Please comment on the benefits and challenges of 3D manuals for the aviation maintenance community for the purpose of EDUCATION/TRAINING.

请说明3D维修手册在教育或者培训方面的优势和挑战

5. Please comment on the benefits and challenges of 3D manuals for the aviation maintenance community for the purpose of EFFICIENCY?

请说明3D维修手册在维修效率方面的优势和挑战

6. Please comment on the benefits and challenges of 3D manuals for the aviation maintenance community for the purpose of EASE OF USE.

请说明3D维修手册在易用性方面的优势和挑战

7. Overall, do you feel the incorporation of 3D maintenance manuals to aviation operations is worth pursuing?

总体来讲，你是否认为3D维修手册在航空产业的应用是有意义的?

8. Please provide any additional comments relevant to the development and use of 3D maintenance manuals in aviation.

请针对3D维修手册在航空产业的应用和开发，提出其他相关的意见和建议。

Management and Employee Perceptions of Fuel Conservation Programs within a U.S. Supplemental Air Carrier

Jack E. Troutt III, Timm J. Bliss, and Chad L. Depperschmidt
Oklahoma State University

Abstract

As fuel prices continue to remain a major cost factor to air carriers around the world, steps must be taken in order to reduce the amount of jet fuel that a carrier utilizes on a daily basis. Air carriers; therefore, must try to maximize any fuel conservation program that they might have. In order to do this, a better understanding of employee perceptions with regards to these types of programs would be beneficial. The purpose of this study was to understand the perceptions that employee groups (operation and maintenance) have about fuel conservation programs utilizing a mixed method approach. A Likert scale based series of questions that was distributed in an anonymous survey gathered quantitative data, while a series of open ended questions gathered qualitative data during the completion of the same survey. Additionally a series of open ended questions was also asked of several members of a fuel conservation committee. Four research questions were identified and utilized in order to better guide the findings of the study using various statistical techniques. This study found that; generally management employees had a positive perception of fuel conservation programs, non-management employees had a slightly less positive perception about the programs, and there was no discernible difference between maintenance and operation employee's perceptions. Additionally, several trends were identified that indicated their importance in this fuel conservation program: data, ideas, communication, trust and incentive.

Introduction

In the summer of 2008, the world economy saw unprecedented challenges to growth and prosperity. Market indexes took substantial hits in terms of value from such pressures as the housing crisis, bankruptcy of several large scale financial firms, and the drop in demand for consumer goods. The largest challenge, however, was the meteoric rise of the cost of unrefined oil, and equally, the cost of oil derived fuel (Energy, 2009). For their part, companies that are vulnerable to rises in energy costs saw immense pressure from these rises in prices. Air carriers were particularly sensitive to fuel costs and the effect those costs had to their bottom line. Jet fuel prices can consume up to 30% of an air carrier's operating costs, so any increase in the raw cost of fuel puts negative pressure on an air carrier's profitability (Energy, 2012).

Logically, the focus was turned towards strategic ways that air carriers could actually decrease fuel usage. Just as a person might try various things to get the most out of a tank of gas for their car, air carriers tried to maximize their fuel by looking at ways of reducing their fuel consumption (United Parcel Service, 2013). While it may hold true that most air carriers had some sort of fuel conservation programs in place before the summer of 2008, these programs took on new importance in the high cost for oil environment that air carriers found themselves in.

The issue that arises with fuel conservation programs is that they depend on the full participation of the personnel required to implement the programs on a daily basis in order to maximize effectiveness and gain the most savings for the carrier. Airline employees must perceive that any fuel conservation program is in their best interest as well as in the best interest of the airline in order to fully participate in the program. If employees perceive the benefit of a fuel conservation program, they are more likely to be more dedicated to its functions ensuring a higher level of effectiveness. Companies have been concerned about the attitudes and perceptions of their employees for decades as exhibited in the Hawthorne Studies at Western Electric (J. Wilensky; H. Wilensky 1951). Other studies such as those by Victor Vroom have found that if workers do not want to participate in a program due to psychological factors such as worker's attitudes and expectations then the programs would suffer (Sashkin, 1984). Studies also indicate that job attitudes and participation are related in decision making in regards to workplace programs (Cotton, Vollrath, Froggatt, Lengnick-Hall, Jennings, 1988).

The purpose of this study was to identify the perceptions of fuel conservation programs among airline operation and maintenance employees directly tasked with completing daily performance activities that impact fuel conservation programs. Additionally, the perceptions of airline management supervising fuel conservation programs were also identified in this study. Identifying the perceptions by both air carrier employees and managers regarding their fuel conservation programs can lead to efforts to make fuel conservation programs more efficient and successful by identifying underlining differences and negative perceptions. In addition, corrective steps could be implemented to ensure the efficiencies of the fuel conservation program are maintained daily by all airline personnel directly involved in the program.

Research Methodology

The study utilized a mixed method methodology that was delivered in the form of an anonymous survey and a series of interview questions. The mixed method style of research enables narratives to be added to studies that traditionally have only had quantitative data, giving a greater picture of the studied subject (Hesser-Biber, 2010). Furthermore, mixed method research considers "multiple viewpoints, perspectives, positions, and standpoints" when trying to understand the subject being studied (Johnson, Onwuegbuzie, Turner, 2007). In a survey-type instrument, a mixed method study can accurately illustrate both qualitative and quantitative study by using techniques such as a series of Likert statements and open ended questions. The Likert statements can establish a quantity to any perceptions that employees might have about a fuel conservation program, while a series of open ended questions can establish a qualitative narrative in which a subject can better illustrate their feelings on such programs. Once developed, the survey was distributed to operation and maintenance personnel and their supervising managers at an Oklahoma-based air carrier. Additionally, a series of four interview questions were administered to several members of the fuel conservation program's oversight committee at the same air carrier. The oversight committee were not administered the survey. The interview questions were designed to illustrate the team members' perceptions of what a fuel conservation program is comprised of while also gaining their perception on several additional aspects of conservation programs such as employee engagement. A trend analysis was conducted on these questions to identify and better understand the reoccurring themes regarding the individual perceptions of fuel conservation programs.

Population and Sample

The air carrier chosen for this investigation is a non-scheduled aircraft charter company based in Oklahoma. Major business partners that charter aircraft from the company include governmental agencies, other scheduled air carriers that are in need of additional aircraft and service within their own operations, or private charters such as large groups of businesses or sports personnel. This unique type of flying prevents a long term forecast of business; therefore costs must be kept to a minimum in order for the company to remain profitable. Thus, a fuel conservation program is vital in order to remain competitive in contract bidding and also to reduce overall expenses of operation.

The premise for this study was developed at the beginning of this air carriers' fuel conservation program. At the start of 2013, the carrier decided to establish a fuel conservation program at the behest of one of its long-time contracts. At the same time, an oversight committee was created to oversee the fuel conservation program. Initial program implementation within the employee groups began in February 2013. The study was conducted during the June and July 2013 timeframe, approximately six months after the initial dissemination of the fuel conservation program at the airline. Permission to perform this research study was approved by the Institutional Review Board at Oklahoma State University (IRB application number: ED1319).

The sample population for this study included the entire group of pilots and mechanics, including managers, employed at the air carrier. Additionally, members of the fuel conservation committee were interviewed to understand the perceptions of individuals that were in charge of making strategic decisions for the company's program.

The following research questions set the basis for determining the perceptions about fuel conservation programs within this air carrier.

Research Question 1: What is the perception of fuel conservation programs with regards to airline management (managers) tasked with program implementation?

Research Question 2: What is the perception of fuel conservation programs among airline operation and maintenance personnel directly tasked with completing daily performance activities that impact fuel conservation programs?

Research Question 3: What are the differences, if any, between the perceptions of airline management and the operation and maintenance employees?

Research Question 4: What is the perception of fuel conservation programs among members of the fuel conservation oversight committee?

