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

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AEROSPACE

A perpetual problem:

- With ever increasing information availability, pilots must manage enormous amounts of data while maintaining effective cockpit management.
- Examples - Checklists, operations specifications, approach plates, NOTAM’s, dispatch releases, and enroute charts
- These items can bring a lot of paper and disorganization into the tight confines of the cockpit, which can create problems when the pilot needs to access an item during a high workload flight segment

A possible solution? Electronic Flight Bags (EFB)

- FAA definition:

  An electronic display system intended primarily for cockpit or cabin use. EFB devices can display a variety of aviation data (e.g., checklists, navigation charts, pilot’s operating handbook (POH)) or perform basic calculations (e.g., performance data, fuel calculations).

- FAA guidance:

  Advisory Circular No. 91-78 Use of Class 1 or Class 2 Electronic Flight Bag (EFB)

Benefits/Drawbacks

- 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).

EFB History

- Electronic devices that have been proposed to alleviate the problems of paper are:
  - 1) Dedicated EFB devices - have been on the market for a number of years with limited success. However, these dedicated EFBs have been bulky, complicated, expensive and unreliable (Hughes, 2009b)
  - 2) Integrated EFB units - built into the cockpit of aircraft with advanced avionics systems, is not removable from the cockpit, and is interoperable with the aircraft avionics. These can blend into the aircraft systems, 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. (Fontaine, 2011).

Apple iPad

- The newest entry to the field of EFBs is Apple's iPad tablet, which was introduced in early 2010.
- Attraction - an intuitive interface, small form factor, proven reliability, relatively low price, and outstanding battery life
- 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

Statement of the Problem

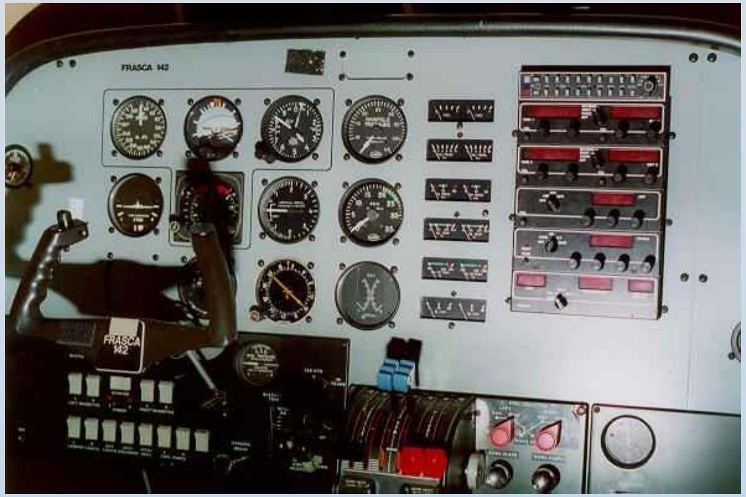
- A review of literature concerning EFBs shows that there have not been any performance-based implementation studies completed.
- Research also indicates that EFBs, in some form, are going to be a part of the aviation world in the future (McKenna, 2012). Before these devices become the new standard, 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:

Research Questions

- Does using charts and approach plates in electronic form on an iPad, as opposed to on paper, effect pilot during rapidly changing flight situations?

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

Methodology



- Experimental study using 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.
- Each participant completed two very similar instrument approach scenarios, one using the EFB and one using paper charts.
- Measurements of the performance of each participant were made on both approaches

Participants

- Fourteen students from a commercial ground school class at MTSU in the spring of 2012.
- The study was approved by the university's Institutional Review Board for human subject research
- All had their instrument rating, and approximately the same amount of flight time (around 100 hours)
- All white males of traditional college age

