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Artificial Intelligence for Real Military Advantage

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ARTIFICIAL INTELLIGENCE FOR REAL MILITARY ADVANTAGE

By Lieutenant-Colonel M.A. Jordan
Par le lieutenant colonel M.A. JORDAN

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LIST OF ACRONYMS

AGI	Artificial General Intelligence
AI	Artificial Intelligence
AIDP	Artificial Intelligence Development Plan
APM	Actions-Per-Minute
C2	Command and Control
CAF	Canadian Armed Forces
CCP	Chinese Comunist Party
CFC	Canadian Forces College
CNAS	Center for a New American Security
COA	Course of Action
CSER	Center for the Study of Existential Risk
CSIS	Center for Strategic and International Studies
DOD	Department of Defense
DOTA	Defense of th Ancients
EO	Electro-Optic
ESM	Electronic Support Measures
FSD	Full Self Driving
GAN	Generative Adversarial Network
GC	Government of Canada
ICRAC	International Committee for Robot Arms Control
IR	International Relations
JADC2	Joint All Domain Command and Control
JAIC	Joint Artificial Intelligence Center
LAWS	Leathal Autonomous Weapons Systems
ML	Machine Learning
MOBA	Multi-player Online Battle Arena
NATO	North Atlantic Treaty Organization
NSCAI	National Secuirty Committee on Artificial Intelligence
OE	Operating Environment
OPP	Operational Planning Process
PLA	People's Liberation Army
RTS	Real-Time Strategy
SSE	Strong Secure Engaged
UN	United Nations
US	United States
WHO	World Health Organization

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ABSTRACT

Artificial Intelligence is no longer a buzzword; it seems to permeate everything around us, and there is no sign of it slowing down. Without getting into the existential questions about Artificial General Intelligence, or the typical platitudes of intelligent weaponry, this paper seeks to provide the reader with an understanding of the corner we are being painted into with the rapid progress of AI. There are fewer and fewer tasks for which a human is better suited to perform, a fact that is being proven almost daily by the world's leading minds in AI. Why, then, do we cling to the idea that AI does not belong in the military? Looking at the state of the playing field, and the world powers who are racing for dominance, the integration of AI into everything we do is not a question of if, but of when. By holding on to a misguided belief that an AI cannot improve on the processes in our profession of arms, we are doing disservice to not only our members, but also to the families and loved ones that depend on us coming home.

ARTIFICIAL INTELLIGENCE FOR REAL MILITARY ADVANTAGE

> *"There is still another factor that can bring military action to a standstill: imperfect knowledge of the situation. The only situation a commander can know fully is his own; his opponent's he can know only from unreliable intelligence. His evaluation, therefore, may be mistaken and can lead him to suppose that the initiative lies with the enemy when in fact it remains with him."*
>
> *– Carl Von Clausewitz, On War*[1]

INTRODUCTION – THE REQUIRED EVOLUTION

Knowing the battlefield, this has been a challenge for military commanders throughout history. Decisions must be made, and forces must be committed before inaction leads to losing the advantage; but how do commanders know they have accurate and timely information on the enemy's position and intentions? In the not too distant past, vast networks of espionage and inference from time-late reconnaissance were required to give a command staff a semblance of what enemy action was being planned. Acting on incomplete information, while relying on distributed experience and instinct was the accepted practice. Now our militaries are faced with a rather disparate problem, we often have access to *too much* information; more than we could hope to process in the time available to make wartime decisions. Who prioritizes this information; what assumptions are *they* making, and; how likely is it that critical information is being missed (either by chance of source selection, or by a weak analysis of the available data)? More directly: how many lives could be saved if *all* available data was processed in a coherent, and timely manner to support the commander's decision-making cycle? Is such complete situational awareness even something that a human could accomplish? I argue strongly that it is not, and pretending otherwise is a costly experiment.

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[1] Michael W Schaefer, *Just What War Is* (Knoxville: Univ. of Tennessee Press, 1997), 84.

We are quickly approaching an era where humans are becoming the weak link in the tasks required to support military decision-making cycles. Whether it is ignorance, or carbon chauvinism, it seems difficult for many to accept the fallibility of humans as the root cause of many unnecessary (and sometimes costly) mistakes. There are many examples of such tragedies, often exacerbated by the very human reaction to emotion and heightened tensions. One recent example was the tragic loss of PS752, the Ukrainian International airliner that was accidentally shot down near Tehran in 2020[2]; in the report (released by Iran, so the statements should be taken with a grain of salt) it is stated that the flight path of the doomed aircraft resembled too closely that of an expected missile strike from the US forces in the area. Although such massive tragedies are infrequent, it is reasonable to infer that less costly errors occur regularly around the world. In the past we could excuse some of these types of critical errors as gaps in the available intelligence, perhaps leading to an incomplete (or erroneous) picture of the Operating Environment (OE). Such excuses are becoming increasingly difficult to accept.

We are now living in an age of information overload; most of the data collected by the sensors we have fielded throughout our pan-domain battlefields is not synthesised into meaningful intelligence. Often the operators are not even trained on how best to employ those sensors; most notably when a new platform is introduced, and the hardware / software interfaces are immature[3]. Capabilities like Electronic Support Measures (ESM) and Electro Optics (EO) often have far more capability than are easily accessible

[2] "PS752 Accident Investigation FACTUAL REPORT" (Iran: Civil Aviation Organization of the Islamic Republic of Iran, July 1, 2020).

[3] This anecdote is from personal experience with the CH148 acquisition program, and the introduction of new capabilities to other RCAF fleets. Capabilities like Electronic Support Measures and Electro Optics often have far more capability than are easily accessible by their user interfaces. Data and opportunities are lost

by the operator. Even simple things like cumbersome data retrieval methods are enough to halt use of a system. Data and opportunities being lost to human apathy about the potential importance of the information available to us.

A major contributor to the problem is that the sensor interfaces are often hampered by the imagination of the humans designing them (who are not generally the same subset of humans who will be operating them). Furthermore, we typically rely on humans to interpret what little data we are collecting; what guarantee is there that 'human A' will complete the task to the same standard as 'human B'? The bottom line is that we are limiting the ability of Command to make the best decisions, because we are not taking full advantage of the data available to us.

The irony is that we are living in an age where we can develop Artificial Intelligence (AI) algorithms that outperform, by an order of magnitude or more[4], in nearly any task we choose to target. Whether it is board games (like chess and go), video games of nearly any description, natural language processing, interpretation of image / video data, or real-world robotics interaction (like self-driving vehicles), we are constantly curtailing the boundaries of human superiority. And while the preceding examples are narrow instances of where AI can excel, the goal of nearly all major technology companies, and some governments, is a more generalized AI (one single agent that can achieve, or exceed, human parity at a wide array of tasks). Elon Musk has been outspoken on this topic, and as the CEO of both OpenAI and Neuralink (a company that aims to merge the human brain with AI) he has some clout with which to posit. At a 2018 conference Elon lamented the complacence of the general population and stated

[4] Examples of metrics will be presented in Chapter 1, and will include projects from OpenAI, DeepMind, Tesla, and various academic researchers.

that: “it [AI] is capable of vastly more than almost anybody knows, and the rate of improvement is exponential”.[5]

To date, the Canadian Armed Forces (CAF) has done very little to capitalize on the potential of AI. It is my contention that we have a moral obligation to investigate where AI solutions can be applied to areas of military operations and planning. The Canadian Armed Forces should look to partner nations for synergies in the field of AI; we should also capitalize on the relatively nascent democratization of AI development to establish a leadership role in realizing the military advantages it will yield. The next three chapters will provide background knowledge to understand the state of AI in 2021, outline the publicly available information on the use of AI by the world’s superpowers (military and monetary), and finally take a look at where Canada should focus its efforts such that a rapid integration of AI results in a real military advantage being achieved.

Following a brief literature review, chapter 1 will present some examples of the monumental achievements of AI to date and some that are just around the corner. These examples will focus on complex tasks that require long-term planning, a contextual understanding of actions being taken, an ability to operate with an imperfect understanding of the problem space, and real-time decision making from millions of possible actions. Examples like this should allow the reader to draw links / parallels to the challenges faced in military decision-making, from the tactical level to the strategic.

Chapter 2 will focus on how AI is being researched and used right now by our allies and adversaries alike. We will briefly explore the international recognition of AI as a leading industry for development, then take a look at the leaders in that development.

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[5] Jonathan Nolan, *Elon Musk Answers Your Questions! | SXSW 2018*, YouTube, 2018, https://www.youtube.com/watch?v=kzlUyrccbos.

By looking at the United States, Russia, and China it should become clear a nation serious about defense needs to be heavily invested in AI. The chapter will include a brief look at some of the counter arguments to military adoption of AI, including the fear of Lethal Autonomous Weapons Systems (LAWS).

Before concluding, Chapter 3 will outline how Canada can integrate AI within the current framework of Strong, Secure, Engaged (SSE) and the 2017 Pan-Canadian AI Strategy. The need for refined collection and synthesis of data will make the case for investing in a new network backbone, and we will contemplate some the most efficient uses of AI within our existing processes for operational planning. The chapter will also be used to outline the importance of public perception, and education, when it comes to AI; the public should be demanding that the CAF secure a strong foothold in AI as doing so will be necessary to protect not only our soldiers, but Canadian interests writ large.

CHAPTER 1 – AI DEFINED, JUSTIFYING THE HYPE

> *AI is not a single technology breakthrough, like a bat-wing stealth bomber. The race for AI supremacy is not like the space race to the moon. AI is not even comparable to a general-purpose technology like electricity. However, what Thomas Edison said of electricity encapsulates the AI future: "It is a field of fields … it holds the secrets which will reorganize the life of the world." Edison's astounding assessment came from humility. All that he discovered was "very little in comparison with the possibilities that appear."*[6]
>
> *- 2021 Final Report, National Security Commission on AI*

After having read hundreds of papers on AI, and watching an equal number of videos / presentations, it is safe to say that research in AI is accelerating at a nearly unimaginable pace. Great achievements of only a few months are often surpassed with ease only one more paper down the line. This presented several challenges to my research, not the least of which is that statements made by experts even a month ago need to be crosschecked with the latest research on the topic. Another challenge is that the field is so active that new conferences, summits, and reports are being issued daily; this creates a very difficult challenge when seeking to write a report that reflects the current situation. One example is the very recent Center for Strategic and International Studies (CSIS) panel for the Future Security Forum, which is ongoing as I revise this report; it focuses on the Future of National Security and Technology, and has already provided many insights into the state of AI and how essential it is to make effective use of it militarily.[7]

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[6] NSCAI, "Final Report of the National Security Commission on Artificial Intelligence," NSCAI (Right Vision Media, March 16, 2021), 7, https://www.nscai.gov/.

[7] *Future Strategy Forum: The Future of National Security and Technology — Day 1*, YouTube (CSIS, 2021), https://www.youtube.com/watch?v=iVL_Otmmzxw.

When we look at the projected global market for AI (~$80 billion for 2021)[8], we can certainly see the monetary incentive to pursue these rapid escalations in achievement. Companies like Google, Amazon, Baidu, and Tesla are all heavily invested in securing a foothold in the eventual democratization of AI. Yet, beyond the promise of a return on investment, there is an apparent technological curiosity that drives many to do phenomenal research for little reward / acclaim. A small group of Seoul National University Researchers, for example, combined a Recurrent Neural Network with Deep Reinforcement Learning to teach a virtual biped to dynamically react to an interactive environment[9]; beyond the honor of being published at SIGGRAPH, the recognition for more natural bipedal navigation in real-time 3D animation is a niche reward (though I find it utterly fascinating).

On the flip side of the coin, there are those who see the pursuit of AI as an existential risk. Elon Musk, who is normally on the side of minimizing regulation, has been a vocal proponent of a regulatory body to ensure AI is being developed safely; he goes on to say that "the danger of AI is *much* greater than the danger of nuclear warheads, by a lot. And nobody would suggest that we just allow anybody to develop nuclear warheads if they want… that would be insane".[10] The concern was also stated, albeit in a less dramatic fashion, by the Cambridge Center for the Study of Existential Risk (CSER) in July of 2019.[11] Clearly the dangers of AI need to be understood, and

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[8] "Artificial Intelligence Market Size & Share Report, 2020-2027," accessed May 4, 2021, https://www.grandviewresearch.com/industry-analysis/artificial-intelligence-ai-market.

[9] Soohwan Park et al., "Learning Predict-and-Simulate Policies from Unorganized Human Motion Data," ACM transactions on graphics 38, 38, no. 6 (November 8, 2019): 205:3, https://doi.org/10.1145/3355089.3356501.

[10] Nolan, *Elon Musk Answers Your Questions! | SXSW 2018*, 38:10.

