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# COLLEGIATE AVIATION REVIEW

**Mary E. Johnson, Ph.D., Editor**
**Timm J. Bliss, Ed.D., Associate Editor**

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Mary E. Johnson, Editor



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No juried publication can excel without the tireless efforts of experts in the field volunteering their time to 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. Sincere 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 2015 Fall Education Conference of the Association in Utah.

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.

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# 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 2016 issue) or April 15 (Fall 2016 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. All paragraphs are to be formatted as 'justified'. 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

The University Aviation Association (UAA) describes itself as the ‘*voice of Collegiate Aviation*’. This voice is important to us as professional academics in the aviation discipline for many reasons. As one part of that voice, the UAA publishes the *Collegiate Aviation Review* (*CAR*) as its peer-reviewed journal. It is important that the research published in the *CAR* address the issues facing collegiate education and extend its reach to encompass issues facing the global air transport system. In this edition, authors submitted six articles to the *CAR* for review. The topics addressed in these paper addresses collegiate aviation education and operations and that extends to the air transport system. Five of these articles were accepted for publication. It is my hope that readers enjoy these articles, that each reader learns something, and that these works inspire readers to rigorously investigate and report the answers to research questions.

In this edition of the *CAR*, there are two articles that address collegiate flight training in terms of electronic flight bag and fleet utilization. A third article surveyed UAA institutions to develop an inventory of training devices. These articles may provide insight into issues facing those collegiate programs that may prove useful to others in the collegiate aviation community. A fourth article describes a university aviation learning community where the students’ majors represent a large portion of the people in the global airspace system. The fifth paper discusses the public perceptions of airline policies for crew rest. With this span of research, the audience of *CAR* articles continues to extend beyond those with solely collegiate interests to include the potential audience of academia, industry, non-governmental organizations, and government. Thanks to the efforts of previous editors, the *CAR* articles are reachable to a wide audience via library research indexes.

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* and our voice of collegiate aviation, the UAA.

Cordially,

Mary E. Johnson, Editor

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# The Effect of Electronic Flight Bag Use on Pilot Performance during an Instrument Approach

**Kevin N. Haddock and Wendy S. Beckman**
Middle Tennessee State University

## Abstract

For years, paper-based navigation aids have been an integral part of safely operating an aircraft. While these tools have served their purpose well, the technology to replace them with a more productive and efficient device may have arrived. Electronic Flight Bags (EFBs) have quickly become popular for both commercial and private use. This study analyzed the effect EFBs have on pilot performance in a single pilot environment by evaluating the performance of instrument rated pilots at a large southeastern flight school. The participants (N=14) were asked to complete two instrument approaches in a flight training device. One approach was executed using an Apple iPad® equipped with ForeFlight™ software (the EFB), while paper charts were utilized during the other approach. Deviations in altitude, heading, airspeed, and localizer course from instrument pilot practical test standards were recorded, as was the time taken for each participant to configure the approach. Statistical analysis was conducted to determine if a difference existed between the two methods. The results showed a statistically significant increase in every analyzed performance metric when using the EFB. A survey of participants' perceived workload during the approaches was also conducted, which revealed participants felt using the EFB decreased their workload.

## Introduction

In an age of increasing information availability, pilots must manage enormous amounts of data while maintaining effective cockpit management. Checklists, operations specifications, approach plates, NOTAM's, dispatch releases, and enroute charts are just a few of the items that must be managed and utilized properly during a typical flight. These items have traditionally brought a great deal of paper and disorganization into the tight confines of the cockpit. This clutter can create problems when the pilot needs to access an item during a high workload flight segment. An Electronic Flight Bag (EFB) may present a solution to this issue. In general, an EFB is a device that is used to display information digitally instead of on paper. The FAA defines an EFB as, "An electronic display system intended primarily for flight deck use that includes the hardware and software needed to support an intended function," (Federal Aviation Administration [FAA], 2003, p. 2). EFBs have the potential to increase productivity, as well as produce cost savings for users. However, like all technological advancements, there are challenges to the widespread adoption of EFBs. As EFBs continue becoming more prevalent, there is a clear need for more research into how the use of these devices affect pilot performance in critical situations (Chandra, Yeh, Riley, & Mangold, 2003).

Until the possibility of using electronic displays to view information became a reality, the consequences of using paper-based products were not even considered. The costs from the paper material itself, the maintenance required to keep it up-to-date, the clutter and inefficiencies it creates in the cockpit, and the effects on aircraft performance were considered facts of life, as there was no other way to provide information. As electronic means of communicating and displaying information have become less expensive and more readily available, the negatives of physical paper use become more apparent.

## Literature Review

The key to understanding the regulatory aspect of EFB use under today's regulations is Advisory Circular No. 120-76A Guidelines for the Certification, Airworthiness, and Operational Approval of Electronic Flight Bag Computing Devices. This AC is not regulatory in nature, but does provide guidelines for EFB use. Of particular note is that the AC maintains that the guidance it provides only applies to operators of large and turbine-powered aircraft, not to those operating under Part 91 (FAA, 2003). This AC further states that 14 CFR Part 91 operators "do not require any specific authorization for EFB operations, provided the EFB does not replace any system or equipment required by the regulations," (FAA, 2003, p. 1). This is noteworthy as it opens EFB use up to 14 CFR Part 91 operators without any real regulatory burden.

To operate aircraft effectively pilots require a number of written resources, and until recent times these written resources appeared on paper. The monetary costs associated with the use of paper are much larger than one might expect. Alaska Airlines estimated that in 2011 it printed over 2.4 million pages of paper just in aircraft manuals (Alaska Airlines, 2011). If one type of document for one airline requires that much paper, it is easy to see how the costs of printing alone can be very significant. Another cost due to the use of paper comes from the maintenance paper documents need in order to remain current. Not only does the use of paper cause unnecessary costs, but it can also create a lack of efficiency and productivity in the cockpit due to clutter. Yet another problem with the use of paper is the weight that is added to the aircraft. Alaska Airlines estimated each pilot was required to have anywhere from 25 to 50 pounds of paper documents with them for each flight, which equates to over $1.5 million dollars each year being spent in fuel costs due to the weight of this paper (Alaska Airlines, 2011).

Many alternatives to eliminate paper charts have been proposed, however the literature suggests drawbacks exist. Until recently, electronic solutions were too bulky, complicated, or unreliable to pose a serious alternative to the use of paper. Some devices proposed to alleviate the problems of paper are dedicated EFB devices, integrated units, and most recently, the iPad®. The idea of a dedicated EFB device has been on the market for several years with limited success. However, these dedicated EFBs have been bulky, complicated, expensive and unreliable (Hughes, 2009b). Many of these devices have used small laptops with pivoting screens and typically a full operating system, usually Microsoft Windows.

This design added a layer of complexity to devices designed to be used inflight. Additional problems identified were that the batteries on these devices had a short duration, and the devices gave off a tremendous amount of heat, which was especially noticed when used in a pilot's lap (Chandra, Yeh, Riley, & Mangold, 2003).

Another form of EFB that has been brought to market is the integrated EFB. These devices are built into the cockpit of aircraft with advanced avionics systems. The most common form of this implementation is seen in large commercial airliners. These devices provide the pilot with aeronautical charts, manuals, taxi diagrams, etc. on a device that is not removable from the cockpit and is usually interoperable with the aircraft avionics. The main benefit of the integrated type of system is the ability to blend seamlessly into the aircraft systems already in place, which can help streamline cockpit procedures. However, these integrated systems do not provide the pilot the ability to do preflight planning and calculations outside of the aircraft as portable EFB systems do, and are relatively expensive. At the time of this study, these systems have not been widely adopted due to the cost involved (Fontaine, 2011).

The newest entry to the field of EFBs is Apple's iPad®. This device, introduced in early 2010, has created an entire industry segment that did not exist previously. Its intuitive interface, small form factor, proven reliability, relatively low price, and outstanding battery life has drawn in consumers who did not even know they wanted a tablet until they saw it for the first time. The reason this is important to the discussion of EFBs is due to the large market this created. Because the device was not built specifically for aviation, it has the necessary sales volume to keep prices low, which means a lower barrier to entry for pilots. The iPad's®'s interface is intuitive for use in-flight, as a pilot simply touches something with which he wants to interact. This strips away the complicated layer of buttons and menus which added complexity to other devices. The success of the iPad® in general aviation has even caught the attention of business and commercial operators, with the iPad® now in use, or in testing for use, at both Part 135 and Part 121 carriers. It looks more and more likely that the iPad® and other consumer devices will be the future of EFBs (Miller, 2011). The problem with the iPad® is that while it is very stable, it is still a consumer grade system so there is some reluctance to adopt it as an official device for use during critical phases of flight (Alaska Airlines, 2011).

**Benefits of using an EFB**

One of the primary benefits of EFBs is their ability to increase the pilot's situational awareness (Flight Safety Foundation Editorial Staff, 2005). Many EFBs allow pilots to see their position on a digital version of the paper charts they have always used. This provides a perfect mix of familiarity with the old while adding the benefits of the new technology (Flight Safety Foundation Editorial Staff, 2005).

Another way that these devices provide situational awareness is the ability to display layered versions of conventional charts. This technology allows pilots to only show the information needed for that particular phase of flight. For example, pilots can activate layers that show only VORs, airways, airports with certain specifications, etc. This allows pilots to have less information to absorb and interpret which allows them to maintain situational awareness without information overload (Flight Safety Foundation Editorial Staff, 2005). When using paper, pilots must switch between checklists, navigational charts, and weather information multiple times. This is an invitation for distraction and for the pilot to become lost in all of the data (Flight Safety Foundation Editorial Staff, 2005). When using an EFB for this task, the pilot is able to change between these different pieces of data much more easily and efficiently, therefore increasing the level of safety (Allen, 2003). Of course, even when an EFB is utilized, switching between display screens is still a necessity.

### Risks of EFB Use

One downside to the use of EFBs as the sole means of viewing critical in-flight information is the possibility of device failure. No matter how reliable electronic devices become, the possibility of equipment failure will always exist. Those that are against the adoption of EFBs bring up equipment failure as a potential catastrophic event. There are ways to mitigate this risk however, through carrying back up batteries, paper copies, or perhaps even back up devices (Flight Safety Foundation Editorial Staff, 2005). While the probability that one EFB could fail is small, the probability that two independent systems could fail at the same time is unlikely. This solution would allow the full benefits of the transition to EFBs be realized, while still maintaining a dependable contingency plan in case of failure. The only problem this introduces is the additional cost of two devices (Hughes, 2009a).

One significant risk that EFBs pose is the possibility of technology overload for pilots as the transition to EFBs begins, and before experience can be developed. Situational awareness, multitasking ability, precision, and workload management have all benefited from technology advancements such as VORs, DME, GPS and advanced avionics. These technologies have consequently made some pilots extremely dependent on technology. It is very easy for a pilot to get in an advanced aircraft and become complacent relative to when flying traditional aircraft (Flight Safety Foundation Editorial Staff, 2005).

As EFBs are developed and implemented, it will be important to take care not to make them too complex. Doing so would negate the benefits of increased situational awareness and better productivity in the cockpit. It is also important that training procedures for using EFBs be established to train pilots to keep scanning outside the aircraft and to not focus inside on the new displays (FAA, 2003). Pilots need to maintain the ability to operate without an EFB or on the backup device if the situation requires (Hughes, 2009a).

### ForeFlight™

There are numerous providers of applications for flight planning, flight tracking, and flight chart situational awareness needs, including ForeFlight™, GlobalNavSource, Navtech, Garmin®, WingX™, ARINC and Jeppesen® (McKenna, 2012). The Jeppesen® application Mobile Flightdeck Pro has been embraced by air carriers, large business operators and military customers (McKenna, 2012), but ForeFlight™ was one of the first applications to be developed and it remains the most popular EFB application for 14 CFR Part 91 aviation operators (Appcrawler, 2015). ForeFlight™ is a company that was started in 2007 by a software engineer and a pilot to give pilots a mobile flight planning tool for the just introduced Apple iPhone. The first piece of software ForeFlight™ created was solely for gathering weather information. As the power of the new iPhone began to be realized, ForeFlight's™ programmers saw that the device could do much more than just gather simple information. They soon released ForeFlight™ Mobile. Today's current version of this software—ForeFlight™ Mobile v.4—sets the standard for what can be done with consumer grade tablets like the Apple iPad®. It allows a pilot to go from route planning, to certified weather and NOTAM briefings, to the needed in-flight charts and checklists all without ever leaving the application. It is, by far, the most popular aviation application on the iPad® (ForeFlight LLC, 2011).

## Statement of the Problem

A review of research concerning EFBs shows that there have not been any performance-based implementation studies completed. There is a significant amount of information concerning EFBs in general, but nothing available regarding pilot performance during their use. Research also indicates that EFBs, in some form, are going to be a part of the aviation world in the future (McKenna, 2012). Before these devices become the new standard, the industry must trust that EFBs will provide reliable pilot performance of at least current levels. This study was conducted to determine the relationship between pilot performance during a relatively high workload period of flight and the use of an EFB versus paper charts, with the following research questions to be answered:

1. Does using charts and approach plates in electronic form on the iPad®, as opposed to on paper, effect pilot performance—as measured by conformance to heading, course, altitude and airspeed requirements, time to set up an approach, and selection of appropriate approach minimums—during rapidly changing flight situations?

2. Does the pilot's perceived workload increase or decrease when using an electronic form of the required material?

## Methodology

To answer the above research questions, an experimental study was developed. The study used a Frasca 142 flight training device (FTD) and a scenario that required the pilot to access charts in a high workload, time sensitive environment. For the study, Apple's iPad® loaded with ForeFlight™ Mobile software was used as the EFB. The high workload environment in this study was the need to find, brief, and set up an instrument approach under instrument meteorological conditions. This particular scenario simulated a sudden change in the approach expected at a destination airport, not an uncommon event. The environment required pilots to divide their attention between flying the aircraft and preparing for the approach. During a time such as this, any improvements in situational awareness or effort required to ready the approach should be obvious in the performance metrics. Each pilot completed two very similar instrument approach scenarios, one using the EFB and one using paper charts. This allowed measurement of the performance of each participant in relation to deviations in airspeed, heading, altitude, and course, along with the time required to prepare for an instrument approach. A survey given at the end of the session was used to determine if pilots had a preference of chart viewing method, and their perception of how each method affected their performance and effectiveness in the cockpit.

## Participants

The participants for this study were drawn from the commercial ground school class at a large southeastern university during the spring semester of 2012. The study was approved by the university's Institutional Review Board for human subject research. A prerequisite of the commercial class is that a student have an instrument rating, which was an important inclusion criterion. This prerequisite ensured that these participants were well versed in the basics required to set up and fly an instrument approach, and that all of the participants had approximately the same amount of instrument flight time. There were 14 students enrolled in the class, and all 14 agreed to participate in this study. All participants were white males of traditional college age.

### Instruments

The flight training device (FTD) used for the study had conventional display instrumentation, and a Garmin® GNS430 GPS unit provided both communication and navigation radio tuners for tracking the localizer and glide slope courses. For this study, the FTD was configured as a single-engine fixed gear generic aircraft.

The scorecard used for this study was designed to allow the researcher to efficiently measure the deviations in altitude, heading, airspeed, and localizer course from instrument pilot practical test standards (PTS). To minimize the need to correctly identify the position of the analog needles of the FTD's instrumentation, the frequencies of these deviations were taken at intervals throughout the simulation rather than measuring the actual amount of deviation. These readings were recorded as either "Within PTS" or "Outside PTS". The specific parameters were: altitude +/- 100 feet, heading +/- 10 degrees, airspeed +/- 10 knots, and localizer course +/- 1 dot of deflection. A stopwatch was used to ensure that the same number of readings was taken at the correct times for each participant. The time taken for each participant to configure the approach was also recorded. Finally, whether the participant had identified the correct minimums for the specified approach was recorded.

The paper charts that were used for the study included a Tennessee/Kentucky Terminal Procedures book published by AeroNav. These AeroNav, or National Aeronautical

Charting Office (NACO) charts as they were once known, are still commonly used among general aviation pilots (Gibson, 2011). For the EFB, an Apple iPad® was used. This iPad® was a 32GB Verizon 3G unit. It was loaded with a current version of ForeFlight™ Mobile HD 4. All other programs were removed from the loaded applications section of the EFB before the study to eliminate interference. All of the required charts for the study were downloaded onto the unit so that internet access would not be required, just as would be done for a flight. The post-test written survey consisted of five questions to gauge how the participant viewed using both the paper charts and the iPad®, as well as to document their previous experience using any form of EFB. A combination of descriptive questions and those using a Likert scale were used.

**Procedure**

When the participants arrived for their session, they were briefed on what to expect, and were given a short tutorial on how to use the iPad®, the AeroNav procedures book, and the equipment in the FTD. They were instructed to only tune in the necessary frequencies and not to load the approaches in the Garmin® GNS 430 unit. This ensured that familiarization with the GNS 430 would not skew the results of the study. The participants were also told to only brief the name of the approach, the location, the missed approach instructions, and the minimums for the approach. Given that each participant was instrumented rated, no instruction on the actual interpretation of approach plates was provided. This was to ensure that the briefing period and setup procedure for each participant was standardized. Participants were also instructed to begin setting up the approach as soon as they were given an "Expect" instruction from Air Traffic Control (ATC), and to announce "done" as soon as the approach was set up and the briefing completed. The scenario for this study was that the participants were pilot in command of a single-engine aircraft cruising at 3,000 feet, at a speed of 110 knots indicated, and a heading of 270 degrees, approximately 15 miles southeast of KMEM. The weather for the FTD sessions included a ceiling of 200 feet overcast, one mile visibility, calm winds, and an altimeter of 29.92 inches of mercury. The researcher acted as Air Traffic Control throughout the session. Suggested power settings were given, but all of the participants had prior experience in the FTD due to their instrument training at the university. Each student flew the scenario twice, once with paper and once with the iPad®. The use of the iPad® or paper first was alternated with each participant so as to not skew the results due to familiarity with the scenario on the second time through the procedure.

Once the FTD was in the pre-set position and the participant indicated that they were ready to proceed, the FTD was activated and a stopwatch started. The participant was instructed to hold the assigned heading, airspeed, and altitude until further instructions were received from Air Traffic Control. The first data points were taken at the 0:05 second mark, and then again at 1:00, and were recorded as either within PTS for each indicated variable or outside of the PTS for these same variables. This time period allowed the participant to become settled and trim the aircraft as needed. At 1:00 the participant was told to expect either the Instrument Landing System (ILS) 36 left or ILS 36 right approach into Memphis International Airport and to turn to a heading of 290 degrees. The exact time that this occurred was noted so that the researcher could see how long it took the participant to set up the approach. From this point forward, data was collected at 20 second intervals, as the participant worked to find the correct approach using either paper or iPad®, and to get the approach ready to fly. At the appropriate point, the participant was instructed by ATC to turn to a heading of 330 degrees, and was given an approach clearance to intercept the ILS localizer. After the participant completed the briefing and announced that they were done, it was determined if they had announced the correct minimums for the correct approach, and the ending time was recorded. When the participant crossed the outer marker, the data recording portion of the session was ended, although the participants finished the approach procedure.

