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TRANSITIONING FROM DIGITAL TO ANALOG INSTRUMENTATION

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Technically Advanced Aircraft (TAA) have seen an increase in manufacturing within the last decade. The growing use of these aircraft will present unique challenges to the aviation infrastructure; as well as flight training. With the large number of analog aircraft remaining in the general aviation fleet, transitions between digital and analog will become more numerous and perhaps more precarious. A recent survey of flight instructors at one college highlighted situational awareness problems for 95% of TAA trained students when exposed to analog equipped instrument panels. Perhaps two options are available to study this problem on the ground: flight simulators or a Personal Computer - Aviation Training Device (PC-ATD). The initial challenge to any study of this issue was to select the option that would minimize, or would allow for control of, extraneous factors, so that the causal factors influencing any decrement in performance and/or situational awareness could be isolated. A comparison of the two options available showed that the PC-ATD was the better option for the study of this issue and a pilot study was carried out using the PC-ATD. The results of the pilot study suggested that the transitioning from digital to analog equipped aircraft produced degradation in performance and that further research was required.

There are many advantages to train new pilots using the latest technically advanced aircraft (TAA). Most believe that the advanced avionic displays, autopilots, and moving maps, which emulate larger commercial aircraft flight decks, are required to give new student pilots a training advantage. Workload, situational awareness, and systems management and integration of these elements will all be enhanced by using TAA. Aircraft were once only equipped with analog instrumentation. Today's general aviation flight schools may have a variety of new generation, digital instrumentation and pilots take their first lesson in digitally equipped aircraft. Once a pilot earns a flight certificate, regardless of whether or not the training aircraft used digital or analog instrumentation, there is no regulation requiring any type of transition training between the different types of instrumentation. Lack of instrumentation display formalization and layout may lead to impaired skills and decreased situational awareness. A related situation maybe expressed using digital and analog clocks for an example. What if an individual learns to read time only based on digital clocks and having never seen another style clock. This individual is then asked to read the time from an analog clock. It is highly likely that the individual's response rate will be reduced and may even be in error from lack of familiarization and practice with the analog time piece. In the early 21st century analog aircraft far outnumber their TAA counterparts. Given the large disproportionate number of analog aircraft, what transitional trap awaits those who lack transitional training?

Although a large number of aircraft accidents include situational awareness as a probable cause, information recorded by the National Transport Safety Board, in their accident data base (http://www.ntsb.gov/ntsb/query.asp), does not contain data of recent flight history. The inclusion of this data would allow analysis of the type of flight instrumentation used and reveal any transition between flight instrumentation types. A future requirement of accident investigation may be the inclusion of this data to help provide a clearer picture of this probable cause.

A recent survey of flight instructors at one college highlighted situational awareness problems for 95% of TAA trained students when exposed to analog equipped instrument panels. Of these 95% who experienced problems 34% had an initial struggle, 33% had a moderate struggle, 21% had a significant struggle, and 7% were still struggling at the end of this flight phase. The 5% who did not experience any situational awareness problems were students who had previous experience flying with analog instrumentation.

While it is assumed that pilots learn new rules or mental models in early practice to master the highly technical skills of instrument flight. It has yet to be determined the depth and complexity by which those mental models are formed and maintained. Given this unknown process, it becomes difficult to assume that transitional adaption of digital training to analog flying will be as reciprocally easy as has been analog training to digital flying. Especially given the fact that most digital displays have been developed to adapt and consolidate representations of dispersed analog instruments.

The purpose of the pilot study is to determine if there is performance degradation for pilots who have only experienced digital flight instrumentation when exposed to analog instrumentation for the first time.