Research Instrument

The population for the research instrument was operation and maintenance employees and their managers within the air carrier based in Oklahoma. Electronic mail (e-mail) was sent to all potential participants utilizing company e-mail addresses. Within this e-mail was a link to a web site that housed the survey along with a password that the participants needed to access the survey. The link contained in the e-mail was anonymous, so no identifying information was collected about the participant or the computer that was utilized to take the survey. The population group for the survey consisted of 263 employees that included all operation and maintenance employees directly related to the airline's fuel conservation program.

Interview Instrument

The population sample selected for the interview portion of the study was members of the fuel conservation oversight committee. A total of eight individuals were purposely selected by the researchers for their diverse professional backgrounds and assigned responsibilities for the air carrier; including finance, maintenance, operation, pilots, training, and executive management.

Reliability and Validity

The Likert-scale statements listed in the research instrument were analyzed for reliability by using Cronbach's alpha. Cronbach's alpha is a general formula for estimating internal consistency based on a determination of how all items on a test to all other items and to the total test (Gay, Mills, & Airasian, 2006). George and Mallery (2003) have established the following Cronbach's alpha acceptance scale: " - > .9 – Excellent, - > .8 – Good, - > .7 – Acceptable, - > .6 – Questionable, - > .5 – Poor, and - < .5 – Unacceptable" (p. 231). An alpha coefficient is generally regarded as one of the most used scales of reliability due to its ease of interpretation and objectiveness (Yang & Green, 2011). Calculated alpha's approach 1 as the reliability increases, with .8 or higher being regarded a good value for the alpha (Peterson, 1994). Cronbach & Meehl (1955) states that "content validity is established by showing that the test items are a sample of a universe in which the investigator is interested" (p. 282).

Content validity for the Likert-scale statements was assured by forwarding the survey to several aviation/airline professionals for review. These suggestions were incorporated into the final research instrument.

Presentation of Data and Analysis

Data for the survey instrument was collected utilizing the Qualtrics system of on-line survey software. This software enabled e-mails to be sent to all potential participants at the airline. E-mails were sent to the complete group of 185 pilots (operation) and 78 mechanics (maintenance) employed by the air carrier for a total of 263 potential participants. Of these potential participants, 53 followed the link to the research instrument. One person did not agree to the information disclosure at the start of the survey; resulting in 52 completed responses and a 20% response rate (Table 1). This response rate, while possibly not providing the definitive answers that other air carriers might desire, provided enough information to offer generalized statements and judgments regarding any current or future fuel conservation program.

Table 1

Summary of Response Rates

Department	Potential Participants	Actual Responses	Response Rate
Maintenance	78	17	22%
Operation	185	35	19%
Total	263	52	20%

The first demographic question contained in the survey asked the participants to list their position within the airline. The second demographic question asked participants to identify which department (operation or maintenance) they worked for within the airline. Of the fifty-two participating respondents, the majority indicated that they worked in the operation department (76%, N=35) and the remaining participants indicated that they worked in the maintenance department (33%, N=17). The third demographic question asked participants if they held a management position within the airline. Only thirteen percent (13%, N=7) of the total participants indicated they were managers. The next demographic question asked the participants how long they have been employed at the airline. Twenty participants (38.5%, N=20) indicated they had been employed less than five years. The majority of participants (44.2%, N=23) indicated they had worked at the air carrier between five and ten years and a smaller percentage (17.3%, N=9) indicated that they had worked at the air carrier for over eleven years. The maximum time that an employee had worked at the air carrier was fifteen years. The final demographic question asked participants to indicate the total number of years they have been employed in the air carrier industry. The smallest percentage of participants (19.2%, N=10) indicated that they had less than ten total years of experience in the air carrier industry; whereas, 30.8% (N=16) indicated they had between ten to twenty years of experience. The largest percentage of respondents indicated they had twenty one years or more of industry experience (50%, N=26).

Survey Likert Scale Responses

A total of 11 Likert scale statements were presented to the participants (Table 2).

Analysis of Likert Statements

Regarding the Likert statements, the Cronbach's alpha was analyzed using the IBM SPSS software. Using data results from all participants, the reliability of the instrument was found to have an alpha coefficient of .807. According to George and Mallery (2003), the internal reliability of the instrument would be rated good. To better understand the relationship between the department variable and the Likert statements, a Pearsons correlation was computed utilizing the SPSS statistical software. Only one Likert statement, statement 10, exhibited a significant correlation between the variables. When the Likert Statements were correlated with the management variables utilizing the SPSS software, there was a significant correlation with 6 of the 11 Likert statements.

Survey Open Ended Question Responses

Question 1: On a daily basis, what job functions do you perform that are directly related to your airline's fuel conservation program?

By asking the participants what daily activities they perform that can impact their fuel conservation program, several threads developed as far as the perceived importance regarding fuel conservation. The management employees (managers) were generally more elaborate as responses included "data analysis and communication," "overseeing mission planning and aircraft schedules," "engine run and taxi operations," and "development of all training curricula, elements, and courseware for all pilots, flight attendants, and dispatchers." Responses from the managers were also more specific. Non-management participants were more simplistic in their responses. 18% (N=8) of non-management participants indicated they operated some form of equipment, including the aircraft.

Table 2

Summary of Likert Statement Responses

	Likert Statement	Strongly Disagreed	Disagreed	Agreed	Strongly Agreed	Total
1	I am aware of my airlines fuel conservation program.	0	4	23	25	52
2	A fuel conservation program is important to my airline.	1	1	25	25	52
3	My airline's fuel conservation program is important to me.	1	4	28	19	52
4	It is important that I consider fuel conservation strategies' when performing my daily job functions.	0	4	29	19	52
5	My perceptions (attitudes, mental image) about my airline’s fuel conservation programs should be very important to the executive management team.	0	2	24	26	52
6	It is important that all employees are adequately involved with any fuel conservation program.	1	4	20	27	52
7	My airline sought my professional input in the creation of its fuel conservation program.	14	17	12	9	52
8	My airline utilized my input in the creation of any fuel conservation program.	20	18	9	5	52
9	Given an opportunity, my airline should listen to any new input I provide about my airline’s fuel conservation program.	0	5	26	21	52
10	Airline employees’ continued input regarding an existing fuel conservation program is important to my airline.	7	9	19	17	52
11	Over time, the fuel conservation program at my airline will positively impact my financial future (profit sharing, wage increase, stock price).	23	8	13	8	52

Question 2: As an employee, do you feel that you are adequately involved in your airline's fuel conservation program? Why or why not?

This question focused more directly on a participant's perceived importance regarding the air carrier's fuel conservation program. Although they were not prompted to do so, most participants replied to the first part of the question either with a yes or no response, and then elaborated on why they indicated as such. In response to this question, 85% (N=6) of management participants indicated that were adequately involved in the fuel conservation program. Non-management participants' results for this question were more varied than the management participants. However, 53% (N=24) of non-management participants did not respond favorably to the question. Several negative responses tried to give logical reasoning for their perceived non-involvement with responses that included "no because of time constraints." Responses also indicated a lack of trust between those in management positions and those operating the equipment.

Question 3: If given the opportunity, what fuel conservation ideas would you bring to the company's attention to improve your airline's overall fuel conservation program?

This question sought fuel conservation ideas that the participants perceived could be brought to the air carrier's attention. Management employees indicated several ideas. Two of the managers indicated that better tracking of the data was needed by responding "better tracking of fuel use," and "find a way to improve the quality and accuracy of the data that is being used to make decisions." Two other management participants indicated that better ground equipment should be made available, stating "better supply and use of ground power units and AC units," and "AC carts and heat carts for the airplanes are mostly junk everywhere you go." Non-management participants were varied in their responses. Several agreed with management participants on the usage of ground power instead of aircraft systems. Other statements suggested practices such as reducing weight and better flight planning through techniques such as "better attention to efficient routings; and the usage of the auxiliary power unit as an area that could be improved in order to better the fuel conservation program. Other non-management participants indicated that an incentive program would be beneficial to the air carrier's fuel conservation program, making statements such as "incentivize the program," "happy employee is an efficient employee," and "I believe to make the program really work there needs to be an incentive program in place."

