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Closing the Tech Gap: A CAF Startup Model for Digital Transformation

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CLOSING THE TECH GAP: A CAF STARTUP MODEL FOR DIGITAL TRANSFORMATION

By Lieutenant-Colonel Kenneth Bedley

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ABSTRACT

The world is being transformed by the growth of digital technology in life, work, and war. Innovations such as Artificial Intelligence have provided organizations with an operational advantage over others that cannot adopt this technology. The Canadian Armed Forces (CAF) is falling behind in its ability to evolve within the world's cyber landscape, creating a capability gap for future warfare. In recognition of this gap, the defence policy Strong Secure Engaged (SSE) has identified the need to advance CAF digital transformation to uphold national security and Canadian sovereignty. The Canadian Government also recognized this need by creating the Minister of Digital Government in 2019 to leverage digital technologies for the service of all Canadians. The DND and CAF now need a path towards digital transformation.

This paper will analyze how the industry best practice of Development and IT Operations (DevOps) is a model to accelerate digital transformation within the CAF. The paper will explore the US/China great power competition and CAF's current capability development model to frame the problem space of this research. The problem space will function as grounds for motivating the CAF's need for urgent digital reform. The foundational elements of DevOps will be detailed and compared against two case studies. The first case will examine the Joint Battlespace Management Capability as an example of the CAF's current ability for digital technology acquisition. The second case will examine the United States Air Force Kessel Run initiative as an example of the DevOps framework. Finally, the analysis will propose that DevOps be used as a CAF Startup model to stimulate innovation and accelerate the CAF's digital evolution for tomorrow's war.

CHAPTER 1: INTRODUCTION

> *In practice, we always base our preparations against an enemy on the assumption that his plans are good; indeed, it is right to rest our hopes not on a belief in his blunders, but on the soundness of our provisions. Nor ought we to believe that there is much difference between man and man, but to think that the superiority lies with him who is reared in the severest school*
>
> — Thucydides, *History of the Peloponnesian War*

Since the advent of warfare, technology has played a pivotal role in its outcome. From paved roads enabling efficient Roman conquest, gunpowder in China, shipbuilding in Britain, nuclear weapons, and the internet in the US, technology and the race to obtain it has been at the forefront of military interest for millennia. It is typically the side that possesses superior advancements in technology and the industrial base that can enable it will win the war. The development of atomic weapons through the Manhattan Project[1] serves to show how advanced technology can revolutionize warfare.[2] Political and defence scientists have established an inextricable link between science and technology development and the global great power competition.[3] In the past century, in addition to the atomic weapon, military Research and Development (R&D) delivered technological breakthroughs with supersonics, orbital space flight, computing technologies and the internet.[4] This last technological development has created a dynamic trend that disrupts

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[1] Thomas Gillier and Sylvain Lenfle, "Experimenting in the Unknown: Lessons from the Manhattan Project," *European Management Review* 16, no. 2 (2019), 449-469. 450. The Manhatten Project was the program that was responsible for developing the first atomic weapon during WWII. The projects success in developing this innovative technology lead to a world-changing revolution in warfare

[2] Max Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today* (New York: Gotham Books, (2006)., 359.

[3] Thomas G. Mahnken, Joseph Maiolo and D. Stevenson, *Arms Races in International Politics: From the Nineteenth to the Twenty-First Century*, eds. Thomas Mahnken, Joseph Maiolo and David Stevenson, 1st ed. (Oxford, UK; New York, NY: Oxford University Press, 2016). 12.

[4] The fist instances of the internet was a DoD DARPA created network (DARPANET) to share and collaborate information which is commonly established as the precursor to the internet.

the strategic environment, which is the basis for power competition.[5] Warfare in the digital landscape now demands armed forces to leverage this new domain to keep pace in the current technological arms race. The new domain is motivated by cyber warfare in an increasingly interconnected battlespace and fuelled by advancements such as Artificial Intelligence/Machine Learning (AI/ML).

The changing nature of conflict demands ingenuity and innovative thinking for success in the future fight. The demand for militaries to adapt and evolve with technological breakthroughs or mass disruption is often called a Revolution in Military Affairs (RMA).[6] It may not be surprising that the reader finds the application of RMA to Information Technology (IT) familiar, as it has been an older military challenge that led to the concepts of Network Centric Warfare (NCW) and Network Centric Operations (NCO).[7] However, while the public and industry enjoyed a steady increase of the advantages brought to them through the information age, the military has been challenged to adopt equivalent benefits at the same rate.[8] Nevertheless, the crux of the issue is still relevant to the CAF today in the pursuit of digitization, which is the motivation of this essay; to examine the divergent path between technological advancement and the rate at which the CAF can adopt it. In 1999, the book *Mind the Gap* described a similar issue

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[5] Ben FitzGerald, Kelley Sayler and William J. Lynn, *Creative Disruption:; Technology, Strategy and the Future of the Global Defense Industry* Center for a New American Security,(2014). http://www.jstor.org/stable/resrep06422., 11

[6] David C. Gompert et al., *Mind the Gap: Promoting a Transatlantic Revolution in Military Affairs* (Washington, DC: National Defense University Press, (1999). 3

[7] Paul T. Mitchell and International Institute for Strategic Studies, *Network Centric Warfare: Coalition Operations in the Age of US Military Primacy*, Vol. no. 385 (Abingdon; New York: Routledge, 2013)., 28. The NCW concept was first introduced in 1998 IN THE US Naval Institute *Proceedings*. In essence it was the application of IT to improve the information sharing and decision-making abilities of military operations.

[8] Paul T. Mitchell, *Network Centric Warfare and Coalition Operations: The New Military Operating System* (New York, NY: Routledge, (2009))., 5.

when comparing the US and NATO's divergent paths of adopting IT and network-enabled warfare, creating a disparity in military capabilities.[9] This problem still exists, which this essay aims to address: Where does the CAF stand in the current digital technology gap? What elements are needed to mitigate exponential growth and proliferation in digital technologies affecting war? Why should the CAF pay attention to this issue now? For two reasons: Operational Relevancy and Digital Evolution. The US and Canadian allies now recognize they are contested on the technology development race and have accelerated efforts to stop it.[10] The CAF also needs to maintain its operational relevancy on this front.

The digital landscape sees a faster evolution of digital technology than ever with AI/ML, block-chain-controlled cryptocurrency, Cloud Computing, and the Internet of Things (IoT), to name a few.[11] As their online and mobile device equivalents replace traditional business services, organizations must now invest in conducting software development and operations with the digital infrastructure enabling it.[12] Accordingly, Canada and its allies are developing new concepts such as Joint All-Domain Command and Control (JADC2) and CAF Pan-domain Force Employment Concept (PFEC).[13] These concepts demand new development and management tools to maintain operational

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[9] Gompert, *Mind the gap…,.* The main problem described in 'Mind the Gap' is that the US was well ahead of its European allies in developing and incorporating the latest advancements in information technology. Because this was envisioned to create a growing gap in US and alliance capabilities, it imposed an operational risk towards contenting with peer adversaries as it eroded the collective effectiveness of NATO.
[10] Eric Edelman et al., *PROVIDING FOR THE COMMON DEFENSE: The Assessment and Recommendations of the National Defense Strategy Commission*, Vol. 99 Fort Leavenworth: Department of the Army Headquarters, (2019). 25.
[11] Michael Kwet, *Digital Colonialism Longreads.Tni.Org/Digital-Colonialism-the-Evolution-of-Us-Empire the Evolution of US Empire*, (2021).
[12] Kieran Taylor, Aruna Ravichandran and Peter Waterhouse, *DevOps for Digital Leaders: Reignite Business with a Modern DevOps-Enabled Software Factory* (Berkeley, CA: Apress, 2016a). 5.
[13] Bao Nguyen, *Ideas for Pan Domain Exercises: Information Operations and the Impact of the Strategy of Winning Hearts and Minds* Defence Research and Development Canada, (2021)., 6.

relevancy in the world's growing digital ecosystem.[14] The CAF must adapt and evolve to close the gap between its current digital state and where the world is progressing.[15]

This paper will study Development and IT Operations (DevOps) framework as a software and technology acquisition model, which will help accelerate the CAF digital evolution and improve the technology acquisition required for current and emergent threats. The study will focus on CAF's current ability to adapt to emergent technological trends and demonstrate that software and agile technology acquisition will be essential for the future. The paper argues that CAF has not made any substantial improvements towards digital technology acquisition. The CAF has fallen short in three substantive areas. First, the CAF has not established the necessary policy and organizational framework from which a digital transformation and acquisition can proceed effectively. Second, the CAF has not fully established an environment conducive to the innovation and talent required for significant change in the digital landscape. Finally, the CAF has not evolved its enterprise architecture to a sufficient degree to enable an enduring platform to enable a fully digital organization.

This paper will develop the study through five chapters that will illustrate the context of the study, then present the grounds for the development of a new acquisition model through two case studies. Chapter two will frame the problem space to demonstrate why the CAF should change its technology acquisition model using the great power competition between the US and China as motivation. Chapter three will describe the current problem with the DND/CAF's capability development model, indicating why

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[14] Kevin Budning, Alex Wilner and Guillaume Cote, "Connecting the Dots on Canada's Connected Battlespace," *International Journal (Toronto)* 76, no. 1 (2021), 154-162. 155.

[15] Phil Zimmerman, Tracee Gilbert and Frank Salvatore, "Digital Engineering Transformation Across the Department of Defense," *Journal of Defense Modeling and Simulation* 16, no. 4 (2019), 325-338. 326

the waterfall project management process is not conducive to digital technology. Chapter four outlines the foundational elements forming a proposed acquisition model, its history, its structure, and how it works. The following chapters will cover two case studies that will explain how the CAF's current technology acquisition model is functioning, followed by a chapter on how the suggested model works through an example in the US Air Force (USAF). For the first case study, a recently closed CAF major capital project illustrates an attempt at digital technology development. The project selected for this was the Joint Intelligence and Information Fusion Capability (JIIFC) and Joint Battlespace Management Capability (JBMC) because it demonstrates the aspects of the CAF where changes to digital capability development are needed.

The second case study will explain how the Department of Defense (DoD) and USAF have already experienced the problem of failed digital evolution impacting operations in Iraq and created a new model for agile technology acquisition. This project formed under the USAF Life Cycle Material Command called Kessel Run was created out of the Defense Innovation Unit Experimental (DIUx). It is one example of DoD creating an acquisition policy reform. The paper concludes with the overall assessment of implementing a new technology acquisition model using principles from DevOps and provides recommendations for digital transformation that the CAF must address.[16]

[16] The DevOps framework will be explained with a primer in Chapter 4: Building the Foundation

CHAPTER 2: STRATEGIC PROBLEMS

> *In a bureaucracy, control is being enforced simply because you can. With new technological possibility, control will be evermore minute.*
>
> ― General Stanley McChrystal, *Team of Teams*

The CAF needs to focus on a new way of fighting in the future battlefield – a battlefield defined by a web of digitization, which breaks through all conventions of traditional domains of warfare.[17] Although the latest defence policy, *Strong, Secure, Engaged* (SSE), recognizes this challenge by committing a technological development effort, there remains a lack of a focus on the digital transformation front needed to keep pace with allies and the evolving threat landscape.[18] The great power competitions are accelerating the rate of change for future warfare. Canada's key allies are already making significant advancements in evolving towards this threat, realizing that the technological advantage of western militaries has eroded over the last two decades.[19] Moreover, the technological advancements by the US are linked to Canada through the collective security of North America and Canada's ability to be interoperable for future wars.[20] DND will need to make significant preparations to understand and adopt the emergent trends in digital technologies; in doing so, the CAF will close the capability gap between Canada and its allies. A new agile technology development framework will serve as the needed agent for these preparations.

Unfortunately, DND's current capability acquisition model for new technology does not enable the agility needed to contend with the proliferation of digitization and its

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[17] Thomas Juneau et al., *Canadian Defence Policy in Theory and Practice* (Cham, Switzerland: Palgrave Macmillan, (2019). 389.
[18] Canada, *Strong Secure Engaged Canada's Defence Policy* Ottawa: Department of National Defence, (2017). 55.
[19] United Kingdom, *Defence in a Competitive Age.* Ministry of Defence, (2021). 8.
[20] Canada, *The Future Security Environment 2013-2040.* Department of National Defence, (2017). 6.

application towards war. [21] DND has traditionally been late to adopt innovative and new technologies. They instead focused on maintaining legacy systems and internal processes.[22] DND's outdated policies from which our capability acquisition strategies are modelled are still based on Cold War-era capabilities and timeframes.[23] These processes are founded on an analogue system design, meaning that the Department is not yet seeking full advantages of a digital organization.[24] The CAF needs to be equipped and prepared to counter emerging threats fuelled by new technologies. If not, operational risk will be introduced, impacting the ability to defend Canada and Canada's interests.[25] A prioritized effort to accelerate DND's technology acquisition strategy can be achieved through incremental steps and accelerating digital transformation.

This chapter will examine the literature and research related to establishing strategic motivation and problems through the great power competition between the US and China. It will also examine the policy issues impacting digital transformation.

[21] In this context capability acquisition will encompass the entire process of DND capability development lifecycle, which includes the steps from concept design, project management, procurement, and in-service support of the capability. For this paper, acquisition will focus on digital technologies.
[22] Juneau et al., *Canadian Defence Policy in Theory and Practice*…, 332.
[23] Ibid. 335.
[24] Aleksandar Boskovic, Dinko Primorac and Goran Kozina, "Digital Organizations and Digital Transformation," *Economic and Social Development: Book of Proceedings* (2019), 263-269. 264.The concept of digital transformation will be further detailed in Chapter 2, but the point here is that digital organization inherently have are more efficient in corporate management and business efficiency.
[25] Canada, *The Future Security Environment 2013-2040.* Department of National Defence,(2017). 3

The Great Power Competition

Let China Sleep, for when she wakes, she will shake the world.

— Napoleon Bonaparte

If Thucydides were alive today, analyzing the ebb and flow of power between nations over the past century, he might have seen much familiarity with what transpired in ancient Greece. Revolution in warfare has coincided with many advancements in technologies and military capability throughout history. However, it is the most recent IT developments that are creating a significant change in warfare.[26] The foreign policies and defence institutions that support the ability to adapt in the last two decades are insufficient. They do not keep up with the rapid pace of digital technology advancement. For example, former Secretary of Defense Ash Carter indicated that the great US power, globally respected by both allies and adversaries, is eroding. "The point of the spear is sharp and hard, but much of the rest of the national security establishment is deficient or broken".[27] Christian Brose, the former National Security Advisor to Senator John McCain, identifies the current power contest between China and the US as an urgent wake-up call to prepare the institution for this new threat landscape.[28] In 2017, President Xi Jinping report to the 19th Communist Party of China (CPC) National Congress set a vision for the middle of the 21st century to be a global leader who will possess international influence. Its military will be a fundamental component.[29] China is

[26] Boot, *War made New...*, 25
[27] Ashton B. Carter and John P. White, *Keeping the Edge: Managing Defense for the Future* (Cambridge, Mass: MIT Press, (2001). 19.
[28] Christian Brose, *The Kill Chain: Defending America in the Future of High-Tech Warfare* (New York, NY: Hachette Books, (2020). 8.
[29] Xi Jinping, "Secure a Decisive Victory in Building a Moderately Prosperous Society in all Respects and Strive for the Great Success of Socialism with Chinese Characteristics for a New Era(I)," *Beijing Review,* 2017, 25.

accelerating technology development that is outpacing US counter technologies, creating critical operational vulnerabilities due to the still Cold War-era development cycle guiding US capability development.

One example of China's ability to begin closing the technology gap with the US is the 'carrier killer' that will be able to render a multi-billion dollar platform inoperable.[30] This weapon, known as the DF-21D, is an anti-carrier ballistic missile that can defeat the largest and most capable aircraft carrier at one-thousandth of the cost of the $13B platform.[31] The US solution to counter this threat is to launch multiple SM-3 interceptor missiles at the cost of $12-24M each.[32] This example illustrates that China can defeat or deter the US carrier strike groups in the western Pacific for a relatively inexpensive development process and questions if significant defence investments in traditional platforms achieve a proportional military advantage. If the US instantly created a solution to defend their carrier strike groups effectively or achieve the same effect as a carrier strike group - what would it look like, and how could they do it? The Chinese are investigating this very question, and their development of Anti-Access / Area Denial (A2/AD) capabilities indicates this.[33]

This competition represents a seminal challenge, fuelled by the accelerating rate of technological advancement testing the limits of future military capabilities.[34] For the first time in history, the US is now at risk of being dislodged from the top of global

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[30] Andrew Erickson, "Ballistic Trajectory: China Develops New Anti-Ship Missile," *Jane's Intelligence Review* (Feb, 2010). 2.
[31] *Ibid*. The estimated cost of one DF-21D is $5-10M
[32] Robert Martinage, "Toward a New Offset Strategy Exploiting U.S. Long-Term Advantages to Restore U.S. Global Power Projection Capability," *Center for Strategic and Budgetary Assessments* (2014). 36
[33] United States of America, *INDO-PACIFIC Strategy Report: Preparedness, Partnerships, and Promoting a Networked Region* Department of Defense, (2019). 8.
[34] Michele Flournoy and Gabrielle Chefitz, *Sharpening the U.S. Military's Edge: Critical Steps for the Next Administration* Center of New American Security, (2020). 1

technological and economic dominance.[35] China's rapid evolution of technology and weapon development across all domains of warfare could defeat the US in a war. In a hypothetical scenario, there are many avenues that China could defeat the US. Cyberwarfare, hypersonic weapons, and A2/AD systems are credible challenges towards US forces.[36] Former Charmain of the Senate Armed Services Committee John McCain concluded in discussing a hypothetical war with China that "Many US forces would be rendered deaf, dumb, and blind [by China]".[37] The US's ability to develop counter capabilities creates a new form of arms racing, only now fueled by cyber warfare and digitization.[38]

The example of China and the US represents polarity in military capabilities driven by an agile development of new technology. Although deeper discussions of the great power competition between China and the US are beyond the scope of this paper, it is essential to recognize that the US does deem China a national security threat because of their accelerating abilities for technology development.[39] However, unlike the Cold War with the former Soviet Union, the threat is not founded on a race to space or a bigger A-bomb; instead, exploiting digital technology and Cyberwarfare can accelerate development used to counter conventional threats.[40]

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[35] Eric Edelman et al., *PROVIDING FOR THE COMMON DEFENSE: The Assessment and Recommendations of the National Defense Strategy Commission*, Vol. 99 Fort Leavenworth: Department of the Army Headquarters, (2019), 89. 6.
[36] U.S. Congress. House Committee on Armed Services, *Future of Defense Task Force Report 2020. Congressional Publications*,(2020)., 36.
[37] Brose, *The Kill Chain...*, 10.
[38] Kathy Gilsinan, "How the U.S. could Lose a War with China," https://www.theatlantic.com/politics/archive/2019/07/china-us-war/594793/ (accessed Apr 22, 2021).
[39] Michael Brown, Eric Chewning and Pavneet Singh, *Preparing the United States for the Superpower Marathon with China*, (2020)., 2.
[40] Anja Manuel And and Kathleen Hicks, *Can China's Military Win the Tech War? how the United States should-and should Not- Counter Beijing's Civil-Military Fusion*, 2020).The national security threat has been recognized by US congress, not necessarily because they are at parity with military capability, by rather due to their long-term economic investment goals with the Belt and Road Initiatives (BRI) with will

For the Chinese, stealing Western intellectual property means they will not need to dedicate time, people and money towards R&D saving them billions of dollars and years of development time.[41] Thus, the Chinese Cyber-espionage strategy represents a significant threat to Western military security by potentially closing the technology superiority gap.[42] Figure 2.1 is an illustrative example of the Chinese J-20 allegedly based on the stolen US F-35 documents.[43] Despite the veracity of this allegation, the J-20 and J-31 development indicate China's accelerated ability to develop peer capabilities that can threaten the US F-35.[44] Although espionage is not a new strategy in seeking military advantage, the development of cyber warfare tactics on an ever-increasing digital landscape makes it more attainable for adversaries.[45] This growing threat has been acknowledged by the CAF in the Future Security Environment (FSE) 2040 paper, indicating that the CAF will need to focus on developing an improved C4ISR architecture, developing the latest networking technology, and increasing the talent and skills needed to manoeuvre in cyberspace.[46]

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provide them with the long-term potential to create an advantage in technology and innovation. Moreover, the human capital and government/civilian intersection with Chinese industry allow them to bring new technologies to bear in the military more quickly in than the US.

[41] Derek Adam Levine, "Made in China 2025: China's Strategy for Becoming a Global High-Tech Superpower and its Implications for the U.S. Economy, National Security, and Free Trade," *Journal of Strategic Security* 13, no. 3 (2020), 1-16., 7.

[42] *Ibid*. An example of this is the Chinese development of the J-20 steal fighter which looks remarkable similar to the US F-22.

[43]. Jason Lomberg, "China's J-20 and J-31 Stealth Fighters Based on Stolen F-35 Documents," *ECN* (2015).

