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Ready Pilot One: Using VR to help solve the pilot absorption problem

by

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Abstract

The United States Air Force (USAF) Air Education and Training Command (AETC) is the command responsible for training and educating Airmen across the Air Force enterprise. AETC is known as “First Command” since this is where every airman starts their Air Force career. AETC sought to revolutionize pilot training, from student selection through content delivery and course completion, by leveraging insights from recent academic studies and experiments, with an orienting objective of reducing the USAF Undergraduate Pilot Training (UPT) course from twelve to six months. This experiment was known as Pilot Training Next (PTN). It served as an initiative for the evaluation of technologies, such as Virtual Reality (VR), Artificial Intelligence (AI), physiological data collection and cognitive mapping, on commercially available hardware while simultaneously conducting pilot training for an initial class of 20 students under accelerated training timelines. PTN also provided data-backed insights into return on investment, training effectiveness, and desired characteristics for use in recruiting future candidate pools. PTN immersed itself in an innovation-centric environment that challenged current thinking on how pilots are trained. Using PTN’s lessons learned, this paper will case study the PTN experiment by discussing the execution of the first PTN course from inception to insights, with a specific focus on exploring the use of commodity Commercial Off the Shelf (COTS) technology to build affordable, portable simulation systems. Finally, this paper provides PTN’s initial insights into training modernization and a path forward for the use of emerging technologies in training across all major weapon systems to help solve the follow-on absorption problems at the flying training units (FTUs) after pilots complete UPT.

Introduction

While Air Force forces continue to operate, fight, and win in air, space, and cyberspace, the top Air Force leaders began sounding the alarm on the shortfall of pilots nearly two years ago. This impending shortfall will negatively affect the force's ability to execute its core missions. Air Force Chief of Staff General David Goldfein emphasized that many factors have led to the roughly 1,500 to 2,000-pilot shortfall which he worries could "break the force"[i]. The Air Force is making headway on a variety of fronts - including recruiting and training more new pilots, bringing back retired pilots, convincing experienced pilots to stay longer, and improving the lives of pilots so they're happier. Leadership is hopeful these measures will help close the gap.

The Air Force's aircrew crisis task force identified several problems associated with recruiting and retaining pilots. The Air Force can recruit more pilots than it has room to produce, so it's not a recruitment problem. It's actually a retention, production and absorption problem. The Air Force has taken significant steps to get after production and retention. I personally witnessed a significant increase in student pilots in the pipeline as an Air Education and Training Command (AETC) squadron commander. We seem to have no shortage of students. However, after the completion of pilot training, several students had to wait months for follow-on training because of backlogs at the formal training units (FTUs) such as Altus Air Force Base and Luke Air Force Base. We cannot neglect this absorption problem.

Institutional paradigms must be challenged to spur the innovation needed to meet the nation's present and future requirements. The pilot shortage must be addressed over the entire training timeline…UPT to operationally mission ready at an assigned unit. This paper will case study the efforts at Pilot Training Next (PTN) located in Austin, Texas, it also outlines the evolution of technology in military aviation, and finally advocates for expanded use of Commercial Off the Shelf (COTS) VR technology to produce an immersive synthetic training environment (STE) during follow-on and operational training. These lessons learned from PTN will serve as a model for training for the Air Force. The final result will be cost savings, and/or in some cases, significant enhancement of military aviation training.

Background

The future of Air Force Aviation training is changing rapidly, and while no one can predict the future with any certainty, virtual reality (VR) has proven to be a game changer. Evidenced by the success of PTN, the Air Force is now able to produce pilots with the right skill level for success in follow-on training in half the time it took people like me to earn their wings. The use of VR is the next stage of an aviation training in a long line of technological advancements since man's first flight.

Expensive flight simulators have been deeply ingrained into the training curriculum for years. Considering the earliest models of flight training was little more than a box with crude levers and pulleys, one can better appreciate the technological, methodological and research advances that have resulted in the virtual reality training used at PTN. The history of aviation and training have evolved over time as technologies have enabled more cost efficient and effective methods of training.