Question 4: What ideas, if any, could be implemented to improve the communication and involvement between employees and management with regards to fuel conservation programs?

The final question was included to better understand the participant's perception of the relationship between management and employees at the air carrier. Among management participants, 85% (N=6) indicated that communication of some sort was needed to improve the relationship between them and employees. As with the management participants, communication was an important topic for non-management participants; 46% (N=21) cited communication or some form of input/feedback system in their response to this question. Responses indicating this included "discussion board on the company website," "ensure communication avenues are kept open and encouraged," and "any communication would help." However, 15% of the non-management participants indicated that there was nothing that could be done to improve relations with the air carrier.

Interview Instrument

To gain further management insight into fuel conservation programs, a series of four interview questions were asked to membership of the air carrier's fuel conservation program committee.

Question 1: What constitutes (procedures/processes) an effective fuel conservation program?

Most participants initially indicated in their response that what is commonly referred to as "buy in" among the employee groups was the most important part of an effective fuel conservation program. Two other committee members suggested that having a data-oriented program would be the most important process; one stating, “if you don't know what you are looking at, you don't know where to go."

Question 2: What are the benefits of a fuel conservation program?

Every participant that was interviewed cited some sort of “financial savings” when it comes to the benefit of a fuel conservation program. Several participants also cited the weight savings on carrying less fuel, which in turn meant the air carrier, could carry additional revenue generating payloads. Another mentioned benefit was that the equipment on the aircraft would be used less and at a lower intensity; thus saving the air carrier money regarding maintenance costs.

Question 3: What are obstacles to a fuel conservation program?

As the previous question dealt with the benefits, it was necessary to also investigate the obstacles. Again, several participants indicated that "buy-in" from the various employee groups was one of the biggest obstacles to a fuel conservation program. Other obstacles included ensuring that the data being collected is accurate, as one participant stated, "majority of the obstacles are making a determination of what your baseline is."

Question 4: How important is employee engagement to an airline's overall strategy regarding a fuel conservation program?

Committee responses included: "it's paramount," "if the workforce is not engaged and supportive of the program, the program will not be successful," and "the more people that are on board with it, the better the chances are that it is going to be successful."

Findings

When the data for the Likert statements between maintenance and operation employees was separated, the results were similar for both groups. After the Likert statements were transferred into an ordinal series, any mean greater than 2.5 indicated that more individuals agree with the statement than disagree. For both groups, the mean for most statements was over 3.0; indicating both operation and maintenance employees agreed with the statements.

Notable exceptions to the mean value, greater than 2.5, were the statements "my airline sought my professional input in the creation of any fuel conservation program" (maintenance mea = 2.35, operation mean = 2.29), "my airline utilized my input in the creation of any fuel conservation program" (maintenance mean = 2.12, operation mean = 1.91), and "over time, the fuel conservation program at my airline will positively impact my financial future (profit sharing, wage increase, stock price)" (maintenance mean = 2.47, operation mean = 1.94). Another notable result was the difference in means between the maintenance and operation employees with regards to statement 10, "airline employees' continued input regarding an existing fuel conservation program is important to my airline." The mean of the operation employees' responses was only 2.69 for this statement, while maintenance employees generally agreed with the statement with a mean of 3.29.

When the Likert data was further differentiated between management and non-management employees, a few more differences emerged. Management participants generally agreed with all Likert statements, as the mean for all management responses was over 2.5; however, several differences emerged with the non-management employee's data. Several statements resulted in non-management responses below 2.5. These included "my airline sought my professional input in the creation of its fuel conservation program," "my airline utilized my input in the creation of any fuel conservation program," and "over time the fuel conservation program at my airline will positively impact my financial future (profit sharing, wage increase, stock price)." The mean for these statements with regards to non-management employees was 2.18, 1.82, and 1.98 respectively.

Open Ended and Interview Questions

Both survey open ended questions and the interview questions were analyzed utilizing trend techniques in order to discover any similarities within the responses. After analyzing this qualitative data, five trends emerged from the responses to both open ended questions and interview questions. These trends were: (1) data, (2) trust, (3) incentives, (4) ideas, and (5) communication.

The importance of data emerged as an important trend; particularly, data driven themes emerged from survey open ended questions three and four, along with interview questions one and three. Several participants identified having a data-oriented program as important with statements such as “improve the quality and accuracy of the data that is being used to make decisions”, and “aircraft generated data with dispatch planning.” Additionally 50% of the interviews identified data as being a key part of a fuel conservation program.

The trend of ideas and the importance of those ideas also emerged among the open ended data and the interview data. The importance of ideas emerged from statements made in response to open ended questions two, three, and four, as well as interview questions one, three, and four. Statements from participants included, "this is an ongoing program that continues to develop and as ideas are presented they are evaluated for future implementation," as well as suggestions such as "better technology (company website to input ideas)." Interview responses also indicated that the need for ideas to be received and evaluated was extremely important.

Communication developed as one of the most prevalent trends within the data. Every open ended survey question had responses that dealt with communication. Also, interview question four had several responses that dealt with communication. A total of 17 survey responses included a direct reference to communication. However, the majority of these responses had a negative connotation with regards to overall communication at the air carrier. Interview responses were less direct with regards to communication, but the importance was stated as well.

Trust was first breached in open ended question two but was also discussed in questions two and three. The majority of responses indicating a lack of trust came from the non-management employees. The importance of trust was also communicated in the interviews, but typically in a more positive format.

The final trend that emerged within both the open ended survey questions and the interviews was the concept of an intrinsic incentive. Several participants responded that an incentive would aid in the implementation of the fuel conservation program. The survey responses with regards to incentives were typically recorded in open ended question four. Interview participants’ responses illustrating the trend of incentives also emphasize the importance for such motivators regarding a fuel conservation program.

Results Interpretation

Given the similarities between both the responses given in the survey, along with the data collected during the interviews; several conclusions can be drawn regarding the fuel conservation program at the air carrier with respect to the four research questions.

Research Question 1: *What is the perception of fuel conservation programs with regards to airline management tasked with program implementation?*

Management responses to the survey questions in both the Likert and open ended questions were generally positive. The calculated mean for the majority of the management responses to the Likert statements was over 2.5, indicating that management participants, on average, agreed with the statements. Also, management participant responses to the open ended questions were positive, with several responses indicating adequate involvement and positive relationships with employees about the conservation program.

Research Question 2: *What is the perception of fuel conservation programs among airline operation and maintenance personnel directly tasked with completing daily performance activities that impact fuel conservation programs?*

While there were differences between both the maintenance and operation groups at the air carrier, these were comparatively small. The only Likert statement that both groups disagreed with each other with any great significance was the statement "Airline employees' continued input regarding an existing fuel conservation program is important to my airline." The mean value for this statement was still above 2.5 for both operation and maintenance employees, meaning the majority of participants still agreed with the statement. However, both groups disagreed and agreed with the other Likert statements relatively equally. This indicates that, as the majority of responses agreed with the Likert statements, the employees had a positive perception of the fuel conservation program.

Research Question 3: *What are the differences, if any, between the perceptions of airline management and the operation and maintenance employees?*

Differences between management and non-management responses were noticeable, but as with the operation and maintenance responses, three differences emerged that centered on the trends of communication, ideas, and incentive. Management participants agreed, on average, with all Likert statements, while non-management participants would disagree with the same three Likert statements that were previously mentioned. The responses collected from the open ended question established the importance of the trends of data and trust.

Research Question 4: *What is the perception of fuel conservation programs among members of the fuel conservation oversight committee?*

Research question four sought to understand the perceptions of the oversight committee in charge of the fuel conservation program. The responses from the oversight committee members were similar to statements given during the survey instrument open ended questions from both management and non-management participants. In general, all committee members expressed a positive perception of the fuel conservation program, which is logical.

