International Journal of Professional Aviation Training & Testing Research
Vol. 7, Issue 2

Leveraging Virtual Training Environments to Develop Professional Flight Officers in a Rapidly Changing Aviation Industry

Derren Duburguet* and George G. King**

ABSTRACT

Pilot education in a university environment, compared to an airline training facility, imposes unique challenges from the standpoint of course design and implementation. Learning objectives at the university level tend to be of broader scope than the focused training objectives at the airlines. University curricula and associated educational technologies must remain nimble in order to meet the required skills and knowledge base for developing professional flight officers capable of adapting to a wide variety of flight operations. Maintaining the necessary flexibility within an aviation program while remaining cost-effective, however, can be a challenge. Greater reliance on software systems to create virtual training environments, rather than the incorporation of advanced flight simulator devices, is one strategy to address these concerns. This paper examines the virtual training strategies implemented at Metropolitan State University of Denver's *Department of Aviation and Aerospace Science and seeks to reconcile* MSU Denver's *approach with the current and future needs of the aviation industry. Suggestions of adaptation and implementation for future needs of virtual training environments within the pilot training domain are also provided.*

On August 1, 2010, Public Law 111-216: The Airline Safety and Federal Aviation Administration Extension Act of 2010, was signed into law. Its passage was the culmination of 15 months of lobbying and congressional activity precipitated by the crash of Continental Flight 3407 in which it was determined that the actions of the flight crew were the principal cause of the disaster. In the four years since the passage of this law, the FAA has promulgated regulations that have a direct impact on the aviation education and training industry. The intent of these regulations is to improve airline safety and address inherent weaknesses in the current system of pilot education and training. Notwithstanding the implicit dilemmas within the implementation of the new regulatory environment created as a result of this law, it is incumbent upon the university aviation community to examine new methods to help overcome these apparent knowledge lapses and gaps during the education of our professional flight officers. Not only must university aviation curricula adapt to address these changing regulations, the supporting educational technology infrastructure must also be flexible enough to respond. This paper outlines Metropolitan State University of Denver's use of non-immersive (Chen, 2009), or PC-based, computer simulation software to create highly adaptable virtual training environments.

The Aviation and Aerospace Sciences Department of Metropolitan State University of Denver maintains and operates two computer-based training (CBT) labs. The larger CBT lab/classroom is for "Advanced Aviation and Aerospace Flight Training" (AAAFT) and consists of 19 (1 instructor, and 18 students) high-powered PC-based workstations equipped with dual, high-speed visual displays and control inputs. The instructor's workstation is connected to two high definition ceiling mounted projectors that allow the visual display to be projected onto large screens at the front of the classroom. The second, and smaller, CBT lab is for "Regional Jet Training" and is equipped with 4 similar PC-based workstations. For classes that use these facilities, the instructor can review the software installed on these workstations (Table 1) and begin to weave various simulation packages together into a virtual training environment solution that will help achieve the learning objectives desired. The challenge is to create an environment that limits extraneous distractions and provides a workspace for the student that is germane to the content being taught. Given that the virtual training environment hosted by the CBT labs is non-immersive in nature, distractions are inherently plentiful. Although the use of simulations encourages active participation (Pantelidis, 2009), Trundle and Bell (2010) indicate that computer simulations are of marginal benefit when utilized outside the framework of an instructional model. A completely heuristic approach, therefore, is ultimately of limited benefit for the student, especially when dealing with complex simulations. Rather, it is important to implement the virtual training environment in a "just-in-time" fashion, when the application is appropriate and purposeful for the content at hand. Instructors utilizing the CBT Labs can provide an overview of the material and demonstrate various scenarios, after which the student can interact with his/her individual installation to, hopefully, gain insight into the operational parameters of the system under study.