After the first session in the FTD, the device was reset to the preset starting position. Radio frequencies and course indicators were also reset to a non-biased position. The participant was given three minutes to rest between the two sessions. Once they indicated they were ready, the scenario was repeated using the alternate method of viewing charts. A different approach than was used for the first session was utilized for the second approach, although the Memphis airport was still used. For example, if the participant had been given the ILS 36R approach the first time, they were now told to expect the ILS 36C approach. This ensured that none of the frequencies or minimums would be the same. A slightly different vector of 300 degrees was also assigned by ATC so that the risk of familiarization was reduced. The data was collected the same way as the first session. Once the second session was complete in the FTD, the participant was allowed to exit, and was immediately instructed to fill out the short survey to measure their perceived workload using each chart viewing method.

## Results

The data for the observed performance metrics of altitude, heading, airspeed, localizer course, and time to set up the approach was recorded, and means and standard deviations of this data can be seen in Table 1. The score for the altitude, heading, airspeed, and localizer course parameters were the percentage of observations during which the participant was within PTS when the observation was made. The time to set up the approach was the actual time in minutes the participants took from the end of their approach clearance until they announced the approach was configured. The performance measures were analyzed using two sample t-tests assuming unequal variances (N=14). It was found that there was a significant effect on pilot performance regarding each of the measured parameters, with the EFB performance being better than the paper chart performance in each case, as can also be seen in Table 1.

Table 1

*Participant Mean Performance Parameters*

| Parameter | Paper Score* mean (std dev) | EFB Score mean (std dev) | t-statistic** |
|---|---|---|---|
| Altitude | 53 (12) | 76 (11) | t = 5.06 |
| Heading | 54 (13) | 80 (10) | t = 5.49 |
| Airspeed | 57 (13) | 73 (12) | t = 3.03 |
| LOC course | 44 (18) | 83 (18) | t = 5.21 |
| Time to set up approach | 2.45 (.78) | 3.92 (1.50) | t = 3.27 |

*The Paper Score is the percentage of observations during which the participant was within PTS when the observation was made
**Two tailed t-test critical value at p=.05 is 2.1604

As to the question of whether the pilot was able to determine the correct minimums for an approach, it was determined that the iPad® increased the likelihood that the minimums were correctly identified the first time. Only 36% of participants were able to identify the correct minimums on their first attempt using paper charts. In addition, when using paper charts, 29% of the participants attempted to use the wrong approach plate such as a Category II or Category III chart, or even a chart for the wrong runway. When using the iPad®, 100% of the participants correctly applied the appropriate minimums for the approach assigned on the first attempt.

**Survey**

Question 1 on the survey the pilots completed after their session in the FTD dealt with the participant's previous experiences with the use of EFBs, including the iPad®, before this study. A large majority of the participants (71%) had never used the iPad® as an EFB, or had used one only a few times (21%). Questions 2 and 3 of the survey asked the participants to rate the effectiveness of the iPad® and paper charts individually under high workload situations such as what they experienced during the FTD session. The difference in the effectiveness rating scores indicated that the iPad® was felt to be more effective, with the iPad® generating an average rating of 5.0, and the paper charts generating an average ranking of 2.64, on a scale of 1-5. Question 4 sought to determine how the participants would describe their perceived workload while using the paper charts versus the EFB. The question was phrased as "How would you say that your workload/stress level changed relative to the type of chart used?" The participants indicated that the iPad® significantly reduced stress levels and perceived workload, with 86% indicating the EFB was "much easier" and 14% indicating the EFB was "somewhat easier." Finally, question 5 of the post-session survey sought to determine the participant's opinion regarding which method they would prefer. The question was posed as "If you were to find yourself in a rapidly changing situation during a flight, which form of chart would allow you to best handle the situation at hand?" The EFB was strongly favored by the participants, with 93% of participants "much preferring" the EFB and 7% "slightly preferring" the EFB in these situations.

## Discussion

This study was conducted to determine the effect of utilizing charts and approach plates on the iPad®, as opposed to on paper, on pilot performance as measured by conformance to heading, course, altitude and airspeed requirements, time to set up an approach, and selection of appropriate approach minimums. The results of this study showed that there is a positive effect on pilot performance when using an EFB. The results for altitude, heading, airspeed, and localizer course were all statistically significant and showed an increase in performance when using the EFB.

When evaluating the time required to set up and brief an approach, the effect was again significant. When using the EFB, the average time to completion decreased by one minute and 29 seconds. This large decrease is extremely important in a situation where every second counts. One of the most compelling results from this study involved the participants choosing the wrong approach chart when using paper. As stated earlier, only 36% of the pilots were able to correctly identify the correct approach minimums on the first attempt when using paper. This was very surprising, but the number of ILS approaches in Memphis, and the various category minimums for a particular approach, evidently led to this confusion. When the pilots used the EFB, 100% of the participants chose the correct approach and the associated minimums on the first attempt. These are critical errors that, maybe more than the others, could result in an accident should the pilot attempt to use the wrong information for an approach. In this study, the EFB seemed to result in the elimination of these errors completely.

The second question this study sought to answer regarded the perceived workload and stress levels the pilots reported when using the two methods. The survey given at the end of the FTD session provided this data, and the results again all pointed toward the utility of the EFB. First, the participants were asked about their past experience using EFBs of any kind. The results of this question show that the majority (71%) of participants had never used an EFB before. When this result is considered along with the performance increases, it is clear that the iPad® provides a very user friendly design that requires little training or experience to master.

Questions two and three sought to determine how effective the participants felt both paper charts and the EFB were in this scenario. Of the pilots in this study 100% rated the EFB as "5-most effective" on the Likert scale provided. In comparison, the average effectiveness rating for the paper charts on the same scale was only 2.64. The survey responses also supported that the EFB was seen as easier to utilize during rapidly changing situations. All of the participants said that the EFB was "somewhat easier" or "much easier" to use than paper charts. Finally, the survey responses to determine the participant's preference of chart viewing method in the future during similar situations favored the EFB, with 93% of the participants "much preferring" the EFB. Not a single participant indicated that they preferred paper charts.

A majority of the literature that was reviewed prior to this study agrees with what was found. The study conducted by Chandra, Yeh, Riley, and Mangold (2003) stated that no matter how advanced EFBs become, they must stay uncomplicated and uncluttered, allowing them to remain easy to use. Many of these ergonomic and human factors issues are addressed by the iPad® with its focus on user interface and ease of use. The ForeFlight™ interface seems to be logical enough that the participants in this study were able to adapt quickly to it even though they had no previous experience and only a very brief tutorial before beginning the session.

## Limitations

While this study showed a statistically significant increase in performance when using an EFB compared to paper charts, its findings do carry certain limitations. The population used in the study was one of convenience and does not represent a large cross-section of demographics when it comes to experience and age. Age, especially when dealing with technology such as this, can play a large role in how easy it is to transition to a new way of doing things in the cockpit. While the vast majority of participants had not used an iPad® specifically in a cockpit setting, the group consisted entirely of college students, who had undoubtedly used similar technology in other settings. The sample size was also quite low, which is a significant drawback to generalizability. This study also did not deal with the possibility of EFB equipment failure and how these pilots would deal with such a situation. There is a definite possibility that the pilots could become too dependent on technology and as a result lose their ability to maintain situational awareness. In addition, this study dealt with a single pilot scenario where one person must both set up and fly the aircraft simultaneously. Many operations require two pilots instead, and it may be that those operations would not see as large an increase in performance.

## Future Research

More research needs to be conducted into the ability of the pilot population as a whole to adapt to this new technology. Research into performance gains involving two pilot environments, where one pilot can focus on setting up an approach while the other flies, should also be conducted. The question of what happens when a device fails in flight should be examined as well. Further study into the actual cost savings of using EFBs is also justified. If the entire in-flight library is completely transferred to a digital version, it may be cheaper for companies and individuals to maintain that library in the long run. Whatever the future brings to technology in aviation, there is no doubt that EFBs in some form will play a large part. With devices like the iPad® pilots can afford this technology in an easy to use package. The research conducted in this study determined that EFBs are likely to bring more safety and efficiency to the cockpit.

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# Controlled Rest in Position (CRIP): Consumer Perceptions in the United States

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## Abstract

Controlled rest in position (CRIP) has been suggested as a viable countermeasure to the Federal Aviation Administration (FAA) in the ongoing efforts to combat in-flight pilot fatigue. It is already in use in other parts of the world; however, it is not currently permitted in the United States. While expert opinion suggested it poses little threat to flight safety, with valuable returns in terms of improved crew alertness and performance, there is some doubt about the level of consumer buy-in. This study completed a preliminary investigation into overall consumer willingness to fly, in the use of CRIP procedures in the United States. Two studies were completed to examine consumer perceptions toward the use of CRIP. It was found in both studies that male and female participants were less willing to fly when CRIP was used. Additionally, female participants were less willing than their male counterparts in both the control and experimental condition. In the second study, affect measures were collected and found to completely mediate the relationship between the use of CRIP and consumers' willingness to fly. Findings may provide both regulators and airlines data that could aid in their decision-making processes as it relates to implementing such practices in the United States.

## Introduction

The issue of pilot fatigue in aviation has always been a widely discussed topic, and is of particular concern in today's work environment as airlines look to maximize revenue by working both man and machine to their limits. Controlled rest in position (CRIP) has been proposed as a solution to reduce pilot fatigue in flight, however not all regulatory bodies permit such procedures to be used, namely the Federal Aviation Administration (FAA). While there may be numerous factors that might have influenced why these procedures are prohibited in the United States, this study sought to look at the issue from the consumer perspective. What are their opinions on the matter; specifically, would they be willing to use air transportation with such protocols in effect? It was the aim of this study to provide such metrics to be able to provide to the aviation community at large, both ordinary airmen and regulators alike, information to help facilitate a global and united approach to combat pilot fatigue in aviation. The purpose of this study was to conduct an investigation into the level of consumer willingness to fly in the practice of CRIP in aviation. Consumer willingness to fly on a flight where CRIP protocols were in effect was studied in both a control and experimental group in the United States. This research investigated overall consumer perception, and explored the relationship gender has on the outcomes.

## Literature Review

Fatigue in commercial aviation proves an unceasing threat to flight safety, and viable countermeasures to combat the in-flight fatigue of pilots are a hotly debated topic. CRIP is, of course, one of the possible solutions, however there seems to be some disparity across the aviation community about its merits. Naturally, any new policies implemented by airlines not only have to meet regulatory guidelines on safety, but must also be accepted by the travelling public at large, who use the airlines. Since this study will be able to determine consumer 'buy-in', it may reduce airline uncertainty over adopting such a policy. This not only has the potential to save airlines time and money, but also by eliminating a major hurdle, could pave the way for a unified industry standard of either allowing or discontinuing the practice of CRIP to combat pilot fatigue in flight.

The issue of pilot fatigue has always been a major concern in the aviation industry, for operators and regulators alike. As aforementioned, the aim of this study is to seek consumer perception and willingness to fly in the countermeasures used to combat this issue, especially the solution of CRIP. In order to comprehensively approach this issue, consideration was given to the issues involved with pilot fatigue.

### Causes of Pilot Fatigue in Aviation

It is widely upheld that pilot fatigue poses one of the greatest risks to flight safety, and there have been numerous studies done detailing the risk associated with having insufficient rest, as well as the factors that may lead to such a situation occurring. According to Hartzler (2013), one of the issues is extended duty periods associated especially with long haul international flights. Furthering that point, there is also sleep loss that is caused by unusually early or late duty periods. The issue of circadian disturbances as well as homeostatic factors also surfaced as contributing factors to pilot fatigue. Caldwell (2005) writes that long haul pilots who fly international routes attribute their fatigue to multiple time zone transitions, while the domestic, short haul pilots cite sleep deprivation and high workload as the major factors. Furthermore, Hartzler (2013) found environmental factors such as the level of automation employed in modern cockpits and pilots' roles as passive monitors, dim cockpit lighting, reduced blood oxygenation from operating at high altitudes, and pilot health to all contribute to overall fatigue.

### Hazards Associated with Pilot Fatigue

These factors all lead to one of the dangerous manifestations of sleep deprivation; in flight micro-sleeps. According to Caldwell (2005), "…pilot micro-sleeps tended to occur most frequently during the cruise portion of long haul operations…and that micro-sleeps were more than 9 times more likely during nighttime flights compared to daytime flights. Of particular interest was the fact that such lapses apparently went unnoticed by the affected crewmembers" (p. 87). This finding serves to reinforce basic aeromedical knowledge, that pilots are susceptible to poor judgment because of fatigue and are often times unable to accurately assess his or her safety for flight.

## Controlled Rest as a Fatigue Countermeasure

A theme in the empirical literature seems to indicate that in flight napping is beneficial to overall pilot alertness and thus, promotes safety. Hartzler (2013) writes, "Strategic naps…can help reverse performance deficits due to sleep loss or disruption, with naps as short as 10 min helping to reduce subjective sleepiness and improve neurophysical performance" (p. 312). It then comes as somewhat of a surprise that the Federal Aviation Administration (FAA) does not allow for napping for unaugmented flight crews in the United States, but a multiplicity of foreign carriers employ it as a fatigue mitigation tool. This policy of prohibiting CRIP seems to be at odds with findings of a NASA study conducted at the Ames facility in the 1990s. The NASA (1994) report found that between a control no-rest group and an experimental group that was allowed 40 minutes of sleep in flight, both objective measures such as response times, as well as subjective alertness ratings, proved superior for the rested group.

Perhaps the reluctance of the FAA to implement CRIP procedures is due to one of the side effects highlighted by the detractors: sleep inertia. It is defined in the work done by Hartzler (2013) as "…the period of cognitive and mood impairment, as well as hypo-vigilance, experienced immediately upon awakening…" (p. 314). Hartzler (2013) further adds that it was found that these detrimental effects can be observed approximately 30-60 minutes after waking up, and have even been observed up to 2 hours after awakening. For as ominous as that may appear, there are several simple industry mitigation solutions to sleep inertia, such as limiting rest periods to cruise flight, and requiring the pilots to be awake for a prescribed amount of time before commencing descent and arrival procedures. Caldwell (2005) suggests:

> As long as technological and economic factors strain available personnel resources and basic human capabilities, fatigue will continue to be an aviation risk factor. However, systematic fatigue education… the implementation of scientifically based scheduling practices…will optimize the safety and well-being of crews, passengers, and payloads everywhere. (p. 194)

## Affect

As was previously mentioned, there exists a myriad of factors that may influence consumer willingness, and internal biases and opinions may influence consumer behavior. Affect is one particular area where research on evaluative processes has been increasing (Bodenhausen, 1993; Bower, 1991; Clore, Schwarz, & Conway, 1994; Forgas, 1995; Loewenstein, 1996; Schwarz & Clore, 1996; Zajonc, 1998). More specifically, this research has investigated the role of emotional influence on human decision-making. Some studies suggest that emotions are used when information needs to be processed quickly (Frijda, 1986; Levenson, 1994; Oatley & Johnson-Laird, 1996) and when longer-term, more deliberate decisions must be made (Johnson-Laird & Oatley, 1992; Lazarus, 1991; Schwarz, 1990; Simon, 1967; Tooby & Cosmides, 1990).

While previous research (Trafimow & Sheeran, 1998, 2004; Trafimow et al., 2004) has shown that affect and cognition are separate entities, research on evaluative judgments has demonstrated that emotions do have a role in the decision-making process (Clore, Schwarz, & Conway, 1994; Schwarz, 1990; Schwarz & Clore, 1983, 1988, 1996). It is possible when individuals are presented with new information, they may respond emotionally or at least have their response influenced by emotions.

Dholakia (2001) brings up the issues of perceived risk and product involvement as affective factors that may influence customer willingness. The author found that risk perceptions are a function of cognitive evaluation of a product by a consumer, which may cause airlines and regulators alike some unease, as travelers are all unique and have personalized thought processes. Dholakia (2001) goes on to state that there was some evidence to support that perceived risk affects consumers' product involvement. Product involvement is defined as "an internal state variable that indicates the amount of arousal, interest or drive evoked by a product class" (Dholakia, 2001, p. 1341). This would then suggest that as has already been happening, the safer a product class is perceived to be, the higher the likelihood of it being utilized. In terms of CRIP, it has been largely supported by the experts, as well as been successfully implemented overseas, so that begs the question why the lag in the U.S. policymaking?

**Willingness as a Metric**

As previously mentioned, the focus of this paper is to investigate consumer perceptions, in terms of the level of consumer willingness to fly in CRIP protocols. Writing in thefreedictionary (2014) defines willingness as "done, given, accepted, or borne voluntarily or ungrudgingly". By using willingness as a metric, consumer views toward controlled rest procedures can now be quantified. Key to any new technology or policy being introduced is consumer acceptance or buy in. Work by Pramatari and Theotokis (2009) identifies personality characteristics, service and technology characteristics, and situational factors as items that can affect consumer perceptions. Naturally, even the best analyses and safeguards that the airlines implement cannot guarantee positive consumer perceptions, nor can they intrinsically alter individual personalities to support CRIP. What they can do, as evidenced in the work by Pramatari and Theotokis (2009), is extol the virtues of the system in terms of ease of use and complexity, or lack thereof. That being said, work by Zhao and Kling (2004) might once again bring pause to the regulators and top airline management alike. According to Zhao and Kling (2004):

> How much one is willing to pay (or accept) for a good at a particular point in time will depend on…the ability to reduce the risk of a bad purchase or sale by gathering more information, and the ease of later reversing the transaction. (p. 504)

One of the unique characteristics of the airline product is that there is little to no way of evaluating the product beforehand, as there are so many variables that could potentially affect product quality. For example, there could easily be delays to on-time service as a result of weather or maintenance issues. Furthermore, reversing the purchase is usually quite difficult if not impossible. In this study the researchers are specifically evaluating willingness to fly. If the customer has any reservations about CRIP procedures, there could well be a reduction in airline passenger traffic, which would naturally concern management. This study may provide useful information on consumer perceptions toward the use of CRIP procedures.

The scale used in this study was a valid and reliable instrument to measure consumer's willingness to fly. Rice et al. (accepted) completed the scale development and validation. Consumers were used in all stages of the instrument creation. This included stages of word generation, word pairing, validation, discrimination, and scenario-based applications. The final instrument consisted of 7 statements to measure a consumer's willingness to fly using a 5-point Likert scale from Strongly Disagree to Strongly Agree.

## Study 1 Research Questions and Hypotheses

Study 1 sought to answer the following research questions:

1) What is the overall willingness to fly of consumers when controlled rest procedures are in effect?
2) How does gender affect consumer willingness to fly ratings when controlled rest in position is used?

The following Hypotheses were posited for Study 1:

$H_1$ – Based on the literature, it was predicted that there would be a decrease in willingness to fly ratings when controlled rest in position was used.
$H_2$ – It was predicted that there would be some difference in willingness to fly ratings between the genders if controlled rest in position is used.
$H_3$ - There would be possible interactions between the variables.