Review of Existing Literature

The transition of pilots from a traditional cockpit to a modern-glass cockpit has been a training challenge for the last two decades (Dahlstrom, Decker &Nahlinder, 2006) and many studies have been conducted on how this transition training should be carried out (Reigner & Decker, 1999; Casner, 2003a, b; Fanjoy & Young, 2003). However, a review of the literature has uncovered no empirical research examining the transition of pilots from a modern-glass cockpit to a traditional analog cockpit and the possible risks involved. TAA can be defined as those aircraft equipped with new-generation avionics that take full advantage of computing power and modern navigational aids to improve pilot awareness, system redundancy, and depending upon equipment, improve in-cockpit information about traffic, weather, and terrain (AOPA Air Safety Foundation, 2005). TAA have seen an increase in manufacturing within the last decade. The growing use of these aircraft will present unique challenges to the aviation infrastructure; as well as flight training. With the large number of analog aircraft remaining in the general aviation fleet, transitions between digital and analog will become more numerous. According to the Federal Aviation Administration regulations in Title 14 part 61.31 which refers to additional training, there is no mention of the need or requirement to obtain transition training between digital and analog cockpits aircraft. (FAR AIM, 2010) Therefore as the fleet of TAA continues to expand, the potential for transitional incidents and accidents is likely to increase.

Initial research has shown that student pilots can be trained in technically advanced aircraft that will meet or exceed current training standards (Craig P. A., Bertrand J. E, Dornan W., Gosset S., Thorsby K. K., 2005). However, one study by Rantz W. G. & Van Houten R. (2011), found that using technically advanced aircraft as a primary trainer did nothing to improve student performance skills in checklist usage between the digital and paper checklists when flying technically advanced aircraft. Hamblin C. J., Gimore C. & Chaparro A., 2006 asserts that pilots armed with new technology, without proper training or understanding, can actually decrease safety. Given this same preface, pilots transitioning from digital to a different technology, such as analog, will likely experience a decrease in safety as well.

Methodology

When considering the options available to study this problem on the ground two possibilities were considered, a flight simulator, or a Personal Computer - Aviation Training Device (PC-ATD). The issue was to select the option that would minimize, or would allow for control of, extraneous factors, so that the causal factors influencing this decrement in performance could be isolated. For each of the two options (flight simulator or PC-ATD) two phases of the study needed to be considered; the simulation of a TAA with digital flight instrumentation, and the simulation of an aircraft with analog flight instrumentation.

For the first phase, the TAA with digital flight instrumentation, the flight simulator option would provide a true representation of the aircraft used in the participant's flight training (Cirrus SR20). The PC-ATD would emulate the Cessna 182 Skylane Glass, and the set-up would provide a limited representation of the cockpit environment.

For the second phase, the aircraft equipped with analog flight instrumentation, the flight simulator option would require a move to a flight simulator equipped with analog instrumentation. The only analog instrumented simulator available would be for a Piper PA-34 Seneca, which is a two-engine aircraft simulator. The PC-ATD would emulate a Cessna 182 Skylane, the analog instrumented version of the aircraft used in the first phase, which would only require a change of display not setting.

The PC-ATD allowed for better control of extraneous variables than the flight simulator and was therefore selected as the better option for this study.

Method

A pilot study was completed using a PC-ATD set up to emulate the Cessna 182 Skylane Glass for the digital equipped aircraft, and the Cessna 182 Skylane RG for the traditional analog aircraft. Participants were 6 college students recruited from junior and senior level aviation courses at Western Michigan University (WMU) who have completed the instrument rating course. The participants were randomly allocated, 3 to the treatment group and 3 to the control group. The experimental task consisted of flying different designated flight patterns using a PC-ATD emulating a Cessna 182 Skylane Glass and, for the treatment group, a Cessna 182 Skylane RG. During the simulated flights, participants were asked to fly a radar vectored flight pattern and to complete an instrument approach.

The performance of the flight student was measured in two ways, (a) their flight skills during the radar vectored flight pattern, and (b) their flight skills during the instrument approach. The dependent variables for comparing flight skills consisted of the number of times the aircraft deviated from the criteria listed in the Practical Test Standards for instrument flight check rides.

The experimental design for this study was a two group control group design. The participants were randomly allocated to either the control group or the treatment group. The pre-test for both groups consisted of a two-hour session flying 4 trials in the simulated Cessna 182 Skylane Glass. The post-test for the treatment group consisted of a two-hour session flying 4 trials in the simulated Cessna 182 Skylane RG and the post test for the control group was a two-hour session flying 4 trials in the simulated Cessna 182 Skylane Glass.