Conclusion

This study revealed that while the perceptions of the fuel conservation program at the air carrier were generally positive, there emerged five trends that any potential air carrier could focus on in order to gain the full benefit of their fuel conservation program. This result was reinforced by the interviews that were performed in conjunction with the survey. However, as the research also revealed, while all members of the fuel conservation program agreed on several aspects such as the trends mentioned previously, if a carrier fails to listen and implement those practices that maximize these trends, then the fuel program cannot operate as effectively and efficiently.

Air carriers will need to understand that it is not enough to simply implement a plan for fuel conservation and then do nothing else for the program, and expect that the program will operate efficiently. While it is true that most employees will perform their job functions as instructed, employees must be engaged in order to maximize any action asked of them. The data results provided in this study indicated that the concepts of data, ideas, communication, trust, and incentives must all be utilized to better involve employees within the air carrier’s fuel conservation program.

In the end though, it is the amount of desire to save fuel that will drive a carrier's fuel conservation program implementation. A carrier will have to be properly motivated at the management level to implement the program, and will have to transfer that motivation to its various employee groups. If this motivation is missing from either the management or employees to fully implement the program, then any air carrier’s fuel conservation program will suffer as a result.

Implications and Recommendations

The potential benefits from this study include the ability to tailor fuel conservation programs to better maximize employee participation and improve perceptions of the program. As noted in this study, while there was a general positive attitude towards the fuel conservation program, there were still areas of improvement. These areas of improvement could fall along the five trends of data, ideas, communication, trust, and incentives as identified in the results of this research study.

As the air carrier industry continues to deal with higher fuel prices, and the constant concern for further fuel price increases; steps must be made to maximize any fuel savings that an established fuel conservation program can provide to the carrier. Additionally, if an air carrier is thinking about establishing a fuel conservation program, attention should be given to these five trends before presenting their program to the employee groups that will be tasked to implement the program.

Based on the results of this study, the following recommendations are suggested for action. In order for air carriers to implement the most effective fuel conservation program, they should attempt to maximize the amount of accurate data regarding the fuel conservation program; constantly seek, consider, and implement new ideas into the program; communicate the goals and purpose of the program to the various employee groups; build the trust of those that are implementing the program on a daily basis; and offer an incentive to those that are executing the program in order to keep a positive attitude.

For any air carrier that has a fuel conservation program already established, the carrier should attempt to understand the perceptions that the employees have regarding the program. Attention should be focused to the areas of communication, trust and incentives. The air carrier should try to foster an environment where any and all communication, even negative communication, is welcomed and considered. If the carrier is only welcoming to positive communication, the trust aspect of a fuel conservation program will suffer.

To better foster the trust aspect, as well as keeping communications open, anonymous avenues like the survey utilized in this research should be considered. If employees feel that their communication is confidential, they will be more forthcoming with their opinions and ideas. This openness will build trust in the program. Another option for building employee trust in the program is to encourage management to talk directly with the employees implementing the program. This should be done either through direct face to face communication, or if employees are in a different location than the management employees traveling to the various employee locations in order to build the trust in the employee groups so the fuel conservation program management understands the employees concerns and relays the goals and intent of the conservation program.

Finally, any air carrier that seeks to maximize their program should consider offering incentives to the employees that are implementing the program effectively. Incentives can be financial benefits such as profit sharing or related bonuses, or even the simple act of recognizing top performers within the program in a company newsletter or other widely disseminated document. When employees see and understand that the company appreciates the employee actions with regards to the fuel conservation program, the employees as a whole will understand that it is important and will hopefully implement the program to the upmost of their ability.

The scope of the study was limited to one air carrier operating within the U.S. As such, to increase the applicability to the entire population of air carriers operating within the U.S., serious consideration should be made to perform further research at other air carriers. Hopefully, any further study would include larger air carriers, as the total population for the air carrier where the study was preformed was only 263 potential participants. Surveying a major Group III carrier such as those defined by the U.S Department of Transportation would enable a better understanding of the perceptions of fuel conservation programs among the entire population of U.S. air carriers (Suissa, 2012). Additional studies at other carriers would also aid in the validation of the questions and statements utilized in the survey instrument.

Another limitation of the study was the small sample size of the population. Only 52 individuals participated in the survey instrument for a total response rate of 20%, and only eight individuals were interviewed for the additional management/oversight committee perspective. As such, the results of the study should not be considered the potential complete data set of the perceptions of the entire employee group that is involved with the fuel conservation program at this air carrier. The researchers believe a contributing factor to the low response rate could be attributed to the reluctance of employees to indicate negative perceptions of a fuel conservation program implemented by their employer. Therefore, if potential respondents to this study were not supportive of fuel conservation programs or adequately understood their importance, they may have been reluctant to participate in this study.

This study did not include any research into the actual practices and procedures of a fuel conservation program. To best understand what actual fuel conservation practices, such as flying at different altitudes or using the auxiliary power unit less, make for a more effective program, further research consideration should be given to the practices that make up any fuel conservation program in order to establish the best practices for a conservation program. Only once these practices have been documented and calculated can a fuel conservation program truly be validated as the most efficient one possible.

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Interaction of Weather and Other Contributing Factors in General Aviation Instrument Approach Accidents

Julius C. Keller, Micah S. Walala, and Richard O. Fanjoy
Purdue University

Abstract

General aviation accidents continue to be a concern for the Federal Aviation Administration. The purpose of this study was to identify the primary and secondary contributing factors of general aviation instrument approach accidents between the years of 2004-2014; identify the weather conditions of these accidents; and test for an association between the contributing factors and weather conditions during the accidents. Findings suggested that 'Failure to Control' and 'Adverse Weather' were identified as the leading causes of accidents during instrument flight rules operations while 'Failure to Control' and 'Flight Below Published Minimums' were the leading causes of accidents during visual flight rules. A Chi-square test of the data indicated a significant association between weather conditions and reported contributing factors with a moderate level of strength.

Introduction

On September 15, 2012, a U.S. registered Cirrus SR 22 airplane operating in instrument meteorological conditions (IMC) was cleared for an instrument landing system (ILS) approach. A few minutes after acknowledging a frequency change, radar tracking showed the airplane off course by 0.25 miles. The pilot then aborted the approach and requested vectors to attempt a second approach during which radar tracking showed the aircraft drifting back and forth across the localizer centerline by 0.25 miles. The airplane eventually began a flight path parallel to the localizer, 0.12 miles off centerline. The airplane then entered into a left turn which continued until the final data radar point. Additional data indicated the airplane descended at an average of 6,000 feet per minute before it impacted a wooded area six miles northwest of the destination airport killing the pilot and all four passengers. National Transportation Safety Board (NTSB) investigators suggested spatial disorientation experienced during night IMC led the pilot to lose control of the airplane (ASI, *n.d.*a).

According to the accident report, the pilot had an estimated 1,000 total flight hours including 75 hours of actual instrument time and approximately 650 hours in the make and model of the accident aircraft. Weather conditions recorded by the local Automated Surface Observing System (ASOS) indicated 8 miles of visibility and overcast clouds at 700 feet above ground level (AGL). Although the pilot filed an IFR flight plan, there was no record of a weather briefing associated with the accident aircraft tail number. During the period 2004-2014, one hundred and thirty- four general aviation (GA) instrument approach accidents occurred of which approximately 70% were fatal. (ASI, *n.d.*a*.)*.

Purpose of Current Study

General aviation includes all flight operations except air carrier scheduled service (Part 121), non-scheduled air transport flights (Part 135) and military (FAA, 2008). This sector of aviation represents one of the FAA's last unresolved safety areas. Consequently, the FAA has created a five-year plan to improve safety in GA through four main approaches: risk management, outreach and engagement, safety promotion, and training. Risk management entails effective identification of risks and application of mitigating solutions. One of the FAA's methods to reduce accident rates is by collaborating with industry to study accident data and use it to identify risky patterns (FAA, 2011). The approach and landing phases of flight account for the highest number of GA accidents (FAA, 2010a).