Simulators made it possible for a pilot to experience a near replication of flight while never actually leaving the ground. But now, virtual reality is taking that experience to a whole new level. Stepping out of a virtual reality session today can evoke feelings of awe for those who know the history of Undergraduate Pilot Training (UPT) and how simulators made the training more realistic. The PTN program is making huge strides in the way the Air Force thinks conducts pilot training with the use of realistic training devices that cost less than $15,000 each at the undergraduate level. Using similar technology as PTN, this paper advocates expanded use of VR at follow-on training in more advance weapons systems across all aviation platforms.

The idea for PTN emerged from a study conducted at Air University to evaluate the Targeted Learning System Theory (TLST) as it applies to adaptive flight training. TLST is an immersive, student-centered, multi-modal learning structure that empowers the learner and leverages emerging technology to provide high fidelity assessments and feedback[ii]. Rather than focusing on individual technologies used in the system, the study looked at the technologies' combined ability to increase students' contextual understanding and indicated that biometric sensing is a key component to understanding the impacts and relevance of the multi-modal approach.

While PTN sought to analyze the impacts of multiple technologies and concepts on overall pilot training, the most significant aspect of the first PTN course is the immersive synthetic training environment (STE). Studies focused on pilots who are still developing the necessary motor skills to control an aircraft, such as UPT students, show a significant decrease in the minimum number of live flight hours required to reach first solo and to receive a private pilot's license when they use simulator-based training[iii]. In addition to traditional simulator training, PTN also introduced the VR simulator environment with the expectation that an immersive environment aids with transference of skills from the training environment. By eliminating distracting visual and audio cues from the real world, students are more fully present during training. Anecdotally, higher presence (this will be defined later) has been associated with higher transfer, and studies empirically demonstrated a positive correlation between presence and transfer[iv].

By examining the technical details of PTN, I hope to show this process is repeatable. Aspects of PTN have already been incorporated at traditional UPT bases with some measure of success. The PTN model is repeatable and transferable to all levels of training in the Air Force.

What is Virtual Reality?

Virtual reality is a broad term that comes from the definitions for both ‘virtual’ and ‘reality’. The definition of ‘virtual’ is near and the definition of reality is what we experience as human beings. So, the term ‘virtual reality’ basically means near to what we experience as human beings. Virtual reality is the term used to describe a “three-dimensional, computer generated environment which can be explored and interacted with by a person”[v].

The virtual reality environment can be comprised of interactive role-play or even a replica of aircraft systems and the instrument panel for manipulation and interaction. A person can become part of the virtual world, or immersed, within the digital environment and able to perform actions or manipulate objects. When virtual reality works well, it is seamless, and the virtual world feels like the physical world. The feeling of “being there” is what researchers call psychological presence.

Psychological presence is a fundamental characteristic of VR[vi]. Presence is the magic of VR. It’s the feeling that you’re actually in the virtual world. Presence will cause a user to suspend disbelief and believe they are in the virtual environment, reacting to stimuli as if they were in the real world. It’s tough to create true presence, because for this to occur all your senses need to be convinced that you are in a new reality. This is one of the technological challenges of VR in aviation training. Currently, VR can satisfy our vision and hearing, and there are some significant developments in regards to touch, but there is still much work to do in regards to smell and taste and the physiological effects of flying on the body. Despite these limitations, some level of presence is achievable using VR in aviation training today. Presence is the holy grail…the purpose of VR.

Presence is one of the aspects of VR that along with a realistic enough immersive environment to convince you that you are actually inside it. The artificial environment could be anything from a photograph, video game or video footage. The possibilities are endless. The only thing that matters is that you are not actually there, in the virtual environment. And when VR is working well, your physical senses tell your brain that you are really experiencing the thing you are virtually experiencing. In military aviation training, presence is achieved through relatively cheap technological solutions allowing the user to feel like they are actually in the cockpit of the desired aircraft.

