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IMPROVING AIRCREW TRAINING BY EMBRACING MODERN GAMING TECHNOLOGIES

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JCSP 47

Service Paper

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PCEMI 47

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CANADIAN FORCES COLLEGE - COLLÈGE DES FORCES CANADIENNES

JCSP 47 - PCEMI 47
2020 – 2021

SERVICE PAPER – ÉTUDE MILITAIRE

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Word Count: 2,538

Nombre de mots : 2.538

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AIM

1. The aim of this service paper is to ensure that our aircrew are prepared to execute the missions demanded of them by their trade, whatever the platform or theatre; this has always been a challenge, and the past year of COVID restrictions has only amplified it. The best training will always occur on aircraft, but the cost and availability of resources often means that our crews struggle to meet minimum currency requirements[1]. Continuing to rely on a limited quantity of dated (and expensive[2]) simulators and part task trainers will not fix the problem; leveraging the rapid pace of gaming technology to provide a more immersive, accessible, and robust training experience may. The Royal Canadian Air Force (RCAF) should engage in the rapid testing, cooperative development, and fielding of modern Virtual and Augmented Reality (VR/AR) solutions for aircrew training. The benefits will extend well beyond accelerated Force Generation (FG); a standardized and highly portable training suite will enhance expeditionary Force Employment (FE) in the Joint / Combined environments.

INTRODUCTION

2. Having worked on the acquisition, testing, and development of the RCAF's more advanced Flight Training Devices (FTDs), I can say with confidence that they invariably cost too much and deliver too little in the way FG. Our current business model leverages tens of millions of dollars to build not only the simulators, but also the facilities and support networks required to operate them. For the Squadrons lucky enough to have simulators[3], the benefits are weighed against the realized fidelity (often hampered by the dated visuals and lagging representations of aircraft configurations[4]). Attempts rectify these shortcomings are often met with the contractor phrase "we can fix that, for a million dollars". Meanwhile our aircrew can go home and play the latest in raytraced immersive VR games on their $500 consoles, or their custom-built PCs (or even streamed from cloud-based services onto cheaper devices[5]). The disparity would be laughable if it were not so consequential; it must be corrected.

3. Instead of focusing on the numerous deficiencies of the RCAF's fielded FTDs, this service paper seeks to inform on what is possible with the VR/AR gaming technology that is readily available today. By outlining the advantages and key

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[1] WOPS, "Shearwater Planning Priorities," accessed February 7, 2020, http://shearwater.mil.ca/en/flypro/_Flypro/Shearwater/Priorities_List.html. Anecdotal from experience on both operational squadrons, and the Aerospace Engineering Test Establishment.

[2] Cost not published on most contractor sites, but CH148 FTDs were a significant fraction of the entire CH148 Acquisition Contract (which totaled more than$6B), and took nearly a decade to become operational.

[3] Note that 443 Squadron resides in Victoria BC, and yet the only CH148 FTDs are with 423 Squadron in Halifax, NS. This leads to wasteful travel to maintain certain currencies.

[4] Personal Experience from 5+ years of work on the CH148 Flight Simulators, and Operational Mission Simulators; and 1+ year of work on the CH147 Flight Simulators (fixed, and deployable).

[5] GMSA, "Cloud AR/VR Streaming: Accelerate Mass Adoption and Improve Quality of Experience of AR/VR Using 5G and Edge Cloud," Whitepaper, GMSA, 2019, https://www.gsma.com/futurenetworks/wp-content/uploads/2019/03/Cloud-ARVR-booklet-for-MWC19.pdf.

technologies of the most recent commercial flight simulator software[6], an understanding of the superior training potential should become apparent. The paper will also introduce some of the enabling hardware to assist with immersion. While there have been historical counter arguments the use of VR for flight training, the advances in gaming technology in the last 6 months alone have negated most of them (and made previously complex training scenarios simple). Peripheral advantages to the RCAF upon adoption of the proposed approach to aircrew training paradigm will be presented. The discussion will be supplemented with an annex of 4K imagery from Microsoft Flight Simulator 2020 (MSFS2020) to give the reader an understanding on what our young aviators have come to expect in terms of graphical fidelity.

DISCUSSION

4. The display hardware will key to enabling the proposed modernization of aircrew training. Current headsets offer a compact standalone (or PC connected) experience with 6 Degrees of Freedom (6DOF) inside out tracking, and native hand tracking, for less than $500[7]. Figure 1 details the Oculus Quest 2 complete unit; it is worth noting that the Quest 3 is due out later this year. There are competing (and emerging) headset from other manufacturers, some with more capable AR / Mixed Reality (MR) capabilities. A robust solution will focus on the enabling features, not the manufacturer.