[44] Mark B. Schneider, *The U.s. F-35 Versus the Prc J-20*, Vol. 143 (Annapolis: United States Naval Institute, 2017), 70-72.,71. Although there was no conclusive evidence of the J-20 and J-31 being developed as a direct result of cyber-espionage, Lockheed Martin HQ did admit that a 2007 cyber-attack resulted in F-35 stolen data contained information on radar systems, engine design, contour maps in addition to F-35 capabilities

[45] Anja Manuel, Pavneet Singh and Thompson Paine, *Compete, Contest and Collaborate: How to Win the Technology Race with China*, (2019). 7.

[46] Canada, *The Future Security Environment…*, 73.

Figure 2.1 – The Chinese J-20 Stealth Fighter compared to the US F-22, an alleged result of cyber-espionage

Source: China's J-20 can Take Down US F-22 with these Special Tactics - Defence View." https://defenceview.in/chinas-j-20-can-take-down-us-f-22-with-this-special-tactics/

Since the Cold War, there has been a growing gap between industries' ability to deliver digital technology and a state's ability to adopt it effectively into its military. China is closing this gap, giving them an advantage in technology acquisition by investing in the development of science and technology directly applicable to military capabilities.[47] This strategy is in line with what the Chinese President has proclaimed: "We must keep it firm in our minds that technology is the core combat capability, encourage innovations in major technologies, and conduct innovations independently".[48] The Chinese defence spending has increased 900% from 1990-2017. Their technological development for the military is more closely integrated with the defence industry than Western countries, meaning they can outpace competing states in military capability

[47] James Manyika, William H. McCraven and Adam Segal, *Innovation and National Security Keeping our Edge*Council of Foreign Relations, (2019)., 12.
[48] Xi, "Secure a Decisive Victory…"….48

development.[49] Therefore, does this suggest US, Canada and Western allies need to increase industry collaboration to accelerate military technology development?

According to US and Canadian defence policies, increasing the speed and agility of military procurement and technology development will counter current and emergent threats and maintain interoperability in future warfare, highlighting emergent digital technology. The US DoD 'Future of Defense' Task Force indicates using the Manhattan Project era as a model to re-align military capabilities with defence policy to accelerate technology acquisition through increased focus on R&D, agile procurement and leveraging innovative digital advancements in AI/ML.[50] Canada also recognizes this challenge. In 2013, a report analyzing the Canada First Defence Strategy stated that the application of defence policy did not reflect vulnerabilities associated with a lack of R&D, nor did it address the emergent technology trends within the industry. Furthermore, the latest report on the DND Investment plan notes the need to keep pace with the technology-driven power balance to maintain interoperability with allies.[51] Stone and Soloman highlight that technology must gain a military and strategic advantage and be at the forefront of capability acquisition, indicating that information technology would be a key enabler in capability development within DND.[52] This statement aligns federally with the new mandate to provide a digital governance framework based on installing a new Minister of Digital Government.[53] Finally, the Treasury Board of Canada's Digital

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[49] Brown et al., *Preparing the United States for the Superpower Marathon…*,. 11. Chinese defence spending was $17B in 1990 and increased to $152B in 2017.
[50] U.S. Congress. House Committee on Armed Services, *Future of Defense Task Force Report 2020. Congressional Publications*, (2020). 67.
[51] Canada, *Defence Investment Plan Update 2019*Department of National Defence,[2019]). 7.
[52] Juneau et al., *Canadian Defence Policy…*, 148.
[53] Canada, "Minister of Digital Government Mandate Letter," https://pm.gc.ca/en/mandate-letters/2019/12/13/minister-digital-government-mandate-letter (accessed Apr 26, 2021).

Operations Strategic Plan indicates that emergent technologies will be crucial for modernizing procurement and achieving digital government transformation.[54] Therefore, the DND/CAF will need to align its procurement transformation efforts accordingly.

Enabling digital transformation with defence establishments will be dependent on the private sector's ability and willingness to assist. The private sector has a growing reluctance to offer their technology for violence due to insufficient incentive and misalignment of goals. In a Brookings Institution Webinar moderated by Senior Research Fellow and Director of Research on Foreign Policy, Michael O'Hanlon commented on DoD and private sector relations. O'Hanlon indicated that if DoD shifted just 5 % of their budget towards improving private sector incentives to improved alignment with defence objectives, it would be an effective enabler for R&D, and in turn, accelerate new capabilities.[55] However, the current integration of the private sector in digital technologies is met with two fundamental challenges when attempting to close the technology gap; Security and Culture.

Culturally, private sector technology or Big Tech, has fundamentally different goals than the defence industry, creating integration challenges. From the security standpoint, the alignment of standards for the maintenance of information assurance and cybersecurity leads to a challenge in integrating private digital technology into military systems. Mitchell describes this issue as 'Control vs Anarchy', where the comparative open architecture of the public internet contrasts with military operational networks' strict security requirements.[56] Because of this issue, defence establishments have instituted

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[54] https://www.canada.ca/en/government/system/digital-government/digital-operations-strategic-plan-2018-2022.html (accessed Apr 26, 2021).
[55] Michael O'Hanlon et al., *The Brookings Institution Webinar the Future of High-Tech Warfare*,(2020)., 9.
[56] Mitchell, *Network Centric Warfare and Coalition Operations…*, 40.

rigid controls to integrate commercially available digital technologies.[57] Turner described the emergence of a 'counterculture' that was born out of the Manhattan Project era. The military-sponsored technology development during WW II through collaboration with industry and academia was an influencing factor in creating the internet in addition to the a-bomb it famously developed. [58] Ironically, the new tech culture from the Manhattan Project eventually grew to oppose the very military-industry collaboration that created it.[59] DoD's Project Maven demonstrated this concern.[60] In the early 2000s, one of Google Inc's mottos was 'Don't do Evil', which was to inform a culture of developing technology for the good and benefit of all.[61] This cultural bias created a crossroads with Project Maven, where now Google AI technology was being used to kill with US drone strikes.[62] Project Maven created much controversy and created a movement and division

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[57] Patrick Gallagher, *NIST 800-53 Security and Privacy Controls for Federal Information Systems and Organizations,* U.S. Department of Commerce, 2013).; Canada, *IT Security Risk Management: A Lifecycle Approach* Communication Security Establishment, (2012). The National Institute of Standards and Technology (NIST 800-53) and the Canadian Security Establishments (CSE) IT Security Guidance (ITSG-33) provide the security governance for the integration of commercial digital technologies into the defence IT architecture.

[58] Frederick Turner, *From Counterculture to Cyberculture: How Stewart Brand and the "Whole Earth Catalog" Brought Us "Wired" Magazine*, 2006)., 90. A counterculture is one that is opposed to the mainstream and in the context of technology, it is the cultural nucleus that laid the foundations for the culture of Silicon Valley and the 'dot com' era. The counterculture was essential for the innovation and collaboration needed for rapid scientific and technological breakthrough in the Manhatten Project, but in the 80s and 90s with the growth of the internet that same subculture that was spawned from military-industry collaboration became opposed to the military-industrial complex of the Vietnam Era.

[59] *Ibid.* 98.

[60] Deputy Secretary of Defense, *Memorandum: Establishment of an Algorithmic Warfare Cross-Functional Team (Project Maven)* (Washington: Department of Defense,[2017]). Project Maven was the pentagon's initiative to integrate A.I. and ML across all operational domains to keep pace with adversaries such as China. This project was imitated on 26 April 2017 in a Memorandum from the Deputy Secretary of Defense for the establishment of an Algorithmic Warfare Cross-Functional (AWCFT). The AWCFT subsequently partnered with Google to develop A.I. and ML algorithms to exploit Full-Motion Video (FMV) feeds from Unmanned Aerial Systems (UAS) for targeting the Islamic State of Iraq and Syria (ISIS) forces – effectively using A.I. and ML to kill.

[61] Penny Crofts and Honni van Rijswijk, "Negotiating 'Evil': Google, Project Maven and the Corporate Form," *Law, Technology and Humans* 2, no. 1 (2020), 75-90, 75.

[62] Timothy Bretl, Ludovic Righetti and Raj Madhavan, "Epstein, Project Maven, and some Reasons to Think about Where we Get our Funding [Ethical, Legal, and Societal Issues]," *IEEE Robotics & Automation Magazine* 26, no. 4 (2019), 8-13. 10.

between Silicon Valley and the DoD. As a result, Google decided to withdraw from continued collaboration with the DoD on AI, which is an indication that more significant effort and investment into industry collaboration and relationship building should occur.

An assessment of the US National Defense Strategy stresses that promoting alliances in bolstering collaboration within the commercial sector will be vital to countering emergent threats posed by China and disruptive technologies.[63] Canada needs to address this within its technology sector, keep pace with allies and not introduce any vulnerabilities that China, or near-peer adversaries, could exploit. One such example where the US is making progress is the Defence Innovation Unit (DIU), where it is recreating the partnerships with industry that the DoD once had.[64] This paper will explore one such initiative of the DIU in the Chapter 5 Case Study on Kessel Run.

The Policy

> *Even well-meaning gatekeepers slow innovation*.
>
> — Jeff Bezos, *Letter to Amazon Shareholders*

The development of warfighting capabilities was traditionally the domain of military and state-sponsored initiatives. They led the innovation and technology front, as was the case until the Cold War. More centralized and rigorous oversight in defence spending stymied the agility of capability development and defence acquisition throughout the Cold War.[65] The fundamental ability for a defence organization is to adapt

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[63] Eric Edelman et al., *PROVIDING FOR THE COMMON DEFENSE: The Assessment and Recommendations of the National Defense Strategy Commission*, Vol. 99 Fort Leavenworth: Department of the Army Headquarters, (2019), 28.
[64] Dan Lamothe, *Pentagon Chief Overhauls Silicon Valley Office, Will Open Similar Unit in Boston* (Washington: WP Company LLC d/b/a The Washington Post, (2016). 2.
[65] Ronald J. Fox et al., *Defence Acquisition Reform 1960-2009 an Elusive Goal* Washington, DC: Center of Military History, (2014). 98.

to the realm of digital technology is by keeping the focus on innovation and R&D.[66] The former Chairman of the Joint Chiefs of Staff, General John Dunford, stated in testimony to Congress in 2017, "In just a few years if we do not change the trajectory, we will lose our qualitative and quantitative competitive advantage."[67] The trajectory Dunford was alluding to was the downward trend that the US sees in Federal investment in technology. In 2019 the Council of Foreign Relations (CFR) indicated that federal spending on R&D in 2016 was 0.66% of the total Gross Domestic Product (GDP), compared to 1.86%, where it used to be in the 1960s during the space race. [68] However, private industry has replaced US Government defence R&D spending.[69] Over the last decade, the balance of R&D is inverted, exposing a critical vulnerability in defence innovation and capability development, as shown in Figure 2.2.

[66] Carter et al., *Keeping the Edge...*, 9.
[67] Jim Garamone, "Mattis, Dunford: 2018 Budget Will Continue Readiness Recovery," https://www.defense.gov/Explore/News/Article/Article/1214704/mattis-dunford-2018-budget-will-continue-readiness-recovery/ (accessed Feb 26, 2021). 1.
[68] Manyika et al., *Innovation and National Security*…, iii. The CFR is an independent and nonpartisan membership organization, think-tank and publisher aimed to deliver a better understanding of the world and foreign policy issues faced by the U.S. and other countries. The CFR sponsors independent Task Forces to analyse critical issues impacting US foreign policy to provide policy makers sound judgments and recommendations for the future. The Task Force members are from a diverse background focused on delivering constructive consensus through independent deliberations. The data in figure 2.2 was strictly focused on R&D spending to not include operational and capital investment costs of defence.
[69] *Ibid.* 22.

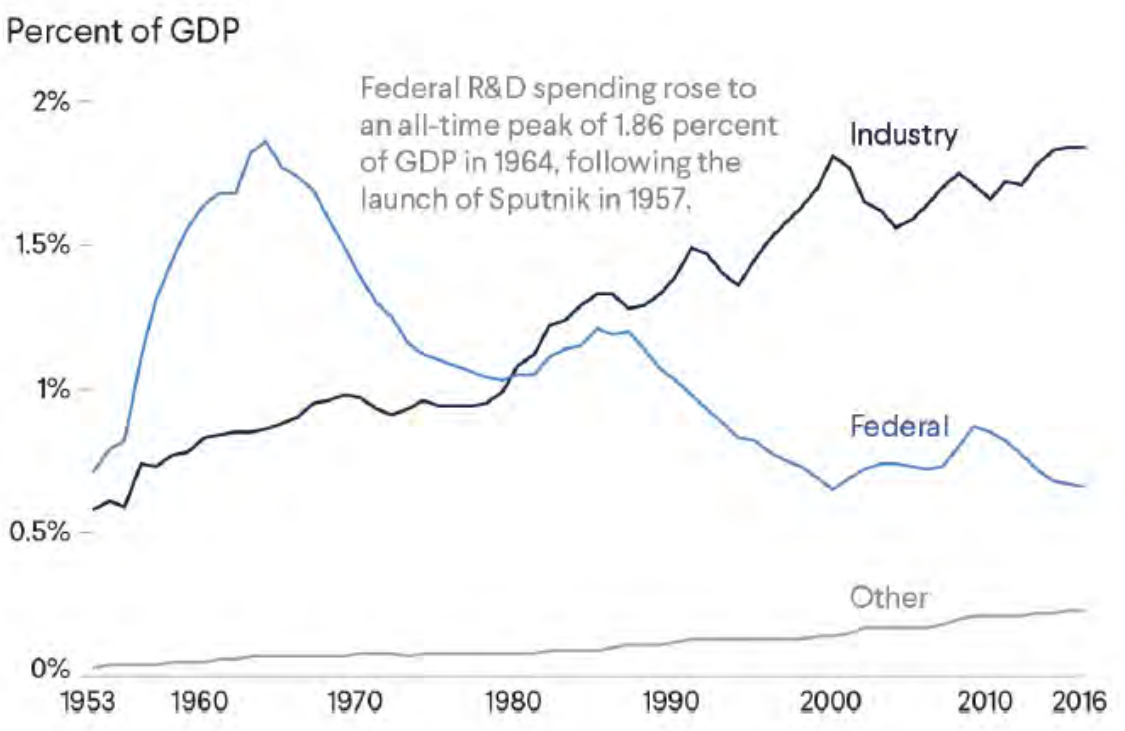

Figure 2.2 – US R&D Funding by Sector as a percentage of GDP

Source: National Science Foundation

Canadian defence shares this trend in defence spending shown in Figure 2.3. In 1980, there was an inflection point with DND capital investments, a downward trend that coincided with the deficit and reduction in defence spending ending the Cold War.[70] Although this downward trend indicates a reduction in economic potential, it diminishes DND's ability to adapt to emergent digital technologies needed for future warfare. [71]

[70] O'Hanlan, *Policy Paper: Defense Budgets...*, 2.

[71]. Canada, *Defence Investment Plan Update 2019* Department of National Defence, (2019). 8. Capital Investments one of three major components of defence spending. The other being people and operating and maintenance (O&M) costs. Capital Investments funding are those committed over longer periods time reserved for capital acquisition such as new air platforms, ships or major infrastructure project

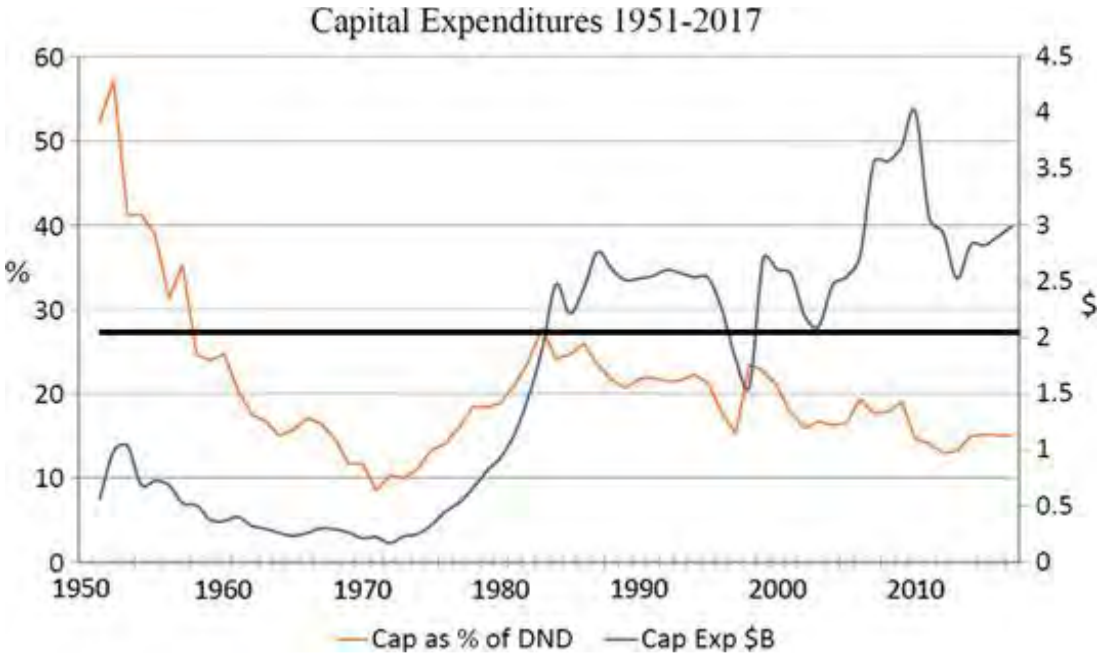

Figure 2.3 – Capital Expenditures as a Percentage of the Defence Services Program

Source: Receiver General Public Accounts - Excerpt[72]

Additionally, DND has locked capital funding into a non-agile procurement model and rigid accrual accounting.[73] In private industry, investment in innovation and R&D is now outpacing defence R&D. Figure 2.4 indicates the trend in R&D comparing Big Tech to defence R&D. If the defence can no longer be the leader in advancing digital technologies, then efforts to improving industry partnership will be necessary for the digital evolution.[74]

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[72] *Ibid.* 145.

[73] Juneau et al., *Canadian Defence Policy...*, 144

[74] When the Author was working in sub-unit command at the Canadian Air Defence Sector, he received a visit from the former NORAD Commander – General O'Shaughnessy where we discussed future challenges of North American Defence. In this discussion, it was an anecdotally shared that defence organization should recognize that there are current and future challenges in cyberspace that defence cannot solve, so we must rely industry as they can solve defence problems in the digital realm far better than defence could.

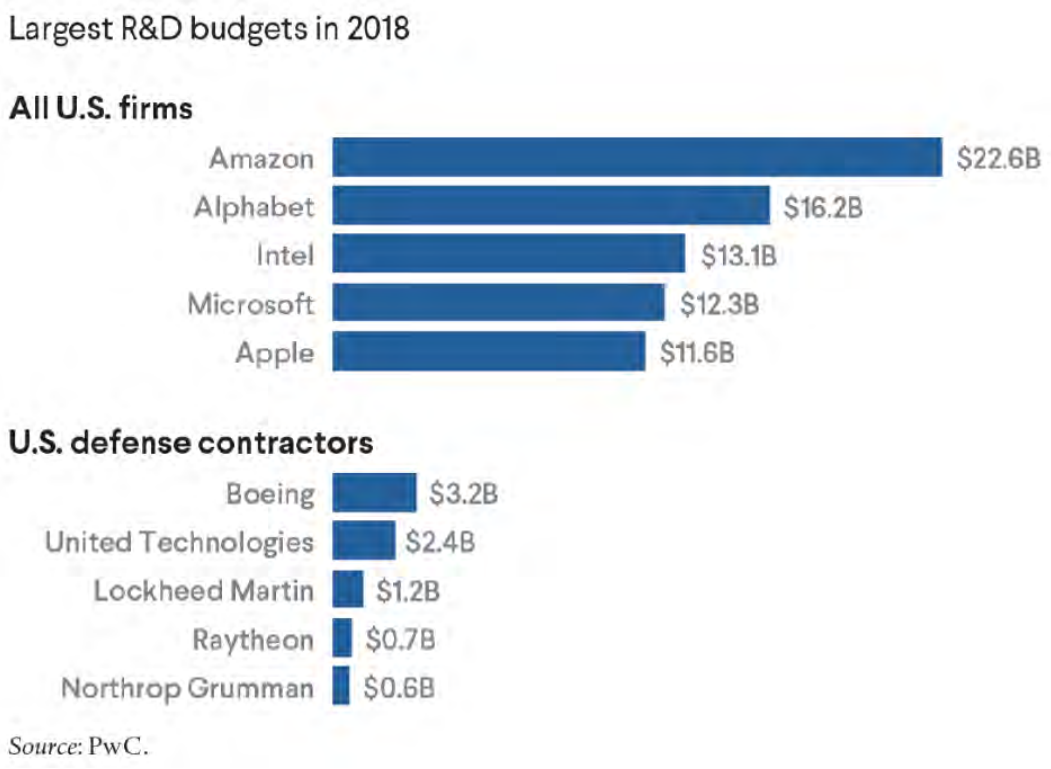

Figure 2.4 – Research and Development Investments in 2018

Source: Innovation and National Security Task Force

However, recognizing that the R&D efforts in commercial technologies may not be relevant to all military applications, DoD has recognized it is relevant in the realm of digital technology, as demonstrated by the Joint Enterprise Defence Infrastructure (JEDI) contract.[75] In 2017, the DoD Defense Deputy Secretary Patrick Shanahan issued a memorandum on 'Accelerating Cloud Adoption' stating:

> "I am directing aggressive steps to establish a culture of experimentation, adaption, and risk-taking; to ensure we are employing emerging technologies to

[75] Heather Kuldell and Frank Konkel, "JEDI: One Year in the Pentagon's Push for a Revolutionary Cloud," https://www.nextgov.com/feature/jedi-contract/ (accessed Apr 28, 2021). The JEDI contract was an $10B initiative started in 2017 with Defense Deputy Secretary Shanahan announcing that DoD will need a cloud-based computing platform to enable the increasingly interconnected defence organization and to better enable C4ISR and C2 capabilities to the warfighter. DoD recognizing they could not develop such an undertaking so they pursued Bit Tech (Amazon) to solve the problem for them.

