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MORE THAN MEETS THE EYE: ARMY VEHICLE SIMULATION IN THE 21ST CENTURY

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AIM

1. The purpose of this service paper is to assess whether the Canadian Army (CA) should look at taking a technological leap and moving past high fidelity simulators (HFS) to virtual reality simulation (VRS) for its combat vehicle fleet, given the rapidly evolving technology and the latter's ability adjust to new vehicle types. Through the discussion presented herein, I believe that the weight of benefits inherent to HFS demonstrate how it will continue to present the best training value in the near to mid-term future.

INTRODUCTION

2. The Canadian Army has utilized simulation of some type for over 50 years. AFV simulators began with the use of indoor miniature ranges, which used ballistically-matched small rifle calibers to approximate main armament projectiles shot at scale models of towns and range complexes. Once electronic computation gained the ability to generate visual outputs in real-time, simulation began to migrate to a synthetic environment. Synthetic environment (SE) training and the Canadian Army have always had a rocky relationship. This is partly to do with the limitations of SE training in the latter 20th century, and attitudes of the trainees/instructors of the time. Starting in the 1990s, the CA introduced appended simulation systems to the field force. The first two systems were the Teleflex for the Leopard C1 and the LAV/Coyote Gunnery Trainer (LCGT) for the Coyote CRV; these are prime examples of a limited system that saw little buy-in beyond mandated individual training programs.

3. As currently defined, the Land Vehicle Crew Training System (LVCTS) seeks to replicate all crew stations within the LAV, Leopard 2 Main Battle Tank and TAPV systems with sufficient realism to enable soldiers to train both as individuals and collectively up to the combat team level. The system will use a networked synthetic environment that accurately simulates various terrain and enemy capabilities.[1] This type of system is the logical and linear progression of SE training that began in the CA over 30 years ago. However, with the renaissance of VRS technology in the past few years, some have wondered if it would not be more cost-effective and advantageous to abandon the pursuit of the HFS system in favour of an infinitely permutable, *future proof* VRS training system.

DISCUSSION

4. Any discussion on this topic must lead with an examination of what a HFS means in the context of LVCTS? A high-fidelity simulator in the current military context is a physical proxy that replicates to a high-degree the man-machine interface while fusing inputs from the networked synthetic environment in order to meet training aims. The Leopard Tank Gunnery Skills Trainer (LGST) provides a good real-world example of a HFS system. The interior of the turret has been faithfully recreated using the same equipment, devices, structures, and

1 Canadian Army Today, "Vehicle crew training: Welcome to a new (virtual) reality," last accessed 10 Oct, 2018, https://canadianarmytoday.com/vehicle-crew-training-welcome-to-a-new-virtual-reality/

dimensions as the original vehicle. This is what would be called the man-machine interface, or the physical proxy. To that interface, the SE has been fused to provide inputs/outputs. Some of those inputs/outputs would be obvious to even the uninitiated outside observer, such as LCD screens that simulate the visual stimuli of the environment, but some of the inputs/outputs are more subtle – such as readouts and auditory cues. A control station shapes the simulation to meet training goals, and provides the means for networking should a collective training aim need be met.

5. A virtual reality system principality relies on its ability to generate a synthetic audio-visual environment to meet training goals. By means of goggles or glasses, the wearer (or training subject) is immersed in a tailor-made SE in accordance with training aims. The subject interacts with the SE by means of a control device. These could be highly abstract to the real nature of the environment (such as a game console controller used to move the subject within the SE), or a more factual representation (a model of a rifle, within the context of a small arms range in a VRS).[2]

6. What training goals are to be satisfied by SE training? Both individual and collective training are domains that can benefit from SE training. The Army combat vehicle environment, individual training such a driving, gunnery, and information systems proficiency can be practised and honed in a relatively low-cost and low-risk environment. Even a simple mounted gunnery range can have substantial associated costs in the maintenance, personnel, and munitions purviews. Much of that time is spend when students do not have a requite skills to make the most of their training, or rather they are in the *low proficiency* part of their learning curve. SE train can replace those associated costs during a student's nascent skill levels, persevering the remainder of real-world training (and expense) for *high proficiency* confirmations.