As an illustrative example, we shall focus on the upper-division course "Advanced Commercial Aircraft Systems" taken by students pursuing the Professional Pilot degree track. The aircraft chosen for this class, the Bombardier CRJ 200, is utilized as a case example for the students to explore the broader context of complex aircraft systems and operation. Students in this course are required to demonstrate systems knowledge while performing cockpit procedures that transition aircraft configuration from a power-off state through to engine start. For this class, each workstation in the CBT labs is loaded with the Aerosim CRJ 200 Virtual Flight Deck (VFD) used to simulate system interface and response in the cockpit. The VFD is ideal for system interaction and creates a dynamic virtual workspace for each individual student to analyze system behavior under normal and abnormal operations. The VFD can also readily facilitate scenario-based and/or exploratory exercises. As part of their interaction with the VFD, students are required to utilize procedural flows backed up by checklists. Flow patterns followed by challenge and response checklists are commonplace for pilot-systems interaction in a complex aircraft. Adherence to flow patterns when interacting with the VFD software helps achieve purposeful and guided simulation experience that is part of the virtual training environment.

A drawback of the VFD is its inability to provide an immediate spatial context for the student. This spatially inaccurate presentation may introduce extraneous loads in learning for students with weaker spatial cognitive abilities. A more germane learning application of this software would involve interactive touch-screens spatially arranged so that the simulated control panel interfaces are oriented in the correct cockpit spatial configuration. Aerosim's Virtual Procedural Trainer is an excellent example of this type of training device and certainly the ideal choice where financial resources allow for such capital expenditures. In lieu of a system such as this, however, a viable work around employed in the "Regional Jet" CBT lab is the use of a simple cockpit procedural trainer, where high quality static cockpit control panel diagrams, provided by AvSoft, are arranged in a manner that approximates their spatial orientation in the actual flight deck. The application of the cockpit procedural trainer in combination with the VFD software comprises the virtual training environment for the "Advanced Commercial Aircraft Systems" course. Practicing the flow procedures in the spatially correct presentation of the cockpit procedural trainer followed by flow pattern use in the Virtual Flight Deck software has been observed to help alleviate the potential spatial confusion inherent in the simulation software. Trundle and Bell (2010) also suggest that learning outcomes can be improved when computer simulations are used in conjunction with other representations.

The Aviation and Aerospace Department of Metropolitan State University of Denver maintains a "World Indoor Airport" which is equipped with 10 Frasca 141 single-engine level one FTD's, 5 Frasca 142 twin-engine level one FTD's (two of which are equipped with Avidyne "Integra" glass cockpits), 2 Frasca "Mentor" single-engine, glass cockpit FTD's, 2 Frasca 242 Twin-engine turboprop level one FTD's and a Cessna Mustang level-5 FTD. These devices are well utilized and very effective teaching tools which are fundamental in several "core" curriculum courses such as "Single Engine Flight Simulation," "Instrument Flight Simulation," "Multi-engine Flight Simulation" and "Turboprop Flight Simulation." These Flight Training Devices range in cost from $100K to $500K. The 20 FTDs described above, therefore, represent an acquisition cost of approximately $3 million to $4 million. Approximately 10% to 15% of the acquisition cost can be estimated as an annual maintenance cost. The high performance, dual screen workstations used in the CBT labs cost approximately $5,000 per unit. About 30 such units are maintained in the two CBT labs and elsewhere around the department, making the cost of acquisition approximately $150,000. Software licensing is also required for many of the program sets used in the CBT labs. These ongoing "support" costs range from several hundred to, in some cases, several thousand dollars. All the workstations, however, are essentially equally configurable, providing a good deal of flexibility with respect to the number of classes that can utilize the workstation hardware/software combination. This provides very good cost efficiency. Pantelidis (1996) cites one factor in the consideration of not using CBT-based teaching as the relative costs involved in providing the "virtual reality" environment. In the case for MSU Denver, however, it is the "virtual" environment that offers cost savings.

