MICROFLIGHT SIMULATOR

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ABSTRACT

The Air Education and Training Command (AETC) conducted a proof of concept test of Commercial-Off-The-Shelf (COTS) PC flight simulators in undergraduate pilot training. Based on the successful employment of this technology in the Navy, the Air Force tested it's own version of the "Microflight Simulator" at Laughlin AFB TX. AETC compared 55 undergraduate pilot trainees who used Microflight to 209 students who did not. The students using Microflight achieved individual "Time-to-MIF" (Maneuver Item File) sooner and these same students' classes had an average of 33 percent less dispersion among their individual "Time-to-MIF" scores. This paper presents the study results and provides lessons learned and conclusions from the study that can be directly applied to implementation.

ABOUT THE AUTHORS

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INTRODUCTION

Based on the successful employment of Commercial-Off-The-Shelf (COTS) PC flight simulators in the Navy, the Air Education and Training Command (AETC) conducted a proof of concept for this technology in the Air Force.

Background

Previous Studies

Until now, no study has reported on the effectiveness of PC-based COTS simulators for pilot training in the Air Force. Previous studies confirm the success of this technology in the Army, Navy, and Marines, as well as NASA and the private sector (Bonanni, 1997; Dennis & Harris, 1998; Dunlap & Alexander, 1998).

These previous studies indicate that PC sims provide a cost effective supplement to the expensive full motion, high fidelity simulators widely used for flight training in DoD. While the low fidelity models are not as effective for psychomotor skills (Koonce & Bramble, 1998), they do enhance aircrew coordination (Prince & Salas, 1991) and cognitive skills such as cockpit familiarization, instrumentation, and basic flight maneuvers (Dunlap & Alexander, 1998; Taylor, Lintern, Hulin, Talleur, & Phillips, 1996). They improve attentiveness and self-confidence (Rantz, 1998); plus, they accelerate learning (Dennis & Harris, 1998; Taylor et al, 1996).

The PC sims also belie the assumption that low fidelity aids produce negative training (Burki-Colhart, Soja & Longridge, 1998; Jentch & Bowers, 1998; Rantz, 1998; Salas, Bowers, & Rhodenizer, 1998). For example, one study of aircrew coordination showed a significant positive transfer of learning from low to high fidelity simulators (Brannick, Prince, Salas, & Stout, 1998).

The present study investigates whether the same positive results observed in the other services occur when PC flight simulation is applied to the Air Force.

Navy History

Since the Air Force Microflight Simulator is based largely on the Navy's Micro-sim, in order to understand the use of the Simulator in the Air Force, the reader first needs to understand its genesis in the Navy.

Origination

In 1997 Ensign Herb Lacy, USNR, in pilot training at Corpus Christi, came to the attention of his instructors. Despite having no prior flying experience, he earned highest grades for the year at the command where he was winged. When asked how he had performed so well, Ensign Lacy showed a "desk-top flight simulator" he had developed by programming Microsoft Flight Simulator 98 with T-34C flight characteristics and Corpus Christi terrain. With this simulator, Ensign Lacy was able to pre-fly (or "chair-fly") each mission before he actually got in the airplane.

The following passage from the US Navy Micro-sim briefing explains the development of Micro-sim up to the time the Air Force became involved.

> Ensign Lacy USNR – a student with no prior flight time developed a T-34C aircraft model and supporting files to be used with MS Flight Sim 98. (He) practiced the procedures used in each flight prior to each syllabus flight and earned the highest grades for the year at the command where he was winged.

Preliminary data gathered by the Navy indicated that over 50% of the students at Training Command were using some type of COTS flight simulation package to augment training. That same data indicated that the students who regularly used the software were consistently outperforming their peers.

Learning Management Shell

Recognizing a good thing when they saw it, the Navy training personnel implemented Micro-sim in flying training at Corpus Christi as a formal training aid. They did this by constructing a Learning Management Shell (LMS) designed to work with Microsoft Flight Simulator 98 and T-34C support files. The LMS provided structure to what had, up to then, been a free style training aid the student could use any way he chose. While the student still had access to free flight in a T-34C over Corpus Christi, the LMS provided specific maneuvers for each mission. It also provided digital demonstration files of each maneuver and references to the pertinent regulation. In addition, the student has access to files that allow him to try each maneuver starting in the proper air space, so he doesn't have to begin on the ground and complete the takeoff sequence each time he wants to practice.