Figure 1 – Oculus Quest 2 Device Footprint
Source: Oculus, Quest 2 Home Page

5. While our current FTDs rely on costly contracts to deliver 'high fidelity' representations of our common operating areas, companies like Microsoft have leveraged AI and advanced rendering techniques to enable near photo realistic flight to/from any airport in the world. Annex A contains demonstration images taken from Microsoft Flight Simulator 2020[8]. Our aviators are typically coming into the RCAF with experience in the gaming world; their expectations will continue to evolve, while our in-place devices fall behind. Beyond heightened visual fidelity, modern flight simulators

[6] "Microsoft Flight Simulator - The next Generation of One of the Most Beloved Simulation Franchises," Microsoft Flight Simulator, accessed February 8, 2021, https://www.flightsimulator.com/.
[7] "Quest 2 - Untether Your Expectations," Oculus, accessed February 7, 2020, https://www.oculus.com/quest-2/.
[8] Some images are from the upcoming Xbox Series X release of the software, while others are screenshots from my mid-range PC (running an Intel Core i7 6850k & a GTX1080).

incorporate streaming real-world data for incorporation of real-time air / sea traffic, weather, NOTAMs, and can even facilitate multiplayer sessions with ease[9].

6. Previous generations of flight simulators were rudimentary in their approach to aerodynamics (computational constraints often required a single lift vector on the center of mass). While this has been a valid criticism against serious use of commercial flight simulation, the current technology enables the accurate calculation of 1306 lift vectors per aircraft model. Each aerodynamic surface has a physically based lift profile, based on vastly improved simulations of aerodynamics which were previously reserved for research laboratories (like full/partial stall of individual aero surfaces, adverse yaw, and induced roll)[10]. Figure 2 shows some a comparison of legacy flight model with a current model from Microsoft. Although the current commercial capability may still fall slightly short of the most modern military simulators, a Test Pilot study should be done of the aggregate of representativeness of VR + commercial versus current models like GENHEL[11].

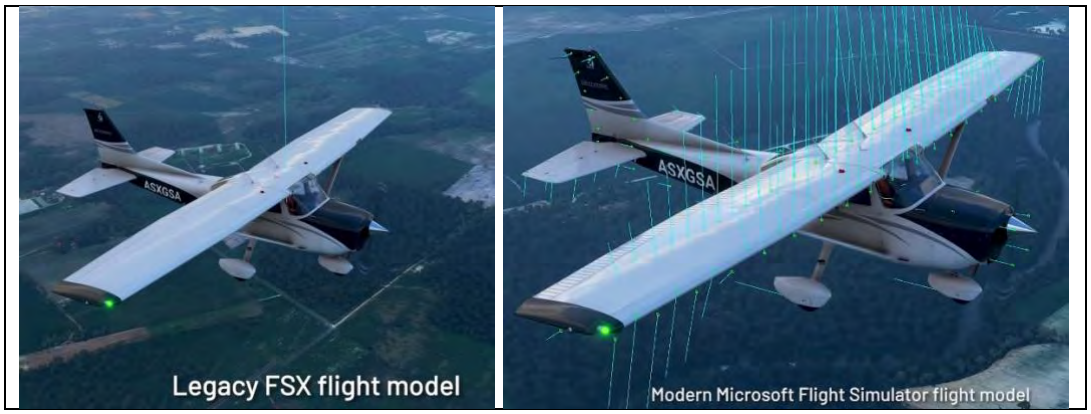

Figure 2 – Legacy vs. (simplified view of) Current Aerodynamic Simulation
Source: Microsoft Flight Sim – Official Aerodynamics Explanation Video[12]

7. Combing the latest in VR hardware and flight simulator software creates a level of immersion that is well beyond what is capable from walking into even our most advanced full motion simulators[13]. The issue with non-VR simulators is that the visual projections are single viewpoint, non-stereoscopically rendered flat images; this reduces believability of the scene, and presents parallax issues for multi-crew flight decks[14]. With the added immersion offered by 6DOF stereoscopic viewpoints, experience more

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[9] "Microsoft Flight Simulator - The next Generation of One of the Most Beloved Simulation Franchises."

[10] *Feature Discovery Series: Aerodynamics Part 2*, YouTube, 2021, https://www.youtube.com/watch?v=2KdM2pT1hI8&t=179s.

[11] Robert L Barrie, "Time Domain Validation of the Sikorsky General Helicopter (GenHel) Flight Dynamics Simulation Model for the UH-60L Wide Chord Blade Modification" (Monterey, California: Naval Postgraduate School, 1999), http://hdl.handle.net/10945/13406.

[12] *Feature Discovery Series: Aerodynamics Part 2* 4:42.

[13] Based on personal experience flying Microsoft Flight Simulator 2020 on an Oculus Quest 2 headset; I often found myself reaching for items in the cockpit, and marveling at the level of detail with the 6DOF tracking in the cockpit.