> meet warfighter needs; and to increase speed and agility in technology development and procurement."[76]

The memorandum not only kicked off the multi-billion dollar JEDI contract, but it represented a start of how DoD is transforming R&D and technology acquisition. The commercial technology industry has been accelerating innovation and delivering new capabilities faster than the Government can develop ways to adopt them. A 2020 Pricewaterhouse Coopers Annual Trend Report to CEOs indicates a significant upward trend in Digital Technologies R&D as compared to the flat-lined Aerospace and Defence industry (Figure 2.5).[77] As with the DoD's JEDI contract, DND will need to take advantage of the private sector growth in digital technology and use it to evolve the capability and acquisition models for the future.

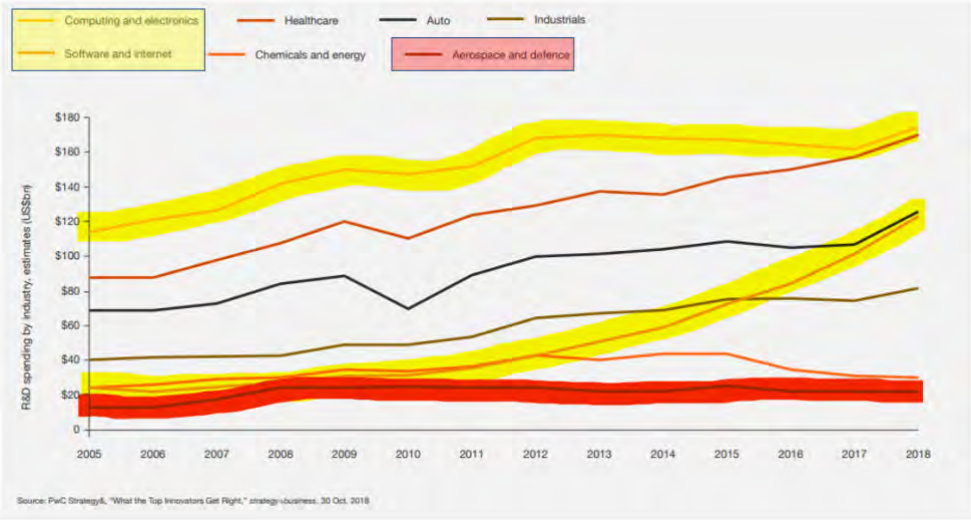

Figure 2.5 – Comparison of R&D Spending across industries

Source: PricewaterhouseCoopers, *Defence Trends 2020: Investing in a Digital Future*,[2020]). https://www.pwc.com/gx/en/ceo-survey/2020/trends/defence-trends-2020.pdf

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[76] Patrick Shanahan, *Memorandum: Accelerating Cloud Adoption.* Department of Defense,(2017).
[77] PricewaterhouseCoopers, *Defence Trends 2020: Investing in a Digital Future*,(2020). 6.

The proliferation of digital technologies is shifting the balance of military advantage away from traditional platforms towards a new form of investment based on digital and cyber technologies.[78] Former USAF officer Lieutenant Colonel Dan Ward likened the platform problem to the Death Star — the empire-sized investment was directed into the few but powerful, intimidating platforms.[79] The point here is that although they could unleash tremendous devastation, its proportional counter did not need to be as such. It just took one 'X-wing' and a vulnerability the size of a 'womprat'[80] to see its demise, likened to the earlier example with the Chinese-produced anti-carrier missile. This questions how defence investment should be focused; should it commit heavy investments towards significant 'Death Star-like' capabilities, or should it look towards the digital technologies that make them work?

Technologies such as Artificial Intelligence, Quantum Computing, Bio-engineering and Robotics are potential areas that will disrupt the future of warfare. Cheaper and more plentiful capabilities across all domains will exploit vulnerability exposed by an emergent technology gap. Relating this to the great power competition, Barry Buzan, professor emeritus of international relations, and Eric Herring, professor of

[78] In this context, platforms is generally referred to large capital investments such as ships, tanks, and aircraft to deliver military capabilities. Budning, Wilner and Cote, "Connecting the Dots on Canada's Connected Battlespace," *International Journal (Toronto)* 76, no. 1 (2021), 154-162, 156.
[79] Dan Ward, "Don't Come to the Dark Side: Acquisition Lessons from a Galaxy Far, Far Away," *Defense AT & L,* Sep 01, 2011, 67.
[80] In the popular science fiction move Star Wars, the Death Star was labeled as a plant killer that was the size of a small moon. It was ultimately defeated by leaked information a relatively cheap assault by with precisely placed munitions by an x-wing fighter that exploited a hole in the Death Star's defences..a hole the size of a womprat (which was a large racoon-like fictional creature).

World Politics, write extensively on factors affecting arms racing frame this as the 'technological imperative.'[81]

> The leading edge of technological advance set the standard for the international system, and its continuous forward movement exerts pressure on the whole process of spread. As the leading edge [of technology] creates higher standards of military capability, followers either have to upgrade their weapons or else decline in capability relative to those who do.[82]

Therefore, since the most influential drivers of digital technologies are residents within Big Tech, then defence establishments will need to determine how to maximize their technological advancements through industry collaboration.

The crux of this problem is that defence establishments must adapt and pivot faster than the adversaries when it comes to technology and innovation.[83] Military platforms are becoming more and more expensive and less agile. Joseph Maiolo, a professor of international history and researcher of conflict and security, described the dynamics of arms racing as existing on a continuum of technological advancements. Maiolo indicates that the balance of a power competition could be tipped based on the state's ability to leverage the latest technological advancements.[84] Additionally, in the 1980s, an American aerospace businessman Norm Augustine developed a set of tongue-

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[81] Judith Reppy, "The Technological Imperative in Strategic Thought -- an Introduction to Strategic Studies: Military Technology and International Relations by Barry Buzan," *Journal of Peace Research* 27, no. 1 (1990), 101. The technological imperative to describe both the direct and indirect elements influencing an arms race between states. The important aspect here is the very pursuit of R&D that in advanced technology weather applied to military from the onset, will eventually drive new weapon development and military capabilities in relation to each other. Therefore, the private sector advancements of digital technology can indirectly fuel an arms race.

[82] Barry Buzan and Eric Herring, *The Arms Dynamic in World Politics* (Boulder: Lynne Rienner, 1998). 30.

[83] Brown, Chewning and Singh, *Preparing the United States for the Superpower Marathon with China*, (2020). 4.

[84] Mahnken et al., *Arms Races in International Politics…,* 6.

in-cheek laws that predicted the DoD spending combat aircraft trend in a series of aphorisms[85]. In one aphorism, he predicts that by the year 2054, the entire DoD budget will be committed to just one air platform based on current trends (Figure 2.6). [86]

Figure 2.6 – Augustine's Law

Source: *The Economist (London)* 396, no. 8697 (2010), 20.

A defence establishment's capability development strategy must evolve beyond its traditional platforms. As Buzan and Herring put it, "..states have to assess their military procurement in relation to the standard or the technological leading edge…".[87] This statement indicates that defence establishments would need to weigh investments in current platforms (the bomb-and-bullets) against those in emergent technology. However,

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[85] "Defence Spending in a Time of Austerity; the Cost of Weapons." *The Economist (London)* 396, no. 8697 (2010), 20.

[86] Norman R. Augustine and Inc Books24x7, *Augustine's Laws*, 6th ed. Reston, Va: American Institute of Aeronautics and Astronautics, (1997)., 107

[87] Reppy, "The Technological Imperative ..., 102.

DND's capital investment model locks significant investment decisions into a multi-year process.[88] Due to outdated policies driving the current capability development and acquisition process, this model would try to balance too many political and departmental objectives, causing delays.[89] Dr. Kim Nossal, a professor of political science at the Centre for International and Defence studies at Queens University, describes the CAF's procurement model as a 'serious problem'. He argues that it stems from an overly politicized bureaucratic process.

Additionally, he recognizes that this is not a new revelation. It is well-known that defence procurement is broken. What needs to be revealed is the sense of urgency towards developing a model to address acquisition in the digital technology space. Canada faces the same seminal challenge as the US, and there needs to be an urgent effort to reform DND's digital acquisition strategy. If this does not occur, there will be operational risk introduced in the CAF impacting the ability to defend Canada, work with our key allies and be ready for future warfare.

Although DND's investment plan and SSE recognize the need to modernize procurement, the current acquisition model has not evolved sufficiently to the changing landscape of the digital revolution.[90] DND needs to urgently reform technology development and prepare the CAF with the necessary technology for the digital battlefield. The move to digitized forces will demand heavy investment in the technology

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[88] Canada, *Defence Investment Plan 2018….*, DND's budget was renamed the Capital Investment Fund (CIF) in 2017 to coincide with SSE and locked long-term investment funding into accrual space which is the sole source of funds any major defence capability projects.

[89] Elinor Sloan, "Something has to Give: Why Delays are the New Reality of Canada's Defence Procurement Strategy," *The School of Public Policy Publications (SPPP)* 7 (2014), 1-54.5.

[90] Canada, *Strong Secure Engaged …*, 112. SSE lists 110 initiatives to modernize and change the CAF, seven of them are dedicated to 'Improving Defence Procurement where the objective is to 'Streamline defence procurement, better meet the needs of the military, and deliver projects in a timely manner…'however none of them focus on improving digital technology acquisition.

to enable NCW and have software development at its core. A Canadian Global Affairs Institute policy paper states: “In many ways, the Canadian defence procurement process is akin to a legacy weapon system. It can get the job done when it needs to, but it is ill-suited to the contemporary security and technological environment”.[91] Since the 2000s, the Government of Canada has been indicating that acquisition reform was a top priority[92]. More recently, a step in the right direction is shown through at 2019 initiative with Public Services and Procurement Canada (PSPC) in developing an Agile Procurement Playbook.

Furthermore, one of the SSEs initiatives that would aid future acquisitions and capability development was the creation Innovation for Defence Excellence and Security (IDEaS) program to reform how the CAF will work and collaborate more with industry.[93] With PSPC’s shift in recognition to Agile Procurement and SSE initiatives to reform DND acquisition for the CAF, the potential to accelerate digital technology acquisition exists. However, significant efforts are needed to focus these initiatives on CAF digitization to close the digital technology gap.

Another factor that DND and the CAF will need to is the effective employment and management of data and the networks enabling military operations.[94] The acquisition of digital technology does not represent a panacea of digital transformation. For an organization to create an enduring and functional digital transformation, it must consider

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[91] William Richardson et al., *Toward Agile Procurement for National Defence: Matching the Pace of Technological Change*, (2020).
[92] David Pugliese, "Wading through a Bureaucratic Quagmire: Solutions for an Inefficient Procurement System," *Esprit De Corps, Canadian Military then & Now* 20, no. 1 (2013). 2.
[93] Canada, *Strong Secure Engaged* …, 78. The IDEaS program is slated to receive $1.6B over 20 years to stimulate innovation and collaboration with industry.
[94] *Ibid.,* 55. Canada’s defence policy outlines that future technological development will depend on agile information management focused on the processing and manipulation of data. Although this is a shared objective across all sectors, this is to illustrate where DND is progressing in this regard.

the peripheral factors such as culture, command and control and the strategies that apply to war. Carvin states that "technologies are as only as effective as a military can work them into its operational concepts and cultural understanding".[95] Additionally, former US Defense Secretary Jim Mattis stated that "Success no longer goes to the country that develops a new technology first, but rather to the one that better integrates it and adapts to its way of fighting."[96]

So, how can the CAF better integrate the technology? One solution will be illustrated in Chapter 4 of this paper - *Building the Foundation*. It will outline the elements needed for an organization-wide digital transformation from process to people centered around its use of data.[97] The DND/CAF *Data Strategy* recognizes the increasing importance of data to meet future defence requirements.[98] This strategy outlines eight data-centric challenges that DND/CAF must contend with to stay relevant in the future. Although this paper will not address all eight challenges, it will recommend the foundation that will enable potential solutions to them:[99]

1. Lack of awareness of DND/CAF data.
2. Inability to make decisions about data.
3. Ineffective data management practices.
4. Unwillingness to share data.
5. Lack of trust in data.

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[95] Juneau et al., *Canadian Defence Policy…,*. 390.
[96] Jim Mattis, *2018 National Defense Strategy Summary - Sharpening the American Military's Competitive Edge* Department of Defense, [nd]. 10.
[97] Shyamalkumar Desai and Subramanya Joshi, *Data-Centric Organization: A New Paradigm*,[nd])., 4. A data-centric organization is about having the tools, abilities and most importantly a data culture that puts data at the center of the decision making and business process.
[98] Canada, *The Department of National Defence and Canadian Armed Forces DATA STRATEGY* Department of National Defence, (2019).
[99] *Ibid.* 6.

6. Inflexible legacy systems and processes.

7. Relatively low data literacy.

8. Lack of data culture.

As indicated in the previous section, business and military activities are becoming more dependent on the technologies and activities in the digital domain than ever before. The global trend from business enterprises to battlefield dynamics is now employing the same digital technologies that are accelerating a disruptive shift worldwide. It is the organizations that find new and innovative ways to leverage digitization that will be successful.

The good news is that the DND/CAF has already made some initial steps to address its data-centric challenges. In July 2018, a new Level 1 organization was created within the CAF as the Assistant Deputy Minister (Data, Innovation and Analytics) ADM(DIA), which will act as the bulwark for organizational reform towards data-centrality.[100] The defence policy also recognizes the need for innovation and agile development; however, they are still shrouded by the same bureaucracy and inefficient project approval process designed in the Cold War, posing a challenge.[101]

The former Vice Chief of Defence Staff (VCDS), Lieutenant-General Mike Rouleau, recognizes this problem and, in November 2020, issued planning guidance to all Level 1 organizations demanding digital transformation across the CAF to shift the forces from the analogue one which is digitized and interconnected.[102] In this guidance, Rouleau

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[100] *Ibid* 3. DND has recognized the importance

[101] Ian Mack, *A Single Canadian Defence Procurement Agent* Canadian Global Affairs Institute, (2019). 3.

[102] LGen M. Rouleau, *VCDS DMA Planning Guidance Data and Digitization*, (2020). In this context the term analogue refers to a process that is largely manual and paper based, one that lacks automation and network collaboration. Digital forces are ones that fully exploit IT and network connectivity as an enabling function

states that “Digital Transformation is not just about new technologies, but requires an overhaul of organizational structure, governance, work processes, culture and mindset”. As a motivating factor, Rouleau declared that “[the adversary] will punish military forces who remain analogue at their core.”[103] Accordingly, Rouleau laid out four priorities that will focus capability development efforts towards achieving this.[104] “As stewards of the profession of arms…we owe the next generations…the down-payment of smartly progressing into a digital future”.[105] There is work to do to develop the policy to pave the way to bring the CAF into the digital future and focus on digital technology acquisition strategy. A DevOps framework can form the fundamental building blocks towards achieving CAF objectives for a digital future.

Although DND has the strategic foresight to recognize the need for digital transformation, the internal DND capital investments models are due for reform. For DND/CAF to achieve effective digital transformation, a ‘remodel’ capability development will need to occur. Given the geo-political and economic drivers, DND is experiencing a technology gap due to its slow rate of digital evolution, which is primarily due to outdated yet extant acquisition models that are no longer effective for adopting digital technology.

This chapter has shown that technological advancement has been accelerated by the global influence of digitization, which demands organizations to adapt rapidly.

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[103] *Ibid*.
[104] *Ibid*. 2 The four VCDS priorities are: 1. Data and Digitization (including business modernizations); 2. A supported C4ISR spine; 3. Supply Chain Reformation; and 4. A Reimagined CAF Professional Military Education regime.
[105] *Ibid*. 1.

DND's current acquisition model is too slow and inefficient for the pace needed for digital technology. The following chapter will explain why this is the case.

CHAPTER 3: CAPABILITY DEVELOPMENT 'RE-MODEL'

The Waterfall Model is wrong and harmful; we must out grow it.

— Fred Brooks, *The Design of Design: Essays From a Computer Scientist*

While the latest advancements in digital technologies from software to emergent computing and communication systems improve how people live and how businesses operate, the same cannot be said for the CAF due to its challenging procurement process. DND's current directive on project acquisition is the Project Approval Directive (PAD), which outlines the process for delivering new capabilities from inception to sustainment.[106] Despite its 2019 update, the PAD follows a project process that not conducive to digital technology and is causing a capability gap within the CAF. In order to appreciate this paper's recommendation for transforming CAF digitization, it is essential to understand where it stands now in terms of capability acquisition. This chapter will explain how the current acquisition model works and identify why it does not align with digital technology capability development.

THE DND WATERFALL AND ACQUISITION MODEL

Capability delivery within the CAF is driven by DND's Defence Services Program (DSP).[107] The PAD is the process to translate money from the defence budget to a capability for the warfighter. Unfortunately, this process generally follows the 'Waterfall' approach to project management for all defence acquisition projects. The

[106] Canada, *Project Approval Directive (PAD)* Department of National Defence, 2019). The PAD is DND policy directive regarding project delivery which consists outlining the necessary levels of project approval and project management and is based on the Project Management Institute's Project Management Body of Knowledge (PMBoK) outlining all the phases of project management. The overarching policy is Canada's Defence Policy

[107] The DSP is a unified architecture of DND's approved program, which contains all DND-approved projects, services and activities deemed to be essential for the delivery of defence services to the Government and Canadians. It is particularly important to note that the VCDS manages the DSP

term ‘Waterfall’ refers to the linear (or downward) flow of sequential steps of discrete project activities, where the completion of one is necessary before proceeding to the next.[108] There is a defined beginning (top) of the project path, measurable phases, and a defined end (bottom) in a waterfall model.

Because the Treasure Board (TB) deems DND a unique and risky institution for fiscal spending, it adopted the Project Management Institute’s project management best practices for enterprise resource planning for complex projects and was modelled after the standards and practices of the manufacturing industry.[109] As such, all projects must follow the PAD regardless of type, which is marshalled through five stages of the DND’s project waterfall process, as illustrated in Figure 3.1.