From the Link Trainer to the VR Simulator: A Brief History

For many in the aviation industry, the word simulation evokes thoughts of high-tech computer-generated replications that mimic the cockpit's appearance and function very closely to the aircraft. Simulators have a humble beginning. The possibilities of what flight could offer emerged not long after the aviation technological breakthroughs of the late 1800s and early 1900s that produced controllable, engine-propelled flight. The Wright Brothers first public flight in 1908 marked the much-needed breakthrough for aviation.

With World War I and the development in military aviation, there emerged the first requirements to teach flying skills to a large number of people, quickly and effectively[vii]. Efforts to produce simulated flight for training purposes were designed to mitigate the number of lives and aircraft lost. Edwin Link, an engineer in his father's firm, the Link Piano and Organ Company, gained notoriety with the creation of the "Link Trainer" engineered in the company's basement over two years, 1927-1929[viii].

Figure 1: The Link Trainer

The Link Trainer was intended to demonstrate to students the effect of the control surfaces on the altitude of the simulated airplane and train for coordinated operations of the controls.

Over time, the need for more complex trainers to teach the instrument flying used in the aviation industry drove more innovation. The Link Trainers were soon outfitted with instrumentation as standard equipment, then the simulator sales took off. As more instrumentation was added to the Link Trainer, the instructors were able to provide more realistic inputs to the students as they operated the simulator. The Link Trainer was sold to several countries, including the USSR, Japan, France, and Germany. The first Link Trainer sold to a major airline was delivered to American Airlines in 1937[ix].

Eventually, mechanical and pneumatic simulators had reached their usefulness and gave way to electronic simulators prior to World War II. The Royal Air Force (RAF) was on the leading edge of development and implementation with the Silloth Trainer[x]. After Commander Luis de Florez, US Navy, visited the British, he wrote his report on "British Synthetic Training" which influenced the establishment of the Special Devices Division of the Bureau of Aeronautics. The Bureau was the forerunner of the Naval Air Warfare Center Training Systems Division[xi]. As aircraft manufacturers gained more analytical information on the performance of their airframes and engines, simulator fidelity took on its modern-day form.

Better computing power and other technological explosions now combined computer image generation systems to simulators. The first computer image generation systems for simulation were produced by US General Electric Company for the space program[xii]. The flight simulators arrived at its modern form near the end of the 1960s with improvements based on aircraft enhancements over the previous few decades. Now simulators are as realistic as flying the aircraft for many systems.

Despite their realism, modern day simulators are very expensive. The T-6 Texan simulator costs approximately $4.5M. PTN leveraged the VR, simulation and gaming capabilities from Army Game Studio. Shown in Figure 1, traditional UPT uses chair flying, a visualization technique in which a student imagines executing a series of tasks from a desk chair, to introduce initial flight concepts. PTN introduces similar concepts using commercially available software and hardware to create a VR simulator station, also shown in Figure 2.

Figure 2: Chair Flying

Figure 3: PTN Simulator Stations

In addition to chair flying, classroom lectures, and live flights, traditional UPT students use high fidelity, high haptic feedback simulators which are formally validated for training on the T-6A training platform. However, students have limited access to these simulators because of their high cost. By integrating commodity and commercially available products, PTN produced realistic training stations that cost less than $15,000 each, making the stations highly available to the students. During the first cohort, PTN assigned each student their own station in the classroom as well as a separate station that is shared with their roommate (2:1 student to device ration) for training outside of normal class hours, giving students almost unlimited access to simulation-based training for self-study. This access is unprecedented at traditional UPT.