[11] Jose Hernandez-Orallo and Sean O Heigeartiagh, "Paradigms of Artificial General Intelligence and Their Associated Risks 1. MOTIVATION AND STATE OF THE ART," n.d., 6.

responsibly managed, to avoid a situation where the very advanced AI is wielded by maligned actors – and to a lesser extent (for now) to ensure that AI is not developed that determines humans are an obstacle to its goals.

Although Canada is not leading AI in a technical sense, we were the first to publish a national strategy that seeks to advocate for the ethical pursuit of AI[12]. The 2017 Pan-Canadian AI Strategy encourages ethical development of AI, such that it evolves to reflect the best of humanity in a way that upholds the values of freedom and life; over $170 million has been allocated by the Government of Canada (GC) to fund research towards that goal. Canada also co-founded the Global Partnership on AI (comprised of 14 prominent nations, and the EU) with the goal of adopting human-centric AI that reflects our societal values.[13] Clearly, we are cognizant of the fact that AI is a future technology worth paying attention to - but our level of commitment must increase to prevent being left behind.

For all the hype around AI, it is easy to get lost in a sea of platitudes about what it can and can not do. This chapter seeks to provide a basic understanding of the building blocks of an AI agent, and some recent examples of what has been achieved through their use. We will see that today's AI agents are far more agile than a typical computer program that responds to inputs through pre-programed logical recursion loops; instead, they iterate and explore towards maximizing a stated parameter of success and do so in a way that is not dissimilar to a human exploring something unfamiliar. After reviewing

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[12] "Pan-Canadian Artificial Intelligence Strategy," CIFAR, accessed September 30, 2020, https://www.cifar.ca/ai/pan-canadian-artificial-intelligence-strategy.

[13] Science and Economic Development Canada Innovation, "Joint Statement from Founding Members of the Global Partnership on Artificial Intelligence," Gcnws, June 14, 2020, https://www.canada.ca/en/innovation-science-economic-development/news/2020/06/joint-statement-from-founding-members-of-the-global-partnership-on-artificial-intelligence.html.

some of the examples of what AI *can* do, it is my hope that the readers will begin to ponder how these achievements could lend themselves to the problems regularly tackled in our profession of arms.

A Computer Could Never Beat Humans at…

It is natural for humans to believe that they are superior to the machines we create. This kind of hubris is all too common and was on full display when Jack Ma was speaking at the World AI Conference in 2019 (while executive chairman of Alibaba) and said "My view is that computers may be clever, but human beings are much smarter. Clever is very academic, it is knowledge driven. Smarter is experience driven".[14] He then went on to say that humans should just stick to what they are good at, and not compete with computers at all (especially when it is obvious that the computer would easily win). His opinion ignores the fact that it is human nature to compete, and we have done so with computers since we began to program them.

What Jack Ma seems to be stating is that once it is proven that a machine is vastly superior to humans at a given task, then we should simply abandon our efforts to compete with them at that task. This sentiment is somewhat dismissive of the long path of human effort and challenges required to elevate the machine to a level that can outperform us. I believe that the need for constant challenge spurs innovation, and if we simply accept a defeatist mindset every time 'the machine' notches another decisive victory then we are likely to lose the desire to innovate in those fields – we would then develop a stagnation of creativity towards future breakthroughs.

[14] *Jack Ma and Elon Musk Hold Debate in Shanghai*, YouTube (World AI Conference, 2019), 32:15, https://www.youtube.com/watch?v=f3lUEnMaiAU.

Jack's opinion on the matter is not without merit, as it largely stems from DeepBlue's 1997 victory over the reigning chess world champion (Garry Kasparov).[15] It should be noted that it took 12 years of research and development before the victory was possible. Admittedly, now that there is a complete solution to the game of chess (meaning that all possible game sequences are known) and the technology exists to implement a very capable agent on our smartphones, the idea of professional human competition with a Chess AI has fallen out of favor. The recent Champions Chess Tour had only human competitors, but it did use an AI Chess agent (via chess24) to analyse what the human players were doing and derive live probabilities of victory.[16]

Since DeepBlue's dominance of chess, AIs have achieved world champion status at: Go, every original Atari Game, Defense of the Ancients 2 (DOTA 2) (a 5 vs. 5 Multiplayer Online Battle Arena (MOBA) game), and Starcraft 2 (a 1 vs. 1 Real-Time Strategy (RTS) game) – to name a few. Beyond simply beating rated grandmasters and world champions, the AIs are capable of doing so at super-human speeds. DeepMind's AlphaGo agent went from beating the reigning world Go champion (Lee Sedol) in 2016, to an evolution of itself the next year called AlphaGo Zero that would go on to beat the AlphaGo Agent 100-0.[17] AlphaGo Zero learned from scratch (with zero knowledge of the game) by playing literally thousands of years of Go against its predecessor (AlphaGo)

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[15] Posted 25 Jan 2021 | 19:00 GMT, "How IBM's Deep Blue Beat World Champion Chess Player Garry Kasparov - IEEE Spectrum," IEEE Spectrum: Technology, Engineering, and Science News, accessed May 4, 2021, https://spectrum.ieee.org/the-institute/ieee-history/how-ibms-deep-blue-beat-world-champion-chess-player-garry-kasparov.

[16] "Champions Chess Tour Regulations," Meltwater Champions Chess Tour 2021, accessed May 10, 2021, https://championschesstour.com/regulations/.

[17] David Silver and Demis Hassabis, "AlphaGo Zero: Starting from Scratch," DeepMind.Com (DeepMind, October 18, 2017), https://deepmind.com/blog/article/alphago-zero-starting-scratch.

in a matter of days in the real world.[18] Figure 1 show the progress of DeepMind's AlphaGo Zero learning the game of Go from scratch, simply by adhering to the rules, and exploring the game interactions. It is worth noting that his achievement is from 2017. This type of accelerated learning is possible thanks to the ever-increasing clock speeds of the microchips we are creating; and the scalable hardware clusters that are enabled by higher efficiency computers and reduced footprint.

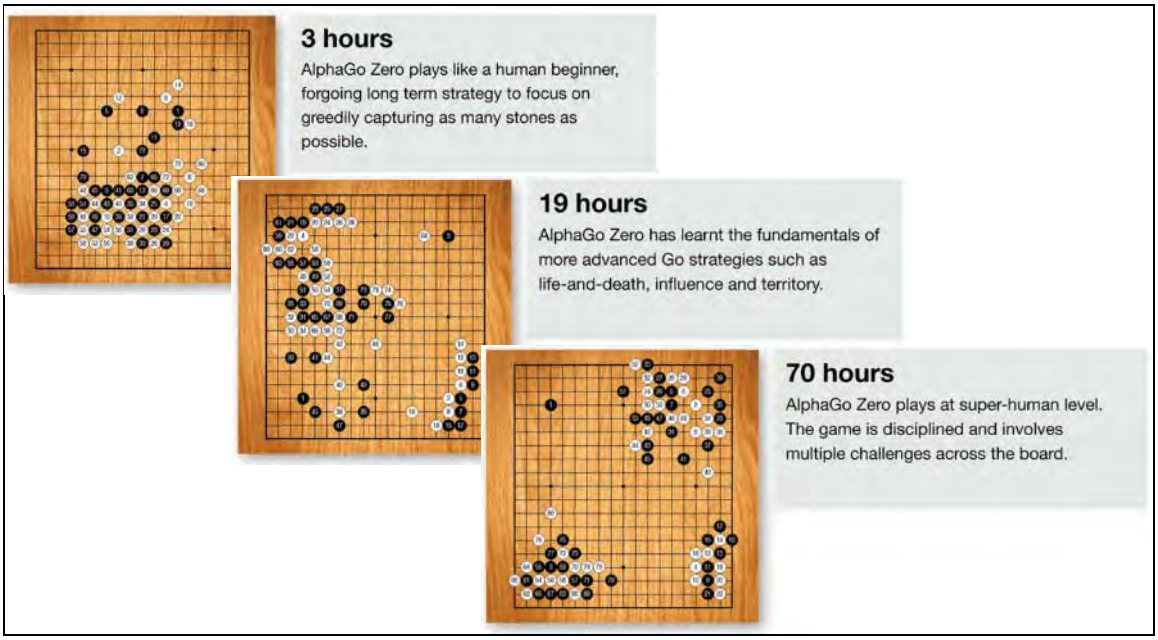

Figure 1. AlphaGO Zero's Learning Progression

While training a neural network at superhuman speeds is essential to gather the most information possible to improve the agent's performance, it is costly (in terms of compute) and is hardly a fair comparison to humans who are incapable of 'upping their clock speed'. To truly test an AI agent against a human, we must level the playing field. Both the OpenAI Five DOTA 2 agent and DeepMind AlphaStar Starcraft 2 agent are purposefully designed not to exceed a reasonable level of interaction with the games

[18] Google, "AlphaGo | DeepMind," DeepMind, accessed November 6, 2020, https://deepmind.com/research/case-studies/alphago-the-story-so-far#the_matches.

(based on metrics like 'Actions Per Minute' (APM) deemed achievable by a pro-level human).[19] The purposeful slowdown of the agent's rate of interaction with the games is needed not only to maintain some level of measurable fairness, but also to ensure that any victories are attributable to the decisions being made by the AI and not just a mechanical advantage.

What is perhaps more impressive than the fact that these AI are consistently beating world class players at very complex games, is that they are doing so in ways that surprise and confound the humans that are competing against them. In the evolution of AlphaGo and AlphaGo Zero, the humans observed that the AI was "developing unconventional strategies, and creative new moves" that conveyed a sense of superhuman foresight into how the game would evolve.[20] With OpenAI Five, playing DOTA 2, the observers were initially surprised by the non-standard and seemingly erratic playstyle; they were shocked the first time the AI used the in-game chat function to predict (correctly) its victory with a 95% confidence in a seemingly even mid-game.[21]

As impressive as it is to watch these AIs achieve 'world's best' status at so many games, the stated goal of companies OpenAI and DeepMind are much broader than winning at games. OpenAI's mission statement is to "ensure that Artificial General Intelligence (AGI) – by which we mean highly autonomous systems that outperform humans at most economically viable work – benefits all of humanity".[22] DeepMind

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[19] AlphaStar Team, "AlphaStar: Mastering the Real-Time Strategy Game StarCraft II," DeepMind.Com (DeepMind, January 24, 2019), https://deepmind.com/blog/article/alphastar-mastering-real-time-strategy-game-starcraft-ii.

[20] DeepMind Team, "AlphaGo - The Story So Far," DeepMind, accessed May 4, 2021, https://deepmind.com/research/case-studies/alphago-the-story-so-far#the_matches.

[21] Károly Zsolnai-Fehér, *OpenAI Five Beats World Champion DOTA2 Team 2-0*, YouTube, 2019, 3:30, https://www.youtube.com/watch?v=tfb6aEUMC04.

[22] OpenAI, "OpenAI Charter," OpenAI, April 9, 2018, https://openai.com/charter/.

similarly seeks to "advance the state of the art in AI (as one of) humanity's most useful inventions".[23] From these two statements it should be clear that the goal is to extract behaviors from the game agents that can be generalized to other problems sets. For the purposes of this paper, I will focus on how AI can be adapted to improve the operating efficiency of militaries around the world (and specifically the CAF).

How Does AI… AI?

To understand how our superiority is gradually being shaved away, it helps to understand a little bit about how AI and machine learning works. DeepBlue, for all its historical significance, was largely a custom-built computer to conduct parallel search on determinative chess positions at extremely high speed (100-200 million searches per second).[24] The system was successful because it could evaluate the possible moves against the set of all known moves (as programmed) much faster (and to greater depth of subsequent moves) than a human. It was essentially victory through brute force, there was not a lot of elegance involved by today's standards. Much is owed to the IBM team that designed DeepBlue, but AI has come a long way since those days.

Today, Machine Learning (ML) is the cornerstone of AI development; so, it is important to understand what makes ML different from the hand-crafted technology of DeepBlue. Instead of making calculated decisions based on a predetermined set of known variables or states, ML generally derives knowledge by testing iterative actions against a set of data from which it can make inference towards achieving a stated goal

[23] Hassabis Demis, "DeepMind -> About," 2021, https://deepmind.com/about.
[24] Murray Campbell, A Joseph Hoane, and Feng-Hsiung Hsu, "Deep Blue," Artificial Intelligence 134, 2002, 61.

according to a set of provided rules.[25] Essentially, the AI agent is learning in much the same way that a human baby learns, through trial an error in an initially unfamiliar environment. Unlike human baby, the AI can achieve mastery at tasks in hours / days instead of decades.