Micro-sim Lab

The final step for the Navy was to give this learning tool to the students. They provided the LMS free to each student for home use; however, the student had to furnish the other components on their own (Microsoft Flight Simulator 98, Sticks and throttles, rudder pedals, and computer). To ensure access by all students, the Navy also implemented a Micro-sim lab – ten networked Micro-sim systems accessible to students on a voluntary basis after they have received initial orientation. Upper class "mentors" were also on duty to assist students using the trainer with both system operation and flying training concepts. According to CNET, their lab system has been very successful.

Navy Conclusions

The Navy evaluated the Micro-sim concept (Dunlap & Alexander, 1999) and concluded the following:

a. Projected to help reduce time to train and decrease attrition (fewer total UNSATS).

b. Use micro-simulators early in the primary phase to introduce basic training concepts.

c. A structured learning methodology is necessary to ensure success.

d. Anecdotally, numerous students report improvement in problem solving after the lab.

e. Micro-sims won't replace higher fidelity sims, but support "task shedding" off higher cost assets.

f. Micro-simulator labs are necessary since many students have no computers at home.

g. Peripheral products such as sticks, rudders, and throttles vary in reliability. Must be very rugged for use in a lab.

h. Near-term implementation is planned for students to use voluntarily as a learning aid.

i. Navy aviation students as of April 2001 use Micro-sim an average of 17 hours per month. These 17 hours include an average of 5 hours in the lab and 12 hours at home.

j. Students will continue to use PC flight simulators whether or not we endorse, use, or provide them as part of the training toolkit.

Air Force History

Origination

On hearing about the Navy's Micro-sim, AETC senior staff questioned whether this technology would work for the Air Force as well. This study is the result of that question. AETC decided to tailor the Navy Micro-sim in house, then implement it in a small group trial to see its effect on student performance in Air Force undergraduate pilot training (UPT). Fundamental differences between Navy and Air Force pilot training prevent the assumption that the success of this technology would directly transfer across services.

System Model Development

Development of the Air Force version began November 1999, and was accomplished by AETC Studies and Analysis Squadron (SAS). Major milestones included: creation of T-37 aircraft characteristic files, creation of Laughlin AFB terrain files, recording of maneuver demonstration files to follow UPT syllabus and modification of Navy LMS.

Creation of T-37 aircraft characteristics files

Aircraft characteristics were dealt with in two stages. The first task was to create the physical appearance of the T-37, including cockpit and instrumentation. The AETC SAS developers were able to pull instrument files directly from the web. Once the rough outline of the aircraft was in place, an approximation of flight characteristics was accomplished. The only way to closely emulate the T-37 in the air was to reverse engineer the aircraft. Volunteer pilots from 12 FTW "flew" Microflight, then provided feedback to the developer on the appearance of the aircraft, behavior of instrumentation, and flight characteristics (Figure 1).

Figure 1. Cockpit View from the Sim

Creation of Laughlin Terrain Files

Concurrent with creation of the aircraft was generation of the environment in which the aircraft would fly. Basic files of Laughlin Air Force Base, TX and the surrounding area were downloaded from the Internet and modified to "look like the real thing."

Figure 2. Flight Scenario Screen

Modification of the LMS

Once the aircraft characteristics and terrain files were complete, modification of the Navy LMS began. The framework stayed the same, but all of the content was changed to reflect the Air Force syllabus and maneuvers performed in the T-37 aircraft.

The student is presented with a screen (Figure 2) that allows him or her to choose from a list the desired flight and maneuver. For each maneuver the student has access to: a technical order and regulation reference; a digitally created demonstration file; and an adventure file. The adventure file allows students to practice each maneuver starting in the proper air space and not on the ground. Students don't have to complete the takeoff sequence each time they want to practice a certain maneuver.

Syllabus Outline

Instructor Pilots from Randolph AFB, TX were asked to determine which maneuvers in the T-37 phase of UPT would benefit from a Microflight simulator. The list consists of 17 maneuvers divided into three major categories:

<u>Basic Contact</u>: Takeoff, Local Departure, Local Recovery, Normal Overhead Pattern, Normal Straight-in pattern, Normal Landing

<u>Intermediate Contact</u>: Single-engine Landing, No Flap Straight-in and Landing

<u>Advanced Contact</u>: Aileron Roll, Loop, Split S, Cuban Eight, Chandelle, Lazy 8, Cloverleaf, Immelmann, Barrel Roll

Maneuver Demonstrations

Maneuver demonstrations are digital recordings of maneuvers flown on Microflight in the T-37 aircraft over Laughlin terrain by Instructor Pilots (IP). This gives the student a chance to "observe" an expert fly the maneuver. Maneuver demonstration creation was the most time consuming portion of LMS modification since it required an IP to first get familiar with the subtleties of flying Microflight, then fly each maneuver repeatedly until a quality acceptable for a teaching aid was reached. This required the pilot to pay attention to several dimensions at once: the position of the aircraft in relation to the terrain, the accuracy of the gauges, and the instructions to the student. After an acceptable version of the maneuver was recorded, dialogue to explain the maneuver to the student was added.