## Study 1 Methodology

### Participants

Two hundred and fifty-four total participants for this study were sampled from the American population, 159 males (*M* = 32.91 years, *SD* = 9.91) and 95 females (*M* = 34.83 years, *SD* = 12.62) and were limited to persons aged 18 years or older. They were sourced from the online population of persons who complete electronic surveys for compensation via Amazon's ® Mechanical Turk ® (MTurk). This is an interface available through Amazon that provided electronic means to facilitate the compensation of participants for the completion of tasks. Participants received a small monetary compensation for their time. Research has shown that MTurk provides data that is as reliable as laboratory data (Buhrmester, Kwang, & Gosling, 2011; Germine, et al., 2012).

## Procedure and Materials

The survey was distributed electronically via FluidSurveys ® on Amazon's ® Mechanical Turk ®. Participants were asked questions about their willingness to fly rating if controlled rest in position procedures are being practiced. In the control condition participants read the following scenario*: Imagine that you are on an overnight 7-hour international flight between two major cities with two pilots on-board. You learn that the airline requires both pilots to remain awake for the duration of the flight.* The scenario in the experimental condition read: *Imagine that you are on an overnight 7-hour international flight between two major cities with two pilots on-board. You learn that the airline allows that one pilot at a time may nap in the cockpit provided the other remains awake and a flight attendant has been notified that one of the pilots will be napping. The flight attendant serves as a backup to ensure the nap only lasts for the specified duration.*

Responses measuring willingness used a Likert-type scale from strongly disagree (-2), to strongly agree (+2), with a neutral option included, and were analyzed to quantify consumer results. This scale was a valid and reliable instrument that has been shown to measure consumer's willingness to fly (Rice et al., accepted). Demographic information was also collected and analyzed to determine if there were any gender differences, and then participants were debriefed on the study.

## Study 1 Results

A valid and reliable instrument was used in the study to test the dependent variable of willingness to fly (Rice et al., accepted); however, to verify internal consistency, a Cronbach's Alpha test was conducted. Scores ranged from .96 to .98, which implied high consistency between answers, allowing the data to be averaged into a single score for each participant.

A 2 x 2 Factorial ANOVA analysis was conducted on the data using condition and gender as between participant factors. The main effect of condition was found to be significant, $F(1, 250) = 20.16$, $p < 0.001$, $\eta p^2 = 0.075$, as well as that of gender, $F(1, 250) = 7.31$, $p = 0.007$, $\eta p^2 = 0.03$. There was no significant interaction between gender and condition, $F(1, 250) = 0.045$, $p = 0.83$, $\eta p^2 = 0.00$. Study results are depicted in Figure 1.

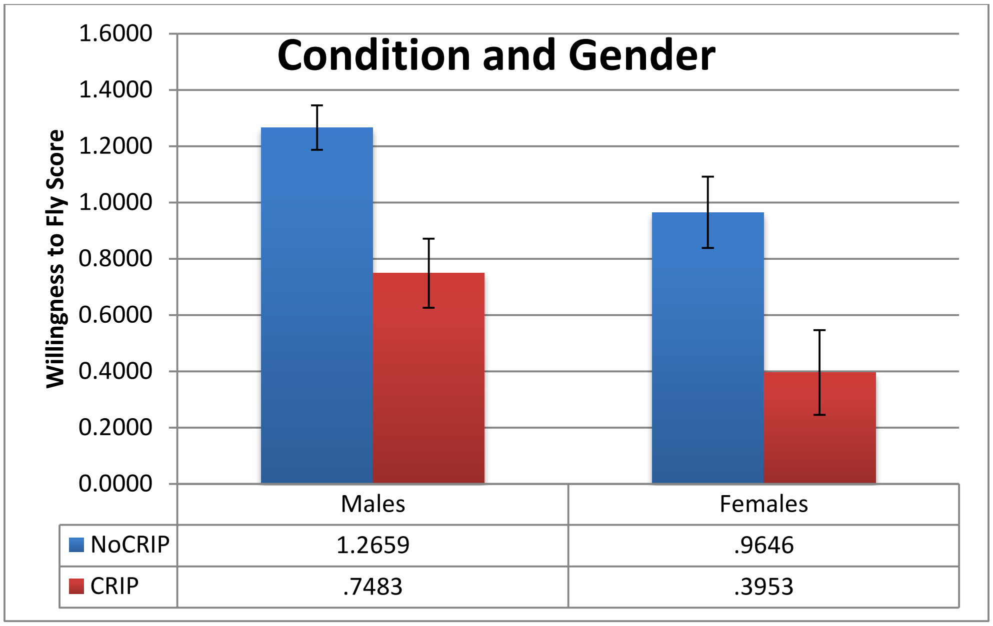


*Figure 1*. Study 1 Willingness to Fly Data. SE bars included.

## Study 2 Research Questions and Hypotheses

The second study sought to replicate the findings of Study 1. Therefore the research questions and hypotheses remained the same. Additionally, the researchers wanted to determine if Affect would mediate, at least partially, the relationship between the condition and willingness to fly score. Based on similar studies (Remy, Winter, & Rice, 2014; Winter, Rice, & Mehta, 2014), it was hypothesized that Affect would mediate, at least partially, the relationship between the condition and willingness to fly.

## Study 2 Methodology

### Participants

Two hundred and seventy-six participants were sampled from the American population using Amazon's ® MTurk ®. Participants included 156 males (*M* = 31.22, *SD* = 8.51) and 142 females (*M* = 32.95, *SD* = 10.27) that were all over the age of 18 from the United States.

### Procedure and Materials

The procedure for Study 2 was identical to Study 1, except participants in Study 2 were additionally asked 3 questions related to Affect (Remy, Winter, & Rice, 2014; Winter, Rice, & Mehta, 2014) and asked to indicate how the scenario made them feel on a 7-point Likert scale from extremely bad/negative/unfavorable (-3) to extremely good/positive/favorable (+3), with a neutral option of 0 before being asked to rate their willingness to fly.

## Study 2 Results

Study 2 used the same valid and reliable instrument from Study 1. The two dependent variables (willingness to fly and Affect) were subjected to a Cronbach's Alpha analysis for internal consistency. The values for willingness to fly ranged from .96 to .98 and for Affect both scores were .97; therefore, due to the high internal consistency for each of the dependent variables a single average score was produced for willingness to fly and Affect for each participant.

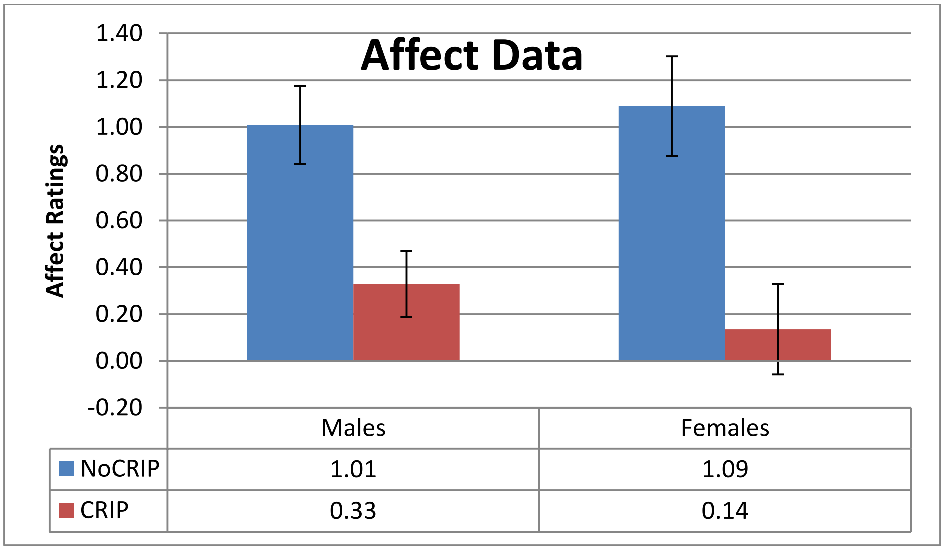


*Figure 2.* Study 2 Affect Data. SE bars included.

### Factorial Analyses

A 2 x 2 Factorial ANOVA analysis was conducted on the data using condition and gender as between participant factors. For the Affect data, the main effect of condition was found to be significant, $F(1, 272) = 45.09$, $p < 0.001$, $\eta p^2 = 0.072$. The main effect of gender was found to not be significant, $F(1, 272) = 0.10$, $p > 0.05$, $\eta p^2 = 0.00$ nor was the interaction , $F(1, 272) = 0.597$, $p > 0.05$, $\eta p^2 = 0.00$. Figure 2 depicts the Affect data. For the willingness to fly data, the main effect of condition was found to be significant, $F(1, 272) = 15.04$, $p < 0.001$, $\eta p^2 = 0.052$, as well as that of gender, $F(1, 272) = 6.40$, $p < 0.05$, $\eta p^2 = 0.023$. There was no significant interaction between gender and condition, $F(1, 272) = 0.047$, $p = 0.83$, $\eta p^2 = 0.00$. Willingness to fly data are depicted in Figure 3.

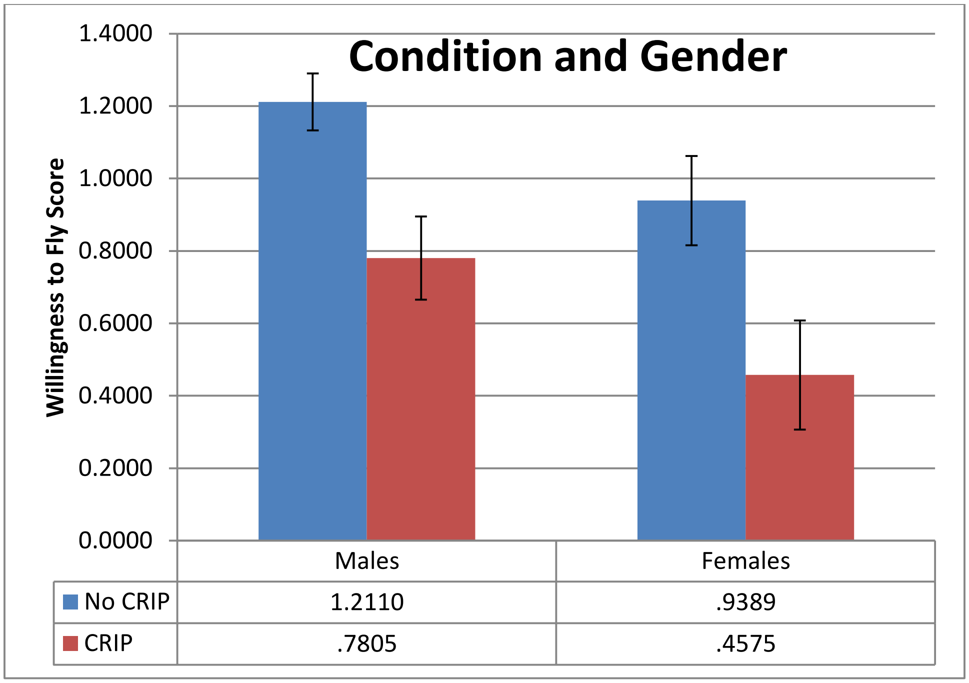


*Figure 3.* Study 2 Willingness to Fly Data. SE bars included.

**Mediation Analysis**

The mediation analysis for males is presented in Figure 4. In order to conduct the mediation analysis, the correlation between condition and willingness to fly was first found to be significant, $r = .242$, $p < 0.05$, showing that the initial variable correlated with the outcome variable. The standardized path coefficients were: condition to affect (.242, $p < 0.05$); affect to willingness to fly (.614, $p < 0.001$); condition to willingness to fly controlling for affect (-.093, $p = .147$). These data show that Affect has complete mediation on the relationship between use of controlled rest and willingness to fly for males.

The mediation analysis for females is presented in Figure 5. In order to conduct the mediation analysis, the correlation between condition and willingness to fly was first found to be significant, $r = .218$, $p < 0.05$, showing that the initial variable correlated with the outcome variable. The standardized path coefficients were: condition to affect (.293, $p < 0.05$); affect to willingness to fly (.826, $p < 0.001$); condition to willingness to fly controlling for affect (-.023, $p = .675$). These data show that Affect has complete mediation on the relationship between use of controlled rest and willingness to fly for females.

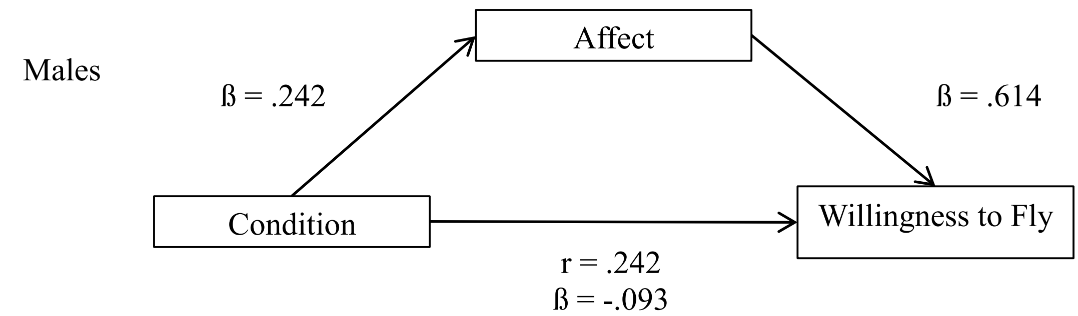


*Figure 4.* Path analysis for Males.

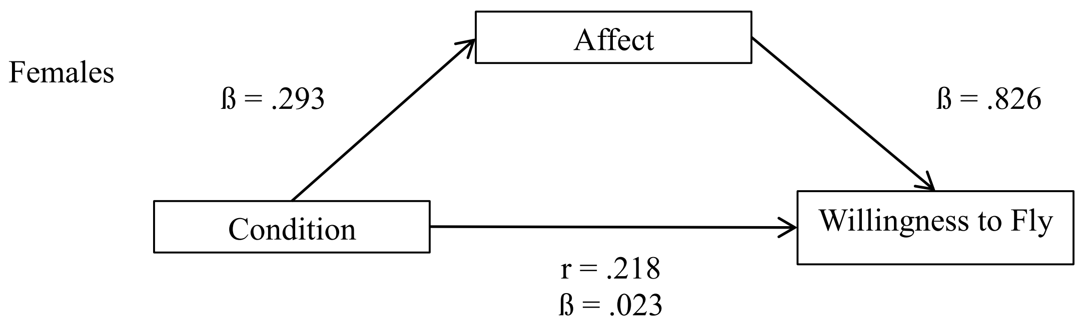


*Figure 5.* Path analysis for Females.

## General Discussion

The purpose of this paper was to investigate both the general public perception of CRIP, as well as to examine any differences in responses between the genders. Using an instrument on consumer's willingness to fly, the study examined for differences based on the use of controlled rest procedures, gender, and if Affect mediated any relationship between condition and gender.

In the first hypothesis, data indicated a significant difference in willingness to fly ratings between the controlled rest usage scenario and no controlled rest conditions. Despite expert opinion on the benefits of controlled rest, participants were much more willing to fly when controlled rest was not practiced. This finding seems to suggest unfamiliarity on the part of the participants with the concept of controlled rest, and offers regulators an idea of likely public feedback if such rules were implemented (Pramatari &Theotokis, 2009). While generally the responses did not indicate an unwillingness to fly while controlled rest in position was being used (average responses still above 0), public education is likely necessary to convince the general population of the benefits of using such procedures. One would imagine if the public was made aware of the role of automation, coupled with the opportunity to rest in the low workload cruise portion of flight and be more alert for the high workloads of approach to landing, their opinions may change somewhat.

Similarly, the null hypothesis was also rejected in the second hypothesis, as there was a significant difference in willingness to fly ratings between the genders. The data indicated males were more willing than females when it came to flying while controlled rest was being used. This somewhat contradicts findings by Porter, Donthu, and Baker (2012), which stated there typically is no significant difference in levels of willingness to fly between the genders. This finding encourages further research into determining why this might be true. Perhaps answers might be found when comparing how the genders define and assess risk, which according to these findings, suggests a more risk averse nature of females.

Finally, it was predicted that Affect would at least partially mediate the relationship between the condition, use of controlled rest or not, and willingness to fly score. For both males and females, Affect was found to completely mediate this relationship. While research has demonstrated the advantages of strategic use of napping, it is plausible to understand a passenger's potential shock to learn of a pilot napping in the aircraft. As reported by Dholakia (2001), when consumers perceive a situation as being more risky than an alternative, it is possible that they may respond emotionally. For countries that have implemented controlled rest, very specific procedures and policies are in place to ensure that the practice is completed safely. With Affect providing mediation, it is possible that providing education to consumers of the benefits of CRIP may help them understand the value of this procedure and benefits it can provide to help keeping the flight crew alert during critical phases of flight.

## Practical Implications

The results of this study may be of practical value to both airline management and industry regulators alike. In the cases of both parties, it is of critical importance to determine consumer buy-in when new rules or procedures are proposed, as there is a strong risk aversion to isolating any portion of the customer base. These early findings help to paint a picture of general consumer perceptions on the implementation of controlled rest, and so allow both invested parties to make more informed decisions. Based on study findings, it seems that a public education program will need to be implemented well in advance of implementing controlled rest regulations, since both genders were significantly less willing to fly when such procedures were used. One would want to ensure the best possible opportunity for a cognitive, rather than emotional assessment from the public with regard to their support of these procedures.

## Limitations and Recommendations for Further Research

Naturally, the findings presented in this study must be considered with the study's limitations. The major limitation of this study is the fact that the population surveyed was only persons who completed online human intelligence tests, thereby limiting the generalizations to that particular subset, which may or may not be representative of the larger population. Additionally, the participants may not accurately represent the travelling public that uses commercial aviation, as there was no requirement to be a user of commercial air service to participate in the study. Opportunities for further study are numerous. Questions were raised in the discussion about whether the overall consumer perception ratings were influenced by an emotional response rather than a cognitive assessment. This might be investigated by modifying the study to compare responses between participants who received a factual briefing on controlled rest procedures and those who did not. The addition of affective measures may also assist in confirming that research question. Additionally, more research could be conducted to determine why there was a significant difference in willingness to fly ratings between the genders, which is a quasi-experimental variable.

## Conclusions

This study examined the consumer perceptions of the American population in terms of their willingness to fly rating and the use of CRIP procedures on commercial aviation flights. Results indicated a lower average consumer willingness to fly rating while these procedures were in effect compared to when they were not, and that between the genders, females were less willing than males for the same condition. These findings can be used by airlines operating in United States as well as the Federal Aviation Administration to garner insight into consumer buy in, and can hopefully guide policy-making to determine the most effective countermeasure to combat in flight pilot fatigue.