The machines we are using for AI do not (yet) have the benefit of a custom developed brain that has evolved over eons to effectively process the sensory inputs received through out equally tailored senses. Instead, AIs generally make use of an approximation of the brain's connections to the world in what is commonly called a neural network (NN); these can be thought of as a set of malleable weighted parameters that are reinforced when the AI makes progress towards the stated goal. Iterations of the task make it more likely that the agent will re-perform the task that generated a positive outcome and begin to ignore the ones that do not. This iterative cycle can be repeated indefinitely, and the parameters can be tailored to evolve the agent towards even greater capability.

One of DeepMind's latest AI, Agent57 (which was the first to achieved superhuman play level on all 57 original Atari games), shows what can be considered a state of the art combination of neural networks and deep reinforcement learning; figure 2 represents the framework of Agent57's AI.[26] Within this framework the 'actors' at the top are responsible for observing and taking action (knowing only what is on the screen and the desired parameters to optimize – like a score), while the 'replay buffer' and the

[25] Greg Allen, "Understanding AI Technology A Concise, Practical, and Readable Overview of Artificial Intelligence and Machine Learning Technology Designed for Non-Technical Managers, Officers, and Executives April 2020," n.d., 4.

[26] Adrià Puigdomènech Badia et al., "Agent57: Outperforming the Atari Human Benchmark," March 30, 2020, https://arxiv.org/abs/2003.13350.

'learner' can be thought of as the mechanisms for maximizing the win condition while taking into account the results of past behavior (effectively weighting the parameters that drive behavior). This triad is likely to become a standard for AI's trying to achieve a complex learning tasks in challenging learning environments.

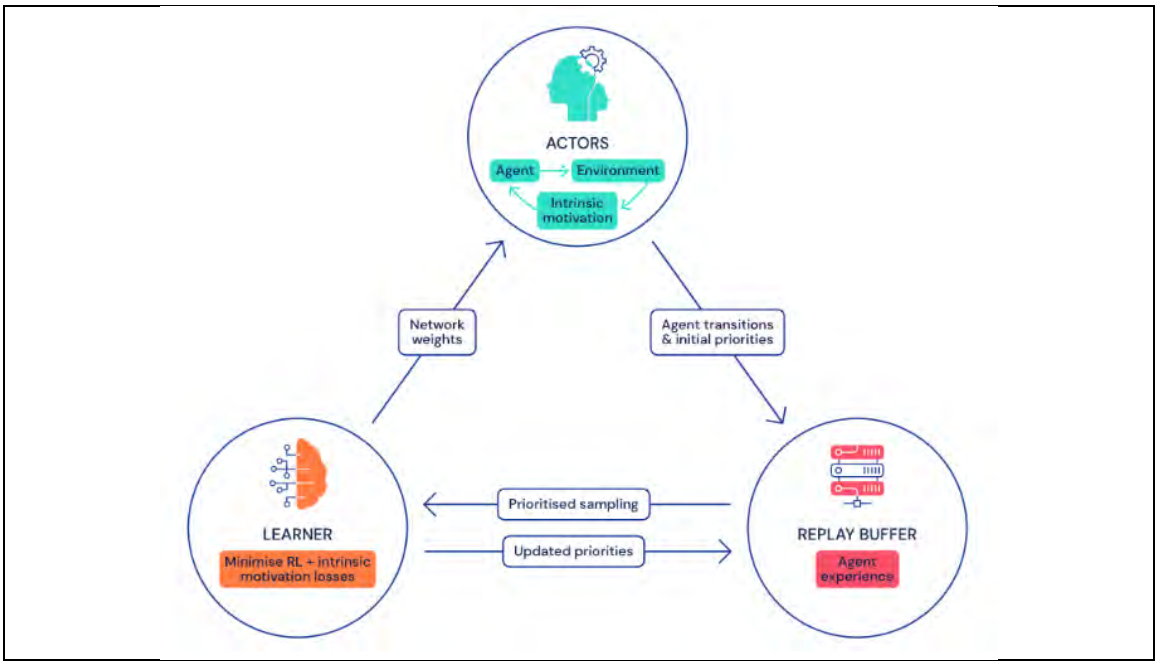

Figure 2. DeepMind's Agent57 Framework

It would be easy to go on for pages about the advances in AI. In a way, it is unfortunate that the fast pace of AI development means that there is always a new paper, or announcement, just around the corner that would make a great addition to this discussion. Tesla, for instance, is planning an AI day in July 2021 to address what they term 'solving a large part of real-world AI' as a necessary step toward their Full Self-Driving (FSD) rollout. Neuralink is another example of a cutting edge venture that aims to establish a neuron scale read/write connection between humans and computers such that we increase our bandwidth for interaction to keep up with the AI's we create[27]; most

[27] Neuralink Team, "Neuralink - Approach and Method," Neuralink, 2021, https://neuralink.com/approach/.

recently they have demonstrated that the interface allows a monkey to play pong with its mind[28] (see figure 3); note that the inset image is alive feed of more than 1000 neurons in the monkey's brain. While the potential for Neuralink to change the world is profound, perhaps it will also convince Jack Ma that we should continue to compete with machines at chess.

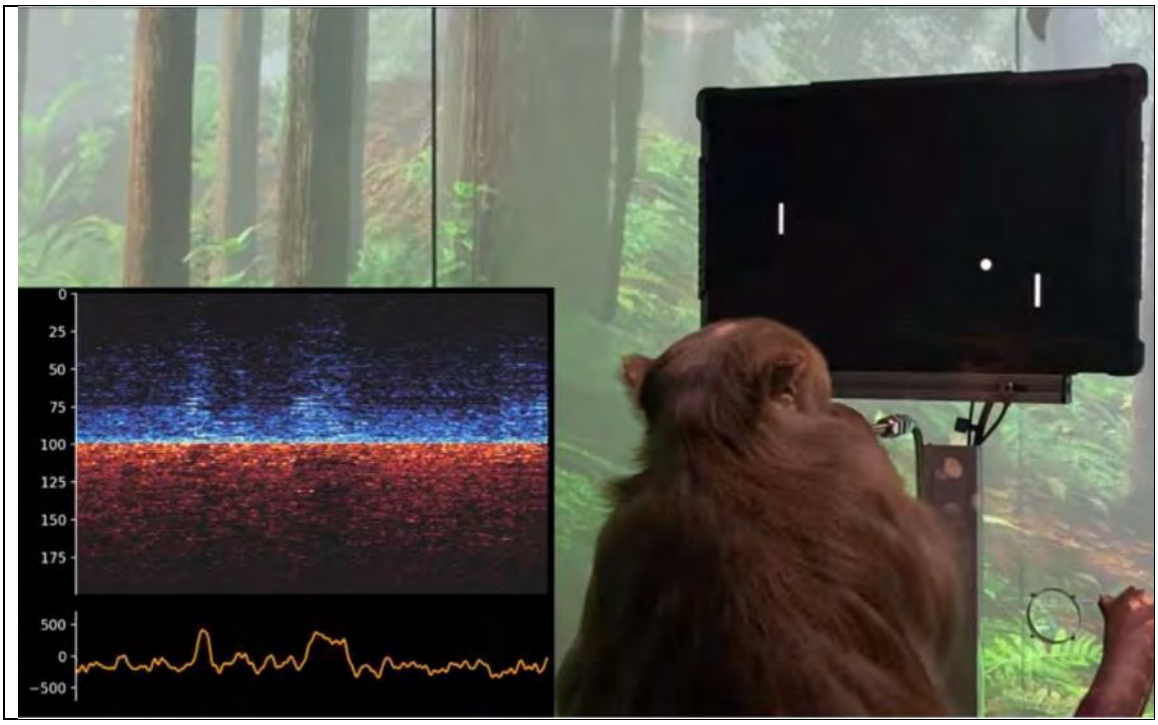

Figure 3. Neuralink Research Subject Playing Pong

Beyond Games

One can quickly draw some parallels between solving the problems associated with increasingly challenging games, and how the technology behind AI can be used to solve a growing set of real-world problems. DeepMind's AlphaStar, for instance, focuses on Starcraft 2; it is a game that requires the player to gather resources, research technology, build a base and fighting force, explore an unknown map, and defeat an

[28] "The First Fully-Implanted 1000+ Channel Brain-Machine Interface," Neuralink, accessed May 10, 2021, https://neuralink.com/blog/.

enemy that is trying to do the same. For every unit created (which can number in the hundreds per game), the AI must provide constant commands after deciding what to do (move, attack, build), who should be targeted, where to move (and where to look), and plan ahead to future actions; it must do this all while adhering to certain constraints and restraints imposed by the rules / expectations of the game.[29] A graphical depiction of AlphaStar's training and implementation cycle is presented in Figure 4; it depicts a cycle of monitoring, analysis, and action that is familiar to many military strategists.

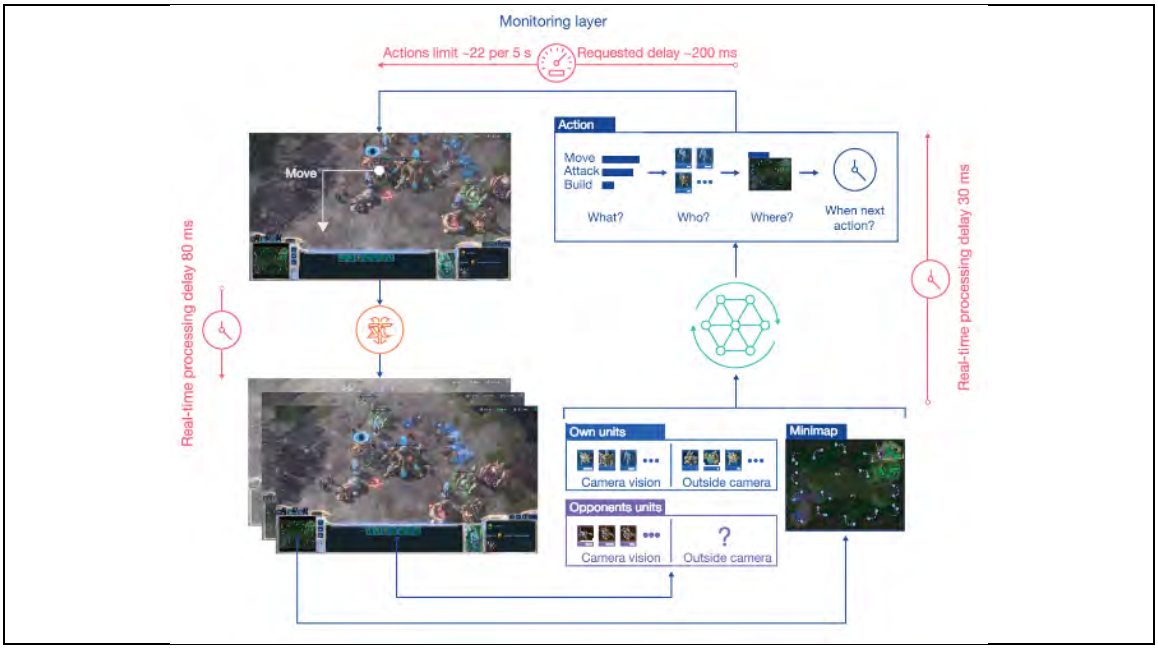

Figure 4. AlphaStar's training & implementation cycle

In its training, the agent was even challenged with 'exploits' against its perceived weaknesses in strategy and tactics, much as military leaders are challenged when 'wargaming' a plan of action. DeepMind concludes their report on AlphaStar by drawing a comparison to real-world domains that require real-time decisions with imperfect

[29] Oriol Vinyals et al., "Grandmaster Level in StarCraft II Using Multi-Agent Reinforcement Learning," Nature 575, 575, no. 7782 (2019): 351, https://doi.org/10.1038/s41586-019-1724-z.

information, like self-driving or a useful personal assistant.[30] I would suggest that the value of what is being researched in such endeavors should not be overlooked for application to the problem space of military decision-making cycles.

Second Order Effects

The same basic technologies which are proliferating in the space of AI gaming can be used for a wide array of interesting, and potentially dangerous, applications. Deep Fakes, for instance, have emerged as a topic of concern over the past few years; basically a neural network (more specifically, a Generative Adversarial Network (GAN)) can learn patterns in a limited set of source data (usually images or video) and use those patterns in conjunction with the input data to output new, but plausible, examples of the source subject doing or saying something other than what is contained in the sources data.[31] While just a few years ago these attempts at fakery were quite obvious to detect, more recent papers, like the 2020 Stanford paper on Iterative Text-based Editing of Talking-heads Using Neural Retargeting, have shown that humans are categorizing the manipulated media as real ~60% of the time (meaning that the fakes are so good that users might as well be guessing).[32]

We are quickly getting to the point where it will be nearly impossible to tell if something is real or not, unless we are watching it in person (which has been a rare occurrence over the last year or so). This problem is compounded by the fact that the amount of input data required for the GANs to learn the patterns necessary to generate a

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[30] Ibid., 353.