The PTN student simulator station was the crucial element of training for the first PTN course. Student stations include a VR-enabled flight simulator with vibrating cockpit-style seats, hands-on throttle and stick (HOTAS), rudder pedals, an electronic virtual kneeboard, accurate Austin, Texas, area scenery, and a T-6A 3D visual, auditory and flight model that is realistic, according to expert opinion, but not validated[xiii]. Each student station maintained an identical image of configured hardware and software.

The hardware is mounted on a Volair simulation chair and includes an Origin Intel Core i7 6-core processor with NVIDIA GeForce GTX 1080 8GB graphics card, a Thrustmaster HOTAS with an attached stick extender, Thrustmaster pedals, a Guitammer Buttkicker 2, and a HTC Vive Pro headset with an embedded Pupil Labs camera. The entire system was mounted on a wooden platform with locking casters for easy mobility. Classroom simulation stations had a more powerful personal computer than stations located at the student housing but are otherwise identical. In addition, students each had an iPad Mini that is used as a virtual kneeboard for flight planning and used a Zephyr chest strap for monitoring physiological data such as heart rate, heart rate variability (HRV) and breath rate.[xiv]

The baseline simulation software consisted of Prepar3D v4.2 working with FlyInside, SteamVR and FSUIPC to improve VR performance and stability. Lonely Screen provided AirPlay mirroring to Windows, which allowed FlyInside to bring a virtualization of the iPad into the VR environment. Students periodically used additional software to address temporary capability gaps or to evaluate emerging technologies for inclusion into the baseline.

The student station also included Senseye software to measure muscle movements in the eye and uses this information to show a student's real-time cognitive load, a measure of the mental effort a student is exerting[xv]. The team anticipated Senseye software would allow automated changes to the training scenario in real time based on the student's cognitive load. Although studies indicated HRV can also show real-time cognitive load changes, the Zephyr chest straps require 300 heartbeats, or approximately three to five minutes, before it can accurately report changes to HRV. Senseye software was able to report changes to cognitive load after two seconds, the threshold for ensuring pupil movements do not indicate shock, surprise or a response to light, rather than mental effort.

One of the biggest benefits of the PTN technical solution was system and application availability. In this context, two variables primarily impact availability: how many systems per user exist, how often do they break and how long do they take to fix. PTN provided a high number of simulators for the first cohert with three stations for every two students. In addition, each component of the student stations was a line replaceable unit (LRU), meaning the team can easily replace broken parts since they are not customized or specialized.

Increasing the fidelity or resolution of the system, such as adding motion or other means of haptic feedback, only served to create a more complex system – both to purchase and maintain. Therefore, the operating theory behind PTN was that availability of the system far outweighs additional capability additions. Until any given component or capability-enhancing feature matures in both stability and affordability, the team decided to delay including more capability in favor of ensuring the availability of a less complex system.

The journey from the Link Trainer to the PTN VR simulator did not occur overnight. However, as technology and availability increase, these low-cost simulators could replace a portion of the training required in more expensive fully realistic modern simulators. Until then, look to the PTN roadmap for a proven way ahead. This roadmap is further teased out in more details about PTN in the sections to follow.

Pilot Training Next (PTN): Innovation in Action!

Pilot Training Next (PTN) is an initiative sponsored by AETC and executed by the Human Dimensions Team within the Trainers Division of Systems Simulation Software and Integration (S3I), Aviation and Missile Research Development and Engineering Center (AMRDEC). Its mission was to explore and apply insights and conclusions from previous studies and experiments to redefine how we train and educate future Airmen. The result was a holistic simulation-centric training environment with industry-leading virtual reality (VR) Commercial Off the Shelf (COTS) equipment, immersive scene generation, three-dimensional (3D) aircraft models with realistic flight dynamics and sub-system models, physiological data generation, student-centric Learning Records Stores (LRS), cognitive enhancement techniques, and multi-modal content delivery. Each technology, employed on its own, improves training. PTN was able to realize non-linear improvements by employing these technologies collectively.