[14] The CH148 Simulator requires that the instructor switches the eyepoint to whichever pilot is actively flying for high gain tasks like deck landings, or engine failures. Other simulators simply choose an eyepoint that is averaged between the crew positions. A shared multi-user VR experience would enable independent, full stereoscopic, viewpoints far all users.

effective demonstrations of hazardous flight regimes (such as icing, windshield glare, storms, and in-flight emergencies) all with fully realized vehicle performance impacts. Figure 3. shows the icing, and rain modelled in MSFS2020. Current simulators do a poor job with visual occlusions; this often results in negative training, and a potentially dangerous sense of comfort with adverse conditions.

Figure 3 – Legacy vs. (simplified view of) Current Aerodynamic Simulation
Source: MSFS2020 - Screenshots from my PC

8. Beyond routine training missions, the latest MSFS offer the chance to train for expeditionary flights anywhere in the world. Typical RCAF simulators are limited to very rudimentary pre-defined regions at great cost to the project[15]. MSFS2020 uses AI backed world generation that automatically populates the flight area with detailed 3D objects, airports, and terrain from constantly evolving satellite data (and adds animated objects like cars and windmills). Microsoft also offers a developer mode that enabled users to enhance a given area according to their own information and imagery. Beyond developer tools, Microsoft has shown a willingness to partner with companies and organizations to create hyper realistic locations that can be shared or kept for internal use[16]. The advantages for mission planning / rehearsal are undeniable.

What about touching the controls?

9. There is a valid argument that the cockpit needs to be physically present for a pilot to truly get a feel for the aircraft. While an AR solution with real aircraft

[15] Both the CH148 (Collins Aerospace) and CH147 (CAE) had 'desert', 'tundra', and 'northern' operating environments, with 1995 level 3D models that were bore little to no resemblance to the anything useful. Though the Collins model did eventually include a couple of major Middle-East cities.

[16] *Partnership Series: ORBX Simulation Systems*, YouTube, 2021, https://www.youtube.com/watch?v=0aBgH1mqhoc&t=414s.

components and a 'green screen' type display filter could solve the problem, it takes away the elegance of a portable VR solution. In a completely virtual environment, there are two main workarounds:

a. Accept the limitation and overcome it with software that tracks hand contact with areas of the cockpit / aircraft and renders the virtual hand as stationary at the point of contact. This simple, but effective, proprioceptive cue has been used in several applications and inherently causes the user to pause physical movement to realign with the virtual representation[17].

b. The second option is to incorporate haptic feedback gloves, which have been showcased as recently as CES2021[18]. Hardware like the Senseglove[19] give tactile feedback on contact with virtual objects and are specifically designed for a virtual training environment. The pace of miniaturization in these haptic technologies is impressive and will likely see incorporation into regular flight gloves in the coming years.

Future Capabilities and Advantages

10. VR / AR Flight Training Devices could be issued to each aircrew for initial training and could become the standard of training throughout the RCAF. Devices would be portable enough that ad hoc training could occur in ready rooms, at a member's desk, or even at home. In a large enough space, aircrew could conduct full walk-arounds of aircraft, and learn basic maintenance actions.

11. As the RCAF evolves to include new aircrew visual aids, like advanced head tracked Helmet Mounted Displays (HMDs)[20], the visual cues of those systems could easily be integrated into the VR/AR training solution.

12. There are other nations experimenting with VR Aircrew Training, most notably the United States Air Force (USAF)[21]. Canada could establish itself as a world leader of a unified VR/AR pilot training standard. Eventually, an evaluation of legacy simulator versus VR simulation could show a better aircrew product in less time, for less money.

13. With the advent of new communications technologies (5G, Starlink, etc.) truly limitless Joint / Combined VR/AR training could occur at a moment's notice, and with drop-in drop-out levels of fluidity. NATO partners could train combined air assaults, NORAD intercepts, or humanitarian relief profiles. Enemy aircraft could be accurately simulated and flown by real pilots. Detailed personnel performance metrics could also be

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[17] Based on personal experience with a number of games and applications.

[18] "CES 2021 - Exhibitor Directory," CES, accessed February 8, 2021, http://www.ces.tech/.

[19] "SenseGlove Nova - The New Sense for VR Training," SenseGlove, accessed February 8, 2021, https://www.senseglove.com/nova/.

[20] "HDTS Helmet Display and Tracking System (ANVIS/HUD ® 24T) ELBIT SYSTEMS -AEROSPACE HELICOPTER SOLUTIONS," n.d.

[21] "4th Flying Training Squadron Innovation Flight Augments Pilot Training Through Virtual Reality Technology," February 17, 2020.

collected (like attention heat maps, input analysis, and selective replay / retry). These metrics could even be "gamified" to promote competition among unit members.