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# Aviation Living Learning Community: Impacts on Student Success

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**Abstract**

The purpose of this study was to examine the impact on student academic success and retention while participating in an aviation-themed living learning community on a college campus. The data for this study was drawn from 625 new students (freshman and transfer) who enrolled at the University with an aviation major declared at the start of the 2012 and 2013 fall semesters. The study compared the difference in academic performance and retention between students (N=82) living in the Aviation Living Learning Community (ALLC) against those not living in the ALLC. The study found significant differences between the two groups of students in Fall GPA and academic grade in the Private Pilot ground school, students participating in the ALLC did significantly better than their peers not living in the ALLC. There was no significance found between the two groups in regards to retention at the University, or staying in the aviation program.

## Introduction

Higher education has been under increasing pressure from the general public, lawmakers, and even the President of the United States to bring student outcomes and accountability for those outcomes to the forefront of the debate on the quality of higher education. In a December 2014 article in the *Chronicle of Higher Education*, the author outlined the initial plan of the current Administration to quantify student success (Field). Metrics which are proposed to be included within this program include, but may not be limited to, average net price of the institution, completion rate, labor market outcomes (readiness for employment and salary), and loan repayment rates. The purpose of this program is to determine a standardized method to rank like-caliber colleges and universities and increase transparency for prospective students and parents who are about to embark on the journey of higher education (or funding of said journey). This program has been under development for over a year (Field, 2014) and brings with it both skepticism and increased scrutiny from those who may, at some point in the not-so-distant future, have to abide by its tenets.

As an alternative to the President's plan, some of the nation's respected higher education institutions have collaborated and created their own higher education metric called the *Student Achievement Measure* (Mangan, 2013). The obvious benefit of this alternative is that it originates within the organizations for which it is intended to govern, which should lead to increased buy-in from participating institutions as well as incorporating the expertise of professionals dedicated to improving student success metrics on a daily basis. Both options have the same end-goal in mind, but exercising parallel paths in pursuing the end-goal.

Academic programs in higher education have seen an increasing pressure to ensure student success from various levels of authority from the federal government down to the University or college level. With the pressure to increase accountability and improve various performance metrics such as increasing student retention and graduation rates, academic departments are implementing various high impact practices. Kuh (2008) identifies 10 high-impact practices such as first-year seminars, internships, service learning and learning communities that have been widely tested and proven successful in colleges around the nation.

Within the context of student success, the researchers involved in this study sought to quantify student success on a micro-scale with the desire of using this information to enhance the higher education experience and observed success metrics, retention and academic performance. The format employed was a grouping of students living together with the same chosen academic field of Aviation, commonly referred to as a Living Learning Community (LLC). A Living Learning Community can be further defined as a place where students both live and gather and where direct or auxiliary instruction of academic material takes place. Additionally both formal and informal career and academic advising by faculty and departmental staff is typically considered to be a core component of many Living Learning Communities. Many variations exist on how exactly living learning communities are structured and which student populations are involved.

## Institutional Profile

Specifically examined in this study are the first-year student participants in the Aviation Living Learning Community (ALLC) living in an on-campus residence hall located at a public four-year institution. The ALLC is a partnership between the Department of Aviation and campus Residence Life. The institution reported a Fall 2014 total student enrollment of 14,906 of which 11,537 are undergraduate students and approximately 17.4% of these students live in University-provided residence halls (University of North Dakota Division of University & Public Affairs, 2014). Aviation student enrollment numbers are broken down by major in the table below.

Table 1

*Aviation Student Enrollment by Major.*

| Major / Term | Fall 2014 |
|---|---|
| Air Traffic Control | 226 |
| Airport Management | 50 |
| Aviation Management | 111 |
| Aviation Tech. Management | 10 |
| Commercial Aviation | 865 |
| Flight Education | 31 |
| Unmanned Aircraft Systems | 154 |
| Total Undergraduate | 1447 |

Researchers involved in this study sought to determine whether a difference exists between student participants in the ALLC and their academic performance and persistence within the declared program of study compared to non-participant peers at the University. Although numerous research has been performed on Living Learning Communities and their impact on student success, the authors were not able to locate any previous research related to aviation-themed residential living communities on university campuses.

## Review of the Literature

During an analysis of literature involving LLCs and related subtopics of student persistence and academic success, several important themes were noted as they relate to this study. As presented in Tinto's (1993) Model of Student Departure and associated with the question of retention addressed in this study, six characteristics predict likelihood of student premature departure from selected four-year institution, including: pre-entry attributes, initial goals and commitments, institutional experiences, integration, goals and commitments over time and departure decision/outcome. Tinto's (1993) reference to Institutional Experiences highlights the partnership between the Academic and Social System which the Living Learning Community concept is specifically designed to address.

Living Learning Communities and studies related to their impact on student success and retention have been occurring for over five decades. The theory suggests that a strong linkage between the academic department and student life aspects of a post-secondary education have a direct correlation to student success. According to Inkelas, Vogt, Longerbeam, Owen, & Johnson (2006) "…students in [Living Learning] programs are more likely to persist, exhibit stronger academic achievement, interact with faculty, and engage in a more intellectual residence hall atmosphere than students in traditional residence halls." (p. 41) This theory has been tested in a variety of universal and "themed" residential learning communities including, but not limited to engineering (Shushok & Sriram, 2010), psychology (Grills, Fingerhut, Thadani, & Machon, 2012), and 1st year student leadership focused communities (Stewart, 2008).

To illustrate the importance of linked academic and social environment, Grills et al (2012) stated:

> As students are able to nurture student-student relationships and connections to a disciplinary interest and faculty associated with that discipline, they grow socially and intellectually. Subsequently, students' commitments to their undergraduate institution, their chosen major, and career trajectory are strengthened. (p. 44)

Specific attributes of the Psychology Early Awareness Program (PEAP) noted in the article include highly integrated learning environments where students take specifically identified courses as a cohort, are admitted earlier into residence halls as compared to non-PEAP participants, and participate in monthly "fireside chats" or socials with Psychology faculty members. (Grills et al, 2012)

Similarities and differences exist between the LLC literature reviewed and the structure and administration of the studied ALLC. Similarities include ALLC subjects being provided with uniquely designed programming opportunities both aviation-related as well as social and "live-well" (overall health improvement) presentations by residence hall staff. Additionally, particpants are invited to monthly or semi-monthly faculty socials which are typically informal, but are provided for the purpose of enhancing academic and/or career-related discussion and mentorship. ALLC participants are also provided with more focused academic advising with faculty and staff on-site support. This process occurs prior to enrollment in the spring and fall semesters.

Although certain similarities exist between the studied ALLC and those referenced in the literature review, there exist several differences. ALLC participants are not currently offered uniquely designed courses or take courses exclusively as a cohort, however this opportunity may be introduced in subsequent years. ALLC participants currently self-select which is a common trait with selected other studies (Grills et al, 2012) however, this differs from what is practiced with the College Park Scholars Program at the University of Maryland where students are uniquely invited into the program based on academic achievement and prior high school involvement (Stewart, 2008). The present state of the ALLC program also differs from the College Park Scholars Program with respect to the level of infrastructure integration accomplished as a part of the initial preparation. Stewart (2008) notes, "Resident faciltities renovated the first floor of a vacant high-rise to accommodate classrooms, faculty, and administration office space. Floors 2 through 8 were painted; bathrooms and lounges were updated." (p. 52). At the initiation of the ALLC, no infrastructure modifications (other than cosmetic additions) were made to change the way the students live and integrate their learning expereience within the ALLC. Addition of classrooms or dedicated faculty offices could be one area for future consideration as the ALLC program advances at the University.

Table 2

*Attributes of Living Learning Communities*

| Attributes of Living Learning Communities Found in the Literature | ALLC Attributes Included in Study |
|---|---|
| Self-Selection into LLC | X |
| Monthly Programing | X |
| Partnership between Student Affairs and Academic Department | X |
| Participation from Faculty | X |
| Embedded Faculty (office space) | |
| Designated Physical Space for Classes | |
| Courses Linked to LLC | |
| Early Admission to Halls | |

*Note.* Table data consolidated from reviewed literature; Brower & Inkelas, 2010; Grills, Fingerhut, Thadani, & Machon, 2012; Stewart, 2008; Shushok & Sriram, 2010.

As can be identified above, one of the more interesting aspects noted in the literature review was the high degree of variation on administrative responsibility and integration between the Academic Department and the partnering Residence Life unit of the University. This fact was specifically noted as it relates to the ALLC and how improvements and modifications may be realized in subsequent years.

Research regarding living learning communities has been widely published over the years, however the authors failed to find any literature exploring specific aviation-themed living learning communities during their search. This study serves to add to the body of knowledge in regards to living learning communities by examining academic success and retention data in relation to participation on an aviation-themed living learning community and answers the following research questions:

1) Is there is a difference in academic success between students participating in the aviation living learning community versus students not participating?
2) Is there a difference in retention both at the University as well as in the aviation program between students participating in the aviation living learning community versus students not participating?

## Methodology

### Setting

This study was conducted at a public, four-year, research university. As was noted earlier, during the Fall of 2014 there were nearly 15,000 students enrolled in over 200 fields of study at the University. On average, there are nearly 3,000 new students enrolled each fall semester. New students include both new freshman as well as new transfer students to the University. The Department of Aviation offers five aviation specific majors, and accounts for over 10% of the undergraduate population at the University.

During the Fall of 2012, the Department of Aviation partnered with Residence Life to offer the first aviation-themed living learning community at the University. The first year was limited to one wing of a residence hall with 35 available slots, the second year it doubled consisting of an entire floor of the residence hall. Only new students to the University, with a declared interest in aviation were permitted access to live in the ALLC during their first year on campus. The resident assistants (RAs) in the LLC were aviation majors, and the Department of Aviation worked closely with Residence Life to provide various programs to the residents.

## Participants

Two cohorts of students comprise the sample for this study. Each cohort consists of new students (freshman and transfer) enrolled as aviation majors at the University. One cohort began in the Fall of 2012, while the other began on the Fall of 2013. Students participating in the aviation living learning community were identified allowing for comparison analysis. Much of the literature in regards to first year student success focuses solely on new freshman data. However, since both new freshman and new transfer students were allowed to live in the ALLC, this research will include both for analysis.

## Data Collection

The data used in this study was obtained from existing academic records through the University's Office of Institutional Research (OIR). Students participating in the ALLC were identified in the data set. This study uses a quantitative approach to compare student success and persistence between students participating in the ALLC and those not participating.

Student success is measured by term grade point average (GPA), credit hours passed and academic grade in the Introduction to Aviation course which is commonly referred to as Private Pilot ground school. Student persistence is measured by enrolling in the subsequent fall semester. Persistence is subsequently broken down by both remaining at the University as well as remaining an aviation major. The single independent variable in this study relates to participating in the ALLC.

## Procedures

The original dataset was obtained from the Office of Institutional Research as a detailed Excel file. Once the data was sorted and coded, it was uploaded into the Statistical Package for Social Science (SPSS) version 20. Part-time students and students entering into the University as non-aviation majors were deleted from the dataset. For the purposes of answering the research questions, both descriptive and inferential statistics were used. The significance for this study was set at the .05 level.

## Results

The sample for this study consisted of two cohorts of students entering into the University during the Fall of 2012 and the Fall of 2013. Both new freshman and new transfer students were included in the analysis of data, as both types of new students participated in the ALLC. The following tables provide descriptive analysis of the dataset in its entirety, followed by the comparison between students participating in the ALLC and those not participating.

Table 3

*Descriptive Analysis of Dataset (N=625)*

| Characteristics | N | % |
|---|---|---|
| Year Enter | | |
| Fall 2012 | 351 | 56.2 |
| Fall 2013 | 274 | 43.8 |
| Admit Type | | |
| New Freshman | 486 | 77.8 |
| New Transfer | 139 | 22.2 |
| Participation | | |
| Aviation Living Learning Community | 82 | 13.1 |
| Non-ALLC | 543 | 86.9 |

In this study student success is defined by a variety of metrics. First, student credit hours passed and failed was used as a measure of degree completeness. A student at this particular university requires 125 credit hours to graduate, thus the more credit hours completed successfully, versus credits failed, would lead to greater degree completions at a faster rate. Term GPA was also included as a success measure. Lastly, since this living learning community was focused in the aviation department, an analysis of academic performance during the Private Pilot ground school was also included, the score is based on a typical 4.0 grading scale. Table 4 lists the descriptive analysis of the various success variables.

Table 4

*Descriptive Analysis of Success Variables*

| Success Variable | Mean | Standard deviation | Sample size (n) |
|---|---|---|---|
| Student Credit Hours | | | |
| Fall Credit Pass | 11.55 | 3.53 | 625 |
| Fall Credit Fail | 0.75 | 2.11 | 625 |
| Spring Credit Pass | 11.70 | 4.43 | 598 |
| Spring Credit Fail | 0.73 | 2.04 | 598 |
| Term Grade Point Average | | | |
| Fall GPA | 3.01 | 0.86 | 625 |
| Spring GPA | 2.81 | 1.00 | 598 |
| Academic Course Grade | | | |
| Private Pilot Ground School | 2.65 | 1.29 | 413 |

Student retention in this study was defined two ways: retention at the University and retention within the aviation program. The overall retention rate at the University between the first and second year for the aviation students identified was 86%, indicating that 537 of the 625 students remained enrolled at the University after the first year. This is significantly higher than the University's overall retention rate which is typically maintained near 75%. It is important to note that of the 625 students who initially came into the University as an aviation major, 77% or 481 students remained as an aviation student at the University after the first year

This study aimed to answer two defined research questions in regards to the impact of participating in an ALLC on the success of students during their first year at the University. The first research question sought to see if there was a significant difference in academic success between students participating in the ALLC and non-participants. Success was measured through seven different dependent variables: fall credits passed, fall credits failed, spring credits passed, spring credits failed, Fall GPA, Spring GPA and grade in Private Pilot ground school. Of the seven variables, four proved to be significantly different. Table 4 displays the results of the t-test analysis for the seven variables. (University of North Dakota Division of University & Public Affairs, 2014) (OIR)

Table 5

*t-test Analysis of Success Variables for ALLC and non-ALLC*

| | ALLC Participation | | | |
|---|---|---|---|---|
| | ALLC | Non-ALLC | *t* | *df* |
| Fall Credits Passed | 12.23 (1.78) | 11.44 (3.57) | 1.89 | 623 |
| Fall Credits Failed | 0.27 (1.09) | 0.82 (2.22) | -2.20* | 623 |
| Spring Credits Passed | 12.75 (4.29) | 11.54 (4.44) | 2.26* | 596 |
| Spring Credits Failed | 0.81 (2.84) | 0.71 (1.89) | 0.39 | 596 |
| Fall GPA | 3.17 (0.70) | 2.99 (0.88) | 2.03* | 623 |
| Spring GPA | 2.96 (0.94) | 2.79 (1.01) | 1.44 | 596 |
| Grade Private Pilot Ground School | 2.97 (1.07) | 2.59 (1.32) | 2.19* | 411 |

*Note.* *p<.05. Standard Deviations appear in parenthesis below means

The second research question aimed to identify if there was a difference in retention rates between students participating in the aviation living learning community compared to students not participating. For this analysis, a chi-square test was chosen due to the nature of the variables. Although no significance was found, Table 6 and 7 depict the results in regards to university retention and aviation major retention respectively.

Table 6

*Chi-Square of ALLC participation and university retention (N=625)*

| | ALLC Participation | | |
|---|---|---|---|
| | ALLC | Non-ALLC | $\chi 2$ |
| Yes (Observed/Expected) | 72/70.6 | 46/466.4 | 0.240 |
| No (Observed/Expected) | 10/11.4 | 78/76.6 | |

Table 7

*Chi-Square of ALLC participation and aviation major retention (N=625)*

| | ALLC Participation | | |
|---|---|---|---|
| | ALLC | Non-ALLC | $\chi 2$ |
| Yes (Observed/Expected) | 67/63.1 | 414/417.9 | 1.20 |
| No (Observed/Expected) | 15/18.9 | 129/125.1 | |

## Discussion and Recommendations

The two research questions analyzed centered around two student metrics, academic success and retention rates. The findings of this study correlate to previous research (Grills et al., 2012) which saw an increase in GPAs from students participating in living learning communities. Departments, colleges and universities are concerned about retaining students from year to year so further examination into possible retention techniques is necessary.

### Academic Success

Students participating in the ALLC had a significantly higher GPA their first semester on campus, versus those that did not participate in the ALLC. Also, the number of attempted and failed fall credits were significantly less for those students participating in the ALLC. These results could be attributed to the tutoring available on the ALLC. Various faculty and airport staff visited the wing once or twice a semester to specifically cover Aviation course content. For the past two years the RAs have held weekly study sessions, “Homework Mondays” and “Sunday Afternoon Study Sessions” to name few examples of ALLC facilitated study.

Another contributing factor to these results is that the students are integrated within a floor with multiple other students and RAs of the same or similar aviation majors. If the students have questions they can simply leave their room and ask an RA or another student for help. When selecting a suitable RA, the Department of Aviation was involved in selecting a student who would serve as a positive role model for the new students entering the program. One of biggest criterion for the department was that the potential RA had successfully completed the Introduction to Aviation Private Pilot ground school and subsequent flight training.

The specific grade in the Private Pilot ground school was also found to be significantly higher for those students living in the ALLC. The Private Pilot ground school is a typical freshman course and could be taken fall or spring or summer semester. Again, since the students participating in this LLC were all freshmen or transfer students a high number of them would be in the course at the same time. Study groups were easily formed on the floor or in their community. Faculty and staff that work with students within the Private

Pilot ground school also attended scheduled monthly socials similar to what the Department of Psychology did with their PEAP LLC study (Grills et al, 2012), as well as attending various study sessions held on the community.

The amount of credits completed successfully during the Spring semester was also significantly higher for those students who live on the LLC. The study habits and techniques learned from the Fall semester may have created an environment which fostered learning therefore students knew what to expect from their second semester at college. The various study sessions continued into the Spring semester as well as monthly visits from faculty and staff. The interaction with the faculty and staff may also have increased the comfort level of students asking questions if they needed help. Research has shown that student-faculty interactions have been proven to promote integration of students into the academic life of the University (Garrett & Zabriskie, 2003) .

**Student Retention**

Historically, the Department of Aviation within the University has a higher retention rate than the rest of the University averaging around 80%, (University of North Dakota Division of University & Public Affairs, 2014) The researchers wanted to determine if there was a significant difference in retaining students at a higher rate if they were a part of the ALLC. The data did not show that the ALLC had any significance in retaining students within the University. Although the data did not show significance, the percentage of students retained from the ALLC did prove to be 88% as compared to 86% from students that were not a part of the ALLC. Through compiling the data the researchers did note that although small numbers, there were some transfer students on the ALLC. Further research opportunity exists to research retention of transfer students participating in the ALLC as compared to transfer students not participating in the ALLC.