7. VRS systems present an early and obvious advantage to SE training given its low dependency on physical structures and devices. Ostensibly all that is required to deliver some manner of training are VRS goggles and the networked SE system. The VRS system should then be able to provide an immersive environment that can be scaled and shaped to meet training needs. That system could be easily upgraded, as it would mostly involve software work, and would likely be derived from existing VRS systems perfected in the private sector – thus decreasing the overall financial burden for the Armed Forces. Further, a VRS system would not require dedicated physical space. Much of the networked SE support system could be easily retrofitted into existing buildings, and the training subjects could utilize common classrooms and offices in order to employ the VRS system. In an era of rapidly increasing capital costs and reticence on building new permanent infrastructure, these are enticing benefits.

8. In contrast to VRS, HFS systems seem to have a myriad of drawbacks. They are dependent on a physical proxy (vehicle mock up) to deliver training, which cost money to develop. Those proxies are tied to a specific vehicle, thus cannot be easily rerolled to another vehicle. Those systems have a larger maintenance bill, as they involve complicated systems engineering. And finally a HFS that seeks to replicate collective training to the combat team level will require a very large permanent physical structure for housing purposes. Some of these

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[2] Kaushal Kumar Bhagat, Liou Wei-kai, and Chang Chun-yen, "A Cost-Effective Interactive 3D Virtual Reality System Applied to Military Live Firing Training," *Virtual Reality 20*, no. 2 (06, 2016): 129.

drawbacks may seem grave at first blush, but are actually misleading. Truthful, some of these problems are actually advantages of a HFS system.

9. Chief among these false drawbacks is the dependency to a physical proxy. Regarding the concern that each proxy is tied to one vehicle type, consideration must be given that the vehicles being emulated are in the early stages of their implementation, and will likely serve for another 20 to 30 years. Need for physical space is a real concern, but most of the units that would be utilizing these simulators already have dedicated space to extant simulation systems already. Given the network connectivity of HFS, there is no great compelling need to co-locate all simulators in the same space, thus allowing them to be disaggregated across one base (or multiple bases). Lastly, there is a concern for the high cost, and hastened obsolesce if HFS are not keep up-to-date. It is true at the physical HFS system would be more costly to maintain than a VRS system; however there are mechanisms to lower costs via contracting. In fact, much of the delivery and maintenance of HFS can be done through effects-based contracting with companies already operating in this field.

10. The U.S. Army has a widely successful HFS system, called the *Close Combat Tactical Trainer (CCTT)* - primarily for its M1 MBT and M2/M3 Bradley IFV fleets. This capacity is delivery by *Lockheed Martin Information Systems (LMIS),* headquartered in Orlando, Florida.[3] LMIS has been contracted to provide continuing maintained and up-to-date HFS systems on bases with the aforementioned vehicle fleets. The buildings in which they operate are publicly owned; however all the physical and intellectual property within those buildings remains the property and responsibility of LMIS. That also includes the staff to ensure 100% operational capacity on an hour-to-hour basis.

11. This arrangement allows to U.S. Army to ensure that its soldiers have access to the most modern HFS systems available, while not being saddled with the maintenance of obsolete systems that producing diminishing returns on training investment. Both the physical HFS proxies and its SE network are frequently upgraded at a cost that is transparent to the intuitional army. Should a new combat vehicle be procured, the existing contract would be able to accommodate it inclusion. The future of additive construction (i.e. 3d printing) will allow for even easier proxy manufacture, thus lowered contracted cost.

12. What of the drawbacks of a VRS system applied to the combat vehicle context? The principle issue with the use of VRS is that lack of haptics, which is defined as the VRS system's ability to recreate the sense of touch and spatial constraints. Current VRS haptic response relies on a proxy device, as already mentioned above.[4] For example, there would be a requirement to us a mock-up of the gunnery control stick to provide both the physical inputs to the VRS system, and for the VRS system to feed back a haptic stimulus that matches the original device. Of course, modern AFVs have many more control devices that just a single stick, and those too would need some manner of proxy in order to function along the input/output haptic loop.