Regulation References

Regulation references for each maneuver were added to the regulation reference portion of the screen which allowed students to find the chosen maneuver in their texts.

Flying Files
Flying files allow the student to practice each maneuver starting in the proper air space. This allows them to skip the time-consuming takeoff sequence and practice just the specific maneuver chosen.

STUDY APPROACH

AETC SAS posed the following questions:

a. Do students achieve Maneuver Item File (MIF= proficiency) sooner?

b. Are students more proficient?

AIR FORCE UPT GRADING

In order to understand how improvements were quantified, the reader must understand the Air Force UPT grading system.

The Maneuver Item File (MIF), located in the syllabus, is a list of maneuvers and level of proficiency for each maneuver required in each block of training. The phrase "achieve MIF" is a pilot training term for a student achieving the required level of proficiency for a specific maneuver. In order to graduate, the student must reach the required level of proficiency for each maneuver in each block. The phrase "Time-to-MIF" is the number of lessons required within a specific training block to "achieve MIF".

STUDY TRIAL

The Microflight Simulator small group trial was held with two UPT classes (55 students) at Laughlin Air Force Base, TX. The two classes chosen to participate were 01-10, 85 Flying Training Squadron (FTS) and 01-11, 84 FTS. Students in these two classes were given complete Microflight Simulator set-ups to be used at home. Students were issued a $90 stick and throttle set, $72 rudder set, and the customized Microsoft Flight Simulator software. Laptop PCs were temporarily issued to students who did not own a PC. The remaining 209 students at Laughlin AFB formed the control group.

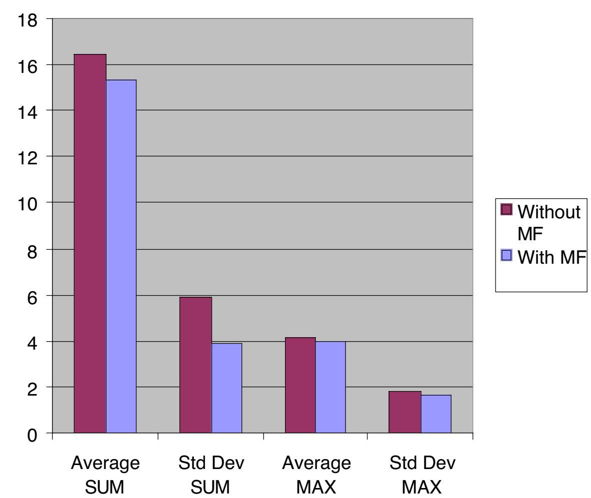
STUDY RESULTS

The effectiveness of the Microflight Simulator was measured by comparing the flying performance during the nine "Advanced Contact" flight maneuvers of 55 students who had the Microflight Simulator to 209 students from 8 UPT classes that did not have the Microflight Simulator. The "Advanced Contact" syllabus was chosen for scheduling convenience at the training wing.

TIME TO MIF

Table 1 depicts four metrics based on Time to MIF.

Table 1. Time to MIF Metrics



Average SUM
SUM stands for the total number of lessons that it took all students in a class to achieve MIF. The average SUM refers to the average of the two classes that used Microflight compared to the average of eight classes that did not. As table 1 shows, the Microflight students achieved mastery slightly sooner on average that the non- Microflight students (15.70 lessons vs. 16.46 lessons).

Std Dev SUM
Std Dev SUM stands for the standard deviation of the average SUM scores. The Std Dev SUM for Microflight classes was 3.93, compared to 5.92 for non-Microflight classes. In other words, the Microflight classes were more consistent.

Average MAX
MAX is a figure closely scrutinized by the UPT community. It is the "worst case." It stands for the longest Time to MIF per student. In other words, of the nine advanced maneuvers, which one took the student the longest, and how long did it take? The average MAX refers to the average of the MF classes vs. the average of the non- Microflight. As table 1 shows, the Microflight students had a lower "worst case" score (4.02 lessons) than the non- Microflight students (4.15 lessons).