If we accept that, in the case of MSU Denver, the cost argument is favorable for the use of CBT-based learning and training systems, the discussion should be primarily concerned with the relative efficacy of the use of "soft" simulations verses a more FTD-centered, hardware oriented curricula. The authors of this paper do not suggest that these two areas be considered at all mutually exclusive. A course curriculum that utilizes, wherever possible, a combination of these technologies would seem, a priori, the optimal solution. This conclusion is reached by observations made within both environments that underscore the relative strengths and weaknesses presented by these environments with respect to student comprehension of the systems' operations. For example, if the learning objective is to help the student understand the physical model of a particular system (electrical, fuel, hydraulic, pneumatic, etc.) and the interaction of its various components, the use of schematic diagrams combined with lectures has been, historically, the information delivery system. After an appropriate amount of study, the student can be put into an FTD-lab environment where the operation of the particular system can be observed through the "normal" pilot/aircraft interface available on the flight deck. System operation is visualized through the interpretation of the specific instrumentation available for a particular flight deck. Learning this interpretive skill is fundamental, and FTD-like simulators are very effective. The shortcomings of such an approach, however, are that the "hands-on" reinforcement of student understanding is limited by the subset of "irregularities" that can be programmed and by the simulators' fidelity to a particular flight deck environment. The depth of system understanding achieved by the student depends in good part, on his or her ability to create a mental picture of the "invisible" components of the system and their relevant actions. Veermans, K., van Joolingen, W., & de Jong, T. (2006), and others have pointed out how a computer simulation environment can greatly facilitate a student's cognitive recognition of this type of system structure. The primary appeal of the CBT lab approach to certain subjects is found in this premise. In the virtual training environment, a student can explore hypothetical situations (at least to the degree allowed by the software) and interact with the system in a purposeful way to build a mental model of the process that is most effective for the individual. A student's discovery of the immediate effects precipitated by manipulations of the system components can lead to a more fundamental understanding of overall operation (Windschitl & Andre, 1998). In addition, PC-based flight simulator software packages offer an excellent "studio" with which to create inexpensive, photo-realistic, animations to use in class for pilot-system interaction demonstrations. Realistic representational animation for procedural motor knowledge is far more effective than static illustrations (Hoffler & Leutner, 2007).

In addition to specific software suites that address highly complex aircraft systems, the Aviation and Aerospace Science Department at Metropolitan State University of Denver is also experimenting with the use of its CBT labs to enhance the delivery of lower division, foundational aviation courses. One such implementation is through the use of Microsoft Flight Simulator that provides students with an additional means to augment the understanding of material presented in pilot ground school curricula. The University has historically utilized the FTD lab simulators to provide this experience, and continues to do so. In many cases, however, particularly for students with little or no aeronautical experience, the use of the FTD was a serious challenge armed with only ground school information. By allowing students to utilize various virtual environments within the CBT labs, with full guidance from an instructor, a more individualized and self-paced application of fundamental aviation principles is possible in a manner that can be less of a cognitive overload compared to an experience in the FTD. The effect that this will have on the level of learning for our students remains to be assessed, but results such as those achieved in other foundational technical areas such as physics (Chang et al, 2008) can hopefully be reproduced. This approach proved useful during a STEM outreach program hosted by the Aviation and Aerospace Sciences Department for local high school students during the summer of 2012. A virtual training environment was created by customizing specific scenarios within Microsoft Flight Simulator to introduce students, with no prior aviation experience, to human factor issues in flight training (Duburguet et al, 2013).