[31] Jason Brownlee, "A Gentle Introduction to Generative Adversarial Networks (GANs)," Machine Learning Mastery, 2019, https://machinelearningmastery.com/what-are-generative-adversarial-networks-gans/.

[32] Xinwei Yao et al., "Iterative Text-Based Editing of Talking-Heads Using Neural Retargeting," November 20, 2020, 12, https://arxiv.org/abs/2011.10688.

convincing deep fake (to avoid occlusions, obvious deformations, or artifacts) has been reduced from over an hour of quality video of a subject to 2-3 minutes; moreover, the time needed to generate the output has been reduced from 12 hours to 40 seconds in the latest work.[33] Figure 5 extracts the headline image from the paper being discussed, as it is an excellent illustration of how easy this process has become. Where level of effort used to be an obstacle to creating convincing deep fakes, what we see now is that anyone with 4 minutes to spare (and a modicum of knowledge in the practice) can fool people 60% of the time.

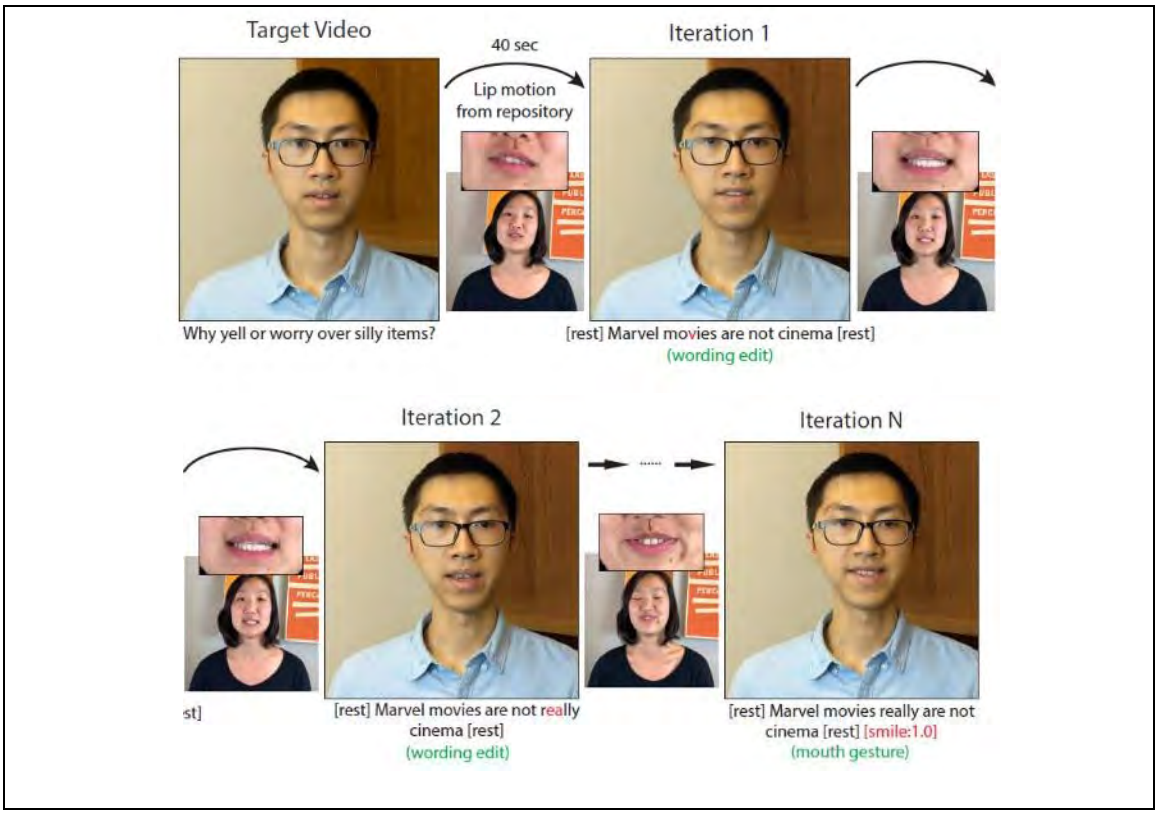

Figure 5. Yoa et al. Iterative Text-Based Editing of Talking-heads

Let us dwell for a minute on the idea of undetectable deep fakes, as it was a stated concern by the US Deputy National Security Advisor for Cyber and Emerging

[33] Ibid., 3.

Technology (Anne Neuberger) in the ongoing CSIS Future Strategy Forum.[34] If we could make a prominent world leader say something completely outlandish, like randomly declaring war on an unsuspecting nation (which is completely doable with the technology described in the Stanford paper), there doesn't seem to be any positive recourse. Such a fake could simply be posted to YouTube, or a deceptive Twitter account (or even a hacked real twitter account) and cause rampant chaos before being disavowed once the subject becomes aware. But the damage has been done, there are only two main outcomes: (1) the receiving party assumes truth and prepares for / pre-empts war; or (2) the receiving party assumes deception, which then weakens the source party's standing such that future messaging will be questioned or dismissed. A possible counter is to develop a method of detecting deep fakes or establishing a secure media validation metric that can accompany messaging from prominent figures. Clearly there is cause for concern. If a population cannot trust what they see with their own eyes, they will grow dependent on outside agents to tell them what to believe and what to dismiss. This presents a massive potential for exploitation and abuse.

Combine deep fakes with the capabilities of OpenAI's DALL-E agent, which can generate unique images based on simple text input (an amusing example is show in Figure 6)[35], and we will soon have a simple interface where we can tell our device to "generate an image/video of the President of <country> shaking hands with the president of <adversary> in front of a nuclear warhead" and we will be presented with hundreds of samples of that construct to choose from. Note that the text prompts advertised by the

[34] *Future Strategy Forum: The Future of National Security and Technology — Day 1*.
[35] Aditya Ramesh et al., "Zero-Shot Text-to-Image Generation," February 24, 2021, https://arxiv.org/abs/2102.12092.

interactive paper blog are purposely curtailed to avoid potential misuse of the AI, but with access to the full agent there would be few safeguards. Now imagine 2-3 papers down the road.

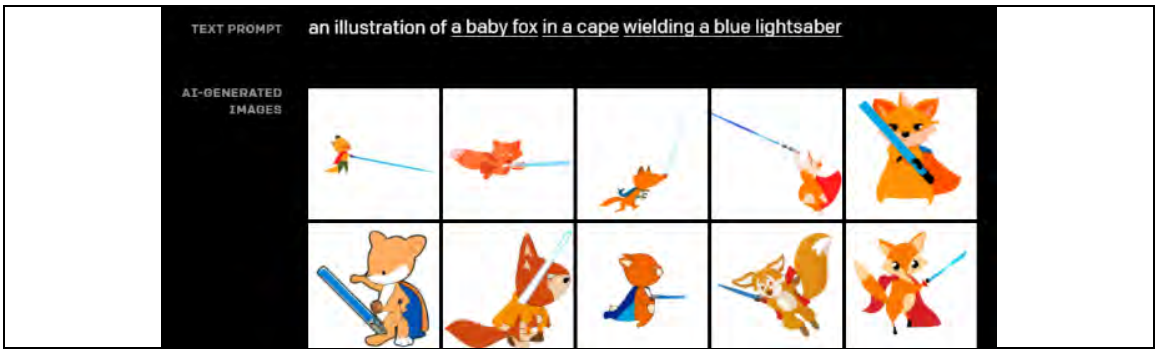

Figure 6. Random OpenAI DALL-E Zero Shot Text-to-Image Prompt

We are now equipped with an understanding of the basics of AI, what it is capable of today, and how it might be both advantageous and concerning in the future. Chapter 2 will focus on how the world powers are gearing up to establish AI superiority. It will also look at how Canada, as a middle power, can maximize its global positioning in AI. The chapter will wrap up with a brief discussion about the largely illegitimate concerns about Lethal Autonomous Weapons Systems.

CHAPTER 2 – KEEPING UP WITH THE JONESES

> *We now know that the uses of AI in all aspects of life will grow and the pace of innovation will continue to accelerate. We know adversaries are determined to turn AI capabilities against us. We know China is determined to surpass us in AI leadership. We know advances in AI build on themselves and confer significant first mover advantages. Now we must act.*[36]
>
> *- 2021 Final Report, National Security Commission on AI*

AI has been researched for decades, going back to the famous work of Alan Turing in his 1950 paper 'Computing Machinery and Intelligence'.[37] While we are still struggling to answer his main question of whether machines can think, we have executed on many of his proposed methods of making intelligent machines. For interest, I have recreated his 'specimen question and answer' in the paper using the OpenAI GPT-3 Beta; the rather amusing results are shown as a full-page comparison image at the end of this paper (along with some other GPT-3 prompts). AI research used to require significant resources to accomplish meaningful results, and was typically limited to universities and government labs; we are now in an age where our phones have extremely powerful neural network processors in them.[38] Anyone can download AI programing interfaces and start to experiment with them; furthermore, many pre-trained agents are available for free on sites like github (an open-source code repository). With such a democratization of AI development / implementation opportunities, we are living in a world where nearly anyone could be the source of a creative breakthrough, or a significant threat vector. It is no wonder AI is a pressing issue for nearly every technologically advanced nation, as

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[36] NSCAI, "Final Report of the National Security Commission on Artificial Intelligence," 14.

[37] Alan M Turing, *Computing Machinery and Intelligence*, vol. 49, Parsing the Turing Test 49 (Dordrecht: Springer Netherlands, 2007), 23–65, https://doi.org/10.1007/978-1-4020-6710-5_3.

[38] Apple's Neural Engine was first introduced in the 2017 A11 mobile chipset, it has been iterated on since and the latest version in the M1 personal computer chipset boasts 11 trillion operations per second (as compared to 600 billion in the A11) – Source: Apple.com and it's archived press releases.

pointed out by the 2019 United Nations (UN) report on the 'Activities on Artificial Intelligence'.[39]

When we look at the types of conventional conflicts that we have been faced with in recent years, we have been able to use our technological superiority over the enemy to gain a significant advantage. With the rise of AI, it is likely that the advantage will go to the side with the best understanding and implementation of the technology (even if there is a mismatch in kinetic power). As my thesis states, a military should hold a moral obligation to pursue the best possible outcome for their troops; as the world embraces AI, so too should our governments and militaries if we are to meet this obligation.

Coming to the realization that AI should be pursued and being in a position to put the resources behind that pursuit are certainly two separate things. Although the global market for AI is estimated to be around $80 billion this year (as previously noted), only a small portion of that is from government spending on defence. The vast majority of the research, development, and implementation is concentrated in the private sector. Given this reality, if a military wants to capitalize on the cutting-edge technology then the cautionary words of the 2021 National Security Commission on AI (NSCAI) should be heeded: "Warfighters (sic) cannot change the way the fight without also changing the way they think".[40]

US Department of Defence

While declaring a moral obligation to pursue AI within the military might seem bold on the surface, it is something that the Department of Defence (DoD) seems to have

[39] "United Nations Activities on Artificial Intelligence (AI)," United Nations (International Telecommunication Union, 2019), vi, https://www.itu.int/dms_pub/itu-s/opb/gen/S-GEN-UNACT-2019-1-PDF-E.pdf.

[40] NSCAI, "Final Report of the National Security Commission on Artificial Intelligence," 64.

realized in 2018 when it released its Artificial Intelligence Strategy.[41] In it, they cite the potential of AI to enhance national security, and to vastly improve the operational effectiveness of their forces. Beyond this recognition, the DoD formally established the Joint Artificial Intelligence Center (JAIC) in June of 2018 with the broad goal of "lead(ing) the world in the development and adoption of transformative defense AI solutions".[42,43] Starting with 4 people in a couple offices in the Pentagon, the JAIC has expanded to include a dedicated building space and nearly 200 personnel; their budget has expanded from $89 million to ~$250 million in fiscal year 2020 ($184 million of which is earmarked for Research and Development).[44] The JAIC's 2021 budget has not yet been made public, but the 2020 director expressed satisfaction with it during an interview with the Center for Strategic and International Studies.[45] For comparison: the global AI market was estimated at ~$62 billion USD in 2020.[46]

Since the JAIC was established, the DoD has openly sought partnerships with the private sector[47]; even with the generous allocations within the congressional budgets, it is clear that the DoD was late to the game and could not compete with the amount of money that the private sector had already invested in AI.[48] Beyond the monetary issue, the DoD also faces an uphill battle to attract talent to their AI efforts. The Center for Security and

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[41] US Dept of Defense, "Summary of the 2018 Departments of Defense Artificial Intelligence Strategy," DOCUMENT, January 1, 2018, https://media.defense.gov/2019/Feb/12/2002088963/-1/-1/1/SUMMARY-OF-DOD-AI-STRATEGY.PDF.

[42] Ibid., 17.