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3 Jane's Simulation and Training Systems, "Lockheed Martin Rotary and Mission Systems - Close Combat Tactical Trainer and Reconfigurable Vehicle Tactical Trainer," last accessed 10 Oct 2018, https://janes.ihs.com/SimulationTraining/Display/jsts1113-jsts

4 Cecilie Våpenstad, Fagertun Hofstad Erlend, Thomas Langø, Ronald Mårvik, and Magdalena Karolina Chmarra, "Perceiving Haptic Feedback in Virtual Reality Simulators," *Surgical Endoscopy 27,* no. 7 (07, 2013): 2392.

Evidently, these issues start to decrease the relative cost advantage of VRS systems, as they need similar levels of proxies in order to function properly.

13. There has been early development of haptic VRS device that do not require a physical proxy, such as haptic wearable technology that provides some manner of stimuli through gloves or body suits. While this would solve the issue of proxy dependency for haptic feedback, wearable technology is still in its infancy and cannot provide the level of feedback required for immersive and realistic simulation. At best, these devices can provide the sensation that you are touching something, but not with the fidelity that you can recognize precisely what by touch alone. Further, there is no ability to provide a complete physical constraint by way of haptic suit. Physical constraints would be the feeling by a subject that s/he was inside the same physical space as the vehicle being simulated. This would also means that panels, safety cages and seats would also impose their own space limitations on the subject. VRS systems with current haptic capability provide a very poor recreation of the man-machine interface.[5]

14. Haptic feedback is clearly where HFS systems enjoy the most relative advantage. The physical system is designed to closely correspond to the actual vehicle being simulated; there is a high degree of martial and corporeal exertion that cannot be approximated with a VRS system. A subject in a HFS has the same sense on spatial limitations and associations has they would in the real vehicle. This is extremely important as the quick reaction times we seek to develop in our crew members is dependent on the muscle memories developed through repetition. Those reaction times can be gained at low cost in a HFS simulator before ever setting foot in a real vehicle and consuming time, fuel, maintenance, and ammunition.

15. Beyond reaction times and spatial relationship of control devices, a HFS simulated the physical constraints of a real vehicle which in and of its self is incredibly beneficial to the subject. A good degree of combat function proficiency is being able to execute a task to a standard under prolonged physical and mental duress. In a combat vehicle, that physical duress is provided by the space the soldier inhabits, and the limitations it imposes upon the subject’s freedom of action. As any soldier knows that has undergone mounted collective training, part of the challenge is being able to endure the conditions inside the vehicle for hours, if not days, while carrying out one’s duties to a high standard. There is also the matter of the subjects own soldier systems (i.e. personal protective equipment; helmets and ballistic vests, etc.) and how they interact with the vehicle parameters which provides useful feedback to the soldier. All of these factors play a crucial role to creating an immersive environment that accurately replicated the conditions of controlling an AFV in combat conditions.

CONCLUSION

16. In summation, the Canadian Army should continue its current trajectory of utilizing HFS systems to provide mounted individual and collective training, vice attempting a technological leap toward a VRS system. HFS system drawbacks – such as proxy dependency and structural cost, are not as daunting as they might seem. Physical proxies that emulate the vehicle cabins provide an especially important component of the simulation, namely replicating the physical

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[5] Hayward, Vincent, Oliver R. Astley, Manuel Cruz-Hernandez, Grant, and Robles-De-La-Torre. "Haptic Interfaces and Devices," *Sensor Review* 24, no. 1 (2004): 21.

constraints and personal duress that the subject would face in real-life. Also, there are contracting options available currently that would lessen he fiscal burden and risk to the institution. Finally, the inability of VRS systems to replicate the haptic sensations and physical confines of a combat vehicle will greatly diminish its utility as immersive trainer.

RECOMMENDATION

17. It is recommended that a HFS system be pursued along timelines already promulgated by the Directorate of Land Requirements. Given the high cost and aforementioned issues with obsolesce; the statement of requirements should incorporate elements of cost/risk sharing on behalf of the prime contractor. Given prior successes in the U.S. Army experience in this domain, it may be most beneficial for the CA to construct the building itself, with the prime contractor provide the ensuring effect of a updated, highly capable, and well maintained HFS system. VRS system have a place in the SE training, such as dismounted training for the infantry, however they are poor conduit for combat vehicle training.

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