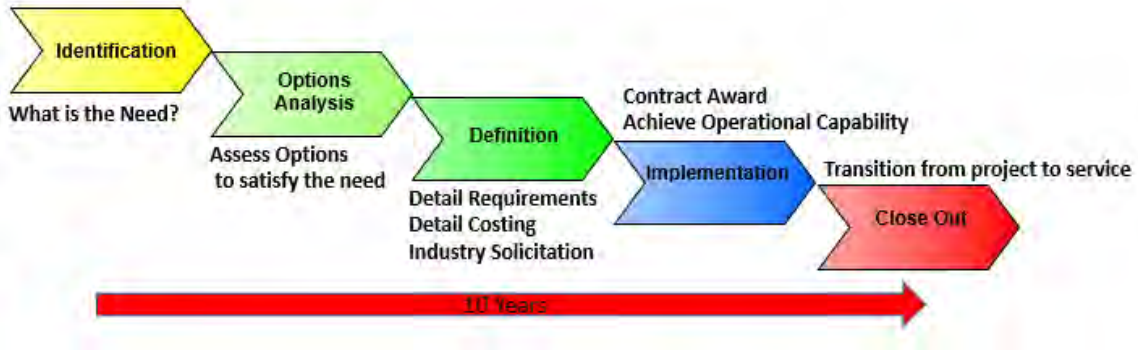

Figure 3.1 – The DND Waterfall/Project Management Process.[110]
Source: Canada, *Project Approval Directive (PAD).* 25

The process was designed to procure large, expensive, and complex projects such as fighter aircraft, tanks or ships, and the traditional military hardware. Depending on the

[108] Michael R. Fox, "IT Governance in a DevOps World," *IT Professional* 22, no. 5 (2020), 54-61. 56.
[109] Canada, *Project Approval Directive (PAD).* 25.
[110] Canada, "Defence Purchases and Upgrades Process," https://www.canada.ca/en/department-national-defence/services/procurement/defence-purchases-and-upgrades-process.html. This five phases are also described in the *Defence Purchases and Upgrades Process* which is governed by the Treasury Board of Canada to achieve value, stewardship, accountability, transparency for projects that are achieved within time and cost constraints.

project, each discrete phase can take approximately 1-4 years to complete. A project can take ten years to deliver a capability.[111] At each phase of the waterfall model, there is a significant amount of required documentation, approvals and oversight engagement that function as project 'gates' that allow the project to progress[112]. Although the PAD does have a tailored process for IT-related projects, a 'Cyclical Process', it is remains burdened with even greater demand for documentation and even more rigid control.[113]

TB defines the level of control and process rigidity as its Organizational Project Management Capacity (OPMCA) level.[114] The OPMCA is a tool that TB uses to score a department in its ability to manage a project across factors such as risk, cost, complexity, and scope.[115] A department's OPMCA score sets the department's baseline of risk tolerance, determining how much external oversight is needed from TB in the management of projects – the lower the level, the more oversight is required, as illustrated in Figure 3.2. Once TB determines the OPMCA baseline, each project is assessed using a similar methodology to determine the Project Complexity and Risk Assessment (PCRA).[116]

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[111] Canada, *Evaluation of the Information Systems Lifecycle Program* Assistant Deputy Ministry (Review Services), (2017). 12. The average length of IT related projects that followed the waterfall model was 9.6 years. This is based on 12 major IT projects from 2011-2015. This average only includes projects that have been closed out. At the time of this report there were still IT related project open for 16 years.
[112] Canada, *Project Approval Directive (PAD).*33.
[113] *Ibid.* 44.
[114] *Ibid.* 367. There are 4 functional OPMCA levels, DND is currently at Level 3 (Evolutionary). The higher the level the more trust and autonomy a department will have in managing a capital investment or project.
[115] Canada, "Guide to using the Organizational Project Management Capacity Assessment Tool," https://www.tbs-sct.gc.ca/pm-gp/doc/ompcag-ecogpg/ompcag-ecogpg01-eng.asp
[116] The PCRA when compared against the OPMCA will determine if TB oversight is needed and at which approval levels need to be sought. For example, as DND's OPMCA is level 3, only project with PCRAs of level 4 will require TB oversight.

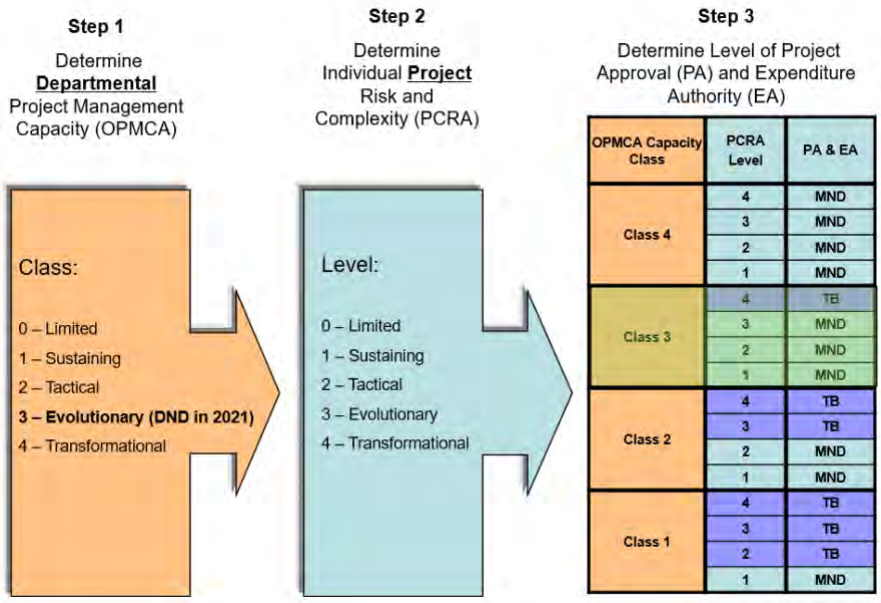

Figure 3.2 – OPMCA, PRCA and Authority Relationships
Source: Canada, 'The Big Picture' *Project Approval Course (PAC).* Slide 59.

DND's OPMCA assessment sets the risk threshold by which projects are deemed a 'Major Capital Project' or 'Minor Project'. The metric that defines this threshold is cost, with an OPMCA of level 3, that cost is $10M. Meaning a project with a valuation of less than $10M will be exempt from much of the oversight and rigour of the waterfall model in Figure 3.1 and will not require a PCRA for TB consideration.[117] Although OPMCA and PRCA mechanisms were implemented to reduce project timelines[118], the waterfall model remains incompatible with digital technology acquisition due to its lengthy timelines and inflexible process.

Consider how this process can be used to acquire digital technology to contend with the challenges posed in Chapter 1. Suppose DND confirms a need for advanced C2

[117] Canada, *Project Approval Directive (PAD).* 44.
[118] David Perry, "2015 Status Report on Major Defence Equipment Procurements," *The School of Public Policy Publications (SPPP)* 8 (Jan 01, 2015), 1-73. 9.

software or a CAF-wide classified cloud-based architecture that will better enable the next-generation fighter aircraft; how fast can these be delivered to the warfighter, given the process outlined in the PAD? According to an Assistant Deputy Minister (Review Services) 2017 report, Major Capital IT projects took an average of a decade to flow through the waterfall.[119] With DND's current OPMCA level, if any of the new requirements are less than $10M, they could be achievable in 1-2 years, but above $10M, new requirements need to follow the waterfall process. Therefore, any potential for relatively rapid and agile delivery is capped at $10M.[120] Any capital investment greater than $10M should be those military capabilities that can afford to wait for the decade-long acquisition cycle, such as aircraft, ships, and tanks – or hardware versus software. Figure 3.3 illustrates an example of how digital technology acquisition works within the current model. In this example, DND is set to procure an enterprise-level 'Portable Productivity User Device', or in everyday language, a tablet for DND employees. The business need was defined in 2005, where a cost estimate of over $10M forced it to follow the waterfall model. From the time the business need was identified to the first effective delivery of an Interim Operational Capability in 2017, approximately 12 years have lapsed, and 15 iterations of the original technology evolved.

[119] Canada, *Evaluation of the Information Systems Lifecycle Program*….12

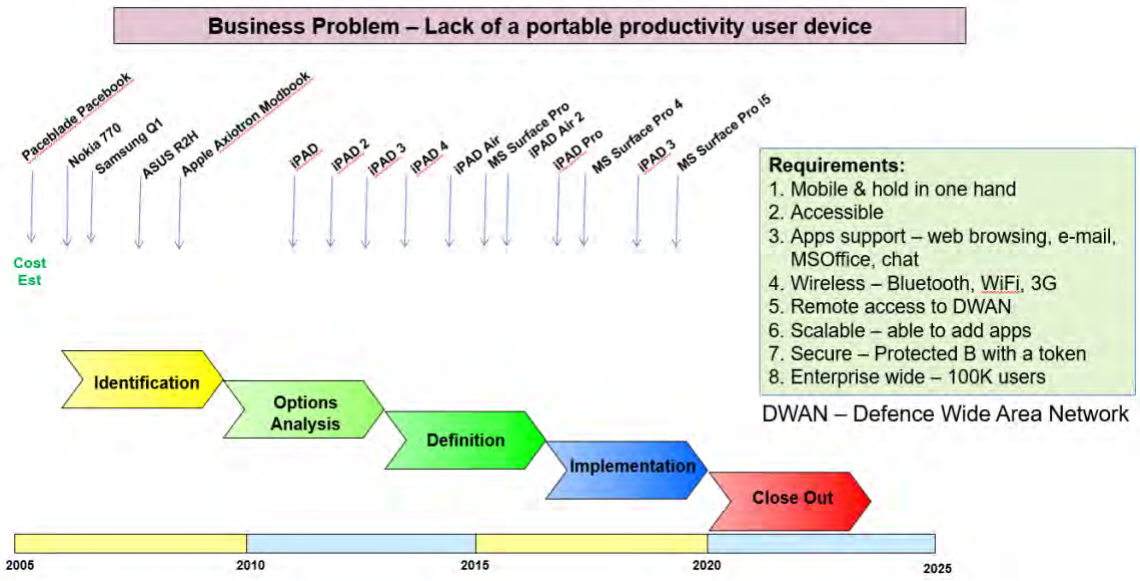

Figure 3.3 – The Tech Procurement Challenge – Speed of Tech vs Rate of Acquisition
Source: Canada, 'IT Enabled Projects' *Project Approval Course (PAC).* Slide 7.

DND's acquisition model is not aligned sufficiently to capitalize on the industry's trend towards R&D and thus loses capability development potential. As shown in Figures 2.4 and 2.5 in the previous chapter, industry R&D is trending heavily towards software and digital technologies, where traditional 'military hardware' R&D has flat-lined. Therefore, to ensure DND has the correct mechanism to deliver the digital technologies, DND's acquisition model needs to align with where technology is trending in private industry and allow more efficient access to digital technology and software development.

Given the industry trend towards digital technology, the Deputy Commander of the RCAF Major-General Keiver questioned whether DND's current acquisition model was still "fit for purpose". It is no longer suitable for software and IT-related technology.[121] Keiver highlighted the necessity to stay below the $10M and within the

[121] Colin MGen Keiver and David Perry, "Defence Deconstructed: Priorities for Canada's Air Force," https://soundcloud.com/user-609485369/defence-deconstructed-priorities-for-canadas-air-force

Minor Project space. The organization can achieve the "flexibility and agility" needed to acquire the digital technology needed for operations.[122] In Kiever's example, the RCAF accelerated the acquisition of an advanced cellular detection suite placed on SAR aircraft, which improved the speed and accuracy of rescue efforts. If the RCAF breached the $10M threshold for delivering a similar digital technology, DND's waterfall model would have burdened the process. The RCAF would have waited approximately ten years to deliver the same capability missing out on capitalizing on digital technology available today — a capability that saves lives. Imagine what could be achieved with digital technology acquisition if DND was not capped by a $10M threshold? [123] Therefore, the PAD and DND's acquisition process needs a remodel. A new foundation of defence acquisition needs to be established for the DND/CAF to close the technology gap in digital transformation.

Another acquisition vehicle that could afford more agility towards digital technology is called the Urgent Operational Requirement (UOR). The PAD can provide urgent operational capabilities by unlocking investment capacity to address evolving threats and technological advancements to meet the demands of combat operations.[124] The UOR process streamlines the acquisition process to address short-term operational deficiencies.[125] The tenets of the UOR are to focus resources, trade-off project risk to expedite delivery, and receive priority over standard projects. At the face of it, UORs

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[122] *Ibid.* MGen Keiver used the example of the RCAF procuring advanced cellular detection systems on board Search and Rescue (SAR) aircraft in the Cellular Airborne Sensor Search and Rescue (CASSAR) project. Keiver indicated that the RCAF "broke records" in spending under the $10M Minor Project space knowing that the RCAF needs to keep a funding stream towards advancing digital technology.
[123] Although DND's current OPMCA level of 3 gives DND $10M, this could be reduced to $5M if its OPMCA level dropped to 2, which it has in the past.
[124] Canada, *Project Approval Directive (PAD).* 45.
[125] *Ibid.* 140. UORs are categorized by Minor project $2.5M; Minor $2.5-$10M; and Major Project >$10M. The average timeline to submit a UOR was 42 days compared to 170 days for a regular project submission.

seem to address the requirements for digital technology acquisition. However, the UOR approval requirements demand that the project directly affect combat operations and contribute to a life-saving capability.[126] Although the UOR process proved successful during the Afghanistan era, this process cannot be used in non-combat-related capability development.

A 2018 DoD Defense Science Board report stated that commercial companies abandoned the waterfall approach as it lacked the speed and flexibility needed for modern technology.[127] Moreover, A PricewaterhouseCoopers report on defence trends highlights that the waterfall model, with its lengthily lead times, hinders the ability to adapt to technology. The report emphasizes the need to integrate emergent technology; "[A] reduction in procurement timelines would facilitate the ability to respond more quickly and efficiently to the changing demands in fighting wars over time."[128]

In writing of Canadian acquisition challenges, Major General Ret. Douglas Dempster stated: "Transformative large projects, especially with organizational redesign and software development, are inherently prone to fail." As it pertains to digital technology that will enable the CAF to undergo an effective digital transformation, it cannot fail in the future battlespace. Mr. Eugene Lang, former Chief of Staff to the Minister of National Defence (MND), stated: "there is a chronic shortage of ideas that are practical and implementable to try to improve [the procurement] process."[129] The longer

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[126] *Ibid.* 141
[127] Defense Science Board, *Design and Acquisition of Software for Defense Systems* Washington, DC: Department of Defence, (2018) 1.
[128] PricewaterhouseCoopers, *Defence Trends…*, 12.
[129] Mr Lang was the moderator of a panel in a Canadian Global Affairs Institute conference 'Creating a Big Bang: Implementing the procurement Ambition of SSE'. His panel focused on the topic of 'Framing the Challenge'. Eugene Lang et al., "CGAI - 5th Annual Defence Procurement Conference - Panel 2, 6:10" https://www.cpac.ca/en/ (accessed May 1, 2021).

DND takes to develop a model for digital technology acquisition, the wider the technology gap will grow to hinder the CAFs ability to fight the war of tomorrow. DND will need to develop a new acquisition model suitable for software development and defence acquisition, and DevOps can provide that ‘practical idea’ to reform its process.

This Chapter outlined why digital technology acquisition is not congruent with DND’s current waterfall model. The overall risk framework through the OPMCA and PCRA creates the boundary conditions that limit the flexibility and agility of Major Capital investments. The next chapter will outline a new framework by establishing critical elements for building a foundation for digital transformation. This foundation can be used to create an acquisition remodel suitable for digital technology acquisition and closing the technology gap.

CHAPTER 4: BUILDING THE FOUNDATION

> *Improved software engineering and a focus on artificial intelligence (AI) will accelerate DoD's speed, but only if the Department invests enterprise-wide resources towards this effort.*
>
> — Dr. Eric Schmidt CEO Google INC, *Statement to the House of Armed Services Committee*

The previous chapter outlined the problem space motiving digital transformation in closing the technology gap. This chapter will identify the fundamental building blocks where the CAF should develop an agile acquisition model based on a DevOps framework. Beginning with a primer on the DevOps model, the first section will explain digital readiness and transformation concepts as it applies to an organization's evolution in a data-centric ecosystem. Second, the concepts of agile software development methodologies using DevOps as a mechanism to enable digital capabilities. The third section will provide a network architecture model to form the foundation for digital transformation, innovation, and agile digital technology development. The final section of this chapter will explore the innovation culture as a fundamental enabler for establishing an enduring baseline to sustain organizational and policy reform for effective digital transformation.

DEVELOPMENT AND IT OPERATIONS

Agile development has become the industry standard for software development and has evolved to the development operations or DevOps framework. As the waterfall model described in the previous chapter required the project to flow down a unidirectional linear path from top to bottom, agile development does not require a defined path; it is more like a 'whirlpool' of iteration. Agile development is not confined by the five phases outlined in Figure 3.1. As a result, processing ideas for product

delivery have more flexibility.[130] Agile methodologies have the flexibility to adjust and adapt to changing requirements and aim to deliver value to the user faster, get feedback, and then iterate on it. Figure 4.1 shows the difference between the two models.

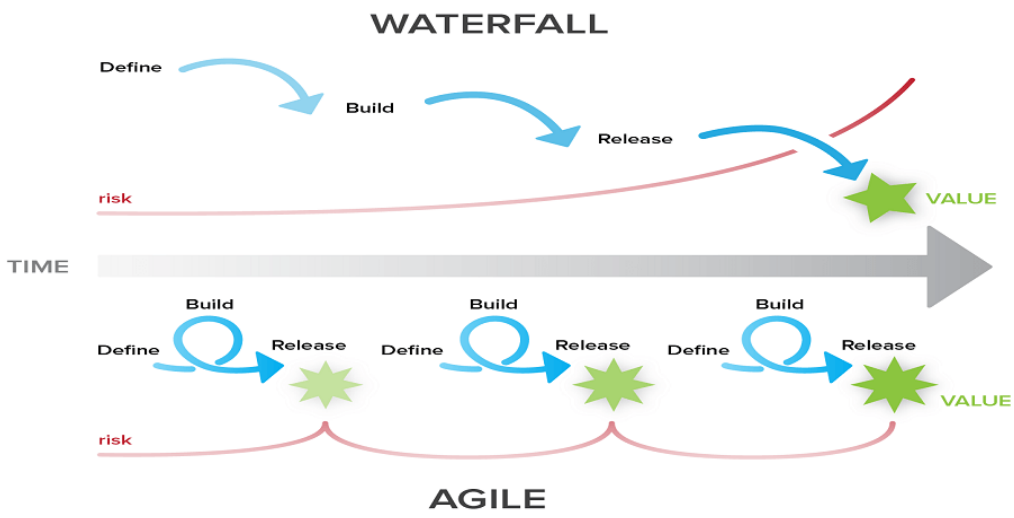

Figure 4.1 – Agile vs Waterfall
Source: https://www.binfire.com/blog/wp-content/uploads/2016/09/Agile-vs.-waterfall-4-1.png

In the waterfall model, value or a final capability cannot be delivered to the end-user until the project process has completed all phases of the project. Only then is when an organization sees the value of its investment. Moreover, the potential risk is higher at the end of the waterfall model because designs are locked in the process, and the requirements, technology, or environment may have changed by the time it is delivered. Recalling the average decade-long timelines for DND projects, the probability of this happening when applied to digital technology is high. Conversely, the Agile or DevOps methodology focuses on delivering early, with successive releases as a Minimum Viable Product (MVP). The first iteration of the MVP may be off the mark in terms of user

[130] Fox, "IT Governance in a DevOps World,". 56

demands and requirements. However, Agile/DevOps methodologies have the flexibility to restart the process and iterate on it, improving the product for the next MVP. The organization's operational requirements are achieved through successive iterations of MVP, incrementally building the product while delivering early value to the user.

The benefit of this method is not only the time needed to deliver a product but the ability to reduce overall project risk. Because the MVP is delivered early and frequently, Agile/DevOps can adapt the product to changing requirements and technology. Agile/DevOps can incorporate the rapid advancements of new technologies into its acquisition process regardless of the phase of the project. Today's organizations within the evolving digital landscape are moving towards adopting more agile technology development practices providing them with speed to move at the pace needed for customer demand and technology evolution.[131]

The DevOps movement was first branded as such in 2009 and grew worldwide as the accepted standard for agile digital technology development in private and public sectors.[132] Despite its global recognition as an innovative approach, there was not a commonly accepted definition; recognizing this, Andrej Dyck, a software engineering researcher from Aachen University, presented the following definition at a 2015 conference on Release Engineering:

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[131] Taylor et al., *DevOps for Digital Leaders…,* 6. An added benefit of the iterative nature of DevOps shares commonality with Design Thinking, a concept that not only will tackle digital technology procurement but be used to tackle other complex problems within the organization. David Dunne, *Design Thinking at Work: How Innovative Organizations are Embracing Design* (London; Toronto; Buffalo: University of Toronto Press, (2018). 13. The Design Thinking concept is a user-centered focus to deliver end value leveraging what is technically feasible and viable within the an organizations strategy. This concept has been adopted by the Australian Defence Force to develop solutions to their complex problems and the Canadian Forces College is teaching it to address complex issues of the next step to Operation Honour

[132] *Ibid*.

> DevOps is an organizational approach that stresses empathy and cross-functional collaboration within and between teams – especially development and IT operations – in software development organizations in order to operate resilient systems and accelerate delivery of changes.[133]

The seminal book on DevOps 'The Phoenix Project' identified that organizations that adopt its framework see tremendous efficiency in capability delivery while creating a work environment with increased employee productivity and job satisfaction.[134] Various companies in all industries are now seeing the value in the DevOps framework. The US DoD is adopting DevOps as they see software development as a crucial component of military power.[135] The DevOps framework eliminates the traditional siloes of capability development and focuses on delivering value to the customer continuously and expediently. Traditionally, software engineers, design staff, and developers represented the development or 'Dev' staff, who worked on requirements in isolation from the ones expected to use the final product.[136] On the other hand, the IT Operations department, the technicians, and the users of the product or capability represented the operations' Ops' staff. They primarily worked in their silo, keeping systems operational, or from the user perspective, concerned about how its performance affected them.