## Recommendations

Brower and Inkelas (2010) stated that successful LLCs need to have clear learning objectives with an academic focus. To address the pre-requisite relationship for a successful program, the ALLC was created with mutual desire between the University Residence Life and the Department of Aviation. Both of these campus stakeholders thought it would be a great addition to the University's experience for a select number of aviation students. The University's ALLC had very informal goals that have been verbally communicated, but nothing has been formally documented or advertised. Verbal feedback from the RAs has indicated that participation in wing/floor/hall planned events has been declining. Over the years, the Department of Aviation has changed the focusing of programs from more formal monthly dinners, to hosting socials in the ALLC residence hall. This has subsequently increased participation. This improved participation could be partially attributed to the student mix this semester, the hall staff involved, or the convenience of the exchange with faculty on the wing versus at a secondary location. Researchers propose that establishing clear goals and communicating said goals will serve to improve the efficacy of the ALLC experience and the overall academic success and retention of those participating.

### Coordination

Referenced in the PEAP study (Grills et al, 2012, p.47), Brower and Inkelas (2010) also stated that another characteristic of a successful LLC was for the program to have a strong relationship between the academics and student affairs components. Various LLCs have faculty that live within the community (Shushok & Sriram, 2010), however the current ALLC environment is not presently equipped to handle this option. Although current university faculty do not live on the floor, they are still involved in routine interactions with ALLC students. ALLC faculty liaisons have bi-weekly meetings with the RAs and Resident Life Coordinator. These meetings are designed to discuss programming ideas, existing upcoming programs, and in general to see how student life on the wing is proceeding. These meetings are a great way to communicate, however faculty have noted that the same or similar discussion topics have taken place from year one to year three. For example, if a collaborative program was very successful one year, then the organizational information should be kept and used for the following year.

### Selection process

During the formation of the ALLC at the University, the Department of Aviation was asked which student populations should be included as participants in the ALLC. It was decided that the focus should be on new students to the University (freshman or transfer). When students receive their acceptance letter to the University they receive their housing application and on the application is an option to select that you are an aviation major and that you would be interested in living on the ALLC. The applications are collected and students are selected to live on the ALLC on a first come first serve basis. The only exception is for female students. As aviation is a male-dominated career field and the ALLC is embedded within a co-ed hall, the likelihood of a gender imbalance exists due to the majority of potential candidates being male. To address this, Residential Life offered some degree of preference to female applicants into the ALLC to facilitate a gender distribution which more closely reflects the remainder of the residence hall.

As it pertains to program growth, the first year of the ALLC there was one suite of four beds for females and it filled. The other 31 beds on the community were occupied by male students. The second year the ALLC was expanded to an entire floor of 70 beds. A little less than half the rooms were held with the intent that female students would request to live on the floor. The rooms were soon released to male students as there were only enough female responses to fill one suite (of four) again in addition to the female RA. Now in year three there are two suites of female students (8 total with 62 male students) and a female RA.

As growth has been witnessed in the ALLC program, researchers propose more formal selection processes be established for participants. Researchers believe that implementing moderate, not overly arduous, entrance requirements will improve the experience for students who have expressed more formal commitment to the mission of the ALLC. The logic is that a certain degree of personal ownership is required, for example, to write a one page essay indicating your interest in ALLC participation and how it may impact your university experience. Although researchers did not uncover specific research which supports this proposed condition, it is worth investigating in the interest of program refinement.

## Limitations of this Study

Researchers note certain limitations associated with the ALLC study. The first of these limitations was the small sample size of the ALLC population. Although the community has been growing steadily from 35 residents the first year of its existence in the Fall of 2012 to 70 residence starting the Fall of 2014 (note: no data was collected or reported on for Fall 2014 participants due to the timing of this study) addition to the sample size (N) will serve to validate findings listed previously in this study. To facilitate this statistical preference, the ALLC participants may be paired in the future with the three other Living Learning Communities on campus, being Honors, Engineering and Wellness, however it should be noted that this may not serve the end-goal of focusing specifically on aviation students' retention and academic performance.

The second limitation of the study is the admission process of ALLC participants. Presently there is no entrance requirement or additional process required of ALLC participants as students are admitted into the program. ALLC participants "self-select" into the program without respect for their prior academic performance, extracurricular participation, or level of commitment to the degree program. The positive attribute to this approach is that the impact of the ALLC on the residence may be less based on their degree-commitment and prior experience and more on the exposure they receive while receiving specialized programs and exposure to faculty interaction not typically witnessed by non-ALLC participants. The potential negative to this approach as that the ALLC as a whole may not be as academically committed or accomplished as would a group more specifically recruited for participation. The side-effect may include a larger variation in commitment coming into the program and students not taking full advantage of the additional resources being afforded to them.

## Conclusion

Researchers in this study were able to show the relationship between participation in the Aviation Living Learning Community and student success. Of the variables selected for testing student success, four returned results which indicated a statistically significant difference which can be used to explain the association between participation in the ALLC and positive student academic outcomes. These variables included a lower number of fall semester credits failed, an increased number of spring credits passed, fall semester GPA and the final grade in the Private Pilot ground school. In addition to student success, the researchers also sought to determine whether participation in the ALLC led to higher retention within the degree program, however no statistically significant differences were noted in the data.

Although more research is needed, the researchers believe that several factors contribute to the findings summarized above. Some of these proposed factors include increased student-faculty interaction, living amongst like-minded peers with similar career aspirations, and specialized programming opportunities tailored to the academic programs. Although this list is not all encompassing, the researchers believe these factors are the most influential towards contributing to student academic success. As for additional opportunity to enhance the student experience and impact of the ALLC, the researchers propose determining clear goals for the ALLC with Residence Life partners and communicating these goals to students, staff and faculty advisors as has proven successful in other themed-LLCs. Finally, researchers propose a modified selection program for student participants in the LLC. Although currently students come on a first-come, first-served basis, the researchers believe a judicious process for selecting academically-committed and goal-oriented aviation students will further enhance the impact to the entire ALLC as a whole and create environment where living and learning is truly exemplified.

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# The Use of FAA Flight Training and Aviation Training Devices at UAA Institutions

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## Abstract

This study undertook a survey of University Aviation Association (UAA) member institutions to determine the composition of the simulation fleet available to UAA institutions. Additionally, this survey asked about the financial and cultural impacts of the Federal Aviation Administration (FAA) January 2, 2014 policy change that altered the creditable training conducted in Aviation Training Devices (ATDs). The survey found that there is a plethora of training devices in use by UAA member institutions and that 62% of respondents will have to change the way they conduct training, and 48% will spend more than $20,000 to bring their institutions in compliance with the policy. Furthermore, 66% of respondents expect that their students will be charged an additional $1000 or more to complete their training because of the policy.

## Introduction

Simulation devices called Aviation Training Devices (ATDs) and Flight Training Devices (FTDs) are two types of devices generally used in the flight training industry because they are less costly to own and operate than the higher fidelity full flight simulators used in the airline industry. Aviation Training Devices and FTDs are highly effective training tools for initial flight students that are more interested in learning basic flight and navigation skills as opposed to aircraft type specific skills gained through the use of higher fidelity devices. In January of 2014, the FAA issued a policy change that would change the allowable training credit from ATDs toward private, instrument, and commercial certification (Policy change, 2014). This study sought to identify some of the impacts that these changes could have on collegiate flight training by surveying University Aviation Association (UAA) member institutions regarding their variety of flight simulation equipment, the use of their flight simulation equipment, and the potential financial and curricular impacts of the recent FAA policy change.

## Background

A survey of simulation equipment was undertaken in 2002 by Wiggins, Hampton, Morin, Larssen, and Troncoso. Their study had a broader scope than the one undertaken for this study as it was sent to a sample of 14 CFR Part 61 and 14 CFR Part 141 flight schools in addition to UAA member institutions. They found that UAA members had a total of 4 Full Flight simulators (FFS), 261 total FTDs, 133 Personal Computer Aviation Training Devices (PCATD), and 86 other training aids for a grand total of 484 devices.

Wiggins et al. also found that 84% of universities used these devices for training toward an instrument rating, 64% for multi-engine rating, 62% for private certification, and 57% toward commercial certification (Wiggins, Hampton, Morin, Larssen, & Troncoso, 2002). The new simulation policy will limit the creditable training time for any institution using FTDs below level 4 and PCATDs from the Wiggins et al. study (Policy change, 2014). Wiggins et al. did not give data on how many universities had FTDs certified less than level 4, so the full impact cannot be gathered from their study.

## Changes to ATD Training Credits

The FAA was able to explain the reasoning behind the initial policy change dated January 2, 2014 in a phone call in April of 2014. During this call, the FAA representative explained that this policy was a result of a Notice of Proposed Rulemaking (NPRM) that was issued in 2009, which had many of the same elements as the current policy change. These included the updating of letters of authorization for aviation training devices as well as the changes to training allotments. These changes were not enforced by the local Flight Standards District Offices (FSDO), and so this policy change was issued to enforce the existing rule. The original rule was proposed and adopted primarily to ensure the quality of the training devices in use. The argument was that if devices were not properly maintained, then they would do more harm than good when training students. The January 2nd policy change presented difficulties for flight training providers because of the seemingly sudden change in training time allotted to ATDs, due to lack of enforcement at the level of the local FSDOs, but in truth, it is an implementation of existing regulation (personal communication with M. Bernard, April 2014).

The January 2, 2014, FAA policy change removed nearly all allowable training in lower level FTDs. Under the policy, level 1, 2, and 3 FTDs are reclassified as ATDs, and thereby subject to the maximum training time allowable in ATDs (Policy change, 2014). Table 1 summarizes how the maximum allowable training times will be changed from before to after the policy change (Certification, 2014; Pilot schools, 2014; Policy change, 2014).

On December 3, 2014, the FAA issued a direct final rule to mitigate some of the impact of the January 2, 2014 policy change by increasing the amount of instrument training credit that a student can receive in Advanced ATDs (AATDs) and Basic ATDs (BATDs) under Part 61 and 141 (Aviation training device, 2014). This increased utilization of ATD's for instrument training would have essentially restored former level 1, 2, and 3 FTD's (if recertified as AATD's) to the original amount of training time as prior to the January 2, 2014 policy change. On January 15, 2015 the FAA withdrew the December 3, 2014 direct final rule due to two negative comments and indicated that, any future necessary changes would be through a notice of proposed rulemaking process (Aviation training device credit for pilot certification; withdrawal, 2015). The changes to creditable training time due to both policy changes can be seen in Table 1 below. The December 3, 2014 direct final rule would not have changed the creditable training time in ATD's for private and commercial training from the January 2014 policy change.

Table 1

*Creditable Training Time in Level 1, 2, or 3 FTDs Before Policy Changes, in the January 2014 change, and the December 2014 Direct Final Rule*

| | Part 61 | | | Part 141 | | |
|---|---|---|---|---|---|---|
| Training Course | Before policy change | Policy Change (January 2014) | Rescinded Direct Final Rule (December 2014) | Before policy change | Policy Change (January 2014) | Rescinded Direct Final Rule (December 2014) |
| Private | 2.5 | 0 | 0 | 5.25 | 0 | 0 |
| Instrument | 20 | 10 | 20 | 14 | 3.5 | 14 |
| Commercial | 50 | 0 | 0 | 24 | 0 | 0 |
| Total | 72.5 | 10 | 20 | 43.25 | 3.5 | 14 |

*Note.* Part 141 states maximum FTD time in percentages, which were converted to hours for comparison.

As can be seen in Table 1, Part 61 operators that fail to upgrade their devices will have a reduction in the total creditable time from 72.5 hours to 10 hours by using their former level 1, 2, or 3 FTDs if they are granted AATD status for these devices. For a Part 141 flight school, the time drops from 43.25 hours to 3.5 hours if they continue to utilize devices that were formerly certified as level 1, 2, and 3 FTDs. This is a significant change for both part 61 and 141 flight schools. Due to this large drop in creditable time, the FAA issued a one year grace period for students to complete their current training in level 1, 2, or 3 FTDs. After the end of the grace period, on December 31, 2014, no training time in a low level FTD can be counted as FTD time for certification (Policy change, 2014).

Additionally, all devices which are classified as ATDs must have their letters of authorization (LOA) reissued, including devices previously certified as a level 1-3 FTD. Letters of authorization are normally sought by manufacturers, but many devices have become "orphans" as their manufacturers are no longer in business. This means that the operators must recertify their devices, ensuring they meet the current ATD standards, and apply to the FAA for a new LOA. The new LOAs will have a five year expiration date, causing the operator in this situation to repeat the application process every five years (Policy change, 2014).

## Options for Policy Compliance

The January 2$^{nd}$ policy provided three ways to address the change; all three alternatives have curricular as well as financial impacts. The first method is to simply stop using the ATDs and move the training into aircraft. The second is to upgrade the ATDs, where applicable, and recertify them as level 4, 5, 6, or 7 FTDs and operate them in accordance with FAR Part 60. The final method involves changing the regulations under which flight training is provided (Policy change, 2014). All of these options have advantages and disadvantages, but all options will penalize students in some way.

Moving training into aircraft has the advantage of being readily accessible and a seamless transition for students and flight training providers. An additional advantage is that not all training must be moved into an airplane. If the ATD receives a new LOA, then training is permissible up to the reduced limits as listed in Table 1. For part 61 operators, this means that 2.5 hours of private pilot training, up to 10 hours of instrument training (if only upgraded to BATD), and 50 hours of commercial pilot training would move into an airplane. However the instrument training time is not a 1:1 move, as only about 80 percent of training done in an airplane can be logged as instrument training due to the time spent on the ground taxing and performing the run-up. This means that the 10 hours of instrument training translates to roughly 12.5 hours of airplane flight time. As mentioned previously, the advantage to this approach is the ease of transition as flight training providers will already have aircraft available. The disadvantages though are twofold. The first problem is financial; aircraft cost more to operate than ATDs, so that cost is passed onto the students. The second and more serious concern is the loss of training flexibility for students and instructors. One of the greatest benefits of simulation devices is that they can be used to demonstrate situations that would be impossible or unsafe in an airplane. Examples include inclement weather operations, aircraft system failures, and emergency procedures. By removing training from simulation devices, the FAA is removing a valuable training tool from instructors and taking an important learning opportunity out of many flight training curricula (Ratvasky, Ranaudo, Barnhart, Dickes, & Gingras, 2003).

Upgrading the ATDs, where appropriate, to level 4, 5, 6, or 7 FTDs is the second solution to this FAA policy. This solution has the advantage of leaving simulation training intact in the flight training curriculum, and so some financial and curricular burdens of the first solution are eliminated. For the student, this may be the best solution because it does not necessitate any curricular changes. However, the problem with this solution has to do with the availability and costs of upgrades. Only those ATDs which were manufactured as level 1, 2, or 3 FTDs can be upgraded to higher level FTDs, while not all level 1-3 FTDs will meet modern ATD standards. For those that do qualify, the cost to upgrade a single device is nearly $40,000, according to one representative of a FTD manufacturer. While this cost would be initially borne by the flight training provider, the students would eventually pay higher fees to cover this cost. Additionally, there is no guarantee that the upgrade will be complete in time for it to benefit the students. The FAA has granted a grandfathering period in their policy that allowed all ATDs to be used as they were currently certified until December 31, 2014. After that date, they must have a new LOA in order to be used. If a device cannot be upgraded before that date, then any training in it will not count toward a certificate or rating, and must be completed again in either an airplane or higher level simulation device (Policy change, 2014).

The third method of addressing the FAA's simulation policy is to change the regulations under which the training is conducted. 14 CFR 141.55(d) and (e) allow for training courses that do not meet the minimum time requirements in the appendices of 14 CFR 141. This would allow a training provider to continue using their ATDs as they are now while neither changing curriculum nor adding a financial burden (Pilot schools, 2014). Not mentioned in the policy change is that flight schools cannot be granted examining authority under 14 CFR 141.55, causing some students to pay increased examination costs. This approach will force the students to use the services of a designated pilot examiner or a representative of the FAA.

## Research Questions

This research sought to answer the following three questions:

1. What is the current composition of the simulation fleet available to UAA member institutions?
2. What is the curricular impact on UAA member institutions of the January 2, 2014 FAA policy change regarding creditable ATD time?
3. What is the economic impact on UAA member institutions of the January 2, 2014 FAA policy change regarding creditable ATD time?

## Methodology

### Participants

To address the research questions, representatives of the 102 UAA member institutions were asked to participate in the study by completing a survey. The individual representatives were selected based on the publically available institutional contact list. The research questions were focused on UAA member institutions, and all 102 were included in the survey request, and so the entire population of interest was surveyed.

### Materials/Instruments

A survey was created to determine the types of flight simulation equipment utilized by UAA member institutions and how institutions would be impacted by the January 2, 2014 FAA simulation policy change. The survey was pilot tested for content validity before being submitted to the Human Subjects Committee (HSC), the SIUC institutional review board, for approval. The survey included demographic information about the institution, but no questions were asked about the respondent.

### Research Design

This was designed as a descriptive study, in order to obtain information on the current composition of the simulation fleet available to UAA member institutions and the curricular and financial impact of the January 2, 2014 FAA ATD training credit policy change.  After the survey was pilot tested and approved by the HSC, it was sent to UAA member representatives via surveymonkey.com.  Surveymonkey.com automatically sent reminder emails twice to those who did not respond, once every ten days after the survey opened.  This automation allowed the survey responses to be collected anonymously as the system could keep track of respondents without reporting that information to the researchers.

## Results

### Response Rate

Of the 102 surveys sent, two were undeliverable.  A total of 29 responses were received, but only 27 were usable as two were unanswered, leading to a response rate of 26.4%. While a higher response rate is desirable, it is within the norm for response rates of organizational representatives of 36% +/- 13% established by Baruch (1999).

### Institutional Demographic Information

Of the 27 respondents, only one institution used no flight simulation equipment and only used aircraft.  All other respondents indicated a use of both simulation and aircraft. Twenty-four (89%) of the responses were from institutions that conferred baccalaureate degrees for their flight training program as compared to three (11%) that conferred associate degrees.  Additionally, 24 (89%) respondents indicated they provided flight training under 14 CFR Part 141.  Fourteen (54%) respondents indicated that all of their students utilize their institution's simulation equipment, but only ten (38%) respondents indicated that their simulation equipment is used for evaluations and course checks.  The relative size of institutions can be seen in Figure 1.