The purpose of this exploratory study was to identify contributing factors of GA accidents during the instrument approach phase; classify the weather conditions related to these accidents; and determine whether there was a significant association between contributing factors to accidents and weather conditions. Identifying such relationships can assist the aviation research community to understand how weather can influence the type of errors that result in accidents. This can lead to further research that investigates mitigation strategies to improve GA safety.

Literature Review

Causes of GA instrument approach accidents include: ineffective or non-existent crew resource management (CRM), adverse weather and physiological factors (FAA, 2009; FAA, 2012; Gibb, Ercoline & Scharff, 2011; Price & Groff, 2006). Methods for categorizing causes of GA accidents have included Human Factors Accident Classification System (HFACS) (Wiegmann et al., 2005) and examining probable causes retrieved from accident reports (Fanjoy & Keller, 2013).

According to the FAA (2009a), a GA flight is more likely to operate with a single pilot rather than a multi pilot crew. CRM was designed to reduce human error by increasing performance and coordination (FAA, 2004). The absence of an additional pilot may partly explain why the GA accident rate has not shown significant improvement over the last decade. In contrast, the Air Carrier accident rate has decreased by 80% (NTSB, 2012). Results of an 8-year study conducted by Price & Groff (2006) indicated a multi-engine turbo-prop aircraft with a single pilot was 1.6 times more likely to be involved in an accident when encountering visually degraded conditions when compared to a multi-crew operation in the same type of aircraft.

An FAA study (2012) carried out 26 interviews of GA pilots that requested for help, initiated an emergency or made an alteration while encountering declining or extreme weather conditions. Weather conditions at the time of the incident were also examined and analyzed. Results from that study indicated a shortfall in education and training when pilots were tasked with interpreting weather information. The study recommended all pilots undergo additional weather training by authorized instructors.

A method to investigate causes of GA accidents is classification of errors. Wiegmann et al. (2005) used HFACS to analyze GA accidents. The study suggested that skilled based errors contributed the most to accidents followed by decision and perception errors. Poor procedures and instructions were the major latent causes of these accidents. The study recommended increased use of aircraft automation, improved checklists, and workload management training as measures to reduce future accidents. Thus HFACS has enabled adoption of more relevant intervention measures to reduce errors and safety hazards.

An FAA study (2010b) categorized GA weather related accidents as resulting from skill based, decision and perceptual errors. The study noted that skill-based errors were the hardest to understand because in fatal cases, it was often difficult to capture the exact causes. In addition, pilots who survived might have a propensity to alter the facts associated with the accident if they felt their statement could cause self-incrimination. It was also noted, instrument rated pilots were often susceptible to becoming overconfident in their abilities and likely to fly into conditions beyond their capabilities.

Spatial disorientation plays a significant role in GA accidents but has not been adequately addressed. Thirty percent of GA accidents are caused by spatial disorientation and those have nearly a 100% fatality rate. Further research is needed to develop a more effective reporting process, data analysis, and appropriate mitigating strategies (Gibb, Ercoline & Scharff, 2011).

An exploratory study conducted by Fanjoy and Keller (2013), used the ASI database to investigate the relationship between primary causes of instrument approach accidents and instrument proficiency checks (IPC). Results suggested more than half of the instrument approach accidents examined occurred within three and half months of the last IPC. A leading cause of these accidents was failure to control the aircraft. Further investigation into IPC training procedures and requirements was suggested.

Methodology

Researchers for the current study used the Air Safety Institute accident database to acquire data from GA instrument approach accident reports collected over the last ten years. Researchers then performed a filtered search to obtain all fixed wing accidents that occurred while on an instrument approach, resulting in 134 data sets. From these accident reports researchers obtained information which included: accident report number, weather conditions, phase of flight, type of approach, and primary and secondary causes. Next, researchers sorted the data by weather conditions reported at the time of the accident. Some airports did not have weather observation facilities on site. In these cases, secondary weather information was used. The secondary weather information was either recorded from a nearby weather observation station or a weather report collected by the accident investigators. The reports obtained from the ASI database are identical to the official NTSB reports.

Categorization of Weather Minimums

The FAA (2009b) defines and categorizes VFR and IFR weather minimums as follows; low instrument flight rules (LIFR), instrument flight rules (IFR), marginal visual flight rules (MVFR) and visual flight rules (VFR). Researchers used these definitions to categorize weather observations for each data set. These weather categorizations can be viewed in Table 1.

Table 1

Weather Categories

Category	Ceiling (AGL)		Visibility (SM)
VFR	Greater than 3,000 feet AGL	and	Greater than 5 miles
MVFR	1,000 to 3,000 feet AGL	and/or	3 to 5 miles
IFR	500 to 999 feet AGL	and/or	1 mile to less than 3 miles
LIFR	Below 500 feet AGL	and/or	Less than 1 mile

Note: VFR and IFR weather categories. Adapted from "General aviation pilot's guide to preflight weather planning, weather self-briefings, and weather decision making" by Federal Aviation Administration, 2009, p. 29.

Categorization of Contributing Factors

Researchers categorized primary and secondary causes of accidents by using the language found in the accident causes section of the report. Twenty-one categories from the data analysis emerged as the data was analyzed. However, researchers decided to reduce the categories to twelve by combining specific categories. This was done because some categories were similar and/or had a small frequency of occurrence. 'Failure to Follow Published Approach Procedures' includes failure to execute missed approach, 'Failure to control" includes failure to establish approach and 'Situational Awareness' includes controlled flight into terrain. 'Aeromedical Factors' includes fatigue, medical and drugs. 'Lack of Oversight' includes inadequate oversight of air traffic control (ATC), inadequate oversight of FAA, inadequate standard operating procedures (SOP's), inadequate organizational oversight and failure of captain duties. 'Other' includes failed equipment, misuse of automation, undetermined reasons and violations. Table 2 shows the final listing of categories and abbreviations. Reference these abbreviations for figures two through six.

Table 2

Categorization of contributing factors

Aeronautical Decision Making (ADM)	Improper Airspeed (A/S)
Adverse Weather (AW)	Lack of Oversight (LOO)
Aeromedical Factors (AF)	Other (Other)
Failure to Control (FTC)	Situational Awareness (SA)
Failure to Follow Published Approach Procedures (FFPAP)	Spatial Disorientation (SD)
Flight Below Published Minimums (FBPM)	Weather Below Published Minimums (WBPM)

Findings

A search of the ASI database produced 134 GA accident reports that happened between 2004 and 2014. Eight data sets were removed. Five of the eight omitted accidents involved airplanes registered outside of the United States. Consequently, these five accidents did not have comprehensive accident reports as the investigations were outside the NTSB's jurisdiction. The remaining three omitted accidents had insufficient information to be considered usable. Therefore, the data set of interest for this study is (N=126). Of the 126 accidents of interest, their frequencies and categories of weather conditions are graphically presented in Figure 1.

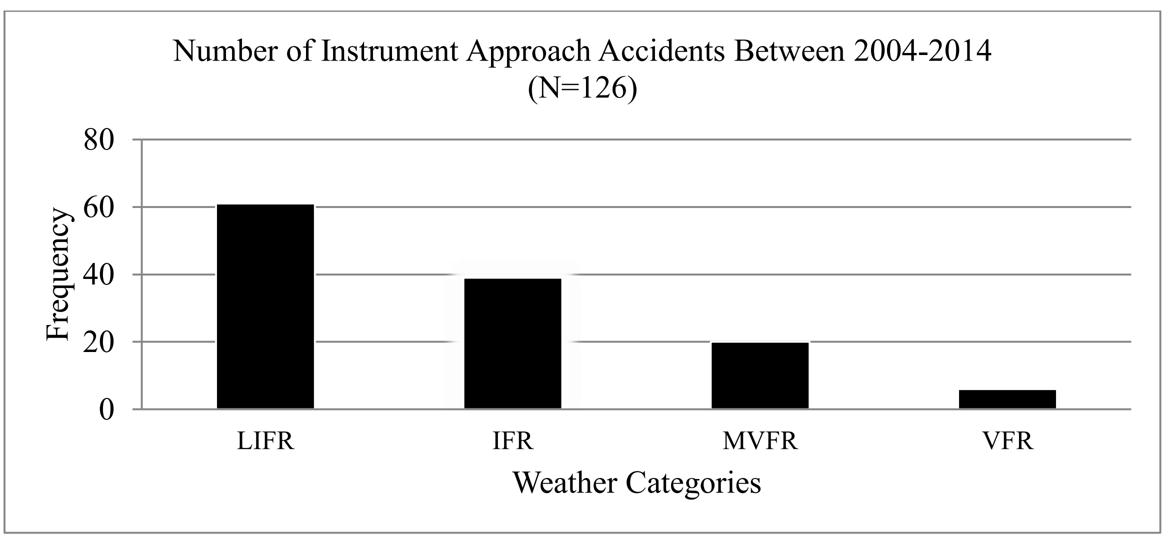

Figure 1. Frequency distribution of instrument approach accidents between 2004-2014.