[43] DoD, "Joint AI Center," 2020, www.ai.mil.

[44] @DoDJAIC, "Joint Artificial Intelligence Center Medical Artificial Intelligence ," Presentation, JAIC (DOD, May 1, 2020), 8.

[45] *Online Event: A Conversation with JAIC Director Lt. Gen. John N.T. "Jack" Shanahan*, YouTube, 2020, https://www.youtube.com/watch?v=XzQ9NzTNzwo.

[46] "Artificial Intelligence Market Size & Share Report, 2020-2027."

[47] "Tradewind - An Acquisition Business Model for AI at the DoD," Tradewind (DoD, nd), https://tradewindfaq.org/.

[48] *Online Event: A Conversation with JAIC Director Lt. Gen. John N.T. "Jack" Shanahan*.

Emerging Technology released a 2020 report that showed the 'government' as the least likely employer to be considered for recent PhD level graduates in the field of AI.[49] Figure 7, extracted from the same report, shows the overwhelming preference for remaining in research or perusing a more lucrative career option. The military has never been a career path for those seeking extreme wealth, and yet AI seems to promise that to those who study it; combined with the public perception of use of AI in the military (largely spurred by Hollywood), the DoD seems to have an uphill battle to onside the private sector in the development of the tools and processes necessary to ensure national security.

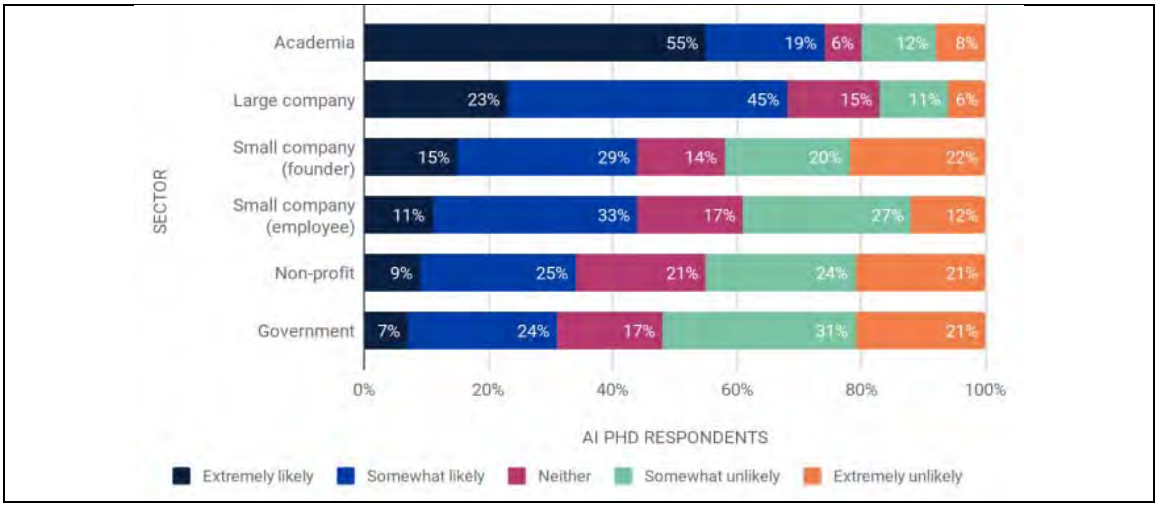

Figure 7. US AI PhD Respondents' likelihood of considering a job by sector

Companies like Google (who have been investing in AI since at least 2014 when they began working with DeepMind[50]) realized the potential of AI nearly 5 years before the DoD. Google was such a prolific leader in the field of AI that Eric Schmidt, Executive Chairman of Alphabet at the time, was announced as the Defense Innovations

[49] Catherine Aiken, James Dunham, and Remco Zwetsloot, "Career Preferences of AI Talent CSET Data Brief," 2020, 10.

[50] Deep Mind Team, "DeepMind - About," DeepMind, nd, https://deepmind.com/about.

Advisory Board chair in 2016[51]. In that role, he was a proponent of accepting a contract with the government in support of Project Maven (which was seeking to use AI to accelerate the processing of military drone imagery).[52] Although the company honoured their contract for the research, there was an outcry of opposition from employees who were not initially aware that the work they were doing was supporting a military objective; in addition to thousands of google employees, nearly 1200 prominent academics signed a petition through the International Committee for Robot Arms Control (ICRAC) to pressure Google to pull out of the contract.[53] Even with the challenges of contracting and growing its talent pool, the DoD has accomplished a lot in the 3 years since committing to developing AI solutions.

What the US seems to have embraced is the fact that we are in an ongoing race with other world powers to develop, refine, and deploy Artificial Intelligence throughout nearly every imaginable sector. This is made abundantly clear throughout the 750 page 2021 NSCAI report.[54] Spoils of this race include the potential for significant shifts in the global power structure. While it would be nice to believe that the world might collaborate on this evolutionary technology, the potential advantages of being 'first to market' are simply too great; tensions are inevitable, and regulation and policy struggle to keep pace with the leaps in innovation throughout the world.

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[51] DiB, "Defence Innovations Advisory Board - Signed Public Meeting Minutes," Opening Minutes (The Pentagon, Washington, D.C., 2016), .

[52] *Eric Schmidt Keynote Address - Artificial Intelligence and Global Security Summit*, YouTube (Center for a New American Security, 2017), https://www.youtube.com/watch?v=EqMe1J4a6IQ&list=PLFvlQ0wG5zoXTLzGdvZvWDPAKku6AeVxQ.

[53] ICRAC, "Open Letter in Support of Google Employees and Tech Workers | ICRAC," ICRAC.Net (International Center for Robot Arms Control, June 25, 2018), https://www.icrac.net/open-letter-in-support-of-google-employees-and-tech-workers/.

[54] NSCAI, "Final Report of the National Security Commission on Artificial Intelligence."

Russian's Realization

In a previous CFC paper (Global Vortex[55]) I outlined both Russia's recognition of AI as a determinant for global power, and an enabler on the battlefield. In an address to the 2020 United Nations General Assembly, Putin was cautionary in his words on AI; he urged the Assembly to cooperate in the pursuit of a safe and equitable development of AI, to avert the military and societal threats that misuse of AI might bring.[56] He is also on record as early as 2017 stating that "AI is the future, not only for Russia, but for all humankind. It comes with colossal opportunities, but also threats that are difficult to predict. Whoever becomes the leader in this sphere will become ruler of the world".[57] Depending on what International Relations (IR) theory we subscribe to, Putin's apparent olive branch from could either be an admission of concern that they are falling behind, or a feint to throw off their perceived competition. We will see in time which is true, but we can already get a fairly good idea of where Russia is heading if we look at their us of AI in public facing business ventures.

In a 2019 survey, which included over 800 business leaders from France, Germany, Italy, Netherlands, Russia, Switzerland, the United Kingdom, and the United States, it was found that Russia was more likely to be incorporating AI into their business workflows than any of the other participating nations.[58] Whether Russia is effective in their use of AI is a matter of debate, and their statements on the world stage must be

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[55] Michael Jordan, "Global Vortex Paper - AI C2 " (Toronto, ON: CFC, December 8, 2020).
[56] Team of the Official Website of the President of Russia, "75th Session of the UN General Assembly," President of Russia, accessed December 7, 2020, http://en.kremlin.ru/events/president/news/64074.
[57] Alina Polyakova, "Weapons of the Weak: Russia and AI-Driven Asymmetric Warfare," Brookings, 2018, https://www.brookings.edu/research/weapons-of-the-weak-russia-and-ai-driven-asymmetric-warfare/.
[58] "Russia is ahead of the United States and Europe in the active implementation of artificial intelligence," Microsoft News and Stories | Press Information, 2019, https://news.microsoft.com/ru-ru/business-leaders-age-of-ai/.

taken with a grain of salt, given the their challenged claims of dominance in other fields. Ultimately, it does not matter if they are effective or not; Russia is setting the stage for acceptance of AI by its public, and public support is a powerful tool when it comes to implementing wide scale adoption of a new (and potentially dangerous) technology – though admittedly more so in the political systems of Western Nations that require more consent from the people.

Beyond the business sector Russia has also embraced AI on the battlefield. Several publicized demonstrations have been held with what they are referring to as their 'Information System of Combat Management' and 'Automated Control System'.[59] The multifaceted system is reported to have already cost Russia nearly $300 million, and supports all level of command with: (1) real-time analysis of the battlefield (taking into account distributed sensors and other command data); (2) tablet style field computers that provided analysis, and suggested actions to battlefield commanders, and; (3) a centralized situational awareness and Command and Control (C2) node.[60] The available information on the system was also assessed by the Jamestown Foundation, who believe that it puts Russia ahead of NATO as it relates to automated C2 and decision-making on the battlefield.[61]

Beyond the ambitions of automated C2, a 2018 CNAS report on Strategic Competition in an era of AI cited public reporting that Russia has been testing small to

[59] "Russia to Finish Development of Tactical-Level Automated Control System in 2021 - Military," Sputnik, December 28, 2019, https://search.proquest.com/docview/2330964999.
[60] Alexey Kretsul, Alexey Ramm, and Roman Kozachenko, "Commemorative Big Data: Artificial Intelligence will help Generals," Notifications, 2019, https://iz.ru/941925/aleksei-ramm-aleksei-kozachenko-roman-kretcul/pamiatnaia-bigdata-generalam-pomozhet-iskusstvennyi-intellekt.
[61] Roger McDermott, "Moscow Showcases Breakthrough in Automated Command and Control," Jamestown Foundation, November 20, 2019, https://jamestown.org/program/moscow-showcases-breakthrough-in-automated-command-and-control/.

large scale AI enhanced weapons systems.[62] The report mentions AI guided missiles, swarm technology, and neural-net driven image classification and targeting; there was even talk about Autonomous Unmanned Vehicles. Although there is no immediate indication that Russia will go so far as to field fully autonomous weapons systems, the 2017 commander of the Russian Aerospace Force embraced the idea of AI replacing soldiers and aviators.[63]

Whether Russia is truly ahead of our NATO allies or not, it is clear that they are taking AI very seriously (and in line with Putin's 2017 statement noted above) and are not afraid to implement a less than perfect solution if they believe it will result in an advantage over perceived adversaries. As with any new technology: the sooner someone starts to tinker with it, the more likely it is that they will understand how it can be implemented into their problem space. By this metric alone it seems that Russia has a leg up on Canada and most middle powers who are either incapable, or unwilling, to make the initial investments (and gambles) needed to lead in AI. Until other nations come to the plate, let us hope that the United States is making strides with project like the Joint All Domain Command and Control (JADC2) initiative, and other AI initiatives through the JAIC, to counter whatever realized progress is being made by potential adversaries.

China is Awake, and Grabbing for Data

China was interested in AI through its private sector tech companies as early as 2013, when Baidu opened what it called an 'Institute for Deep Learning' in Beijing; this

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[62] Michael Horowitz, Elsa B. Kania, and Gregory C. Allen and Paul Scharre, "Strategic Competition in an Era of Artificial Intelligence," Center for a New American Security Reports (Washington: Center for a New American Security, July 18, 2018), 16, https://search.proquest.com/docview/2072898763.

[63] "Artificial Intelligence to Replace Pilot in Aircraft Cockpit — Russian Senator," TASS, accessed April 20, 2021, https://tass.com/defense/973707.

was quickly followed by a US based equivalent in 2014 (the Silicon valley AI Lab).[64] While it is safe to say that the Chinese Communist Party (CCP) had some level of interest in what Baidu was doing at the time, AI did not become a publicized national strategy for China until a few years later. As noted in Kai-Fu Lee's book (AI Superpowers[65]) China's interest in AI was sparked in 2017 when the previously mentioned AlphaGo agent by DeepMind embarrassed the Chinese Go master Ke Jie at the 'Future of Go Summit'.[66] Lee, who was working in Beijing's 'Silicon Valley of China' when the defeat took place, described it as "China's 'Sputnik Moment' for Artificial Intelligence". China's AI goals became very public, and very ambitious in the months following the loss of the Go title; they published an AI Development Plan (AIDP) in July of 2017, where they vowed to invest ~$15 billion to become a world leader in AI by 2020.[67] If Russia was able to lead NATO militaries with an AI investment of $300 million, it is safe to assume that China is amassing a formidable capability.

Beyond the advertise AIDP, which makes it very clear that China understands the potential benefits of AI, little official information is available on how the Chinese Military might be incorporating AI into their manoeuvres. In 2019 CNAS prepared a report for a hearing before the US-China Economic and Security Review Commission entitled 'Chinese Military Innovations in AI'.[68] In this report, they outline how China has

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[64] Baidu, "Baidu Opens Silicon Valley Lab, Appoints Andrew Ng as Head of Baidu Research | Baidu Inc," Ir.Baidu.Com, May 16, 2014, https://ir.baidu.com/news-releases/news-release-details/baidu-opens-silicon-valley-lab-appoints-andrew-ng-head-baidu/.