Instruments

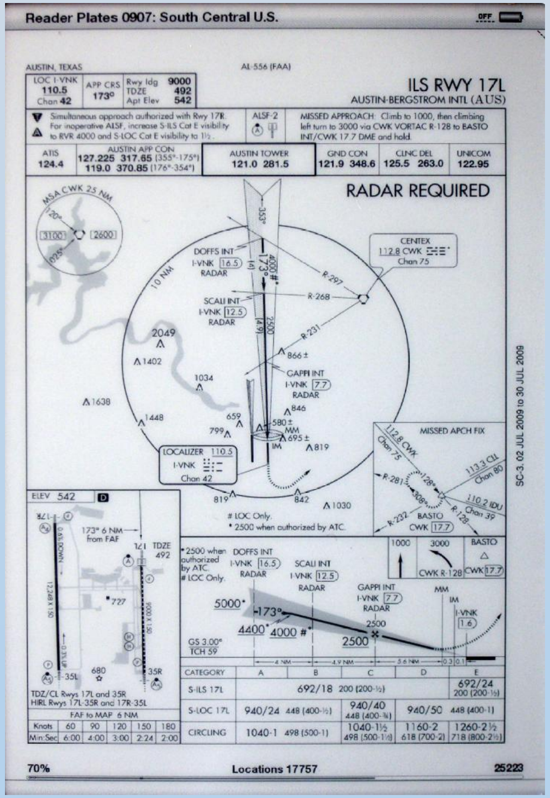
- A “scorecard” was designed to allow efficient measurement of deviations in altitude, heading, airspeed, and localizer course from instrument pilot practical test standards (PTS).
- These readings were recorded as either “Within PTS” or “Outside PTS” at specified intervals
- The specific parameters were: altitude +/- 100 feet, heading +/- 10 degrees, airspeed +/- 10 knots, and localizer course +/- 1 dot of deflection.
- 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.

Participant Results Sheet		
Simulator Results (PAPER)		
Variable and PTS Range	***Within PTS***	***Outside PTS***
Altitude (+/- 100ft)		
Heading (+/- 10°)		
Airspeed (+/- 10 kts)		
Localizer Course (< 1 dot)		
How long until the ***1st*** localizer frequencey tuned and trackable? (seconds)	______Seconds	
Did participant terminate the approach at the correct MAP	YES	NO

Simulator Results (iPad)		
Variable and PTS Range	***Within PTS***	***Outside PTS***
Altitude (+/- 100ft)		
Heading (+/- 10°)		
Airspeed (+/- 10 kts)		
Localizer Course (< 1 dot)		
How long until the ***1st*** localizer frequencey tuned and trackable? (seconds)	______Seconds	
Did participant terminate the approach at the correct MAP	YES	NO

Instruments

- The paper charts that were used for the study included a Tennessee/Kentucky Terminal Procedures book published by AeroNav
- The EFB that was utilized was an Apple iPad. This iPad was a 32GB Verizon 3G unit. It was loaded with a then current version of ForeFlight Mobile HD 4



Procedure

- Participants arrived at individually assigned time slots, 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.
- 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.
- 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.

Procedure

- 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
- Each student flew the scenario twice, once with paper and once with the iPad (order was alternated for equitability)

First Approach

- Participants were instructed to hold their assigned heading, airspeed, and altitude until further instructions were received from ATC.
- 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.
- From this point forward, data was collected at 20 second intervals, as the participant found the correct approach using either paper or iPad, and set the approach up.
- 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, 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.

Second Approach

- After the first approach was concluded, the participant took a 3 minute break and the FTD was reset to the preset starting position.
- Radio frequencies and course indicators were also reset to a non-biased position.
- The scenario was repeated using the alternate method of viewing charts.
- A different KMEM approach was used for the second. 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 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 approach was complete, the participant was asked to fill out the short survey to measure their perceived workload using each chart viewing method.

Results

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 below:

Parameter	Paper Score*	EFB Score*	t-statistic**
	mean (SD)	mean (SD)	
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	3.92 (1.50)	2.45 (.78)	t = 3.27

* The Paper and EFB 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

Other Results

- 36% of participants were able to identify the correct minimums on their first attempt 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 paper charts.
- When using the iPad, 100% of the participants correctly applied the appropriate minimums for the approach assigned on the first attempt.

Survey Results

Question 1 asked about participants' previous experiences with the use of EFBs 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 iPad generated 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 was, "How would you say that your workload/stress level changed relative to the type of chart used?"

- 86% indicated the EFB was "much easier" and 14% indicated the EFB was "somewhat easier" than paper charts.

Question 5 was "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?"

- 93% of participants "much preferred" the EFB and 7% "slightly preferred" the EFB in this question.

Discussion

- The results of this study showed that in the given scenario there was 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.
- One of the most surprising findings involved the participants choosing the wrong approach chart when using paper. Again, only 36% of the pilots were able to correctly identify the correct approach minimums on the first attempt when using paper. 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.

Discussion

- Given that 71% of participants had not used an EFB before, coupled with the performance increases, it is seems that the iPad provides a user friendly design that requires little training or experience to utilize
- 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.
- All of the participants indicated that the EFB was “somewhat easier” or “much easier” to use than paper charts.
- 93% of the participants indicated “much preferring” the EFB. Not a single participant indicated that they preferred paper charts.

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.
- 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.

Conclusion

- Whatever the future brings to technology in aviation, there seems to be little 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 indicates that EFBs are likely to bring more safety and efficiency to the cockpit

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Questions?