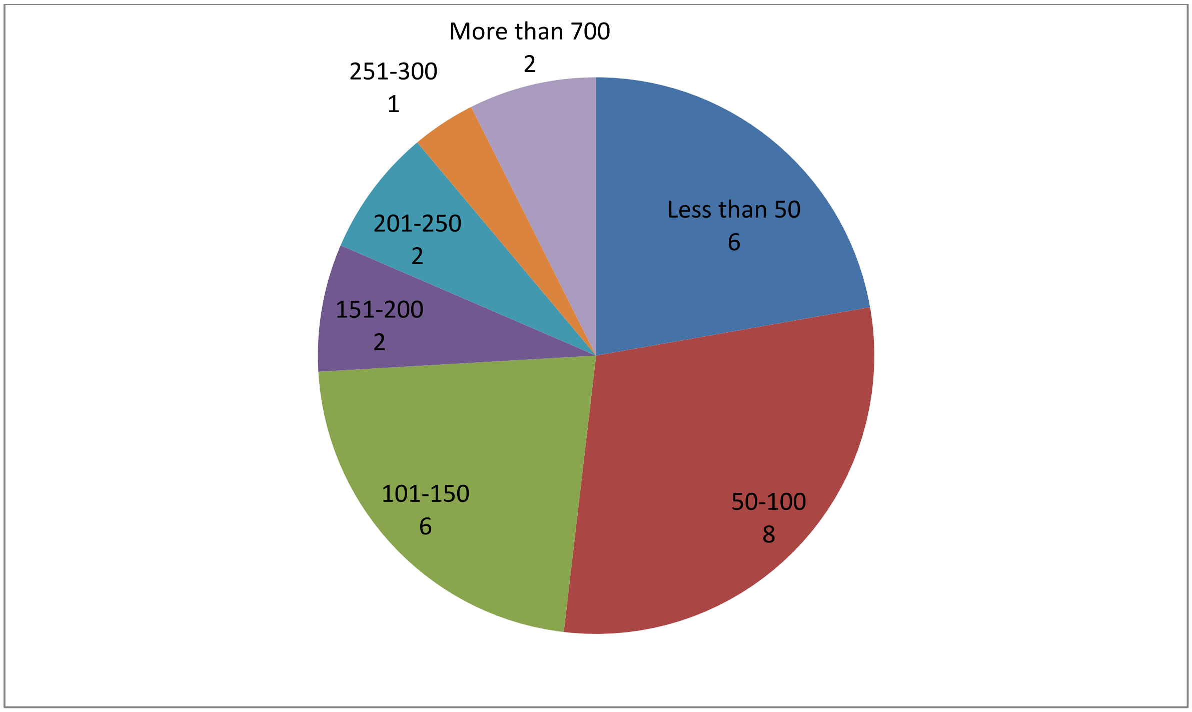


*Figure 1.* How many total students, on average, are enrolled in your flight training program?

**Simulation Equipment**

Twenty-two survey respondents listed a total of 78 different device models at varying levels of certification from no certification to level D full flight simulator. Respondents were able to list up to ten device types, though the greatest number of device types listed was seven. The most common manufacturer of devices reported in this survey was Frasca International, Inc., with 46.15%, followed by Redbird Flight Simulations, Inc., with 20.51% of the reported devices. Some institutions had more than one device of the same type. Table 2 lists 111 individual simulation devices listed by respondents. Detailed device make and model information can be found in Appendix A.

Table 2.

*Simulation Equipment Device Type by Part 141 Approval Status*

| | Part 141 Approved | | | |
|---|---|---|---|---|
| Certification Level | Yes | No | Not Answered | Total |
| AATD | 18 | 1 | | 19 |
| BATD | 2 | 9 | | 11 |
| Level 1 FTD | 18 | 1 | | 19 |
| Level 2 FTD | 1 | | | 1 |
| Level 3 FTD | 17 | 1 | 2 | 20 |
| Level 5 FTD | 2 | | | 2 |
| Level 6 FTD | 11 | | 3 | 14 |
| Level D FFS | | | 1 | 1 |
| Non-Certified | 1 | 10 | 2 | 13 |
| PCATD | 11 | | | 11 |
| Total | 81 | 22 | 8 | 111 |

Table 3 identifies if the devices utilized a visual display by device type. Respondents indicated that 90% of their devices utilized some form of visual display.

Table 3.

*Visual Display by Device Type*

| Device type | Yes | No | Total |
|---|---|---|---|
| AATD | 19 | | 19 |
| BATD | 9 | 2 | 11 |
| FFS | 1 | | 1 |
| Level 1-3 FTD | 34 | 6 | 40 |
| Level 4-7 FTD | 16 | | 16 |
| Non-Certified | 10 | 3 | 13 |
| PCATD | 11 | | 11 |
| Total | 100 | 11 | 111 |

Table 4 identifies if devices had motion capability. Respondents indicated that 25 devices (22.5%) had electrically based motion capability, 4 devices (3.6%) had hydraulically based motion capability, and 82 (73.9%) had no motion capability.

Table 4

*Motion Capability by Device Type*

| Device Type | Electrically Based | Hydraulically Based | No | Total |
|---|---|---|---|---|
| AATD | 5 | | 14 | 19 |
| BATD | | | 11 | 11 |
| FFS | | 1 | | 1 |
| Level 1-3 FTD | 3 | 3 | 34 | 40 |
| Level 4-7 FTD | | | 16 | 16 |
| Non-Certified | 6 | | 7 | 13 |
| PCATD | 11 | | | 11 |
| Total | 25 | 4 | 82 | 111 |

Table 5 indicates flight control loading capability of devices. The respondents indicated that 38 devices (34.2%) had spring control loading, 47 (42.3%) had electronic control loading, 1 (0.9%) had Pneumatic control loading, and 25 (22.5%) had either no loading or were unsure of control loading capability.

Table 5.

*Control Loading Capability by Device Type*

| Device Type | Spring | Electronic | Pneumatic | None | Not Sure | Total |
|---|---|---|---|---|---|---|
| AATD | 7 | 7 | | 4 | 1 | 19 |
| BATD | 9 | | | 2 | | 11 |
| FFS | | 1 | | | | 1 |
| Level 1-3 FTD | 7 | 24 | 1 | 5 | 3 | 40 |
| Level 4-7 FTD | | 15 | | | 1 | 16 |
| Non-Certified | 4 | | | 9 | | 13 |
| PCATD | 11 | | | | | 11 |
| Total | 38 | 47 | 1 | 20 | 5 | 111 |

Table 6 indicates in what training curricula the devices are utilized. The data in this table are different from previous tables because these data are by type of device rather than number of devices. The total number of devices in Table 6 is greater than listed in previous tables because many institutions utilize of type of device in multiple courses of training.

Table 6.

*Course of Training by Device Type*

| Device Type | Private | Instrument | Commercial | Multi-Engine | Other |
|---|---|---|---|---|---|
| AATD | 9 | 9 | 6 | 5 | |
| BATD | 6 | 1 | | | |
| Level 1-3 FTD | 20 | 20 | 15 | 10 | 2 |
| Level 4-7 FTD | 2 | 2 | 3 | 2 | |
| Level D FFS | | | | | |
| Non-Certified | 2 | 3 | 2 | 3 | |
| PCATD | 1 | | | | |
| Unknown Type | 1 | 1 | 1 | | |
| Total | 41 | 36 | 27 | 20 | 3 |

## Results of financial and curricular impact survey

Only 21 respondents answered the following survey questions regarding financial and curricular impact of the January 2nd policy change. Survey respondents indicated that 38.1% would not be impacted and 61.9% would be impacted by the FAA's new simulation policy. Of those impacted, 46.15% (28.57% of all respondents) planned to upgrade simulation equipment, and the same number planned to provide more training in aircraft than they had in the past.

Table 7.

*Will This Policy Cause Your Institution to Change How Flight Training is Delivered (please select all that apply)?*

| Answer Choices | Responses |
|---|---|
| No, my institution will not be affected by this policy. | 8 (38%) |
| Yes, my institution will have to upgrade our simulation equipment in order to meet the policy requirements. | 6 (29%) |
| Yes, my institution will provide less training in simulation equipment and more in aircraft. | 6 (29%) |
| Yes, my institution will change the regulations under which it provides flight training. | 0 (0%) |
| Yes, other. | 2 (10%) |

When asked how much of a financial burden this policy might represent to their institution, 38.1% reported that there would be no financial burden. The next most common response was over $200,000, reported by 19.1% of respondents. Complete results are shown in Figure 2.

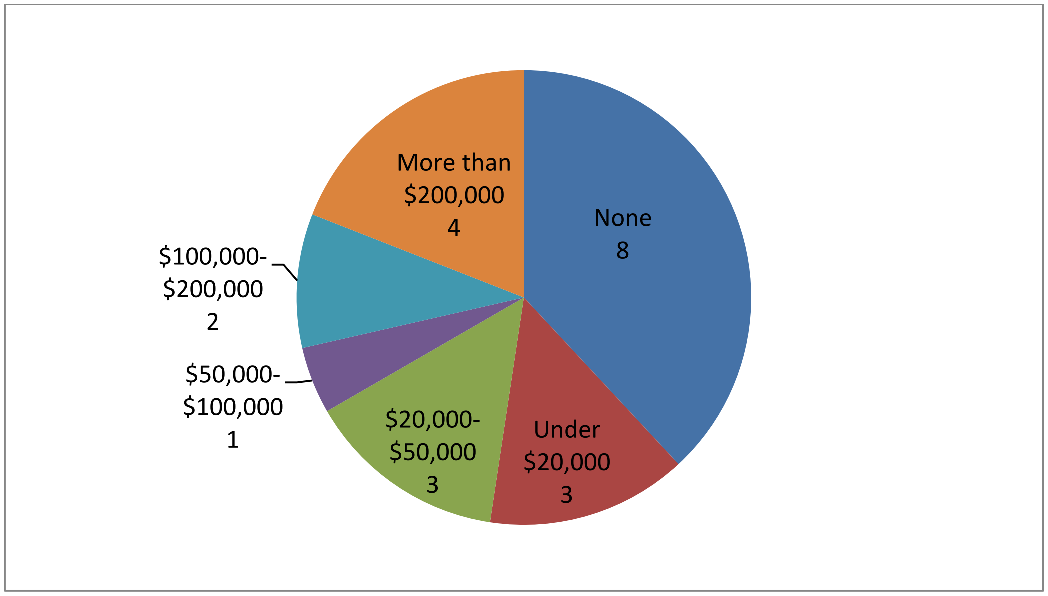


*Figure 2.* How much of a financial burden might your institution incur to meet the needs of this policy?

When asked the same question with respect to their flight students, only 14.29% of respondents reported that their students would face no financial burden due to this policy. While 71.4% of respondents indicated that the financial burden to their students would be $4000 or less, 9.52% reported their students will face over $10,000 in additional financial burden due to the FAA policy change. Complete results to this survey question are shown in Figure 3.

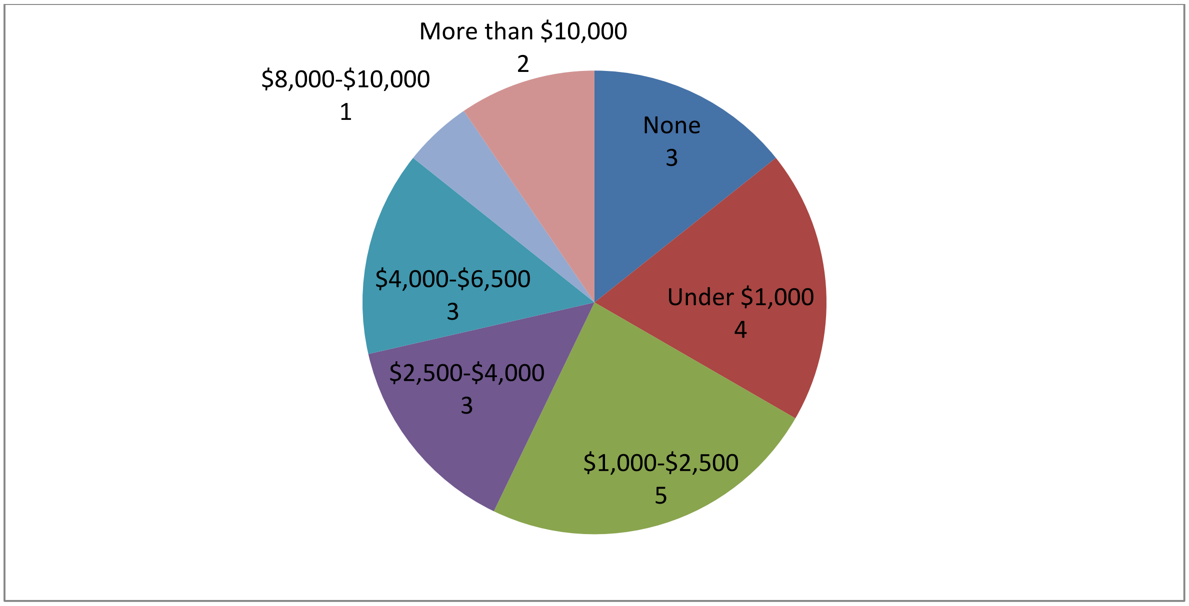


*Figure 3.* How much of an additional financial burden will this policy's implementation put on your institution's flight students over their course of training?

## Limitations

While this study may be valuable to the industry, it is important to note the limitations of the study itself. The first limitation is the issue of response rate. Even though the response rate was within the norms established in the literature, it was on the lower end of those norms. This study, and any conclusions applicable to the industry, could be greatly enhanced by a higher response rate. The second limitation comes from the lack of respondent demographics. While the survey was sent to the UAA designated institutional representative, there is no guarantee that person is the one who completed the survey and also no guarantee that person would be the appropriate person to complete the survey. No information was requested in order to further guarantee anonymity of the respondents and their institutions.

## Conclusions

According to the survey respondents, 81 of the 111 device models (73%) are affected by the new FAA policy. Of those, only 40 have the potential to be upgraded to level 4-7 FTDs; it is likely that not all of them will be eligible for upgrade. Each flight school utilizing lower level FTD’s will have to evaluate the costs and benefits from both financial and curricular perspectives to determine the best course of action for their programs and students, whether it be moving training to aircraft, upgrading equipment, utilizing 14 CFR 141.55, or seeking ATD status for their current equipment. No matter what flight schools choose to do, those that provide training in low level FTDs will need to make changes to remain in compliance with the regulations.

Nearly half (48%) of survey respondents expected their institutions to incur $20,000 or more in costs due to the January policy change. Fourteen respondents (67%) expected students to incur $1,000 or more in flight training costs. Though the December 3 direct final rule was an attempt by the FAA to mitigate the effects of the January 2 policy change, it still did not allow for any use of an ATD in private and commercial training. As with many recent regulatory changes, the costs of flight training are likely to increase for students. As noted in the results, eight respondents indicated that their institution wouldn't incur any costs due to the January 2$^{nd}$ policy change, while only three indicated that students wouldn't incur any additional costs.

## Implications

These results indicate how much of an impact the policy change may have on the flight training industry. Bjerke and Malott (2011) found that cost was a major factor in whether students continued to pursue an aviation career. Though some of the costs of the January 2$^{nd}$ policy change could have been mitigated by the December 3$^{rd}$ ATD direct final rule, the direct final rule was rescinded. Either way, an increased financial burden placed on students will likely drive some students away from being the next generation of pilots.

## Recommendations

The direct final rule issued on December 3, 2014 by the FAA would have gone a long way to reduce the financial and curricular burden on instrument training. It still didn't address the point that if ATD's are good enough for instrument training why their use can't be increased for private and commercial training. The intent of the FAA policy is to ensure the quality of training being given using ATDs. There are several actions which could both allow the FAA to ensure the quality of training as well as providing the flight training community time to respond to the changes in the least impactful way possible. These include:

1. Conduct a notice for proposed rulemaking to allow greater use of ATDs in pilot training.

A formal NPRM process would allow for a fair and open discussion about the benefits and drawbacks of the use of ATDs in flight training. This discussion between the FAA, the flight training industry, and ATD manufacturers is needed to shape the landscape of flight training using training devices. Until such a discussion happens the flight training industry will be left wondering why a device which in 2013 was sufficient for one level of training is in 2015 sufficient for a reduced level of training.

2. Permitting ATDs to be used for private and commercial training.

This suggestion has the benefit of simplicity for training providers as it would allow the same training credit as before the January 2014 policy change. By maintaining the expiration of the LOA, this suggestion also allows for better control of the quality of ATD being utilized by training providers. This suggestion, however, may place a burden on manufacturers of higher level FTDs as there would be little to no training benefit from the higher level devices.

3. Conducting a study of the training differences and effectiveness of ATDs and higher level FTDs.

If ATDs can be shown to be as effective at providing training as higher level FTDs, then an argument can be made to restore the training time that was removed from them. If they cannot be shown as effective as higher level FTDs, then perhaps an argument could be made to allow more training credit for higher level FTDs.

These recommendations may not fully rectify the impacts that the policy change may have on the flight training community, but they will allow the FAA to ensure the quality of the ATD training fleet through a renewal of the LOA process, and also give the flight training community time to better study the impact of these changes on the flight training industry.

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## Appendix A. Simulation Devices Results by Make and Model

| Make and Model | Certification Level | Part 141 approved: Yes | No | Not Answered | Total |
|---|---|---|---|---|---|
| ATC 710 | BATD | 2 | | | 2 |
| Frasca 141/142 | BATD | | 3 | | 3 |
| | Level 1 FTD | 12 | | | 12 |
| | Level 3 FTD | 6 | | | 6 |
| | Non-Certified | | 2 | | 2 |
| Frasca 141/142 Total | | 18 | 5 | | 23 |
| Frasca 241/242 | BATD | | 3 | | 3 |
| | Level 1 FTD | 4 | | | 4 |
| | Level 3 FTD | 4 | | | 4 |
| | Non-Certified | | 1 | | 1 |
| Frasca 241/242 Total | | 8 | 4 | | 12 |
| Frasca Other (please specify) | AATD | 4 | | | 4 |
| | Level 1 FTD | 1 | 1 | | 2 |
| | Level 3 FTD | 2 | 1 | 2 | 5 |
| | Level 5 FTD | 2 | | | 2 |
| | Level 6 FTD | 10 | | 3 | 13 |
| Frasca Other (please specify) Total | | 19 | 2 | 5 | 26 |
| GAT -1 | Non-Certified | | 1 | | 1 |
| GAT -2 | Level 2 FTD | 1 | | | 1 |
| Other (please specify) | AATD | 4 | 1 | | 5 |
| | Level 3 FTD | 3 | | | 3 |
| | Level 6 FTD | 1 | | | 1 |
| | Level D FFS | | | 1 | 1 |
| | Non-Certified | | 2 | | 2 |
| | PCATD | 11 | | | 11 |
| Other (please specify) Total | | 19 | 3 | 1 | 23 |
| Precision Flight Controls MFD | AATD | 3 | | | 3 |
| Redbird FMX | AATD | 5 | | | 5 |
| | Level 3 FTD | 1 | | | 1 |
| Redbird FMX Total | | 6 | | | 6 |
| Redbird Jay | Non-Certified | 1 | 1 | | 2 |
| Redbird MCX | AATD | 1 | | | 1 |
| | Level 1 FTD | 1 | | | 1 |
| Redbird MCX Total | | 2 | | | 2 |
| Redbird SD | AATD | 1 | | | 1 |
| | Level 3 FTD | 1 | | | 1 |
| Redbird SD Total | | 2 | | | 2 |
| Redbird TD | BATD | | 2 | | 2 |
| Redbird TD2 | BATD | | 1 | | 1 |
| Redbird Xwind | Non-Certified | | 1 | 2 | 3 |
| Redbird Xwind SE | Non-Certified | | 2 | | 2 |
| **Grand Total** | | **81** | **22** | **8** | **111** |

# Improving Training Aircraft Utilization in Collegiate Flight Programs: A Case Study at Purdue University

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## Abstract

Aircraft fleets employed for student training in collegiate aviation programs are operated to varying degrees of efficiency, a metric that is influenced by such factors as scheduling, weather, and maintenance requirements. Recent research focusing on the utilization rate of the Cirrus training fleet at Purdue University indicated an average rate of 24% (Avery, 2014). An improvement in the efficiency of the scheduling of the Cirrus fleet would subsequently allow an accurate determination of the degree of excess capacity in the system. This excess capacity should ideally be treated as an asset that could be used to support an increase in enrollment in the Professional Flight program, a concept that could ultimately result in a reduction of student flight fees by spreading fixed costs across a larger student base, thereby improving the overall affordability of the program. This article examines the overall Cirrus utilization at Purdue, identifies both supply and demand components that affect the metric, and proposes recommendations for improving utilization. Through application of the recommendations developed in this paper, it is estimated that the Professional Flight program can accommodate a 20% increase in enrollment, resulting in significant incremental revenue which can be allocated to support additional program growth, reduce student fees, and provide internal employment opportunities for Aeronautical Engineering Technology students studying to obtain their Airframe and Powerplant Mechanic certification. Implementation and monitoring of these recommendations is being integrated into an undergraduate course in aviation managerial economics to provide additional experiential educational opportunities for Aviation Technology students.