[65] Kai-Fu Lee, *AI Superpowers : China, Silicon Valley, and the New World Order* (Boston: Houghton Mifflin Harcourt, 2018), https://ebookcentral.proquest.com/lib/[SITE_ID]/detail.action?docID=5228576.

[66] Ibid., 9.

[67] Gregory C Allen, "Understanding China's AI Strategy: Clues to Chinese Strategic Thinking on Artificial Intelligence and National Security Introduction" (CNAS, February 1, 2019), 4.

[68] Elsa B Kania, "Chinese Military Innovation in Artificial Intelligence," June 7, 2019.

a long history of AI research, with some weapons development dating back to the early 2000's. CNAS extrapolates on available information to infer that the PLA is likely to be pursuing a wide gambit of AI attack vectors, including: (1) remote sensing and battlefield support; (2) natural language processing to analyse intelligence; (3) psyops and deepfakes; (4) Automatic Target Recognition, and; (5) the use of AI as a war-gaming tool (including improved SA through automated sensor information processing).[69] Somewhat concerning, in terms of the apparent vector of China's AI ambitions, was a 2019 statement from the head of one of China's largest defence companies; he predicted that "there will be no people fighting in battlegrounds" as early as 2025[70]; this is a somewhat ambiguous statement, but certainly something to pay attention to as China marches towards what it coins as 'intelligentized' (sic) warfare.[71]

While their Military advancements may be obfuscated by the secrecy of the People's Liberation Army, China clearly intends on winning in a race for big data by ramping up collection amongst its civilian populations. In a 2020 RAND study, it was pointed out that the CCP seeks to "leverage big data analytic capabilities to strictly control and comprehensively monitor China's population"[72]. If we recall some of the examples in chapter 1, it should be clear that the more data we provide AI (in terms of games played, or real-world truth data), the better it will perform. By leveraging its own population to gather massive amounts of data on human interactions, preferences, daily

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[69] Ibid., 11.

[70] Matt Bartlett, "The AI Arms Race in 2020," Medium, 2020, https://towardsdatascience.com/the-ai-arms-race-in-2020-e7f049cb69ac.

[71] Kania, "Chinese Military Innovation in Artificial Intelligence," 1.

[72] Derek Grossman et al., "CHINESE VIEWS OF BIG DATA ANALYTICS," States News Service, September 1, 2020, viii.

routines, and more, they will have access to a training data set that far exceeds anything that a more freedom conscious nation could hope to collect.

The head start that China is amassing by monitoring a large percentage of its population is analogous to Tesla's overmatch on real-world driving data collection (which will be used to cement them as the world leaders in autonomous vehicle research).[73] Knowing how people move, how they act, and what properties are recognizable with different sensors lends itself to many military applications. Inference on adversary intent, or even penetration of camouflage seem to be likely vectors for AI in the information rich world of the Peoples Liberation Army. China could be using AI right now to devise methods of deception and control that are effective in influencing their adversaries away from conflicting with the interests of the CCP.

Even if a regulatory body emerged, possibly within the UN, it is unlikely that China would be forthright with its intentions for AI. The previously cited CNAS report concludes that "If the US wants to lead the world in AI [instead of China], it will require funding, focus, and a willingness among U.S. Policymakers to drive large scale necessary change".[74]

The World is not Waiting

One thing should be clear: the world is pursuing AI at a rapid pace, and those who are not leading the charge, are soon to be relegated to a group of followers who must adopt the progress of others according to their conditions of access. Depending on how powerful emergent AI become, there could be a fracturing of nations: those who jump

[73] *Tesla Autonomy Day*, YouTube, 2019, 1:54:00, https://www.youtube.com/watch?v=Ucp0TTmvqOE.
[74] Allen, "Understanding China's AI Strategy: Clues to Chinese Strategic Thinking on Artificial Intelligence and National Security Introduction," 22.

onboard with China, possibly due to the promise of economic support, and those who side with the United States for a more ethical AI implementation. I do not believe that there has been such a massive potential shift in the balance of power as there is with the race to make effective use of AI. Our actions in the next 5 years with regards to AI will have a massive impact on the role we will play in future conflicts.

Canada's Unique Opportunity to Expand on its Strategy

Canada may not be leading in the implementation of AI, but we did attempt to lead the world discussion on how to pursue AI responsibly. We have a reasonably well funded (by Canadian standards) $175 million AI research grant program in the 2017 Pan-Canadian AI Strategy[75], and our neutral status on the world stage means that we are perhaps a more trusted partner for those seeking to cooperate on AI development. We also benefit from existing intelligence partnerships which may give us inroads with the US and EU as they formalize their path to AI-Military integration. Figure 8, taken from the 2021 NSCAI full report, illustrates Canada's positions within the major intelligence partnerships and provides a notional concept of where we should be going with AI.[76]

[75] "Pan-Canadian Artificial Intelligence Strategy," CIFAR, accessed December 7, 2020, https://www.cifar.ca/ai/pan-canadian-artificial-intelligence-strategy.

[76] NSCAI, "Final Report of the National Security Commission on Artificial Intelligence," 83.

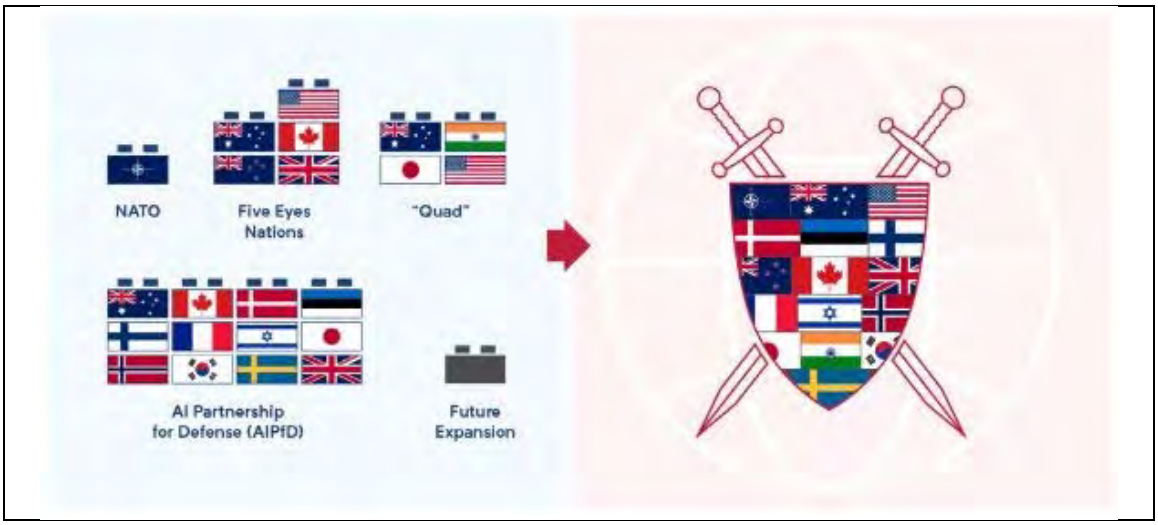

Figure 8. NSCAI – Intelligence Partnerships and national AI Pact

Canada should leverage our strong partnership with the US and actively seek to establish exchange positions within the DoD's JAIC; it should also consider adopting the American JADC2 implementation when determining how to setup the future of Canadian intelligence and C2. It would be difficult to assume that we could be an equitable partner in such an arrangement, but we do have a substantial incentive to maintain our NORAD interoperability. With any luck, as the US further refines where it wants to go with AI, C4ISR, and JADC2, it will be assumed that Canada will be 'tagging along'.

Within our own borders, Canada does have a wealth of data available to us from a wide range of sensors and platforms; unfortunately, we are not making good use of it and often times not even making the effort to collect it. Developing a robust C4ISR spine, as has been alluded to by many levels of CAF leadership including at the '2021 C4ISR and Beyond Conference'[77], will not be enough to guarantee any sort of realized gain in our operational capabilities. The spine will only be as good as the data we put onto it and the

[77] Ron VAdm Lloyd, "Lessons Learned from C4ISR and Beyond 2021 – Vanguard," VANGAURD (VAMGUARD, March 2, 2021), https://vanguardcanada.com/lessons-learned-from-c4isr-and-beyond-2021/.

processing that we are able to do. This means that we must tackle the root causes of lax data collection / management, from system design all the way to force generation; this must be done to re-baseline the expectations for what I think of as 'maximum collection, for maximum inference'.

AI will need to be leveraged to be a vigilant monitor of the collected data, using constantly evolving neural networks to identify data of interest among a sea of irrelevance. Asking a human staff member to complete such a task would be a mundane and costly endeavour. Costly not only because of the people hours that would be needed to achieve any sort of relevant data extraction, but also because the inevitable errors of omission could negate campaign advantage that would otherwise be possible.

By contrast: we are seeing with the rapid progress of self-driving vision systems that leverage the power of AI and ML to recognize the world through real-time 4D (temporal) mapping and object recognition across multiple camera angles[78]. An AI enabled system could take these massive data sets and complete the tasks with ease. AI will never get tired, it will constantly improve as we feed it more data, and it will perform the task with orders of magnitude more accuracy than a human could hope to (in a fraction of the time).

It is essential that we start down the path of CAF-AI integration; even if the first few iterations are not perfect, we will be pushing the boundaries and proving our resolve to be a contributing member to future AI partnerships.

[78] Tesla Team, "Autopilot AI," Tesla, accessed April 10, 2021, https://www.tesla.com/autopilotAI.

What about the LAW?

Inevitably, when discussing AI with any sort of proximity to the word 'Military', there needs to be an acknowledgement of autonomous weapons, or LAWS. While there is value in the consideration of the potential concerns with LAWS, I find the opposition to them is generally rooted in ignorance rather than well formed arguments. Will we ever have AI in the kill chain? Yes. Will it designate and destroy targets that a human would disapprove of? Doubtful. Does it have a chance of making a mistake, and striking the wrong target? Yes, but at a much lower rate than the current human operators. The NSCAI report seems to agree with my opinions on the matter; in its chapter on ways to mitigate strategic risks associated with AI-Enabled Weapon Systems, one of the key determinations was that properly implemented LAWS could improve compliance with International Humanitarian Law (IHL) by "reducing the risk of accidental engagements, decreasing civilian casualties, minimizing collateral infrastructure damage, and allowing for detailed auditing of the decisions and actions of operators and their command chains".[79] The seemingly institutional desire to avoid the topic of LAWS (or at least regulate the issue away until someone else has to deal with it) seems similar to the provably false belief that having a human at the controls of a highly automated passenger aircraft is safer than passing those controls to the computer.

Back in the early days of aviation, it was true that mechanical failure or systems malfunctions were disproportionately the cause of aviation accidents. This is not wholly unexpected, as the technology was nascent and we had only a rudimentary understanding of the intricacies of flight. In a 2007 Boeing study, it was reported that over the last 100

[79] NSCAI, "Final Report of the National Security Commission on Artificial Intelligence," 91.

years the root cause of accidents inverted from 80% machine related failure to 20% machine rooted failure.[80] One could argue that more complicated aircraft systems have led to a new kind of 'human error' where the automation does not meet the pilot's expectation, leading to confusion and occasionally fatal accidents. One example of such a case would be the famous 2009 Air France flight 447, where an obstructed pitot tube caused a stall indication leading to the disconnect of autopilot.[81] This otherwise normal occurrence, where the plane was actually still flying perfectly fine was misinterpreted by the pilots, leading them to command a climb in an attempt to lower the airspeed on the indicator affected by the icing. The nose up input was maintained long enough that the aircrafts actual airspeed decreased well below the stall threshold, and the aircraft crashed into the ocean from a human sustained stall from cruising altitude. If the pilot had let go of the flight controls, at almost anytime during the emergency, the aircraft would have quickly become recoverable. At best, the lives of over 200 people can be blamed on a combination of a mechanical failure and human failure, but the mechanical error was so minute that a well-trained pilot should have been able to diagnose it and adapt through knowledge of the systems involved. There are, sadly, many similar stories in the past 20-30 years, yet human nature (or perhaps ignorance) seems to prevent airline passengers from demanding higher levels of automation. I realize the irony of arguing myself, and other pilots out of a job, the reality is that optionally and unmanned aircraft are far more capable; but that is the topic of another paper.

[80] William Rankin, "MEDA Investigation Process," BOEING Aero (BOEING, 2007), 14–21.
[81] BAE, "BAE Air France 447 - Phase 3 Evaluation - Interim Report" (Archaeology Data Service, June 1, 2009), https://doi.org/10.5284/1025189.