The traditional process followed the waterfall model of project management. This division created inefficiencies with longer lead times, decreased customer value (Figure 4.2). When the 'Dev' team completed their product, update, or modification, the Ops staff needed to work a specific schedule for a product release or system upgrade to create

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[133] Andrej Dyck, Ralf Penners and Horst Lichter, "Towards Definitions for Release Engineering and DevOps" IEEE, 2015). 1.
[134] Gene Kim, Kevin Behr and George Spafford, *The Phoenix Project: A Novel about IT, DevOps, and Helping Your Business Win* IT Revolution Press, 2013). 380.
[135] Defense Science Board, *Design and Acquisition of Software for Defense Systems* (Washington, DC: Department of Defence, 2018) 3.
[136] Christof Ebert et al., "DevOps," *IEEE Software* 33, no. 3 (2016), 94-100. 94.

issues and disrupt operations. This traditional division between Dev and Ops and imposed operational risk.[137] For example, think of how the workflow is disrupted when an organization pushes an update to an e-mail or operating system (traditional model). Now compare it to the seamless and transparent continuous updates on social media applications with minimal impact on its users (DevOps model)[138]. The DevOps framework effectively allows the groups on both sides of the wall to work collectively towards a common goal, which results in a higher quality product and a more efficient work environment.[139]

It also allows companies and organizations that adopt the DevOps model to buy down risk by employing the concept of 'fail fast and fail often' to iterate quickly and adapt to user feedback more efficiently than a waterfall model would allow.[140] Unfortunately, DND is still working in a siloed model with a brick wall between the Development and Operations staff, following a waterfall model of capability development.[141] With the increased rate of change in the digital landscape, the CAF will need to break down the wall and integrate the siloes of capability development, and the DevOps framework is a model the CAF should follow.

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[137] *Ibid* 21
[138] Recognizing that there are necessarily large scale updates for corporate systems, this just illustrates the operating differences of software delivery.
[139] Kim, Behr and Spafford, *The Phoenix Project: A Novel about IT, DevOps, and Helping Your Business Win* IT Revolution Press, 2013). 380
[140] Taylor et al., *DevOps for Digital Leaders…,* 95
[141] Canada, *Project Approval Directive…*, 43.

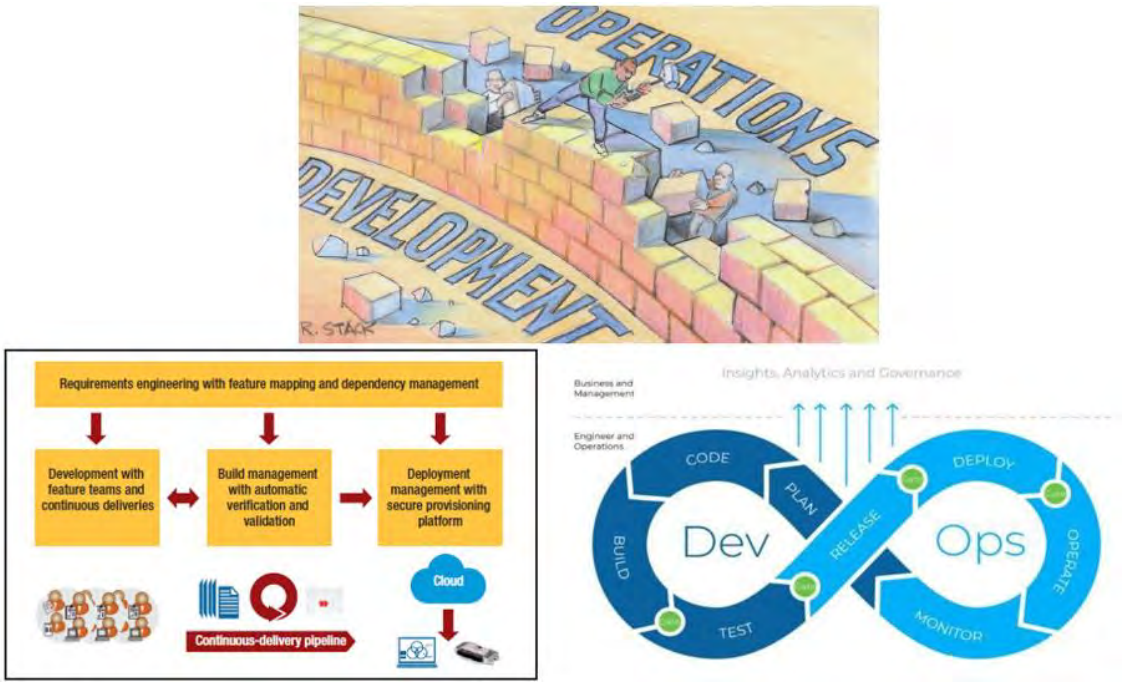

Figure 4.2 – Generic DevOps Model and Process

Source: Christof Ebert et al., "DevOps," *IEEE Software* 33, no. 3 (2016), 94-100., 95; and https://dev.to/dhruvesh_patel/devops-and-ci-cd-faster-time-to-market-4g07

DIGITAL READINESS AND TRANSFORMATION

To maintain military power through technological dominance, the US recognized they would need to invest in an innovation strategy aimed at software and digital technology development. As indicated in chapter two, the software and digital technology sectors are outpacing traditional defence R&D efforts. The DoD Digital Modernization Strategy outlines a roadmap that will focus on software development for cloud, AI, Command and Control (C2) and Cybersecurity, the foundation for future military capabilities.[142] An organization with a data-based ecosystem that requires digital systems to enable it requires what Rouleau referred to as the 'C4ISR Spine'.[143] The C4ISR spine

[142] United States of America, *DoD Digital Modernization Strategy* Department of Defense, (2019). 3.
[143] Rouleau, V*CDS DMA Planning Guidance…*, 2

is the digital network that will act as the central nervous system of the CAF. Currently, the problem is that the CAF has no central or common 'spine', and as a result, it cannot be fully networked or linked digitally to work in unison. Creating a C4ISR spine will unify digital functions enabling DND digital transformation.

The CAF Force Posture and Readiness (FP&R) ultimately determines the CAF's strategic effectiveness to respond to government direction efficiently.[144] The FP&R is a critical function to apprize the CDS on the ability to commit Canada's armed forces; however, it currently does not assess the disposition of the CAF's ability to operate effectively in the digital landscape and fight within the cyber domain. A 2017 report from the Assistant Deputy Ministry of Review Services (ADM(RS)) evaluating the CAFs Joint Force Readiness found that the CAF readiness system does not integrate new technologies.[145] As an indication that ADM(RS) sees more engagement with IT and digital technologies, they recommended that the Assistant Deputy Minister (Information Management) (ADM(IM)) be responsible for enhancing joint and shared governance.[146] Moreover, the latest Canada Defence Plan highlights risks in capability delivery and integrating Information Management (IM) and IT (IM/IT) that will create capability gaps that threaten operational effectiveness and lead to future mission failure.[147] The US also shares the digital transformation readiness issue. In 2019, the Defense Innovation Board (DIB) assessed that the US DoD was in the midst of a "Digital Readiness" crisis that

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[144] Yvan Gauthier and Peter Archambault, *Informing Strategic Decision-Making on Force Posture and Readiness* Defence Research and Development Canada, 2016).
[145] The ADM(RS) report found through various interviews at CJOC that the Collective Training and Exercise Scheduling that evaluates Joint Effectiveness does not use the latest technologies. Canada, *Evaluation of Joint and Common Force Readiness* Assistant Deputy Ministry (Review Services), 2017
[146] *Ibid. A-1/3*
[147] Canada, *Defence Plan 2019-2023* Department of National Defence, (2018)., 19.

cross-cut areas from technologies to the workforce that enables it.[148] Given the widespread proliferation of digital technologies across organizations, the mechanisms and procedures that govern their output are now facing disruption.[149] To be successful, the CAF must focus on incorporating technology and digital capabilities in evaluating its operational effectiveness.

To set the foundations that will allow for digital transformation and address requirements such as the 'C4ISR Spine", DND should establish an Enterprise Architecture (EA) that allows for the required integration of digital technologies. The Department of National Defence Architecture Framework (DNDAF) defines the EA as:

> A collection of strategic information that defines a business, the information and technologies necessary to operate the business, and the transitional processes necessary for implementing new technologies in response to the changing needs of the business. It is represented through a set of integrated blueprints.[150]

In their strategic vision document, NATO also identifies the need for a digital transformation to develop a more data-centric force ready to adapt for future complex engagements.[151] Therefore, CAF will need to keep pace with our allies in creating an interoperable data ecosystem. From a systems engineering perspective, examining the constituent elements of the CAF organization, digitization influences how each element interacts and affects the other. To accelerate CAF digital transformation, the EA will

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[148] DoD, *Workforce Now: Responding to the Digital Readiness Crisis in Today's Military.*Department of Defence,(2019). 3.
[149] Tobias Kretschmer and Pooyan Khashabi, "Digital Transformation and Organization Design: An Integrated Approach," *California Management Review* 62, no. 4 (2020), 86-104. 86. The process and effects digital technologies have on organizations is referred to as *Digital Transformation*
[150] Canada, *DND/CF Architecture Framework Vol 1: Definitions and Overview*, (2013).
[151] Thomas de Maizière Dr. and Mitchell Wess Dr., *NATO 2030: United for a New Era.* NATO,[2020]). 48.

need to create a suitable foundation for a digital technology development model, such as DevOps, for leverage.[152]

Companies that revolutionize digital transformation, such as Google and Amazon, can offer solutions to evolve the CAF EA.[153] These companies created the ecosystem that enabled increased interconnectivity among the masses, but they realized that at the center of this evolutionary digital landscape was the data itself.[154] DND historically put this responsibility of managing data on the IT organizations of the Department. However, the way data is managed and used is better handled at strategic levels of the organization[155]. Although DND has made some progress in addressing this issue by creating ADM(DIA), governance and its application to acquisition remain challenging.[156] Although a military can be deemed state of the art in some regards, there are remaining challenges regarding digitization and integration. For example, the F-22 and F-35A fighter jets still cannot share essential information necessary for effective C2, such as targeting data and positioning information.[157]

Achieving a data-centric EA within the CAF will enable the foundation to evolve the Canadian military capabilities towards the future. The latest defence plan identifies that VCDS will lead the EA program to incorporate the latest technologies and

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[152] Bingfeng Ge et al., "A Data-centric Capability-focused Approach for System-of-systems Architecture Modeling and Analysis," *Systems Engineering* 16, no. 3 (2013), 363-377. 364.
[153] Heather Kuldell and Frank Konkel, "JEDI: One Year in the Pentagon's Push for a Revolutionary Cloud," https://www.nextgov.com/feature/jedi-contract/ (accessed Apr 28, 2021). Although companies such as Google and Amazon have completely different set of operating standards and business objectives, as explained in Chapter 1, DoD has recognized the value in extrapolating their best practices for development in the area of digital transformation and cloud computing as was done with the JEDI contract.
[154] Wheeler, *Digital Learning in Organizations: Help Your Workforce Capitalize on Technology* (London: Kogan Page, Limited, (2019). 146.
[155] Aleksandar Boskovic, Dinko Primorac and Goran Kozina, "Digital Organizations and Digital Transformation," *Economic and Social Development: Book of Proceedings* (2019), 263-269. 264.
[156]Rouleau, V*CDS DMA Planning Guidance...*, 2. This is the issue that was raised by the VCDS stating that ADM(DIA) is still sub-optimized to achieve success in digital transformation
[157] Brose, *The Kill Chain...*, 34.

digitization.[158] However, because the CAF is not monitoring its state of digital readiness against its FP&R process, there is no mechanism to assess the current state of digital transformation. A reformed EA and DevOps framework monitored and assessed through the FP&R will allow the VCDS to focus CAF 'digital readiness' toward achieving the C4ISR spine.

AGILE AND DEVOPS METHODOLOGIES

The world has seen many examples of companies not being agile enough to adapt their business to the increasing digital technology revolution. One example, Blockbuster Video not foreseeing the media revolution of video streaming services. Another is Blackberry not forecasting a plan to contend with a revolution in personal cellular devices with the iPhone. [159] These are examples of companies that could not bridge the technology gap within their business; ultimately, the inability to adapt led to their demise. These examples of not adapting to close the technology gap can be compared to the theory of boiling frogs.[160] The United Kingdom Government Communication Headquarters (GCHQ) likened their challenges in adapting to technological change to the boiling frog theory. "There is a risk of being blissfully unaware that the world is changing so dramatically that there is a danger of boiling alive whilst asleep…we need to jump out of our world and consider the big picture."[161] To mitigate this, agile and DevOps methodologies will be a crucial agent for change that enables the CAF to initiate a digital

[158] Canada, *Defence Plan 2019-2023…*, 11.
[159] Taylor et al., *DevOps for Digital Leaders…,*16.
[160] The theory is that if a frog is a pot of water that is slowly heated, it will gradually go to sleep at 40 C and die when the temperature reaches 100 C. Whereas if a frog were to jump into the pot of already boiling water, it would immediately jump out, avoiding a tragic fate
[161] Russ, Mike and Steve, *GCHQ: Boiling Frogs?* UK MoD, (2016)., 5.

start-up initiative—that will get it out of the confines of its antiquated process and into the future…as not to suffer the same fate as poached amphibians.

DND's current waterfall acquisition model leads to slow results and an inability to adapt quickly to change, especially when considering the rate of change necessitated by digital transformation. Adopting a DevOps framework will allow DND to procure and deliver the digital capabilities needed for future wars. It will foment a shift in culture and mindset. It will be more conducive to solving the complex problems our forces will face.[162]

General Stanley McChrystal, who commanded the Joint Special Operations Task Force in Iraq in 2004, realized that conventional military organizations and C2 methods failed to fight against the dynamic Al Qaeda in Iraq (AQI). An agile organizational construct was needed, termed "Team of Teams".[163] AQI's ability to rapidly evolve and adapt through a dynamic and decentralized command structure was akin to the dynamics of disruptive technology. It was the impetus that McChrystal required to implement organizational change in what he referred to as "The Proteus Problem," which serves as a powerful allegory to the demand for change stimulated by technology and digital transformation.[164] McChrystal's responsibility as a leader was to examine his organization to address the question: "If we were the best of the best, why were such

[162] PhD Forsgren Nicole, Jez Humble and Gene Kim, *Accelerate : The Science of Lean Software and DevOps: Building and Scaling High Performing Technology Organizations* (Portland, OR: IT Revolution Press, 2018)., 51. Examples from organizations who adopted the DevOps model have shown a positive impact on their culture.
[163] Stanley A. McChrystal et al., *Team of Teams: New Rules of Engagement for a Complex World* (New York, NY: Portfolio/Penguin, (2015). 12.
[164] *Ibid*. 21.

attacks [from AQI] not disappearing, but increasing? Why were we unable to defeat an under-resourced insurgency? Why were we losing?".[165]

A DevOps model applied to the complexities of a military organization can provide utility towards combating the ambiguity that the future warfighting domain will bring. As with tech start-up companies endeavouring to bring a product to an ambiguous market that will address an unknown customer base, so too must armed forces develop a capability to contest an unknown enemy or operational environment. Successful start-ups do not follow the rigid project management practices as DND's PAD; instead, they focus on delivering value to the customer through iterative development and the utility of thinking of an agile methodology as it applies to organizational design.[166]

As McCrystal needed to contend with challenges in the Middle East, technology and digital transformation require organizations to adapt by becoming more interconnected and flexible to technological change. By fostering creative thinking and exploring curiosity to solve his C2 challenges, McCrystal inadvertently employed the same DevOps principles needed for agile software development.[167] Agile software development can be the catalyst for the necessary organizational reform needed for digital transformation.[168]

Fortunately, through SSE and PSPC, DND realizes that the acquisition model is insufficient to keep up with the demands of technological evolution, digitization, and the

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[165] *Ibid*. 26.
[166] Steve Blank and Bob Dorf, *The Startup Owner's Manual : The Step-by-Step Guide for Building a Great Company* Hoboken, New Jersey: Wiley, (2020). xxiii.
[167] Petri Kettunen and Maarit Laanti, "Future Software Organizations – Agile Goals and Roles," *European Journal of Futures Research* 5, no. 1 (2017), 1-15. 2.
[168] Carter et al., *Keeping the Edge…*, 51.

accelerating landscape of business.[169] As indicated earlier in this chapter, the Agile/DevOps model provides advantages in efficiency and optimizing the MVP to an organization and reduces the overall project risk. PSPC, as strategic lead for national procurement within Canada, wants to generate greater awareness throughout other departments' national procurement programs. They have recently developed their first agile procurement playbook, which recognized that the DND waterfall acquisition model is no longer sufficient with fast-paced technology.[170] Figure 3.2 describes the differences between the traditional Waterfall model DND uses and the Agile model, which a DevOps framework would use. PSPC developed this to illustrate where government organizations may apply one over the other.

Traditional "Waterfall"		Agile Procurement
Procurement planning at beginning of procurement process only	→	Procurement planning at beginning of and throughout procurement process
Little or no engagement with stakeholders.	→	Ongoing engagements with stakeholders throughout procurement process
Adversarial relationship with industry.	→	Collaborative relationship with industry
Low user buy-in.	→	High user buy-in
Detailed technical requirements (high specificity, low flexibility)	→	Outcome-based specifications (less specific, more flexibility)
Evaluation of lengthy, written proposals	→	Evaluation of more concise written proposals plus presentations, prototypes, samples, demonstrations, videos, etc.
Evaluated on ability to write	→	Evaluated on strength and demonstration of innovation and approaches
Long contract periods	→	Shorter contract periods with Go/No Go decision points
No negotiation before contract award	→	Potential to negotiate before contract award (Consult legal services)
Course corrections, if possible are costly, in time and money	→	Continuous corrections are expected and save time and money
Most failures take place after considerable investment	→	Any failures take place earlier and are less expensive
Distributed Effort	→	Resource Intensive (Many FTEs involved/dedicated to project)

Figure 4.3 – Waterfall vs Agile Procurement Comparison

Source: *Vinet, Hassan, PSPC Town Hall Presentation, 2020, (with permission),* 8

[169] Public Services and Procurement Canada, *PSPC Acquisitions Program Agile Procurement Playbook*, 2020). 5
[170] *Ibid.*

THE IT STACK

Although DND is not, nor does it profess to be an IT or software development company, it does need to evolve its digital acquisition governance and policy. As demonstrated earlier in this chapter, the DevOps model can provide the mechanism to accelerate evolution. However, the model requires an IT architecture that is more conducive for agile software and technology development – this architecture is referred to as the IT-Stack.[171] The CAF Data Strategy says that with the proliferation of large volumes of data, cloud computing solutions, AI, there will be an emergence of 'converged architecture' that will need to comply with Canadian government policies and directions.[172] The Government of Canada Digital Operations Plan 2018-2022 indicates that government departments implement agile approaches into their business solutions. The plan states: "application development teams should adopt modern and agile approaches to development to enable greater adaptability to evolutions in both business requirements and enabling technologies."[173] The plan will involve transforming the CAFs digital architecture towards a model that will leverage cloud-based computing, edge computing, and AI.

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[171]The IT stack is a simplified representation of the Open System Interconnection (OSI) model that describes all seven layers of networking, switching and computer processing form the keyboard to cursor on the screen. It describes the rules computer programs and all of the hardware devices must follow to achieve effective operations with each other and throughout the internet. The IT stack is simply a distilled version of the OSI model which describe its functional parts. As it pertains to implementing DevOps and agile acquisition, it is important to understand which of these functional parts can and should be affected. For more information on the OSI layers see: "TCP/IP Model: Layers & Protocol | what is TCP IP Stack?" https://www.guru99.com/tcp-ip-model.html (accessed April 4, 2021).

[172] Canada, *The Department of National Defence and Canadian Armed Forces DATA STRATEGY…*, 30. The 'converged architecture' refers to centralization of an organizations data centers, and to achieve this, services are typically consolidated onto the IT stack.

[173] Canada, "Digital Operations Strategic Plan: 2018-2022," https://www.canada.ca/en/government/system/digital-government/digital-operations-strategic-plan-2018-2022.html (accessed Apr 6, 2021).

A common platform that will enable DND to bolster a new digital acquisition model will be fundamental for an enduring agile software and high-tech procurement model. This platform will allow DND/CAF to manoeuvre with more agility in the capability development process while adding value to the warfighter at the speed of demand rather than at the pace dictated by outdated procurement strategies.

The DNDAF is DND's strategy to establish a common EA across all branches and services of DND and CAF. The strategy was prompted in 2001 by a Defence Planning Guidance set out to achieve EA stewardship across all DND programs and services.[174] One of the critical tenets of establishing DevOps is to create a conducive EA. As defence establishments will need to be supported by software and advanced algorithms, DevOps will be imperative for future warfare developments.[175] Dr. Will Roper, known in the DoD for his innovative thinking towards digital acquisition reform and as the former assistant secretary to the USAF acquisition program, spearheaded revolutionary programs that established the culture of innovative thinking necessary for leading change.[176] He wrote a précis that established a roadmap for digital acquisition reform where he defined the 'technology stack' as fundamental to creating the necessary architecture that will allow organizations to adopt a DevOps model and accelerate digital transformation.[177]

The DNDAF has set an objective is to correct the many "dispersed and non-sharable products that fall short of providing the holistic view necessary to support our

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[174] *Ibid.* 1.
[175] Defense Science Board, *Design and Acquisition of Software for Defense Systems* (Washington, DC: Department of Defence, (2018). 3.
[176] Aaron Mehta, "Future of Strategic Capabilities Office Uncertain, as Director Lands Air Force Nomination," https://www.defensenews.com/air/2018/01/03/sco-head-roper-nominated-for-air-force-job/ (accessed May 3, 2021).
[177] Will Dr Roper, "There is no Spoon: _The New Digital Acquisition Reality," (October 7, 2020). 5.

decision-makers".[178] Despite being promulgated in 2008, there has been a marginal improvement to the siloed organization within DND. This stove-piped approach limits capability development initiatives. With the increased development of Cloud-based architecture, DND's adoption of this technology within its EA could dissolve the existing silos and improved enterprise collaboration. However, to do this, DND would need to fundamentally change how IT services are managed at the enterprise level. The enterprise-level development of a cloud-based architecture would allow DND to outsource most of its IT services, allowing DND/CAF resources to focus on capability development and delivering value to the warfighter. Roper identifies this as an instrumental step into establishing a high-performing DevOps organization.[179] DND's current acquisition model aims to manage and control every component of our digital environment, from the wires that connect them to the software and applications that deliver the capability.[180] The IT-Stack focuses on where DND's EA needs to transform. Figure 3.3 indicates the area EA shift that will also work for an enterprise-level DevOps environment.