PTN Roots: Targeted Learning Systems Theory (TLST)

Targeted Learning System Theory is a performance-based educational and training structure grounded in student-centered experiential learning aimed at maximizing human potential[xvi]. TLST combines the art of student empowerment with the science of emerging technologies like VR to create real-time feedback loops. TLST is designed to make better use of time and information than traditional learning models by giving students the structure and tools to be self-maximizing learners without changing the current standards or requirements. TLST uses VR's immersive experiences with minimal guidance to create learning pathways within the VR experience. Sheets and Moore proved that using noninvasive biosensing data, an instructor can correlate a student's performance, their relationship to contextual environment, and how they are being affected biologically and neurologically. The TLST can modify the experience based on these inputs and give each student a tailored environment based on their current skill level.

PTN: Data Driven Training

The ideas and research from TLST spurred AETC to initiate an experimental UPT course separate and unique from traditional USAF UPT courses, with an initial focus on the impacts of an immersive synthetic training environment (STE). By partnering with AMRDEC's Human Dimensions Team for cognitive enhancement expertise, PTN leveraged the VR, simulation, and gaming capabilities from Army Game Studio. This section describes PTN's processes for data collection and analysis.

The PTN environment provided multiple types of data analysis, specifically real-time feedback, conducted during simulated flight; after action review (AAR), conducted within one hour of simulated or live flight; and post processing, provided days, weeks or months after the fact and entails more computation intensive analysis. Like traditional UPT, human instructor pilots provide real-time feedback to the students. However, the synthetic tutor also provided feedback to student pilots compounding the learning experience. According to Science Application International Corporation (SAIC) researchers Jennifer Lewis and Joyner Livingston, the Zephyr and Senseye programs also provided a real-time display of physiological data for the IPs. Students were not permitted to view their own physiological data in real time[xvii].

The Joint After Action Review (JAAR) and Cloud Ahoy software solutions provided AAR solutions. JAAR focuses on simulated flight and gauge data through the Distributed Interactive Simulation (DIS) interface while Cloud Ahoy imported data from the student's mission planning tool, ForeFlight. Both tools synchronized multiple pieces of the PTN environment, to include biometrics and recorded video, into a synchronous playback for AAR.

The post processing style of data analysis used Alteryx for data modeling and Tableau for visualization. It joined all available data to look for correlations and trends in the dataset. The full PTN dataset included simulated flight and gauges data, generated by Prepar3D and collected in DIS and video formats; live flight data collected by Foreflight in Keyhole Markup Language (KML); iris muscle measurements, cognitive load and student gaze point, generated by Senseye and collected in Comma Separated Value (CSV) and DIS format; heart rate, HRV, three-axis G-force measurements and respiratory rate, generated by Zephyr and collected in CSV format; responses to instructor and student surveys, to include subjective assessment of VR sickness and cognitive load, collected in CSV format; student flight performance data and deviation to ideal flight plan, generated by RAM and collected in JavaScript Object Notation (JSON) format; student experiential data collected in xAPI-based JSON format; student academic data, generated by the LMS and human IPs collected in CSV format; and demographic information to include prior experience and generalized student interests, collected in CSV format[xviii].

The team is making a specific effort to collect scenario difficulty parameters for both simulated and live flight. This information is critical to quantitative evaluation of student performance since a successful landing with sunny skies and no wind at an empty airport is much easier than landing in a thunderstorm at a busy hub. For simulated flight, Prepar3D provides the scenario factors that affect difficulty. However, in live flight, the team will look to Meteorological Terminal Air Report (METAR) and Terminal Air Forecast (TAF) reports, correlated to live flight times and altitudes as well as post-flight student survey reports of radio communication traffic and other factors that may impact performance. This data can be generated at any formal training unit (FTU) with the right technology using the PTN systematic approach.