A very similar argument could be made for self-driving cars, where we accept the fact that over a million people die every year due to humans making bad decisions while behind the wheel[82], but tolerate a media frenzy every time there is an injury that has any peripheral association with an attempt at autonomous driving. Figure 9 shows the year-to-date total death due to driving accidents (>480,000), as estimated by the World Health Organization (WHO). Tesla, who is arguably the world leader in self-driving vehicle technology, released an impact report in 2019 showing that vehicles driving with their Autopilot System engaged were approximately seven times less likely to get into an accident than the US average (0.3 accidents per million miles, compared to 2.0).[83] Since that time the system has improved significantly, and Tesla is expected to reach level 5 autonomy by the end of the year (fielded in at least a subset of their fleet) – this fact may be announced in July at a Tesla AI day presentation. Odd then, that the public perception of self-driving vehicles is still so low.

Figure 9. WHO Estimate of Road User Deaths, Year-to-Date (486,458+)

[82] "Road Traffic Injuries and Deaths—A Global Problem," Centers for Disease Control and Prevention, December 14, 2020, https://www.cdc.gov/injury/features/global-road-safety/index.html.
[83] Tesla Team, "2019 Impact Report," Tesla, 2019, https://www.tesla.com/impact-report/2019.

With the evidence to support the use of AI and automation above basic human capabilities, how do we effectively combat the human nature that seems to reject the data in favor of their own biases against trusting emerging technology? The apparent logical misalignments could be actively addressed by governments and media, assuming that they are willing to put the lives of citizens above the various lobbying interests. I would argue that the same can be said for using AI to improve most aspects of military operations, as doing so would ultimately reduce the casualties of war (both direct and indirect). Chapter 3 tries to identify what areas of CAF operations could be improved if we are willing to let go of the reigns a bit and embrace AI. What are the potential 'real military gains' that can brought forward through a willingness to experiment in a field that is globally accepted as a game changer?

CHAPTER 3 – WHERE DOES AI FIT IN THE CANADIAN ARMED FORCES

> *We will harness the potential of AI to transform all functions of the Department positively, thereby supporting and protecting U.S. servicemembers, safeguarding U.S. citizens, defending allies and partners, and improving the affordability, effectiveness, and speed of our operations. The women and men in the U.S. armed forces remain our enduring source of strength; we will use AI-enabled information, tools, and systems to empower, not replace, those who serve.*
>
> *- Preface, US DoD AI Strategy 2018*

As we have discussed, AI is perhaps the most transformative technology of our time. Through hard work, and significant research, AI continues to surpass human capability in almost every test we devise (often by several orders of magnitude). Many of the world powers have already concluded that AI must be integrated into their military

processes for data collection and decision making in order to maintain relevance in the future of warfare. Many governments have similarly committed to establishing themselves as the world leader in AI, because they see the dramatic potential for 'first movers' to reshape the balance of global power. Although Canada is a middle power, with much less economic weight to put behind AI development, we do have some initiative in the global conversation (being the first to publish an AI Strategy)[84] and we have a reputation for fairness that may put us in a position to lead efforts to formalize the meaning of ethical development of AI. But is this enough?

As was posited at the beginning of this paper, I believe that the Canadian civilian and military leadership has a moral obligation to rapidly pursue AI integration into nearly every aspect of our military processes. As noted in the chapter's leading quote, the US came to the same conclusion 3 years ago. In the 2020 Congressional Report on AI and National Security, the US identified seven main areas where AI can augment defence: (1) Intelligence, Surveillance, and Reconnaissance (ISR); (2) Logistics; (3) Cyber Ops; (4) Info Ops & Deep Fakes; (5) Command and Control; (6) Autonomous Vehicles, and; (7) LAWS.[85] Clearly Canada can not yet hope to have as robust an approach to AI, but I truly believe that it will be something expected (if not demanded) by the public once AI is better understood. I am also cognizant of the fact that we will not magically transform the military overnight; Canada does not currently have the monetary backing, or the political impetus to seek such widespread reform (and this is not likely to change in the near term).

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[84] "Pan-Canadian Artificial Intelligence Strategy."

[85] NSCAI, "Final Report of the National Security Commission on Artificial Intelligence," NSCAI (Right Vision Media, March 16, 2021), https://www.nscai.gov/.

If we do not have the capacity to at least start on a robust and a 'proudly Canadian' Military-AI pairing in the near term, then we risk becoming subservient to the design decisions of a partner nation; or worse, a target for nations that did not procrastinate on AI and have developed exploitative techniques that we are powerless to counter. With that in mind, the best thing would be for us to focus on some key areas where exploration of AI enablers can be marketed as 'low risk, high reward'. Even before mounting a grand roadmap for AI development within the CAF, small projects should be encouraged to start the conversation. Looking at the list from the US Congressional Report, two areas where Canada could focus are: (1) Planning (as a subset of Command and Control), and; (2) the collection / processing for ISR (which can also feed into the planning cycle). The key issue that I have experienced in the CAF is that we simply do not have enough people to do the task we are assigned; we often make them work, but at an untold cost to the people who are working much harder than they should. AI has the potential to drastically reduce the workload associated with many military tasks, particularly as they relate to staff. At the risk of redundancy: we have a responsibility to do everything we can to safeguard our members, both on the battlefield and at 'home'.

C2 - Operational Planning Process (OPP)

Commanders issue orders to their subordinates based largely on recommendations and Courses of Action (COAs) that are generated by hundreds of people hours being put into what is known as the Operational Planning Process (OPP). The Canadian OPP is largely modelled after the NATO Allied Command Operations Comprehensive Operations Planning Directive, and is a very scripted sequence of tasks that are used at all

levels of the CAF to "prepare plans and orders for CF operations" and is "applicable to all aspects of the employment of military force, not just war fighting".[86] The fact that the process is so scripted is both good and bad. On the plus side, teaching the process to someone new is a matter of walking them through the steps as outlined in whichever manual being used. On the negative side, the entire process is arduous and significant experience is needed to know how and when it can be abbreviated.

Figure 10 depicts the entire flow chart for the CF OPP; it is purposefully left to be unreadable, as the intent is to show the complexity of the 5-stage process and not be a reference for the individual steps within those stages.[87] For some CAF officers, the first introduction to OPP comes during their year at JCSP; and the introduction to the process for some members in my group was eye opening. At some point an excel workbook was created as a tool to manage the flow of OPP and ensure that the critical prompts for information are not missed. This workbook (also pictured in figure 10) contains 61 tabs, and was largely avoided by the JCSP our students after the first use.

[86] Strategic Joint Command, "The Canadian Forces Operational Planning Process (OPP) Change 2 Issued on Authority of the Chief of the Defence Staff Canada," CFJP 5.0 (SJS, April 1, 2008).
[87] CFC Staff, "CF OPP Templates," CFCLearn, 2021, https://mars.cfc.forces.gc.ca/CFCLearn/mod/folder/view.php?id=7301.

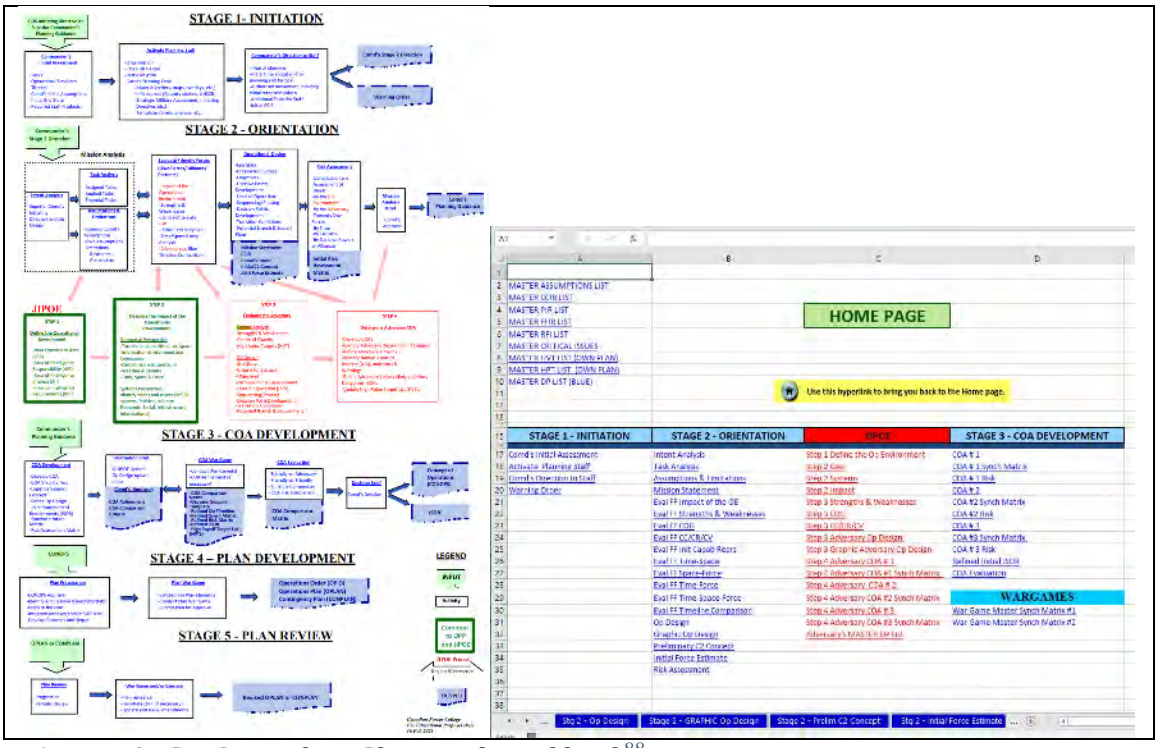

Figure 10. CF OPP Flow Chart and Workbook[88]

Despite the complexities / frustrations noted above of the OPP, is embraced by our NATO allies, and is taught as part of command level courses across the world. The output of the entire process is generally a Wargame, which is often played out in a room filled with charts and a large map of the operating area; alternatively, the wargame can be played using online meeting tools like Miro (see figure 11). The time required to work through an OPP is not trivial, and at times certain staff members are incredibly busy for days at a time, while others are bored out of their mind waiting for another member to deliver on a product. There is also the very real issue that the products being delivered vary in quality based on the experience level of the person who created them. When we consider that the average rank / salary of the individuals sequestered into this OPP

[88] Ibid.

process, I see an opportunity for AI to balance the workload and significantly reduce the number of people involved and increase the consistency of output quality.

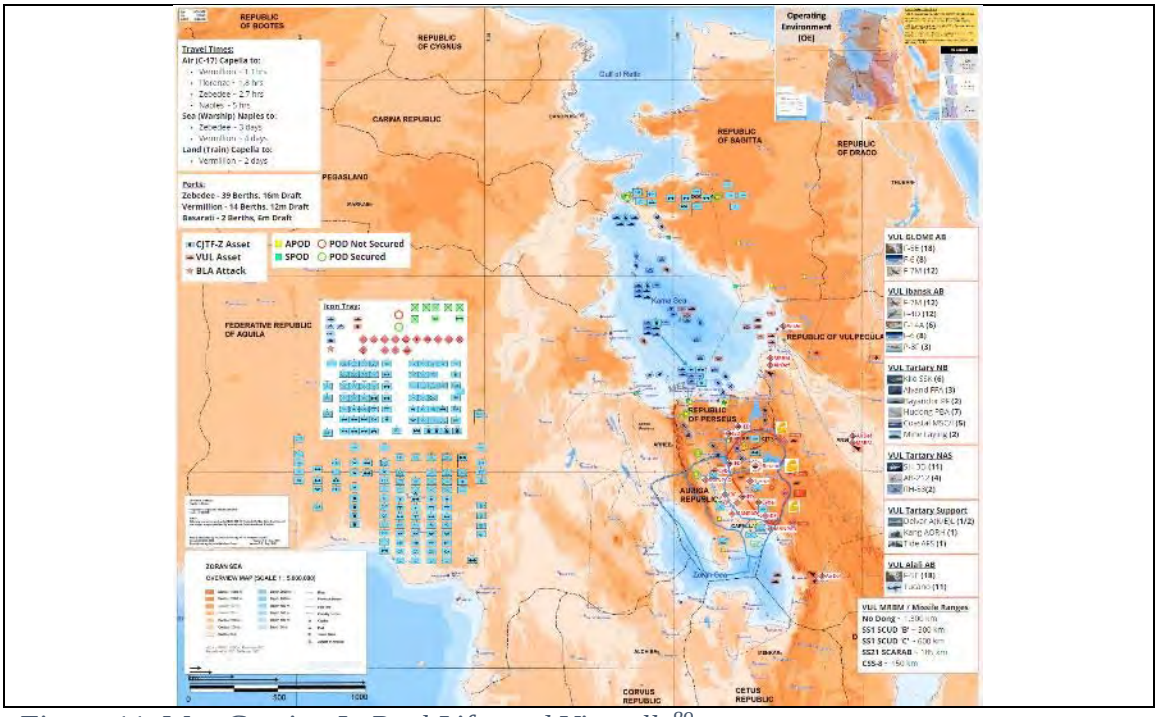

Figure 11. War Gaming In Real Life, and Virtually[89]

Adapting an AI to 'play OPP', in the same way that we discussed AlphaStar and OpenAI Five playing non-deterministic MOBA and RTS games against human adversaries, may initially seem difficult because some of the deductions and inferences required during the OPP do not seem like things a typical computer program could generate meaningful output for. This is indeed a problem for the tools we typically have at our disposal; it is tricky to write a macro for excel that can automate a Stage 1 impact analysis, for instance. Yet, if we break the problem down and look at what AI is good at, we can quickly see that a neural network could learn OPP. Furthermore, many of the tasks that are challenging for humans (like range determinations on maps, and producing meaningful visualizations of force packages on various game boards) would be trivial for

[89] These images were taken from CFC course material, and from the Phoenix Warrior Exercise of JCSP 47.

an AI. Speaking from experience, as the creator of the JCSP 47 gameboards and tools, entirely too much time can be spent on setup which has little inherent benefit to the actual steps of the OPP (beyond enabling the process).