[178] Canada, *DND/CF Architecture Framework Vol 1: Definitions and Overview*, (2013). 1.
[179] Will Dr Roper, "There is no Spoon: _The New Digital Acquisition Reality," (October 7, 2020). 5.
[180] Taylor et al., *DevOps for Digital Leaders…,* 24.

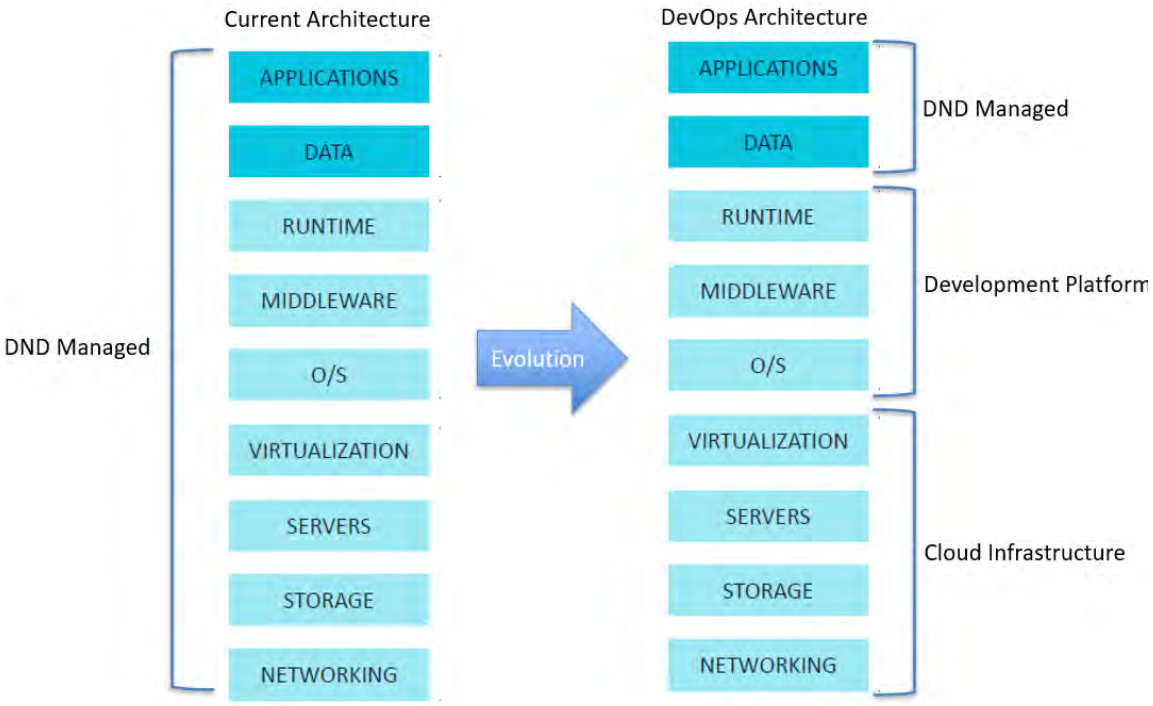

Figure 4.4 – Transforming DNDs tech stack

The DevOps architecture will allow DND to focus more on the value or output of capability development rather than focus on the processes or inputs of requirements. This new architecture will require a cultural and policy change from the inside out, which will provide the motive necessary to shift the organizational inertia towards a more agile framework.

INNOVATION CULTURE AND TALENT

> What makes innovating thinking happen?...I think it's really a mindset. You have to decide.
>
> — Elon Musk

The dawn of large-scale digital transformation is fundamentally one of the biggest challenges that organizations are facing today. Cultural change will need to occur within any organization adapting to digital transformation, and fueling this change will be with

the necessary talent and innovation to drive it.[181] The workforce that will enable DNDs successful digital transformation will be rooted in the mindset and talent needed to understand how a data-centric ecosystem can benefit an organization. Defence organizations have been traditionally good at hardware and operating them within the fundamental confines of physical laws in the analogue world. However, as these same systems are becoming interconnected and orchestrated by data, DND needs more people with the skillsets that focus on the science and processes that define them. With the proliferation of networked-enabled devices and the increasingly advanced algorithms that govern them, DND will need to increase its ability to manage and fight these systems. Core skills such as coding, data sciences, and computer engineering will be pivotal towards embracing this.[182] Carter identified nearly two decades ago that the DoD needs a cultural reform to accelerate its acquisition program to a sufficient degree to keep up with the demands of the technology revolution.[183]

A study on what the DoD would need to do to create the institutional change to capitalize on technology and create a culture of innovation would ultimately demand a total commitment from the entire Department, from the Secretary of Defence with support from the US President.[184] DND is not making this happen to the extent necessary for departmental change and, as a result, will lose the existing talent and not recruit new talent. Dempster states that "the center of gravity for achievability [of future defence policies] will be resourcing talented people… ."[185] The talent and innovation that DND

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[181] Phyllis Messalina Gilch and Jost Sieweke, "Recruiting Digital Talent: The Strategic Role of Recruitment in Organisations' Digital Transformation," *German Journal of Human Resource Management* 35, no. 1 (2021), 53-82. 54.
[182] DoD, *Workforce Now: Responding to the Digital Readiness Crisis*)..., 2
[183] Carter et al., *Keeping the Edge...*, 298
[184] *Ibid.* 299.
[185] Juneau et al., *Canadian Defence Policy...*, 346

needs reside within the ambition to see functional change happen with the latest technology. The current CAF does not showcase this, and it is due to its Cold War development model that takes a decade to deliver a new capability.[186] Companies like Google, Space X, and Amazon illustrate industry standards for future innovation and development, making it difficult for defence organizations to compete for talent. DoD's '..risk-averse bureaucracies that seem inclined to resist and stymie change at every turn'.[187] The defence organizational culture and outdated processes (e.g. waterfall model) are at direct odds with the culture of innovation that DND requires and is not conducive to retaining and drawing the skills and talent necessary for digital transformation.[188]

A DevOps environment will ultimately require the skill sets necessary to exploit the benefits of digital transformation in a data-centric ecosystem. The DND strategy for Data and Innovation identifies that DND's current and future state of Data Literacy, as shown in Figure 3.4. The DND/CAF aims to achieve a skilled workforce with sufficient Data Literacy to leverage data for innovation and decision-making to deliver a more efficient and effective organization. This concept is shared by industry leads where DevOps Research and Assessment (DORA) indicates that a fundamental step to evolve to a DevOps environment is to have a data-centric organizational mindset and the technical skill to support it.[189]

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[186] *Ibid. 194*
[187] Brose, *The Kill Chain...*, 21.
[188] Carter et al., *Keeping the Edge…*, 10.
[189]DORA, "Puppet Releases 2019 State of DevOps: Industry Report Card," *Entertainment Close-Up* (2020)., 11

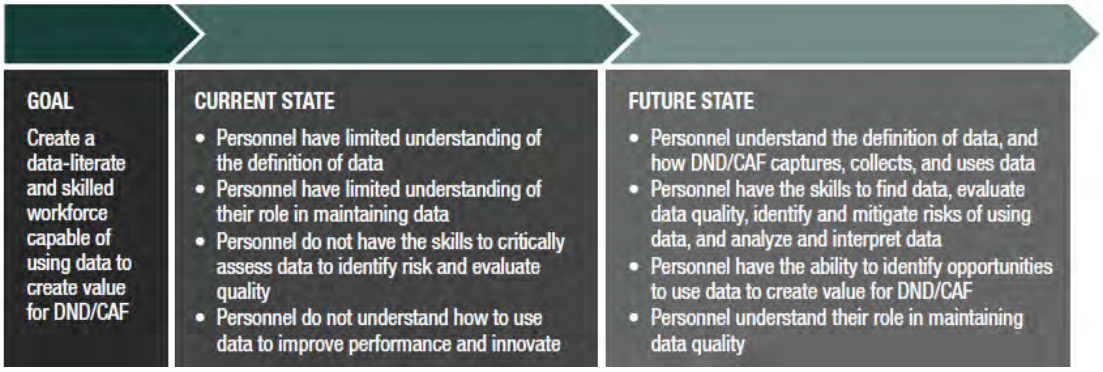

Figure 4.5: The Data Literacy and Skill Pillar[190]

Source: Canada, *The Department of National Defence and Canadian Armed Forces DATA STRATEGY* Department of National Defence, (2019). 14

A 2018 report from the DoD Defence Science Board indicated that one of the primary recommendations to institute an agile framework is to invest in software development expertise across all services to create the core workforce knowledgeable in the digital domain.[191] They put this as a primary focus in defence acquisition. Their objective is to have over 500 software acquisition experts by FY2019 to have the sufficient skill base necessary to advance their forces into the future of DevOps.[192]

Although SSE and the DND/CAF data strategy set goals to increase innovation and the necessary technical skills to address the capability gap of agile technology acquisition, there is still procedural, organizational and policy momentum hindering advancement in this regard. The small-scale establishment of a DevOps framework will require a shift in focus to value outputs versus process inputs. In doing so, create a shift in momentum towards a more modern capable force.

[190] Canada, *The Department of National Defence and Canadian Armed Forces DATA STRATEGY…*, 14.
[191] Defense Science Board, *Design and Acquisition of Software for Defense Systems…*, 43.
[192] *Ibid*. 44

It is promising that the Canadian Government recognizes the strategic situation outlined in this paper. There are various initiatives identified in the latest defence policy to leverage innovation and ingenuity within the DND. SSE recognizes that technology will be a critical enabler for the CAF and has formulated programs capitalized on Space, Cyber and Remotely Piloted systems.[193] In order to capitalize on these new capabilities, SSE also asserts that it will modernize its business practice and improve defence procurement.[194]

According to SSE, "effective defence procurement is vital to ensuring the CAF is equipped and ready to fulfill the important mission we ask of it."[195] However, there is no mention of how to focus on potential procurement reform. Organizations that need to modernize their business model need to alter their organizational inertia and focus on the CAF's fundamental values rather than the process itself. Although achieving budgetary efficiencies and improved workflow productivity within the CAF may be deemed a success, it comes at odds with creating the shift in organizational culture necessary to contend with the complexities of digital transformation.

Organizational inertia built up through business culture, organizational rigidity, and unfocused skills create the problem space that hinders a shift towards agile procurement.[196] The 2018 *Defence Investment Update* deems projects successful if they are delivered within the planned scope and budget while using the waterfall model.[197] Although DND acknowledges that this is not an indicator of practical value and

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[193] Canada, *Strong Secure Engaged…*, 73
[194] *Ibid*. 74.
[195] Ibid. 74.
[196] Russ et al., *GCHQ: Boiling Frogs?…,7*
[197] Canada, *Defence Investment Plan Update 2019…*,13

efficiency, it is a metric that validates the waterfall process and the policy that created it, sustaining the organizational inertia.

This leads to the next point that creates organizational resistance to adapting to technology: DND is a primarily inward-focused business culture, where budgets, effective spending, and staff incentives are evaluated as performance metrics, not the actual product or capability itself. For example, within Capability Development organizations at DND, staff are focused on following and meeting the objectives of the PAD to ensure they are hitting the mark on budgets and timelines with little regard to the value they are providing to the warfighter.[198] Although this may be a necessary process for large platforms, such as aircraft and ships, much of the capabilities that the warfighters need reside within the digital landscape and require capability development in the cyber domain.

The revolution of the information and cyber domains is changing how we define military capability. Is a fighter aircraft a platform from which the military can deliver effects, or is it now just a node on the network run by software of a greater military system of systems?.[199] The answer to this question will reveal that there needs to be more focus on the digital landscape that connects the capabilities that are being developed. Rouleau alluded to this in this concept of the 'C4ISR spine' and the need to shift away from analogue forces.[200] However, the need to establish a C4ISR focus across the CAF was recognized even earlier. In 2012, the Chief of Defence Staff (CDS) issued an initiating directive for a joint C4ISR requirement that demanded establishing an

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[198] Canada, *Defence Investment Plan 2018...*, 17.
[199] Brose, *The Kill Chain...*
[200] Rouleau, *VCDS DMA Planning Guidance...*

integrated C4ISR architecture or a "data transmission and information management *backbone*."[201] Since there is no enterprise-level digital chiropractor available to address the CAF's digital-skeletal issues, a renewed effort needs to address the digital framework, so another eight years does not pass without a significant adjustment. Capability development needs to be done in an agile manner and in a concerted effort with operations that will allow incremental restructure of the enterprise framework needed for the CAFs digital spine. In order to build the momentum needed for change, there needs to be a unifying element that will coordinate existing software and technology development capabilities into a new model, effectively creating a 'start-up' within the CAF.

[201] Canada, *CDS Directive - Joint C4ISR Requirements* Department of National Defence, (2012). 1.

CHAPTER 5: JOINT INTELLIGENCE AND INFORMATION FUSION CAPABILITY (JIIFC)/JOINT BATTLESPACE MANAGEMENT CAPABILITY (JBMC) CASE STUDY

BACKGROUND

In 2002 the Chief of Defence Staff (CDS) issued a three-year plan in a statement that included several transformation initiatives. The CAF would expand its information and intelligence fusion capability.[202] The focus of the JIIFC project was to provide:

> A Joint, command-centric, information-based integrated operating environment that enables the optimization of the creative thinking and decision processes of the Commander and staff, resulting in improved synchronization of operational functions in the conduct of assigned missions.[203]

This description makes it easy to see how this would be heavily software-dependent and leverage the latest IT available to make this work. The project charter noted that this capability would depend on the operational information (or data), which in the context of this project was defined as "the information and intelligence required to support operational decision making."[204] However, was the JIIFC/JBMC a platform, a capability delivered by software, or both? This type of capability is just as relevant to the CAF today as it was then as they align with the current VCDS priorities towards digitization.

Therefore, this case represents a valuable area of study as it will highlight critical issues that are currently plaguing the CAF acquisition process. It was selected for two

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[202] Canada, *Joint Information and Intelligence Fusion Capability Project Charter* Department of National Defence,(2017)., 2
[203] Canada, *Joint Intelligence Fusion Capability Project Charter*…, 3.
[204] *Ibid.,* 4.

reasons. First, because the project requirements still align with the demands and intents of the CAF today. Second, the project achieved closed-out in 2019[205] and will illustrate how information, IT, and heavy software project worked within the DND capability development and acquisition process.

The critical elements of this project were to deliver the following High-Level Mandatory Requirements (HLMR):[206]

1. An Integrated Operating Environment
2. Representation of the Battlespace Geometry
3. Representation of Force Dispositions
4. Interoperability.

The HLMRs were heavily reliant on data, business processes, and a conducive EA — each key element in an organization was to ensure efficient and effective capability and software development.

This case will investigate project documentation and accounts from past project staff about how effective this project was executed from a policy, organization, and technology framework. This analysis will be compared with the other case and then assessed against CAF procurement policy. Below are key figure to appreciate the scope and scale of this project:[207]

Budget: The total capital investment committed to the JIIFC/JBMC project was $63M

Human Resources: 13 Personnel Years at the peak of project activity

[205] As indicated in Chapter 3, project Close-out is the last phase of the waterfall model.
[206] *Ibid.*
[207] *Ibid.,* D1.

Time: 15 years from Identification to Closeout.

Project Risk: Medium

LESSONS TO LEARN

The official project lessons learned document provided the necessary information that will be used in a future project of similar requirements. The timeline within the LL document will cover the time from developing the JBMC requirements to the ultimate fielding of its capability. Although the LL document is meant for Project Directors and Project Managers, this paper will use its information to provide a qualitative analysis of the project in the four foundational DevOps elements.[208] It will then derive the strategic issues contributing to this paper's research.

Digital Readiness

The JIIFC project aimed to deliver a digital business solution to the CAF; however, it required an organization that had already achieved a certain level of digital readiness. Organizations must have a sufficient data ecosystem backed by governance and talent to achieve the digital ecosystem necessary for an enterprise-level transformation or a project with the scale of JIIFC/JBMC.[209]

As the JIIFC project was to deliver a Battlespace management capability that alleviated staff from the labour-intensive burden with the preparation and dissemination of information to Commanders, it required a digital ecosystem from which it could operate. The project was required to draw data from multiple sources and networks that

[208] As described in Chapter 2, the four areas of case study are: Digital Readiness, Acquisition Agility, Enterprise Architecture, and Innovation and Culture

[209] Boskovic, Primorac and Kozina, "Digital Organizations and Digital Transformation," *Economic and Social Development: Book of Proceedings* (2019), 263-269. 264

included classified and unclassified networks. However, this created a significant challenge for the project because the insular fashion data was stored and processed across DND's networks. Additionally, there was no formal governance body within DND to standardize the data interfaces between various networks and systems. Every time the project was ready to implement a new software solution, it encountered a roadblock in either DND technology, policy or the organization that was not ready for the scale of digital transformation that the project set out to deliver.[210]

As the project followed the outdated waterfall model and not operating in an agile or DevOps framework, any change that needed to be incorporated was done solely within the development teams' lanes and not coordinated with the operational staff. This issue resulted in entire system outages when a new capability was implemented onto operational systems.[211] Because the required EA did not have a design that allowed for software to be implemented with minimal disruption, the project team needed to engineer a separate solution that bridged the technology gap rather than developing the project's main objective. This problem is akin to an auto manufacturer needing to design and build roads rather than focus on building a car.

The project identified a need for data governance and oversight in integrating data across all networks within DND. Although the project was delayed by building some of the data roads and bridges along the way, the by-product did help improve the flow of information and data across the networks DND employs today. Although SSE and ADM(DIA) indicate investment on this front, they will need to be integrated within DND

[210] Canada, *JIIFC Project and JBMC Fielding Lessons Learned*Department of National Defence,[2019]). 4.
[211] *Ibid.,* 12. When new major software are implemented onto operational systems, there needs to be services outages to allow for proper integration.

Capability Development activities so projects will not be met with the same level of friction as the JIIFC project. Projects like JIFFC/JBMC will become increasingly common, and the path forward needs to be built.

Acquisition Agility

The ability to quickly adapt a project within the digital landscape is essential to deliver a viable product to the end-user at the speed of operational demand. In DevOps, the delivery of an MVP allows for quick delivery of a useable product. Developers then iterate and receive feedback from the user community, making an overall better product. However, to do this, the project will need the policy, funding, and authorities to permit it.

Unfortunately, as indicated, the JIIFC project was following the DND PAD, aligned with the waterfall model, which did not permit such flexibility. Because the project needed to make multiple adjustments to its project scope to address the low level of digital readiness within the CAF, it required to follow a change management process that was lengthy and very costly to implement.[212] The discrete and unidirectional nature of the waterfall model meant that the project team did not have the flexibility to adapt to change quickly. Instead, they needed to revisit contracts with the vendor and follow the strict procures for project redesign as outlined in the PAD.[213] JIIFC was involved with a Foreign Military Sales (FMS) case,[214] creating contracting delays, as noted in an independent review of the project.[215]

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[212] *Ibid*, 3. The Lessons learned document highlights that some of the requirements they needed to follow did not align with the end user requirements for the project.
[213] Canada, *Project Approval Directive (PAD). 102*.
[214] *Ibid.* 204. The FMS is an inter-governmental contract to acquire military equipment or capabilities from allies. In this case, the project has an FMS case with the US.
[215] Grant Westcott and Catherine Hoople, *Independent Review of the Joint Information and Intelligence Fusion Capability (JIIFC) Project*INTERIS,[2011]). 9.