Developing the Brain: Cognitive Enhancement Training

PTN also evaluated the effectiveness of cognitive enhancement training as a method for accelerating skill acquisition. The AMRDEC S3I Human Dimensions Team Cognitive Enhancement for Performance Program (CEPP) trained PTN IPs and students to manage their mental energy, thoughts and attention in a manner which will provide consistent performance even in stressful environments. The CEPP focuses on skills such as energy management, attention to detail, focus control and stress regulation. IPs and students are educated on specific cognitive skills needed for aviation. With the student pilots, the focus is effective learning in the classroom. Student pilots are then coached individually as they practice those cognitive skills in a classroom and in the cockpit. This cognitive training will benefit pilots as they continue through the pipeline toward operational mission ready status. Much research has proven that mental strengthening increases performance especially in a skill as demanding as military aviation.

Additionally, CEPP facilitates skill development during classroom, simulator, and live flights which helped student pilots manage cognitive overload, moderate spikes that occur from the over-activation of the sympathetic nervous system, and increase short term and active working memory. CEPP also used baseline tests from Zephyr and Senseye to identify techniques that were successful in the program and where more training was needed. CEPP's work in the field of applied sports and performance psychology shows these cognitive enhancement techniques also allow students to develop and execute their skills at the upper range of their potential, which may provide insights into the FTU student selection, as discussed in the following sections.

Assumption

This approach worked well at PTN. The Air Force proved it can produce a pilot in about half the time as traditional UPT because the student pilots were able to progress at a quicker pace with TLST. The foundational principles of TLST should be applicable when learning any new weapon system.

Literature Review

How We Learn/How Pilots Learn

In his book, Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do, Jeremy Bailenson draws on his experience in the field of VR to help readers understand how powerful VR can be[xix]. Nancy Adams' article discusses in detail the levels of Bloom's taxonomy as it relates to the cognitive domain, as it relates to an educational setting. The definitions are clear of the levels for knowledge, comprehension, application, analysis, synthesis, and evaluation[xx]. Adams combined with the Oberhauser, and Dreyer article, we are able to describe what level of learning the pilot trainees will need to get to in the virtual environment. These levels are based off the classic Bloom's taxonomy model, and not the revised list of remember, understand, apply, analyze, evaluate, and create.

There is a mark difference between basic computer-based training (CBT) and full motion, multi-million dollar simulators. Research suggest the use of feedback through haptics and even just wood panels helps ensure the trainee gets more realistic feeling of the cockpit environment in the learning process. This paper argues for expanded use of VR simulators to other the aircraft models for basic switchology training to enhance the current training at the FTUs. No matter the pilot's learning style, VR offers promise in accommodating individual differences in terms of learning styles. VR is able to motivate learning through intuitive interaction, the sense of physical imagination, and the feeling of immersion[xxi].

Military Aviation Cockpit Design: Using VR To Cut Cost

New methods to evaluate the cockpit in the virtual world prior to making it physically will reduce cost and provide the Air Force with more realistic trainers. Suresh Kumar's study provides valuable insight for future and more advanced cockpits. The design of cockpit is one of the important tasks performed for combat aircraft development to understand the operational requirements of pilot. Usually the finalization of this requirements are carried out in a real-time cockpit flight simulator having physical cockpits and high end projection and cockpit display environment, which lead to number of trails there by it increases the effort, time and cost. Kumar proposed using Virtual Reality Flight simulator, the commercial off the self-helmet-mounted displays and motion sensing technologies, to bring out the environment of aircraft in virtual world for the user to completely visualize the requirements in 360 degree. This research capitalizes on a lot of the assumptions made regarding VR technology and system design to better serve the pilot. PTN has advanced this research to prove a low cost simulators can serve as a realistic training device to augment traditional simulator training.