You can do what?

Let us take a look at some examples of the ways an AI could dominate OPP in the same way that so many other 'games' were defeated. For one an AI could track a nearly infinite number of variables related to each unit being considered. A human has a notional understanding of what a CC-177 is and can generally come up with some stats on how far / fast it can travel in a given operating environment. An AI could instantiate a complete virtual representation of a CC-177 and automatically prompt the planners when a suggested route would be dangerous (due to enemy air defense), or if there a diversion was necessary for weather. Furthermore, the AI would not be confined to operating within a static game board; it could draw in real-time or simulated data about the operating environment and populate everything into a virtual environment that could be accessible to anyone with an authorized viewing device (PC, VR, Tablet, etc).

The simple example above shows how one unit could be enhanced by AI, imagine tying in the *actual* force disposition of both the friendly and enemy forces via real-time ISR feeds. In an instant the AI would be able to start making inferences about capabilities and limitations for each faction based on either pre-loaded data or even self-generated data based on playing with a unit in some form of 'sandbox' until a complete understanding of the physical characteristics is achieved. Imagine being given a Chinese amphibious landing craft, and thousands of years to run it through its paces; this is exactly what an AI could in a matter of days by running physical simulations across

various types of terrain, temperatures, sea states, etc. The simulation could also be as high fidelity as computationally possible (which would scale with time); eventually you could include stress calculations on individual components of the vehicle and track when, during a campaign, a certain unit might experience a breakdown.

With the same data set you could simulate millions of ballistic impacts to determine the most effective targeting parameters. This is *not* science fiction, this is an example of what AI can do today to produce an exponentially better comprehension of the operating environment with which to plan. In fact, this level of fidelity was achieved in 2020 in a paper by NVIDIA and the University of Copenhagen entitled "Detailed Rigid Body Simulation with Extended Position Based Dynamics".[90] Figure 12 shows a frame of a simulation of a toy car; it is physically modelled to a very high level of detail, including the electric motor brushes and steering arms. In video of the animation, you can see torsion on the components, deformation of the springs and tires, and bending in the frame as the vehicle encounters obstacles. Even more amazing is that each frame of that simulation was rendered in 18 milliseconds (or ~55.5 frames per second).[91] Imagine what a nearly endless supply of physically based data on an opponent's unit level capabilities could mean for enhanced decision making, Course of Action (COA) development, and the fidelity of planning in general.

[90] Matthias Müller et al., "Detailed Rigid Body Simulation with Extended Position Based Dynamics," 39, 2020, no. 8.
[91] Ibid., 8.

Figure 12. Screen capture from Müller et al. – Real-time deformation / wear of a complex virtual vehicle

Beyond the Wargame

As we discussed in Chapter 2, Russia has advertised that they have already fielded a sort of AI driven C2 tablet at the unit level in exercise. Presumably the Russian system is doing some of what was described above but sticking to the basics like using ISR to plot the position of various battlespace object, marking hazard maps for weapons ranges, and offering rudimentary path finding / fires recommendations to the soldiers. Now imagine what else could be done with the addition of Augmented Reality, and a more robust AI that could be re-trained based on what it was actually seeing in the field.

Another aspect of AI that we haven't discussed beyond a mention of personal assistants is natural language processing. We should all be familiar with the likes of Apple's Siri, Amazon Echo, and Google Assistant; these all have somewhat mechanical tones, and would not pass the Turing test described in Chapter 1. Companies are, however, using AI to enhance both the inference, and the intonation of these 'chat-bots'. Google Duplex, for instance, was revealed in 2018 as an AI based 'natural conversation

agent' that was capable of a live performance where it was able to make a reservation for dinner over the phone without alerting the receiving party to the fact that they were talking to an AI.[92] Enabling this kind of interface with a wearable head mounted display / AR device could enable soldiers on the battle field to maintain combat effectiveness while receiving high fidelity contextual updates of the battlespace.

The American DoD has been looking at the kind of technology described above with their Joint All Domain Command and Control initiative.[93] The Defense Innovations Board noted of the use of AI in such situations: "These benefits are particularly relevant to the Department of Defense (DoD), where data-driven situational awareness and speed of decision-making define advantage on and off the battlefield".[94] This paints an exciting future for AI on the battlefield, but also a warning that this technology is likely already being fielded and nations who are not in close pursuit will be at a significant disadvantage.

Joint AI Planning of the Operational Environment

The current OPP relies heavily on something called Joint Intelligence Preparation of the Operating Environment (JIPOE), which can be seen in Stage 2 of the flow chart in Figure 10. The British adaptation of the OPP process defines JIPOE as "describe(ing) the main characteristics and allows the planning staff to further assess the potential impact of

92 "Google Duplex: An AI System for Accomplishing Real-World Tasks Over the Phone," Google AI Blog, accessed May 11, 2021, http://ai.googleblog.com/2018/05/duplex-ai-system-for-natural-conversation.html.

93 Charles Pope, "Advanced Battle Management System Field Test," U.S. Air Force, September 3, 2020, https://www.af.mil/News/Article-Display/Article/2336618/advanced-battle-management-system-field-test-brings-joint-force-together-across/..

94 DiB, "Defence Innovations Advisory Board - Signed Public Meeting Minutes," Opening Minutes (The Pentagon, Washington, D.C., 2016).

the operating environment on accomplishment of the mission".[95] In our training the JIPOE team was largely responsible for collecting information on the enemy, and 'red-teaming' during the wargame. Having played the role during JCSP, I can say that the JIPOE role is extremely important to enable the friendly forces to develop a coherent plan that has a chance of achieving success. I can also say that the process is imperfect, riddled with assumptions, and highly dependent on having someone who is experienced with both the process and the enemy capability. Unfortunately, such a person does not always exist on the planning staff; this means that there are either gaps in the planning, or false assumptions being made that could result in a significant disadvantage if a poor plan makes it to the front lines.

What if, by adding just one letter, we could demonstrate the potential advantages of incorporating AI into an already familiar process? I propose that the CAF begins a project to test an AI agent for JIPOE, or JAIPOE. The distinction could be semantics, but the impact it would have on the results of planning exercises has the potential to save lives, and significantly reduce the workload of the staff members who typically get run to the bone anytime a serious plan has to come together. With the technology available today, there is simply no excuse to hope that you have the right people on a planning team; with AI the size of planning teams can shrink, and the reliance on familiarity with the process (and enemy) could nearly be eliminated. Better command level decisions, and a better work life balance seem like a good outcome.

[95] "Allied Joint Doctrine for the Planning of Operations" (UK: MoD, 2019), 3–5, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/971390/20210310-AJP_5_with_UK_elem_final_web.pdf.

An End State to be Proud of

There are certainly challenges to implementing AI within the CAF as I have outlined above. The amount of data required to train the AI agents prior to useful output being generated likely exceeds our current collection regimes; although this could be remedied through the tailoring of sensor employment and user interfaces mentioned in Chapter 2. We could also use a 'MilAI sandbox' that could generate data from high fidelity physical models (as described above), which would be an excellent method of creating a proof of concept for command to buy into the idea.

To do any of this, we will need people within our ranks that are comfortable with the tools of AI. PyTorch, Tensor Flow, Apple ML, and other open-source AI frameworks make it easier than ever to get started; unfortunately, there is a barrier to entry for people who are perhaps not familiar with computer programing environments (though they have become very user-friendly lately). What would be ideal is if we take Eric Schmidt's advice, and develop a program for graduate students to simply come do research with the Military (hopefully while avoiding a situation like Google's blowback over Project Maven).[96]

Of course, we need to adhere to the tenet of the ethical frameworks that Canada has committed to; we should also be a guiding entity within the discussions of AI ethics as the relate to military application. It is far to easy to get drawn into the fanciful ideas of movies, with killer robots and world ending errors in the evolution of AI, but the truth is that developing AI solutions for the military will save lives. Either by making better plans to reduce the time in conflict, or by giving back a handful of hours to our service

[96] CRAC, "Open Letter in Support of Google Employees and Tech Workers | ICRAC," ICRAC.Net

members every day, a military that can fight smarter is more likely to come home at the end of conflict. Ultimately, we owe it to those who put on the uniform to maximize the benefit of the information available to us, such that we can minimize the risk we ask our members to take in service to the country.

Serving the Public: Expectations and Perceptions

Public education on AI will hopefully become a priority for the GC. If we can shed the misconceptions, I would be surprised if the civilian population we protect would not be demanding the maximize the use of AI in our military. It will be especially important to keep people abreast of the developments of other nations, and how falling behind is too large a gamble with the stakes so high. As senior officers, we must also do what we can to educate the government and military leaders on what AI brings to the table, and why it is a moral responsibility to make it work. With the evidence available today, there can be no denying that AI will be integrated with national security matters; the only variables seem to be ‘who’ and ‘when’.

CONCLUSION

When humans attempt to solve problems, we are often constrained by the perceived logic of 'the know'; we have difficulty thinking outside the paradigm of our own experience. The preceding statement forms a basis for the need to start the conversation on AI in the military as a moral imperative for our servicemembers and our nation as a whole. Such a conversation should have started years ago, when Canada issued its initial AI Strategy.

In Chapter 1, we looked at the field of AI in 2021, with a wide range of examples that may have initially seemed tangential to the concept of integrating AI with military matters. By expanding on the technology behind those examples and identifying the long game of the companies / entities involved, the tangents should have started to conform more closely with the thesis of this paper. Some of the progress that has been made is truly remarkable, and I encourage readers to check in to see what advancements have been made since (we might be surprised by what the Nerualink monkey is able to do now).

Chapter 2 allowed us to see the reality of AI on the world stage, as we are often too insulated as Canadians. We looked at the global market share, which is largely vested in the private sector, and took the time to investigate what three of the world's superpowers are getting up to in the field. Though the United States seems to be leading a good charge in the development and democratization of AI (in both the military and private sectors), China and Russia are taking significant steps to compete. Russia's thrust seems to favor early adoption of sub-optimal AI solutions; this may work out in their favor compared to nations that get no experience before a 'perfect' solution is on offer.

China, for all its secrecy, has seemingly been working on AI the longest; the CCP has committed to becoming the world leader in AI, and doesn't seem to care how much it will cost. The West must be conscious of the fact that the Russian and Chinese regulatory structures may not be sufficient to prevent the sloppy development of AI defence solutions that have unintended consequences. In the (insane) absence of a regulative body on AI, we must remember that the access to the tools for AI development are largely open source; this means that while we focus on the obvious players, there may be a massive disruption about come out of left field. This furthers the argument that we must act quickly to ensure that we are not put at risk from vectors we have not considered (due to a lackadaisical approach to understanding the implications of AI).

Finally, Chapter 3 got to the crux of what Canada may want to do to explore defence related AI teaming, acknowledging the significant financial and societal constrains we have to contend with. Given that the US features prominently in our strategic partnerships, we could probably ride their coattails until a proven Mil-AI concept is fielded; I suggest that this would be a missed opportunity, given the relative ease with which we could demonstrate leadership instead. Doing so would go a long way to instill confidence in our CAF members, and the public writ large, that AI is a net gain across all domains. One of the biggest challenges to maximizing the utility of AI, whether part of an OPP overhaul or not, will be challenging our preconceptions about data – we need more, much more, and should stop wasting opportunities to collect it.

We can not wait for someone else to drag us into the 21st century. The sooner we resume a leadership role in AI, the sooner we will secure a safer future for all Canadians. We are morally bound to ensure that we are using available technology to maximum

effect to safeguard the lives under our command; and only by facing the challenge of AI *now* can we meet that obligation.

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