Setting

The experimental setting was a 12 by 16 foot room that is used as the PC-ATD flight and driving simulator laboratory. The laboratory is located in Wood Hall on WMU's Main Campus in Kalamazoo, MI USA.

Apparatus

The PC-ATD equipment consists of a Dell Optiplex SX260® computer with a Pentium (R) ® 2.40 gigahertz processor, and 1.0 gigabytes of SDRAM memory. Operating software is Microsoft Windows XP and simulation software is On-Top version 9.5. Flight support equipment for the PC-ATD will include a Cirrus yoke, a throttle quadrant, an avionics panel, and rudder pedals. On-Top software permits the simulation of several different aircraft types including the two that will be used in this study, the Cessna 182 Skylane RG and the Cessna 182 Skylane Glass. The technical flight parameters, which depict how well participants fly the designated flight patterns, vertically and horizontally, will be recorded for each flight on an external Seagate 1.0 terabyte hard drive. The On-Top simulation software automatically records these technical parameters and enables them to be printed.

Flight Patterns

In an effort to minimize any practice effects, a different flight pattern was used for each of the 4 trial flights. Participants were told that the PC-ATD aircraft was not programmed for any system failures and that the flight pattern would be a radar-vectored instrument flight, with an instrument landing system approach to a full stop landing. By using vectored instrument approaches and not having system faults, the flight environment should have allowed for consistent flight performance. The approach patterns used should not have provided the participant with any adverse stress or pressure to perform, as these patterns were typical of their existing training environment. The flight pattern that participants flew were divided into two segments for analysis: (a) cruise; consisting of take-off, climb and radar vectored flight (b) instrument approach; consisting of localizer interception, instrument approach and landing. The flight pattern took approximately 30 minutes to complete. To realistically simulate an actual flight pattern and ensure that it was flown in a consistent way across trials and participants, the experimenter provided typical air traffic control instructions throughout the flight pattern. These instructions were transmitted using a commercially available intercom system. The speaker was placed in the PC-ATD and the experimenter, who was in an adjacent area, used the push-to-talk feature on the monitor to transmit the air traffic control instructions.

Observation Equipment

The participants were observed remotely via EzWatch Pro Version 4.0 HiDef surveillance equipment as well as a dual computer monitor arrangement. The observing equipment consisted of 1 indoor/outdoor IR night vision bullet camera and 1 resolution indoor dome camera. The observer recording computer was a Dell Latitude D510® with a 5.7 gigabyte hard drive, a Pentium M® 1866 megahertz processor, and a plug and play monitor with 128 megabytes of memory. Other PC equipment included a Dell Microsoft Natural® PS/2 keyboard and a Sigma Tel C-Major® audio adapter. The observer occupied a room that was adjacent to the participant’s room. One camera was mounted on the wall in front of the participant to capture hand and arm movements. The other camera was mounted on the wall behind the participant to observe the participant’s interaction with the flight panel. All flights will be recorded and stored digitally for the purposes of conducting inter-observer agreement.

Analysis of Data

To reduce error variance an Analysis of Covariance (ANCOVA) with the pre-test scores as the covariate was used to analyze the data for both performance measures; flight skills during cruise and flight skills during instrument approach.

Results

Analysis of the pilot study data, see Table 1 and Table 2, suggests that there are differences between the control and treatment groups in the cruise and instrument approach phases of the flight. Further research, using a larger sample size, is required to provide the statistical power required for conclusive evidence of this difference.

Table 1

ANCOVA of Cruise Data

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	42.6667	1	42.6667	4.9621	0.0365	4.3009
Within Groups	189.1667	22	8.5985			
Total	231.833333	23				

Table 2

ANCOVA of Instrument Approach Data

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	28.1667	1	28.1667	12.1107	0.0021	4.3009
Within Groups	51.1667	22	2.3258			
Total	79.3333	23				

Benefits of Research

The full study may identify significant performance differences in digital and analog instrumented aircraft and provide empirical evidence of practice time needed to reach the required criteria using analog instruments.

The full study may identify instructional methods to increase flight safety by recommending transitional training objectives and practice time, thereby reducing the risk of errors associated with digital to analog transition.

Participants may improve their flight and instrument landing approach skills with repeated simulated flights and technical and vocal feedback.

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