14. We will eventually move away from aircrew physically in our aircraft. The skillset acquired by developing and training in a VR flight environment may end up being the exact skill set needed to control the future of autonomous / remotely piloted aerospace systems (especially as latency is reduced though more robust beyond line-of-sight communications systems).

CONCLUSION

15. Asking our young aviators to train on legacy devices is like to asking today's youth to get excited about technology from the 90; they might take something away from it, but the experience will always be measured against the current state of the art.

16. An inexpensive trial of a VR/AR aircrew training program at the unit level would offset some of the senior leaderships memories of what VR used to be and solidify what it can be with today's commercially available gaming technology. It would also engage our new recruits, showing them that the RCAF has the capacity to grow and keep pace with technology trends to deliver the best possible learning environment. With even the current level of technology, aircrew will almost certainly become more engaged with their airframe; the ease of access would increase the amount of time spent training. The new opportunities for flying specific missions ahead of short notice deployments, drop-in networks for Joint and Combined Ops, and the freedom to train from anywhere would serve to improve the overall readiness (and safety culture) a given the unit.

17. The form factor of the hardware and the capability of the software will change rapidly, but as it does the cost and trade-offs will too. Canada has a chance to take a bold step to lead the world in the future of aircrew training; there is much to be gained by a modest investment. The transition to more streamlined training could also serve to improve recruitment and retention for undermanned trades.

RECOMMENDATION

18. Based on the information presented above, it is recommended that parallel efforts be made to:

a. acquire a VR/AR flight simulator capability at each flying unit, and

   i. Investments at the unit level need not be greater than ~$2000, and could even be a member level initiative (if they already have the technology) to bring others up to date on the realities of the technology as of February 2021.

b. get AETE to start a project on the relative training benefits of 6DOF immersive VR/AR aircrew training and conventional Flight Training Devices.

19. It is recommended that the RCAF liaise with partner nations to find our where they are in the effort to bring VR Aircrew training to light and work on areas of cooperation to ensure compatibility for future networked capabilities.

20. It is recommended that leadership within aviation units organize an open demonstration, as it is difficult to convey the sense of immersion that a 6DOF high fidelity VR flight simulator can deliver without one. Microsoft has published a recent video of their VR Flight Sim Patch which might help[22].

[22] *Microsoft Flight Simulator VR Overview*, YouTube, 2020, https://www.youtube.com/watch?v=F9B6a5uklvU.

BIBLIOGRAPHY

Air Force News Service. "4th Flying Training Squadron Innovation Flight Augments Pilot Training Through Virtual Reality Technology," February 17, 2020. https://www.af.mil/News/Article-Display/Article/2084928/14th-ftw-innovation-flight-augments-pilot-training-through-vr-technology/

Barrie, Robert L. "Time Domain Validation of the Sikorsky General Helicopter (GenHel) Flight Dynamics Simulation Model for the UH-60L Wide Chord Blade Modification." Monterey, California: Naval Postgraduate School, 1999. http://hdl.handle.net/10945/13406.

"CES 2021 - Exhibitor Directory." CES. Accessed February 8, 2021. http://www.ces.tech/.

Feature Discovery Series: Aerodynamics Part 2. YouTube, 2021. https://www.youtube.com/watch?v=2KdM2pT1hI8&t=179s.

GMSA. "Cloud AR/VR Streaming: Accelerate Mass Adoption and Improve Quality of Experience of AR/VR Using 5G and Edge Cloud." Whitepaper. GMSA, 2019. https://www.gsma.com/futurenetworks/wp-content/uploads/2019/03/Cloud-ARVR-booklet-for-MWC19.pdf.

"HDTS Helmet Display and Tracking System (ANVIS/HUD ® 24T) ELBIT SYSTEMS - AEROSPACE HELICOPTER SOLUTIONS," n.d.

"Microsoft Flight Simulator - The next Generation of One of the Most Beloved Simulation Franchises." Microsoft Flight Simulator. Accessed February 8, 2021. https://www.flightsimulator.com/.

Microsoft Flight Simulator VR Overview. YouTube, 2020. https://www.youtube.com/watch?v=F9B6a5uklvU.

Partnership Series: ORBX Simulation Systems. YouTube, 2021. https://www.youtube.com/watch?v=0aBgH1mqhoc&t=414s.

"Quest 2 - Untether Your Expectations." Oculus. Accessed February 7, 2020. https://www.oculus.com/quest-2/.

"SenseGlove Nova - The New Sense for VR Training." SenseGlove. Accessed February 8, 2021. https://www.senseglove.com/nova/.

WOPS. "Shearwater Planning Priorities." Accessed February 7, 2020. http://shearwater.mil.ca/en/flypro/_Flypro/Shearwater/Priorities_List.html.