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The Digital to Analog Risk: Should We Teach New Dogs Old Tricks?

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Imagine being competent and certified to fly under both visual and instrument rules in a single engine aircraft. Then imagine flying cross country, entering actual instrument conditions and having the stark realization that most of the instrumentation on the panel doesn’t make sense to you. You have difficulty integrating the instruments and find yourself fixating on a select few. Less than one minute later you lose your sense of up and down and moments later you hear the stall horn, feel the centrifugal forces and only see the white, whirling shades of deep cloud immersion. Suddenly you jerk awake to realize you are safe in your bed and this is nothing more than a pilot’s bad dream; or could it be?

Learning to fly only a short time ago, one had limited choices in training aircraft. Usually the aircraft was a single engine trainer with forgiving flight characteristics and limited equipment. Once the new student pilots learned to scan the instrument panel they could count on common flight instrument displays in most aircraft parked on the flight line. Currently many new students may choose the option to start training in a technically advanced aircraft (TAA). These TAA are equipped with advanced avionic displays, autopilots, GPS and in many cases, moving map displays and flight management systems (FMS). TAA equipped with FMS can automatically switch the autopilot modes during transitions from en route to approach phases of flight giving the student pilot a truly “hands off and monitor” experience. One goal of many collegiate aviation programs is to have their graduates make a quick and seamless transition to the more complex electronic navigation and communication equipment that are standard in aircraft operated by commercial air carriers. The practical challenge is single engine analog aircraft outnumber their TAA counterparts. No federal regulations require any form of additional training in the transition from the advanced digital avionic displays to the older analog displays. While many pilot graduates may end up on the flight deck of regional carriers, many may first experience the analog fleets of the world. Given the large disproportionate number of analog aircraft, should there be concern for pilots trained only in TAA? Will pilots trained only in TAA suffer performance degradation when first transitioning to analog instrumentation?

The purpose of this feasibility study was to determine if there was evidence of performance degradation for pilots, when first transitioning to analog instrumentation, which would justify a full study.

Review of Existing Literature
TAA is defined as 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 flight deck information about traffic, weather, and terrain (AOPA Air Safety Foundation, 2005). During the last twenty years, a plethora of technological advancements, found on airliners and corporate jets, have been introduced into most of the current TAA training aircraft. Challenges in training, to those educated in an analog world, given these new displays remain important. Since many of the primary and secondary flight displays were patterned after analog displays (Dahlstrom, Decker & Nahlinger, 2006). Most commonly, studies examined the best training techniques to accomplish transitional training from analog to digital (Reigner & Decker, 1999; Casner, 2003a,b; Fanjoy & Young, 2003). Unfortunately, a search of the literature has not uncovered any empirical research examining the transition of pilots from a modern-glass flight deck to a traditional analog flight deck, and the possible risks involved in this transition. TAA have seen an increase in manufacturing within the last decade. The growing use of these aircraft will present unique challenges to the aviation
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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 (Whitehurst & Rantz, 2011). According to the Federal Aviation Administration regulations of Title 14 part 61.31, 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.

Research on pilots trained in TAA has indicated they will meet or exceed current practical test standards (Craig P. A., Bertrand J. E, Dorman W., Gosset S., & Thorsby K. K., 2005). However, Hamblin C. J., Gimore, C. and Chaparro A. (2006) assert 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 any 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 an aircraft with digital flight instrumentation, and the simulation of an aircraft with analog flight instrumentation.

For the first phase, the aircraft 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, a different aircraft to that flown during training, 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 could be reconfigured to emulate a Cessna 182 Skylane, the analog instrumented version of the aircraft used in the first phase. This would only require a change of display not a change of 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 feasibility study.

Method

A feasibility 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 six college students recruited from junior and senior level aviation courses at Western Michigan University (WMU) who had completed, or were within five flights of completing, the instrument rating course. The participants were randomly assigned to one of two groups and each participant flew two sessions using the PC-ATD. Each session, lasting approximately two hours, consisted of four designated flight patterns involving a cruise and an approach phase of flight.

The first session was used to establish baseline data for flying the PC-ATD. Each participant flew the 4 different designated flight patterns with the PC-ATD configured to emulate a Cessna 182 Skylane Glass, which has the digital instrument display they were used to flying with. During the simulated flights, participants were asked to fly a radar vectored flight pattern and to complete an instrument approach.

The performance of each participant was measured in two ways. First, their flight skills during the radar vectored flight pattern (cruise), and secondly, their flight skills during the instrument approach (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 (PTS) for instrument flight check rides.

The second session was used to compare the flight performance of the two groups when the cockpit display of one group was changed from digital to analog whilst the other group’s cockpit display remained digital. Each participant, in both groups, again flew the four different designated flight patterns flown in the first session. The participants in group one flew the PC-ATD again configure to emulate a Cessna 182 Skylane Glass with the digital cockpit display. The participants in group two flew the PC-ATD reconfigured to emulate a Cessna 182 Skylane RG equipped with the analog instrumented cockpit display.