The next step in the analysis was to extract primary and secondary contributing factors. Researchers combined primary and secondary causes to provide a perspective on overall contributing factors to accidents, as accidents are likely caused by the totality of the situation. The probable causes of accidents were cross-tabulated against weather conditions. When considering all probable causes and all four weather categories, the order of frequency is depicted in figure 2.

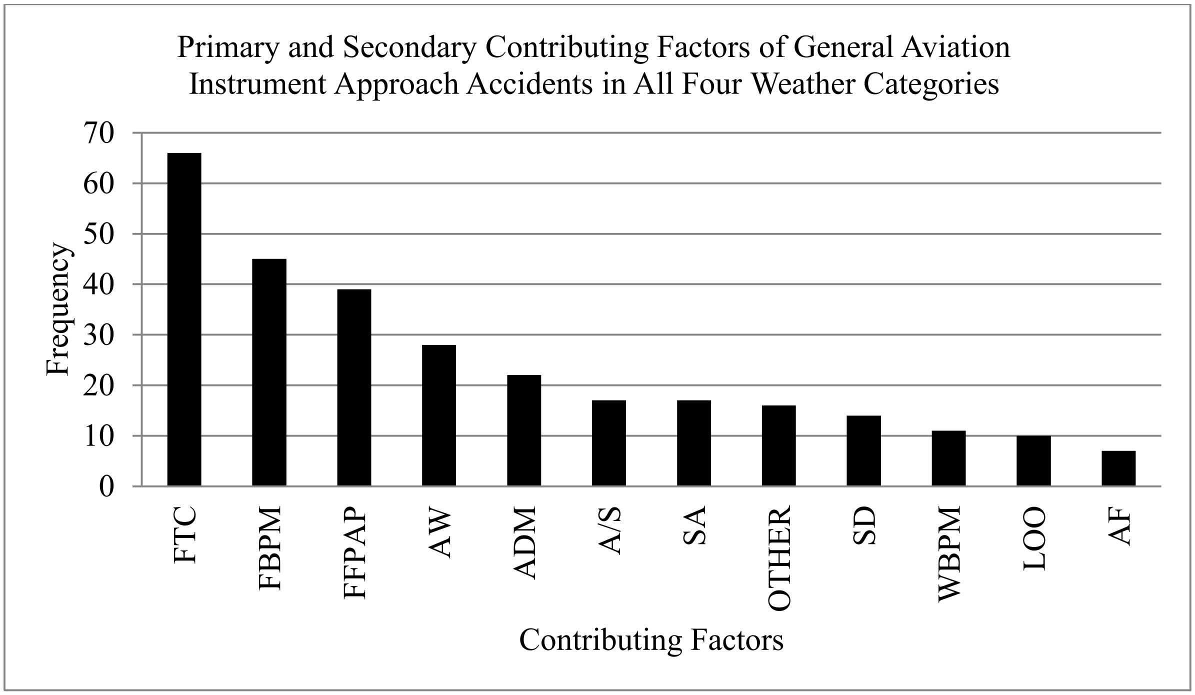

Figure 2. Primary and secondary causes of instrument approach accidents in all four weather categories.
Note: FTC = 'Failure to Control'; FBPM = 'Flight Below Published Minimums'; FFPAP = 'Failure to Follow Published Approach Procedures'; AW = 'Adverse Weather'; ADM = 'Aeronautical Decision Making'; A/S = 'Improper Airspeed'; SA = 'Situational Awareness'; OTHER = 'Other'; SD = 'Spatial Disorientation'; WBPM = 'Weather Below Published Minimums'; LOO = 'Lack of Oversight'; AF = 'Aeromedical Factors'.

Next, researchers separated the weather categories and identified the causes of accidents in each of the four weather categories. The 61 accidents under LIFR operations had 146 causes listed by the accident investigators while IFR operations had a total of 85 causes. MVFR and VFR operations had 46 and 13 accident causes respectively according to the NTSB investigators. This information is graphically summarized in figures three to six.

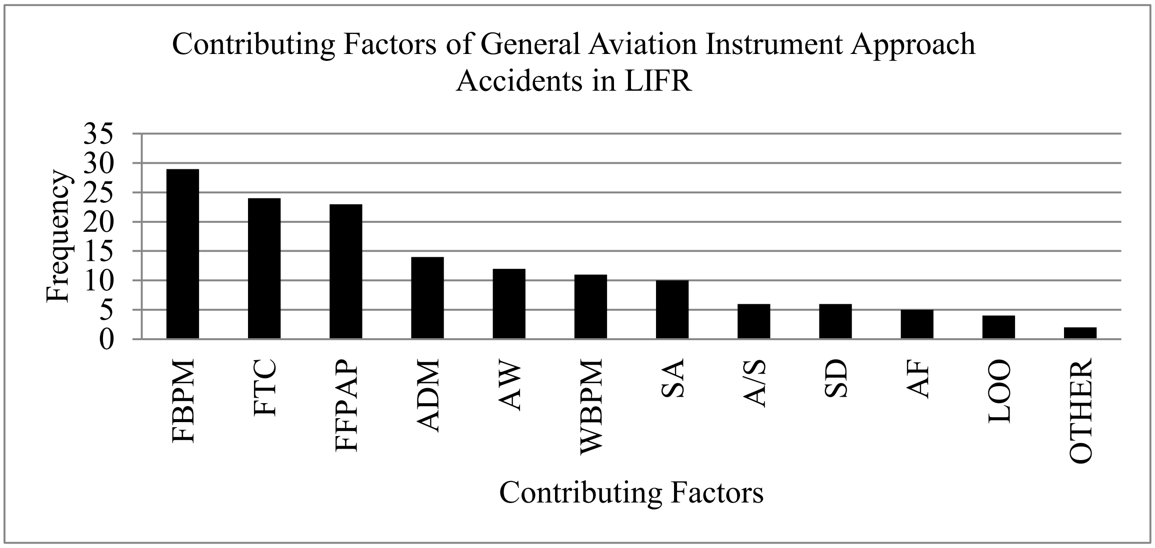

Figure 3. Causes of instrument approach accidents in LIFR.
Note: FBPM = 'Flight Below Published Minimums'; FTC = 'Failure to Control'; FFPAP = 'Failure to Follow Published Approach Procedures'; ADM = 'Aeronautical Decision Making'; AW = 'Adverse Weather'; WBPM = 'Weather Below Published Minimums'; SA = 'Situational Awareness'; A/S = 'Improper Airspeed'; SD = 'Spatial Disorientation'; AF = 'Aeromedical Factors'; LOO = 'Lack of Oversight' OTHER = 'Other'.