Civilian AR/VR Aviation Training

The virtual training strategies implemented at Metropolitan State University (MSU) of Denver's Department of Aviation and Aerospace Science have great promise for the future of military aviation. MSU Denver's has outlined a systematic approach with the current and future needs of the aviation industry. The researchers provide suggestions of adaptation and implementation for future needs of virtual training environments within the pilot training domain also. Pilot education in the military environment, compared to an airline training facility, imposes unique challenges from the standpoint of course design and implementation and learning objectives. The authors, Derren Duburguet and George G King, examine some of the differences and offer suggestions for VR use at collegiate universities and possibly the military training environment. The PTN model takes this research a step further with unique data collection methods and devices.

Analysis and Evaluation

PTN has set the stage for what is possible when innovation is unconstrained to solve problems. Led from the top of Air Education and Training Command, the men and women of PTN formally tested and evaluated a research concept transforming the way the Air Force trains pilots. This innovation has caught fire and spread to all undergraduate pilot training bases. This bold action is set to take place beginning May 31, 2019[xxii]. The data-driven approach will now be integrated into the undergraduate pilot training syllabi for the T-6A Texan, T-1A Jayhawk and the T-38C Talon aircraft at the UPT wings.

This approach will accelerate student learning and build better aviators for the future. "The Air Force we need requires us to provide better pilots, more of them and at a cheaper price point because we can't sustain or increase the current production engine in its current format," according to Maj. Gen. Patrick Doherty, 19th AF commander. He went on to say, "through analysis at PTN, we know many of the ideas and innovations are working towards those goals. Introducing the technology into our normal pilot production flight rooms is the next natural step to scaling these concepts across the flying training enterprise"[xxiii].

This researcher proposes to take this to the next, next logical step…the advance formal flying training units (FTUs) across the force. For example at Altus Air Force Base, the newly minted pilots from UPT learn to fly the C-17A Globemaster and the KC-135R Stratotanker. These training units are Air Education and Training Command FTUs. The Air Force should not stop this innovation wave at UPT. The service should let the PTN example serve as the model for solving the Air Force pilot crisis. The PTN model should serve as a model to solve the Air Force absorption problem after UPT completion. We can train better and faster without sacrificing quality. It's been proven at PTN and it will work at the FTUs.

Discussion of Issues, Counter-Arguments, and/or Challenges

There are some that would argue that once an Air Force pilot has wings, he or she no longer learns the way he or she learned during UPT. The argument is that somehow new pilots do not need this innovative technology to learn more advanced follow-on aircraft. This assumption goes counter to the countless research examples that show how effective VR/AR technology can be in cognitive, affective and psycho-motor levels of learning.

Expect some major resistance to change from the FTUs. These professional units have successfully produced the world's most lethal and capable Air Force. The innovations proposed from the PTN lessons learned may be a touch sell for the FTUs particularly in the fighter community (Luke AFB, Davis Monthan, etc). In order to successfully plow the innovation field, leadership at the highest levels will need to be engaged. The Air Education and Training

Command commander, Lieutenant General Steven Kwast was an indispensable force for PTN success. It will take this type of leadership engagement for the FTUs to get on board. Top-level leadership oversight and direct involvement is key to overcoming barriers to institutional change.

This researcher does not suggest we completely replace the current simulators at the FTUs. However, the Air Force should augment the simulator training with VR/AR solutions to expedite learning and reduce training timelines. Basic switchology, pattern and air refueling procedures are areas for VR augmentation and self-study if VR simulators were available outside of the classroom environment. The commercial, off the shelf (COTS) technology is available at relatively low cost compared to simulator cost and maintenance.

Conclusion

The groundbreaking PTN program successfully produced high quality pilots in less time than traditional UPT. This model and data-driven approach will soon be utilized at every UPT base in AETC. The Air Force should not stop at UPT for this necessary innovation. This data driven solution at the FTUs will get after the Air Force absorption problem from a backlog of recent UPT graduates awaiting training. The FTUs will be able to produce more operationally ready pilots for operational units across the entire Air Force to continue to operate, fight, and win in air, space, and cyberspace. Our nation is counting on our innovation to continue to ensure our security.

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