The experience of Metropolitan State University of Denver with the implementation of virtual training environments has been overwhelmingly positive. This approach implicitly affords a level of flexibility that allows for more affordable and responsive adaptations in course design. In the example of the "Advanced Commercial Aircraft Systems" course, one of the advantages in employing a virtual training environment has been that as the industry fleet trends change and the CRJ relevance diminishes, the aircraft type used as a case example can be modified accordingly. In addition, other aircraft platforms can be introduced and used in tandem during the course to compare/contrast system implementation differences and similarities. The use of new techniques and knowledge delivery schemes, however, has not been without its problems. Software, by its very nature, is subject to system defects that must be addressed and can often lead to changes in the program application. Within a teaching environment this adds additional challenges for providing consistent delivery of course materials. Software providers are normally eager to cooperate with end users such as the University, but they are also governed by the rules of the market place and ultimately responsible to their own management. The demands of the end user are, therefore, not always satisfied in a timely manner. On a more abstract level, the use of CBT-type learning tools makes the interaction of the instructor and the student less direct and more difficult to assess with respect to effectiveness. These challenges make the adoption of more and newer CBT tools within the curriculum more difficult because of the added workload imposed on the faculty to create meaningful and guided virtual training environments. It is the opinion of the authors, however, that these difficulties can be more than compensated by the promise of what the use of these powerful teaching tools can deliver in the pursuit of the ultimate goal of increasing the depth of knowledge of our students and the resulting enhancements to the safety of the aviation and aerospace environment.

Aerospace Software:	Systems Tool Kit (STK) 10x + Space Environment & Effects
	STK Orbit Tuner
	NASA - Systems Analysis of Planetary Entry, Descent, and Landing) (SAPE)
Aviation Software:	Aerosim CRJ200 VFD + Jetpac (FMS)
	Aerosim Cirrus Avidyne AST
	AVSoft CRJ 200-900 CBT
	Cessna NAV III G1000 Trainer
	GTN Trainer
	Microsoft Flight Simulator X + Updates/Service Packs
	GPS Manual Documents Folder
	Jeppview

Table 1. Example of a typical software installation on the AAAFT workstation

REFERENCE LIST

Chang, K. E., Chen, Y. L., Lin, H. Y. & Sung, Y. T. (2008). Effects of learning support in simulation-based physics learning. *Computers and Education*, 51(4), 1486–1498.

Chen, C. J. (2009). Theoretical basis for using virtual reality in education. *Themes in Science and Technology Education*, 2(1-2), 71-90.

Duburguet, D. P., Ansburg, P. I., De Cino, T. J., Forrest, J., Gatlin, T., Jennings, C., & King, G. G. (2013, May). *STEM: introducing students to aviation psychology through flight simulation.* Poster presented at the 17th International Symposium on Aviation Psychology, Dayton, OH.

Hoffler, T. N. & Leutner, D. (2007). Instructional animation versus static pictures: a meta-analysis. *Learning and Instruction*, 17, 722-738.

Pantelidis, V. S. (1996), Suggestions on when to use and when not to use virtual reality in education. *VR in the Schools*, 2(1), 18.

Pantelidis, V. S. (2009). Reasons to use virtual reality in education and training courses and a model to determine when to use virtual reality. *Themes in Science and Technology Education*, 2(1-2), 59-70.

Trundle, K. C. & Bell, R. L. (2010). The use of a computer simulation to promote conceptual change: a quasi-experimental study. *Computers and Education*, 54, 1078-1088.

Veermans, K., van Joolingen, W., & de Jong, T. (2006). Use of heuristics to facilitate scientific discovery learning in a simulation learning environment in a physics domain. *International Journal of Science Education*, 28(4), 341–361.

Windschitl, M., & Andre, T. (1998). Using computer simulations to enhance conceptual change: the roles of constructivist instruction and student epistemological beliefs. *Journal of Research in Science Teaching*, 35(2), 145–160.

---

* Assistant Professor of Aviation and Aerospace Science
Metropolitan State University of Denver
Campus Box 30, P.O. Box 173362
Denver, CO 80217-3362
Telephone: 303 556 4291
duburgue@msudenver.edu

** Associate Professor of Aviation and Aerospace Science
Metropolitan State University of Denver
Campus Box 30, P.O. Box 173362
Denver, CO 80217-3362
Telephone: 303 556 4625
kingge@msudenver.edu