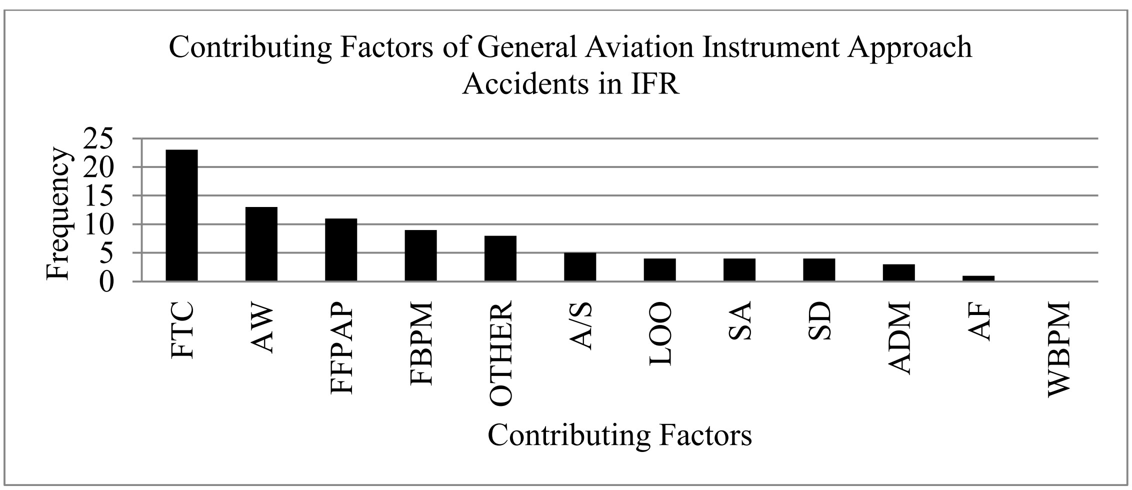

Figure 4. Causes of instrument approach accidents in IFR.
Note: FTC = 'Failure to Control'; AW = 'Adverse Weather'; FFPAP = 'Failure to Follow Published Approach Procedures'; FBPM = 'Flight Below Published Minimums'; OTHER = 'Other'; A/S = 'Improper Airspeed'; LOO = 'Lack of Oversight'; SA = 'Situational Awareness'; SD = 'Spatial Disorientation'; ADM = 'Aeronautical Decision Making'; AF = 'Aeromedical Factors'; WBPM = 'Weather Below Published Minimums'.

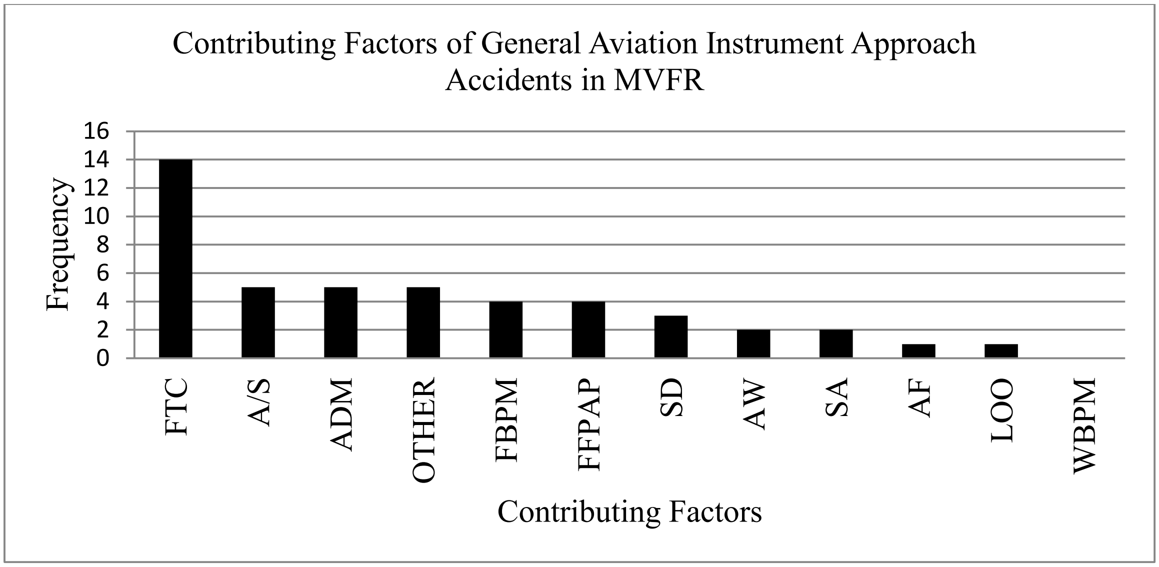

Figure 5. Causes of instrument approach accidents in MVFR.
Note: FTC = 'Failure to Control'; A/S = 'Improper Airspeed'; ADM = 'Aeronautical Decision Making'; OTHER = 'Other'; FBPM = 'Flight Below Published Minimums'; FFPAP = 'Failure to Follow Published Approach Procedures'; SD = 'Spatial Disorientation'; AW = 'Adverse Weather'; SA = 'Situational Awareness'; AF = 'Aeromedical Factors'; LOO = 'Lack of Oversight'; WBPM = 'Weather Below Published Minimums'.

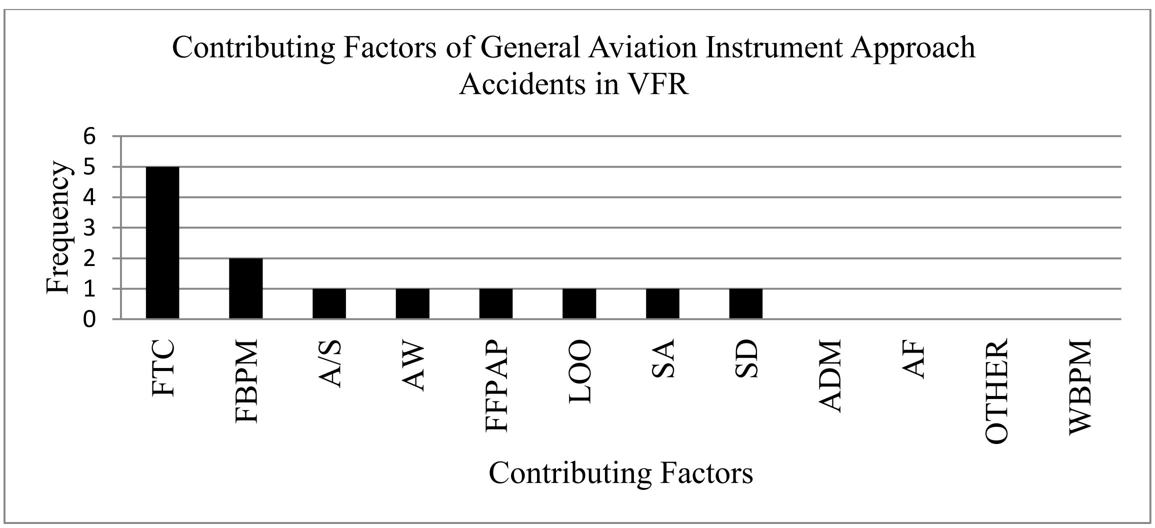

Figure 6. Causes of instrument approach accidents in VFR.
Note: FTC = 'Failure to Control'; FBPM = 'Flight Below Published Minimums'; A/S = 'Improper Airspeed'; AW = 'Adverse Weather'; FFPAP = 'Failure to Follow Published Approach Procedures'; LOO = 'Lack of Oversight'; SA = 'Situational Awareness'; SD = 'Spatial Disorientation'; ADM = 'Aeronautical Decision Making'; AF = 'Aeromedical Factors'; OTHER = 'Other'; WBPM = 'Weather Below Published Minimums'.

Chi-Square Analysis

Of the 126 accidents considered in this dataset, there were a total of 291 causes or contributing factors as cited by the accident investigators. Most of the accidents had more than one cause or contributing factor, such as 'Failure to Control' due to 'Spatial Disorientation'. A Chi- square test was conducted to determine if a significant association between weather categories and causes of accidents exists. The Chi-square probability value was 0.0337 (α=.05). However, 57% of the cells had expected counts of less than 5. Thus, a Fisher's Exact test was conducted using the Monte Carlo method to obtain a more accurate and powerful Chi-square test probability (Pett, 1997). The Fisher's Exact test was p = <0.0001 (α=.05) and the Monte Carlo Estimate for the Exact test was 0.0189 (α=.05). These results provide enough evidence to indicate a statistically significant association between weather categories and causes of accidents. The Cramer's V test was 0.2259 which indicates a moderate level of association. The test statistics can be viewed in Table 3.