As identified in Chapter 4 (Figure 4.1), this was the downside of the waterfall model, where the inability to iterate on MVPs can increase end-project risk. Since the JIIFC/JBMC project had a PCRA of three (3), design changes needed to follow a lengthy process under the PAD's change management directive leaving no capacity for quick iteration.[216]

Furthermore, users were also not engaged in the development process.[217] As such, requirements developed by the project were outdated and developed in isolation that resulted in a final product that did not maximize the value potential. Early user engagement is vital in ensuring that the project's product is remains aligned with user requirements. With the Agile/DevOps model, users receive an MVP early and often provide feedback to the acquisition team to iterate on recommended changes, ensuring they need what they need, not what the project anticipates as a need. As the JIIFC project was following the waterfall model, there was no opportunity to iterate on the product with the users; thus, the product diverged from their operational requirements creating friction in adopting it.[218]

Enterprise Architecture

Hindering the development of the project solution was the lack of a test and development network from which to test and develop the project's new solutions. As this was critical for successful software development, a separate contract was required to establish a suitable environment for software development separate from DND.[219] This

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[216] Canada, *Project Approval Directive (PAD).* 190
[217] Canada, *JIIFC Project and JBMC Fielding Lessons Learned…*, 9.
[218] *Ibid.* 6.
[219] *Ibid*., 12. Outlined in lesson 8 of the Lessons Learned document, the lack of a DND controlled development environment significantly hindered the project.

issue was a critical lesson learned because the project team did not want to depend on resources external to their approved project funding. Because DND's waterfall acquisition model is more conducive to hardware, the PAD has not incorporated the supporting architecture to enable software or digital technology development. Because the waterfall model does not allow for iteration, there is no need to create an EA that will allow for that. Therefore, IT-related projects are left having to build a test and development environment outside the project's scope, increasing time and cost, or risk delivering a solution that is not effective. DND's architecture was not supportive of software development at the scale JIIFC/JBMC required.

Innovative Culture and Talent

The innovative initiatives such as the JIIFC/JBMC followed an acquisition process designed around traditional military hardware, not software. The waterfall process within the PAD stymies innovation because it did not allow the JIIFC/JBMC project to iterate and test their ideas and solutions. This issue highlights the problem areas identified in the DND *Data Strategy* where there is low data literacy, lack of data culture and inflexible processes.[220] As it pertains to DND's procurement process, Alan Williams states that 'The Government needs to change its culture into one that promotes innovation, creativity in order to improve confidence with industry".[221]

The PCRA of the JIIFC/JBMC project was assessed to be at level three (3) largely because of its $63M valuation and Medium risk assessment.[222] Given that the OPMCA of DND at the time was only at a level two (2), this mandated TB oversight as Project

[220] Canada, *DATA STRATEGY…*6
[221] Charlotte Duval-Lantoine et al., *Defence Procurement in the 43 Rd Parliament*, (2020). 24.
[222] Canada, *JIIFC Project Complexity and Risk Assessment*, (2011). 1.

Approval (PA) authority, slowing the already lengthy waterfall model.[223] The PAD's governance model creates an inflexible environment that is at odds with the innovation needed for software development, illustrating what Carter was referring to regarding acquisition reform and what Rouleau wants to achieve for digital transformation described earlier.

The LL document indicated that one of the critical elements that hindered the acceptance of the new technology was a lack of an overarching business transformation and change management champion of innovation and enterprise software development. Even though the JIIFC/JBMC project was rescoped to focus on the Canadian Joint Operations Command (CJOC) as the primary client and user of the system, there was no synergy between the Operations/User and the Development sides of the project.[224]

In 2011 an independent review of the JIIFC project was completed that identified six issues and two recommendations.[225] The project lacked governance and management, which led to unclear accounting and requirements definition.[226] The report recommended using external agencies and a horizontal management approach, indicators of a DevOps framework the project didn't have. Specifically, the report encouraged more of a "hand-on" validation using the warfare center, compared to the "theoretical paper examination" that the waterfall model demands.[227] These findings of the JIIFC project in 2011 allude to a need to shift towards a more agile framework as a "hands-on" approach speaks to

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[223] *Ibid.*
[224] Canada, *JIIFC Project and JBMC Fielding Lessons Learned…*, 4.
[225] Grant Westcott and Catherine Hoople, *Independent Review of the Joint Information and Intelligence Fusion Capability (JIIFC) Project.* INTERIS, (2011). ii. Due to TB oversight as PA, independent reviews are required for the project to progress down each phase of the waterfall model.
[226] *Ibid.* 12.
[227] *Ibid*. 11.

iterative development to achieve an MVP instead of a paper exercise to satisfy the project management requirements of the PAD.

CONCLUSION

When the CDS set out the requirements that prompted the initiation of the JIIFC project in 2002, it was a call for more innovation. It recognized the need for digital transformation that remains true today. In 17 years of trying to deliver the solution, the JIIFC/JBMC project faced process friction that eroded its capability to deliver on the initial project plan. DND's digital transformation lacked overall governance that did not set the correct initial conditions needed for JBMC.[228] The EA within DND was neither sufficiently advanced nor managed, which led to stovepipes of data and information exchange that did not allow for the implementation of agile software development. Neither the culture nor the talent was focused on the necessary skills for delivering value to the warfighter. Instead, the culture was focused on following an industrial-age suited waterfall process that dragged out acquisition timelines within DND's current procurement model.

While the JIIFC/JBMC project represents the capabilities that CAF needs now, it is a harbinger of why we need to change the way CAF conducts software acquisition. The many friction points in the JIIFC/JBMC case study are still present now, almost two decades from when the project started. The good news is that with the initiatives set out in SSE and more attention to future capabilities and expanded responsibility of ADM(DIA), there is a path for change.

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[228]Canada, *DND/CF Architecture Framework* ... This is based on the conditions that predated the creation of ADM(DIA) and the Chief of Force Development creation of the Director of Enterprise Architecture responsible for the DNDAF framework which didn't come into effect until 2013

CHAPTER 6: DEFENSE INNOVATION UNIT EXPERIMENTAL (DIUX) – KESSEL RUN CASE STUDY

This section will look at a case of agile software acquisition within the USAF. This case study will reveal a potential path forward that DND/CAF could emulate to accelerate technology acquisition. Before his position as Secretary of Defence, Ashton Carter, worked with Academia and Industry to produce seminal literature on how the US could maintain a military advantage over its adversaries amidst the bow wave of technological revolution.[229] Then when he became Secretary of Defense in 2015, he brought to fruition some of the recommendations he previously researched on this topic. The Defense Innovation Unit Experimental (DIUx) was one of the results.[230]

BACKGROUND

The DIUx organization is a DoD-led initiative realized to increase agility and innovation for advanced technology acquisition by fusing efforts between military and private industry.[231] To understand the context surrounding "Kessel Run", it is important to understand the creation of the parent organization that provided the impetus to implement it. The DIUx organization was created due to significant project failures in the digital acquisition realm, illustrated by a digital transformation capability within the USAF 609th Combined Air Operation Center (CAOC) in Al Udid Qatar.[232] Although the case study could focus on the creation of the DIUx itself, Kessel Run was chosen as it specifically highlights the merits of a DevOps framework.

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[229] Carter et al., *Keeping the Edge…*
[230] "Remarks on Opening DIUx East and Announcing the Defense Innovation Board."https://www.defense.gov/Newsroom/Speeches/Speech/Article/858155/remarks-on-opening-diux-east-and-announcing-the-defense-innovation-board/ (accessed Apr 13, 2021).
[231] Carolyn Wong, *Enhancing ACC Collaboration with DIUx*RAND Corportation, (2017). vii.
[232] *Ibid, 1.*

The grounds for creating Kessel Run stems from a USAF Air to Air Refuelling (AAR) scheduling process the 609th CAOC had dealt with for ten years. This process involved manually planning, scheduling, and coordinating AAR assets with other USAF assets during combat operations in the Middle East. Each day this process comprised hundreds of hours to complete and was highly prone to human error. The technology they used to do this planning was a combination of whiteboards and convoluted excel files that required manual input and extraction for every step of the process (Figure 6.1). The 609th CAOC deficiencies were similar to the C2 challenge the JIIFC/JBMC project was trying to address.

In 2017, after ten years and $750M spent with no effective software solution delivered for the AAR problem, there was significant motivation to make a change.[233] As chairman of the U.S. Defence Innovation Board (DIB), CEO of Google, Dr. Eric Schmidt visited Qatar in 2016 to see firsthand the innovation challenge the USAF was facing. When Schmidt asked the commander of the CAOC what the biggest challenge was, he was surprised to hear that he wanted to 'keep his whiteboard.'[234] In short, the US needed the motivation to dislodge themselves from their inefficient bureaucratic acquisition process of the Cold War ways to bring them into a digital era. Perhaps, the defence organization need to balance their rigidity and process against flexibility and speed of software acquisition. This balance will be a question of trust in adopting fast software development in the highly secure environment of defence operations. Through key talent

[233] Mark Wallace, "The U.S. Air Force Learned to Code—and Saved the Pentagon Millions," https://www.fastcompany.com/40588729/the-air-force-learned-to-code-and-saved-the-pentagon-millions (accessed Mar 30, 2021)
[234] *Ibid.*

and expertise from the industry embedded in the DIUx and Kessel Run is an example of how it can work.

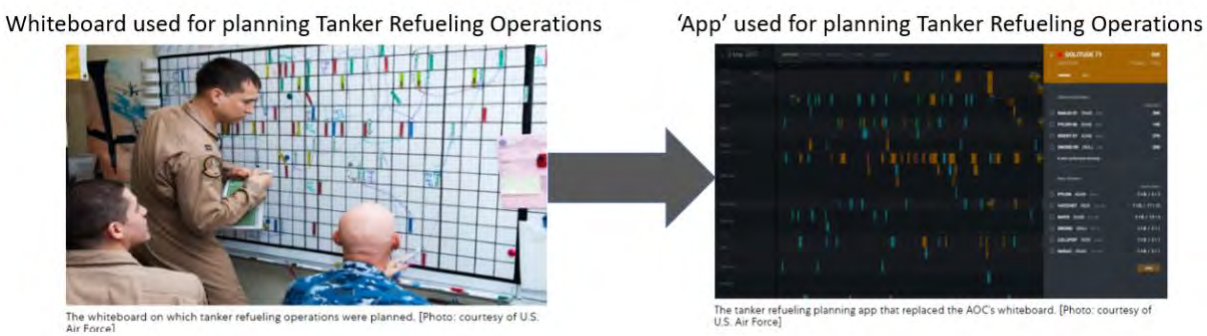

Figure 6.1 – Digitizing the USAF's Tanker Refueling Planning Tool.
Source: The U.S. Air Force Learned to Code – Fast Company

DIUx adopted the AAR project under the USAFs initiative to create agile software development through Kessel Run. Kessel Run prompted a fusion between military service members and industry experts. Service members would learn the fundamentals of agile software development, and the industry experts learn about unique USAF operational requirements. The result of this collaborative effort delivered a fully functioning software solution to the AAR problem in just four months at the cost of $2M, proving an early success of the Kessel Run acquisition model. As a 2017 RAND Corporation report on DIUx indicates, Kessel Run initiatives are well suited to USAF requirements by leveraging rapid acquisition and innovation solutions from the best technology companies.[235] The Kessel Run initiative evolved from a proof of concept into a new digital acquisition and software development model that shows potential utility in the CAF.

[235] Wong, *Enhancing ACC Collaboration with DIUx...*, viii.

KESSEL RUN ENGAGEMENT

This case study will be examined through the same lens as the foundational factors in the JIIFC case study. However, it will be using material from the author's professional engagement with the organization, the formal documentation outlining the organization's procedures and the academic study of the unit.[236]

Digital Readiness

The Kessel Run organization based its business on the foundations of a DevOps framework. The inflection point that drove the USAF to adopt the DIUx innovation model was mainly prompted by the gross failure of their CAOC modernization effort and inefficient acquisition model, combined with a senior-level endorsement for change. The leadership was driven for a more efficient digital transformation across government departments. For example, the White House recognizing how slow and inefficient their digital services were, initiated the US Digital Services (USDS) unit that looked at implementing agile and DevOps methodologies across the US Government, where it was coined as 'America's Start Up.'[237] Positioned within the Executive Office of the President of the United States, the USDS had the leadership and organizational endorsement to be an influencer of change across all government departments. [238] It was one of the motivating factors aiding DIUx in the creation of Kessel Run. The former USDS Deputy Administrator Haley Van Dyck, during a TED talk in 2016 stated that "94 % of federal IT project are over budget or behind schedule..40% of those never end up

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[236] The author of this paper, in his capacity of Project Director for the RCAF Future CAOC Capability had personal engagement and correspondence with Kessel Run,-including a site visit.
[237] U.S. Digital Service, "Our Mission," https://usds.gov/mission (accessed Mar 27, 2021).
[238] *Ibid*.

seeing the light of day; they are completely scrapped or abandoned".[239] The former Commanding officer of Kessel Run, Colonel Enrique Oti, when forming the unit in 2016, was given strict direction from the Director of DIUx to leverage industry in creating a software development capability that would bring the USAF into the 21st century.[240] Recognizing the early success of Kessel Run's AAR project, the Secretary of the Air Force, Heather Wilson, in a 2018 report to US Congress, highlighted Kessel Run's potential for growth.

> The use of Agile DevOps methodologies…is proving successful and we are able to rapidly deliver cloud-native applications that increase operational utility…We believe we have demonstrated the ability to continuously deliver software that adds value to the warfighter.[241]

The USAF was motivated and supported by the highest level of government within the US. The White House's Digital Transformation services and Congress's awareness and support accelerated how the government and, by extension, the DoD conducts software development and digital acquisition. This US Government and DoD's recognition of a need for digital transformation created an environment from which Kessel Run's efforts could be adopted and scaled. An organization's ability to scale from a relatively small investment of resources to grow into a transformative capability is imperative for digital transformation and a DevOps environment[242] and is the path that Kessel Run is on.

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[239] *How a Start-Up in the White House is Changing Business as Usual,* directed by TED Talk (2016)
[240] Jim Perkins and James Long, "Software Wins Modern Wars: What the Air Force Learned from Doing the Kessel Run," *Modern War Institute* (Jan, 2020).
[241] Michael McQuade et al., *Software is Never done: Refactoring the Acquisition Code for Competitive Advantage* Department of Defense, (2019). 54.
[242] Perkins and Long, "Software Wins Modern Wars: What the Air Force Learned from Doing the Kessel Run," *Modern War Institute* (Jan, 2020).

So how did Kessel Run get to this point? It started with the Air Operations Center (AOC) Pathfinder Initiative under a USAF investment portfolio as a 'Start-up' trial in addressing AAR issue described earlier. Since the DoD/USAF were dealing with the same waterfall-like acquisition challenge described in Chapter 3, the AOC Pathfinder pilot project was intended to test a hypothesis of using agile/DevOps to address it.[243] The pilot was meant to last nine months with a target of delivering an AAR MVP within 90 working days.[244] The pilot project leveraged a modular contracting approach with varying contracting vehicles.[245] In relation to the DND acquisition model, it meant the AOC Pathfinder pilot was able to conduct the same acquisition efficiency and flexibility of a minor project (<$10M) while having the resources of a Major Capitol acquisition with a PCRA level 3. The pilot project had a budget of $48M, and the DIUx was their Project Authority for approval giving them tremendous flexibility.[246] This arrangement allowed the accelerated delivery of a fully functioning capability in just four months with only $2M.[247] This pilot proved successful, and the AOC Pathfinder was launched into an official unit (Kessel Run); and they have been gradually scaling in size and have been emulated across the DoD since its inception in 2017.[248] This success was achieved

[243] USAF, *Agile Pilot AOC Pathfinder (Aka Kessel Run) Sec 874 Pilot Plan Target Discovery Manager (Aka Terminator 2)*, (2018). 3.
[244] *Ibid.* 4.
[245] *Ibid.* 10
[246] With the same project valuation and complexity, the Project Authority and Expenditure Authority would have been the Treasury Board. As DND does not have a DIUx equivalent, the current IDEaS is the closest facsimile for comparison. Comparing this to the JIIFC/JBMC project, this would have been equivalent to the project team only going as high as the IDEaS program for all project approvals and expenditure authorities. Moreover, as the JIIFC/JBMC would not have been burdened by the lengthy waterfall model.
[247] Wallace, "The U.S. Air Force Learned to Code—and Saved the Pentagon Millions,"
[248] Phil Dr Budden et al., *Kessel Run: An Innovation Opportunity for the USAF* Massachusetts Institute of Technology, (2021). 14

because the DoD and USAF were willing to test a hypothesis of implementing agile methodologies on high-value and high-risk projects.

Acquisition Agility

Kessel Run's main advantage in achieving a practical DevOps framework is their continuous delivery and the associated continuous authority to operate (ATO). The ATO was noted as one of Kessel Run's most significant successes as it was the key to unlocking agility in a security-constrained defence acquisition environment.[249] Kessel Run's highest priority was to 'satisfy their warfighter through continuous delivery of valuable software.[250] To do this, they enabled DevOps and Lean Startup methodologies with the model around delivering MVP every four months. As the USAF did not have the resident experience and expertise to do this, the AOR Pathfinder pilot contracted Pivotal Labs leveraging a DoD's Prototype Other Transaction Authority (OTA).[251] Since the OTA provides the DoD access to up to $500M[252] in funding, it enabled Kessel Run with the financial support to conduct their DevOps pilot. With the contracted help of Pivotal Labs, Kessel Run developed an accredited cloud-based DevOps platform or IT-Stack approved for use on the DoD Secret Internet Protocol Router (SIPR) network. [253] This approval and IT-Stack set the necessary foundation for implementing a DevOps process

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[249] Jenny Aroune, Robert Hollister and Nathan Taylor, "Kessel Run: An Analysis of the Air Forces Internal Software Development Organizat" Naval Postgraduate School), 50.
[250] Enrique Col Oti, *Presentation: Kessel Run - Continuous Testing*, 2018).
[251] Victoria Galvin, *Air Operations Center (AOC) Section 804 Middle Tier of Acquisition (Rapid Prototyping/Rapid Fielding) Plan*, 2018). 2. The OTA refers to DoDs authority to carry out prototypes, research and production projects. The closest DND analog to this OTA would be DND UOR process or the new IDEaS program. However, with the UOR, combat operations are the key to entry, and IDEaS are limited in funding. National Defence, "IDEaS Past Opportuities," https://www.canada.ca/en/department-national-defence/programs/defence-ideas/past-opportunities.html
[252] DoD, "Title 10 U.S. Code 2371b - Authority of the Department of Defense to Carry Out Certain Prototype Projects," https://www.law.cornell.edu/uscode/text/10/2371b. In relative terms in DND this would be equivalent to $17M based on the differences in DoD vs DND budgets.
[253] Galvin, *Air Operations Center…*2. Pivotal Labs is a software development consulting firm.

establishing their ATO approval and was a key element missing in DND's network architecture for JIIFC/JBMC.

As defence organizations are typically risk-averse with delivering new capabilities on secret enterprise networks, the process for change approval can be lengthy and is not congruent with the rapid development for which Kessel Run was established. Therefore, Kessel Run's achievement in establishing an IT-Stack approved for software development for classified systems meant that they were able to accelerate development times. To achieve this, they were authorized under the National Defense Authorizations Act (NDAA) Section 804 - Middle Tier Of Acquisition for Rapid Prototyping and Rapid Fielding.[254] Kessel Run obtained approval under the secretary of Defense for Acquisition, Technology and Logistics due to the proven AOC Pathfinder pilot and endorsement of USAF leadership and Congress.

The NDAA Sec 804 status combined with the funding with the OTA unlocked the ability for accelerated and flexible agile development. As a result, Kessel Run was the first DoD organization to achieve continuous delivery of new features to real-world operations on SIPR with ten new applications per week. It was able to push new applications to SIPR users in less than an hour.[255] Additionally, Kessel Run was the first DoD organization to achieve the ATO due to the achievement of automated security control obtained by their accredited IT-Stack and NDAA 804 status.[256] The ATO allowed Kessel Run to achieve continuous delivery to the operational community with DevOps

[254] "Middle Tier Acquisition NDAA Language | AiDA."https://aida.mitre.org/middle-tier/ndaa-language/
[255] Galvin, *Air Operations Center…*2.
[256] Galvin, *Air Operations Center…*3.

instead of waiting on a higher level and external approvals, which slow the process.[257] However, while operating under NDAA 804, Kessel Run was required to provide quarterly updates to USAF senior leadership on recommendations to transition to DoD Instruction 5000.02, the Operation of the Adaptive Acquisition Framework (AAF) in the future.[258] The AAF is the DoD's mechanism to approve permanent alternative acquisition pathways based on authorized, approved processes and DoD investment value.[259] The AAF was the gateway that the USAF used to cut through their outdated waterfall model and leveraged Kessel Run to prove their case. However, no equivalent process exists within the PAD that would allow for a similar process.