Std Dev MAX
Std Dev MAX stands for the standard deviation of the average MAX scores. The Std Dev MAX for Microflight classes was 1.67, compared to 1.83 for non-Microflight classes. In other words, the Microflight classes were slightly more consistent in their "worst case" scores.

Significance
Only the Std Dev SUM numbers were statistically significant at the <.05 confidence level. In fact, the Microflight classes had 33 percent less variation or spread in their "Time-to-MIF" scores than did the classes without Microflight.

At face value, this does not imply that the Microflight students were any better or worse than the non-Microflight. It does suggest, however, that the performance of Microflight students is more standardized. With less of a spread between worst and best performing students, the instructor doesn't have to divide as much of his classroom time among divergent groups of learners.

Although three of the metrics were not statistically significant, the fact is that all four metrics point in the same direction: Microflight classes are uniformly better than non-Microflight classes. This lends credence to a positive interpretation of the results.

Student and Instructor Questionnaires

In addition to Time to MIF scores, this study also administered questionnaires to all 55 students and 6 instructors who used the simulator. In general, results were disappointing. The main question asked, "How useful was the Microflight study aid Overall?" On a scale of 1 to 9, with 1 being "Useless" and 9 being "Very Useful," the mean score for students in the first class was 3.5. The mean score for students in the second class was 5.3. Median scores for the two classes were 3 and 5, respectively.

Students
In their comments, students liked the concept of Microflight training. Sample statements were, "Good idea. Just needs refining;" "The concept is valuable, just need to refine the bugs;" "Great idea but the execution wasn't detailed enough to warrant spending what precious time we have in trying to make it work."

Most students had trouble setting the system up or getting it to work. Sample comments were "I attempted to load this program onto my original computer but could not get it to work due to lack of parts;" "I could not get the rudder pedals or buttons on the throttles to work;" "Did not use it." In retrospect, it is clear that students needed a more user-friendly system with better on-site support.

Instructors
The average score for the six instructors who answered the "Overall" question was 5.5. Two of them said their students used Microflight rarely if ever, while two others said they weren't aware of the extent of student participation.

LESSONS LEARNED

Many lessons were learned from the adaptation of Microsoft Flight Simulator to the T-37. As the student comments indicate, the trainer would probably have been received more enthusiastically and made a greater impact if hardware and support problems were corrected and product assistance provided.

The first try at adapting a COTS-based PC simulator for AF training was not an unalloyed success. Nevertheless, many valuable lessons were learned in the process, which, in retrospect, would likely have produced a better result. Here are some of the main pointers.

Implementation Lessons

1. The student setup should be plug and play (*students were discouraged by the complexity of setup*).

2. Emphasis should be placed on simplicity and user-friendliness, versus authenticity and detail (*the simulator should do a few things well*).

3. Student use of the simulator should be incorporated into curriculum (*many instructors had no idea whether or not students were actually using the simulator*).

4. Students need some type of on-site or instructor support in their initial installation and subsequent use of the simulator (*Students installed and operated the systems on their own*).

Technical Lessons

5. Minimum PC processor configuration should be 400 MHz, with 600 preferable (*we used 200 MHz).*

6. Students must have the advanced contact maneuvers in their line of sight (*our students had to look up).*

7. The developers should not build a "photo realistic" instrument panel that is too difficult to view on a standard 17" monitor with 1024 x 768 resolution. A

simplified panel with priority on making critical gauges legible is best (*both instructor pilots and students heavily criticized the layout of our original instrument panel*).

8. Sufficient time needs to be allotted for development and test. Even though Microsoft Flight Simulator 98 is an off-the-shelf product, tailoring it to fit local requirements was an extensive effort. The lesson is to contract out the development (*we developed the system in-house*).

SUMMARY

Conclusion

All quantitative measures are positive. Compared to students without Microflight, students with Microflight took slightly fewer lessons to achieve proficiency, even performing somewhat better on their worst-case maneuvers. These Time-to-MIF results are more significant than student scores, per se, because the key issue for pilot training is how soon they gain proficiency. Microflight student performance was also more standardized than non-Microflight.

Subjective responses on student and instructor questionnaires help us interpret the lack of statistical significance of the data. While respondents generally regarded Microflight as a promising technology, most had great difficulty installing the system at home, or getting it to work thereafter.

The Future

Although results are mixed, they generally point in a positive direction. To the extent that students gain proficiency sooner, they will be able to advance to higher levels and be combat ready faster when they arrive at their operational unit.

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