## Introduction

The Purdue University Professional Flight Program is housed within the Department of Aviation Technology, which itself resides in the Purdue College of Technology. The College of Technology consists of five departments and one school, and notes in its most recent academic program assessment report that each is focused on “putting state-of-the-industry concepts into practice through use-inspired research that is responsive to world challenges and relevant to small, medium, and large industry needs” (Technology, 2012, p. 1). The College underscores that it has “taken the land-grant mission to action through interdisciplinary collaborations, partnerships with industry, community engagement, and physically and virtually taking access to higher education and putting it into the regional and rural sectors of the state,” (p. 2) allowing Indiana residents to learn and benefit in a manner that will enable them to become immersed in the global community. It is apparent, therefore, that the College considers itself an embodiment of the concepts, such as teaching branches of learning related to the mechanic arts, stated in the Morrill Land Grant Act of 1862 (Morrill Act of 1862).

The Department of Aviation Technology itself serves Purdue's land-grant mission by providing access to its programs through the West Lafayette campus, and through an extended campus in Indianapolis operated by the Statewide College of Technology and shared by Vincennes University, although the flight major is not delivered at the Indianapolis location. Purdue is one of three institutions in the State of Indiana classified by the Carnegie Foundation as RU/VH, and the only such institution offering aviation technology programs. It is the only institution of higher learning in Indiana to offer a full complement of these programs to include Aviation Management, Professional Flight, and Aeronautical Engineering Technology. Purdue's aviation programs are generally recognized within the industry to be within a top tier of similar programs offered by peer institutions such as The Ohio State University, Arizona State University, and others.

Although enrollment in in the College of Technology declined by 7.7 percent over a three-year period from Fall 2009 through Fall 2011, undergraduate enrollment in the Professional Flight Technology program increased by nine percent over the same period, a trend which runs counter to not only the College enrollment trend, but the overall University enrollment trend, as well. Admissions into the program are currently managed to achieve a maximum cohort size of 72 students once a year in the fall semester, a metric that is largely driven by available flight slots. This paper examines the opportunity for improving the utilization of existing training aircraft to enable increased student enrollment and reduced student flight fees.

## Examining Aircraft Utilization

Purdue University employs 16 Cirrus SR-20 aircraft in the primary portion of its Professional Flight program; while four Piper Arrow aircraft are used for a small portion of the Instrument / Commercial courses, the SR-20s account for 95% of the total student flight time in the primary flight courses and are therefore the only aircraft considered in this utilization study. A recent examination of utilization data for the Cirrus portion of the fleet indicated an average aircraft utilization rate of 26.25% during normal operating times of the training facility over a period extending back to the beginning of the Fall 2014 semester. An improvement in the efficiency of the scheduling of the Cirrus fleet would allow an accurate determination of the degree of excess capacity in the system. This excess capacity should ideally be treated as an asset that could be used to support an increase in enrollment in the flight training program. By spreading the fixed costs of the program across a larger number of students, the course fees for the program could be potentially decreased, thereby improving the overall affordability of the program. This would not only contribute to reversing the enrollment decline in the College of Technology, but also assist the University in meeting President Daniels' goal of improving affordability for all Purdue students (Daniels, 2014; Daniels, 2015).

As noted in the previous section, utilization of Purdue's fleet of Cirrus training aircraft tends to average below 30%. While the term "utilization" can be defined in different ways, and is dependent on the exposure basis, it is apparent that there is an opportunity to increase the operational efficiency of the Purdue training fleet through improvements in the scheduling process. The exposure basis used for the present calculations covers a period from 7:30 am to 7:30 pm (with some exceptions that will be described later), Monday through Saturday, during the regular academic semester and excluding academic holidays. Total weekly schedulable hours (WSH) are given by Equation 1.

$$WSH = A * D * S * L, \tag{1}$$

where

$A$ is the number of aircraft in the fleet,
$D$ is the number of days per week that flight training is scheduled,
$S$ is the number of flight slots in a flight training day, and
$L$ is the length of a flight slot in hours.

For the Fall 2014 semester, which covers the period August 25 to December 20, $A$ = 16, $D$ = 6, and $L$ = 2. During the portion of the semester from August 25 through November 1, $S$ = 6, while during the portion extending from November 2 to December 20, $S$ = 5. This reduction in $S$ midway through the semester is due to lack of availability of the 1730 flight slot because of the change from Daylight Savings Time to Standard Time. The weekly utilization of Purdue's Cirrus fleet is depicted in Figure 2. A description of the utilization categories shown in Figure 2 is in the following sections.

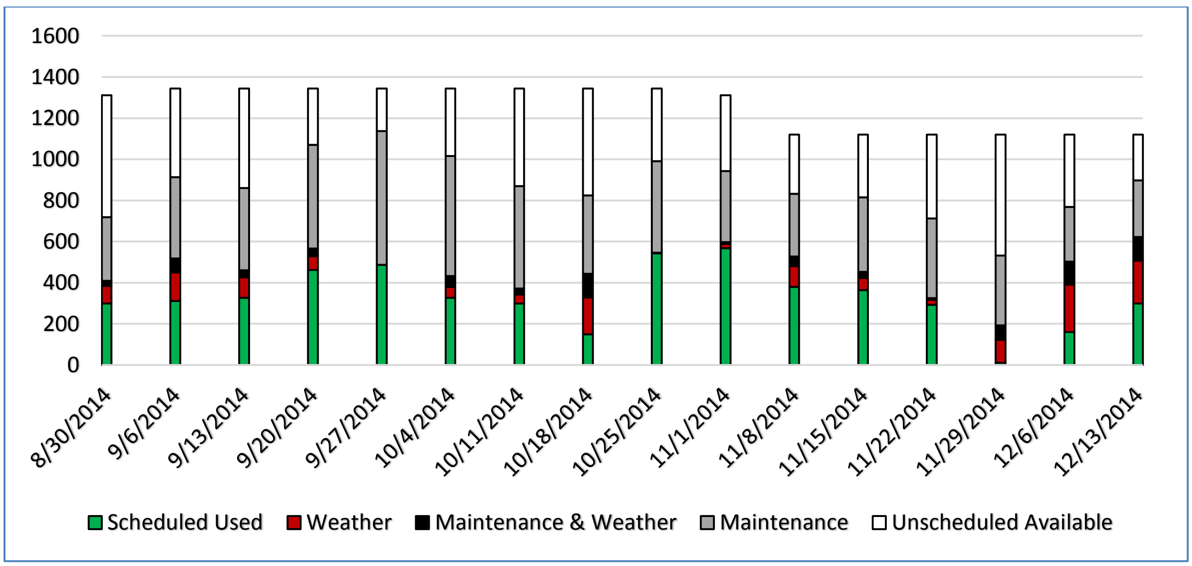


*Figure 2.* Weekly Cirrus utilization (hours), Fall semester, 2014.

**Scheduled used**: The total amount of time for which aircraft were dispatched for potential use. This is not equivalent to either Hobbs time (time during which the aircraft electrical system was in operation) or Tachometer time (time during which the aircraft's engine was operating), but simply the time between check out and check in of the aircraft. It is assumed that as soon as the aircraft is dispatched, it is being used by the individual to whom it is dispatched, and that no one else would have access to the aircraft for the duration of the dispatched period, regardless of whether or not the aircraft actually flew.

**Weather**: Aircraft are unflyable due to the most restrictive weather minimums not being met. Note that the pilot in command is the final authority regarding whether a flight can be initiated, so time will occasionally be recorded as "Scheduled used" while weather minimums are not actually met.

**Maintenance and Weather**: This utilization category occurs while an aircraft is down for maintenance and the weather minimums are also not met. The hours in this category are generally small (approximately five percent of total Cirrus time).

**Maintenance**: An aircraft is unable to be dispatched because it is either in a maintenance queue awaiting maintenance or having maintenance performed.

**Unscheduled Available**: The aircraft is not scheduled to be used and is available to be dispatched. Such aircraft are generally positioned on the ramp or in a hangar.

The efficiency problem can be further decomposed into challenges related to supply and challenges related to demand. Each of these are examined in the following sections.

### Scheduling Inefficiencies Related to Supply

Two overall hard scheduling constraints are imposed by weather and by operating hours, as follows:

1. Weather minimums in terms of ceiling and visibility are set by Federal Aviation regulations and by best practices in collegiate flight training operations. These minimums are inviolable.

2. Operating hours tend to follow daylight patterns, since almost all primary flight training and much (but not all) advanced training needs to occur in the daytime.

There are a number of scheduling constraints which lead to reduced efficiencies and which appear to be controllable. Such dispatch-related constraints include:

1. Inflexible flight training blocks that last two hours each. A portion of this time is used for briefings that could be more efficiently conducted during separate ground periods. The schedule blocks follow University-imposed slots for course section times.

2. Operating hours are set to cover times during official daylight hours. This is an administrative policy decision.

Maintenance-related constraints include:

1. Administratively-decoupled maintenance scheduling and weather-imposed flight restrictions. As a result, there are missed opportunities to perform routine maintenance when aircraft are close to required hourly maintenance points and weather conditions are worse than the most restrictive weather policy guidelines.

2. An indeterminate maintenance queue; i.e., an uncertain amount of time between the point an aircraft is removed from service and the starting time of maintenance performed on the aircraft.

3. Lack of maintenance service availability at times when aircraft would not normally be operated. Maintenance operations are conducted during a single shift. No maintenance service is available at night. This is due to departmental administrative policy and overtime pay considerations.

**Scheduling Inefficiencies Related to Demand**

There are three cyclical utilization patterns that are apparent:

1. A daily pattern in which the demand for early morning flight slots and late afternoon flight slots is not as great as that for slots in the middle of the day. This could be the result of a propensity on the part of students or academic schedulers to establish a regular slot that will not be as greatly affected by early morning fog and afternoon thunderstorms. This pattern is evident from Figure 3, which shows average scheduled hours per flight slot during the Fall 2014 semester. The peak slot utilization of approximately 33% occurs from the 1130 through the 1530 slots. Note that each slot is averaged over the full semester with the exception of the 1730 slot, which is averaged only over the portion of the semester in which daylight savings time is in effect; this will be explained in the following section.

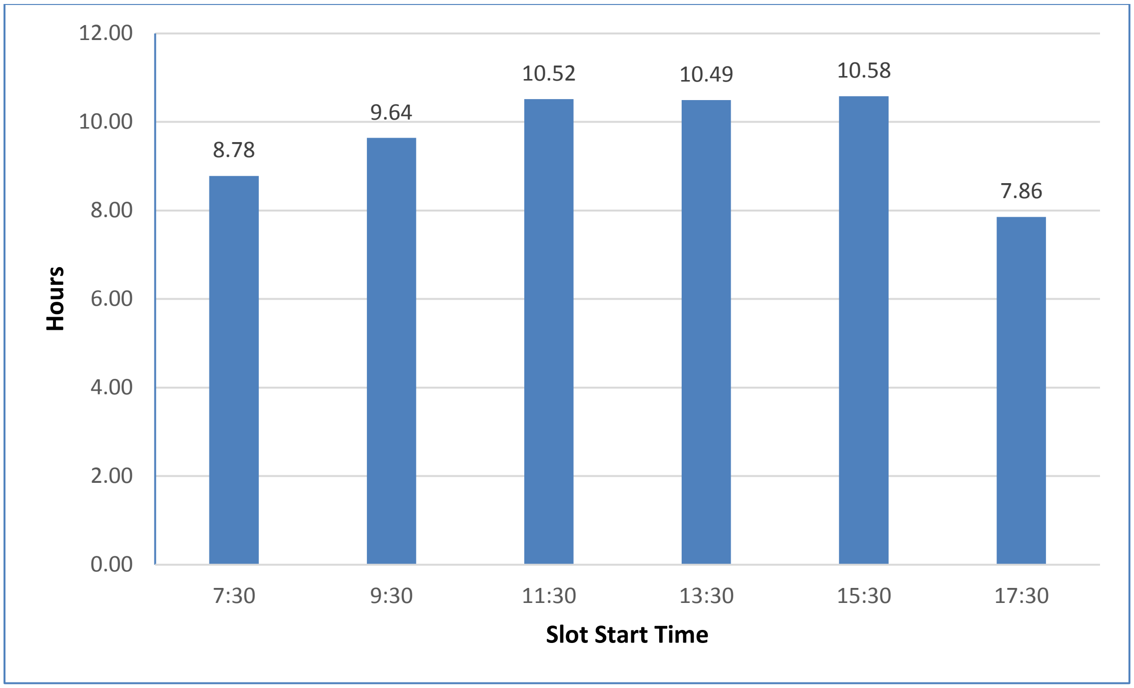


*Figure 3.* Daily scheduled Cirrus hours by flight slot, Fall 2014 semester.

2. A weekly pattern in which slots on days in the middle of the week are in greater demand than slots at the beginning and end of the week. This data is depicted in Figure 4.
3. A semester-long cycle in which demand tends to increase as the semester progresses, peaking around week 10. This cycle is particularly disruptive in the fall semester, since it would tend to coincide with a general decrease in the number of hours available for which weather conditions are sufficiently greater than minimum limits for flying as that semester progresses.

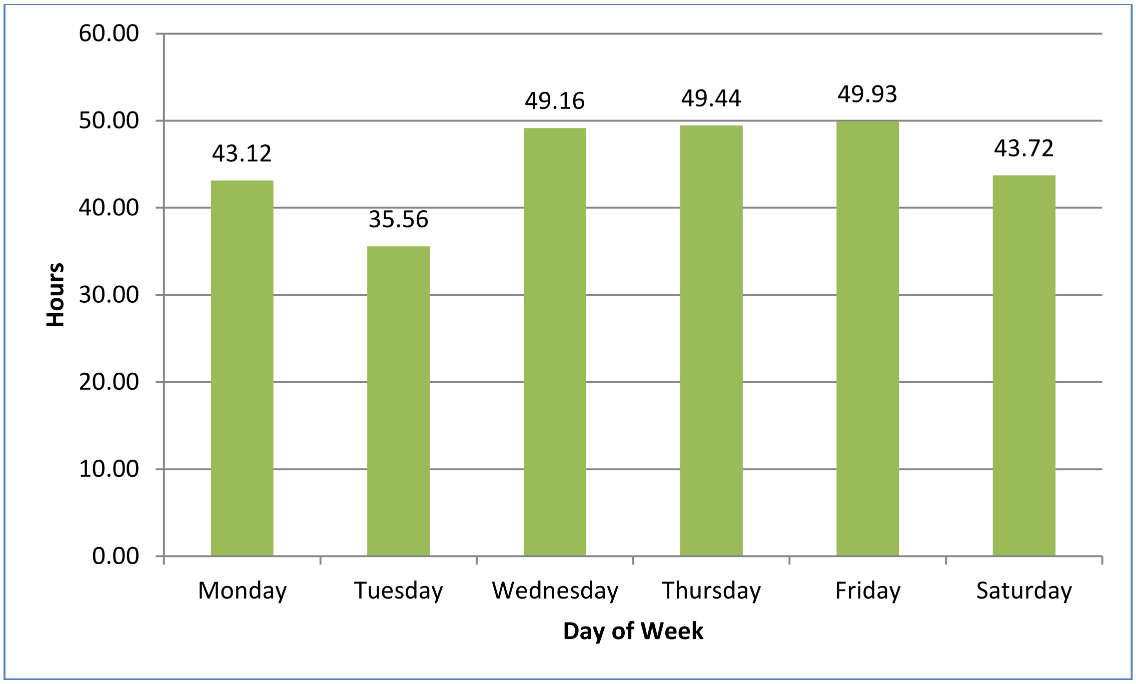


*Figure 4.* Scheduled Cirrus hours by day of week, Fall 2014 semester.

## Potential Opportunities to Improve Utilization

The present research is primarily oriented to improving the demand side of the overall training system. It is anticipated that future research will focus on the supply side. With that said, a brief discussion of opportunities related to both sides of the system is in order.

Opportunities to improve the supply side of the overall system could potentially impact both the flight scheduling and dispatch operation and the maintenance operation. A solution to the limitation in supply imposed by what are apparently longer than necessary scheduled flight periods could be the reduction of the schedule block length for the aircraft; i.e., the establishing of more, shorter schedule blocks for the aircraft. As determined through a conversation with the Office of the Registrar, these aircraft schedule blocks do not necessarily have to follow the class blocks that are standard at the University level, although they currently do so. An additional solution to supply constraints from the flight scheduling and dispatch perspective is the shift of some advanced training slots to nighttime hours. As noted previously, almost all operations are currently conducted during daylight hours.

There appear to be opportunities present to shift some maintenance activities when aircraft are close to scheduled maintenance intervals such that maintenance can be performed during unflyable weather. For example, if an aircraft is scheduled to receive a phase inspection at 100 hours and a period where weather conditions are expected to be unflyable for the next 36 hours is being entered, it would be desirable to proceed with the scheduled maintenance 0.5 hours advance of its scheduled time. This initiative could be combined with an opportunity to communicate current and forecast maintenance queue lengths to administrative stakeholders in order to identify future windows where there is a need to schedule overtime maintenance activities.

An important component of the overall flight time supply inefficiency is the lack of maintenance capacity at times when the demand for the aircraft is low or nonexistent; i.e., during the period from 7:30 pm until 7:30 am. That maintenance capacity could be greatly increased by instituting an additional shift of personnel, comprised of a supervising airframe and powerplant-certified (A&P) mechanic and a number of students in the Aeronautical Engineering Technology program who are either studying to obtain their A&P certification or who have received it as seniors. There also exist opportunities to schedule some maintenance activities outside of peak flight times during regular shifts. It may be possible to schedule maintenance staff such that a greater portion of their schedules would fall in either the early morning hours or late evening, thereby shifting capacity such that it is available when the demand for aircraft is lower.