Kessel Run identified they needed to change the USAF contracting mindset rejecting the past tendency to develop all-in-one contracts, including questioning the rules. Their deputy director Lieutenant-Colonel Jerimiah Sanders summed up their mind like this "When someone says, 'this is how we've always done it,' I hear 'this is how we lose the next war'."[260] They wanted fervently to push the limits of what was possible to allow them to achieve the acquisition agility they needed. Kessel Run opted to increase the volume of contracts versus the size of contracts as it is more suited for efficiency in software development.[261]

Kessel Run's ATO allowed them to be masters of their process, and authority levels provided them with the autonomy necessary to adopt a DevOps environment. Kessel Run software code is scrutinized and tested by both operations and development

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[257] Jenny Aroune, Robert Hollister and Nathan Taylor, "Kessel Run: An Analysis of the Air Forces Internal Software Development Organization" (Naval Postgraduate School), 50.
[258] Victoria Galvin, "Air Operations Center (AOC) Middle Tier of Acquisition (Rapid Prototyping/Rapid Fielding) Plan" Kessel Run, 2018). 4.
[259] DoD, *DoD Instruction 5000.02 the Defense Acquisition System*, (2017).
[260] Jeremiah Lt Col Sanders, "Kessel Run's Agile Imperative" Kessel Run, (2019). 24
[261] *Ibid…25.* Indicating the Software vs Harware paradigm shift.

staff continuously throughout the development process, rather than at the end of the process as traditional defence acquisition models require.[262] In effect, this allows them to incrementally mitigate more negligible risks in-house rather than contending with more considerable risks at the end of a project requiring higher levels of approval. The result is that this allows the software to be developed faster, with higher quality and lower risk than the traditional waterfall model of defence acquisition.[263] The director of Kessel Run's software lab, Adam Furtado said that "…it has taken us a long time to figure out all of the mechanisms behind [ATO] to get there...many in the commercial industry adopted these processes about a decade ago."[264] Kessel Run is an example of what leveraging industry best practices for digital technology acquisition can provide. The Massachusetts Institute of Technology has examined the process that has led to the successful scaling of Kessel Run model as a model innovation.[265]

During a 2020 presentation, Kessel Run indicated some of their success through the following results:[266]

- Kessel Run acquisition process saved $13M and 2350 hrs work/month while developing 18 new capabilities.
- Average time from 'need' to delivery of an operational capability - ~ 4.5 months.
- Lead time for industry solicitation 3.5 days (reduced from ~5 years).[267]

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[262] Mark Pomerleau, "How the Air Force's New Software Team is Proving its Worth," https://www.c4isrnet.com/it-networks/2019/01/14/how-the-air-forces-new-software-team-is-proving-its-worth/ (accessed May 3, 2021

[263] *Ibid.*

[264] *Ibid.*

[265] Phil Dr Budden et al., *Kessel Run: An Innovation Opportunity for the USAF* Massachusetts Institute of Technology, (2021). 1.

[266] Jeremiah Lt Col Sanders, "Kessel Run's Agile Imperative" Kessel Run, (2019). 4

[267] As a comparison, the JIIFC project took 8 years from idea to industry engagement through the FMS case.

- Software production frequency: ~42/month (Delivering a new capability to operations every 14.8 hrs and getting faster)[268]

The waterfall acquisition process is not conducive to the level of efficiency that a DevOps methodology can deliver, as demonstrated by Kessel Run. Sanders said that DoDs previous acquisition challenges for digital transformation resulted from a risk-averse system with layers of bureaucracy that take away decision-making power from where it needs to be and drive higher risks and program failures.[269] This statement speaks to the challenge identified in Chapter 3, where DND's acquisition model is not adequately aligned with private industry's R&D efforts for digital technology and speaks to the issue Kiever indicated and the necessity to stay below $10M OPMCA threshold.

One of the challenges in increasing the speed of software acquisition is the inherent risk it imposes within defence operations given necessary security measures. The dichotomy that militaries need to contend with is balancing digital capabilities with their associated vulnerabilities. Therefore, militaries need to ensure strict processes are implemented to mitigate risks introduced while maintaining military capabilities. Unfortunately, this process of information security often delays software development projects. USAF officer Daniel Shoeni discussed that balancing software acquisition agility with cybersecurity can cause friction, ensuring a secure solution is often met with increased time and cost while compromising quality.[270] Kessel Run's classified network-approved IT-Stack and ATO mitigated this challenge, allowing them to achieve the speed of a DevOps framework while ensuring a secure solution for military operations.

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[268] This is either a new software capability or an upgrade to an existing system.
[269] Ibid, 7.
[270] Daniel Shoeni, "Top-Down IT Approach Too Slow to Meet Threats," *Defense One* (24 Aug, 2015). https://www.defenseone.com/ideas/2015/08/top-down-it-approach-too-slow-growing-threats/119387/.

Enterprise Architecture

Kessel Run looked to change how the DoD historically managed its IT infrastructure by leveraging the expertise from industry to create the foundation for a DevOps environment. As Kessel Run needed to deliver capabilities to the warfighter on classified networks, they needed to develop the IT-Stack that was accredited for their SIPR network. An outsourced cloud-based architecture allowed Kessel Run to focus on developing software capabilities to support operations rather than maintaining and configuring networks.[271] The cloud solution enabled Kessel Run to "be dismissive on the things that do not matter, but very disciplined on things that do…", allowing a continuous delivery cycle that can be faster than their adversary. As explained in Chapter 2, fast software development will be a crucial enabler for future warfare.

The USAF CAOC modernization had previously suffered the same problems as the JIIFC project. These problems were because USAF relied on a $745M contract with a large defence contractor (Lockheed Martin) that followed the traditional platform-centric, industrial-age process, the same process (and contractor) used to procure a new aircraft but needed it to produce software.[272]As the linear waterfall model for defence acquisition was designed around large defence contractors (the platform builders), it made it easy to rely on them for all their defence needs, as it has been done for decades. Kessel Run

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[271]Sanders, "Kessel Run's Agile Imperative"…, 13. Recall the issues with JIIFC and their lack of a development environment. They lost focus and time in working a IT interface with DND's enterprise architecture

[272] Mark Wallace, "The U.S. Air Force Learned to Code—and Saved the Pentagon Millions," https://www.fastcompany.com/40588729/the-air-force-learned-to-code-and-saved-the-pentagon-millions Defence contractors may be suitable for delivering complex military equipment/hardware, but they are not the industry leads in software. Coincidently, the USAF relied on Lockheed Martin to develop their software solution to the CAOC AAR challenge. Indicating that industrial age processes (e.g. PAD) begets industrial age contractors.

asked the question, is it necessary to rely on a typical defence company, an aerospace company (Lockheed Martin), to build software for them? – the answer was no. Therefore, they enlisted a contractor that specializes in software development, not airplanes. Kessel Run enlisted Pivotal Labs' help with a cloud-based architecture that allowed Kessel Run to develop, test, deploy, and scale their products in concert with industry experts in the field.[273] Pivotal Labs worked together with uniformed members to generate expertise on the USAF side and generate operational understanding on the side of the industry, which initiated a DevOps architecture. The hybrid employment concept from the perspective of architecture management and software development is an essential element that should be adopted within DND to create the conditions necessary for DevOps.

Innovation Culture and Talent

An agile and responsive capability development environment successfully generates and retains the skill and talent necessary to work in an environment of software development and technology. However, this same environment is not always congruent with typical military culture. To create sustainable change with culture and talent, Kessel Run looked at three main areas of focus. A Generative Culture, their Workplace Environment, and Being an Employer of Choice.[274] Ron Westrum, a sociologist, has researched organizational cultures in complex organizations. Westrum defines three cultural models; a Pathological Culture preoccupied with personal power, needs and

[273] Andrew Lt Altizer, "Continuous Authorization - Risk Management Playbook" Kessel Run, 2018). 16.
[274] "DevOps Culture: Westrum Organizational Culture."https://cloud.google.com/architecture/devops/devops-culture-westrum-organizational-culture (accessed May 3, 2021).

glory; a Bureaucratic Culture preoccupied with rules, position and departmental needs; and a Generative Culture preoccupied with the mission (Figure 6.2).[275]

Pathological	Bureaucratic	Generative
Power oriented	Rule oriented	Performance oriented
Low cooperation	Modest cooperation	High cooperation
Messengers "shot"	Messengers neglected	Messengers trained
Responsibilities shirked	Narrow responsibilities	Risks are shared
Bridging discouraged	Bridging tolerated	Bridging encouraged
Failure leads to scapegoating	Failure leads to justice	Failure leads to inquiry
Novelty crushed	Novelty leads to problems	Novelty implemented

Figure 6.2 – Westrum's Cultural Comparison
Source: DevOps Culture: Westrum Organizational Culture. Google Inc.

Westrum found that looking at various case studies, which included US DoD R&D facilities at China Lake, a generative culture is more conducive to innovation and creativity.[276] Kessel Run has developed a generative culture that enables small teams, critical thinking and design-focused methodologies while engendering value in their people.[277] They achieved this by promoting the principle of Design Thinking[278] by maintaining an environment of experimentation while leveraging DevOps methodologies by coupling engineers, designers and operators together in small teams.[279] Kessel Run uses a balanced team model employing best practices from lean start-up companies, where they have substituted a single leader with a three-person team who shares ownership and accountability. Their small teams consist of a Product Manager, a Product

[275] R. Westrum, "A Typology of Organisational Cultures," *Quality & Safety in Health Care* 13, no. suppl 2 (2004), 22-27.,23
[276] *Ibid.*
[277]Sanders, "Kessel Run's Agile Imperative"..., 33
[278] David Dunne, *Design Thinking at Work: How Innovative Organizations are Embracing Design* (London; Toronto; Buffalo: University of Toronto Press, (2018). 111.
[279] USAF, *Agile Pilot AOC Pathfinder (Aka Kessel Run) Sec 874 Pilot Plan Target Discovery Manager (Aka Terminator 2)*, (2018). 16.

Designer, and an Anchor.[280] The Product Manager is responsible for managing the workflow and prioritization of tasks. The Product Designer is the primary liaison with the end-user or operations community. They use Design Thinking concepts to ensure the users get what they want and enjoy using. Finally, the Anchor is the Lead Engineer who ensures the software product fits into the overall concept of the system or project and is familiar with the technical programming of the product. This balanced team uses empathy throughout the process to ensure value to the user and generate cohesion within their team.[281] It is also worth noting that these three-member teams are a mix of uniformed, contractor and civilian staff who can interchange roles based on their experience and skills or simply their desire to learn.

Kessel Run attributes their success at achieving this productive DevOps environment through their software consultancy Pivotal Labs. The USAF recognized they did not have the expertise to transform digital technology acquisition, so they hired experts who do and leveraged various contracting vehicles to retain their partnership until the USAF masters the culture and acquisition methodologies needed to be self-sufficient. Kessel Run and DoD have also recognized that the benefit of DevOps culture beyond its function towards software and digital technology development. The same practices that improve the software to the user can be leveraged to improve organization efficiencies across other lines of business.[282]

Finally, they needed to brand themselves to be an employer of choice. When the author spoke to the various staff members at Kessel Run and asked how they liked

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[280] *Ibid.* 28
[281] *Ibid.* 28
[282] *Ibid.* 30.

working there, they responded emphatically, saying it was a great job and a great atmosphere. In an era where DoD and DND will be competing for the talent needed in this software development and technology space, there needs to be the draw and motive to stay. Kessel Run is making it work very well as they have a brand, mission and value proposition that is competitive with commercial equivalent organizations. To ensure they stay competitive, Kessel Run continuously measures how well they are doing by using an Employee Net Promoter Score (eNPS) to assess their organizational fitness in this regard.[283]

The overall organization was people and talent-focused above all else. The leadership's responsibility was to foster that valuable asset by providing the environment to thrive. To date, there is no such organization or unit that exists within DND that comes close to the level of innovation displayed at Kessel Run.[284] However, there are the people and ambition to make it so.

CONCLUSION

If DND wants to stay competitive in the software and tech development space, then the critical lessons from Kessel Run should be examined and emulated. It is important to note that Kessel Run was just one example within the DoD that has adopted the DevOps framework for capability development. Because the DoD has adopted an enterprise architecture conducive to a DevOps framework, they can now scale initiatives

[283]An eNPS is a way of measuring how your employees assess your company or organization. Similar to a job satisfaction survey but is more similar to a customer satisfaction survery but instead of a repeat customer, it measures repeat emoployablity. It based on three metrics: Detractors, Passives and Promoters. More info: "Employee Net Promoter Score: A Good Measure of Engagement?"https://www.hrtechnologist.com/articles/employee-engagement/employee-net-promoter-score-a-good-measure-of-engagement/ . Sanders, "Kessel Run's Agile Imperative" Kessel Run, 2019). 29.

[284] Based on the authors various unit and Senior Level engagement as Project Director discussing the merits of DevOps and DIUx while managing a major capital investment.

such as Kessel Run. The DoD now has dozens of other initiatives and units to scale the DevOps model for other defence initiatives.[285] These initiatives have increased DoD resiliency, security and adaptability needed for future warfare. The work that the USAF and other grass-roots DevOps initiatives are progressing is allowing the DoD to accelerate warfighting capabilities of the future and maintain its technological edge.[286] The future of warfare will heavily depend on the advanced technological threat discussed in the paper. The focus towards accelerating software development practice within DND will be critical to keeping pace with Canada's allies and adversaries.[287]

[285] Jenny Aroune, Robert Hollister and Nathan Taylor, "Kessel Run: An Analysis of the Air Forces Internal Software Development Organization" Naval Postgraduate School), .51.
[286] Steve Blank, Joseph H. Felter, "Maintaining America's Technological Edge: Build on our Strengths," The Center for the National Interest, https://nationalinterest.org/blog/buzz/maintaining-america%E2%80%99s-technological-edge-build-our-strengths-177377 (accessed Mar 28, 2021).
[287] Perkins and Long, "Software Wins Modern Wars: What the Air Force Learned from Doing the Kessel Run," *Modern War Institute* (Jan, 2020).

CHAPTER 7: CONCLUSION AND RECOMMENDATION

> *We are as gods and might as well get good at it. So far, remotely done power and glory – as via government, big business, formal education, church – has succeeded to the point where gross defects obscure actual gains.*
>
> — Stuart Brand, *The Whole Earth Catalog*

DIGITAL READINESS

Digital transformation is a complex problem. The DoD has recognized this, and with the highest levels of government within the US, from the White House down to a small start-up unit within the USAF, there needs to be the same support towards evolving CAF digitization. Although Canada's latest defence policy indicates a need to adopt innovative strategies in capability development and acquisition, the proposed initiatives are still hindered by DND's outdated waterfall acquisition model. Although some departments are initiating innovative strategies such as PSPC's agile procurement strategies and DND IDEaS program, they have not gained enough momentum to change the PAD significantly enough for accelerated acquisition. Additionally, the CAF has not fully adopted the ability to leverage a data-centric ecosystem to enable an effective digital transformation necessary for emergent technologies such as AI. As indicated in the JIIFC/JBMC case study, the CAF is still operating insularly regarding its management and data processing. Although the former VCDS issued guidance regarding digitizing the force, changes to the current capability development and acquisition process will need to be done to realize digital transformation.[288] Furthermore, ADM(DIA) will address and provide more focus on creating the necessary data ecosystems of the future; there still

[288] Canada, *CANFORGEN 022/21 - Promotions and Senior Officer Appointments 2021 - General and Flag Officers* Department of National Defence. As this paper was being finalized, the former VCDS LGen Rouleau was identified to become the Advisory for Future Capability development. He was also replaced by LGen Allen, who has extensive background in technology and cyber capabilities. This is a step in the right direction for creating an organizational shift for digital transformation that this paper discusses.

needs to be a national push to mandating government departments to increase their rate of digital transformation. The Kessel Run pilot was a trial that tested a hypothesis of accelerating software development. The DND/CAF, will also need to adopt a start-up methodology to indicate a path for acquisition reform.

ACQUISITION STRATEGY

DND/CAF is still operating under an outdated capability development and acquisition model based on industrial age practices that are platform-centric and process-focused. Unfortunately, this creates a reactionary capability environment versus one that is anticipatory. As Keiver indicated in Chapter 3, the demand for change already exists. The effect of smaller scale DevOps initiatives will provide proof of concept and provide evidence of a value proposition used as a case for change within DND. Although the PAD has some avenues of acquisition flexibility, such as the UOR or the minor project space, they are limited in scope by policy and funding thresholds. Leadership within the CAF will need to provide the endorsement and champion change for this environment and explore the development of a path equivalent to the DoD's AAF. The MND will ultimately need to be the voice to institutionalize a departmental-wide shift in the capability development process.

The continuous ATO was a cornerstone of Kessel Run's success and enabled them to scale as a start-up initiative and is something that DND will need to focus on developing. This process will need to be developed in concert with the approving authorities of the current change management process within DND for IT systems and software. DND will need to share a common viewpoint on the merits of creating a continuous ATO, not only in DND but for other departments. DND should, however,

lead the way in this regard and indicate the value this could deliver in the development of new military capabilities.

ENTERPRISE ARCHITECTURE

The digital landscape in which the future technologies will depend on demands an IT architecture that will allow for rapid delivery and modification of new capabilities. DND will need to build a systems-of-systems architecture that will provide a data-centric operating environment that will be the foundation of the future battlespace. The new architecture will represent a significant shift in how DND operates and manages its IT infrastructure to date. DND will need to investigate more investment into the virtual environment and harness the benefits the IT-Stack can deliver. This work will need to be done in conjunction with the acquisition model reform that was previously mentioned. Exploiting the benefits of the IT Stack by employing a cloud-based architecture with industry partners is a move that is being prioritized through the US DoD and is the critical enabler that provided Kessel Run its success moving forward.

Moreover, the lack of shared, standardized enterprise architecture represents significant challenges. It impacted the JIIFC/JBMC project's ability to implement its solution at the enterprise level, which is why it encountered delays. However, with Kessel Run's collaboration with Pivotal Labs, they created a classified-level cloud-based solution to establish a software development foundation that enabled DevOps methodologies. This in turn also allowed Kessel Run to prove their model to achieve ATO accreditation, allowing them to accelerate development timelines.

The US DoD's JEDI program is a cloud-based EA leveraging the latest industry technology as a potential model the CAF could use for digital evolution.[289] DND should explore adopting the cloud-based EA and partnership with private industry. It will act as a force multiplier for accelerating change in its digital acquisition process and allow for rapid adoption of new and emergent technology.

INNOVATION AND TALENT

The organizational culture within DND is by and large still operating in an analogue fashion, reflecting both the personnel and the policies that govern them or "a flip-phone military in a smartphone world".[290] DND employs technology often decades behind industry and its allies in this regard. The US DoD's sense of urgency regarding digital transformation should send signals to DND to follow. However, there is an indication that the Canadian Government and CAF leadership have recognized this need, but an underlying element is establishing an innovative culture. An effective CAF digital transformation is not just about new technology or organizational structure; it is about the people that will enable it. Industry best practices and Kessel Run have shown that adopting a generative culture will instill the necessary attributes needed for innovation and the talent necessary for reform within the digital landscape. A DevOps framework can be an agent of change, creating the conditions for future success rather than marshalling them down the archaic processes of the past.

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[289] Kevin Budning, Alex Wilner and Guillaume Cote, "Connecting the Dots on Canada's Connected Battlespace," *International Journal (Toronto)* 76, no. 1 (2021), 154-162, 159.
[290] Will Dr Roper, *Guide Book for Digital Engineers: Bending_the_Spoon*, (2021). Roper is often attributed to this quote.

CONCLUSION

This paper's goal was to explore the DevOps framework and methodologies as a recommended model for CAF digital transformation. With the challenges the CAF faces with the evolving technology landscape, this paper examined the strategic problems space that involved the US/China great power competition and the policy challenges as an impetus for change. The problem was framed around the current issue with DND/CAFs current acquisition model by identifying how the waterfall model is not compatible with acquiring digital technologies. The DevOps model was analyzed as a foundation from which CAF digital transformation could be launched by highlighting four areas for study: Digital Readiness, Agile Acquisition, Enterprise Architecture, and Culture. These studies were then applied and compared across two case studies; one explored a recent CAF IT and software development project (JIIFC/JBMC). The second explored a USAF software development initiative (Kessel Run).

In exploring the case studies, the foundational elements of a DevOps framework were compared by identifying potential areas for change within the CAF. The JIIFC/JBMC case study identified that the CAF is currently not achieving sufficient digital technology acquisition agility levels necessary to keep up with the pace of technological advancement. On the other hand, the USAF case study was used as an example of a successful implementation of a DevOps model in a defence organization. The foundational elements of the DevOps framework were also analyzed against the Kessel Run initiative to determine what elements could be used as a recommended model for CAF digital evolution.

Finally, this paper recommended exploring the four foundational areas of the DevOps framework that will enable the CAF to close the technology gap and be ready for war in tomorrow's digital battlefield. The strategic threat space highlighted by the US/China power competition is a motive for change. Moreover, the policy issue driving acquisition governance within the CAF has not yet evolved at the rate needed for the technological landscape.

Historically, the nation-states that could obtain superior technologies gained a military advantage over the adversary. However, the development of bigger bombs or faster jets is no longer the deciding factor in the information age of cyber warfare. It is now the state which can best manoeuvre in the digital ecosystem that will gain a military advantage now and in the future. As the tide of new technologies engulfs our world, fueling change, those who possess the innovative mindset of the information age will flourish. 'stay hungry, stay foolish'.[291]

[291] Stuart Brand, *The Last Whole Earth Catalog: Access to Tools* (New York: Random House, 1971). Although is famously attributed to Steve Jobs during a 2005 Stanford University commencement speech, it was originally posted on back cover of the last copy of the Whole Earth Catalog as a call to keeping a curious mind and exploring new frontiers.

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