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

Setting
The experimental setting was a 12 by 16 foot room 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 consisted of a Dell Optiplex SX260® computer with a Pentium® 2.40 gigahertz processor, and 1.0 gigabytes of SDRAM memory. Operating software was Microsoft Windows XP and simulation software was On-Top version 9.5. Flight support equipment for the PC-ATD included a Cirrus yoke, a throttle quadrant, an avionics panel, and rudder pedals. The On-Top software simulated the two aircraft types used in this study, the Cessna 182 Skylane Glass and the Cessna 182 Skylane RG. The technical flight parameters, which depicted how well participants flew the designated flight patterns, vertically and horizontally, were recorded for each flight on an external Seagate 1.0 terabyte hard drive. The On-Top simulation software automatically recorded these technical parameters enabling them to be printed for debrief purposes and analysis.

Flight Patterns
In an effort to minimize any practice effects, a different flight pattern was used for each of the four trial flights used in each session. Participants were told that the PC-ATD aircraft was not programmed for any system failures and 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, and (b) 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 consistently 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 one indoor/outdoor IR night vision bullet camera and one 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 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 were recorded and stored digitally for the purposes of conducting inter-observer agreement.

Data
Table 1 shows the number of deviations beyond PTS for each participant in each group for each session. For the first session, both groups flew the simulated Cessna 182 Skylane Glass, the mean number of deviations beyond PTS for the cruise segment and the approach segment: for group one were 1.0833 and 1.9167, and for the group two were 3.0000 and 1.7500.

In the second session, group one flew the simulated Cessna 182 Skylane Glass and group two flew the Cessna 182 Skylane RG, the mean number of deviations beyond PTS for the cruise and for the approach: for group one were 0.6667 and 0.1667, and for group two were 5.2500 and 2.1667.
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Table 1
Number of Deviations from Practical Test Standard

<table>
<thead>
<tr>
<th>Session</th>
<th>Group</th>
<th>Participant</th>
<th>No of Deviations</th>
<th>Cruise</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cruise</td>
<td>Approach</td>
<td>Cruise</td>
</tr>
<tr>
<td>1</td>
<td>Control</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1.0833</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>3.0000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0.6667</td>
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<tr>
<td></td>
<td></td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>5.25</td>
</tr>
</tbody>
</table>

Group one appeared to perform better in second session, with a reduction in the mean number of deviations from PTS of 0.4200 for the cruise and 1.7500 for the approach. However, the group two appeared to perform worse in second session, with an increase in the mean number of deviations from PTS of 2.2500 for the cruise and 0.4200 for the approach.

Analysis of Data
To reduce error variance an Analysis of Covariance (ANCOVA) with the first session 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
For both the cruise data, see Table 2, and the approach data, see Table 3, we can see that there are statistically significant differences, p = .0365 and p = .0021 respectively, between group 1 and group 2. Of considerable concern is the highly significant difference between the two groups during the approach phase. The approach phase is a critical phase of flight when a pilot needs to be at their peak performance due to the high demands of an instrument approach and the proximity to the ground. These results suggest further research, using more sophisticated equipment and a larger sample size, is needed to provide a higher fidelity flight simulation and more statistical power that is required for conclusive evidence of this potentially lethal problem.
Table 2
**ANCOVA of Cruise Data**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
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</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>42.6667</td>
<td>1</td>
<td>42.6667</td>
<td>4.962</td>
<td>0.0365</td>
<td>4.3009</td>
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<tr>
<td>Within Groups</td>
<td>189.1667</td>
<td>22</td>
<td>8.5985</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>231.833333</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Table 3
**ANCOVA of Instrument Approach Data**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>28.1667</td>
<td>1</td>
<td>28.1667</td>
<td>12.1</td>
<td>0.0021</td>
<td>4.3009</td>
</tr>
<tr>
<td>Within Groups</td>
<td>51.1667</td>
<td>22</td>
<td>2.3258</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>79.3333</td>
<td>23</td>
<td></td>
<td></td>
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</tbody>
</table>

**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. This study has demonstrated the potential for technical skill decrease during a transition from digital to analog instrumentation. As such, it may be time to teach new dogs old tricks if only so they may sleep well at night.

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**Geoffrey Whitehurst** earned a Master of Arts in Evaluation, Measurement and Research at Western Michigan University, and a Bachelor of Science in Mathematics from London University, UK. He is an assistant professor at the College of Aviation, Western Michigan University in Kalamazoo, Michigan. Mr Whitehurst holds a Private Pilot Certificate, and Instrument and Advance Ground Instructor certificates. Mr Whitehurst was a navigator in the Royal Air Force for 23 years before moving into academia.
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References