Table 3

Chi-square test probabilities

Statistic	DF	Value	Probability
Chi-Square	30	45.6297	0.0337
Likelihood Ratio Chi-Square	30	51.6842	0.0082
Mantel-Haenszel Chi-Square	1	0.0003	0.9864
Phi Coefficient		0.396	
Contingency Coefficient		0.3682	
Cramer's V		0.2286	

WARNING: 57% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Monte Carlo Estimate for the Exact Test	
Probability <= *p*	0.0131
99% Upper Confidence Limit	0.0102
99% Lower Confidence Limit	0.016
Number of Samples	10000
Initial Seed	272055001

Sample size : 291

Fisher's Exact Test
Probability (P) < 0.0001

The leading causes of the accidents for the complete dataset were 'Failure to Control', 'Flight Below Published Minimums' and 'Failure to Follow Published Approach Procedures'. These three causes happened most often during LIFR. In addition, 100% of accidents with 'Weather Below Published minimums' occurred during LIFR. The top three causes that contributed positively to the overall Chi-square value (45.6297) were 'Weather Below Published Minimums', 'Adverse Weather', and 'Other' with cell Chi-squares 5.4436, 2.8421 and 2.5556 respectively. Causes with the least contribution to the overall Chi-square value were observed in MVFR and VFR weather categories. These results and values can be viewed in Table 4.

Table 4

Chi-square Table of Primary and Secondary Contributing Factors for General Aviation Instrument Approach Accidents

	Contributing factors											
Surface WX Conditions	A/S	ADM	AF	AW	FBPM	FFPAP	FTC	OTHER	SA	SD	WBPM	Total
IFR												
Frequency	5	3	1	13	9	11	23	12	4	4	0	85
Expected	4.9656	6.4261	2.0447	8.1787	12.852	11.392	19.278	7.5945	4.9656	4.0893	3.2131	
Cell Chi Square	0.0002	1.8267	0.5337	2.8421	1.1546	0.0135	0.7185	2.5556	0.1878	0.002	3.2131	
Percent	1.72	1.03	0.34	4.47	3.09	3.78	7.9	4.12	1.37	1.37	0	29.21
Row Percentage	5.88	3.53	1.18	15.29	10.59	12.94	27.06	14.12	4.71	4.71	0	
Col Percentage	29.41	13.64	14.29	46.43	20.45	28.21	34.85	46.15	23.53	28.57	0	
LIFR												
Frequency	6	14	5	12	29	23	24	6	10	6	11	146
Expected	8.5292	11.038	3.512	14.048	22.076	19.567	33.113	13.045	8.5292	7.0241	5.5189	
Cell Chi Square	0.75	0.795	0.6304	0.2986	2.172	0.6023	2.5082	3.8044	0.2536	0.1493	5.4436	
Percent	2.06	4.81	1.72	4.12	9.97	7.9	8.25	2.06	3.44	2.06	3.18	50.17
Row Percentage	4.11	9.59	3.42	8.22	19.86	15.75	16.44	4.11	6.85	4.11	7.53	
Col Percentage	35.29	63.64	71.43	42.86	65.91	58.97	36.36	23.08	58.52	42.86	100	
MVFR												
Frequency	5	5	1	2	4	4	14	7	2	3	0	47
Expected	2.7457	3.5533	1.1306	4.5223	7.1065	6.299	10.66	4.1993	2.7457	2.2612	1.7766	
Cell Chi Square	1.8508	0.589	0.0151	1.4068	1.358	0.8391	1.0446	1.8679	0.2025	0.2414	1.7766	
Percent	1.72	1.72	0.34	0.69	1.37	1.37	4.81	2.41	0.69	1.03	0	16.15
Row Percentage	10.64	10.64	2.13	4.26	8.51	8.51	29.79	14.89	4.26	6.38	0	
Col Percentage	29.41	22.73	14.29	7.14	9.09	10.26	21.21	26.91	11.76	21.43	0	
VFR												
Frequency	1	0	0	1	2	1	5	1	1	1	0	13
Expected	0.7595	0.9828	0.3127	1.2509	1.9656	1.7423	2.9485	1.1615	0.7595	0.6254	0.4914	
Cell Chi Square	0.0762	0.9828	0.3127	0.0503	0.0006	0.3162	1.4275	0.0225	0.0762	0.2243	0.4914	
Percent	0.34	0	0	0.34	0.69	0.34	1.72	0.0762	0.34	0.34	0	4.47
Row Percentage	7.69	0	0	7.69	15.38	7.69	38.46	7.69	7.69	7.69	7.69	
Col Percentage	5.88	0	0	3.57	4.55	2.56	7.58	3.85	5.88	7.14	0	
Total	17	22	7	28	44	39	66	26	17	14	11	291
	5.84	7.56	2.41	9.6	15.12	13.4	22.68	8.93	5.84	4.81	3.78	100

Note. WX = weather

Discussion and Conclusions

Flying an instrument approach in IMC is more complex than flying an instrument approach in VFR weather. For instance, single pilot operations in IMC may require prolonged concentration and it is likely that a single pilot will encounter an increase in workload compared to VMC operations (AOPA, 2006). Previous research has indicated there are various factors that cause instrument approach accidents (Fanjoy and Keller, 2013; Fanjoy and Young, 2005; Weigmann et al, 2005; Weigmann and Shappell, 2000). Factors such as spatial disorientation and overconfidence in personal abilities are typical causes in instrument approach accidents.

Findings from this study suggest that accidents and errors decrease as weather conditions improve. It was anticipated that the LIFR weather category would account for greatest association with accident contributing factors because it contained the most accidents. This was the case with all but two contributing factors; 'Adverse Weather' and 'Other' were the highest during IFR conditions. It is possible that pilots may cancel their IFR clearance and continue with a visual approach or may not file IFR at all if weather conditions permit. When flying in LIFR conditions there is a lower margin of error because outside visual cues are expected later in the approach. In that case, it takes considerable experience to manage the workload, recognize cues and transition from the approach phase to a landing or missed approach segment. In LIFR conditions, some pilots may not adhere to personal limitations and may continue an approach in conditions beyond their experience or ability. Previous research (Kim, 2011) has shown pilots tend to be overconfident which may affect their aeronautical decision making process. This may lead to "ducking under" minimums, choosing not to divert, impulsiveness, resignation, anti-authority, "machoness", and being distracted.

Flight below published minimums was the leading cause for accidents during LIFR while failure to control was the leading cause in IFR, MVFR and VFR weather categories. When analyzing the data with all accident causes and all four weather categories, failure to control was the leading contributing factor followed by flight below published minimums. Pilots may be reluctant to divert because of time, money and pressure. Flight in LIFR conditions does not provide enough room to "duck under", look for the runway, and maintain clearance from obstacles.

Results from the Chi square table suggested a moderately strong association between the weather categories and other contributing factors. As weather deteriorates, precise aircraft control becomes more difficult. In this case, an increased workload may decrease a pilot's performance thus increasing errors. There may also be psychological factors involved. For example, it can be difficult to recognize and or admit when fatigue begins to degrade performance.

This exploratory project sought to identify patterns of contributing factors to instrument approach accidents and how those factors are associated with different weather categories.

The focus of this research is in support of FAA's initiative to identify risks through data analysis as a proactive approach to improving GA safety. Since this study used a small non-randomized sample, generalizations regarding the current GA pilot population would be inappropriate. However, knowledge of the association between causes of accidents and weather conditions provides a good precedent for further research. Such research could include evaluation of additional variables such as approach types, number of pilots and environmental factors for cross tabulation. Scenario based simulator experiments with pilots could also be effective for identifying missing cognitive cues that are essential for safe operations. Finally, in concert with research initiatives, continued design and evaluation of cost effective technology should be explored to address this particular issue in GA flight.

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