## Flight Slot Demand Management

Inefficiencies noted previously that are related to fluctuating demand on both diurnal and semester cycles can also be addressed. Each of these cyclical patterns could likely be modified by incentivizing students to fly during the less-preferred times. A reduction of flight rates could be implemented, thereby improving utilization in early mornings and late afternoons, as well as during slack times of the semester. In order for this to be successful, one must assume that a supply/demand relationship exists and that student selection of flight slots is relatively elastic with regard to economic behavior. By smoothing demand across daily time slots and across the semester through the use of modest pricing incentives, previously unused slots could be converted into scheduled hours.

According to Avery (2014), student flight slots at Purdue are subject to the following scheduling constraints:

- Flights are scheduled within blocks that are two hours long.
- Hours of operation are from 7:30 a.m. to 5:30 p.m. for eight weeks and 7:30 a.m. to 7:30 p.m. for the other eight weeks, seven days a week (Sundays are optional). The 5:30 p.m. slot is available only when daylight savings time is in effect.
- Night flights occur four days a week but are used only to complete lesson plans.

Currently, students are assigned to flight slots by administrative personnel. Slot times and days of the week do not change throughout the semester. A total of four flight courses utilize the Cirrus fleet. Three of the courses (AT 14500, AT 24300, and AT 24800) are scheduled across three days of each week during the semester: Monday, Wednesday, and Friday, or Tuesday, Thursday, and Saturday. The remaining course (AT 25300) is scheduled across two days of each week: Monday – Friday, Tuesday – Thursday, or

Wednesday – Saturday. Sundays are used as opportunities to allow students to make up slots that were missed during the week.

It is proposed that the slot assignment procedure be changed to allow students to select slots. Presumably, early and late slots have been underutilized due to schedule conflicts encountered by students enrolled in ROTC programs, which tend to have early morning meeting requirements, and co-curricular activities such as marching and concert band, which tend to meet later in the day. The proposed change will allow students to make their own scheduling decisions within a market economic context, and with monetary incentives to select what might be viewed as less desirable slots.

It should be noted that slot no-shows account for a relatively low percentage of unused flight slots. Purdue does not currently penalize students for no-shows; there appears to be little motivation to initiate such a procedure at this point.

## Higher Education Pricing Elasticity Literature

Although little or no research related to price elasticity of demand in flight training or in college course fees exists, there is a body of research related to elasticity in both college tuition rates and college textbook purchases. While neither of these elasticities should be expected to be equivalent to that which might be expected as a student response to decreased (or increased) flight course fees, they can at least provide a reference point to allow the establishment of a baseline for the purposes of the current research.

Leslie and Brinkman (1987) conducted an empirical review of 25 studies that examined student higher education enrollment elasticity in response to tuition changes that had been published as of the date of their research, and presented, in a standardized format, an estimate of the student-price response coefficient (SPRC), a percentage change in enrollment per $100 tuition price change, for each. The SPRC can be converted to an elasticity by multiplying it by $100 and dividing by *P*, the percentage change in price. While all of these studies examined enrollment responses of first-time students in response to tuition changes, they arrived at relatively consistent results, with SPRCs ranging from -0.5 to -1.3. It should be noted that the Leslie and Brinkman research examined studies that considered only first-year enrollment; elasticity of continuing students was not investigated. A review by Heller (1997) examined more recent studies and confirmed the findings of Leslie and Brinkman, indicating an SPRC range of between -0.5 and -1.0.

A study authored by Bryan and Whipple (1995) develops a tuition pricing model that is "useful in predicting the retention rate of current students at increasing tuition rates" (p. 561). The distinction between the Bryan and Whipple study and those of Leslie and Brinkman (1987) and Heller (1995) is that it examines current students, rather than first-time students. None of these studies focuses specifically on enrollment in single courses, instead examining overall institutional enrollment; however, while "this is an aggregate effect and may differ for individual institutions or groups of students …, as a whole, this fundamental relationship – the existence of a downward-sloping demand curve found by Leslie and Brinkman and other researchers – has been confirmed" (Heller, 1997, p. 650). According to Heller, the consensus among the studies reviewed is that the SPRC values between -0.5 and -1.0 are consistent "across all types of institutions."

Two additional recent studies provide separate measures of elasticity in the form of regression coefficients. Research investigating elasticities among first-year, first-time students at four-year institutions in Colorado during the 2004 – 2010 period (Augenblick, Palaich, 2012) indicated a mean odds ratio on net price per $1000 change in tuition to be 0.966. This can be converted into both an elasticity coefficient and an SPRC with the information provided in the study. The odds ratio implies a percentage change in enrollment given a $1000 tuition change of 3.4% (1 – 0.996). Since the SPRCs in the previous research employ a base price change of $100, this value equates to an SPRC of 0.34, which is in line with those studies, albeit at the low end of the range, and which may indicate that student behavior is becoming somewhat less elastic over time. The SPRC can, in turn, be converted to a pure elasticity coefficient, ε, where

$$\varepsilon = \frac{\Delta E}{\Delta P}, \tag{2}$$

*E* is enrollment, and *P* is price, by using the mean tuition price across Colorado institutions across the study period, $15,299. This results in ε = -0.52. Another study of tuition elasticity at Florida Southern College (Brown, McClary, & Bellingar, 2012) does not provide sufficient information such that an SPRC can be calculated; however, the elasticity coefficient provided by that study is -1.2, which seems high, but a separate coefficient applicable for non-Florida residents only was determined to be -0.29, which is more in-line with the Colorado data. These values of ε are also consistent with a recent study using data from the Integrated Postsecondary Education Data System covering the period from 1991 to 2007 (Hemelt & Marcotte, 2008), which indicated an elasticity coefficient of -0.1072.

Chevalier and Goolsbee (2003) used publicly-available data on prices and sales ranks of books listed by online book retailers Amazon and Barnes & Noble to determine price elasticities of demand for those retailers' products. They did so by developing a method of converting sales ranks into sales quantities for 18,000 different books. Their results showed elasticities of -4.0 and -0.6 for BN.com and Amazon.com, respectively, indicating a much higher elasticity for Barnes & Noble than for Amazon. Note that the elasticities here, which are representative of a more general population, might be expected to be somewhat higher than for those representative of college students, since the latter tend to be a far more captive audience. Koch (2007) noted that student textbook demand is relatively price inelastic. Chevalier and Goolsbee (2005) later extended their research to focus specifically on the college textbook market. Their findings from this investigation indicated an elasticity of -0.9 for students purchasing textbooks for which a revision is not expected (a stable market), and one of -3.7 in situations for which a revision is certain to occur (an unstable market). Note that the stable market elasticity determined from the 2005 study by Chevalier and Goolsbee is in line with those found in the enrollment studies examined previously.

### Application of Pricing Principles to Manage Flight Slot Demand

The first step in the process for smoothing slot demand is the adjustment of hourly rates for slots. One must first assume an appropriate price elasticity of demand coefficient for student slot enrollment in response to hourly rate changes. Based on the preceding literature review, a value of -2.0 for ε seems reasonable, due to the changes in the slot assignment procedure of which all students will be made aware. From Figure 3, the average daily scheduled time across all slots is 57.87 hours. Using a weighted average to allocate this time across the five slots that are unaffected by the change to standard time and the one slot that is, one obtains a target value of 5.625x = 57.87, or x=10.288, which represents the average daily scheduled time per slot. It is reasonable, then, to incentivize students to enroll in both the 0730 and the 1730 slots, since those slots fall somewhat below the average in terms of scheduled hours. This suggests a percentage change in hours of 17.1% for the 0730 slot and 30.9% for the 1730 slot. The ratio of actual Hobbs time accumulated on an average aircraft, $T_H$, to scheduled time for that aircraft, $T_S$, is

$$\frac{T_H}{T_S} = 70.3\% \tag{3}$$

Therefore, the nominal rate of $210 per flight hour can be adjusted downward by this amount to compensate for the fact that one scheduled hour translates to only 42 minutes of time in which the average aircraft is actually utilized. This yields an effective rate of $147.63 per scheduled hour, suggesting a student flight rate decrease of $12.62 per hour for the 0730 slot and $22.81 for the 1730 slot.

Once the new hourly rates for each flight slot have been set, the transition to a market-driven scheduling approach will commence. Undergraduate students at Purdue University register for course sections based on the academic classification to which they belong. Prioritization is in decreasing order of classification, starting with seniors. The registration holds which were previously used to ensure that students selected the flight slots to which they were assigned administratively will be removed. In addition, the slot rates, which include incentives for those slots discussed above, will be made available to all flight students. Students will then be assumed to select slots on the basis of chronological and economic preference within their academic classification groups.

### Flight Slot Supply Management

The second portion of the work needed with regard to scheduling of flight slots is related to the supply side of the equation. It was noted previously that constraints on scheduling of flight slots contribute to the overall inefficiency of the process. Because of the fact that a portion of the scheduled flight slot is actually used for pre- and post-flight briefing activities that better lend themselves to separate briefing slots that do not require the use of an aircraft, it is proposed that slot length, *L*, be reduced from 2.0 hours to 1.5 hours. This would then provide eight slots per day: 0730-0900, 0900-1030, 1030-1200, 1200-1330, 1330-1500, 1500-1630, 1630-1800, and 1800-1930.

It is instructive to examine the current path that students follow through the Professional Flight program in order to better understand the constraints that are present. These constraints are an impediment to expanding the overall enrollment of students in the program. Figure 5 depicts the program flow in a flow diagram format.

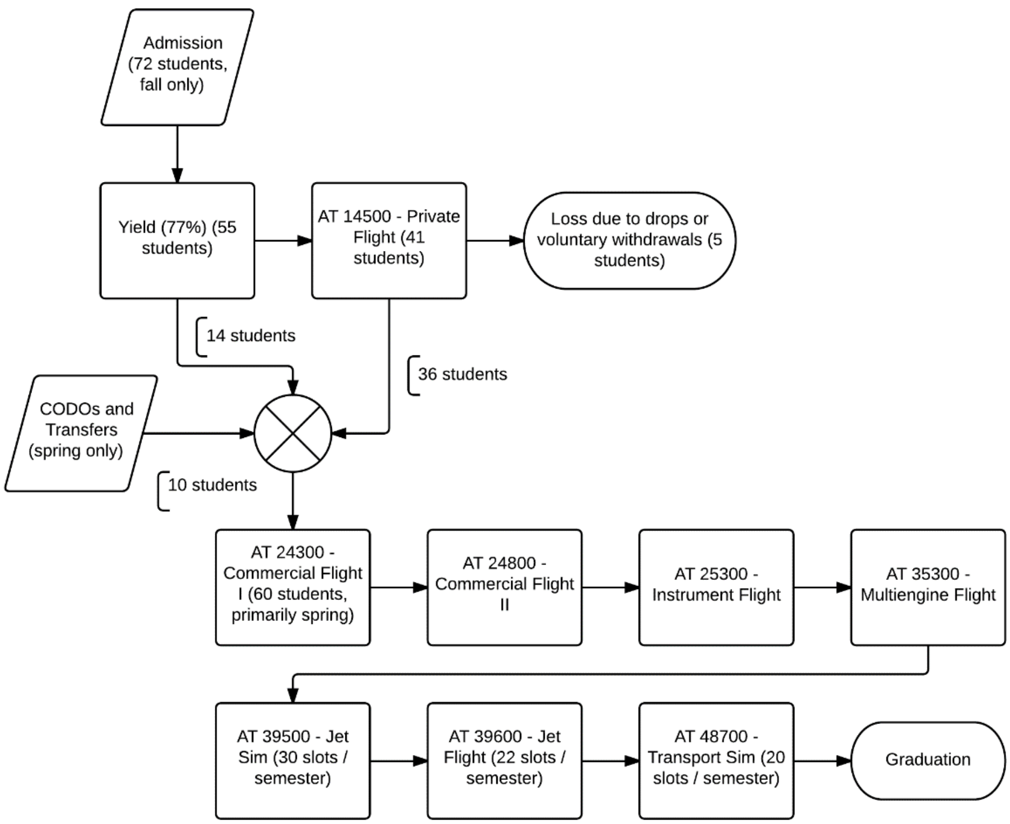


*Figure 5.* Critical path analysis of Professional Flight Program that shows constraints in system.

Two restrictions to student flow that are readily observed from the flow diagram are related to the Private Flight course (AT 14500) and in the Advanced Transport Category Flight course (AT 39600). The latter restricts student flow due to the limited number of slots available for the Embraer Phenom 100 jet training aircraft. Solutions to that issue involve potential fleet additions and are pending. The scope of the current research is limited to improving flow through the Private Flight course in order to mitigate what is currently perceived as a flow restriction through that course.

Further motivation for implementing changes to improve Cirrus flight slot supplies may be derived from estimates of the potential for additional program revenue resulting from increased student enrollment. First, assume that all maintenance can be performed in such a manner that only two aircraft are out of service for maintenance reasons at any given time. If one assumes that eight slots per day are available over seven days per week, an increase of either two or three slots over the current situation, depending upon the time of year, and that two of the sixteen Cirrus aircraft are designated as maintenance reserve aircraft, there are 784 total available slots during a given week. Unflyable weather averages 72 hours per week, or 48 slots. This leaves 736 slots per week, on average, that are schedulable. The number of weekly slots required per flight course is shown in Table 1.

Table 1

*Number of weekly slots required per course*

| Flight Course | Number of Slots |
|---|---|
| Private Pilot Flight | 3 |
| Commercial Flight I | 3 |
| Instrument Flight | 3 |
| Commercial Flight II | 2 |

The total number of weekly slots required for all primary flight courses is then 11 slots. With 736 available weekly slots, this equates to 67 enrolled students across all four primary flight courses. For admissions purposes, assuming a 77% average yield, this translates to 87 admitted students each fall.

As noted in Figure 5, the primary flight courses enroll an average of 55 students each fall. The proposed increase in enrollment from 55 to 67 students is a 21.8% increase. The incremental revenue resulting from that increase, as determined from rates published by Purdue's Office of the Bursar and assuming that 74.5% of incoming students will enroll initially in AT 24300 due to previously having received their Private Pilot certificates, is shown in Table 2.

Table 2

*Incremental Program Revenue Due to Proposed Enrollment Changes*

| Semester | AT 14500 | AT 24300 | AT 24800 | AT 25300 | Total |
|---|---|---|---|---|---|
| Fall 2015 | $91,521 | $ 32,271 | | | $123,792 |
| Spring 2015 | | 129,084 | | | 129,084 |
| Fall 2015 | 91,521 | 32,271 | $129,084 | | 252,876 |
| Spring 2016 | | 129,084 | | $129,084 | 258,168 |

The asymptotic revenue, then, once the additional student flow has propagated through the first two years of the flight program, is $258,168. The 2014-15 program revenue from Cirrus operations was projected to be $2,262,625. If one assumes an aircraft fleet valuation of book value less accumulated reserves, and calculates the capital turns ratio as the ratio of the sum of the projected Cirrus revenue and the incremental revenue increase due to the additional program enrollment to the fleet valuation, the figure of 72.95% is obtained. The capital turns ratio without the incremental revenue increase is 65.47%. This suggests an increase in capital turns of just under 7.5% due to the additional program revenue.

Because a portion of the incremental increase in revenue related to the addition of students in the program is associated with the covering of fixed costs, as opposed to variable costs, a percentage of that portion can be dedicated to lowering overall course fees. The remaining percentage of the revenue increase can be allocated for the purpose of increasing maintenance staffing so as to reduce maintenance downtime.

## Recommendations

It is recommended that enrollment capacity in the Professional Flight program be increased by approximately 20% beginning in in the 2015-16 academic year. This is to be achieved primarily through the assignment of students to currently unused flight slots, and secondarily through the addition of new slots, with the slot assignment system transitioning to a market-driven approach with financial incentives for slots that may be less desirable. Revenue increases from the additional enrollment will be used partially to offset fixed-costs, with the potential to lower flight course fees and improve the overall affordability of the program, and partially to fund additions to maintenance staffing levels. Detailed estimates of the total percentage reduction in program fees are somewhat elusive at this early point in the implementation, but indications from the lead author’s recent participation in Purdue’s biennial budgeting process are for a potential overall decrease in such fees of as much as eight percent.

Maintenance downtime planning meetings are also recommended. These meetings with the maintenance staff will be held in an effort to develop a shared vision with regard to increasing fleet availability. The desired outcome from this process will be the development of key performance indicators and metrics that will be useful to maintenance personnel as they seek to improve maintenance efficiency. The Operations Center, an integrated facility staffed by aviation management students and tasked with the assimilation of operational data and operational decision-making, will be engaged to produce reports for maintenance managers based on the key performance indicators.

In addition, a senior-level undergraduate course in aviation managerial economics has been developed by the lead author. This course is being offered in the spring semester of 2015, and will be employed as a means to allow students to participate in the development of additional recommendations to improve fleet utilization and to assist in the implementation and monitoring of those recommendations. This process will serve the dual purpose of facilitating student buy-in to the changes to the scheduling process, and providing students with experiential learning opportunities consistent with the ongoing transformation of the College of Technology into the Purdue Polytechnic Institute (Purdue, 2015).

It is anticipated that these recommendations will enable an increase in operational efficiency in the primary flight program that will both enable the program to accommodate new flight program majors who would not have otherwise been allowed to matriculate, and sustain a reduction in course fees for all enrolled students that will ultimately improve program affordability.

While the recommendations outlined here are designed specifically for primary flight operations at Purdue University, a certain degree of generalizability ensures that they may be considered extensible to other, similar operations. Some of those generalizable concepts include market-driven scheduling in which less-desirable flight slots are incentivized in a manner suggested by price elasticity of demand research, adjustment of slot lengths to better accommodate the time actually spent in operation of the aircraft, and a systemic approach to schedule interactions between dispatch and maintenance operations.

## Future Research

A pilot implementation of the process recommendations described herein is currently in progress. The initial program modifications will consist of financial incentives for less-desirable flight slots to be implemented and advertised to students during the Fall 2015 enrollment process. Follow-on research designed to measure the effects of the transition to a market-driven slot selection procedure and the slot incentive process, in which the results of the modifications will be compared with current slot assignments to determine the efficacy of the flight slot incentive approach, is planned to commence early in the 2015-16 academic year, once data is available for study. Also, modifications to the lengths and number of slots are expected to occur in the Spring 2016 semester, with further research to determine the effectiveness of those modifications to be conducted in a subsequent semester.

In addition, changes to maintenance staffing levels and maintenance scheduling will be investigated in a following semester with the expectation of improving the deficiencies related to maintenance scheduling procedures that were noted previously.

With regard to non-program-specific research potential, there are certainly opportunities to apply the generalizable concepts suggested previously to other collegiate flight programs that seek improvements to utilization efficiency. It is hoped that such research will lead to improvements that will benefit all programs comprising the collegiate aviation community.

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